A Comparative Study in Two Secondary Schools Aimed at Improving their Energy Management Archbishop McHale College, Tuam Coláiste Cholmcille, Indreabhán

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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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Abstract

Climate change is a crisis that is going to affect all of our lives in the future. Ireland is expected to have increased storms and rain throughout the country. This will affect our lives greatly unless we do something to change it. In an attempt to try and reduce the impacts of climate change, countries across the world met to address the problem. The meeting became known as the Kyoto Protocol. The Kyoto protocol set out objectives for each developed country to achieve with regards to carbon emissions to the same levels as 1990 levels. Due to the economy in Ireland being at a low point in 1990, Ireland was given a target of 13% carbon emissions above 1990 levels. In order to meet targets Ireland produced two energy papers, the green paper and the white paper. The green paper identified drivers for energy management and control; they were security of energy supply, economic competitiveness and environmental protection. The white paper produced targets in which we should aim to achieve to try and address the green papers drivers. Within the targets was the plan to reduce energy consumption in the public sector by 33% by 2020 through energy conservation measures. Schools are part of the public sector that has targets to reduce its energy consumption. To help to achieve targets in schools initiatives have been developed by the government for schools. Energy audits should be performed in order to identify areas where the schools can improve their current trends and show where they can invest in the future to save money and reduce the schools overall environmental footprint. Grants are available for the schools for insulation through the energy efficiency scheme and for renewable energy technologies through the ReHeat scheme. The promotion of energy efficient programs in schools can have a positive effect for students to have an understanding. The Display Energy Certificate is a legal document that can be used to understand how each school is performing from an energy perspective. It can help schools to understand why they need to change their current energy management structure. By improving the energy management of the schools they then improve the performance on the Display Energy Certificate. Schools should use these tools wisely and take advantage of the grants available which can in the short to long term help them to save money and reduce their carbon footprint.

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Chapter One: Introduction

Energy management has now become a utilized tool for reduction and conservation of energy with the aim of reducing an organisations environmental footprint whilst reducing costs. It is interchangeable with all sectors and its basic principles are to reduce unnecessary waste of energy that a building or organisation is responsible for by making the required changes.

The drivers of energy management can be different for each individual but in general can be broken down to three basic reasons: Security of supply, market competitiveness and environmental protection. Other drivers include the Kyoto Protocol and legislation.

Security of supply is an issue as Ireland currently import 90% of its energy supply in the form of fossil fuels ([1] *Department of Communication, Marine and Natural Resources 2006).* This is leaving Ireland in a position where we are reliant on other countries to provide us with energy from a source that is continuously depleting. The outcomes once the supply is depleted are that Ireland will not be able to provide enough energy to keep the country running. For this reason it is vital for people to manage their energy and reduce the amount of energy we require collectively.

For businesses to have a market advantage over competitors it is vital to use every technique possible to try and reduce unnecessary waste. The reduction of energy waste is a good example of where money can be saved for a business by taking steps that can have an overall positive environmental impact as well.

The overuse of fossil fuels both directly-by overuse of heating and transport and indirectly-by the overuse of electricity has a detrimental effect on the environment. Climate change will have a negative impact on the lives of Irish people and consumption of fossil fuels is adding to this *([2] Ray McGrath et all 2008)* Energy management can be used to reduce the amount of fossil fuels that the country is responsible for.

Ireland have agreed as part of the Kyoto Protocol to reduce its overall CO^2 emissions to levels that are 13% above 1990 levels *([14] SEAI, 2010).* The use of energy management can greatly improve Ireland's chances of meeting objectives.

The public sector has targets to reduce energy usage by 33% by the year 2020 ([33] *Department of Communication, Marine and Natural Resources 2006).* The fact that the government has set out these targets in all public buildings shows that they believe that the target is achievable. If this kind of initiative could then in turn reflect on the private and residential sectors Ireland could achieve targets set out by the Kyoto Protocol and Europe.

There is always room for improvement when it comes to energy management and each organisation should take a lean manufacturing type of approach and try and continuously improve whilst setting the targets at zero waste. By continuously bettering your system you are gaining more control and you are going to continuously save money whilst reducing your negative environmental impacts.

In schools, energy reduction methods should be introduced and integrated with learning. By introducing energy management to students in school, it not only promotes energy management at home, it also sets these students up to have a better attitude towards energy consumption in the future. Students can then bring these good habits home with them and their parents can learn from them. Teaching people at a young age will benefit the environment now and in the future. *([4] SEAI 2010)*

Any goals set out are then enhanced as a there will then be a generation of students are aware of the consequences of climate change and they will have an understanding of what we can do to change that.

1.1 Thesis Motivation

Due to the current economic climate financial cuts proposed by the government are affecting every department within the public sector. The department of education is no different having been cut by €415 million for 2010 *([5] Department of Finance 2010)*. The reduction of energy waste in the schools can save them substantial amounts of money. The money saved can then be used for educational purposes instead of being wasted on unnecessary energy.

The most costly areas in energy consumption for schools are space heating, lighting, electrical use and cooking *([6] SEAI 2010)*. During this project I will look into a means of reducing the consumption levels by using techniques that and advising them on areas where they can improve which in turn will hopefully benefit the schools in the future both financially and environmentally.

1.2 Thesis Structure

Chapter 2: The literature review will include the background of environmental issues in general followed by background of energy management and energy management in schools. I will also look into legislation, grants available and techniques that can aid the school to develop an energy management plan.

Chapter 3: This chapter is about materials and methods and is basically how I will get the information and what aspects relating to energy management the schools should be noted.

Chapter 4: This chapter is the results of my findings and what can be done with them. This chapter will include the details of the display energy certificate and energy bills findings.

Chapter 5: This chapter is the discussion for each school based on the results. It shows scenarios based on earlier information. It will include benefits and payback period. From this I can then give recommendations.

Chapter 6: This chapter is the conclusion of the entire project which includes a summary of results and a critical analysis of the project.

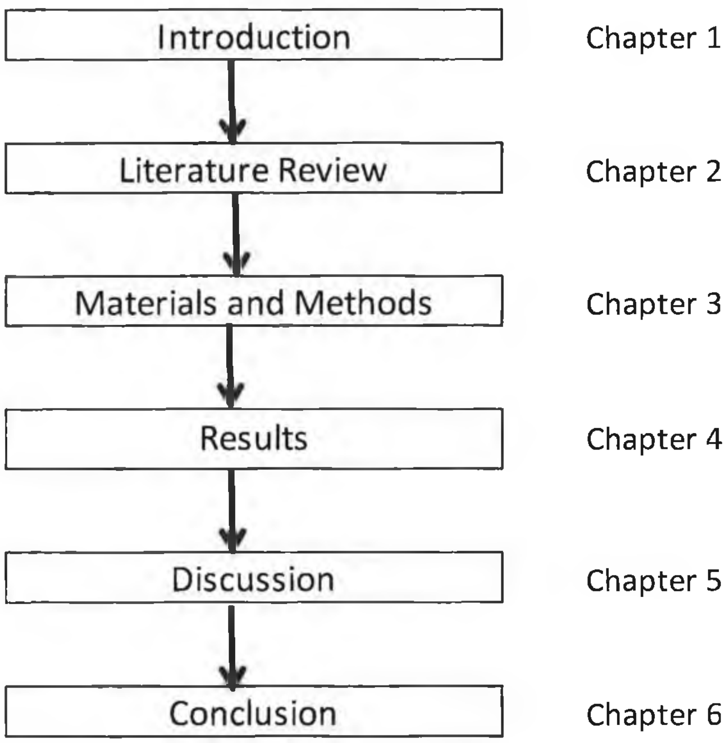


Figure 1: Structure of the Thesis

Chapter Two: Literature Review

2.1 Climate change

Climate change is becoming an ever increasing threat to our lives and the environment around us. History has shown that the Earth undergoes a natural process where temperatures change; these changes clearly show that when carbon dioxide and methane levels rise temperature increases follow. Reliance on fossil fuel based technologies in the past 100 years has increased the amount of Carbon dioxide and methane that are being released into the atmosphere; this in turn can theoretically cause an increase in temperature worldwide.

"We know that human activities have been increasing the concentration of CO^2 and other greenhouse gases in the atmosphere for at least the last century or two. Basic physics provides strong theoretical reasons to believe that such an increase in greenhouse gases should warm up the Earth" ([7] Dessler, Parson 2006)

Data has been retrieved by taking samples from the ice in the Antarctic which is represented in the diagram below. It shows the relationship between temperature, carbon dioxide and methane released into the atmosphere. It is clear from the diagram that when carbon dioxide and methane increase a temperature increase follows.

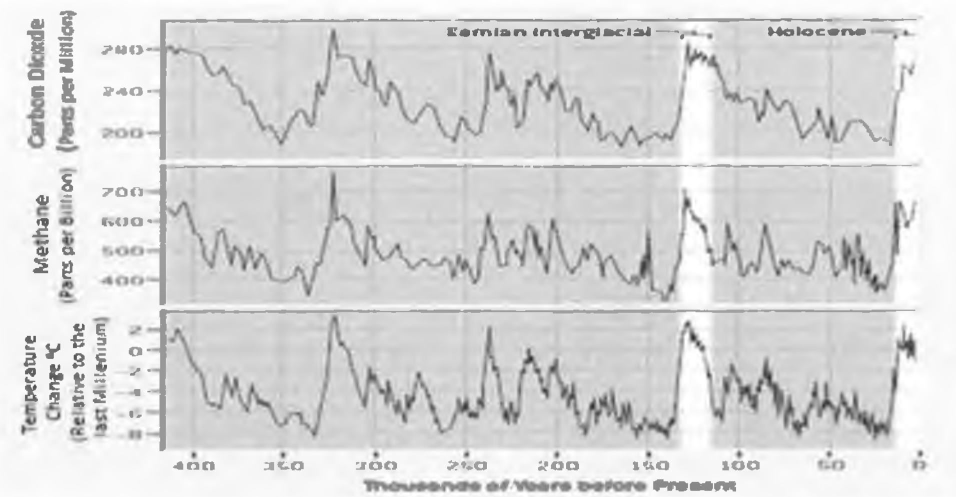


Figure 2: Comparison of Carbon dioxide James Hanson 2004

2.1.1 The Greenhouse effect

According to NASA, *"Life on Earth is supported by the atmosphere, solar energy, and our planet's magnetic fields. The atmosphere absorbs the energy from the Sun, recycles water and other chemicals, and works with the electrical and magnetic forces to provide a moderate climate" ([8] NASA, 2010)*

The sun's rays enter the Earth through the atmosphere. Most of the heat is absorbed by the Earth's surface and the atmosphere whilst some escapes back through the atmosphere. The theory behind the greenhouse effect is that gases such carbon dioxide and Methane have a higher heat absorption rate then air thus holding in radiation or heat that would have previously escaped out of the atmosphere.

By using fossil fuel consuming energy systems such as cars or oil boilers we are aiding in the release of carbon dioxide into the atmosphere which in turn is causing the Earth to heat up as less solar rays are escaping. The more carbon dioxide present in the atmosphere the higher the temperature is expected to be.

"The Earth is kept warm in a similar way, by the absorption of radiant heat emitted from the warm surface by the gases carbon dioxide, water vapour and methane. These gases, although transparent to light, are partially opaque to the longer wavelengths emitted by a warm surface" ([3] James Lovelock 2006)

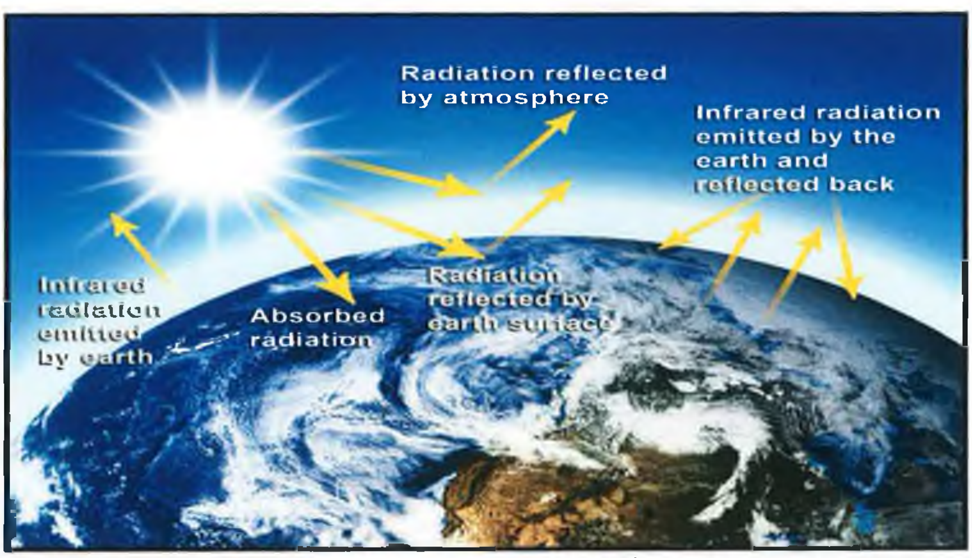


Figure 3: Greenhouse Effect

2.1.2 The Effects of Climate Change

The potential problems that can be caused by temperature increases worldwide are phenomenal. Not only will temperatures rise and cause the obvious outcomes such as droughts and melting of the ice caps, other potentially population reducing effects that can follow if we don't take action are alarming.

Flooding due to the ice caps melting can potentially wipe out small low land islands such as the Maldives where the highest point is 2.3 metres above sea level and damage coastlines in many countries.*([9] Central Intelligence Agency 2010).*

"Sea level rise is expected to exacerbate inundation, storm surge, erosion and other coastal hazards, thus threatening vital infrastructure, settlements and facilities that support the livelihood of island communities. Deterioration in coastal conditions, for example through erosion of beaches and coral bleaching, is expected to affect local resources." ([10] IPCC Report 2007)

Death is expected to be a result of the results of Climate Change in the world.
"Endemic morbidity and mortality due to diarrhoeal disease primarily associated with floods and droughts are expected to rise in East, South and South-East Asia due to projected changes in the hydrological cycle"

"By 2030, production from agriculture and forestry is projected to decline over much of southern and eastern Australia, and over parts of eastern New Zealand, due to increased drought and fire"

"Climate change is also projected to increase the health risks due to heat waves and the frequency of wildfires." "In southern Europe, climate change is projected to worsen conditions (high temperatures and drought)" ([5] IPCC Report 2007)

These issues need to be dealt with by every means necessary in order to ensure the safety of all species throughout the planet. Measures have been put in place by World leaders with each country throughout the world required by law to achieve goals with regard to Climate Change. This was known as the United Nations Framework Convention on Climate Change. (UNFCCC)

2.1.3 Ireland and Climate Change

In 2006 Bertie Ahern released a statement saying: *"Climate change is among the greatest challenges of our time. The debate is no longer about whether climate change is happening: we now know that it is. The recent report from the Intergovernmental Panel on Climate Change reinforces our understanding of the scale of action required." ([11] Bertie Ahern 2006)*

According to Ray McGrath et all in *Ireland in a Warmer Climate* The predicted outcomes of climate change in Ireland

- Warmer temperatures of between 3 and 4°C in the summer and autumn
- Between 15-25% more rain in autumn and winter whilst summers will be drier
- Increased risk of intense cyclones
- Sea Levels rising by approximately 3.5cm per decade
- Increased water levels mean harsher more damaging storms
- Higher precipitation means more floods expected
  ([12] Ray McGrath et all 2008)

If we do not act, each of the above outcomes could have a substantial impact on our lives in Ireland. Increased temperatures could result in water shortages in some parts of the country, whilst a rise in sea levels could affect infrastructure and eco-systems on coastal towns. In November 2009 Ireland got a perception of how damaging nature can be when we were witness to severe floods which is estimated to be a persistent problem that Ireland would face if Climate Change was to occur. Below is a picture of Cork City during this period.

Figure 4: Cork City, 98fm 2009

2.2 The Kyoto Protocol

The Kyoto protocol (Conference of the parties III) took place in December 1997 in Kyoto in Japan which was put into force in February 2005. Its goal was to stabilize greenhouse gas concentrations in the atmosphere in order to minimize human interference with climate change. As of the 3rd December 2009, 189 countries have signed up for the treaty. ([4] United Nations 1998)

2.2.1 Objectives

The objectives and goals set out for the Kyoto Protocol were to establish an international agreement with the aim of reducing the density of Greenhouse Gas emissions in the atmosphere to a level that would be considered stable. The agreement is legally binding for all Annex I countries and there are commitments from all other member states. There are 37 Annex I countries and they are the developed countries.

The protocol required all Annex I countries to commit to reduce the levels of Greenhouse Gas Emissions that they were responsible for. The target was to reduce the four greenhouse gases: carbon dioxide, methane, nitrous oxide and sulphur hexafluoride collectively by 5.2% from 1990 levels as well as reducing harmful gases hydro-fluorocarbons and per-fluorocarbons.

"The Parties included in Annex I shall strive to implement policies and measures under this Article in such a way as to minimize adverse effects, including the adverse effects of climate change, effects on international trade, and social, environmental and economic impacts on other Parties, especially developing country Parties" ([13] United Nations,1998)

"The Parties included in Annex I shall, individually or jointly, ensure that their aggregate anthropogenic carbon dioxide equivalent emissions of the greenhouse gases listed in Annex A do not exceed their assigned amounts, calculated pursuant to their quantified emission limitation and reduction commitments inscribed in Annex B and in accordance with the provisions of this Article, with a view to reducing their overall emissions of such gases by at least 5 per cent below 1990 levels in the commitment period 2008 to 2012."([14] United Nations, 1998)

The results of the intergovernmental panel on climate change second assessment report were vital for the directors of the protocol when it came to choosing targets for the protocol.

The report outlined the potential crisis we would face if the temperatures were to rise. It was put together by use of modelling, scientific theory and scientific reports and facts that was comprised by various scientists worldwide. The focus of the Kyoto protocol was to put in place procedures for participating countries to try and avert the potential crisis in the future. *([15] IPCC 2007)*

"The Conference of the Parties serving as the meeting of the Parties to this Protocol shall take into account the methodological work of the Intergovernmental Panel on Climate Change, the advice provided by the Subsidiary Body for Scientific and Technological Advice" ([16] United Nations, 1998)

"Each Party included in Annex I shall incorporate in its annual inventory of anthropogenic emissions" ([17] United Nations 1998)

2.2.2 The Kyoto Protocol and Ireland

Ireland is an Annex I country and has massive implementations to put in place if they want to meet Kyoto Protocol targets set out for them. The problem for Ireland is the change in status since 1990. In 1990 the economy in Ireland was weak so consumption was low. Since then Irelands economy has become stronger allowing consumption to increase. The directors of the protocol took this change in economies into account, Ireland are required to bring our GHG emissions to 13% above 1990 levels.

"Ireland's target is to limit the increase in its greenhouse gas emissions under the Kyoto Protocol to 13% above 1990 levels by 2008-2012" ([18] SEAI, 2010).

"Ireland's total emissions in 2006 of 69.77 million tonnes are now 25.5% above 1990 levels. Under the Kyoto Protocol Ireland is allowed a 13% increase on 1990 levels, which amounts to 62.84 million tonnes." ([3] EPA 2008)

2.4 Energy

In order to meet targets set out by the Kyoto protocol it is essential that the correct steps are taken to ensure so that CO^2 emissions are reduced. A great deal of CO^2 is produced from the energy sector and from direct and indirect use of energy systems. The majority of CO^2 Emissions are energy related be it for fuel, transport or from electricity. This shows that management of energy is essential in meeting objectives. ([19] *International Energy Agency 2009)*

The diagram below shows the breakdown of CO^2 emissions in Ireland. It is evident from this that a large proportion of emissions are created through electricity and heating in buildings. This shows there is room for reduction of overall emissions by using energy management techniques in buildings.

From the diagram we can see that thermal energy emissions have not escalated drastically since economic and population growth. Electricity starts off quite low but steadily gains as the economy and population grows. The largest increase of emissions is in transport. They have continued to rise since 1990. Emissions from transport have almost tripled, which significantly need to be addressed by the government. There is room for improvement in all areas.

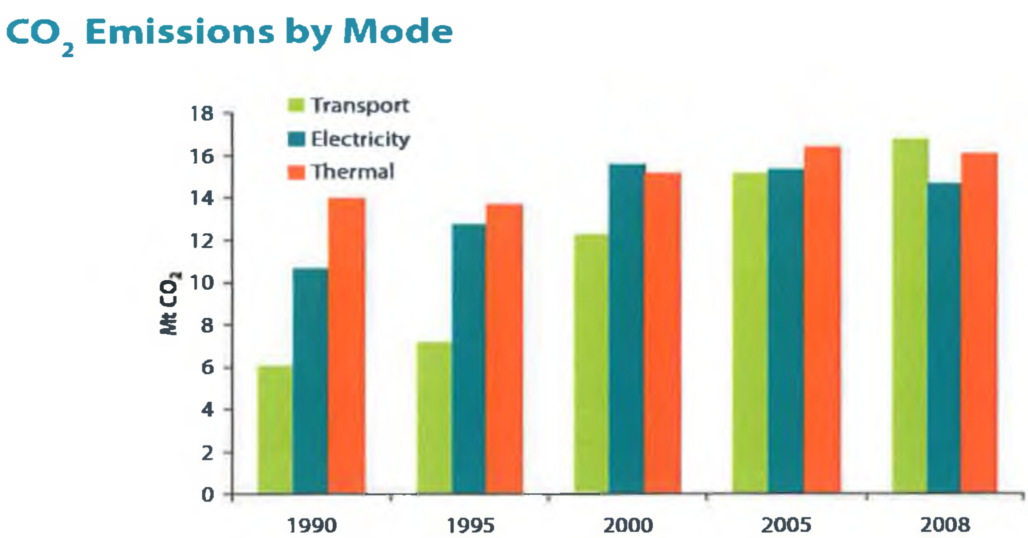


Figure 5: CO2 emissions, SEAI 2010

2.4.1 Electricity in Ireland

Ireland's electricity demand increased during the economic boom. *"The increase in demand in recent years has been among the highest in the OECD due to strong economic and population growth" ([20] Forfas 2007)*

Technically considering current markets, electricity usage should now be falling. The economic downturn should be used to promote the importance of energy management and conservation so that people with financial difficulties can save money on energy bills. Statistics now show that Ireland as of 2007 is the second most expensive country for electricity and these prices are affecting people's finances. *([21] Forfas 2007)*

"Fuel makes up the largest component of retail prices in Ireland, accounting for 56 per cent of the average price. This will be higher for heavy users and lower for lighter users, such as domestic users" ([22] Forfas 2009)

In order to be a competitive nation - globally Ireland needs to focus on reducing its electricity prices. Ireland's reliance on fossil fuel consuming energy systems for electricity generation is a major contributor to electricity prices being so high. This is due to the fluctuations of oil prices.

"A reliable and competitively priced supply of energy is vital for business and its ability to compete successfully in international markets." ([23] Forfas 2009)

Thankfully, progress has been made on renewable energies. In 2005 electricity generation from renewable energy and hydropower was at 8.6%. The aim for 2010 is 15% which is quite a significant increase in 5 years. Ireland wish to achieve a target of 40% of electricity generation is from renewable energies by 2020.

"The Irish government target is to achieve a 15% share of renewables in gross electricity consumption by 2010."([24] SEAI 2009)

"In order to achieve our national targets for renewable electricity by 2020 (40%) an estimated 5,500-6,000 MW of wind generation is required" ([25] SEAI 2010)

2.4.2 Energy from Heating Systems

Ireland faces the same issues as with electricity when it comes to heating fuel. If fossil fuels are continued to be used the way they are we may face financial crisis due to lack of security in supply. In 2008 energy use for heating accounted for 34% of total energy consumed in Ireland. Out of this 55% is oil and just 3.6% is renewable energy systems. *([26] SEAI 2009)*

This shows that Ireland relies significantly on imports of fuel for thermal purposes. Development of renewable systems must be increased but before investments like that are made energy management techniques such as insulating buildings should be promoted. It is evident that the government agree with this considering that grants that are available for energy management *([27] SEAI 2010)*

SEAI have developed a scheme called Energy Efficiency Retrofit Fund (EERF) which funds public sector establishments that wish to redevelop there building. In the private sector there is a grant available for combined heat and power systems (CHP). ([93] SEAI 2010) The ReHeat Scheme is a grant for the public sector to help fund the purchase of thermal solar panels, wood chip/pellet boilers and Heat Pumps, all of which are considered renewable energies. *([28] SEAI* 2010).

2.4.3 Security of Supply

Security of supply is a major issue facing Ireland today. Most of Irelands heating systems are run from oil consuming systems. *"Each year since 1981, the world has consumed more oil than is discovered. The relatively poor volume of discoveries in recent years, against a background of rising oil consumption, means that the gap is widening." ([29] Forfas, 2006)*

There is also opportunity to develop an economy from selling excess energy produced from renewable energies to countries throughout Europe, through the developing grid interconnections. *([30] Forfas 2009)*

The green paper and the white paper are energy plans that have been developed by Ireland and published to show the measures that need to be made in order to achieve targets of agreements made with Europe and the Kyoto Protocol. The aims of the papers are to develop a sustainable Ireland for the future.

2.4.5 The Green Paper

In October 2006 the Government published an energy paper called The Green Paper – Towards a Sustainable Energy Future for Ireland. The Green paper stated that the Government acknowledged the challenges of energy policy facing a country which has high energy requirements, continuously rising oil prices as well as reliance on oil and most crucially lack of security of supply. The aim of the paper was to provide a platform for Ireland to develop energy security for the future. *([31] International Energy Agency 2010)*

Security of supply

According to the green paper *"Security of energy supply is a priority issue. It is a complex and evolving concept that can encompass aspects of energy demand, supply and prices". ([32] Department of Communication, Marine and Natural Resources 2006)*

Environmental Sustainability

They believe that *"A key energy policy objective to 2020 will be to ensure the continued ambitious growth of sustainable energy resources" ([33] Department of Communication, Marine and Natural Resources 2006*

Economic Competitiveness

On economic competitiveness it is said that *"Harmonising the market regime as part of the development of an All-island market involves the movement to a Gross Pool market arrangement for the all-island electricity market." "Government is committed to ensuring an increasingly competitive natural gas market in the interests of consumers" ([34] Department of Communication, Marine and Natural Resources 2006)*

Developing the White Paper from the Green Paper

The Green Paper put forward 22 questions to be answered from consultants under the above headings. The questions asked were intended as feedback to give the Government additional knowledge before finalising the White paper. *([35] Department of Communication, Marine and Natural Resources 2006)*

2.4.6 The White Paper

The Government's Energy White Paper was launched in 2007 named *Delivering a Sustainable Future for Ireland. It* details the Governments Energy Policy Framework 2007-2020, reacting to the combined confront of climate change and energy.

"This White Paper sets out the roadmap by which we will steer Ireland to a new and sustainable energy future. My vision for the Ireland of 2020 in energy terms is ambitious, challenging and optimistic" ([36] Minister Noel Dempsey 2007)

Main targets of the white paper

1. An aim of 33% energy saving across public sector by 2020;
2. Public sector is to lead the way in bio-energy heating, renewable electricity, CHP and biofuels
3. Re-evaluate part L (Conservation of fuel and energy) of building regulations in 2008 to decrease energy demand by 40% in comparison to current energy use
4. Sustainable transport action plan to consider biofuels in local authority vehicles
5. Electricity demand side management will be dealt with, as plans to establish smart metering, from the ESB, for all new and existing houses
6. Existing social housing design guidelines to be restructured.

([37] Department of Communication, Marine and Natural Resources 2007)

These papers are developed with targets to be achieved by certain dates. To achieve targets it is essential that the public, private and residential sectors work together. To do this guidelines are required so that the maximum energy savings and financial benefits are received. The first target in the white paper relates to energy management. This shows the importance of energy management when it comes to meeting original targets set out by the Kyoto Protocol.

2.5 Energy Management

Energy management is basically taking control of energy consumption and reducing it by taking a selection of measures. To understand what measures are required energy audits are required. The focus is to reduce the impacts that over consumption of energy has on the environment whilst having a short to long term financial gain. We need to reduce the amount of CO^2 emissions we are responsible for and by choosing to manage our energy we are on the right path to achieving this.

"The primary objective of energy management is to maximize profits or minimize costs. Some desirable sub objectives of energy management programs include:

1. *Improving energy efficiency and reducing energy use, thereby reducing costs*
2. *Reduce greenhouse gases and improve air quality*
3. *Cultivating good energy communications on energy matters*
4. *Developing and maintaining effective monitoring, reporting, and management strategies for wise energy usage*
5. *Finding new and better ways to increase return from energy investments through research and development*
6. *Developing interest in and dedication to energy management program from all employees" ([38] Barney L. Capehart et all, 2008)*

In this chapter I have a look at energy audits which involves the analysis of energy bills, the geographic location, listing of equipment, lighting, dimensions and materials. I then will look at the means in which the schools can improve in energy management and show what systems are available to reduce consumption from the above areas.

Finally I will look into legislation such as SI 542 part 4 and the Display Energy Certificate for Schools that is relevant to the school and what energy management schemes the schools can take part such as the Greener Schools Scheme.

2.6 Energy Audit

An energy audit is an energy management technique that can be used to collect an organisations energy related inventory. It is important to help you to understand where energy is being used and wasted so that costs of energy usage can be identified. There are various different types of energy audits and the method used is at the auditor's discretion. The interpretation that the auditor uses should be defined and prepared before the audit commences.

"Energy audits can mean different things to different individuals. The scope of an energy audit, the complexity of calculations, and the level of economic evaluation are all issues that may be handled differently by each individual auditor and should be defined prior to beginning any audit activities."([39] Albert Thumann et all, 2009)

Before commencing with the audit, details such as history of the building (Year Built), materials used such as insulation and windows, boiler history, facility layout, operating hours, geographic location, equipment lists and utility bills from the previous 12 months should all be gathered.

"The energy audit process starts with an examination of the historical and descriptive energy data for the facility." [40] Barney L. Capehart et all, 2008)

2.6.1 Analysing Energy Bills

It is important that a detailed analysis of the utility bills is taken to understand patterns of usage that the organisation outputs. With 12 months data it is possible to show when the highest consumption was attained, night and day consumption, when peak consumption happens and what type of energy is costing the most. It is also possible to graph consumption over time and identify whether or not there are increases.

It can help the auditor to understand what areas are in need for improvement. It is also possible for the auditor to analyse the bills and advise from them the best options that are available to cut costs, such as watt-less units on an electricity bill.

"Regardless of what type of fuel is used, understanding how energy is billed is fundamental to learning how to control energy use and costs" ([41] Albert Thumann et all, 2009)

2.6.2 Geographic location

It is important to understand where and what weather is expected in the organisation that is being audited. *Barney L. Capehart et all* state that:

"The geographic location of the facility should be noted, together with the weather data for that location. The local weather station, the local utility or the state energy office can provide the average degree days for heating and cooling for that location for the past 12 months" [42] Barney L. Capehart et all, 2008)

2.6.3 Equipment List

This is important so that the auditor can identify which piece or pieces of equipment are responsible for unnecessary energy wastage.

"The auditor should get an equipment list for the facility and review it before conducting the audit. All large pieces of energy consuming equipment such as heaters, boilers, air conditioners, chillers, water heaters, and specific process related equipment should be identified." [43] Barney L. Capehart et all, 2008)

2.6.4 Facility Layout

A facility layout or plan is necessary which show the size and structure of the building. Information on materials used and dimensions of the walls, roof and floor should be recorded. This includes windows, doors and insulation materials. This is important so that it is easy to identify where the main problems with regard to air leakages in the facility are.

"Next the facility layout or plan needs to be obtained, and reviewed to determine facility size, floor plan, and construction feature such as wall and roof materials and insulation levels, as well as door and window sizes and construction"([44] Barney L. Capehart et all, 2008)

2.6.5 Other objectives

Safety and communication is essential for the audit to work.

"Safety is a critical part of any energy audit. The auditor and the audit team should have a basic knowledge of safety equipment and procedures"

"Getting the correct information on facility equipment and operation is important if the audit is going to be most successful in identifying ways to save money on energy bills." ([45] Barney L. Capehart et all, 2008)

2.6.6 The Audit

Physically doing the audit is *"a tour of the facility to visually inspect each of the energy using systems." ([46] Albert Thumann et all, 2009)*

Equipment list

A template can be used to aid in the gathering of the necessary data. An Example is shown in *Figure 14* below.

"The electrical system audit typically includes gathering the following data: Lighting system survey, Power factor and demand, Motor inventory and loads." ([47] Albert Thumann et all, 2009)

Area	Appliance	Model	Quantity	Wattage
Hallway	Florescent Tube Light bulb	Philips	10	58
Hallway	Dimplex electric heater	RDH2010TCA	1	2000

Figure 6: Lighting and Electricity Template

The Building

Materials and dimensions should be recorded. An example can be seen in figure 15.

"The envelope audit should record for each space, the size, physical characteristics, hours of operation and function. The assorted materials of construction, windows, doors, holes, percentage glass, etc. should be recorded" ([48] Albert Thumann et all, 2009)

Organisation Name:	GMIT			Date:	1st June 2010	
Indoors Room	Height	Lengt	Width	Windows	Door	Wall Thick
Boiler Room	2.61m	3.40m	2.18m	0	0.9 x 1.92m	0.42m
Staff Canteen	3.33m	4.19m	7.54m	2.00 x 1.32m (6)	0.9 x 2.08m	0.30m

Figure 7: Building Dimensions Template

Other Information

During the audit observations should be made and taken down that can affect energy outputs. Anything that could reduce the amount of energy consumed should be taken into consideration. For example if one light switch controls ten bulbs then it should be considered that a multi-switch should be installed so that only required lights are turned on.

2.6.7 Post Audit

Once all information is gathered it should be analysed and recommendations should be given via a report based on the information gathered in the audit. Areas of improvement should be specifically reported on. In the public sector the main consumption areas are lighting, water heating, cooking, office equipment, heating use and heating control in the building. The breakdown of energy consumption in the public sector can be seen in the *figure 8* adapted from *"Energy end-use in Ireland"* below.

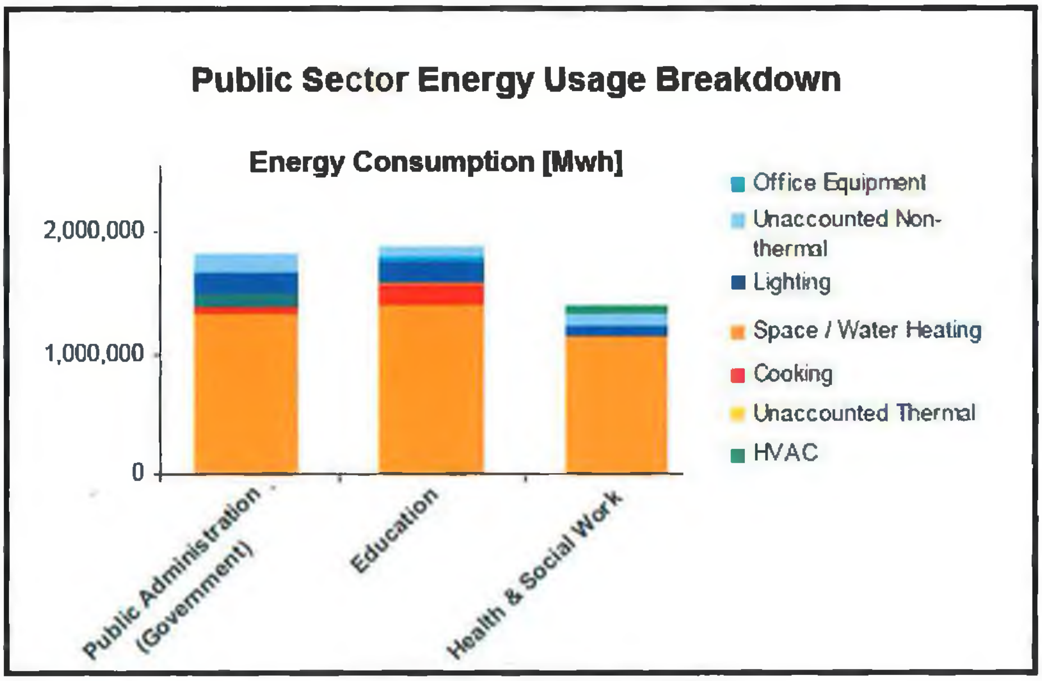


Figure 8: Breakdown of public sector energy consumption SEI et all 2008

2.7 Material Control

2.7.1 Energy Efficiency Scheme

In 2009 an energy efficiency scheme was made available for schools that enabled them to acquire insulation where required. The scheme was developed by the department of education and science in partnership with sustainable energy authority Ireland. The scheme aids schools financially to install wall and roof insulation in order to increase air tightness in the building thus reducing energy costs. The school is responsible for organising the work, attaining the materials and controlling of costs.

"The Minister for Education and Science is pleased to announce details of a new Energy Efficiency Scheme for primary and post primary school buildings, which is being implemented with the assistance of Sustainable Energy Ireland (SEI)." ([59] Energy Education 2009)

"School authorities will be provided with funding from the Department to carry out and manage the works, including control of costs, with guidance from and minimal interaction with the Department" "Schools applying for funding under this Scheme must have proper attics and/or external walls that are based on cavity wall construction" ([59] Energy Education 2009)

The scheme is only available the once so care should be taken when planning to ensure that the best possible outcomes are achieved for the school. It is a requirement to install the insulation during the summer months.

2.7.2 U-Value

A U-Value is a means of measuring the insulation qualities of a material by calculating expected heat loss through it. It can be beneficial during building material selection. The lower the U-Value is, the better the material. It is calculated through the heat loss of energy per metre squared. It is indicated in units of Watts per Meter Squared per Degree Kelvin or W/m2K. The majority of typical materials already have calculations available.

"To put it simply, a U-Value is the measure of the rate of heat loss through a material. Thus in all aspects of home design one should strive for the lowest U-Values possible because, the lower the U-value, the less heat that is needlessly escaping." ([60] SEI circa 2007)

2.7.3 Insulation in the walls and roof

If heat loss is high then then the cost of energy would be colossal. This can be avoided by installing insulation throughout the building thus keeping heat in the building and reducing the effect of thermal bridging.

"Building controls have a vital role to play in preventing waste of energy. The amount of energy required to run a building is determined by: thermal efficiency of the building envelope, thermal insulation, airtightness and provision for passive solar gains."([61] CIBSE circa 2000)

In order to achieve a C1 rating it is a requirement to have walls with a U-Value of 0.27 or better. To achieve this figure on a wall that is made from stone, it is a requirement for the building to have at least 50mm of wall insulation and ceiling fitted internally. *([62] Xtratherm Insulation, 2010)*

BUILDING FABRIC	U-VALUE TARGETS 2006 C1	2007 B1	A3
Walls	0.27	0.22	0.18
Floors	0.25	0.20	0.15
Roof Ceiling	0.16	0.15	0.12
Roof Slope	0.20	0.18	0.16

Figure 9: U-Value Material Requirements Xtratherm 2010

Windows and Doors

"It is possible to reduce energy loss by using windows and doors which have a low U-Value. So for example single glazed windows have a typical U-value of 5.6 while double glazed windows have a typical U-value of 2.8." ([60] SEAI circa 2007)

On doors it is essential to keep them closed whenever possible. If a door is going to be continuously opened then an enclosed porch area or double doors can aid in the reduction of heat loss. When one is open, the other is closed. Where this is not possible materials should be put in place to prevent air leakages. Measures such as springs on doors to keep them closed and draught excluders can be used a start to reducing bills. *([63] SEAI 2002)* *"Porches and draught lobbies can reduce draughts at external doors."*

Other Means

Maintenance of materials is essential to keep heat from escaping from a building. Holes in walls and cracks in windows and other materials can contribute to heat loss from a building.

2.8 Heating Systems

The largest contributor to energy consumption in education in Ireland is through space and water heating. This can be greatly improved by installing renewable energy technologies to heat the space in a building. (See *figure 7*) The main focus for renewable systems is to find out which systems are most feasible financially. With this in mind I have decided to focus on systems that have grants available that can greatly help the schools financially.

2.8.1 Renewable Reheat Deployment Programme (ReHeat)

The purpose of this programme is to help to develop and install the use of renewable energy heating systems in the public and private sectors. The programme will provide financial aid for organisations who wish to install biomass boilers, heat pumps or thermal solar panels. The overall agenda is to reduce carbon emissions by displacement of fossil fuels.

"The Renewable Heat (ReHeat) Deployment Programme is aimed at stimulating the installation of new renewable energy plants. The Programme is focussed on biomass boilers (fuelled by wood chips and wood pellets), solar thermal collectors and heat pumps."([66] SEAI 2010)

The grant is available for any organisation that wishes to update their current energy system. It is also possible to receive a grant for more than one system if there are benefits from both. For example if thermal solar panels are required for water heating and a biomass boiler required for room heating then there is a grant available for both.

"Grant support up to 40% or €5,000 per technology (whichever is less) for feasibility studies; the total amount of support being limited to €300,000 for all feasibility studies, Capital investment support of 30% for eligible costs, limited by a maximum qualifying cost profile for each technology" ([67] SEAI 2010)

The amount of funding given to the organisation depends on various criteria. The type of energy system, the size of the system, the cost of the system and the kWh output of the system all have a role in the amount of financial aid made available by the Sustainable Energy Authority Ireland.

There is a ReHeat calculator available to calculate the grant available for each system: www.seai.ie/Grants/Renewable_Heat.../ReHeat_Grant_Calculator.xls

2.8.2 Solar Thermal panels

A Solar Thermal System is a solar panel system that heats water. Solar panels are installed on the roof with a hot water cylinder installed close by. The thermal panels heat during daylight heating up a liquid inside the panel, usually anti-freeze. The heat is transferred by the medium (anti-freeze) to the hot water cylinder.

"Solar thermal collectors trap the solar radiation between an absorber and a layer of glass. By passing a solar fluid through the hot absorber this free heat energy is soaked up and can be stored ready for use in a solar storage cylinder"([67]Buderus 2010)

According to the *EPA* the life expectancy for a thermal solar panel is 30 years and the payback period for solar thermal panels can range between 8 and 20 years. Using the 40 % grant would then reduce this to between 4.8 and 12 years before payback. It all depends on how much hot water is required for the building throughout the year. *([68] EPA 2010)*

Solar Panels in Ireland

In Ireland if we consider that there is a grant of up to 40% available for thermal solar panels, the payback period would be relatively short and assume that more panels could be installed to raise the energy percentage. In public and private sector buildings it is expected that 40% of water heated from solar panels is achievable. Payback is expected to be between 7 and 8 years in the residential sector and a bit more in the private sector. *([69] Enerfina 2010)*

"In large applications, active solar thermal systems are generally designed to cover 30 to 40% of the heat demand. As the price of energy continues to rise, a solar water heating system can reduce your running costs and provide an excellent return on investment for your business." ([70] SEAI 2010)

2.8.3 Biomass Fuels

When trees grow they absorb CO^2 during photosynthesis, the tree is then chopped and turned into biomass/wood chip/pellet energy, other trees are then planted in their place, the wood chip is burned in the burner and the CO^2 emissions that were absorbed earlier are released into the atmosphere.

"Wood pellet and chip are carbon neutral as the carbon dioxide released at the burning stage is equivalent to the amount absorbed for the growing of the tree." ([71] Renewable Energy Ireland 2010)

Wood chip and wood pellet are biomass solid fuels which are often gathered from waste wood. Biomass boilers are a clean alternative to fossil fuel consuming boilers. They have advanced dramatically in recent years allowing wood fuels to compete with fossil fuels. Wood chip and pellet burners can directly replace oil burners without having to reconfigure the heating system such as radiators and plumbing.

"Wood fire has been used as a heat form for thousands of years. During that time the methods for burning wood and other biomass have progressed from an open pit to very sophisticated controlled combustion systems." "Pellet burners can replace oil burners in existing boilers" ([72] Sjaak van Loo and Jaap Koppejan 2009)

Wood Pellets

Wood pellets are another form of wood fuel. They are a more compact form of energy then wood chip so are suitable for places with limited space. The process of producing wood pellets is stated by *Renewable Energies Ireland*:

"The typical process for making pellets is more complex. It involves kiln drying the raw material grinding it into sawdust, then the pellets take their shape in a machine that forces the material through a series of dies under immense pressure. The newly formed pellets are let cool before storage" ([71] Renewable Energy Ireland 2010)

The main advantages of wood pellets are the fact that large amounts of space are not required. According to ([73] *Massachusetts energy Division* One tonne of wood pellets is the equivalent of 180 gallons of oil. The problem with them is that they are not developed in Ireland yet.

Wood Chips

Wood chips are a fuel source composed of small chippings of wood. The advantages of wood chips are that they require little treatment prior to use except for drying. They can be sourced throughout Ireland which can enhance the local economy and reduced travel ensures that the carbon footprint throughout the product lifecycle is low.

"The process for wood chip typically involves chipping of the wood, a possible drying process and storage" "The growing, harvesting and manufacture of wood chip and pellets can contribute to new business opportunities in rural areas" ([71] Renewable Energy Ireland 2010)

Storage of wood chip is one of the disadvantages as you need up to 3 times more space then wood pellets to store it. In a schools situation this should not be a problem as there is usually storage areas accessible for delivery.

"Wood chips (at 25% moisture content) are cheaper than pellets per unit of energy delivered. Wood pellets: 650kg/m3 (based on wood pellets <10% moisture). Wood chips: 200kg/m3 (based on wood chips 25% moisture" ([74] Building for a Future 2010)

Wood fuel vs. Oil

According to the *([75] Biomass Energy Centre 2010)* a litre of oil gives 10Kwh of energy, 1 tonne of wood chip gives 3500Kwh of energy whilst 1 tonne of wood pellet gives 4800Kwh of energy. This works out at €0.065, €0.023 and €0.035 per Kwh respectively. The price of wood chip and wood pellet boilers can vary depending on the size. The SEAI ReHeat Calculator breaks it down into price per Kwh seen below. *([76] SEAI 2010)*

Maximum Capacity Costs for Biomass Boilers	
Plant scale ranges kW	Maximum Capacity Cost €/kW
≤20 kW	€1,500 / kW
>20 kW and ≤ 50 kW	€650 / kW
>50 kW and ≤ 250 kW	€500 / kW
>250 kW and ≤ 500 kW	€350 / kW
>500 kW and ≤ 1000 kW	€250 / kW
>1000 kW	See Below (€150 / kW)

([76] SEAI 2010)

It should be noted that when boilers are too large they are inefficient. Combinations of automatic wood boiler systems in conjunction with solar panels are very effective and popular solutions. The latest boilers available can burn both wood chip and wood pellet. *([71] Renewable energy Ireland 2010)*

2.8.4 Heat pumps

A heat pump is technically described as follows: *"A heat pump is essentially a vapour compression refrigeration machine which takes heat from a low temperature source such as air or water and upgrades it to be used at a higher temperature. Unlike a conventional refrigeration machine, the heat produced at the condenser is utilized and not wasted to the atmosphere."([77] Clive Begs, 2009)*

The installation of heat pumps in the ground is generally to do with the constant temperature that is held there. The advantages of them are that you will always get more energy out of them than what was put in. *([80] Randall McMullan 2002)*

It is expected that for every unit of electricity that is used by the heat pump, between 3 and 5 units are generated. It is considered a seriously economical mean of heating a building with efficiencies of approximately 400% which in comparison to a maximum of 90% for boilers. *[81] SEAI 2010)*

The major costs involved in heat pumps are the installation procedure. It would involve large amounts of digging up of land around the building as they do require a lot of space. The payback period for heat pumps is expected to be between 8 and 10 years depending on how much heat is required. The heat is generally deployed through an under floor heating system. *([82] SEAI 2010)*

With the installation costs in mind it may be easiest to install geothermal heat pumps just before any planned developments, renovations or extensions to a building are processed.

2.8.5 Heating Control

Wastage happens in buildings with regards to energy when comfort levels are not right for the occupants of the room. Often radiators are at full heat capacity whilst windows are open. For this reason a control system is important. A control system can be:

"Simple on/off control, proportional, integral and derivative control, optimisers and compensators, and intelligent controls". ([55] CIBSE circa 2000)

Where possible, controls should be integrated into the building. Ideally temperature controls would be installed in each room so that comfort levels are relative to the occupants.

2.9 Lighting Control and Maintenance

Lighting can have a major impact on energy consumption in a building. There are various steps that can be taken to ensure that money is saved on lighting. Type of lights used, lighting control, utilization of daylight, maintenance of lighting and energy awareness are all areas that can affect the energy costs from lighting.

"Light and the effects of light stimulate vision so the control of light from natural and artificial sources is an important part of the built environment and our comfort" ([49] Randall McMullan 2002)

2.9.1 Type of lights

It is important to have the best available bulbs installed in a building. The use of incandescent lights can greatly increase the costs of energy. If the organisation has incandescent bulbs it is advisable to replace them with energy efficient CFL bulbs.

In public buildings it is usual to have fluorescent lighting which is regarded as relatively energy efficient. There have been developments in recent years where cheaper to run more efficient T8 LED tubular fluorescent lighting can replace the older less efficient fluorescent tubes. They have a longer life expectancy of 50000 hours compared to 8000 for a florescent tube. 58w florescent tubes can be replaced by 18w LED lights. The price per bulb is €75 from http://www.alliedsolar.ie/ which at first seems expensive but when worked out. Expected payback now is said to be 2 years.

"The development of energy efficient lamps, coupled with the availability of a wider range of luminaire designs has made possible very significant energy savings in general purpose lighting and has brought dramatic lighting effects within reach of relatively modest budgets." ([50] Thermie circa 2002)

2.9.2 Maintenance of lighting

It is important to maintain the lighting that you have. CIBSE reports that

"Long-term variation occurs as a result of light loss as lamps age and dirt accumulates over a period of months. Dirt deposited on or in the luminaire will cause a reduction in light output from the luminaire" ([51] CIBSE 2002)

2.9.3 Utilization of Daylight

Getting the most out of natural daylight available is an effective way of cost savings. Lighting in the *figure 8* above appears to be the second most costly source of energy usage. Natural daylight has enough luminance to provide lighting for a building for most of the working day even during winter months in Ireland thus reducing the need for artificial lighting. The key issue is getting the most out of this free energy and utilizing it to reduce energy costs. *([52] Thermie circa 2002)*

A regular scenario in buildings during the daytime is lights on and blinds down. This can often be due to glare from sunlight. *"Glare occurs whenever one part of an interior is much brighter than the general brightness in the interior. The most common sources of excessive brightness are luminaires and windows, seen directly or by reflection." ([53] CIBSE 2002)*

Measures can be taken to utilize sunlight whilst reducing glare - lighter shade of painting in areas that are least reached by sunlight gives a feeling of brightness throughout, but positioning of windows and reflectors is essential. Screening can be an important aspect of reducing glare and reflectors can enhance the circulation of light. Below in *figure 8* are reflective and screening methods for the utilization of daylight whilst reducing glare.

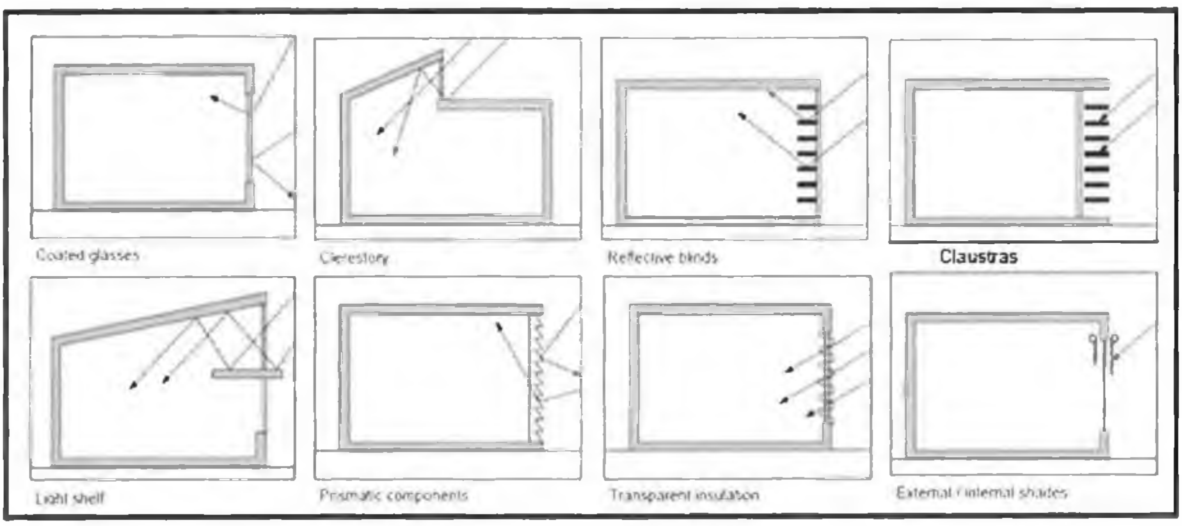


Figure 10: Utilization of sunlight, adapted from Thermie circa 2002

The best method for the utilization of daylight is different for every building. Each circumstance should be analysed and other elements like position, angle facing and the use for the room all need to be taken into account.

2.9.4 Lighting Control

Another area where the cost of lighting can be reduced is through proper control. Switching off lighting that is not in use is an obvious way of reducing energy consumption which unfortunately is not done enough. In the short term energy awareness reminders and posters can be put up for occupants to switch off lights. This may have positive effect although there are other considerations that can be put into place to reduce costs through control. The areas where lighting used can be improved can be done so by using the following:

Timer Control

Timers can be used to control lighting *"Timer Controls: Where timers are set to switch off lighting for periods of unknown activity. ([54] Randall McMullan 2002)*

Occupation Control

"Occupational Control: such as by sensors which can detect noise or movement in an area. The sensors turn lighting on when there is someone in the area and off again if there is a time delay if there is nobody in the room" ([54] Randall McMullan 2002)

Daylight Control

"Daylight control: where lights are switched on or off, or dimmed, according to the level of daylight detected in a room" ([54] Randall McMullan 2002)

Lighting control

"Local switching: where it is possible to switch on lights only in the part of the room which is being occupied." ([54] Randall McMullan 2002). This type of control is well suited for schools.

2.10 Ventilation and Air Conditioning Systems

2.10.1 Air conditioning

In a schools situation in Ireland air conditioning is rarely needed. This is down to the fact that opening hours are during the cooler seasons of autumn, winter and spring. During the hotter summer months they are closed. Where air conditioning units are used it is possible to reduce consumption by:

"One of the easier ways to reduce costs in an HVAC systems is to reduce the amount of energy that must be added to or extracted from an area to bring the area to the desired temperature range (1) reduce the heating or cooling load; (2) change the targeted temperature range."([56] Barney L. Capehart et all 2008)

2.10.2 Ventilation

In a building that is intended to be airtight or well insulated it is essential that a proper ventilation system is installed. Air in a well-insulated building that is not circulated can be the cause of many health and safety issues.

"All occupied buildings require a supply of outside air for ventilation purposes. A minimum supply of air is necessary for the removal of odour, carbon dioxide and any other contaminants produced by human occupation and other activities"([57] CIBSE circa 2000)

Ventilation can be any means of air filtration which introduces fresh air from outside to the air inside be it manually or mechanically. Manually would be simply the opening of a window or door whilst mechanically is the use of a ventilation system.

Mechanical Ventilation Systems

There are now technologies available that can ventilate a building without altering the buildings temperature. They are known as displacement ventilation. It works by mixing the building temperature with the outside air without mixing contaminated air with clean air.

"Displacement ventilation aims to supply clean air directly into the occupied zone. As the air makes its way towards the extract, it picks up heat and contaminants, so that the extract air is significantly hotter and dirtier than the air experienced by the occupants" ([58] CIBSE circa 2000)

2.11 Other Areas

2.11.1 Facility Control

The cheapest way of controlling equipment is by putting initiatives in place that will ensure that occupiers of a building will be involved in the reduction of usage by turning equipment off when not in use. Campaigns and posters can greatly improve schools energy consumption. Newer more efficient equipment such as modern ovens can replace older models in order to reduce electricity consumption. Timers can be used on electrical goods such as computers to ensure that they are off every evening. Timers can also be set on lights and where possible other equipment

"Energy can be controlled in order to reduce costs and maximise profits. The controls can be as simple as manually turning off a switch, but often automated controls ranging from simple clocks to sophisticated computers are required." ([60] Barney L Capehart et all circa 2009)

2.11.2 Water Management

Another area that money can be easily saved is through the management of water. By simply putting sensors on urinals, reducing capacity of toilets and the use of aerators and push stops on all of the taps money can be saved. With charges on water for the private and public sector it is essential to put water conservation into account. If tap pressures are too strong then it is possible to get a plumber or the county council to reduce the pressure from the mains.

Other measures that can be put in place are repairs of leaks and student and staff awareness of water reduction. The installation of a water butt is good for awareness and the water retrieved can be used to water plants. In extreme cases it is possible to install a rainwater harvesting system. The water from it can be used for the toilets and for watering of plants. *([65] NCDNR 2002)*

Water consumption has been taken into account as it can affect the performance of the building. In the display energy certificate for schools water consumption is taken into account and can affect the outcome of the buildings energy rating.

2.12 Energy Management Legislation

The government have set out laws with regards to energy management to try and achieve goals set out in the White Paper and the Kyoto Protocol. In the public sector there are laws that have been brought in for them to set the standard for the private and residential sectors. They are aimed at pushing the public sector to reduce overall consumption by taking measures set out in the documents.

2.12.1 SI 542 part 4

The SI 542 is a statutory instrument that was put in place to deal with the public sectors management of energy. It deals with energy management practices, promotion of energy efficient buildings, annual energy efficiency reporting actions and sustaining energy efficient practices. The target set out in the statutory instrument was set out for all public sector buildings.

"An indicative energy savings target for all public bodies to be achieved in the year 2016 is set at 1,500 GWh (primary energy equivalent). This target is a subset of the targets referred to in Regulation 4."([81] European Communities Regulations, 2009)

"From 1 January 2011, a public body shall include in its annual reports published after that date, a statement describing the actions it is taking, or has taken, to improve its energy efficiency and an assessment of the energy savings arising from those actions." ([81] European Communities Regulations, 2009)

2.12.2 Energy Performance of Buildings Directive

To achieve the EU Directive on the Energy Performance of Buildings (EPBD) targets set out in 2006, the government put in place laws that met guidelines of the directive. A Building Energy Rating was required for the private and residential sector whilst a display energy certificate is required for the public sector.

"At this stage all buildings, both residential and commercial require a BER when offered for sale or rent. This requirement was first introduced in 1 January 2007 and since that date all new dwellings that applied for planning permission on or after this date require a BER when they are offered for sale or rent. This requirement was extended to all new non-residential buildings in July 2008 and to existing buildings offered for sale or rent in January 2009."([93] BER Ireland 2010)

2.12.3 Display Energy Certificate

In the public sector it becomes more difficult to implement this type of a system as existing buildings are never expected to be sold. For this reason a different type of system was developed that was required to be displayed by all public buildings. This system was called the display energy certificate.

The Display Energy Certificate is a legal obligation as of the 1st of January 2009. It requires all buildings with an area larger then $1000m^2$ must display the buildings energy rating which is clearly visible and accessible by the public. The DEC is entered into Irish law through the Energy Performance Building Directive Article 7.

"Member States shall take measures to ensure that for buildings with a total useful floor area over 1000 m2 occupied by public authorities and by institutions providing public services to a large number of persons and therefore frequently visited by these persons an energy certificate, not older than 10 years, is placed in a prominent place clearly visible to the public." ([82] European Communities 2002)

The Display Energy Certificate is based on similar principles as the Building Energy Rating in the sense that the buildings performance from an energy perspective is rated from A to G, with A being extremely energy efficient and G being extremely inefficient. The rating system is based on benchmarking various public buildings around the country and using these statistics to develop a standard for energy efficiency in other public buildings. Actual consumption and CO^2 emissions produced can then be shown on the DEC.

"The DEC for large public buildings is calculated as an operational rating, where the actual energy consumed in the building is compared to a benchmark for buildings of the same type, and shown on the certificate A-G scale in terms of primary energy."([83] SEAI 2010)

2.12.4 Other laws that can affect Energy management in Schools

According to ([84] Citizens Information 2010) *"Schools in Ireland are obliged to open for 183 days per year at primary level and 167 days per year at post-primary level"*

2.13 Energy Programs for Schools

2.13.1 Display Energy Certificate for Schools

The Display Energy Certificate for schools is a step by step guide for schools to receive an energy certificate rating using an online application form. It allows the school to create its own Display Energy Certificate without the need for an external assessor. The details are entered by a member of staff and then Sustainable Energy Authority Ireland send out a physical copy to the school to display the certificate to the public. It is calculated by kWh per m^2 so that the size of the school is accounted for.

"This website calculates the Building Energy Rating of the school in accordance with the national methodology for Public Buildings. The energy use is measured in kWh/m2 so that smaller schools can be compared to larger schools on a one-to-one basis" ([85] Energy Education 2010)

They also state that: "*A school that inputs their energy usage and building construction information to the website will generate a Display Energy Certificate that is based on their current energy use and receive a detailed advice sheet on further energy saving measures which they can consider implementing in their school." ([85] Energy Education 2010)*

Applying for the Display Energy Cert for Schools

Basic details such as address and contact details are firstly required for the Certificate. It is then a requirement to show the school building details such as area of the building, number of students, the year the school was built and hours per year in operation. Next on the agenda is fuel types, suppliers and quantities used followed by insulation in the school such as double glazing and attic insulation.

Details of the heating system are then required such as age of the boiler, type of boiler control and whether individual thermostats are used in each room. Lighting systems is the next topic where questions like type of bulb and switches used. Miscellaneous electrical such as computer rooms are next followed by ventilation control and water controls used in the building with questions such as m^3 of water used per year. Finally the topic of energy policy in the school is questioned where they are asked about student involvement, energy monitoring, lighting management and blind management. *([86] Energy Education 2010)*

2.13.2 Green schools

The green schools programme is set up by An Taisce to aid schools in Ireland in developing an environmentally friendly school. If the school achieves the objectives set out by the programme they receive an award in the form of a green flag which is recognised globally.

Schools must register to enter the scheme which is partially funded by local authorities. They then must implement the Green schools programme. Once the programme is implemented the school must apply for the award every two years so that they are continually reaching targets.

"Since 2001 Green-Schools has been a fully national programme, with all 34 County and City Councils involved. The Green-Schools programme is therefore part of a three-way collaboration involving schools, An Taisce and Local Authorities."([87] An Taisce circa 2007)

The programme is based on seven fundamental steps which include:

- Green School Committee
- Environmental Review
- Action Plan
- Monitoring and Evaluation
- Curriculum work
- Informing and involving
- Green Code

Each step must be fulfilled in order to avail of the award scheme. To apply for the scheme it is a requirement for the school to contact through the website
www.greenschoolsireland.org

2.13.3 Carbon Trust Benchmarking

The carbon trust offers a benchmarking tool for schools to compare their schools fuel, electricity consumption and expected carbon dioxide output with other schools. It bases consumption on expected levels per metre squared. *"This web site provides a tool for comparing the energy used in a school with the typical consumption of similar schools." ([102] Carbon Trust 2010)*

2.13.3 SEAI energy pages

Teacher's information

The SEAI has various resources available for schools to help in energy management techniques. They deal with areas such as energy information for teachers to aid them in teaching students about energy management. There are modules available from the SEAI website that show where energy fits into different subjects such as Geography, History, CSPE, Science, Home Economics, Physics and Transition Year. There is also a school tours section available. *([88] SEAI 2010)*

If teachers wish to know more the energy Management for teachers can be found at http://www.seai.ie/Schools/Secondary_Schools/Teachers/ where an easy to understand display is shown. From this display (below pictured) the teacher can access information in order to aid them in the integration of energy management into their subject.

Student Information

There are various publications and animations available for students to discover and explore different areas of energy facts and techniques that can help them to reduce their overall carbon footprint. There is also a pledge programme for students who wish to reduce energy consumption at home. It is in the form of a checklist and is a reminder to students what simple things can be done.

It may also be possible for students to get involved in the One Good Idea Programme which promotes workshops in schools which deals with energy. This programme is available for a limited number of schools but is suitable for any school that promotes energy in Transition Year and in CSPE.

Schools pages

It is important for the schools to use the information supplied by the SEAI if they want to have major savings and reduce their overall carbon footprint. If they wish to continuously improve energy efficiency in the school they must ensure that everyone including students, teaching staff and non-teaching staff are involved.

Chapter Three: Materials and Methods

In each school information was gathered by using a range of measures. I did a full energy audit in both schools which involved the recording of energy related information. This involved the recording of dimensions, recording all electrical equipment, recording of materials and general observations that I made that related to energy management. I also did relevant interviews with staff involved in both schools to gather information such as history of the school, materials in the building, heating operations and school operating hours.

3.1 Equipment and Lighting Audit

In each school I did a room to room analysis of each piece of equipment. It involved recording all electrical and lighting inventory associated with each school. This way I could link any problems with electrical equipment and lighting to the room it was in. The data I retrieved for each item was

Room name

- Type of equipment
- Model Name
- Wattage
- Quantity

3.2 Recording of dimensions

In order to get overall building dimensions I recorded each room's height, width and length. I also recorded dimensions of windows and doors and the thickness of the walls so that it could be easily mapped. I also recorded distance between outdoor buildings so that a perspective could be shown whilst mapping. The tools I used to record the dimensions were a 15 metre measuring tape and a 15m range laser guided ultrasonic measuring tool.

School Name:	Colaiste Cholmcille			Date:		16/07/2010
Indoors Room	Height	Length	Width	Windows	Door	Wall Thick
Staff Toilets	2.7	2.08	3.62	1.44 x .54	2 x .75	0.2
Room 6	2.67	4.85	4.03	3.61 x 1.32	2.13 x0.82	0.22

Figure 11: Colaiste Cholmcille Dimensions

3.3 Materials Audit

As I went from room to room I also recorded materials in the building such as walls, floor, ceiling, doors, windows and radiators. This included the recording of the insulation levels. This part of the audit also involved the recording of the condition that the materials were in; doors and windows in both schools had air leakages resulting in heat loss. This audit also included the recording of materials in the prefabs.

3.4 Gathering of energy bills

I obtained the electrical, oil and water bills so that analysis could be achieved from them. The electricity bills are important to gather information about electricity trends and total consumption over a year. The oil bills from the heating system were gathered to show trends and total consumption over the year. The water bills were gathered so that total water use for the year was available; the purpose of it was for filling in the Display Energy Certificate. They were also necessary to compare consumption of electricity and oil in both schools. The bills in Colaiste Cholmcille were received via the school secretary whilst they were sent via the VEC for Archbishop McHale College.

3.5 Information through Interviews

I gathered information such as operating hours, number of students, number of teachers and staff, when each area was built, the age of the boiler, the output power of the boiler, the heat retention of the building, the times and dates that the heating systems are left on and the times when the school is closed. I also asked other questions such as do they currently have an energy management program in place. Another question I asked was about whether there was a Transition year program in place: transition year in a school could be responsible for introducing an energy management scheme.

3.6 Other Recordings

In each room I listed down areas of concern and where things could be changed. This made it easier then when deciding what small maintenance changes could be made to improve the school. Areas such as natural light available in each room, lighting control in each room, equipment left on and areas that are causing draughts. Photographs were also taken of important aspects of the project.

Chapter Four: Results

4.1 Colaiste Cholmcille

4.1.1 Basic Information

Colaiste Cholmcille is a school in Indreabhan County Galway. The main or front part of the building was built in 1955 with an extension built in 1993. The building is comprised of 6 classrooms in the main building and 9 prefabs.

The school is located on the R336 road which is the coast Rd. The back of the main building is south facing towards Galway Bay. Due to its close proximity (approx. 200m) of the sea the wind exposure is quite high. There is also a metal work room which is permanent but separate. To the east of the building there is a permanent structure that is used for storage.

The area of the old part of the main building is 440m^2. The area of the new building upstairs and downstairs is 466m^2. The area of the prefabs including the English prefab which is being demolished is 516m^2 and without the English prefab it is 460m^2. The engineering room is 140m^2 and the storage room area is 106m^2. This brings the total area of the school to 1668m^2 with the English prefab and without the English prefab it is 1612m^2.

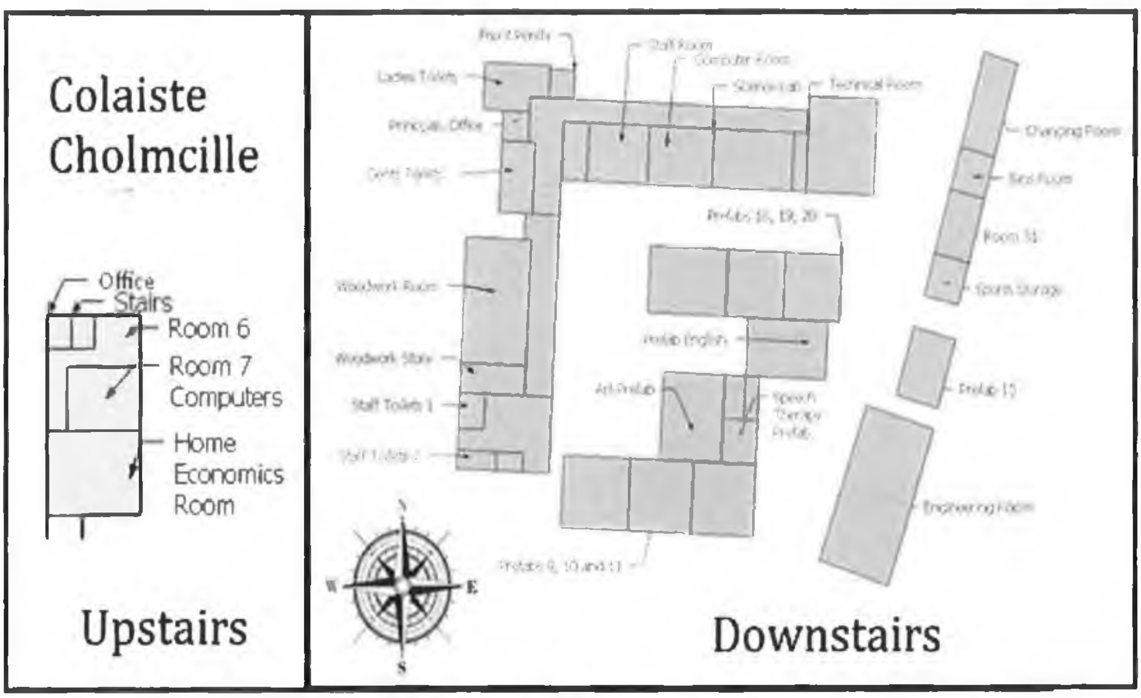


Figure 12: Layout of Colaiste Cholmcille

4.1.2 Occupants

In the school year of 2009/2010 there were 198 students and 21 staff members with plans for 235 students and 23 staff members for the school year 2010/2011.

4.1.3 Operating Hours

The operating hours of the entire building are 8.00am to 5.30pm for the compulsory 167 days per year. Due to extra studies one of the prefabs is operated from 8.00am to 6.15pm and on Thursdays between 8pm to 10pm also. The first week of July is open for a teacher's convention each year where extra offices are open between 8.30am and 5.30pm. During the summer months the school is open whilst maintenance and office work commences. It is totally closed for the last two weeks of July and the first 2 weeks of August.

This then means that the schools main building fully operates for 1586.5 hours per year. The opened prefab operates for approximately 1740 hours and certain rooms for the teacher's convention open for an extra 47.5 hours.

Figure 13: Front of the School (Old Part)

Figure 14: Prefabs in the School

4.1.4 Materials

Walls

The outer walls in the front part of the main building are part concrete part granite 60cm thick. The inner walls are pure concrete which are also 60cm thick. The U- Value is difficult to calculate as the type of concrete used is unknown. A rough estimate would suggest 400mm of it is concrete and 200mm of granite.

In the new part of the building the walls are concrete blocks with a thickness of 22cm. this has a U-Value for un-insulated concrete blocks is approximately 0.39. None of the walls in the main building have insulation.

Doors

The front door has a porch which should be utilized to hold in heat. The front door is made of wood. In the rooms there are doors for fire exits. Downstairs the fire exit is made of wood and is quite thin although door blocks are on it to prevent a draught. The upstairs fire exit is made from PVC and is relatively airtight. At the newer part of the building there are two large double doors with single glazed windows. The door furthest from the front has a porch. All of the windows in the main building are double glazed with a U-Value of approximately 2.8.

Roof

The school recently availed of the grant available for insulating public buildings to insulate the roof. There is 300mm of insulation in the ceiling. The outer part of the ceiling is plasterboard and the roof is tiled. The floor comprises of lino.

Prefabs

The outer part of the prefab is made of wood and the roof is flat and felted. The prefabs are double glazed with the exception of one which is single glazed. The doors are all wooden with single glazed panels. There is 100mm of insulation in the roof and approximately 100mm of insulation in the walls.

Other Materials

The majority of radiators in the old part of the building are cast iron whilst in the newer part of the building they are steel. Iron radiators take longer to heat up but retain heat for longer. The floor in the rooms is generally lino with marble in the halls of the old building.

4.1.5 Heating System

To heat the main building a HOGFORS 21 Nova type H20/8 oil boiler is used. It has a capacity of 150 Kw, with a weight of 965kg, a water volume of 0.159m^3, and a maximum temperature of 120°C. The year it was built was 1992 although it was installed and fully in use once the extension was built in 1993.

In the prefabs storage heaters are used whilst some of the offices also have electric heaters with outputs between 2kw and 3kw. They are operated on a night time basis. These are responsible for consuming large amounts of electricity.

The heating system is on a timer and is on during all school days between 8.30am to 2.00pm from the start of October to the end of March. In the months September and April the heating is on between 8.30am and 12.00pm.

In Order to get the hours of the heating operation the school year must be assessed Assuming that 5 school days are taken away for Halloween, 13 school days are taken away for Christmas and 10 for Easter in March/ April and the school year is from the date Wednesday the 1st of September to the 25th of May which makes up 167 days. This would then mean that the heating system is on for 140 hours for September and April and 698.5 hours for the remaining months. This is a total of **838.5 hours** of controlled heating in the school per calendar year.

Figure 15: Boiler and Boiler specifications

4.1.6 Lighting

The main source of lighting is 58w fluorescent tubes. They are used in the halls, classrooms, offices toilets and prefabs. There are 126 in the main building, 83 in the prefabs, 20 in the engineering room and 7 in storage. There are also 3 80w fluorescent bulbs in the storage area. Fluorescent tube light bulbs are efficient for the amount of light that they produce and energy efficient replacements are expensive. Some of the lights were quite dusty.

There is also plenty of natural light available in most rooms. Most of the prefabs have windows on 2 sides allowing natural light to fill the entire room. The front part of the main building has also been built with natural light in mind. Large windows are south-facing whilst there is also light available from the north from windows above the door. Often this free light is not utilized and lights are switched on and the blinds down. The blinds were closed in the computer room therefore requiring electrical light.

Lighting control is an issue in some areas. Some rooms have only one or two light switches for up to 12 bulbs.

Figure 16: Lighting, Lighting Control and Natural Light Available

4.1.8 Observations by Room

Science Room	Room 7	Room 6	Engineering room	Bin room
Cracks in the ceiling	Not enough natural light	Carpet floor	High ceiling	Large gap in door
Gas piped for burners	Possible installation of windows over door	One light switch for 4 lights	Draft from door	Petrol fuelled lawnmower
Large extractor fan open (possible draft)	Blinds on windows	Attic hatch airtight	Concrete floor	Single glazed window

Changing room	Prefab 11	Technical Graphics Room	Room 8	Prefab Art
Concrete floor	Single glazed windows	Draft from middle of fire exit	Fridge freezer on but no stock	Single glazed windows
Storage heaters	Single glazed windows on doors	Draft resisters on the bottom of the fire exit	Draft from extractor fans	Single glazed window on door
Large gap under door	Walled partitions to 9, 10	Cracks in the roof	Extractor fan filter dirty affecting performance	Signs of damp
Lights dusty	Single light control for 8 lights	Three-way lighting switch for 12 lights	Airtight attic hatch	Two-way light switch 12 lights
No insulation	Slight draft at partition	Blinds for windows	Fire exit PVC double glazed	Draft from window with broken handle

Hallway	English prefab	Storage and porch in Prefab	Staff Room	Computer Room
Crack in window	being demolished	Single glazed window on door	Dusty lights	Cracks in the ceiling
		Insulation not fitted correctly	Blinds on windows	Blinds on windows

Prefab 15	Speech therapy prefab	Prefabs 9	Prefab 10	Prefab 18
Single glazed windows and windows on	Single glazed window	Single glazed windows	Single glazed windows and windows on door	Single glazed windows on doors
Evidence of damp on floor and walls	Printer on	Single glazed windows on doors	Cracked ceiling tiles	Gap on the bottom of the main door
Exposed non reflective florescent lights	Hole in roof tile possible air leakage	Slight draft at partition	Blinds on windows	Crack in ceiling slab
Hole in the wall		Damage on window causing a draft	Damage to door	
Two-way light switches for 8 lights		Single light control for 8 lights	Single light control for 8 lights	

Front Porch	Extension hallway	Prefab 18	Prefab 19	Room 31
Gap in porch door	Two double doors to outside	Two way light switch for 6 lights	Blinds on windows	Single glazed window
No natural light	Single glaze windows on doors	Window on door single glazed	Single glazed windows on door	Single glazed door
Draft resister on bottom of door	Doors don't automatically close	Gap at bottom of door with draft	Two way light switch 8 lights	Gap in door
Door doesn't automatically close	Second door in a large porch	Cracked ceiling tiles	Gap on the bottom of the door	Lights dusty

4.1.9 Water Observations

In the gents toilets the urinals are on a timer to release or flush water every couple of minutes. This is unnecessary water waste, especially during the summer months when they are not occupied. The taps are twist tops and not push tops and there are no aerators. The toilets themselves use approximately 10 litres per flush. There are no dual flush on any toilets. The ATC water heater in the staff canteen is leaking.

4.1.10 Electricity Consumption

The diagram below shows energy used in Kwh per month from May 2009 to April 2010. Holiday dates to be noted are one week in October for Halloween, one week in December for Christmas, over one week in January for Christmas and two weeks holidays in April. The summer holidays progress from the end of May for 1st years, second years, transition years and fourth years whilst Leaving Certificate and Junior Certificate students finished approximately the 20th of June.

May

The month's consumption records relate to days open and are seasonal. In May, consumption is relatively low when compared to other months in the year. This is possibly down to heating systems not being required and less use of equipment from the engineering room, the woodwork room and the Home Economics room due to end of year exams being held. Night time consumption is quite high during this period considering there is no use of storage heaters at this time.

June, July and August

Consumption levels reduce further in June due to reduced numbers of students present. The use of electricity is still required for Leaving Cert and Junior Cert Students during exams. During July and August the school is only occupied by the necessary staff so consumption is at a minimum. Areas of concern during these months are night time consumption; realistically there is no need for any electricity during the summer months.

September and October

There is a rise in consumption in September and October when the schools start back. Night time usage rises considerably which would indicate that equipment is not being turned off and that the storage heating is started up at this stage.

November, December and January

The highest consumer in the year is November. This is largely down to it being a full month of attendance for students in the schools. When days open is considered it is clear that December and January are also large consumers. Night time electricity consumption is extremely high due to storage heating.

February, March April

Consumption in February and March is high due to weather conditions and the fact that there are no holidays. March has a higher consumption amount although this is largely to do with having 3 more days then February. Night time consumption is massive and once again probably down to storage heating in the prefabs. Consumption levels reduce in April due to Easter holidays and a reduction in heating system use. Night time use is still too high.

It is clear from the chart below that electricity consumption is too high and reduction measures can be put in place. It works out at 351Kwh per occupant per year. The second diagram is Kwh per M^2 taken from the Carbon trust website

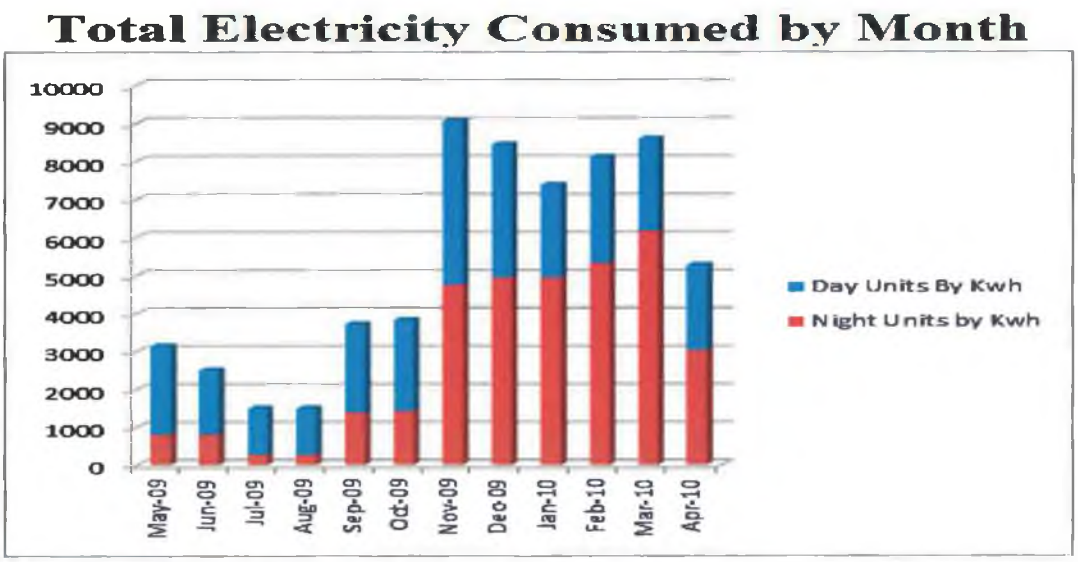


Figure 17: Colaiste Cholmcille Electricity Consumption

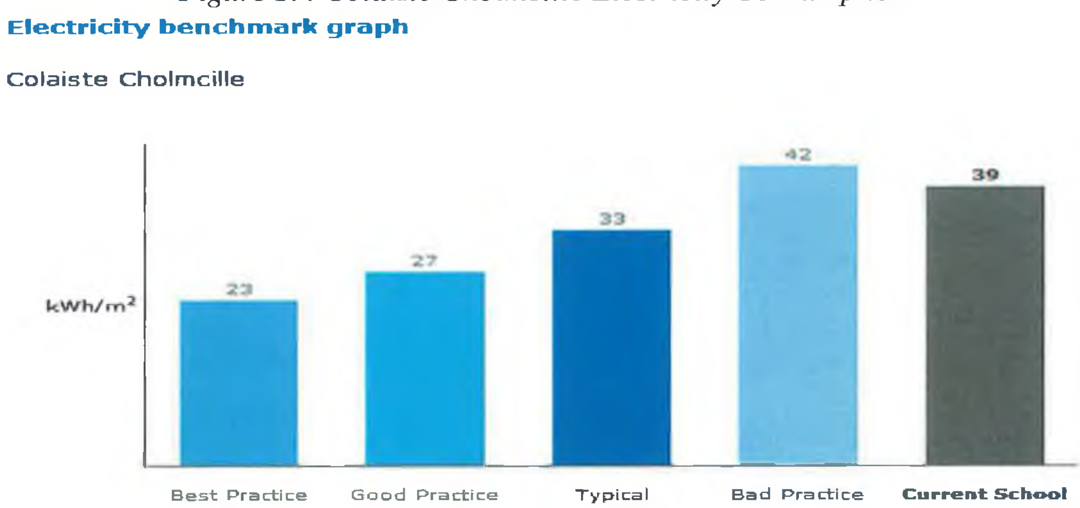


Figure 18: Benchmarking Colaiste Cholmcille's Electricity use with other Schools Worldwide, Carbon Trust 2010

4.1.11 Oil Consumption

The oil used was taken from an average over two years. The conversion factor is 11.21 taken from www.energyeducation.ie so that we can get Kwh. is quite low and considerably drops the amount of energy required for the school. There is a benchmarking tool on the carbon trust energy benchmarking at
http://217.10.129.104/energy_benchmarking/schools/default.asp

When oil consumption is benchmarked to other schools using the Carbon Trust website it is clear that oil usage is quite low. It is also clear that the use of storage heaters offsets from the amount of oil used for a building of this size. If storage heaters were removed and replaced by oil heating the benchmark figure below would increase by quite a bit whilst electricity use during night time would reduce dramatically.

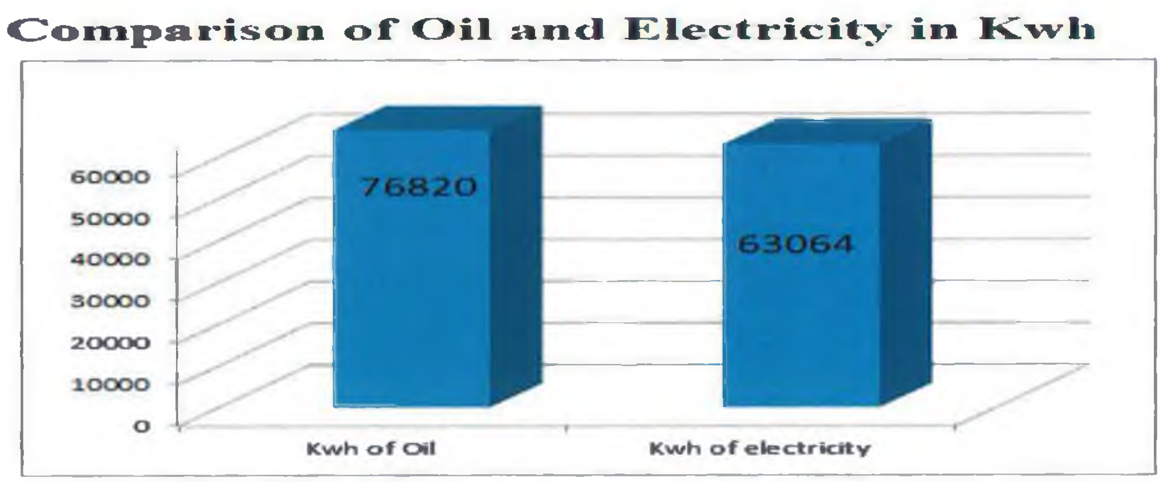


Figure 19: Comparison of Oil Usage in Kwh and Electricity in Kwh

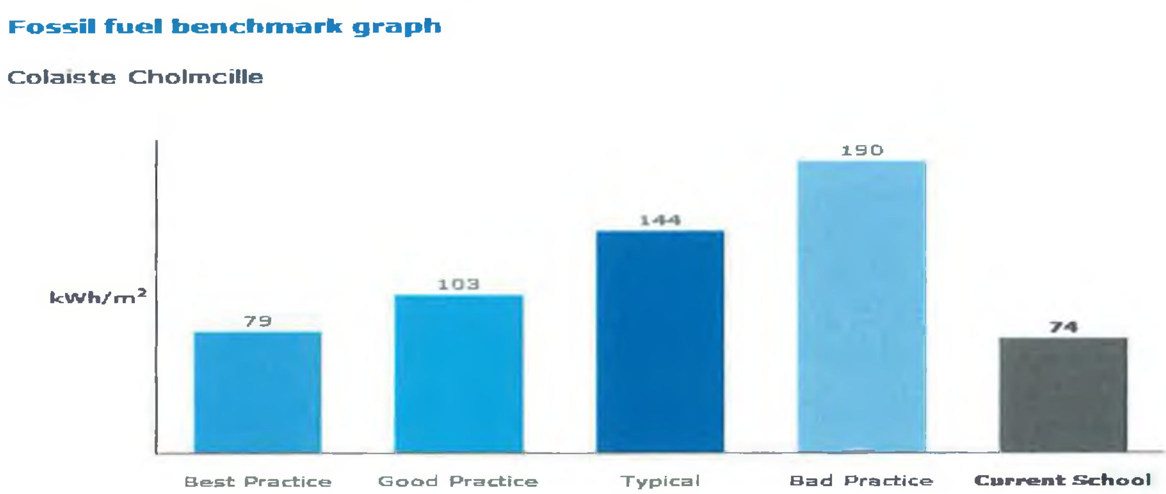


Figure 20: Benchmarking Colaiste Cholmcille's Oil use with other Schools Worldwide Carbon Trust 2010

4.1.12 Water Consumption

The overall consumption is 446m^3 of water per year. The main areas of concern are the use of water being used during summer months. There should be little evidence of water use during these times but there is, and it is still a significant level of consumption at 43m^3. The amount of water used during the spring months which was 211m^3 is very high and should also be looked into. In autumn 72m^3 of water was used and winter it was 120m^3

4.1.13 Overall Energy Performance

The chart below is taken from the Carbon Trust Website. In general the schools energy use and carbon dioxide emissions are above average when benchmarked with other schools globally. Degree day data for the area, electricity consumption, Oil Consumption area in m^2 were all taken into account.

Colaiste Cholmcille has an overall output of 37kg Carbon Dioxide per M^2. This is between good practice and typical when benchmarked against other schools.

Without storage heaters this school would be performing very well as night time electricity would be down. As it stands the school is extremely efficient when it comes to energy use. The boiler is the correct size for a school of this size and it is clear that this is a factor in energy efficiency. Insulation in the roof seems to also be playing a part in conserving energy as there is less of a need for electric heaters to be used.

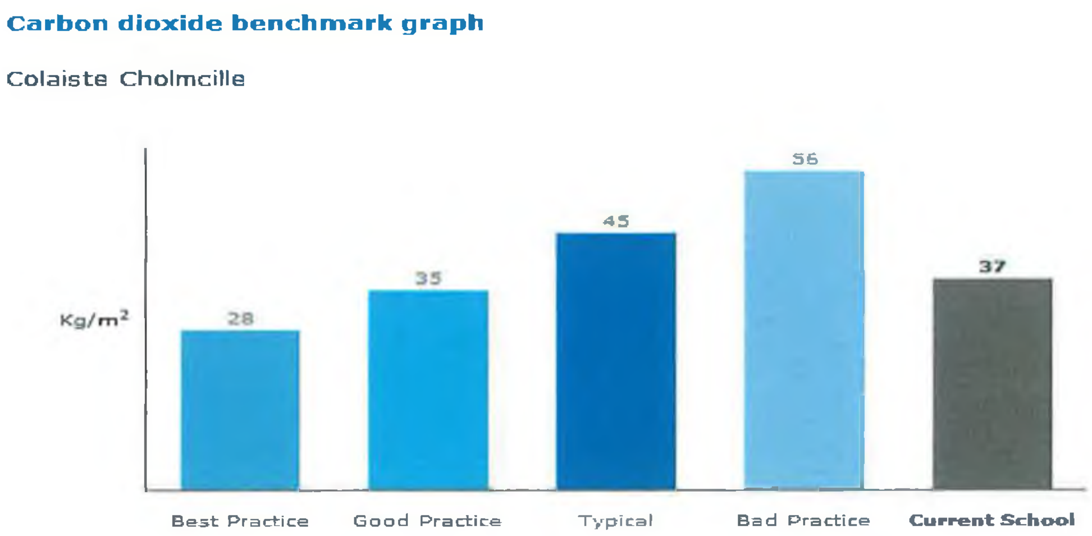


Figure 21: Benchmarking Colaiste Cholmcille's Carbon Dioxide Emissions with other Schools Worldwide, Carbon Trust 2010

4.2 Archbishop McHale College

4.2.1 Basic Information

Archbishop McHale College is a secondary school in Tuam County Galway. The main building was built in 1938. The building is comprised of 8 classrooms in the main building and 7 classrooms in the prefabs. There have been no building upgrades to the building since it was first built.

The school is located on the Athenry Rd which is the main road from Tuam to Athenry. The weather in the area is mild but windy with some exposure from the back of the building due to a field and a graveyard there. The front of the building is north-west facing. The prefabs are all located to the back of the school

The area of the main building is 881m^2.The total area of upstairs is 400m^2 and the total area of downstairs is 481m^2. The combined area of the prefabs is 412m^2. Therefore the total area of the building is then 1293m^2.

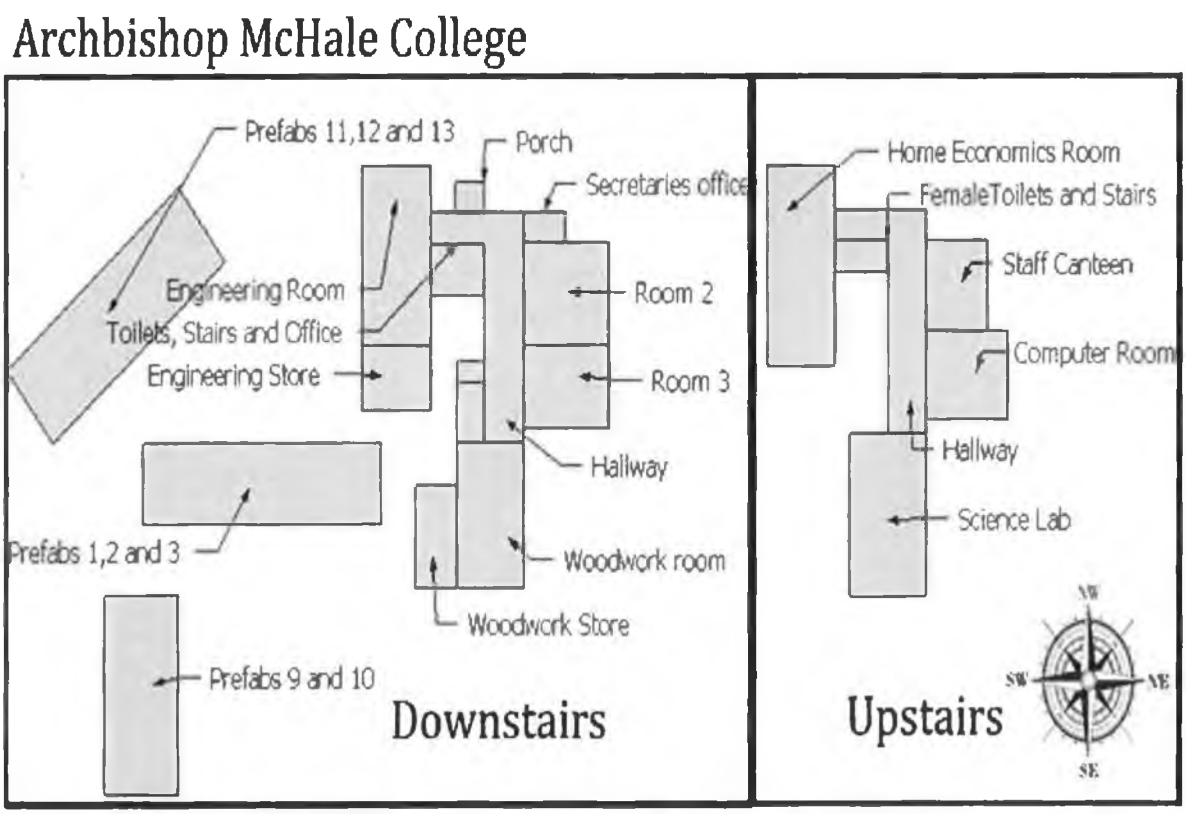


Figure 22: Layout of Archbishop McHale College Tuam

4.2.2 Occupants

There were 150 students and 22 staff for the school on the school year 2009 / 2010.

4.2.3 Operating Hours

The operating hours of the entire building are 8.00am to 5.00pm for the compulsory 167 days per year. For three days of the week the building is open from 8.00am to 9.00pm from October to December and from January to March. The prefabs are open from 9.00am to 4.00pm during the school year. During the summer months the school is open whilst maintenance and office work commences. It is totally closed for the last two weeks of July and the first 2 weeks of August.

This then means that the schools main building fully operates for approximately 1767 hours per school year and the prefabs operates for hours 1169 hours per school year.

Figure 23: Front and side of Archbishop McHale College, including Prefabs

4.2.4 Materials

Walls

The outer walls in the front part of the main building are part concrete 42cm thick. The inner walls are pure concrete which are 35cm thick. The U- Value is difficult to calculate as the type of concrete used is unknown. A rough estimate would suggest 420mm of solid concrete with a U-Value between 50 and 70. There is no insulation in the entire part of the main building which is an area which needs to be focused on.

Doors

The front door has a porch which should be utilized to hold in heat. The front door is made of wood and has a single glazed window on it. There is a fire exit in the engineering room which is made from PVC and is relatively airtight. The back door is also made from wood and has a single glazed window.

The main problem with the doors is that there is no draught control. Both the front and back doors have air gaps in them and both are not closed via a spring. The front door has a porch which can be used for control of air leakages. The back door is in poor condition and leads directly outside. Another door with significant air leaks is that is in the woodwork store room.

From left to right we have pictures of the main porch door, the back door, and the door leading to the outside from the woodwork storage room. All of the doors below have significant air leaks.

Figure 24: Energy Loss through the Front, Side and Back Doors

Windows

Single glazed windows are on both the font and the back doors. All of the windows in the main building are double glazed with a U-Value of approximately 2.8

Roof

Similar to the walls there is no insulation in the ceiling. It is another area which needs attention. The outer part of the ceiling is plasterboard and the roof is flat and made from concrete.

Prefabs

The outer part of the prefab is made of wood and the roof is flat and felted. Two of the prefab blocks are double glazed whilst one block is single glazed. The doors are all wooden with single glazed panels. There is 100mm of insulation in the roof and approximately 100mm of insulation in the walls.

Other Materials

Radiators in the old part of the building are cast iron. The floor covering in the rooms is generally lino with marble in the halls in the main building.

Figure 25: Insulation in Prefabs and Double Glazed Windows in the Main Building

4.2.5 Heating System

To heat the main building a Buderus GE515 oil boiler is used. It has a capacity of up to 510Kw, pressure per m^2 of 6 bar, and a maximum temperature of 120°C. It is a relatively new boiler installed within the last 15 years. This is a very large boiler for a building of this size. Boilers that are too big can be inefficient in fuel consumption as they are being under-utilized. In the prefabs storage heaters are used whilst some of the offices also have electric heaters with outputs between 2kw and 3kw.

"Making sure you have the right size boiler is essential when you're buying a new model. If it's too small it might not meet your needs; too big and it will be over-costly, inefficient, more expensive to run, and be even more damaging to the environment" ([84] Boiler Choices 2010)

The heating system is on a timer and is on during all school days between 8.30am to 4.00pm from the start of October to the end of March. The storage heaters are also on a timer from 1.00am to 8.00am. This is continuous use of high energy consuming heating systems.

In Order to get the hours of the heating operation the school year must be assessed Assuming that 5 school days are taken away for Halloween, 13 school days are taken away for Christmas and 10 for Easter in March/ April and the school year is from the date Wednesday the 1st of September to the 25th of May which makes up 167 days. The total hours per school year for the Oil heating system are 847.5. The total hours that the storage heaters are on are 791 hours per school year.

Figure 26: Boiler and Boiler Specification, Archbishop McHale College

4.2.6 Lighting

The main source of lighting is 58w fluorescent tubes. They are used in the halls, classrooms, offices toilets and prefabs. There are 196 58w florescent bulbs throughout the entire school. There are also 55 28w fluorescent tubes in the Home Economics room and in the upstairs hall. Fluorescent tube light bulbs are efficient for the amount of light that they produce and energy efficient replacements are expensive. Some of the lights were quite dusty.

There is also sufficient natural light available in most rooms. Most of the prefabs have windows on 2 sides allowing natural light to fill the entire room. There are large windows in all rooms. Often this free light is not utilized and lights are switched on and the blinds down. The blinds were closed the in computer room therefore requiring electrical light. Lighting control is an issue in some areas. Some rooms have only one or two light switches for up to 12 bulbs.

Figure 27: Lighting and Natural Light Available

4.2.7 Equipment

Main consumers of energy are the electric heaters, the ovens, computers, power tools, projectors and the water heaters under each sink. Other high powered equipment include, 5 hand dryers that have up to 2.4kw of power, a vacuum cleaner, 15 projectors, 5 kettles at 2Kw, 2 irons, a floor buffer, 2 fridges, 2 toasters and various other kitchen appliances.

Electric heaters

There are 12 Electric heaters in the building which range from 1.5Kw to 3Kw. The need for electric heaters proves that the building is not warm enough and there are large amounts of heat loss. There are 14 storage heaters in the Prefabs that have a power range of between 2Kw and 3Kw and are left on for a number of hours during the night.

Water Heaters

Water in the staff toilets, science room, and Home Economics room is heated via electric heaters. There are 5 water heaters to heat water from the sink. The typical power for them is 1.5Kw. It appears to be the only source for water heating.

Cookers

There are 8 electric ovens and 5 electric hobs. The electric oven power is 3Kw. The gas cookers are newly installed. There are also 2 700w microwave ovens.

Computers and Servers

There are 26 PC's in the computer room. There are a further 28 PC's throughout the school. There were 2 PC's left continuously running whilst 17 monitors were left on standby during the summer months. In the staff room 2 monitors were on standby. In prefabs 6 monitors were left on standby. The servers were continuously running both upstairs and downstairs.

Power tools

There are various power tools in the woodwork room and the engineering room including lathes, drills, and a CNC machine, saws, milling machines, sanders, grinders, cutters and extractor fans. The power ranges from 750w to 3.3Kw

4.2.8 Other Observations

Home Ec Room	Upstairs hall	Room 2	Staff Room	Prefabs 9 and 10
Electric wall heaters	Evidence of damp	Hole in ceiling at wires	Photo-copier on	Single Glazed windows
Empty fridge still on	One way light switch for 7	White board left on		

Engineering room	Front Porch	Hallway downstairs	Female Toilets	Prefabs 1, 2, 3
Evidence of damp on walls	Gap on the bottom of external door	Hole in ceiling at piping	Wall Heater	One lightswitch for 12 lights
concrete floor	Damp on ceiling	Gap in side door	Spring on door to close it	Holes in hallway walls
High ceiling	Door window single glazed	Door window single glazed	Poor natural light	Draft from external door

Woodwork Store	Prefab 11	Prefab 12	Science lab	Prefab 13
Single glaze windows	Evidence of damp on walls	Water marks in the ceiling close to the	3-way light switch for 20 lights	Window on door cracked
Gaps in outer door	Evidence of damp on Fire exit	Hole in the floor at wiring	1 Radiator and 3 electric heaters	Draft under door
Damage to inner door	Trees blocking natural light	Trees blocking natural light	Blinds for windows	Trees blocking natural light
Natural light blocked	Door window single glazed	Door window single glazed	Evidence of damp by windows	Door window single glazed
Concrete floor	Draft from Fire exit	Outside wood on the bottom		

4.2.9 Electricity Consumption

The diagram below shows energy used in Kwh per month from October 2008 to September 2009. Holiday dates to be noted are one week in October for Halloween, one week in December for Christmas, over one week in January for Christmas and two weeks holidays in April. The summer holidays progress from the end of May for 1st years, second years, transition years and fourth years whilst Leaving Certificate and Junior Certificate students finished approximately the 20th of June.

October

The amount of electricity consumed in these 2 months is quite low when compared to the remaining months of the school year. Day usage when compared to other months is quite high. The amount of electricity consumed at night during this month is high considering storage heaters are not fully in use.

November, December and January

Consumption levels are at their highest during these months. This goes in line with the need for the storage heaters to be left on at night and possible use of electric heaters during the day. In the prefabs the storage heaters may also be turned on in the daytime during these months. Night time consumption levels are way too high during these months. With these figures in mind it may be possible that the heating timers for the storage heaters were on over the Christmas period. This would then explain the difference between day units and night units when compared to other months.

February and March

In February overall consumption reduces which may be down to lesser days. In March there is a similar ratio of electricity from day to night. The amount of electricity during night time is way too high.

April, May, June, July, August and September

Night time use is still way too high. It would suggest that storage heaters are still left on at night time over the summer months. The consumption for June and July are higher than April and May which suggests equipment was also left on throughout the entire summer months. The consumption for August to September increases which goes with the school year starting up again.

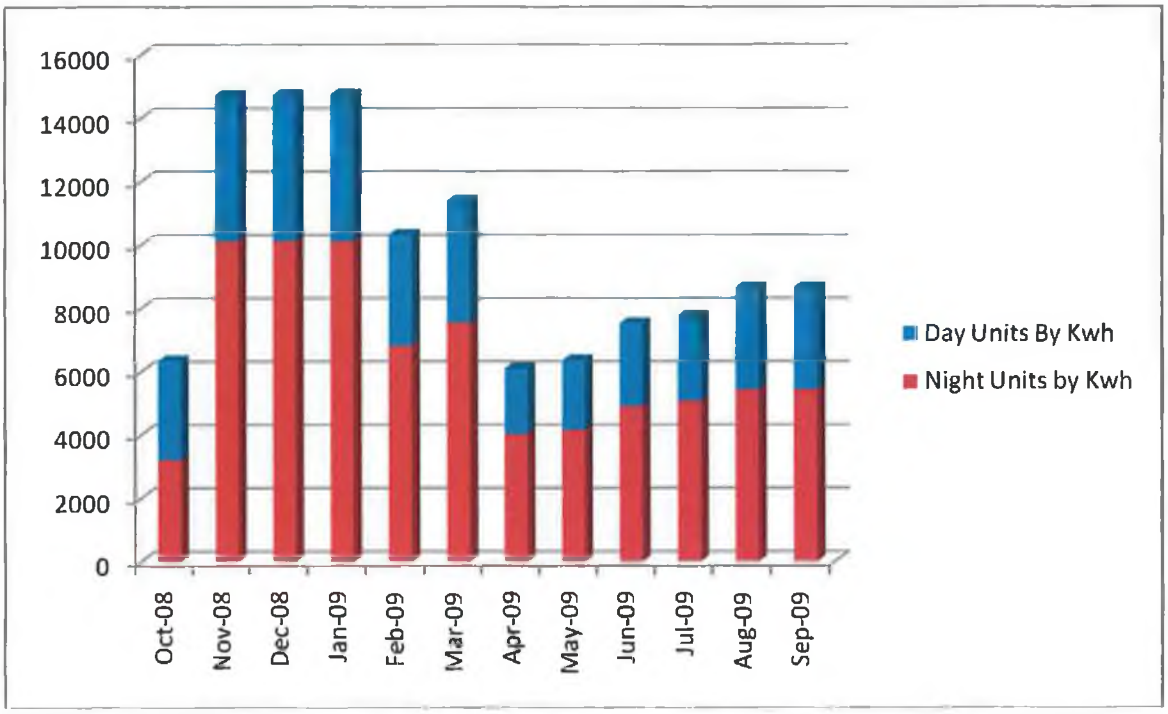


Figure 28: Archbishop McHale Electricity Consumption

It is clear from the chart below that electricity consumption is too high and measures can be put in place. It works out at 663Kwh per occupant per year. The second diagram is Kwh per M^2 taken from the Carbon trust website

Note that the information in the chart above is as accurate as can be with the information that was available. Assumptions in some months had to be made most notably for October, November and December and August and September. The KWh are accurate for the entire year but the distribution is mixed.

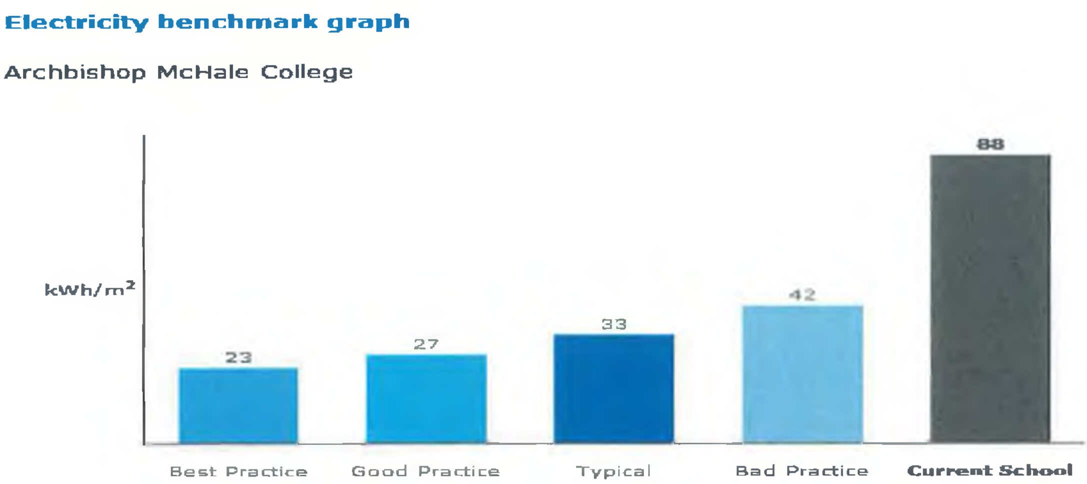


Figure 29: Benchmarking Archbishop McHale Colleges Carbon Electricity Use with other Schools Worldwide, Carbon Trust 2010

4.2.10 Oil Consumption

The oil used was taken from the year 2009. The conversion factor is 11.21 which was taken from the *Display Energy Certificate in Schools* website so that we can get Kwh. The oil Consumption has been factored for the main building only as this is the only area it is used for. When oil consumption is benchmarked to other schools using the Carbon Trust website it is clear that oil usage is typical when compared to other schools. If the capacity of the boiler was reduced, this consumption would drop.

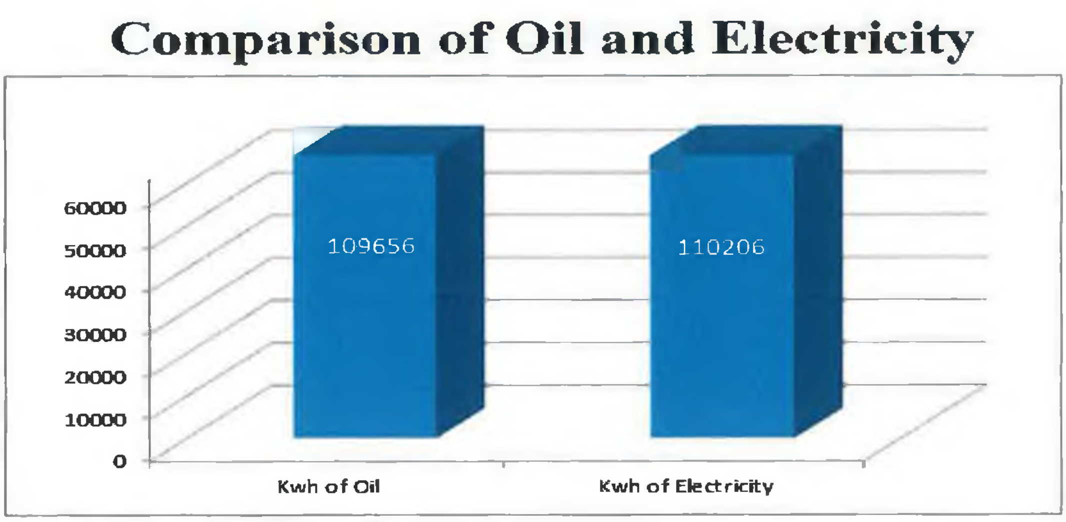


Figure 30: Comparing Archbishop McHale Colleges Oil use in Kwh with Electricity in Kwh

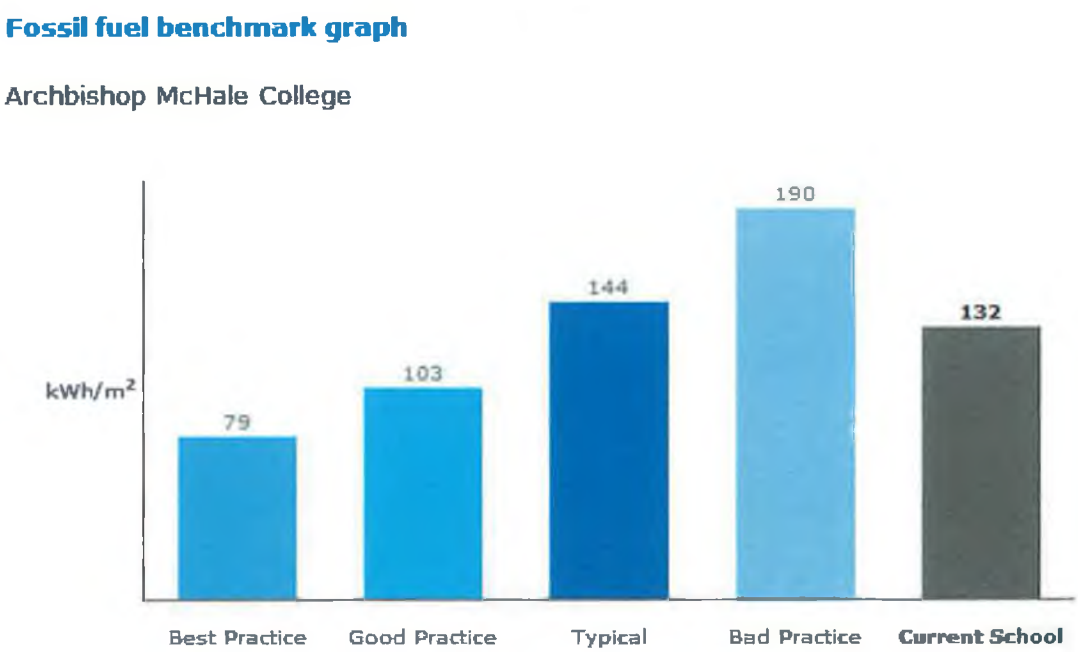


Figure 31: Benchmarking Archbishop McHale Colleges Oil Usage with other Schools Worldwide, Carbon Trust 2010

4.2.11 Water Use

Water use in the building is quite low. The only time there is concern is during the winter months. During the summer months there should be very little water use. Areas such as urinals on a timer need to be switched off. In the winter 42m^3 of water was used, and in the spring, summer and autumn the usage was 7m^3, 6m^3 and 8m^3 respectively.

4.2.12 Overall Performance

The chart below is taken from the Carbon Trust Website. In general the schools energy use and carbon dioxide emissions are above average when benchmarked with other schools globally. Degree day data for the area, electricity consumption, Oil Consumption area in m^2 were all taken into account.

Archbishop McHale College has an overall output of 75kg Carbon Dioxide per M^2. This is considered worse than bad practice when benchmarked against other schools.

Without storage heaters this school would be performing better as night time electricity would be down. The boiler is too large for a school of this size and it seems to be a factor for amount of oil consumed. There is no insulation in the main building which is a clear effect on fuel and electricity consumption.

Carbon dioxide benchmark graph

Archbishop McHale College

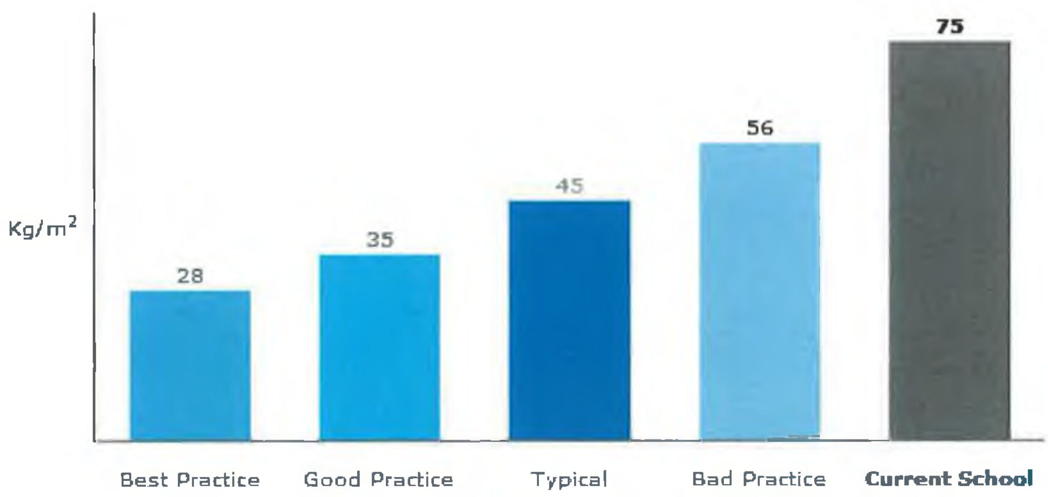


Figure 32: Benchmarking Archbishop McHale Colleges Carbon Dioxide Emissions with other Schools Worldwide, Carbon Trust 2010

4.3 Comparison of Both Schools

Both schools have similar areas which are responsible for consumption. A major issue in both schools are storage heating in the prefabs which is costing them a colossal amount of money each year. This is evident from the amount of electricity consumed at night time. The fact that some months are consuming more energy at night time than daytime shows that the storage heaters alone are responsible for more energy use then an entire day with full occupants

Equipment and lighting follow similar patterns also. Both schools largely use 58w florescent lighting in all areas of the buildings. The main areas of consumption from equipment are water heaters, electric heaters, computers, projectors, kitchen equipment, and power tools.

Oil boilers installed for heating are major contributors to carbon dioxide emissions in both schools. The Schools differ in areas such as boiler size and insulation. The boiler size in Colaiste Cholmcille is 150Kw whilst in Archbishop McHale College is 512Kw. The use of insulation and a correct sized boiler as well as regulated timers has a clear effect on energy patterns.

4.3.1 Water Use

The difference in water consumed suggests that Colaiste Cholmcille has a problem.

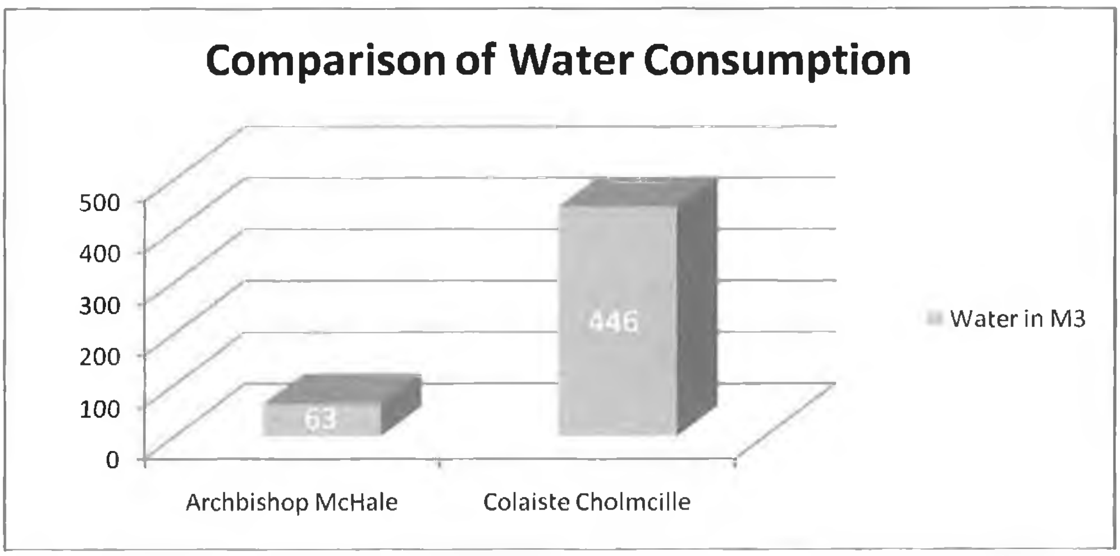


Figure 33: Comparing Colaiste Cholmcilles and Archbishop McHale Colleges Water use

4.3.2 Comparison of Oil and Electricity

It is evident that Archbishop McHale consumes far more electricity and oil than Colaiste Cholmcille. In reality Archbishop McHale should in fact consume less energy as there are less students and it is smaller in total area.

In relation to overall performance of the building through Carbon emissions Archbishop McHale College is estimated to be responsible for twice as much Carbon Dioxide in Kg's per metre squared.

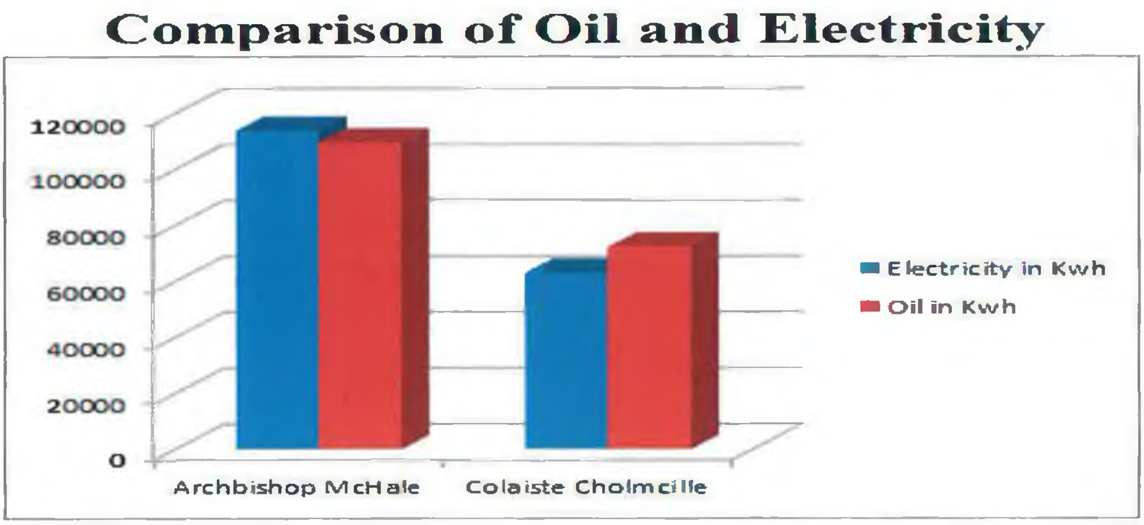


Figure 34: Comparing Colaiste Cholmcilles and Archbishop McHale Colleges Electricity and Oil Use

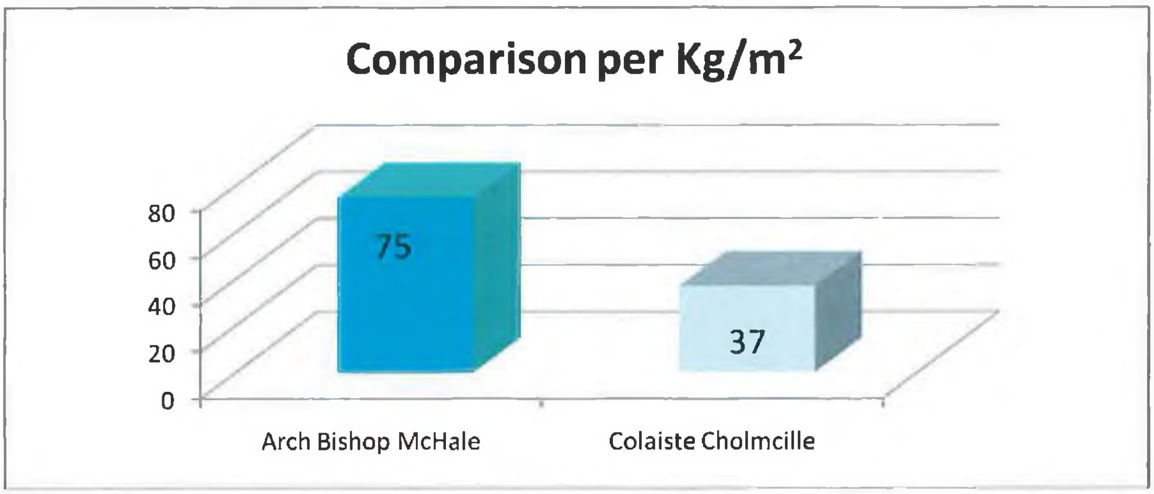


Figure 35: Comparing Colaiste Cholmcilles and Archbishop McHale Colleges Carbon Dioxide in Kg per M2

4.4 Display Energy Certificate

Through the Display Energy Certificate for Schools Program it was possible to gain an energy certificate for both schools by using information gathered during the energy audit. It should be noted that the heating has been calculated by using the square metres of the entire building.

The actual certificates are now being sent to both schools by post by the SEAI to be displayed by the schools for the public to have an insight into energy management in the schools and how the building is performing overall from an energy perspective.

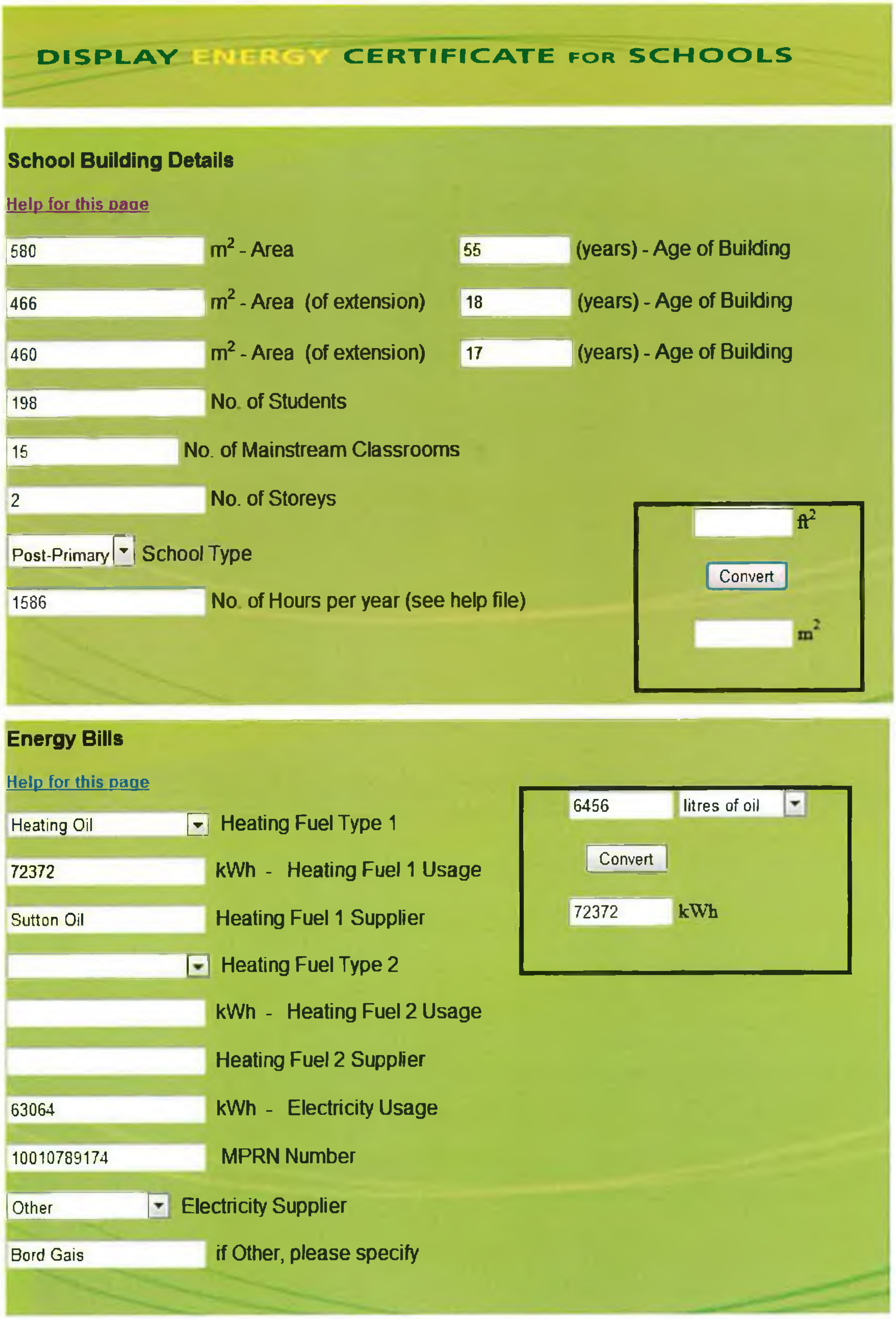
By displaying the certificates the schools will then be meeting legislation set out in the Energy Performance of Buildings Directive. Once a rating is achieved for each school it is possible to move forward and try and find areas where the school can improve and ultimately save money in the future.

The Display Energy Certificate measure the schools performance by taking areas such as School building details, energy consumption, building fabric, ventilation, water conservation, heating systems, lighting and other electrical appliance use. The outcome and rating that the certificate displays can then be improved in these areas.

The information entered is in the charts below. All information entered is correct using the information given by the schools themselves. Energy consumption and water use was taken from bills provided. The remainder of entries are entered using information provided by the schools and observations made.

It works in a similar way as the Carbon Trust benchmarking. The schools are rated by Carbon dioxide in Kg's per m^2. The difference between the two is the fact that local conditions are taken into account more on the display energy certificate. This makes the estimated output far more accurate. In defence for the Carbon Trust method, it does help us to understand how Irish buildings are comparing on a worldwide scale. Ireland relies on fossil fuels to supply 90% of electricity; this is taken into account for the Display Energy Certificate but not for the Carbon Trust Benchmarking

4.4.1 Colaiste Cholmcille Display Energy Certificate Details



DISPLAY ENERGY CERTIFICATE FOR SCHOOLS

School Building Details

Help for this page

580 m^2 - Area | 55 (years) - Age of Building

466 m^2 - Area (of extension) | 18 (years) - Age of Building

460 m^2 - Area (of extension) | 17 (years) - Age of Building

198 No. of Students

15 No. of Mainstream Classrooms

2 No. of Storeys

Post-Primary School Type

1586 No. of Hours per year (see help file)

ft^2 Convert m^2

Energy Bills

Help for this page

Heating Oil Heating Fuel Type 1

72372 kWh - Heating Fuel 1 Usage

Sutton Oil Heating Fuel 1 Supplier

Heating Fuel Type 2

kWh - Heating Fuel 2 Usage

Heating Fuel 2 Supplier

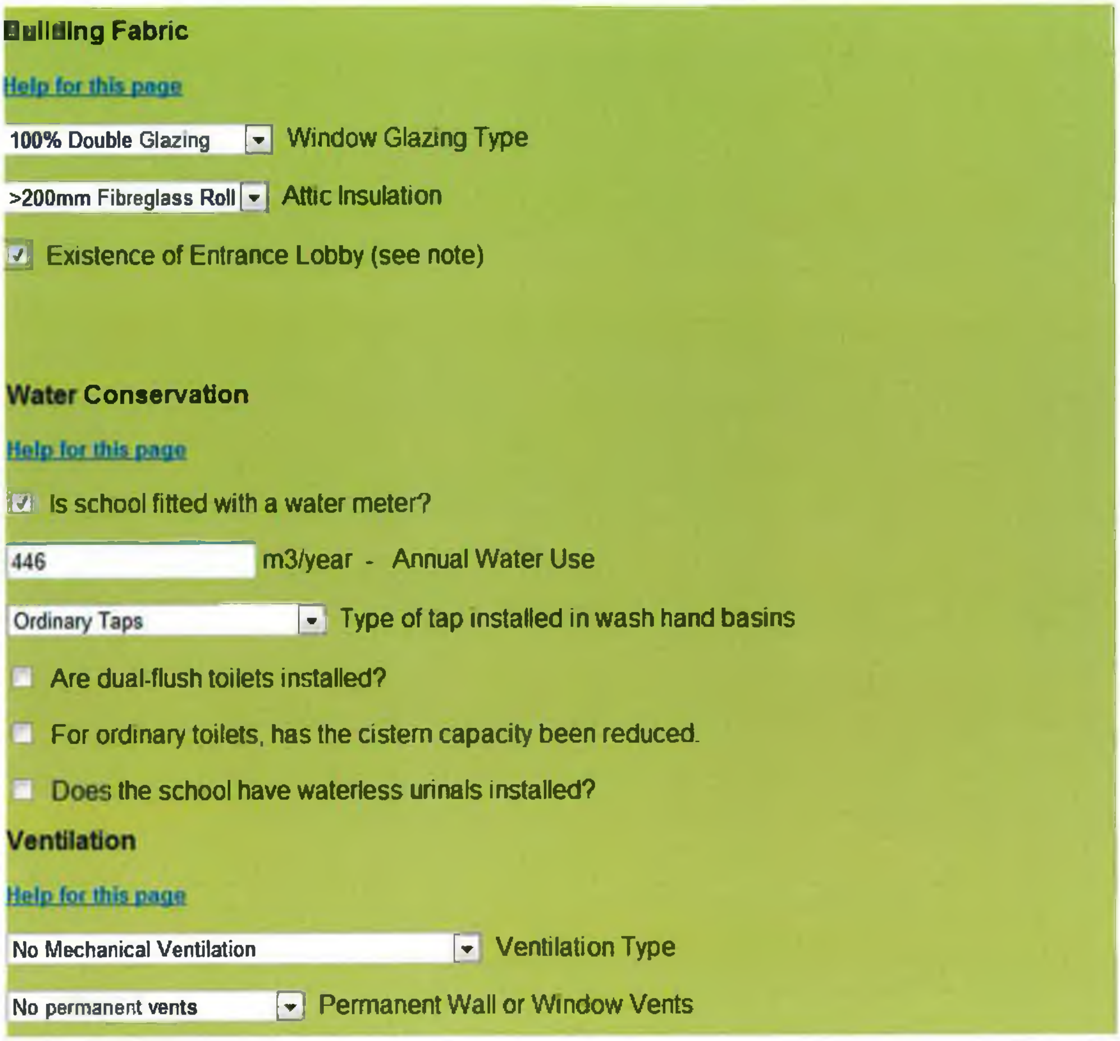
63064 kWh - Electricity Usage

10010789174 MPRN Number

Other Electricity Supplier

Bord Gais if Other, please specify

6456 litres of oil Convert 72372 kWh


Building Fabric

Help for this page

100% Double Glazing ▾ Window Glazing Type

>200mm Fibreglass Roll ▾ Attic Insulation

☑ Existence of Entrance Lobby (see note)

Water Conservation

Help for this page

☑ Is school fitted with a water meter?

446 m3/year - Annual Water Use

Ordinary Taps ▾ Type of tap installed in wash hand basins

☐ Are dual-flush toilets installed?

☐ For ordinary toilets, has the cistern capacity been reduced.

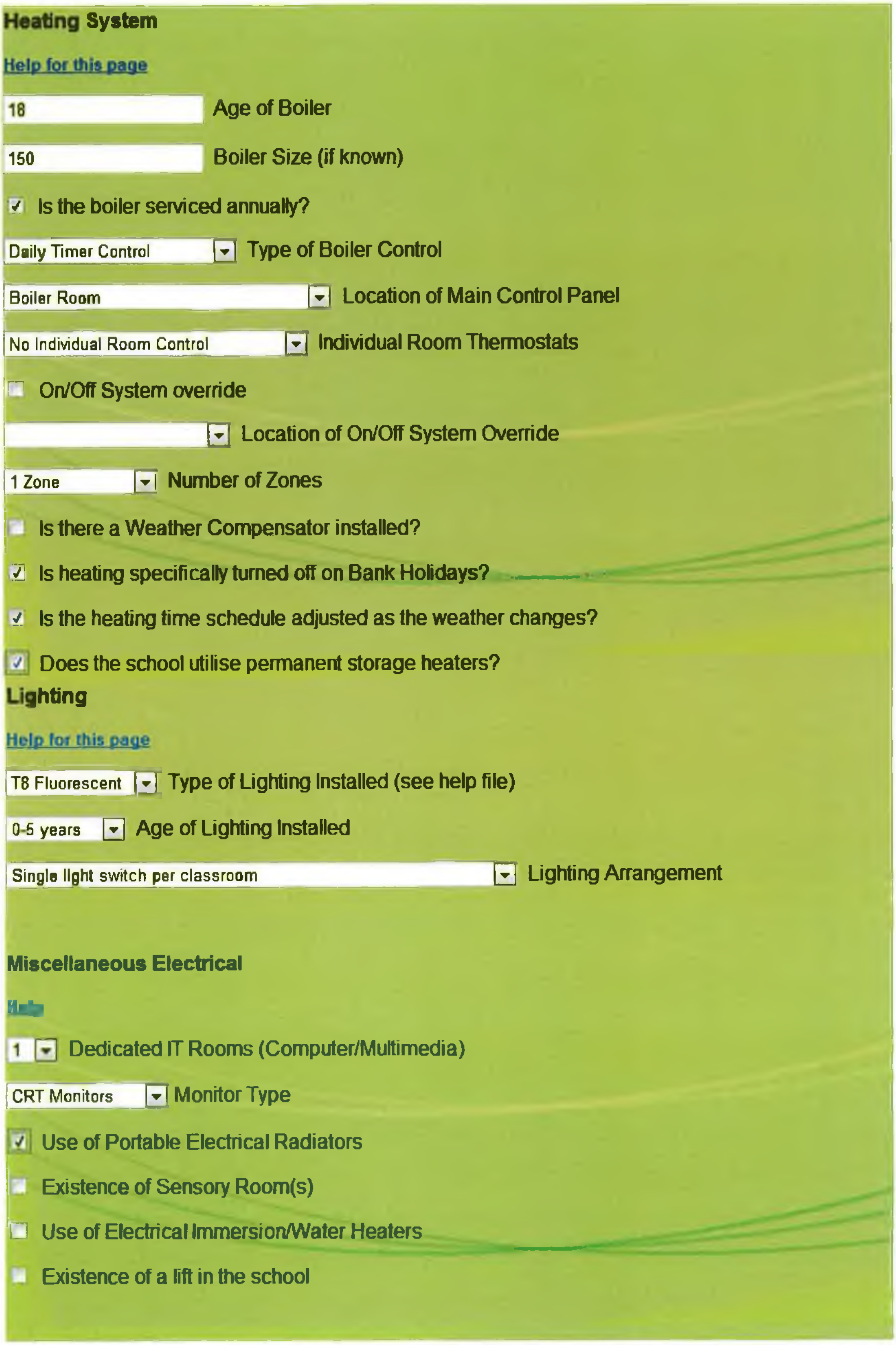
☐ Does the school have waterless urinals installed?

Ventilation

Help for this page

No Mechanical Ventilation ▾ Ventilation Type

No permanent vents ▾ Permanent Wall or Window Vents



Heating System

Help for this page

18 Age of Boiler

150 Boiler Size (if known)

☑ Is the boiler serviced annually?

Daily Timer Control ▾ Type of Boiler Control

Boiler Room ▾ Location of Main Control Panel

No Individual Room Control ▾ Individual Room Thermostats

☐ On/Off System override

▾ Location of On/Off System Override

1 Zone ▾ Number of Zones

☐ Is there a Weather Compensator installed?

☑ Is heating specifically turned off on Bank Holidays?

☑ Is the heating time schedule adjusted as the weather changes?

☑ Does the school utilise permanent storage heaters?

Lighting

Help for this page

T8 Fluorescent ▾ Type of Lighting Installed (see help file)

0-5 years ▾ Age of Lighting Installed

Single light switch per classroom ▾ Lighting Arrangement

Miscellaneous Electrical

Help

1 ▾ Dedicated IT Rooms (Computer/Multimedia)

CRT Monitors ▾ Monitor Type

☑ Use of Portable Electrical Radiators

☐ Existence of Sensory Room(s)

☐ Use of Electrical Immersion/Water Heaters

☐ Existence of a lift in the school

4.4.2 Colaiste Cholmcille Display Energy Certificate

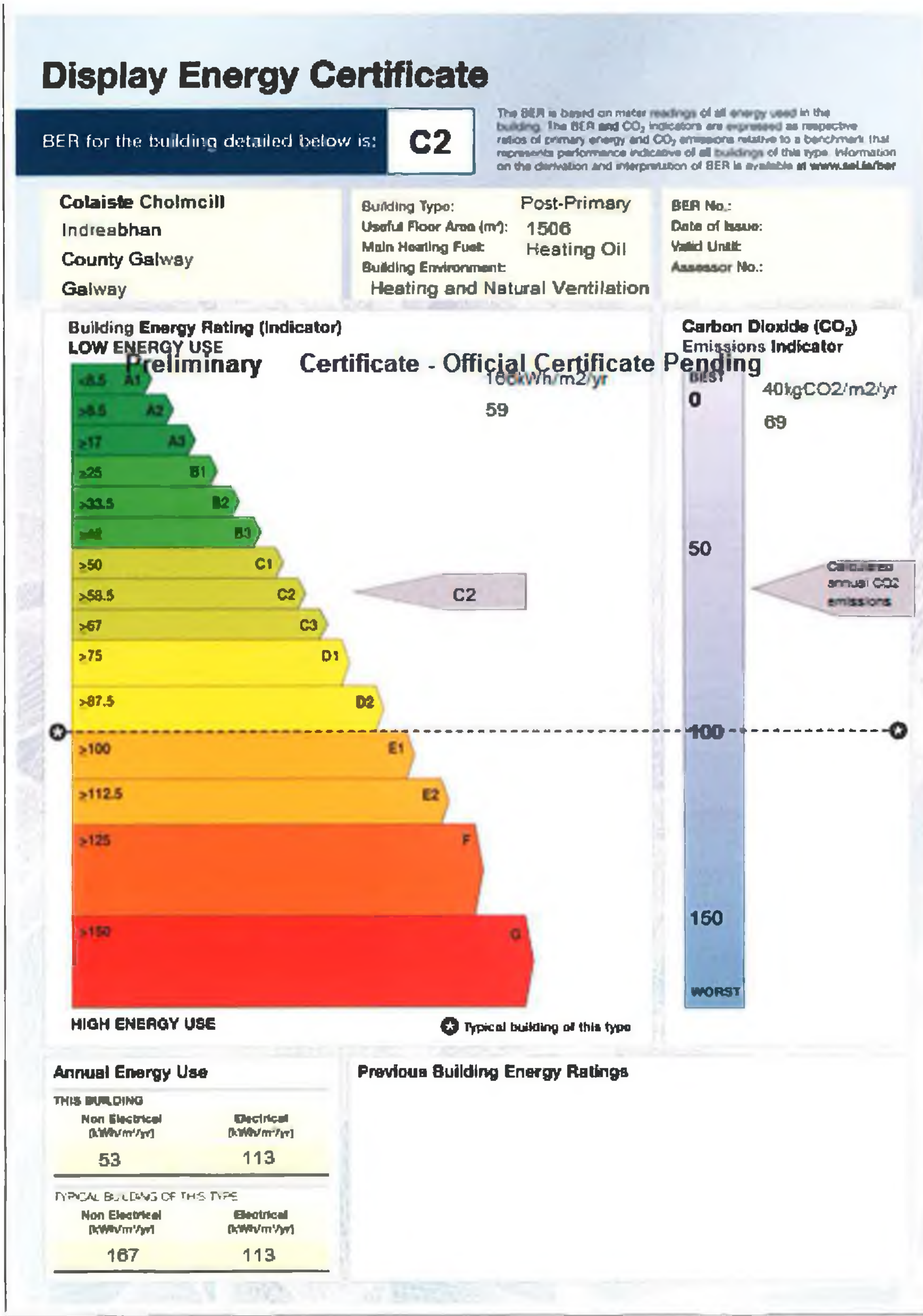
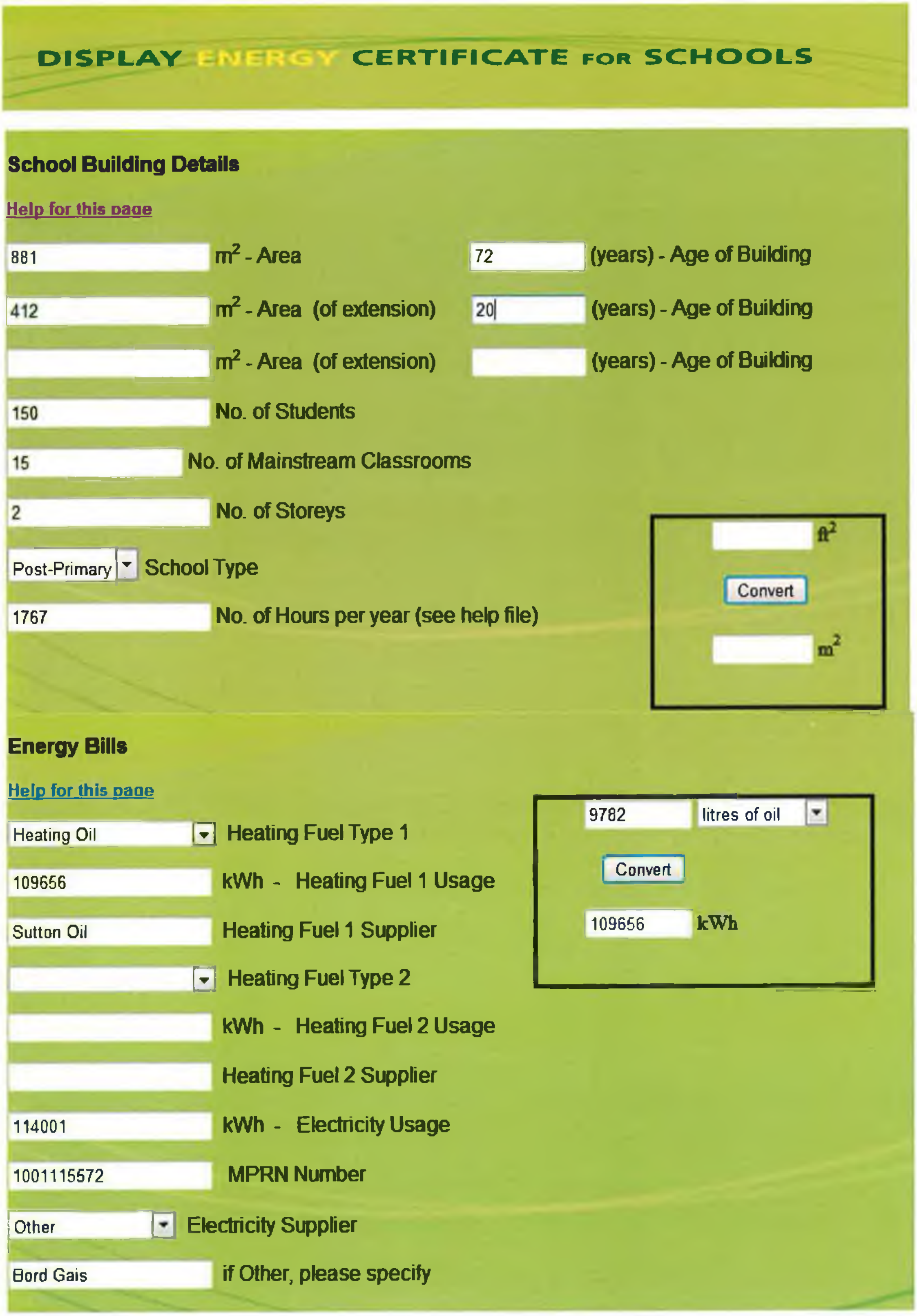


Figure 36: Provisional Display Energy Certificate Colaiste Cholmcille

4.4.3 Archbishop McHale Display Energy Certificate Details



DISPLAY ENERGY CERTIFICATE FOR SCHOOLS

School Building Details

Help for this page

881	m^2 - Area	72	(years) - Age of Building
412	m^2 - Area (of extension)	20	(years) - Age of Building
	m^2 - Area (of extension)		(years) - Age of Building
150	No. of Students		
15	No. of Mainstream Classrooms		
2	No. of Storeys		
Post-Primary	School Type		
1767	No. of Hours per year (see help file)		

ft²
Convert
m²

Energy Bills

Help for this page

Heating Oil	Heating Fuel Type 1
109656	kWh - Heating Fuel 1 Usage
Sutton Oil	Heating Fuel 1 Supplier
	Heating Fuel Type 2
	kWh - Heating Fuel 2 Usage
	Heating Fuel 2 Supplier
114001	kWh - Electricity Usage
1001115572	MPRN Number
Other	Electricity Supplier
Bord Gais	if Other, please specify

9782 litres of oil
Convert
109656 kWh

Building Fabric

Help for this page

100% Double Glazing ▾ Window Glazing Type

No insulation ▾ Attic Insulation

☑ Existence of Entrance Lobby (see note)

Ventilation

Help for this page

No Mechanical Ventilation ▾ Ventilation Type

No permanent vents ▾ Permanent Wall or Window Vents

Heating System

Help for this page

12 Age of Boiler

510 Boiler Size (if known)

☑ Is the boiler serviced annually?

Daily Timer Control ▾ Type of Boiler Control

Boiler Room ▾ Location of Main Control Panel

No Individual Room Control ▾ Individual Room Thermostats

☐ On/Off System override

▾ Location of On/Off System Override

1 Zone ▾ Number of Zones

☐ Is there a Weather Compensator installed?

☑ Is heating specifically turned off on Bank Holidays?

☑ Is the heating time schedule adjusted as the weather changes?

☐ Does the school utilise permanent storage heaters?

Energy Management Policy

Help for this page

☐ Does the school have a formal energy management policy in place?

No student Involvement ▾ To what extent are students involved in the school's energy management?

☐ Does the school monitor energy use and set performance targets?

No Online Monitoring ▾ Online Energy Monitoring

Principal ▾ Who has chief responsibility for energy use in the school?

Computers and Monitors often left on overnight ▾ Computer Management Procedures

Lights left on for school day ▾ Lighting Management Procedures

Dark blinds only drawn to prevent direct glare ▾ Blind Management

Lighting

Help for this page

T8 Fluorescent ▾ Type of Lighting Installed (see help file)

0-5 years ▾ Age of Lighting Installed

Single light switch per classroom ▾ Lighting Arrangement

Miscellaneous Electrical

Help

1 ▾ Dedicated IT Rooms (Computer/Multimedia)

CRT Monitors ▾ Monitor Type

☑ Use of Portable Electrical Radiators

☐ Existence of Sensory Room(s)

☐ Use of Electrical Immersion/Water Heaters

☐ Existence of a lift in the school

Water Conservation

Help for this page

☑ Is school fitted with a water meter?

63 m3/year - Annual Water Use

Ordinary Taps ▾ Type of tap installed in wash hand basins

☐ Are dual-flush toilets installed?

☐ For ordinary toilets, has the cistern capacity been reduced.

☐ Does the school have waterless urinals installed?

4.4.4 Archbishop McHale College Display Energy Certificate

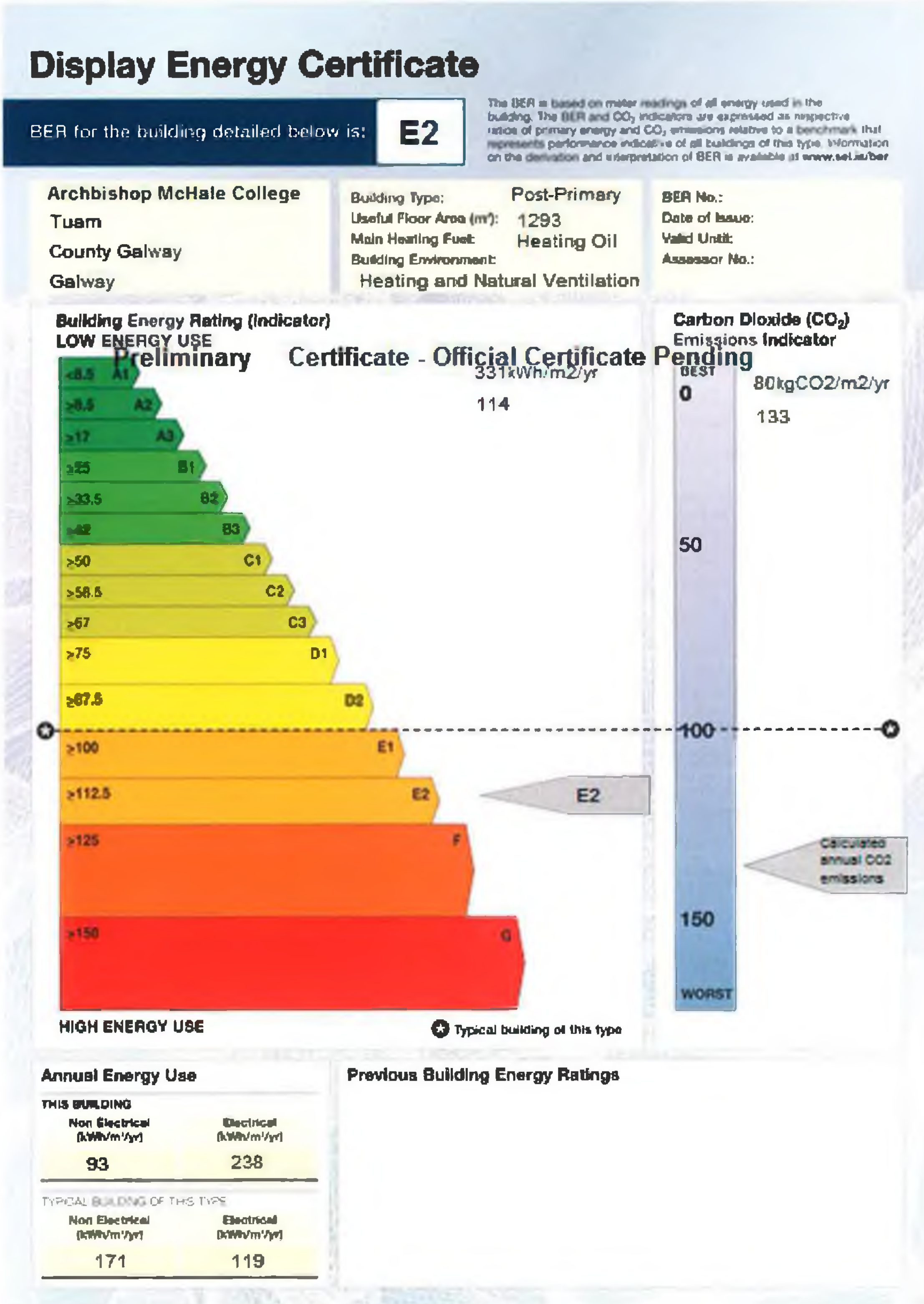


Figure 37: Provisional Display Energy Certificate Archbishop McHale College

4.4.5 Comparison of Display Energy Certificates

Colaiste Cholmcille is performing well in comparison to Archbishop McHale College. Colaiste Cholmcille has a Display Energy Rating of a C2 and an actual figure of 59Kg per metre squared whilst Archbishop McHale has a Display Energy Rating of an E2 and an actual figure of 114Kg of Carbon Dioxide per metre squared. The fact is that the heating systems are only used in the main buildings whilst prefabs are heated by storage heating which is a major contributing factor when it comes to electricity use.

4.4.6 Colaiste Cholmcille Summary

In Colaiste Cholmcille when compared to schools with the same attributes the school is performing excellently from a heating point of view but not so good in electricity use. It is performing 3 times better than a typical school at 53 Kg of CO^2 per m^2 whilst a building with the same attributes typically is responsible for 167 Kg of CO^2 per m^2.

The electricity on the other hand is exactly the same as a typical building with similar attributes at 113 Kg of CO^2 per m^2. There is room for improvement in this area. With regards to the energy rating of 90Kg of CO^2 per m^2 which is a C2 rating; it can be improved to a C1 rating without making huge steps. The C1 rating is less than 89.5Kg of CO^2 per m^2. A reduction of over 0.5Kg of CO^2 emissions in a year is possible by reducing electricity consumption

4.4.7 Archbishop McHale Summary

In Archbishop McHale College when compared to schools with the same attributes the school is performing poorly overall. With regard to heating the school is performing quite well. It is responsible for 93 Kg of CO^2 per m^2. It is performing almost twice as good as a typical school at 93 Kg of CO^2 per m^2 compared to a typical building with similar attributes at 171 Kg of CO^2 per m^2.

The electricity consumption is a problem that needs to be addressed as it is performing poorly at exactly twice as much consumption as a typical school with similar attributes. It has an output of 238 Kg of CO^2 per m^2 compared to 119 Kg of CO^2 per m^2 from a typical building with similar attributes. In order to gain a better energy rating, electricity and oil use needs to be dramatically reduced. This building is costing way too much for the size of it.

Chapter Five: Discussion

5.1 School Energy Programmes

A lot of energy management areas that can be improved in Colaiste Cholmcille and Archbishop McHale College are areas that can be improved through the involvement of staff and students in environmental issues. On the SEAI school pages there is advice for teachers on how to integrate energy management in subjects which can in turn increase awareness for both the teacher and the pupils.

There is an opportunity to run energy management programs within transition year curriculum. Part of the focus could be for the students to improve energy control within the school. Transition year students could be responsible for promoting energy awareness to other students within the school. Campaigns throughout the school and poster competitions should be promoted. They could be awarded with a reward at the end of the year if they can reduce energy consumption from the previous year.

This type of program would be required to have a teacher involved who could play the role of environmental co-ordinator. They would be required to teach the students about the importance of reducing energy consumption and how it can be achieved. This teacher should have access to energy bills and be able to analyse them on a month to month basis comparing them with previous years.

The idea of a program like this is to try and promote continuous improvement on each year. It is also good for student development during the transition year period and it can give an overall purpose for students to use their experiences in the future to reduce energy in other aspects of their life. It would be important to set up the electricity bills online so that access is available and comparison reports can be made.

The school should also avail of the Greener Schools Scheme that is available for all schools which is run by An Taisce. It runs on an award scheme for the school by giving a flag to show that the school is committed to the environment. Other schemes that can aid the school in reducing energy costs can be found on the SEAI energy for schools pages on www.seai.ie

5.2 Colaiste Cholmcille

5.2.1 Materials

Walls

There is currently no insulation in the walls throughout the main building. The current situation is allowing heat to be lost through the walls costing the school money through extra heating. It is expected that 25% of heat loss is through the walls *([93] Building Energy Ireland 2010)*

The alternative is to insulate the walls allowing more heat to be stored in the building and reducing the need for continuous use of the heating system. Unfortunately the energy efficiency scheme states that it can only be used once per building. Colaiste Cholmcille has availed of the grant for the scheme for the insulation in the roof. It should be investigated though as to whether an exception can be made to avail of the grant.

Doors

Currently the front door is wooden and the side doors are wooden with a single glass panel. They are directly exposed to the outside weather conditions. They are responsible for heat loss due to the draught that is being caused by the doors being left open simultaneously.

An alternative to this unnecessary waste of heat in the short term is by possibly installing an industrial spring on the door which will ensure that the doors is closed when there is nobody around.

In the medium term an alternative would be to change the doors. The front door has a slight air gap at the bottom and the back/side doors are single glazed which is another contributor to heat loss.

A long term alternative would be to install a porch on both back/side doors. This would then reduce the overall draught that can potentially flow though from the front to the back thus reducing heat-loss. With the back doors as they are, every time they are opened heated air is escaping. A porch would reduce heat loss from opening these doors.

5.2.2 Heating System

The current boiler system is 17 years old and run from oil. It is a sufficient size and appears to be maintained regularly. This is quite an old system and the school will have to consider changing it in the short to medium future. The main concerns with this is that according to SEAI heating systems this old are less efficient then modern technologies.

An alternative to this system would be a wood chip boiler. There are grants available for the wood chip boiler through the SEAI ReHeat scheme.

According to cheapestoil.ie current cheapest prices in Galway for oil is €0.65 per litre. The price of wood chip was taken from an *([94] SEAI 2010)* case study which estimated that a tonne of woodchip costs €80 per tonne whilst a tonne of wood pellet can be bought from *([90] Tech Store 2010)* €167 per tonne.

According to the *([96] Biomass Energy Centre 2010)* one litre of oil gives 10Kwh of energy, 1 tonne of wood chip gives 3500Kwh of energy whilst 1 tonne of wood pellet gives 4800Kwh of energy. This works out at €0.065, €0.023 and €0.035 per Kwh respectively. The energy required through oil consumption in Colaiste Cholmcille per year is 72366Kwh. Multiplying this figure by the prices above gives an outcome of the chart below for the year.

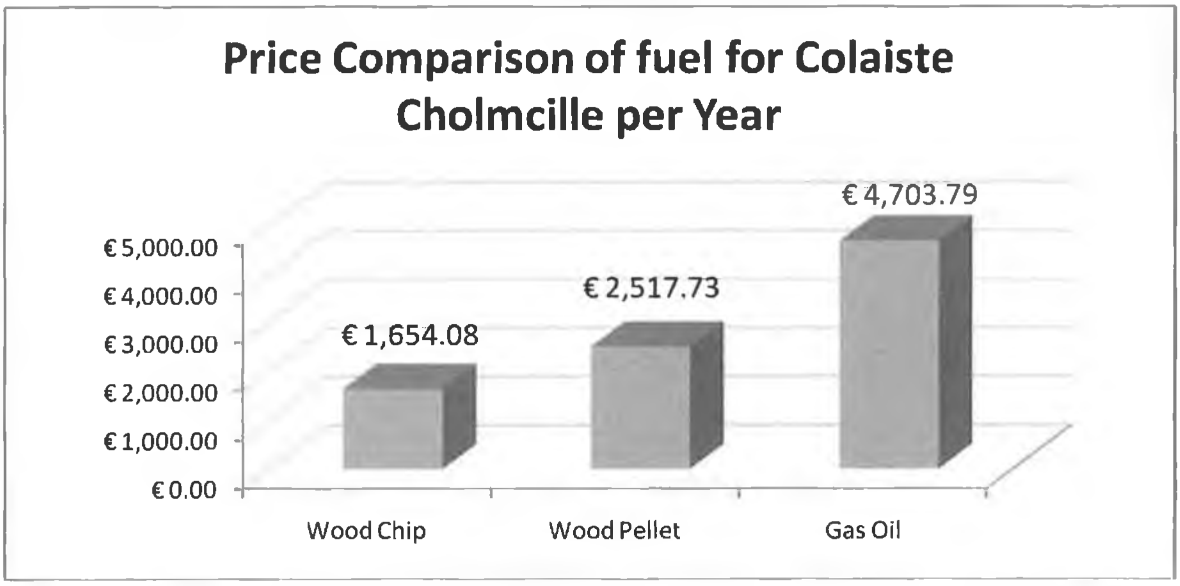


Figure 40: Comparison of fuel prices for Colaiste Cholmcille

Payback Period

This then shows that the school is currently spending way too much on heating and can potentially save thousands of euro per year from changing the heating system. With rising oil prices due to resource depletion, it can be expected that oil prices will increase per litre furthering the potential savings. Wood chips are sourced locally so there is a stability to supply and prices so if anything prices should come down.

According to a *([97] CIBSE 1999)* 110w per metre squared is required for an educational building. This would mean that for a building this size an 110Kwh boiler would be required currently.

Using the SEAI ReHeat scheme calculator, it is estimated that the cost of a boiler with an energy output the same as the current system is expected to be approximately €55000 which has a grant available of €16500 which will then cost a total of €39500 for the school. Taking the expected wood chip price away from oil price you get the saving per year. The saving per year in this case would be €3049.71. Dividing the total cost by the saving per year gives a payback period of less than 13 years. When considering that a new boiler will be required before that time it is clear that it would be a good investment.

From a practical point of view it may be important to invest in a boiler a little bit larger. The purpose of the previous costing was to compare current fuel prices to give a payback period for current fuel use. With an extension to the main building due in the near future it is important that the planned heating system is not over worked. The size required can be gathered by calculating the entire buildings area and multiplying by 110.

Solar Panels

Another alternative would be to install a solar panel system. it could be used to compliment the current or future heating system and could replace the need for electrical water heating.

Colaiste Cholmcille is the ideal building to install solar panels. The rear of the building is south facing which is quite a large area; this is the best direction to utilize the full potential of a solar panel. The roof is also tilted which helps. Using the ReHeat Calculator ([93] SEAI 2010), the estimated cost of flat plate solar panels with an area of 10m2 is €800 per metre squared. This would then amount to €8000 for 10m2. The grant available for this would be €2400.

This would be an overall cost of €5600 for the school. According to ([98] SEAI 2010) solar panels in Ireland have the equivalent energy as 100 litres of oil per m2. Installing 10m2 of solar panels would then have an equivalent of 1000 litres of oil per year. The price of oil per 1000 litres can currently be availed for €670 from www.cheapestoil.ie . At a price of €5600 for this size of a system, payback would be expected in 8.35 years.

Heat Pumps

Another possible future alternative to the current system would be the installation of heat pumps. With an extension planned in the near future, there is an opportunity to avail of an under-floor heating system powered by heat pumps. The restrictions usually with heat pumps are the fact that they are required to be installed under the building that is to be heated. It is possible to for Colaiste Cholmcille to install them prior to development of the structure. The energy available from the heat pumps is well worth taking advantage of. There is a grant available for heat pumps that can be availed with other heating systems.

Combination of Heating Systems

The above areas are just scenarios and if a combination of more than one system is required for the building, an installation expert should be consulted. The payback periods are as accurate as can be with the information available.

5.2.3 Prefabs

The prefabs are an area that is responsible for massive amounts of energy consumption. The sheer amount of electricity consumed at night time is an indicator as to how much the heating of them is costing. Assuming that the prefabs are heated between 1am and 8am each night this would amount to 7 hours per night.

There is a total of 18 storage heaters in the building, 17 of these are in the prefabs. Heaters of this size they would have a power output of 3Kwh each, this would mean that they would be responsible for 1785Kwh per week at a cost of €136.91. Using prices for fuel that was gathered earlier we can see how storage heaters perform from a financial point of view compared to oil, wood pellet and wood chip.

Using the exact same energy of 1785Kwh we can see how much these varieties would have cost. It is clear that energy from the storage heaters when compared to other forms of energy is extremely expensive and over 3 times more expensive then Wood Chip.

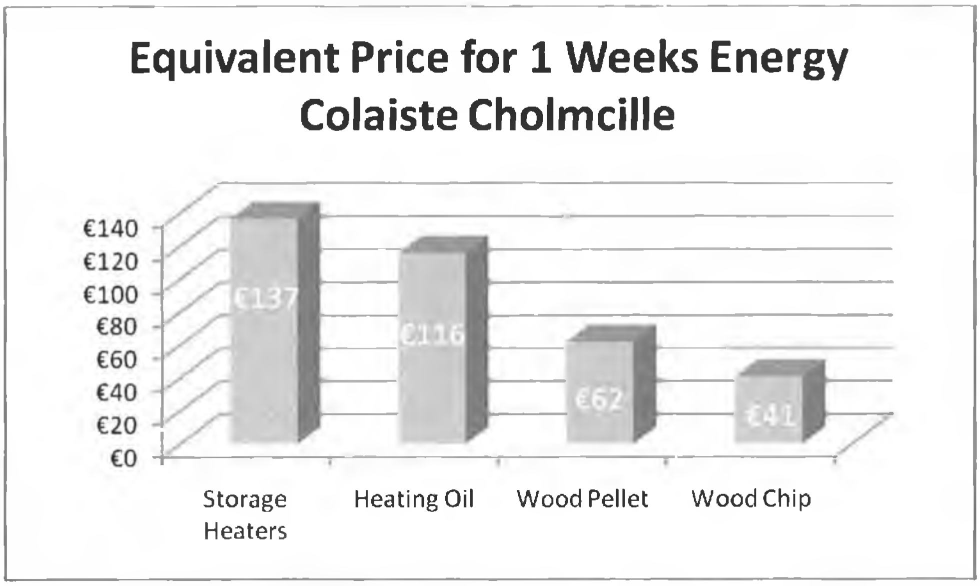


Figure 41: Price Comparison of fuels Colaiste Cholmcille including Storage Heaters

5.3 Archbishop McHale

5.3.1 Materials

Walls and Ceiling

In the current situation there is no insulation in the walls or the ceiling throughout the main building. Up to 50% of heat is said to be lost through the combination of walls and roof *([93] Building Energy Ireland 2010)*

The alternative for the school is to avail of the grant from the energy efficiency scheme. Taking advantage of this scheme, the school would see immediate reductions in fuel costs as well as better heat retention. The fact that it ends up costing nothing is more of a reason to avail of it. It is only possible to apply for the grant during certain months. For more information on it the school should look at http://www.energyeducation.ie/EES/index.aspx. Insulation can be added to the roof in the cavities and on the inside of the building on the walls.

Doors and Windows

The doors that are currently in Archbishop McHale College are all in poor condition especially the side and back door. The draughts that are coming from the doors are unnecessary heat loss. The doors do not close unless done so by the last person to leave which often means that they are left open causing a draught throughout the building resulting in heat loss.

A short term alternative for the school would be to add draught blockers to the bottom of the doors this can increase the airtightness of the building. Keeping the front and back door closed is also important and by installing an industrial spring on the door which would ensure that the door is closed when there is nobody around.

A more costly alternative would be to construct a porch on the side and back doors to reduce the amount of energy being lost as a result of the draught going through the building. The doors could all be replaced too.

The windows in the woodwork store room are single glazed and are responsible for heat loss. An alternative would be to replace them with double glazing as they are currently responsible for heat loss.

5.3.2 Heating System

The current boiler is approximately 12 years old and run from oil. The output of it is 510Kwh. Using the CIBSE Guide of 110w per m^2 it is clear to see that it is oversized. The area of the building that is being heated by the boiler is 881m^2 which would require a boiler with a heat capacity of about 100kwh. This shows that the current boiler is 5 times oversized causing it to consume more as it is not running at its optimum level. A boiler this size would be better suited for an area of 5000m^2.

An alternative to this system would be a proper sized wood chip boiler. There are grants available for the wood chip boiler through the SEAI ReHeat scheme.

According to cheapestoil.ie current cheapest prices in Galway for oil is €0.65 per litre. The price of wood chip was taken from an *[(94] SEAI 2010)* case study which estimated that a tonne of woodchip costs €80 per tonne whilst a tonne of wood pellet can be bought from *([95] Tech Store 2010)* €167 per tonne.

According to the *([96] Biomass Energy Centre 2010)* one litre of oil gives 10Kwh of energy, 1 tonne of wood chip gives 3500Kwh of energy whilst 1 tonne of wood pellet gives 4800Kwh of energy. This works out at €0.065, €0.023 and €0.035 per Kwh respectively. The energy required through oil consumption in Archbishop McHale College per year is 114000Kwh. Multiplying this figure by the prices above gives an outcome of the chart below for the year.

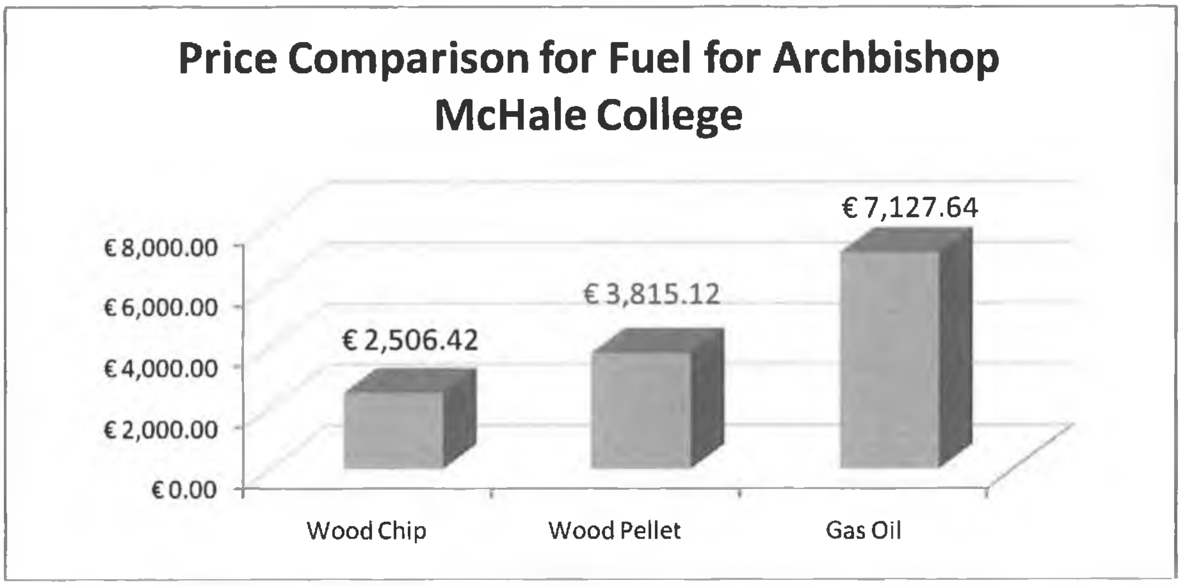


Figure 42: Fuel prices comparison Archbishop McHale College

Payback Period

This then shows that the school is spending way too much on heating and can potentially save thousands of euro per year from changing the heating system. With rising oil prices due to resource depletion, it can be expected that oil prices will increase per litre furthering the potential savings. Wood chips are sourced locally so there is a stability to supply and prices so if anything prices should come down.

Using the *([97] CIBSE 1999)* report, 110w per metre squared is required for an educational building. This would mean that for a building this size of 881m^2 a boiler with an output of approximately 100Kwh would be required currently.

Using the SEAI ReHeat scheme calculator, it is estimated that the cost of a boiler with an energy output the same as the current system is expected to be approximately €50000 which has a grant available of €15000 which will then cost a total of €35000 for the school. Taking the expected wood chip price away from oil price you get the saving per year. The saving per year in this case would be €4621. Dividing the total cost by the saving per year gives a payback period of less than 7.5 years. Every year after that is a saving for the school.

If any extension to the school in planned for the school within the next ten years it is advisable to purchase a boiler with a slightly larger output. This can be calculated by adding the area of the planned extension to 881, multiplying by 110w and dividing by 1000 to get Kwh.

Solar Panels

Another alternative would be to install a solar panel system. it could be used to compliment the current or future heating system and could replace the need for electrical water heating.

Although no area of the building is south facing, the roof is flat so it is ideal for installing solar thermal panels. This can allow them to be tilted at the best angle facing south. The same payback is expected for the solar panels for Archbishop McHale as Colaiste Cholmcille of a cost of €5600 with a payback of 8.35 years.

This would allow the school to remove the water heaters under the sink and compliment the woodchip system.

Combination of Heating Systems

The above areas are just scenarios and if a combination of more than one system is required for the building, an installation expert should be consulted. The payback periods are as accurate as can be with the information available.

5.3.3 Prefabs

The prefabs are an area that is responsible for massive amounts of energy consumption. The sheer amount of electricity consumed at night time is an indicator as to how much the heating of them is costing. Assuming that the prefabs are heated between 1am and 8am each night this would amount to 7 hours per night.

There is a total 14 storage heaters in the prefabs. Heaters of this size would have a power output of 3Kwh each; this would mean that they would be responsible for 1785Kwh per week at a cost of €136.91. Using prices for fuel that was gathered earlier we can see how storage heaters perform from a financial point of view compared to oil, wood pellet and wood chip.

Using the exact same energy of 1470Kwh we can see how much these varieties would have cost. It is clear that energy from the storage heaters when compared to other forms of energy is extremely expensive and over 3 times more expensive then Wood Chip.

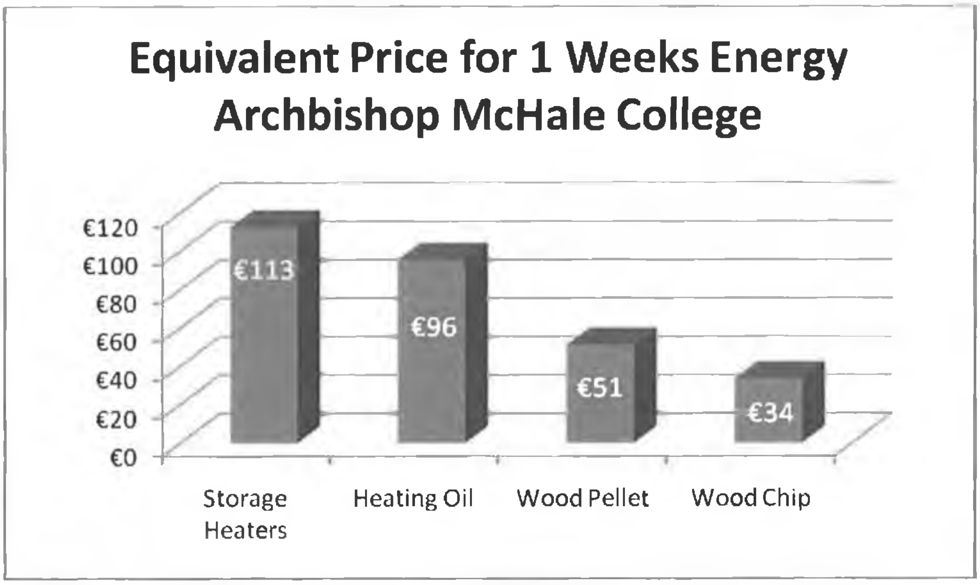


Figure 43: Fuel price comparison for Archbishop McHale College

5.4 Both Schools

5.4.1 Storage of Wood Chip

After looking through various alternatives for types of fuel systems to use, I have come to the conclusion that if the schools were to opt for wood chip the use of an automated boiler would be a good option for both schools. The fact that space is not too much of an obstacle in either school, large amount of money could be potentially saved.

An external container or room is fitted with a spring blade agitator is best suited. Wood chip is loaded into the room via the roof which is adjustable or has an opening to allow wood chip be delivered through. The spring blade agitator feeds the wood chip boiler creating an automated system.

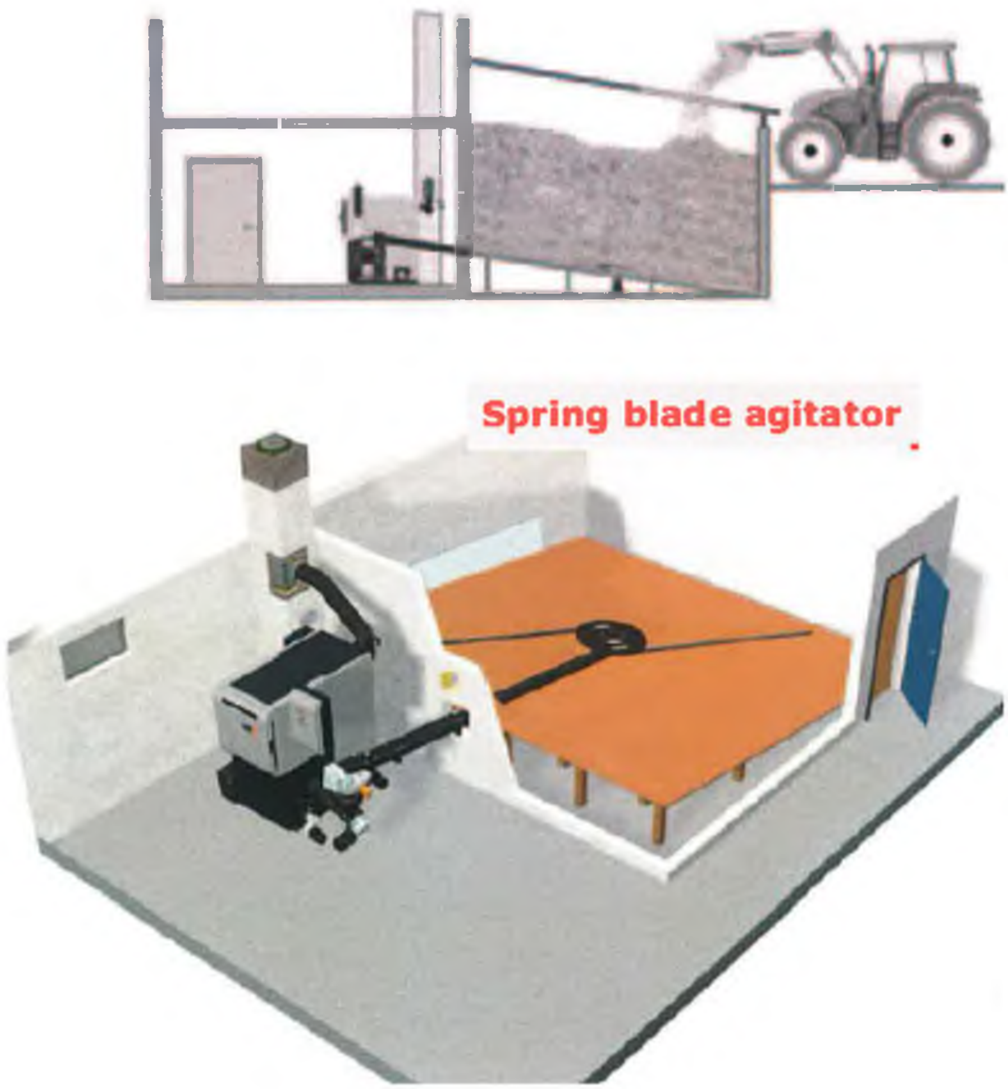


Figure 38: Delivery, Storage and Automated Control of Wood Chip

5.4.2 Water Heating

Currently the water is heated via electrical water heaters which are located under each sink in both schools. The cost associated with heating water from an electrical system is quite expensive when you consider return for money spent. If a water heater that had a power of 1.5Kw was left on for 1 hour at €0.1535 per unit it would cost approximately €0.23 which doesn't seem too costly, but when you consider that the school has 5 water heaters and if each one was left on for 1 hour per day for the entire school year this would amount to €191 per year. If used for a full day it would cost 6-8 times that.

The alternative to this system is to heat the water through the main boiler system where possible. The heating system will be in use most of the time so it will not cost a lot from a heating point of view. During times when the heating system is not on then the electrical heaters can be used as backup.

5.4.3 Heating System Control

Currently there are no temperature controls in either school. The heating system is turned on and it heats every room in the building, if it gets too warm, windows are opened. An alternative to this system would be to introduce temperature controls in every room. This would stop unnecessary opening of windows due to occupants setting the temperature to their comfort levels. In the short term valves could be fixed with an obvious on/off option for occupants to utilize. If it is too hot then at least they can turn of the heat in the room and then open the windows if necessary. The boiler would then not be running unnecessarily at full capacity. Individual room control through digital thermostats linked to 2-port valves should also be looked into.

Figure 39: Radiator Valve Control Colaiste Cholmcille (left) and Archbishop McHale College (Right)

5.4.4 Electrical Equipment

Electrical heaters

Currently electric heaters are used in certain rooms in both schools such as offices and some classrooms. This is a costly form of heat with heaters averaging about 2Kw. A 2Kw heater run during the day time for just 3 hours costs almost €1. When you consider that both schools have 12 heaters each, this could amount to quite a significant amount of money.

The alternative is to avail of insulation through the Energy Efficiency Scheme which would allow each building to provide a comfortable temperature in every room.

Computers

Currently each computer is the responsibility of the previous user. The problem with this is that some people are not as energy conscious as others and they may leave the computer running.

The alternative is to program each PC to shut down via a timer that could be set for 5 in the evening when nobody is using them. During the summer months and in the evenings the modems that serve the computer rooms should not be on. Another alternative would be to set up energy programs that outline the importance of energy management to students and staff so that they are aware of their responsibility.

Kitchen Equipment

Some of the equipment in the kitchens is quite old and may not be running too efficiently. A way of reducing energy consumption in the kitchen would be to replace older models with newer ones. The fridge in the Home Economics room should not be on during the summer months.

5.2.5 Ventilation

Currently the school has no mechanical ventilation system. the vast amount of movement between indoors and outdoors ensures that there is enough air circulation. The doors to the outside will still be opening and closing enough to circulate air throughout the building. In the future if ventilation became a problem it may be advisable to install a displacement ventilation system. This keeps the temperature the same whilst filtering out the unclean air.

5.4.5 Lighting

Both schools use 58w florescent tubes. They are a relatively efficient light that is suitable for a schools scenario.

The alternative to florescent tubes is the use of LED tubes. They cost €75 per bulb. Assume that the school were to have their lights on for 6 hours per day for the school year of 167 days. This would mean that the light would be used for 1002 hours per year. At €0.1535 per unit the florescent bulb at 58w would cost €9.10 whilst the cost of the 18 w LED tube would be €2.85 per year; this would mean that payback for this light would be 12 years which does not seem worthwhile.

Lighting Control

The current way of controlling the light system is a single switch control that turns on/off up to 12 lights. It is up to the last occupant of the room to switch off the lights as they leave.

An alternative to the current system would be to alter the light switch so that each two lights or so has its own switch instead of one switch for 12 lights. The occupants then have the opportunity use only the use the lights that they require. A dimmer could also be installed to try and reduce consumption on days when only a small amount of light is required throughout the room.

In rooms where light is not continuously required such as the toilets, the hallways and classrooms (lunch time), sensors could be installed so that the lights only come on when there are people present. The occupants then would not have to worry about turning off the lights if they are last to leave.

Utilization of Daylight

Currently these schools do not utilize light enough. A regular scenario is to have the blinds down with the lights on. This is generally because of glare caused by sunlight.

The alternative is to use reflective blinds that can utilize the light available so that it shines up instead of down. The use of internal and external shades could also be considered. Colaiste Cholmcille is designed very well so that natural light can be utilized. Archbishop McHale should consider taking steps also.

5.4.6 Storage Heaters

To heat the prefabs storage heaters are used. They run for seven hours at night time in order to use the off peak electricity rate. It is evident when you look at the electricity use at night. Below are alternative scenarios to using storage heaters in the prefabs. There is also a cost comparison study in the discussion for each school.

Control of Current Heaters

Control is an area that can greatly help to reduce the consumption of the heaters. In the current systems the storage heaters are set on a timer at night time regardless of the weather at night. There is no evidence that they are currently serviced.

Alternatively timers should only be set on the nights when the school is open the following day and during the cooler months. The manuals should show what the best settings such as inputs and outputs for the schools performance are. Maintenance and repair is essential to ensure that they are performing to their full heating capacity. *([100] Puravent 2010)*

Replace the heaters with new more efficient heaters

Currently the storage heaters in the prefabs are all quite old aging between 10 and 20 years. The heating element in them is said to deteriorate after 15 years. Alternatively heaters that are older than 15 years could be replaced. *([101] Storage Heaters 2010)*

Integrating the Prefabs with the Main Heating System

The evidence in the electricity shows that the heating of the prefabs is costing a lot of money and an alternative of adjusting to connect the prefabs may be possible.

When you look at this scenario as a whole and consider the consequences it may be disruptive to try and integrate existing structures with the main heating system considering that some of the prefabs are there for over 20 years and it is unknown how much longer they will be in use. If a new prefab is being installed and is not too far from the main heating system, integrating it to the main system may be a good idea. If integration of the main system is possible then a boiler size of 180 to 200Kwh would be required.

Removal of Prefabs

Current methods of extending of the schools show that prefabs are considered the first option. They seem like the best option at first as they are cheaper and no planning permission is required. The cost of a prefab over its lifespan may in fact be far more expensive than an extension over its lifetime

The alternative would be to refuse prefab structures and aim to develop the main building. An extension could be developed in place of the prefab and may end up costing a lot less over its lifetime. The extension would be a permanent structure whilst a prefab would have to be replaced after approximately 20 years. For these reasons it should be considered that when prefabs are knocked they should be replaced by expansion of the main building or at least be connected to the main buildings heating system.

Maintenance of Prefabs

Areas of the prefabs in both schools have damage both internally and externally that is affecting their airtightness. Currently no obvious efforts are being made to fix these areas; this is to do with the fact that the people responsible for maintenance are unaware of the issues. If they were aware of them, these matters would have been fixed.

The fact is that there are areas of the prefabs that are damaged which in turn can affect heat loss within them. The alternative is that the holes could be fixed, air leakages from the windows could be removed and areas that are damp could be investigated. The single glazed windows could be replaced with double glazed and the doors could possibly be fitted with draught blocks

Chapter 6: Conclusions

The previous chapter was an outline of the scenarios for the school. From them I can make a proper judgement when it comes to recommendations for each school

6.1 Both Schools

- Connect water heaters to main system – if the 5 boilers are heated for just 1 hour per day is costing the school approximately €191 per year. The only means of reducing this cost is by connecting the sinks hot water taps to the main heating system so that the water used in the sink is water coming from the radiators. When you consider that it is likely that the water heaters are left on for longer than 1 hour per day then this process could save the school hundreds of euro per year.

- Work towards temperature control in each room starting with fixing valves on radiators – through interviews conducted it is evident that the windows in classrooms are often opened whilst the heating system is on. This is wasted heat and is unnecessarily costing the schools money. The installation of temperature controls in each classroom is necessary to save money in the long term. In the short term valves with a clearly labelled On/Off should be installed. This gives the occupants the choice to turn off the heating in a room where it's not required.

- Control of equipment such as timers on PC's – It is possible to set each computer to turn off automatically each evening. Whilst I was in both schools it was evident that some PC's were being unnecessarily left on. Timer controls would reduce the electricity usage. The modems in the school should be turned off during summer time.

- Temporarily install a spring on the front door so it will automatically close – for the time being, strong springs should be installed on all external doors. This will ensure that the doors are closed when not in use. The door being left open was identified as a problem during an interview undertaken.

- Install singular light control – Each school should change current lighting controls to ensure that lights that don't need to be on are turned off. Each light should be controllable by its own switch; this would mean that only required lights would be switched on.

- Install Light timers or sensors – lights should be set on a timer to ensure that they are switched off at a certain time in the evening. An alternative would be to install sensors that switch off when there is no movement in the room, this would ensure that lights would be switched off every evening time and during lunch breaks. They would also be useful in the halls as they are not continuously occupied.

- Ensure maintenance of all equipment– The maintenance of equipment can keep it performing to its most efficient levels. Each school needs to maintain equipment such as woodwork and mechanical equipment.

- Ensure maintenance of materials – There were areas in both schools that had materials that were damaged which in turn resulted in air leakage. These areas listed above in chapter four should be fixed to avoid this unnecessary heat loss.

- Become part of the greener schools scheme – the benefits of schemes such as the greener school scheme are that they promote involvement of students. There is an opportunity to reduce the schools overall impact without costing any money

6.2 Colaiste Cholmcille

Colaiste Cholmcille overall is performing quite well. It has a C2 Display Energy Certificate Rating which is a relatively high standard. By implementing a few changes the school could perform far better and could be used as a benchmark for other schools to achieve. There are areas listed above and below that can enhance the schools performance. The students within the school can learn from the standards that I propose the school should set. There are areas in which I have identified where the school can save money.

- Utilize daylight where possible by installing relevant reflective technologies – the natural light available in Colaiste Cholmcille is very good. In the classrooms in the old building and in the prefabs there is light available from both sides. The larger windows in the main building are south facing. Reflective blinds and internal and external shading should be installed to make use of this free natural light available. In room 7 upstairs they should consider installing windows above the door so that natural light is available on both sides.

- Apply for insulation grants for the walls through energy efficiency scheme – it may be possible to apply for a grant through the energy efficiency scheme. The installation of insulation in the walls can reduce heat loss by approximately 15%.

- Install a porch at the side door to reduce draught through building – A draught throughout the building causing heat loss has been identified to be caused by the opening and closing of the side doors. They should install an external porch on both side doors to reduce the draught, thus reducing the heat loss and reducing the need for the boiler to be continuously on. When the external door is open, the internal door is closed and vice versa, this essentially stops the draught.

- Change the front door in the future so that the draught is reduced – The current door has a small air gap at the bottom of it, due to the need to keep it closed it is not ideal to put a draught stopper at the bottom of it. For this reason I recommend changing the door for a more airtight alternative.

- Change the boiler for a wood chip boiler – The current system is 17 years old and will required to be changed in the near future. Considering that there are grants available through the ReHeat scheme for wood chip boilers, there is an opportunity to take advantage of it and replace the old boiler. A wood chip boiler is an ideal replacement; using current fuel consumption in Kwh, it would be possible to have a payback period of less than 13 years. This seems like a lot but when you consider that the boiler needs to be changed anyways the school would have a saving on fuel bills every year. The current boiler is in a good position for delivery of wood chip. An automated system would be best as it would be easiest to manage and maintain.

- Add solar panels to compliment the wood chip boiler – Solar panels are also part of the ReHeat scheme. The grant is available for this along with the wood chip boiler. The solar panels when fully utilized can have a payback period of approximately 8.35 years. Colaiste Cholmcille is the ideal building to install them as the back of the old part of the main building has approximately 37.5 metres of roof which is south facing.

- Consider adding heat pumps when the extension is being constructed – Colaiste Cholmcille has plans in the future to extend the main building. During this period it would be advisable to look into heating it using heat pumps.

- Plan to phase out storage heaters within the prefabs and if necessary phase out the prefabs altogether – The main consumer of electricity in Colaiste Cholmcille is the storage heaters in the prefabs. They are very uneconomic and are raising the schools carbon footprint whilst costing a colossal amount. The storage heaters are currently costing the school up to €137 per week. For the equivalent energy from wood chip it would cost just €41. The school should try and push to phase out storage heaters by phasing out the prefabs. If newer structures are built the school should consider connecting it to the mains so that it is heated by the main boiler. In the short term timers should be adjusted accordingly so that they are only on when the prefabs are occupied the next day. Maintenance of the storage heaters is also important so that they are efficient, where necessary storage heaters should be replaced with newer models.

- Take water conservation measures – Currently water usage in Colaiste Cholmcille is too high. The school should investigate as to whether there is a leak in the pipe somewhere. The taps should be push stop, aerators should be installed on them, toilets should have dual flushing and a reduced volume of water and sensors should be installed on the urinals instead of timers.

6.3 Archbishop McHale College

Archbishop McHale College from an energy perspective is performing quite poorly. It has a Display Energy Certificate Rating of an E2. This when compared to other schools of a similar size is a bad rating. The amount of oil and electricity that Archbishop McHale College is consuming when benchmarked for the size of the building and when compared to Colaiste Cholmcille is way too much. It is essential to reduce overall consumption of the school by taking the necessary measures to improve the performance. The school must take these measures as the school is currently wasting substantial amounts of money each year and is having a seriously negative environmental impact. The measures above and below should be taken in to reduce heat loss and remove unnecessary waste of energy.

- Apply for insulation grants for the walls and roof through energy efficiency scheme – Archbishop McHale College should apply for the energy efficiency scheme. There are vast amounts of savings to be made through increasing the air tightness in the building. It is said that up to 50% of heat lost is through the roof and walls. The school should avail of this free funding to reduce the cost of the oil bills and better the schools display energy certificate result.

- Change the doors for the front back and side door as there is serious air leakage - The side and back doors are two doors with large air gaps that are exposed to the outside weather conditions. They are in poor condition and should be changed. The school is losing a large amount of energy through theses doors. In the short term springs should be attached to them to ensure they are closed when not in use, this would temporarily stop the draught evident throughout the building. The front door should also be changed in the future.

- Install a porch at the side and back doors to reduce draught through building – The side and back doors are currently directly exposed to the outside weather. A porch should be installed especially on the side door that is continuously in use. This would stop a draught throughout the building when doors are open as it would be stopped by the external porch door. This would reduce the requirements of the heating system and in turn reduce the amount of money spent on fuel.

- Change the boiler for a wood chip boiler – The current system is not too old but it is way too large for a building this size. The inefficiencies due to its size are effecting the fuels energy consumption causing the building to perform badly in the energy rating. Wood chip boilers are currently funded under the ReHeat scheme so should be availed of. The replacing of the current boiler with a wood chip boiler would be a great investment and would have a payback of approximately 7.5 years. Each year after that is money saved for the school that can be used on educational areas. This would also greatly reduce the amount of carbon dioxide that the school would be responsible for. The use of a wood chip boiler would improve the schools energy rating. For storage of the woodchip there is a room at the back of the engineering room that is ideal. It has a low roof, it is easily accessible, it's not in use for much and most importantly it is directly beside the boiler system.

- Add solar panels to compliment the wood chip boiler – The roof of Archbishop McHale is flat so it is suitable for the installation of solar panels. The solar panels could be used for water heating and to compliment the boiler system. Solar panels are part of the ReHeat scheme so a grant is available for them. The payback period expected for the solar panels is expected to be 8.35 years.

- Utilize daylight where possible by installing relevant reflective technologies – the natural light available in Archbishop McHale College is quite good. The windows in most rooms are large so there is an opportunity to utilize the natural light available. Reflective blinds and internal and external shading should be installed to make use of this free natural light available.

- Plan to phase out storage heaters within the prefabs and if necessary phase out the prefabs altogether – The main consumer of electricity in Archbishop McHale College is the storage heaters in the prefabs. They are very uneconomic and are raising the schools carbon footprint whilst costing a colossal amount. The storage heaters are currently costing the school up to €107 per week. For the equivalent energy from wood chip it would cost just €34. The school should try and push to phase out storage heaters by phasing out the prefabs. If newer structures are built the school should consider connecting it to the mains so that it is heated by the main boiler. In the short term timers should be adjusted accordingly so that they are only on when the prefabs are occupied the next day. Maintenance of the storage heaters is also important so that they are efficient, where necessary storage heaters should be replaced with newer models.

6.4 Critical Analysis

6.4.1 Critical analysis of the material available

Energy management is an excellent technique for reducing costs. There is a vast amount of reading material available for it. The main issue is that there may be too much available which has little detail so that it is interchangeable between business types and there is not enough material available for specific scenarios.

There are various standards available that all could relevantly be used within the project but would all have to be individually interpreted to suit the schools. If you just consider the ISO 14000 family, ISO 19011, IS EN 16000 and IS 393, all of these could be implemented in a school but all of which would be very hard to keep up in a school environment.

The energy audit technique is an excellent way of getting the information required to make the necessary changes to reduce energy consumption. A good guideline for this is *Handbook of energy audits / Albert Thumann, William J. Younger* and the book below. The follow up to the energy audit is also very well outlined in various books particularly *Guide To Energy Management by Barney L. Capehart, Wayne C Turner and William J Kennedy.*

The information available from *SEAI* is excellent also although there are so many publications available it can take a long time to go through them. The availability of grants for public buildings is also very good although information is hard to come by.

Laws are being put in place in order to achieve targets set out by the *Kyoto Protocol* and we should be well in line to achieve them. Targets in the green and white papers are pushing for better developments in energy management and conservation.

The availability for schools to acquire the *Display Energy Certificate* by entering details online is a great initiative for schools to achieve a better energy record. It also allows schools to abide by new laws regarding *Building Energy Regulations*.

Benchmarking the schools using the carbon trust website and using the display energy certificate gives out different results. The Carbon trust benchmarking tool only takes energy bills and size of the building into account whilst the Display energy certificate is more extensive. Although the results say the same thing, Colaiste Cholmcille is performing relatively well whilst Archbishop McHale College is performing poorly. Overall the literature and resources available are very good although some information is hard to find.

6.4.2 Critical Analysis of myself

Overall the project went quite smoothly. The main areas of improvement for me would have been to push to get more data from the use of equipment. The use of a thermal imaging camera, the blower door to backup how I felt about the general airtightness of the building, a light meter to check illumination levels so I could find out what areas of the building required less lighting, a volt meter for checking unknown appliance outputs such as extractor fans, a wattmeter that could show up to hourly consumption patterns instead of the monthly patterns that were available to me and if possible attain a combustion analyser that could check the efficiency of the boiler.

By using these items of equipment I could back up some of my arguments more so that recommendations could be more extensive and pushed further. Measurement of the building was a slow process until I availed of a laser measuring tool. I may have spent too long recording equipment in the schools which was not important when it came to wring the project.

This project really needed more time so that patterns could be recorded properly. As the school year is seasonal it should realistically have taken place over the entire school year. This way the equipment above could be utilized and it would also be possible to personally introduce environmental programs to the teachers and students.

I have learned a massive amount from the project and feel that if the challenge was given to me again I would accept it straight away. I still feel I have a lot to learn but in general I feel I am ready for employment in this field. I thoroughly enjoyed the experience and I am happy that I had the opportunity to write about this topic.

Saving money using energy management came quite easily for me as I did industrial engineering for my undergraduate. Over the course of four years I was taught techniques in how to save money for a business by reducing waste in businesses. Energy management was not too dissimilar; it was about finding wastages and recommending how to remove them.

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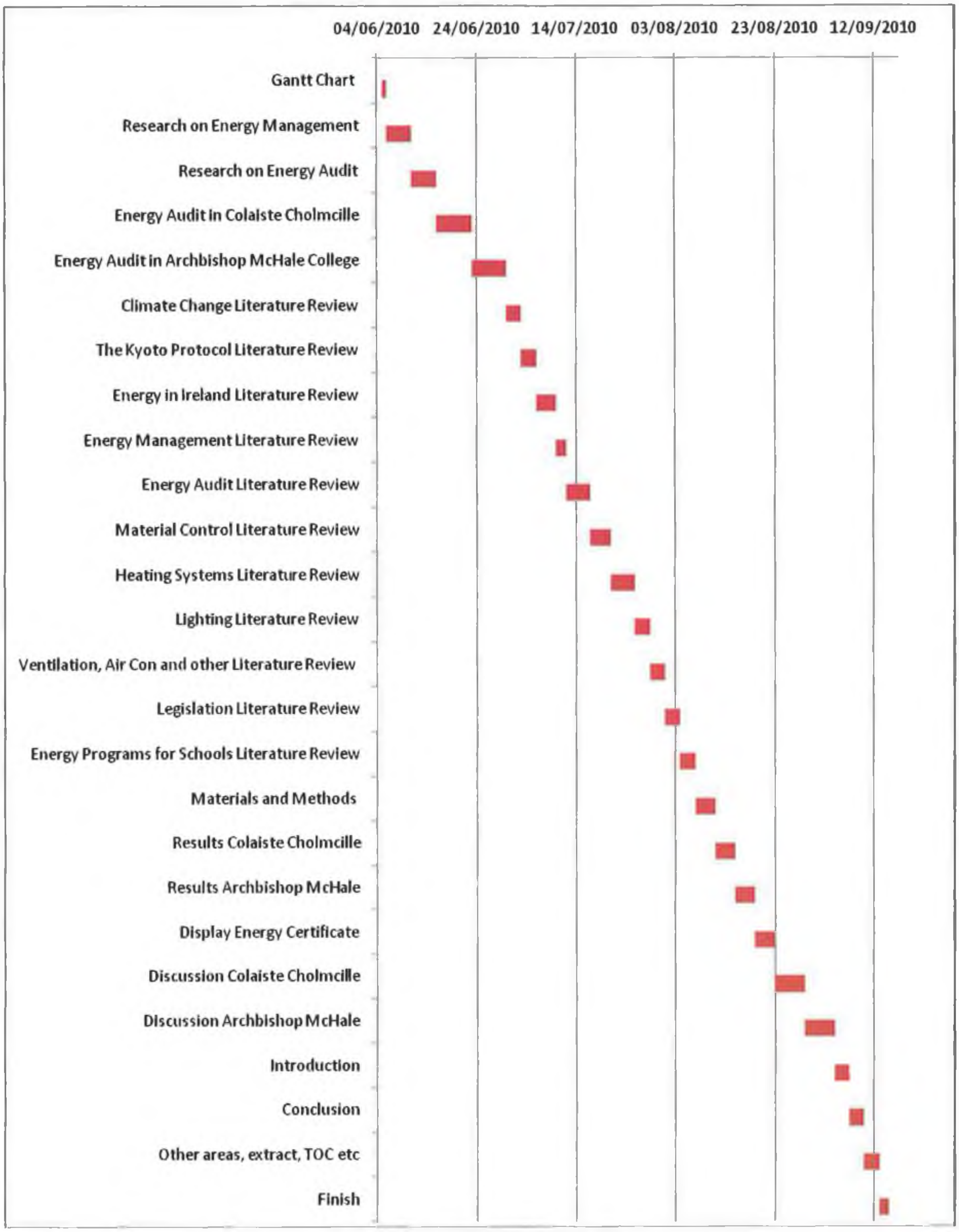
Gantt Chart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Gantt Chart
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Energy Audit in Archbishop McHale College
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The Kyoto Protocol Literature Review
Energy in Ireland Literature Review
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Material Control Literature Review
Heating Systems Literature Review
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Ventilation, Air Con and other Literature Review
Legislation Literature Review
Energy Programs for Schools Literature Review
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Introduction
Conclusion
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