Implementation of the I.S. EN 16001:2009 Energy Management Standard into GlaxoSmithKline (GSK) Ltd, Cork

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DECLARATION OF ORIGINALITY

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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

As manufacturers face an increasingly competitive environment, they seek out opportunities to reduce production costs without negatively affecting the yield or the quality of their finished products. The challenge of maintaining high product quality while simultaneously reducing production costs can often be met through investments in energy efficient technologies and energy efficiency practices. Energy management systems can offer both technological and best practice efficiencies in order to achieve substantial savings.

A strong energy management system provides a solid foundation for an organisation to reduce production costs and improve site efficiency. The I.S EN16001 energy management standard specifies the requirements for establishing, implementing, maintaining and improving an energy management system and represents the latest best practice for energy management in Ireland. The objective of the energy management system is to establish a systematic approach for improving energy performance continuously. The I.S EN16001 standard specifies the requirements for continuous improvement through using energy more efficiently.

The author analysed how GlaxoSmithKline's (GSK) pharmaceutical manufacturing facility in Cork implemented the I.S. EN16001 energy management system model, and defined how energy saving opportunities where identified and introduced to improve efficiency performance. The author performed an extensive literature research in order to determine the current status of the pharmaceutical industry in Ireland, the processes involved in pharmaceutical manufacturing, the energy users required for pharmaceutical manufacturing and the efficiency measures that can be applied to these energy users in order to reduce energy consumption. The author then analysed how energy management standards are introduced to industry and critically analysed the driving factors for energy management performance in Ireland through case studies.

Following an investigation as to how the I.S. EN16001 energy management standard is operated in GSK, a critical analysis of the performance achieved by the GSK energy management system is undertaken in order to determine if implementing the I.S EN16001 standard accelerates achieving energy savings.

Since its introduction, the I.S. EN16001 model for energy management has enabled GSK to monitor, target and identify energy efficiency opportunities throughout the site. The model has put in place an energy management system that is continuously reviewed for improvement and to date has reduced GSK's site operations cost by over 30% through technical improvements and generating energy awareness for smarter energy consumption within the GSK Cork site. Investment in I.S. EN16001 has proved to be a sound business strategy for GSK especially in today's manufacturing environment.

Acknowledgements

I would like to thank all those who supported and encouraged me during this project, in particular the GSK energy champion Ed Collins for giving me the opportunity to work as part of the GSK energy team and providing guidance throughout the project, and to all the staff in GSK Cork who helped me gather and understand information about I.S. EN16001 and energy management within GSK.

Also, the author would like to show his thanks and appreciation to Mr. Ronan McDonagh and Dr. Attracta Brennan for their guidance throughout the project, and also for their help and assistance with all my queries.

Nomenclature

Abbreviation	Description	Abbreviation	Description
ACEEE	American Council for an Energy-Efficient Economy	IDA	Industrial Development Agency
ACPH	Air Changes per Hour	IEA	International Energy Agency
BEMS	Building Energy Monitoring Systems	IEC	Irish Energy Centre
BSI	British Standards Institution	INAB	The Irish National Accreditation Board
cGMP	current Good Manufacturing Practices	LEC	Light Emitting Capacitor
DX	Direct Expansion	LED	Light-Emitting Diode
EAP	Energy Agreement Programmed	LIEN	Large Industry Energy Network
ECO	Energy Conservation Opportunities	OE	Operational Excellence
EMS	Energy Management System	R&D	Research and Development
EPA	Environmental Protection Agency	SEAI	Sustainable Energy Authority of Ireland
ESRI	Economic and Social Research Institute	SEU	Significant Energy Users
FDA	The Food and Drug Administration	SON	Sodium Vapor Lamp
FDI	Foreign Direct Investment	SOP	Standard Operating Procedures
GSK	GlaxoSmithKline	TPER	Total Primary Energy Requirement
GVA	Gross Value Added	ULPA	Ultra Low Penetration Air
HEPA	High Efficiency Particulate Air filters	VSD	Variable Speed Drives
HVAC	Heating, Ventilating, and Air-Conditioning	WHB	Waste Heat Boiler
IAC	Industrial Assessment Center	UDE	Un-Desirable Effect
PIF	Project Initiation Form		

Units		
Unit	**Description**	**Comparison**
kWh	Kilo Watt hour	1 kWh = 1 KWh
MWh	MegaWatt Hour	1 MWH = 1000 KWh
GJ	Giga Joule	1 GJ = 278 kWh
Mtoe	Million tons of oil equivalent	1 Mtoe = 11630000000 kWh
MBtu	Million British thermal units	1 Mbtu = 293 kWh

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Chapter 1 Introduction

1.1 Background Information

1.2 Project Aims & Objectives

1.3 Overview of Chapters

1.1 Background Information

This project is based around the introduction of an energy management standard in a pharmaceutical manufacturing plant. Pharmaceutical manufacturing facilities produce medicines (drug compounds) for human consumption to treat major illness areas such as asthma, virus control, infections, mental health, diabetes and digestive conditions. The production of these medicines is a highly technical and precise process which requires a varying range of energy dependent utilities in order produce a quality and safe end product [2]. These utilities include steam systems, refrigeration systems, and nitrogen systems, compressed air systems, pumping systems, HVAC systems and general electrical power. Other energy users, such as incinerators, are not directly related to the manufacturing process but are required in order to control waste and meet environmental regulations.

The utilities listed above are generated by the input of electricity or gas to the generation equipment, e.g. by providing electrical power to compressor motors or gas to a boiler for heat requirements. Overall operating costs of these utilities is substantial for a pharmaceutical manufacturing facility and due to escalations in energy prices in the last decade operating costs need to be reduced. Production quantities have also fallen due to the economic factors and patent expirations occurring and this has forced the pharmaceutical industry to pay more attention to their energy expenditure in order sustain profits in a more competitive market.

In order to address energy expenditure within an organisation, it is commonly regarded that through the implementation of an energy management system, the best savings can be made. This is done by implementing a framework for energy management within an organisation. In Ireland, the Sustainable Energy Authority of Ireland (SEAI) provides assistance to industry to achieve this goal by participation in their Energy Agreement Programme (EAP). This provides resources to implement the I.S. EN16001 energy management standard into an organisation which will continuously improve their energy performance year on year.

The I.S EN 16001 energy management standard specifies the requirements for establishing, implementing, maintaining and improving an energy management system and represents the latest best practice in energy management. Below is the I.S. EN16001 energy management system model for implementation and compliance to the standard.

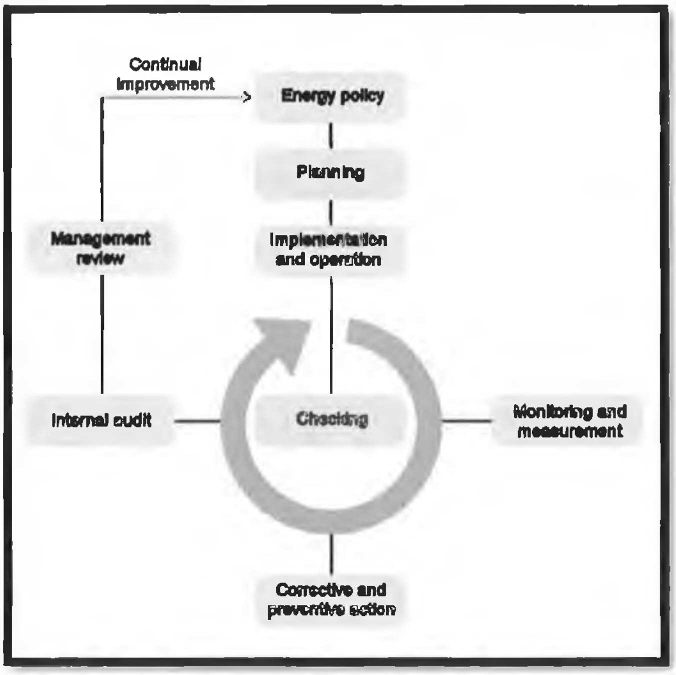

Figure 0: Energy Management System Model for I.S. EN 16001[13]

The model enables an organization to take a systematic approach to the continual improvement of its energy efficiency. The standard lays down requirements for continual improvement in the form of more efficient and more sustainable energy use, irrespective of the type of energy. The standard does not specify techniques to be used to introduce I.S. EN16001, Therefore it allows different approaches to be used by organizations as long they conform to its stated energy policy.

I.S. EN16001 presents an optimal platform to introduce energy efficiency measures in the pharmaceutical industry and reduce operating costs. In this project the author analyses how the I.S. EN16001 energy management standard was implemented into one of Irelands leading pharmaceutical companies, GlaxoSmithkline (GSK) Ltd. The case study analyses are for GSK's Cork manufacturing facility. As of 2008 GSK Corks annual energy expenditure was €7.5 million. GSK registered to participate in the SEAI energy agreement programme (EAP) in 2007 in order to reduce overall energy expenditure. Since 2007 GSK have implemented an energy management system in line with the criteria for I.S. EN16001 and plan to achieve accreditation from the Irish National Accreditation Board (INAB) in December 2010.

This I.S. EN16001 framework for energy management has enabled GSK to monitor, target and identify energy efficiency opportunities throughout the site. The author aims to assess the performance of the GSK energy management system and critically analyse the outcomes from implementing the I.S. EN16001 energy management system model.

1.2 Project Aims & Objectives

The author aims to analyse the techniques and frameworks required in order to implement an energy management system into large pharmaceutical manufacturing facility. From this information the author determines that if through the energy management system model implementation accelerated energy savings are made while not compromising safety requirements and yield quantities. Also, according to I.S. EN16001 by setting energy targets and creating good staff awareness and behavioural skills an organisation can annually reduce their energy consumption. The author aims to examine these targets and determine the level of employee awareness and behaviour towards energy aspects of the site since the introduction of the I.S. EN16001. In order to achieve the overall project hypothesis above, certain objectives need to be achieved to enable the author to analyse and come to a final conclusion performance I.S. EN16001 performance, these objectives are:

- Outline about the pharmaceutical industry in Ireland
- To understand the processes required for pharmaceutical manufacturing
- Analyse the energy price and expenditure trends within the pharmaceutical industry in Ireland
- Identify the potential energy saving opportunities for pharmaceutical operations
- Evaluate the performance of energy management scheme introduced to Irish Industry
- Learn how the I.S. EN16001 energy management standard is implemented in an organisation and how energy saving opportunities are identified and introduced
- Analyse results from both an energy saving and economically worthwhile aspect

1.3 Overview of Chapters

Chapter 1

Introduction

This chapter includes the introduction and some background information about the pharmaceutical industry and the I.S. EN16001 energy management standard. The main objective of this chapter is to give the reader some background information on the study and the aims and objectives the author is trying to achieve.

Chapter 2

Literature Review

This chapter discusses the pharmaceutical industry and the process involved in pharmaceutical drug manufacturing. Also, the author analyses pharmaceutical energy expenditure and previous trends for prices and usage in Irish industry. Energy efficiency measures are identified and assessed for energy intensive utilities and equipment in a pharmaceutical plant. The energy efficiency incentive programs for Ireland are identified and the body that is responsible for their introduction. Finally, case studies of energy management programs initiated in Ireland are assessed.

Chapter 3

Case Study Analysis

Chapter 3 gives an overview to the GSK Cork facility and outlines electricity and gas users. It shows how the energy policy requirement of I.S. EN16001 was developed for GSK Cork and how using the Plan, Do, Check, Act implementation process the I.S. EN16001 energy management system model was implemented at the GSK Cork site.

Chapter 4

Results

This chapter shows the results achieved since introducing and following the I.S. EN16001 energy management system model at the GSK site. Annually the site energy performance is compared to the previous year in order to gauge the magnitude of energy savings achieved.

Chapter 5

Discussion

Chapter 5 discusses some of the energy efficiency measures implemented at the GSK Cork site and how they performed. Also, an awareness and behavioural survey carried out is assessed to determine the level of energy awareness amongst the GSK employees

Chapter 6

Conclusions

Chapter 6 evaluates the performance of the I.S. EN16001 energy management standard in the GSK site. Also, the author discusses recommendations in order to improve the GSK Cork site energy performance.

Chapter 2.0 Literature Review

2.1 Introduction

2.2 The Pharmaceutical Industry in Ireland

2.3 Pharmaceutical Energy Saving Potential

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2.7 Policies, Organisations and Performance of Energy Management in Ireland

2.7.1 Sustainable Energy Authority of Ireland (SEAI) Energy Management Schemes

2.7.2 SEAI Program Performance

2.7.3 Review of Irish Energy Saving Case Studies through EAP

2.8 Conclusion

2.1 Introduction

Recent escalations in energy prices and economic downturn have prompted pharmaceutical companies to review their operating costs. When energy costs were lower, energy saving features had a much longer return on investments and accordingly, there was less incentive to incorporate them. Also, production quantities have fallen due to economic factors and patent expirations which have forced the pharmaceutical industry to pay more attention to their energy expenditure.

In this chapter the author gives an overview of the pharmaceutical drug manufacturing process and it position in Ireland. Using technical data derived from regularly published industry reports in Ireland the author aims to outline the changes in past and present energy usage, trends, prices and expenditure in Ireland.

The pharmaceutical industry is required to comply with strict manufacturing, health and safety and final product regulations, the criteria for these high standards leads to substantial energy cost in order to ensure compliance (E.g. cleanroom quality, HVAC acph). However, there is still substantial potential for savings within current manufacturing practice. The author aims to highlight the potential for these energy savings in the pharmaceutical industry and how these savings can be technically implemented in pharmaceutical facilities.

Energy saving techniques are managed using a energy management system (EMS) models in order to maximize the potential for energy saving in a system. These EMS models have been developed both nationally and internationally for industry to ensure maximum savings are achieved. The author takes a more in depth look at the EMS models and how they are introduced to Irelands industry. To date the EMS models have produced positive results in terms of energy efficiency within an organization by adopting changes in major energy systems, improving energy performance through operational practices and management level support in order to reduce energy costs. Some of these case studies are outlined throughout the paper.

The next section 2.2 gives an overview of the current pharmaceutical status in Ireland.

2.2 The Pharmaceutical Industry in Ireland

The development of the Irish pharmaceutical industry has been, and continues to be, a major international success story. Until the 1960s there was virtually no pharmaceutical industry in Ireland [4]. The pharmaceutical sector really took off in the 1970s following the IDA`s adoption of fine chemicals as one of its target sectors [5]. This led to a series of manufacturing investments, notably by US and UK-based companies.

Ireland is now home to eight out of the top 10 pharmaceutical companies in the world. Ireland has developed a strong relationship between the US pharmaceutical industry due to its history of successful investment and Ireland's ability to meet the needs of US multi-nationals establishing operations in Europe. There are approximately 90 blockbuster drugs on the market; that is, drugs achieving sales of over $1 billion per annum. Today the top 10 blockbuster drugs account for around 10 percent of total industry revenue. Of these top 10 drugs, six are manufactured in Ireland [6]. The pharmaceutical sector is not only of substantial importance to Ireland in terms of industry, but it provides a large amount of employment opportunities:

"Currently there are approximately 20,000 people employed in the pharmaceutical sector in Ireland." Barry O'Leary, CEO IDA Ireland [36]

Ireland poses an attractive location for pharmaceutical companies because it has a 12.5% corporate tax rate and a 25% research and development (R&D) tax credit. There is no stamp duty on intellectual property (IP) transfer in Ireland. Added to this, the industry-relevant infrastructure is second to none [6].

The economic downturn of the last two years has also made Ireland a much more competitive location for foreign direct investment (FDI) due to a decrease in the country's building costs and significant reductions in land costs. An investment history from the pharmaceutical sector going back over 30 years has also led to Ireland's leading reputation for pharmaceutical investment [6].

Ireland has secured over $5 billion of investment over the last number of years from biopharmaceutical corporations including Pfizer, Allergan, Genzyme, Gilead, GlaxoSmithKline, Merck, Lilly and Centocor, and the majority of US pharmaceutical companies have multiple sites for both manufacturing and R&D [6]. However, these investments are decreasing due to a combination of factors including patent expirations, competition from the growth of generic manufacturers and the increased costs of clinical and pre-clinical research. This has led pharmaceutical manufacturers to face an increasingly competitive environment, were they have to seek out opportunities to reduce production costs without negatively affecting the yield or the quality of their products in order to remain financially sustainable, meaning there is now a big focus on industry energy management.

2.3 Pharmaceutical Energy Saving Potential

The Irish pharmaceutical industry consumes on average about €130 million of energy annually [9]. This substantial figure gives an idea of the potential savings that can be achieved by focusing more attention to the energy usages. Figure 1 illustrates how the energy usage in the US pharmaceutical industry has been escalating consistently for nearly a decade up to 2003. The rise can also be attributed to economic growth during this period; however this is now in decline as seen from 2005 on figure 1.

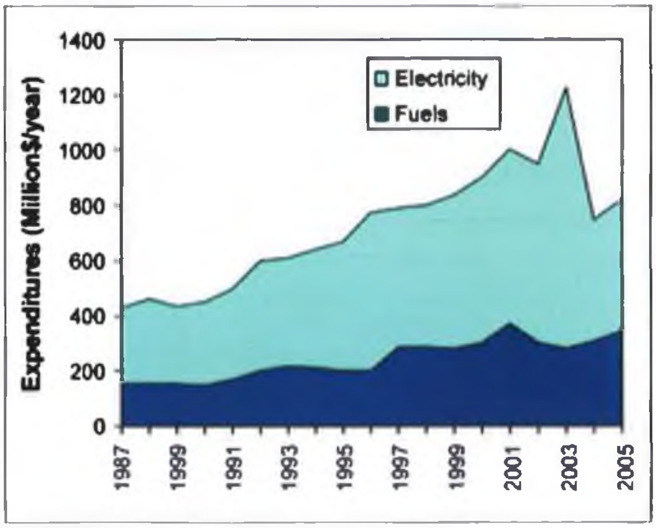

Figure 1: Energy Expenditures of the US Pharmaceutical Industry [2]

The process of pharmaceutical drug making consists of several steps starting from discovery research to pre-clinical testing, clinical manufacturing to bulk active substance manufacturing, and then to formulations/finishing facility. In addition, there are needs for warehousing and administrative offices to support the drug discovery and drug manufacturing. These functions, facilities, and processes vary widely and have very different energy requirements and usages [2]. Figures 2 and 3 are illustrations of how energy consumptions in pharmaceutical facilities vary. These charts also show a typical traditional breakdown of energy usages between the various user categories such as processes, lighting, and Heating, Ventilating, and Air-Conditioning (HVAC).

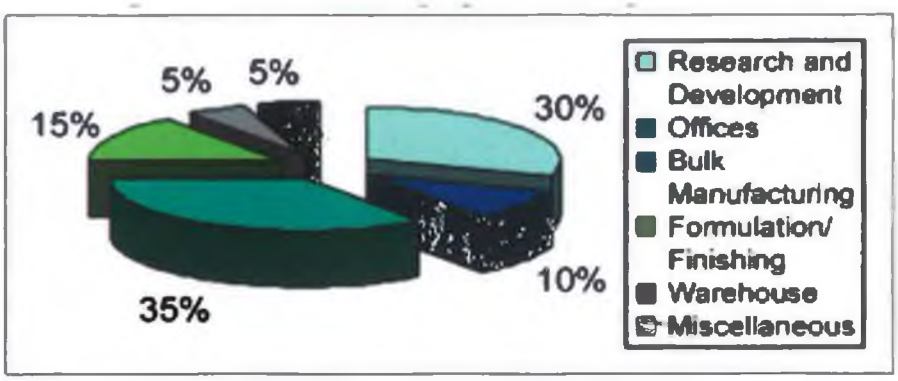

Figure 2: Breakdown of Energy Usages within Pharmaceutical Facility [2]

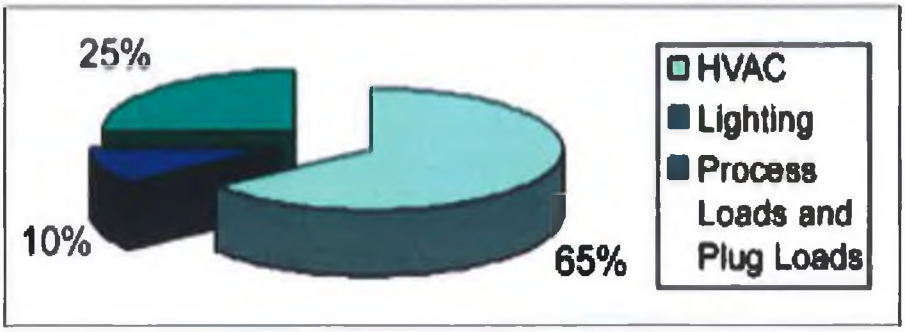

Figure 3: Typical Energy Consumption Breakdown [2]

Identification of Energy Conservation Opportunities (ECO's) form the basis of most of the energy saving and green building discussions in industry. In order to identify the ECO's, and achieve energy savings, it is understood that there are two different methods that can be adopted. One is to review a company's energy procurement management, and the other is to review a company's energy users.

Energy procurement management consists of analysing the procurement contracts (payment rates) and trying to obtain alternative cheaper rates. The energy user management method uses peak demand management, such as peak energy reduction with the use of on-site generators during peak loading or thermal storage on site. However, the primary focus of the user management method is to reduce energy consumptions of various plant users like HVAC, lighting, processes, and operations. One of the largest opportunities for savings are in the HVAC field as it accounts for 65% of energy usage, can be seen in figure 3. A HVAC system requires the generation and distribution of central utilities in order to operate correctly, these utilities include the chilled water systems, steam systems and compressed air systems which would all be heavy on site energy users.

However, the ECO's are not limited to HVAC and lighting. Process, critical utilities and operating philosophy of a facility also have a significant effect on energy consumption, and must be investigated [2]. Examples of these are motors, pumps, refrigeration units and site heat & steam distribution. All the above HVAC, process and additional energy users are described further in the chapter in terms of their application on site, usage in the industry and potential for saving.

2.3.1 Saving Potential Safety Requirements

It should be noted that the energy saving potential often present risks to the pharmaceutical company in terms of product safety, personnel safety, environmental implications and manufacturing reliability. These risks need to be assessed prior to energy saving technique implementations [2].Below the author describes these requirements.

Drug Product Safety

The consumer expects that all drug products be manufactured in the safest way that is humanly possible. Due to the high risks involved, company and regulatory body standards need to be met. The Food and Drug Administration (FDA) and European agencies have taken a very conservative stance to the risks involved in the processes, the environmental threat, and the standard operating procedures (SOP's) related to manufacturing medicines. Examples of the regulatory standards to minimise risk include the Public Health Service Act, Controlled Substances Act and the Federal Anti-Tampering Act [7]. The enforcement of these criteria's in the pharmaceutical industry ensures that the risk of product contamination or product failure is practically eliminated. These cannot afford to be compromised for energy saving purposes. An example of this occurring would be if a company tried to reduce the site refrigeration set point from 27^{o}C to 20^{o}C in order to reduce refrigeration operations costs, yet the new 20^{o}C refrigeration set point was not cold enough and compromised batch safety.

Personnel Safety

Another area of risk for pharmaceutical companies is the human exposure to certain chemicals during the manufacturing process. Most of the current drug products are made from manipulations and handling of various combinations of chemicals. A number of formulations require the use of solvents which can be hazardous to the employee. The Health and Safety Authority of Ireland provide guidelines and regulations under the S.I. No. 299 of 2007 Safety, Health and Welfare at Work (General Application) Regulations. This requirement does not have much relevance in terms of energy saving and would probably be a more appropriate measure for human directly involved in production

Environmental Implications

The chemicals used also pose threats to the environment. Release of these chemicals in the air or in wastes (solids and liquids) must be minimized. In Ireland, the Environmental Protection Agency (EPA) provides guidelines and regulations for any release of such pollutants to the atmosphere. The pharmaceutical companies also have the added responsibility to be "environmentally friendly" [2].

Manufacturing Reliability

In terms of risk management, the concern of reliability in manufacturing facilities is an important issue in the pharmaceutical industry. Certain design elements are deemed too risky as it may compromise reliability of a plant, this sometimes leads to over-emphasized design in order to compensate for a worst case scenario [2].

An example would be sizing the cooling and heating systems for manufacturing facilities to the maximum capacity required for extreme ambient conditions so that manufacturing operation is not interrupted at any time. In most cases, the unit operations of a batch manufacturing process can be interrupted with a little planning. This practice of sizing for the worst condition unduly increases the sizes of chillers and boilers, and, if not properly selected, will function very inefficiently most of its life span. At present design decisions are emphasised toward a low risk of tolerance in the pharmaceutical industry, this has resulted in the use of repetitive design concepts in order to "stick with what we know works" without giving much thought for new innovation.

It can be seen from section 2.3 the potential for energy saving within the pharmaceutical industry. In section 2.4 the author gives a brief overview of the pharmaceutical process in order to determine the steps involved in the manufacturing.

2.4 Outline of the Pharmaceutical Production Process

There are three overall stages in the production of bulk pharmaceutical products:

(1) R&D,
(2) Conversion of natural substances to bulk pharmaceuticals, and
(3) Formulation of final products.

Figure 4 provides an overview of the main process steps in the manufacture of pharmaceuticals. Each of these stages is described in more detail below.

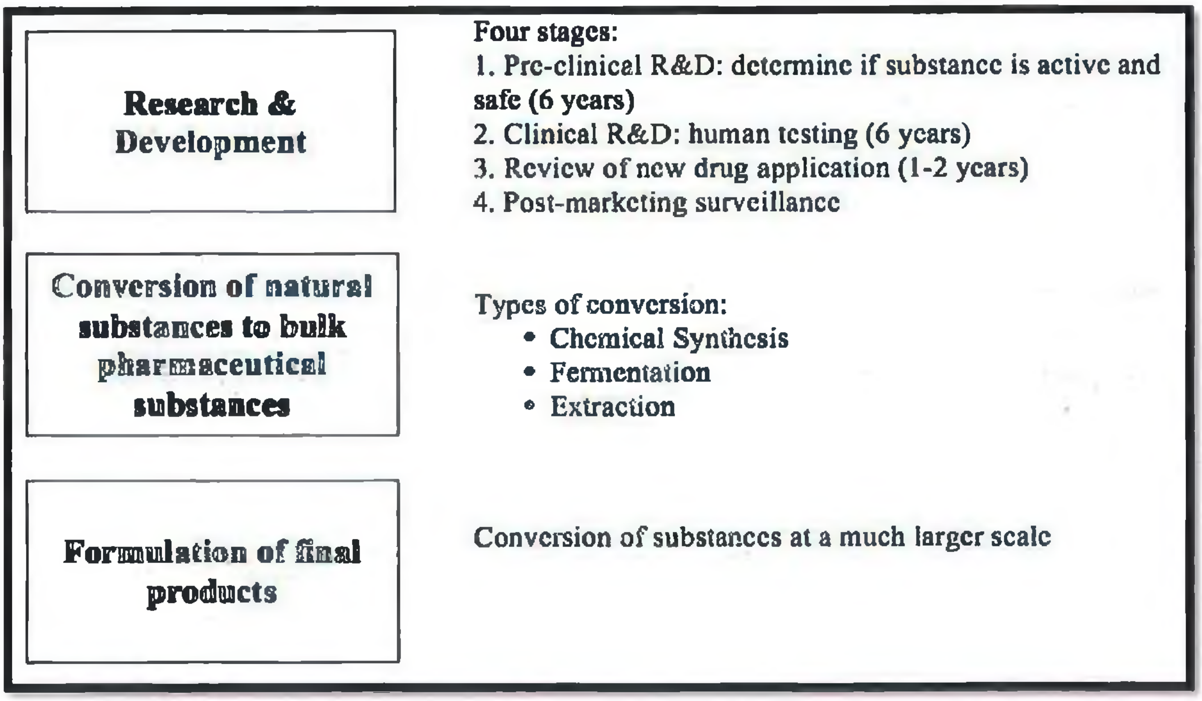

Figure 4: Main Process Steps in the Manufacture of Pharmaceutical Products [3]

Research & Development

Because it is highly regulated, R&D is the longest stage in pharmaceutical product manufacturing. After identifying several thousands of compounds at the beginning stages of R&D, only one will be introduced as a new pharmaceutical drug. Many resources go into this stage of development and can take up to 13 years to reach market approval.

Conversion to Bulk Pharmaceutical Substances

Bulk pharmaceutical substances are produced via chemical synthesis, extraction, fermentation, or a combination of these processes [3]. Figure 5 shows a simplified diagram of the traditional chemical synthesis process for pharmaceuticals. There are five primary stages in chemical synthesis: (i) reaction, (ii) separation, (iii) crystallization, (iv) purification, and (v) drying. Each of these five stages is described below.

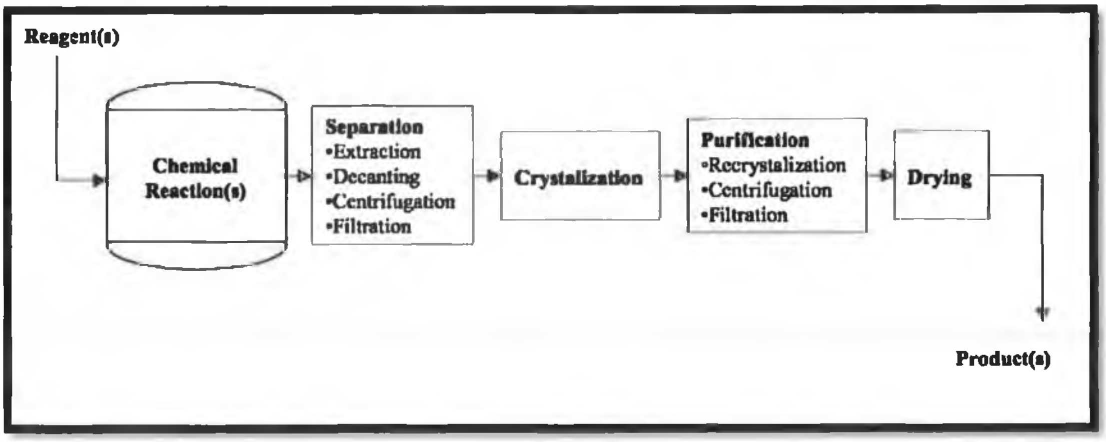

Figure 5: Simplified Chemical Synthesis Diagram [3]

Stage	**Description**
Reaction	In the reaction process, raw materials are fed into a reactor vessel, where reactions such as alkylations, hydrogenations, or brominations are performed. These reactors, which are generally made of stainless steel or glass-lined carbon steel, range from 50 to several thousand gallons in capacity.
Separation	The main types of separation processes are extraction, decanting, centrifugation, filtration, and crystallization. The extraction process is used to separate liquid mixtures. Extraction takes advantage of the differences in the solubility of mixture components.
Crystallization	Crystallization refers to the formation of solid crystals from a supersaturated solution. The most common methods of super saturation in practice are cooling, solvent evaporation, and chemical reaction.
Purification	Purification follows separation, and typically uses the separation methods described above
Drying	The final step in chemical synthesis is drying the product. Drying is done by evaporating solvents from solids. Solvents are then condensed for reuse or disposal. The pharmaceutical industry uses several different types of dryers, including tray dryers, rotary dryers, drum or tumble dryers, or pressure filter dryers. .

Table 1: Description of the Chemical Synthesis Stages

Formulation of Final Products

The final stage of pharmaceutical manufacturing is the conversion of manufactured bulk substances into final, usable forms. Common forms of pharmaceutical products include tablets, capsules, liquids, creams and ointments, aerosols, patches, and injectable dosages [8]. Tablets account for the majority of pharmaceutical solids taken orally.

The most energy intensive stage from the pharmaceutical production process is the conversion of natural substances to bulk pharmaceutical substances, this area has the most saving potential of the overall production process as it requires the most treatment stages.

In section 2.5 the author aims to determine and analyse the previous trends for energy prices and expenditure in the Irish pharmaceutical industry. This is used to determine the status of energy efficiency within the pharmaceutical sector.

2.5 Previous Energy Trends for Prices and Usages in Irish Industry

The amount of energy used in Ireland in a given year is defined as the total primary energy requirement (TPER). This is the measure used to discuss changes to Ireland's energy supply. Five principal sectors of the economy in Ireland are measured to determine the TPER, these are Industry, Transport, Residential, Commercial/Public Services and Agriculture. For the purposes of this study the author only analyses industry as it relevant to the project scope. The TPER for industry made up 22.4% of the energy usage in Ireland in 2007, this equates to over 40,705,000 MWh [11].

2.5.1 Energy Trends

Ireland's energy usage has grown over the past 20 years. Different industry sub-sectors use different fuels, depending on the nature of their economic activity. Most sub-sectors have enterprises using gas, oil and electricity. Some also use coal and two sub-sectors use renewable energy. In the case of the pharmaceutical industry and for the purposes of this study, the fuel types analysed are electricity and natural gas.

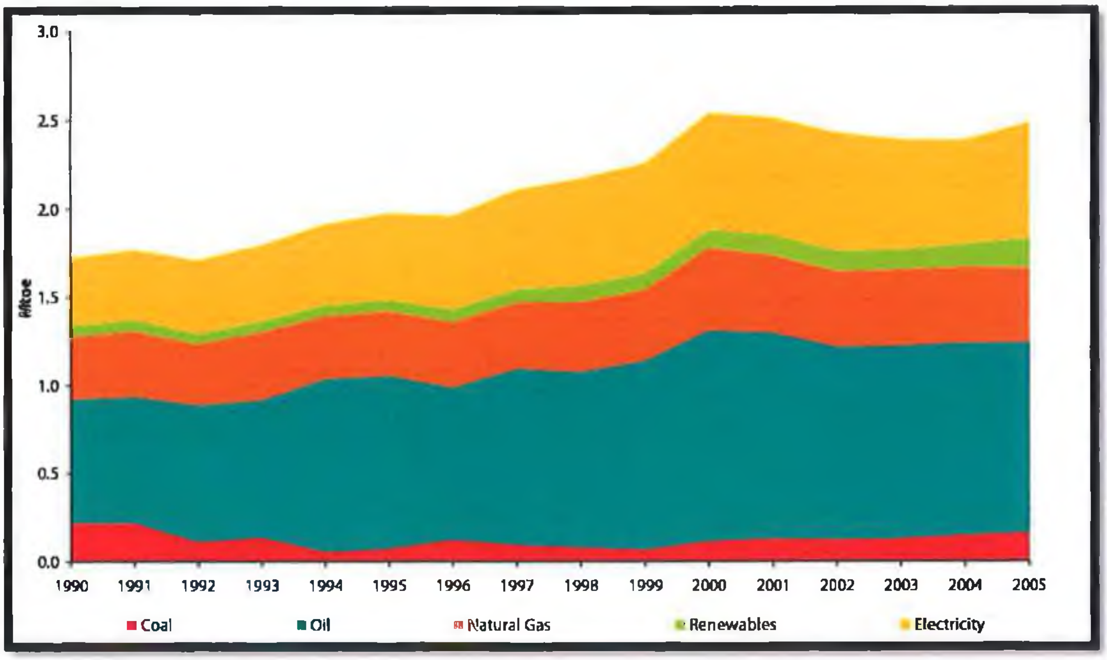

Figure 6: Total Final Energy Consumption by fuel in industry from 1990 to 2005 [9]

Trends in the consumption of these fuels from 1990 to 2005 are shown in Figure 6 for industry as a whole in terms of million tons of oil equivalent (Mtoe). Over this period final energy consumption in industry grew by 45% (2.5% per annum on average) [3]. In 2005, oil had the largest share of total fuel usage at 43% with electricity at 27% and natural gas at 17%. This means as of 2005 electricity and natural gas accounted for 44% of Irelands energy usage in industry as a whole, this equates to 12,677,000 MWh of energy consumed. This is an increase of 4,535,700 MWh on the 1990 electricity and natural gas usage (1990 = 8,141,000 MWh) [9].

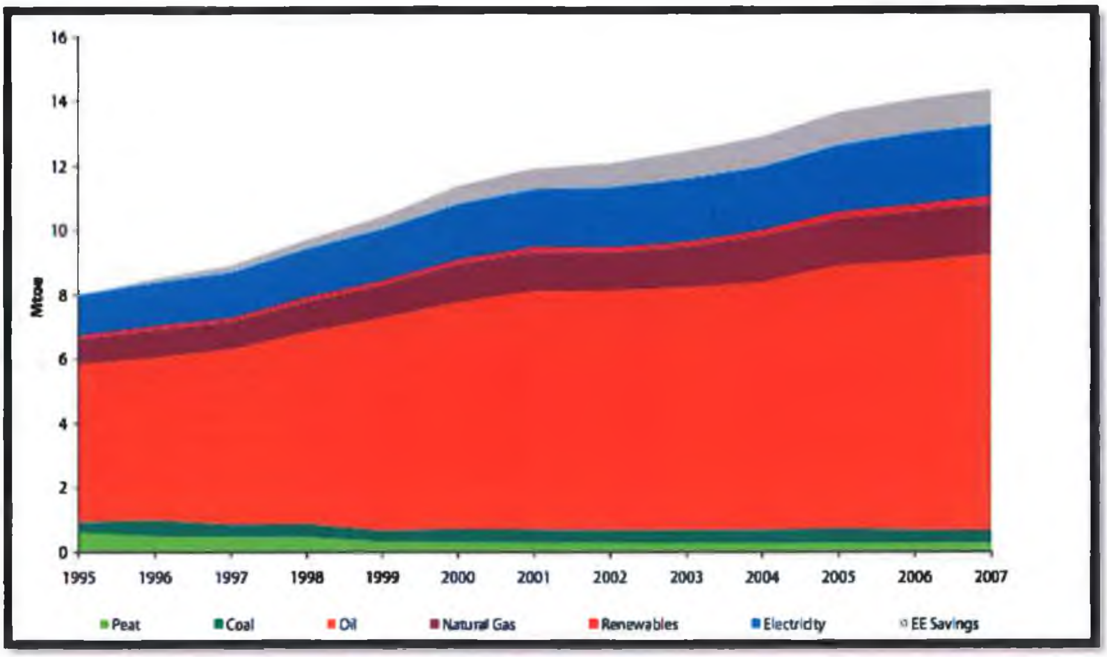

Figure 7: Total Final Energy Consumption by fuel in industry from 1995 to 2007 [11]

Figure 7 is an updated version of figure 6 from the energy efficiency in Ireland 2009 report, this figure includes the estimated energy savings due to energy efficiency improvement measures from 1995 to 2007. It can be seen from the addition of the energy efficiency savings column that linearly Ireland is improving its energy saving techniques since more awareness was introduced in 1995. The savings in 2007 due to energy efficiency represent slightly less than the total amount of natural gas consumed in industry.

Energy Intensity

Energy intensity is defined as the amount of energy required to produce some functional output (it represents the inverse of energy productivity in general). In the case of industry, the measure of output is usually taken to be Gross Value Added (GVA). The energy intensity measures the amount of energy required to produce one euro of value added. GVA measured in constant prices is used to remove the influence of inflation. Between 1990 and 2005 the value added of industry grew by 224% whereas industrial final energy consumption grew by only 45%. This resulted in the energy intensity of industry decreasing quite rapidly throughout the decade, as illustrated in Figure 8 (green line). Over the period actual energy intensity fell (indicating an improvement in energy productivity) by 43% [9].

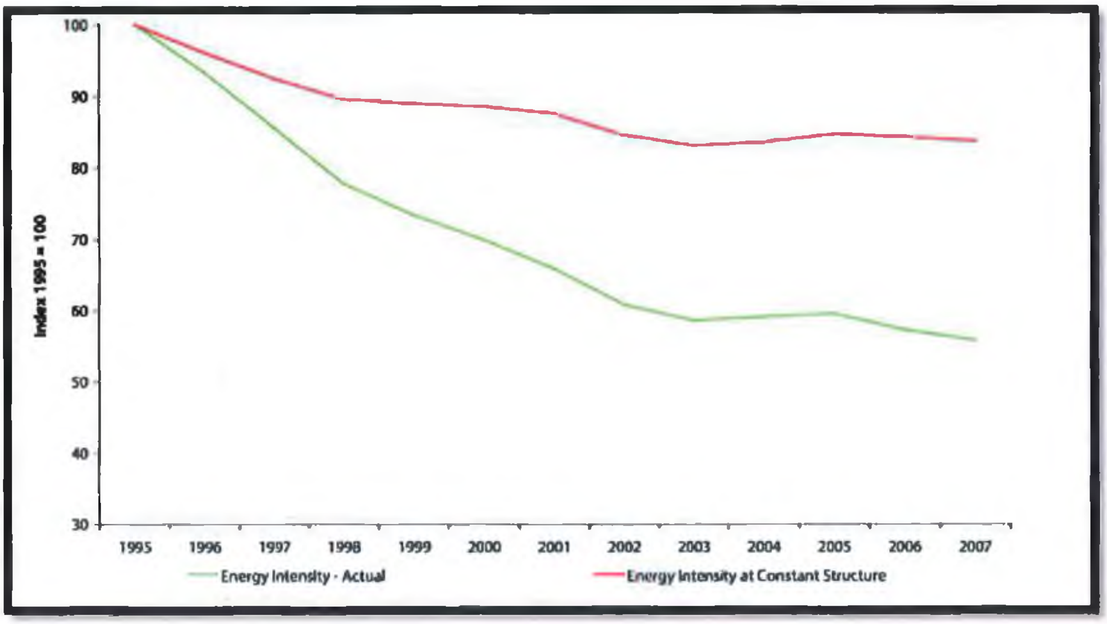

Figure 8: Index of Energy Intensity of Industry (Actual & Constant Structure) from 1995 to 2007 [11]

Figure 8 shows the evolution of industrial energy intensity had the structure stayed the same as it was in 1995, and the actual energy intensity over the 1995 to 2007 period. As from 1995 the structure of industry changed, resulting in lower energy intensity. These structural changes were brought about by global economic influences and Irish industrial policy. The industrial policy concentrated on moving the sector up the value chain to manufacture high value goods such as pharmaceuticals, electronics and value added foodstuffs. This resulted in increased economic efficiencies, contributing to the further reduction in intensity.

From the green line in figure 8 it can be seen how Irish industrial policy lowered the energy intensity. The policy introduced savings through technical efficiency gains arising from the use of more energy efficient technologies. Figure 9 quantifies these energy savings in terms of million tons of oil equivalent (Mtoe). Figure 9 also shows how once the technical savings where introduced it became apparent in industry that savings could be made by adapting behavioural techniques. Behavioural gains are the result of how the technologies are used and managed within the industry. Total energy savings in 2005 were 0.6 Mtoe (6,978,000 MWh). The effect of the behavioural changes introduced can be seen from 2004.

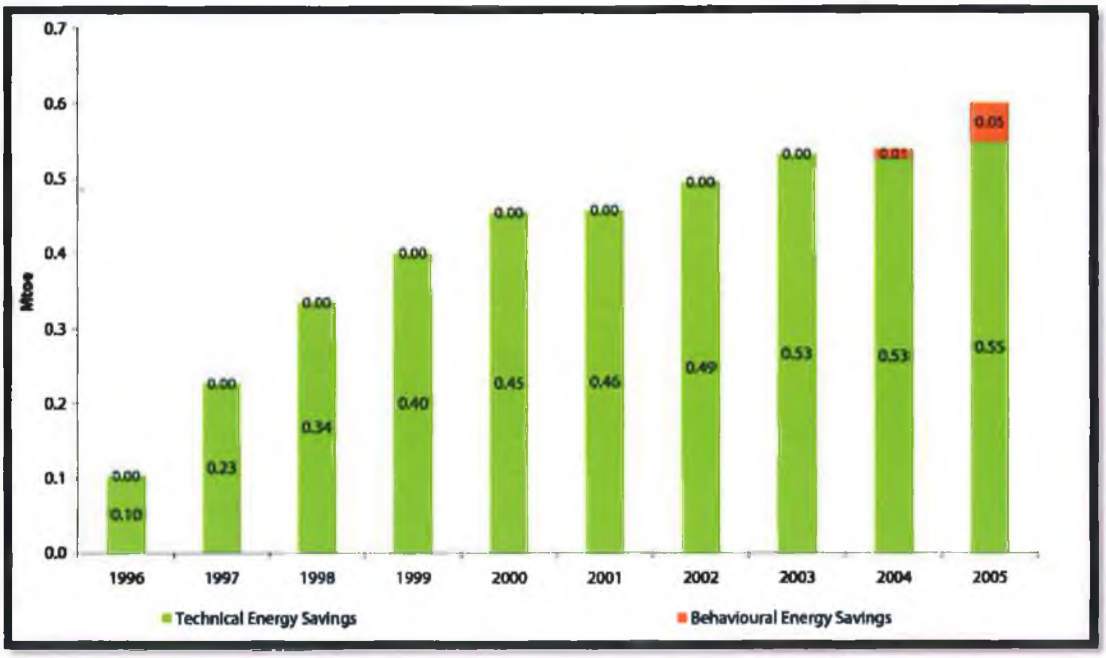

Figure 9: Technical and Behavioural Energy Savings in Industry 1996 to 2005 [9]

These behavioral factors introduced in 2004 have become a core technique in energy saving criteria's in recent years and feature heavily in all national and international energy management standards (IS393 and EN16001). Figure 9 also shows the rate of progressive energy saving occurring in Ireland over the 1996 to 2005 year period that cumulatively amounts to over 3.83Mtoe.

2.5.2 Energy Prices

This section presents comparisons of the cost of energy in terms of electricity and natural gas with selected EU countries in the last decade. At times of rising or fluctuating energy prices there is considerable interest not only in the actual price being paid for energy but also in comparing the relative cost with other countries. These direct comparisons give some crude perspectives on the effects of energy price changes but don't take account of the weighting of energy in the cost base of the economy [9]. Figure 10 and 11 show the electricity and natural gas price trends from the period of 2000 to 2006 for Ireland, France, Portugal, Italy and Finland.

It can seen from figure 10 that electricity prices for Irish industry have risen by 123% between 2000 and 2006, the largest increase of the EU countries. This price trend has linearly increased since 2006 and according to the International Energy Agency (IEA) the 2010 industry price for electricity in Ireland is between €0.14 - €0.15/KWh.

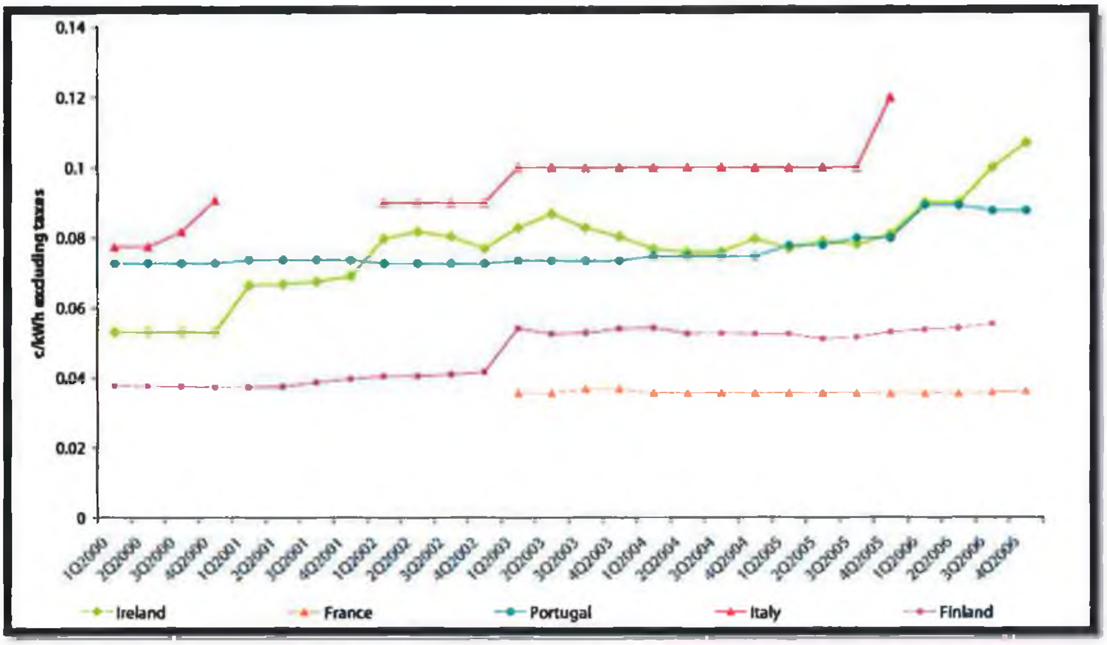

Figure 10: Electricity Prices to Industry [9]

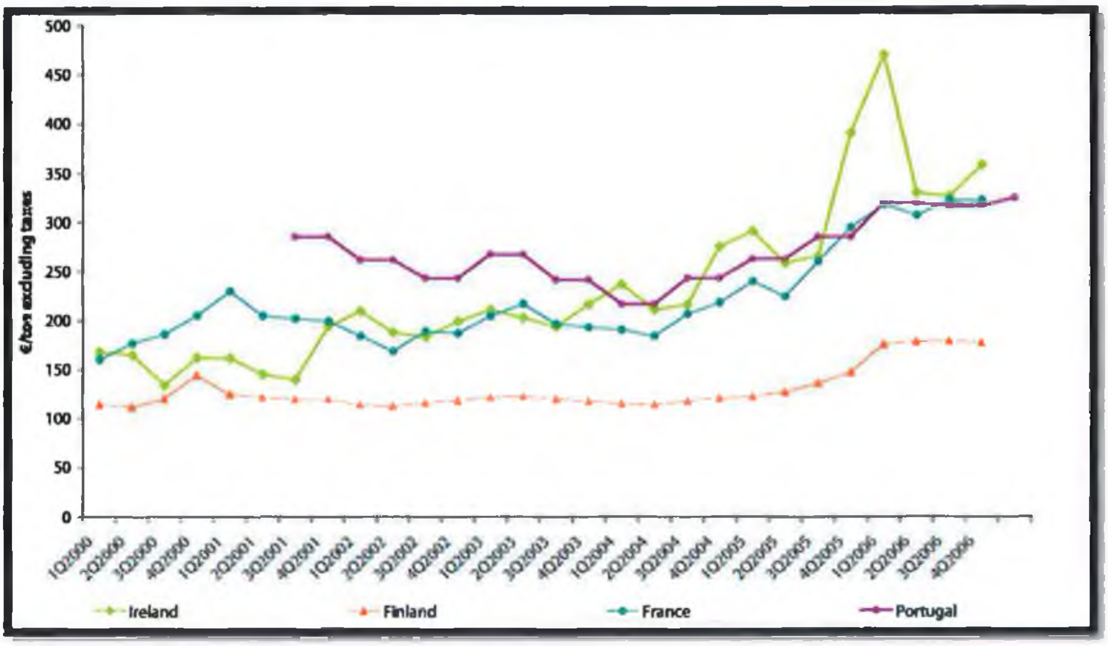

Figure 11: Natural Gas Prices to Industry [9]

Figure 11 shows the linear price increase (in terms of euro/tonne of oil equivalent) for gas from the 1st quarter in 2000 up to the 3rd quarter in 2005 to where it dramatically increased and subsequently decreased in the 3rd quarter of 2006. The large increase over this period is attributed to capacity and storage problems in the UK causing a large price increase. From 2000 up to the 1st quarter in 2006 the natural gas prices to industry had increased 152%. According to the International Energy Agency (IEA) the 2010 industry price for natural gas in Ireland is between €0.04 - €0.05/KWh.

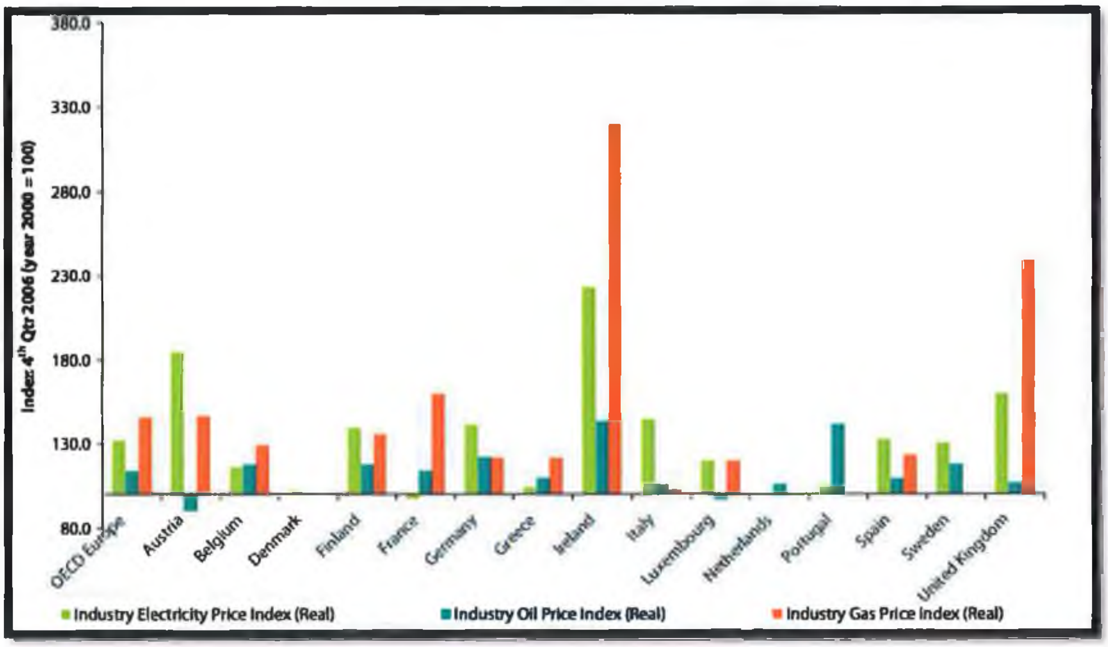

Figure 12: Energy Price Change to Industry since 2000 in the EU [9]

Figure 12 presents the energy price change for electricity and gas for 2000. It shows Ireland, the UK and Austria experienced the highest increases in electricity prices for industry. Also it emphasises the unique problems (due to supply constraints) experienced by Ireland and the UK with respect to gas prices in industry.

2.5.3 Energy Usage in terms of Expenditure

For the previous two sections 2.5.1 and 2.5.2 energy has been analysed in terms of usage across all of industry in Ireland, in section 2.5.3 the expenditure to each individual sub sector is analysed. For the purposes of this study the author only analyses the chemical industry (in which the pharmaceutical industry belongs), as it is relevant to the pharmaceutical based project scope.

Figure 13 shows changes in energy expenditure across nine sub-sectors for the years 1990, 1998, 2001 and 2004. The values shown are based on constant 1995 energy prices. They were converted from current prices by Sustainable Energy Authority of Ireland (SEAI) using a deflator of energy prices constructed by the Economic and Social research Institute (ESRI). For industry as a whole, there was an increase in energy expenditure of 51% (3% per annum on average) over the period 1990 to 2004 and a 6% increase (2% per annum) between 2001 and 2004 [9].

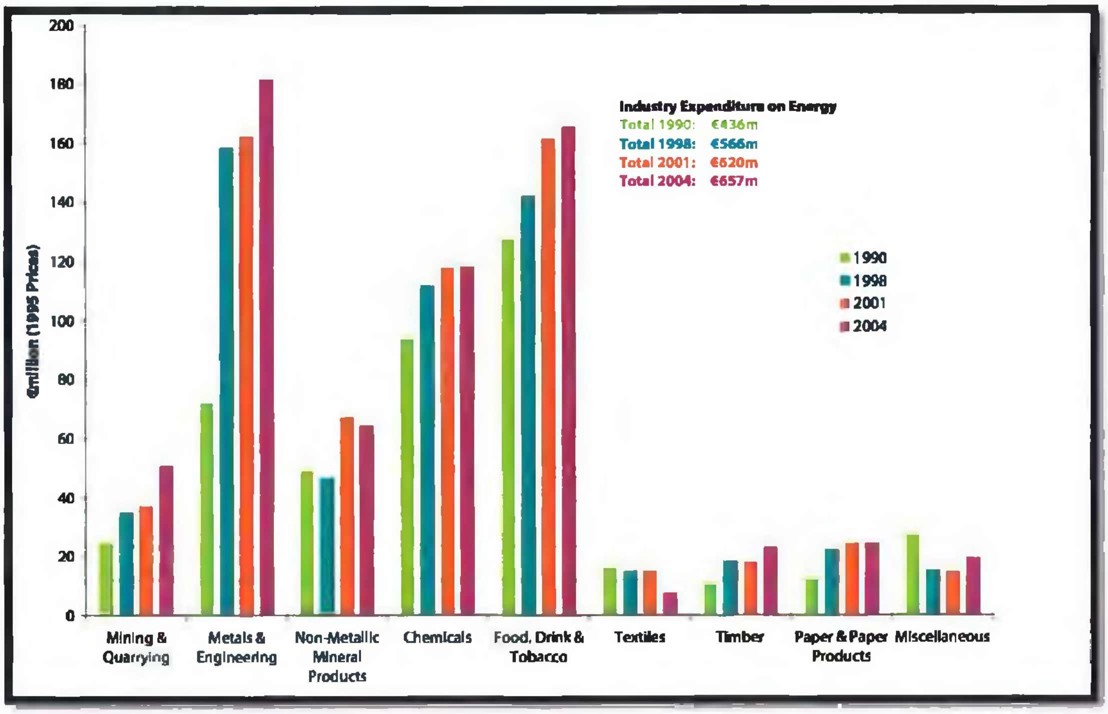

Figure 13: Industry Expenditure on Energy 1990, 1998, 2001 and 2004 [9]

The chemical sub-sector recorded a significant growth of 21% (1.5% per annum) over the period 1990 to 2004, accumulating to €119 million energy expenditure by the end of 2004. A more rapid increase in energy expenditure can be seen from 1990 to 1998 where an industry growth expenditure of 14.5% occurred (1.8% per annum). The chemical industry accounted for over 18% of the overall industry energy expenditure in 2004.

Figure 14 shows the energy expenditure profile for industry in 2004 across thirteen sub-sectors, segmented between fuel and electricity contributions. The additional sub-sectoral details where not available for 1990 therefore the previous figure 13 did not include there detail. The total expenditure on energy in 2004 for industry was €836 million in current prices (based on Energy in Industry 2007 Report current price). For 2004 electricity accounted for 65% of energy expenditure with fuels accounting for the remaining 35%. The chemical industry accounted for €121.9 million of the overall industry energy expenditure for 2004 in current prices. This is the 2nd highest industry behind food, drink & tobacco, which spent 75% more on energy than the chemical industry.

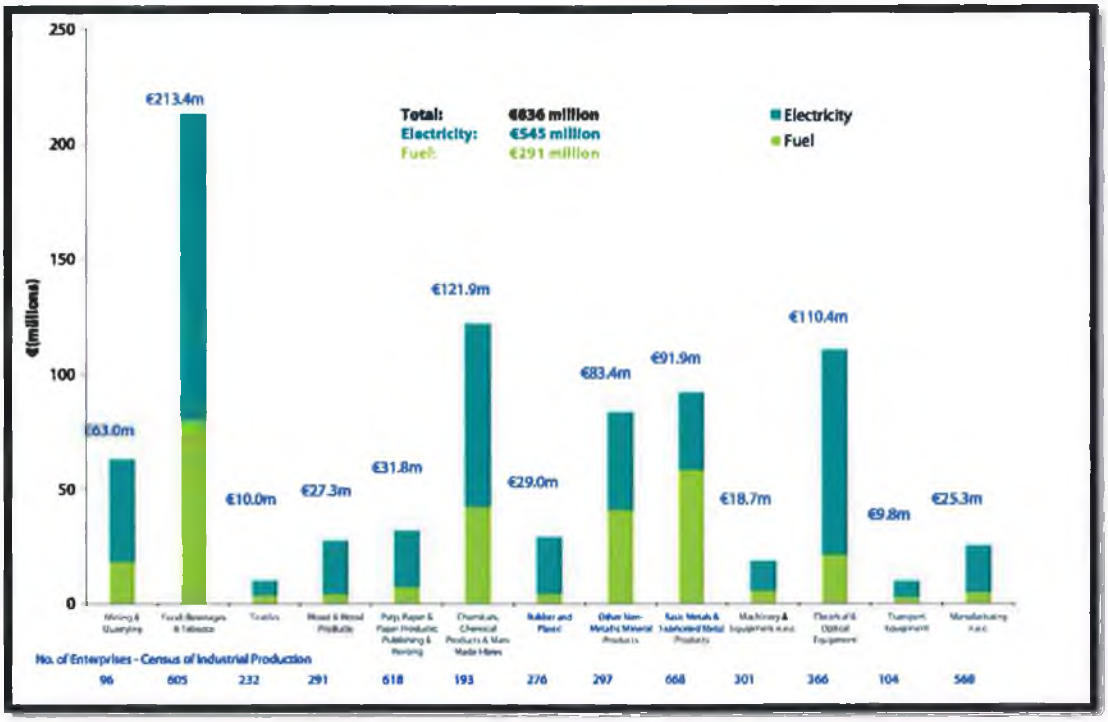

Figure 14: Industry Expenditure on Energy 2004 (2007 prices) [9]

It is interesting to note that comparing the total energy expenditure for 2004 in figure 13 and 14 highlights an improved energy efficiency performance occurring in the chemical industry. Based on 1995 prices the overall industry expenditure was €657 million compared to the 2007 prices which overall industry expenditure of €836 million. This represents 21.5% inflation (€179 million) for the overall energy cost from 1995 to 2004 in terms of price. However, the chemical industry only inflated by 2.4% (€2.9 million) based on the same energy costs, this shows improved energy efficiency performance during this period as the cost increased from inflation, yet the overall expenditure only slightly increased. More evidence of improved efficiency is noted in the Energy in Industry 2009 Report that over the period of 1995 to 2007 Ireland's energy efficiency for industry improved by 16% (1.5% per annum).

It can be seen from figure 8 and 9, showing the energy intensity and technical/behavioural performance in Ireland from 1995 onwards that industry is making advances towards energy saving in Ireland. Nearly all energy saving from 1996-2005 in figure 9 is attributed to technical developments. Section 2.6 analyses some of the technical efficiency measures that can be introduced to a pharmaceutical manufacturing facility and the potential savings the energy efficiency measures can make.

2.6 Energy Efficiency Opportunities for the Pharmaceutical Industry

A variety of energy efficiency opportunities exist within the pharmaceutical industry. These are targeted towards laboratories, manufacturing facilities, and other site buildings to reduce energy the consumption while maintaining or enhancing productivity standards. In the pharmaceutical industry energy efficiency opportunities are categorized into six energy intensive areas, these include:

(1) R&D
(2) Bulk manufacturing
(3) Formulation, packaging and filling
(4) Warehouses
(5) Offices
(6) Miscellaneous

Each area uses varying energy activities so different efficiency measures are applied to different areas, Table 2 provides reference to what relevant energy efficiency measures can be adapted for each area. A description of the main users is given from section 2.6.1 to 2.6.9, these describe their use in industry and the efficiency measures that can be applied to achieve the best energy savings.

(1) Research and Development	**(2) Bulk Manufacturing**
Energy Management	Energy Management
HVAC	HVAC
Fume Hoods	Cleanrooms
Cleanrooms	Motor Systems
Lighting	Compressed Air Systems
	Pumps
	Refrigeration
	Heat and Steam Distribution
(3) Formulation, Packaging and Filling	**(4) Offices**
Energy Management	Energy Management
HVAC	HVAC
Cleanrooms	Lighting
Motor Systems	Miscellaneous
Compressed Air Systems	
Pumps	
Refrigeration	
Lighting	
(5) Warehouses Miscellaneous	**(6) Miscellaneous**
Energy Management	Energy Management
HVAC	HVAC
Motor Systems	Motor Systems
Refrigeration	Lighting
Lighting	Heat and Steam Distribution
	Cogeneration
	Miscellaneous

Table 2: Energy Efficiency Measures [3]

Although technological changes in equipment conserve energy, changes in staff behavior and attitude can also have a great impact. Energy efficiency training programs can help a company's staff incorporate energy efficiency practices into their day-to-day work routines. Personnel at all levels should be aware of energy use and company objectives for energy efficiency improvement. Often such information is acquired by lower-level managers but neither passed up to higher-level management nor passed down to staff [12]. This project aims to show how good feedback through energy efficiency programs achieves good energy saving results. It could be argued that changes in staff behavior only amounts to low energy savings at a given time (e.g. when the lights are turned off, or windows closed). However, these savings taken over a longer period of time can have a large effect on overall energy reductions. A further discussion of energy management programs and practices is offered in section 2.6.1 of this project.

Establishing formal management structures and systems for managing energy that focus on continuous improvement are important strategies for helping companies manage energy use and implement energy efficiency measures. The Sustainable Energy Authority Ireland (SEAI) along with British Standards Institution (BSI) have developed frameworks called IS393 and EN16001 for energy management in industry, these are based on the observed best practices of leading companies practicing energy management. The ISO50001 international framework for Energy Management Systems is not yet published meaning EN16001 is the most current energy management framework. Other management frameworks, such as ISO14001 (framework for Environmental Management Systems) and ISO9001 (Quality Management Systems), can also be used to complement the energy management standards by ensuring better organizational management of energy within a company.

2.6.1 Energy Management Systems and Programs

Firstly, we have to determine what is concept of energy management. This is a management approach as to how much energy is used, and determining where is it used in a company. This is carried out through metering, monitoring and energy auditing. Once these factors are identified a company needs to determine how they are going to approach reducing that use, what can they spend to achieve this, what returns on investment will they achieve and what is going to be the target saving within a certain timeframe. This format is continually reviewed in order to constantly develop energy savings within a company.

Improving energy efficiency should be approached from various angles. By implementing a corporate-wide energy management program better results can be achieved. The program can be implemented into all aspects of a company, this includes facilities, operations, environmental, and management personnel. Energy efficiency improvements to cross-cutting technologies (equipment that is commonly used in many different sectors, such as boilers, pumps, motors, compressed air systems, and lighting), such as the use of energy efficient motors and the optimisation of compressed air systems, present proven opportunities for energy savings.

A strong energy management program is required to achieve the best energy savings. The program creates a foundation for positive change and provides guidance for managing energy throughout an organisation. Energy management programs also help to ensure that energy efficiency improvements are continuously identified and implemented in an ongoing process of continuous improvement. A sound energy management program ensures energy efficiency improvements reach their full potential as they are continuously monitored.

A successful program in energy management begins with a strong organizational commitment to continuous improvement of energy efficiency. This involves assigning oversight and management duties to an energy director/champion, establishing an energy policy, and creating a cross-functional energy team. Steps and procedures are then put in place to assess performance through regular reviews of energy data, technical assessments, and benchmarking. From this assessment, an organization is able to develop a baseline of energy use and set goals for improvement. Performance goals help to shape the development and implementation of an action plan [3]. Figure 15 shows the structure of an energy management plan and how using the procedure described previous is implemented in an organisation.

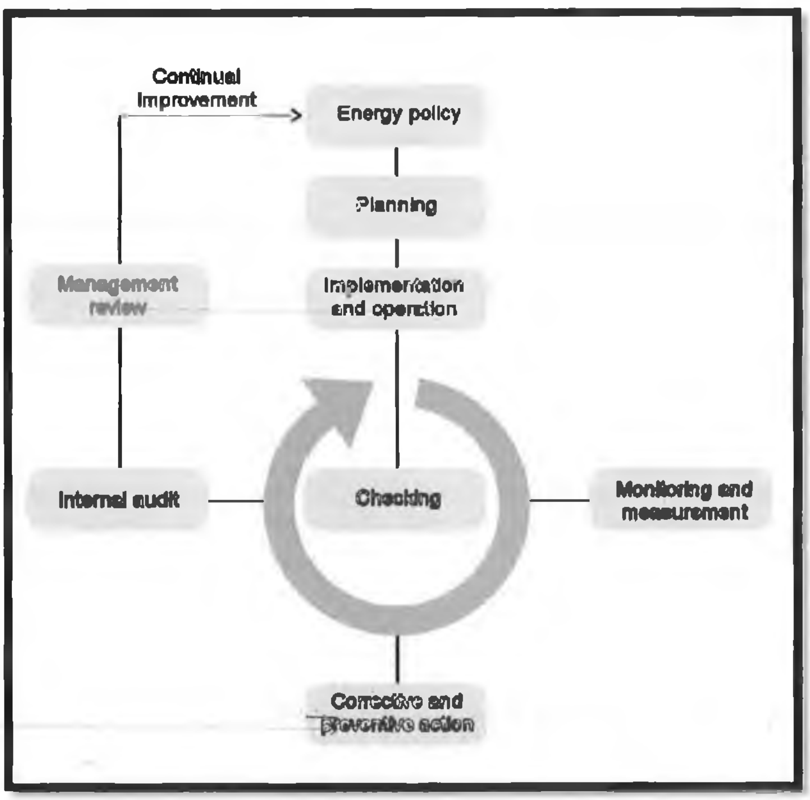

Figure 15: Main elements of a Strategic Energy Management Program [13] (seen previous page 2)

An important aspect for ensuring the success of the energy management program is involving personnel throughout the organisation. Personnel at all levels should be aware of energy use and goals for efficiency. Staff should be trained in both skills and general approaches to energy efficiency in day-to-day practices. In addition, performance results should be regularly evaluated and communicated to all personnel, recognizing high achievement. Progress evaluation involves the regular review of both energy use data and the activities carried out as part of the action plan. Information gathered during the formal review process helps in setting new performance goals and action plans, and in revealing best practices. Once best practices are established, the goal of the cross-functional energy team should be to replicate these practices throughout the organization. Establishing a strong communications program and seeking recognition for accomplishments are also critical steps. Strong communication and receiving recognition help to build support and momentum for future activities [3].

In order to identify where an organisation's energy is being consumed, energy monitoring systems can be installed. Energy monitoring systems and process control systems play an important role in energy management and in reducing energy use. Energy monitoring systems are capable of monitoring and reporting on energy consumption, this is done through site sub-metering, monitoring and use of the control system. They also flag any potential energy issues on site and assign coactive action by alerting the energy team. An example of the energy saving potential of an energy monitoring system can be seen in 2004 from the Wyeth pharmaceutical manufacturing facility in Campinas, Brazil. By installing a state-of-the-art metering, monitoring, and targeting system to help reduce electrical demand during peak periods they reduced their electricity use by 48% and utility costs by 10% as well as generating greater energy awareness among employees.

2.6.2 Heating, Ventilation, and Air Conditioning (HVAC) Systems

A typical HVAC system consist of dampers, supply and exhaust fans, filters, humidifiers, dehumidifiers, heating and cooling coils, ducts, and various sensors [14]. HVAC systems in manufacturing portions of facilities are regulated by the Food and Drug Administration (FDA) and must meet other global regulatory standards, so energy efficiency measures that affect the work environment must conform to current Good Manufacturing Practices (cGMP). Although cGMP allows for new techniques, the reasons for using them must be explained, the additional time required for approval, and the risks associated with a delay in approval of building plans, may have led some drug companies to maintain with less energy-efficient designs [15].

There are many energy efficiency measures that can be applied to HVAC systems in terms of system management. Setting back building temperatures (that is, turning temperatures down in winter or up in summer) during periods of non-use, such as weekends or non- production times, can lead to significant savings in HVAC energy consumption [3]. Additionally, there are many energy efficiency measures that apply to motors and, heat and steam distribution systems that can also be leveraged to improve HVAC system efficiency. These cross-cutting measures for motors, compressed air systems, and heat and steam distribution systems are discussed in more detail in sections 2.6.4, 2.6.5 and 2.6.9 of this project. Three common energy efficiency techniques that can be applied to a HVAC system are discussed below.

Variable Speed Drives (VSD's)

Where conditions demand adjustment of flow from a pump or fan, varying the speed of the drive saves energy as it is only exerting the required energy for a certain condition. In HVAC systems variable speed drives can be installed on variable-volume air handlers, as well as recirculation fans, to match the flow and pressure requirements of air-handling systems precisely. Energy consumed by fans can be lowered considerably since they are not constantly running at full speed. Variable speed drives can also be used on chiller pumps and water systems pumps to minimize power consumption based on system demand [3]. The author describes more energy saving VSD case studies witnessed in the Irish Industry in section 2.7 of this paper.

Heat Recovery Systems

By harnessing the thermal energy of a facility exhaust air, heat recovery systems can reduce the energy required to heat or cool a facility. A typical heat recovery system consists of heat pipes and return loops to re-circulate the air and extract its thermal energy before it is vented to atmosphere.

In 2004, Merck Sharpe and Dohme installed a glycol run-around loop system to recover heat from HVAC exhaust air at a 37,000-square-foot laboratory building in Rahway, New Jersey. After installation, the building could pre-heat and pre-cool up to 120,000 cubic feet per minute (cfm) of outside air with recovered energy. The savings associated with this measure amounted to roughly 265 thousand British thermal units (MBtu) per year (or 77,000 KWh/Yr), which led to avoided CO_2 emissions of over 30 tons per year [15].

Improving HVAC Chiller Efficiency

HVAC chillers are refrigeration systems that provide cooling for industrial and commercial applications. They use water, oils or other fluids as refrigerants. HVAC chillers vary in terms of condenser cooling method (Either air cooled or water cooled) depending on cooling specifications and process pump specifications [17]. The efficiency of water-cooled chillers can be improved by lowering the temperature of the condenser water, thereby increasing the chilled water temperature differential. This can reduce pumping energy requirements. Another possible efficiency measure is installing separate high-temperature chillers for process cooling [18]. Also, by balancing the chiller load with demand by sizing the chillers correctly significant energy savings can be achieved. An example of this can be at Genentech's pharmaceutical facility in Vacaville, Calfornia. Two 1,400-ton chillers and one 600-ton chiller were chosen instead of three equally-sized chillers. This selection was made in an effort to operate the chillers at as close to full load as possible, where they are most efficient. The two larger chillers are run at full load and the smaller chiller is run to supply additional cooling only on an as- needed basis, reducing energy needs. The cost savings associated with this chiller selection strategy were estimated to be $113,250 per year [35].

2.6.3 Cleanrooms

A cleanroom can be defined as an enclosed area in which ambient conditions including airborne particles, temperature, noise, humidity, air pressure, air motion, and lighting are strictly controlled. A significant portion of floor space in pharmaceutical and biotechnology facilities can be occupied by cleanrooms. In general, the largest consumers of energy in cleanrooms are the HVAC system (e.g., systems for chilled water, hot water, and steam) and process machinery [3]. A study carried out by the American Council for an Energy-Efficient Economy (ACEEE) found that HVAC systems accounted for 36-67% of cleanroom energy consumption. The Irish Energy Centre (IEC) also conducted a study on energy distribution in cleanrooms, they concluded that during operation: 56% of the energy is used for cooling, 36% for heating, 5% for fans, and 3% for pumps [19].

Pressure differentials and proper cleanroom filtration standards need to met in order to comply with FDA requirements for pharmaceutical industries. Energy efficiency techniques for optimizing HVAC systems were described previously in section 2.6.2, more specific energy efficiency measures for cleanrooms are discussed below.

Reduced Recirculation Air Change Rates

The rate of clean room air recirculation can sometimes be reduced while still meeting quality control and regulatory standards. A simulation study of a cleanroom in Ireland showed that it was possible to reduce the hourly air change rates of air recirculation units, which would lead to significant cost savings from reduced fan energy and resultant heat load [19].

Improved Air Filtration Quality and Efficiency

Cleanrooms standards are classified according to the number and size of particles permitted per volume of air, the lesser the particles the higher the standard. In order to maintain particulate-free air in the cleanroom, High Efficiency Particulate Air (HEPA) filters and Ultra Low Penetration Air (ULPA) filters are commonly used to filter make-up and re-circulated air. The adoption of alternative filter technologies might allow for lower energy consumption. For example, new air filtration technologies that trap particles in the ultra-fine range (0.001-0.1 microns), a range for which current filter technologies are not effective, might reduce the energy necessary for reheating/re-cooling cleanroom air [20].

Declassification

Occasionally, a cleanroom is classified at a higher cleanliness level than is necessary for its current use, either due to conservative design or to a transition in its production characteristics over time. A simple efficiency measure that might be available for such cleanrooms is to declassify them from a higher class of cleanliness to a lower class of cleanliness, provided that the lower class still meets production requirements for contamination control and air change rates [3].

Use Cooling Towers

In many instances, water cooling requirements can be met by cooling towers in lieu of water chillers. Water towers can cool water much more efficiently than chillers and can therefore reduce the overall energy consumption of cleanroom HVAC systems [15].

2.6.4 Motors and Motor Systems

Motors and drives are used throughout the pharmaceutical industry to operate HVAC systems, to drive laboratory or bulk manufacturing equipment (including agitators, pumps, centrifuges, and dryers), and for transport and equipment operation in the formulation and packaging stages [3]. The energy efficiency measures described in the following section apply to all motor systems.

In order to prioritize areas for improvement, it is best to take a "systems approach" and look at the entire motor system, including pumps, compressors, motors and fans, instead of examining each component individually. The following steps should be taken:

1. Locate and identify all motor applications (e.g., pumps, fans) in the facility.
2. Document their conditions and specifications.
3. Compare your requirements vs. the actual use of the system to determine the energy consumption rate; this will help determine whether the motors have been properly sized.
4. Collect information on potential upgrades or updates to the motor systems, including implementation costs and potential annual savings.
5. If you do elect to upgrade or update any equipment, monitor its performance over time to determine actual costs savings [3].

The energy efficiency measures discussed below reflect aspects of this systems approach, including matching motor speed and load (e.g., via Variable Speed Drives), sizing the system correctly, and upgrading system components. Compressed air systems and pumps are both discussed in more detail in Sections 2.5.5 and 2.6.6, respectively.

Maintenance

Proper Maintenance can save from 2% to 30% of total motor system energy use [15]. Motor maintenance measures can be categorized as either preventive or predictive. Preventive measures consider electrical conditions and load, minimize voltage imbalance and include motor ventilation, alignment and lubrication. Predictive measures observe ongoing temperature, vibration and other operating data to determine when to overhaul or replace a motor before it fails.

Properly Sized Motors

Motors that are sized inappropriately result in unnecessary energy losses. Where peak loads can be reduced, motor size can also be reduced. Replacing oversized motors with properly sized motors saves, on average for industry, 1.2% of total motor system electricity consumption [15].

High-efficiency Motors and Drives

High-efficiency motors reduce energy losses through improved design, better materials, tighter tolerances, and improved manufacturing techniques. With proper installation, high-efficiency motors can run cooler than standard motors and can consequently have higher service factors, longer bearing life, longer insulation life, and less vibration. The Industrial Assessment Center (IAC) conducted a survey in 2003 on high-efficiency motor installations in twenty-three pharmaceutical plants, from their analysis it showed an average payback period of less than 3 years for high-efficiency motor installations [15]. Another option is to rewind the existing motor but it is considered better choice to replace the motor with a high-efficiency motor, as it is a better spec.

Variable Speed Drives (VSD's)

Variable speed drives (VSD's) better match speed to load requirements, offering substantial savings in a variety of applications. This is noted previously in section 2.6.2 for HVAC systems.

2.6.5 Compressed Air Systems

Compressed air is required for many pharmaceutical manufacturing applications, including equipment operation (e.g. Valve opening & closing), vacuum cleaning and spray systems. Despite its importance, compressed air is one of the least energy efficient applications in any drug manufacturing plant. According to the energy star guide for energy and plant managers 2005 the efficiency of compressed air systems is only around 10%, so compressed air should be used sparingly. Techniques for reducing energy consumption in compressed air systems aren't very expensive, and savings can range from 20% to 50% or more of total system electricity consumption [3]. Below are some issues to consider where compressed air systems are concerned.

Maintenance

Maintenance is essential to improving efficiency for compressed air systems. The following guidelines should apply:

- Keep the compressor and intercooling surfaces clean - Blocked filters increase pressure drop, and more frequent filter changing can reduce annual energy consumption by 2%. Fixing improperly operating filters will also prevent contaminants from entering into equipment, which can cause premature wear.
- Keep motors properly lubricated and cleaned - Compressor lubricant should be changed every two to 18 months and checked to make sure it is at the proper level. This will also reduce corrosion and degradation of the system.
- Inspect fans and water pumps for peak performance
- Inspect drain traps periodically - This ensures that they are not stuck in either the open or closed position and that they are clean.
- Maintain the coolers on the compressor to ensure that the dryer gets the lowest possible inlet temperature.
- Minimize leaks
- Excessive Pressure - Check all applications requiring compressed air for excessive pressure, duration or volume [15]. Operating pressure might be to too high in the system meaning additional air is used in the system that is not required (E.g. A manufacturing facilities compressed air pressure is kept constant at 12 bar for valve open/close operation but the equipment might only requires 7 bar pressure to open all valves)

Leak Reduction

Air leaks are a major energy drain, but they also can damage equipment. A poorly maintained compressed air system will likely have a leak rate equal to 20% to 50% of total capacity. Leak maintenance can reduce this number to less than 10%. Fixing leaks pays off, reducing annual energy consumption by 20% [21]. The magnitude of the energy loss varies with the size of the hole in the pipes or equipment in the compressed air loop but generally payback takes less than two months. Leaks are generally detected using an ultrasonic acoustic detector.

2.6.6 Pumps

Pumping systems account for about 25% of the electricity used in manufacturing plants, and pumping coolants is an energy-intensive pharmaceutical application [15]. Studies have shown that over 20% of the energy consumed by pumping systems could be saved through changes to equipment and/or control systems [15]. For a pump system with a 20-year lifetime use the initial capital costs of the pump and motor make up approximately 2.5% of the total costs. Energy costs make up 95% of the lifetime costs of the pump with maintenance costs comprising the remaining

2.5%. For this reason use of a pump system, consisting of a pump, a drive motor, piping networks and system controls such as variable speed drives (VSD's) should be highly dependent on energy cost considerations rather than on initial costs [3]. The energy-efficiency measures outlined below apply to all pump applications. Because pumps are part of a greater motor system, many of the measures described in Section 2.6.4 for motors apply to pumping systems as well.

Maintenance

Better pump maintenance saves between 2% and 7% of pumping electricity, with paybacks within a year. Proper pump system maintenance includes the following:

- Replacement of worn impellers, especially in caustic or semi-solid applications.
- Bearing inspection and repair.
- Bearing lubrication replacement, on an annual or semi-annual basis.
- Inspection and replacement of packing seals.
- Inspection and replacement of mechanical seals. Wear ring and impeller replacement. Pump efficiency degrades 1-6 %for impellers less than the maximum diameter and with increased wear ring clearances.
- Pump/motor alignment check.

Pump Demand Reduction

Bypass loops and other unnecessary flows should be eliminated. This step can save 5-10% of pump system electricity consumption [22].

Controls and Awareness

The objective of the control strategy is to shut off unneeded pumps or, alternatively, to reduce pump load until needed.

Replacing older Pumps with High-Efficiency Pumps

As seen in section 2.6.4 more higher efficiency equipment provides savings in terms of better operation. According to inventory data, 16% of pumps used in industry are more than 20 years old. A pump's efficiency may degrade by 10-25% in its lifetime. Newer pumps are typically 2-5% more efficient, while high-efficiency motors have also been shown to increase the efficiency of a pumping system by 2- 5% [15].

Properly Sized Pumps

Optimal sizing of pumps can save, on average, 15-25% of the electricity consumption of a pumping system. Paybacks for implementing these solutions are typically less than 1 year [22].

Impeller Trimming

If a large differential pressure exists at the operating rate of flow (indicating excessive flow), the impeller diameter can be trimmed so that the pump does not develop as much head. Impeller trimming can save up to 75% of electricity consumption [3].

2.6.7 Refrigeration

Refrigeration is another important utility in the pharmaceutical industry and is used in different applications. Energy savings in refrigeration systems can be found at the component, process, and systems levels. Energy efficiency measures include reducing condenser pressures, the correct selection and sequencing of compressors, optimizing insulation, and eliminating non-essential heat loads within the plant [3]. Additionally, many of the efficiency measures for motors, compressors and pumps described in previous sections of this paper also apply to refrigeration systems.

Operations and Maintenance

Often it is possible to achieve energy savings at very low investment costs with attention to improved operations and maintenance of refrigeration systems. Such improvements can include maintaining correct levels of refrigerant. Energy saving can also be achieved by cleaning the condensers and evaporators. Scale on condensers increases power input and decreases refrigeration output. Three millimeters of scale can increase power input by 30% and reduce output by 20%. Water treatment and blowdown or magnetic water treatment can be used to eliminate scales. In ammonia system evaporators, oil tends to accumulate and needs to be drained to avoid reduction of heat transfer. Additionally, cool outside air in winter months can sometimes be leveraged to reduce facility cooling energy loads [12].

Systems Monitoring

The introduction of automatic monitoring on refrigeration systems can help energy managers and facilities engineers track energy consumption, diagnose poor performance, optimize system performance, and identify problem areas before major repairs are needed. Automated monitoring of energy performance can be very beneficial in exposing poor part-load efficiency and in identifying system deterioration, such as the effects of low refrigerant charge. The cost of automated monitoring is proportional to the size of the system and may be minor on new systems, where much data can often be obtained from control systems. The monitoring system should have the ability to provide system and component level information to operating staff as well as high-level performance summaries for management. It is estimated that applying this measure can save 3% of refrigeration energy [22].

Monitoring of Refrigerant Charge

A low refrigerant charge can exist in many small direct expansion (DX) systems, and can also exist without obvious indicators on larger flooded or recirculation systems. Without proper monitoring to ensure that refrigerant is charged to the appropriate level, significant amounts of energy can be wasted in a refrigeration system. It is estimated for DX systems that one in six have a low refrigerant charge (or sometimes overcharge), which is sufficient to increase energy usage by 20% [3].

Optimization of Condenser and Evaporator Parameters

An optimized refrigeration system works with minimized differences between condenser conditions and evaporator conditions. For the condenser, the goal is to obtain the lowest possible condensing temperature and pressure of the refrigerant. This reduces power input while increasing refrigeration output. For the evaporator, an increase in temperature and pressure increases the power input of the compressor, but can dramatically increase the refrigeration output of the system. Increasing evaporator temperature by one degree can reduce the electricity consumption of the compressor by roughly 3% [22].

Process Line and Jacket Insulation

It can often be cost effective to insulate process lines if the lines are un-insulated and there is a significant average temperature difference between the process lines and the surroundings. Un-insulated process lines can lead to temperature increase during transportation causing loss of energy.

Operation at Lower System Pressure

High operating pressures in refrigeration systems lead to high compressor energy consumption and head loss. Lower operating pressures can reduce compressor energy consumption, while also leading to reduced system maintenance costs (e.g., for distribution pipe maintenance). However, in lowering system operating pressures, one must also consider the optimal pressure and temperature requirements of condensers and evaporators (discussed previously in this section) to ensure maximum energy efficiency [3]. The same concept of lowering operation applies to compressed air and steam condensate systems also.

2.6.8 Lighting

As can be seen from figure 3 in section 2.3, overall energy used in the pharmaceutical industry is typically 10% for lighting. Lighting is used either to provide overall ambient lighting throughout manufacturing, storage, and office spaces or to provide high/low-bay and task lighting to specific areas. Lighting also generates a significant amount of heat. The downstream savings of lighting efficiency measures can therefore include cost savings in facility HVAC operation and energy use.

The magnitude of downstream savings depends on climate and weather conditions [23].

When considering lighting efficiency measures for pharmaceutical plants explosion protection needs to be taken into account. A pharmaceutical manufacturing building is considered a hazardous area meaning explosion protection is of extreme importance. All electrical apparatus fittings for use in hazardous area must meet European Regulations for explosion protection; these include EN50014, EN50017, EN50018, EN50019, EN50020 and EN50028. Due to different levels of hazardous areas in a pharmaceutical facility they are divided into different zone regions. Hazardous areas for combustible gases, vapours and mist are subdivided into three zones. The subdivision of the hazardous areas is according to the probability of the occurrence of a potential explosive atmosphere; these are defined as zone 0, zone 1 and zone 2. The initial zone 0 is the most exposed usually used in reactor vessels, zone 1 is for the surrounding areas of the process within the manufacturing facility and the last zone 2 witnessing the least hazardous exposer usually used in corridors or walkways. The type of electrical fittings used in these zones are required to be what is industry known as Ex-rated, which means explosion proof.

Due to the Ex-rated requirement there is limited opportunities in pharmaceutical manufacturing facilities in terms of lighting efficiency measures in manufacturing facilities. There are more energy efficient techniques in place that are described below but as of yet have not received the Ex-rated standard meaning they can only be used in office and storage facilities. Some of these techniques and other opportunities are described below.

Turning off Lights in Unoccupied Areas

An easy and effective measure is to encourage personnel to turn off lights in unoccupied building spaces. Implementation of an energy management program (as seen in section 2.6.2) would improve the awareness of personnel with regard to energy use can help staff get in the habit of switching off lights and other equipment when not in use.

Lighting Controls

Lights can be shut off during non-working hours by automatic controls, such as occupancy sensors that turn off lights when a space becomes unoccupied. Occupancy sensors can save up to 10-20% of facility lighting energy use and have approximately a 1 year payback period [3]. Another example of a lighting control includes Passive Infrared Sensor (PIR) with daylight dimming, these sensors monitor the light levels in a room/building and reduce the lighting output in order for daylight to compensate for the light level requirement, in turn reducing energy consumption. These features could only be applied to an office or storage facility of a pharmaceutical plant as they are not considered safe in manufacturing hazardous areas.

Exit and Emergency Exit Signs

Energy costs can be reduced by switching from incandescent lamps to light-emitting diode technology (LED) in exit sign lighting or sign lighting that is on 24/7. An incandescent exit sign uses about 40 W, while LED signs may use only about 4-8 W, reducing electricity use by 80-90%. The lifetime of an LED exit sign is about 10 years compared to 1 year for incandescent signs, this leads to reducing maintenance costs considerably for new tubes installations [3]. Most recently, LEC (light emitting capacitor) exit signs have come to market. Drawing only 0.25 W of power with an operational life of 30+ years and far exceeding the actual 5 year life of an LED sign [27].

Electronic Ballasts

A ballast is a mechanism that regulates the amount of electricity required to start a lighting fixture and maintain a steady output of light. Electronic ballasts save 12-30% power over their magnetic predecessors [25]. New electronic ballasts have smooth and silent dimming capabilities, in addition to longer lives (up to 50% longer), faster run-up times, and cooler operation. New electronic ballasts also have automatic switch-off capabilities for faulty or end-of-life lamps [25]. The typical energy savings associated with replacing magnetic ballasts by electronic ballasts are estimated to be roughly 25%. However, the total energy savings will depend on the number of magnetic ballasts still in use [3]. These features could only be applied to the manufacturing facility of a pharmaceutical plant if they are Ex-rated.

Replacing T8 tubes with T5 tubes

In many industrial facilities, it is common to find T8 lighting fixtures in use. T8 fixtures consume significant amounts of electricity, and also have poor efficiency, lamp life, lumen depreciation, and color rendering index. Because of this, the maintenance and energy costs of T8 fixtures are high. Replacing T8 lamps with T5 lamps (smaller diameter) approximately doubles the efficiency of the former. Also, T5 tubes generally last 60% longer than T8 tubes, which leads to savings in maintenance costs. T5 tubes are quite intense when compared to T8 tubes and consequently have enough punch to illuminate a space with fewer fixtures than a system designed around T8 tube technology. Even though T5 fixtures are more expensive than similar configuration T8 models, in most cases the reduced number of fixtures offsets much of this extra cost [24]. Typical energy savings from the replacement of a T8 tube by a T5 tube are around 30% - 40% with a payback of between 9-18 months [26]. However, for the pharmaceutical industry T8 lighting fixtures have Ex-rated approval, T5 fixtures are yet to receive ex-rating approval so cannot be used in manufacturing facilities where most lighting energy is consumed.

Day Lighting

Daylighting involves the efficient use of natural light in order to minimize the need for artificial lighting in buildings. Increasing levels of daylight within rooms can reduce electrical lighting loads by up to 70%. Daylighting differs from other energy efficiency measures because its features are integral to the architecture of a building; therefore, it is applied primarily to new buildings and incorporated at the design stage. However, existing buildings can often be cost effectively refitted with daylighting systems. Various daylighting systems are supplied as kits to retrofit to an existing building. Daylighting technologies include properly placed and shaded windows, atria, angular or traditional (flat) roof lights, clerestories, light shelves, and light ducts. Clerestories, light shelves, and light ducts accommodate various angles of the sun and redirect daylight using walls or reflectors. Not all parts of a facility may be suitable for the application of daylighting. Daylighting is most appropriate for those areas that are used in daytime hours by people. Achieved savings varying depending on the facility and buildings but typically the payback period is around 4 years [3].

2.6.9 Heat and Steam Distribution

Boilers are the heart of a steam system, while the purpose of distribution systems is to get steam from the boiler to the process where it will be used. Boilers and steam distribution systems are major contributors to energy losses at many industrial facilities, they are therefore an area where substantial efficiency improvements are typically feasible [16]. Many common energy efficiency measures for boilers and steam distribution are listed below.

Boiler Process Control

Flue gas monitors maintain optimum flame temperature and monitor carbon monoxide (CO), oxygen, and smoke. Using a combination of CO and oxygen readings, it is possible to optimize the fuel/air mixture for high flame temperature (and thus the best energy efficiency) and lower air pollutant emissions [3].

Reduction of Flue Gas Quantities

Often excessive flue gas results from leaks in the boiler and/or in the flue. This reduces the heat transferred to the steam and increases pumping requirements. These leaks are often easily repaired. Savings amount to 2-5% of the energy formerly used by the boiler [22].

Reduction of Excess Air

The more excess air is used to burn fuel, the more heat is wasted in heating this air rather than in producing steam. A rule of thumb often used is that boiler efficiency can be increased by 1% for each 15% reduction in excess air or 22^{0}C reduction in stack gas temperature [15].

Properly Sized Boiler Systems

Correctly designing the boiler system at the proper steam pressure can save energy by reducing stack temperature, reducing piping radiation losses, and reducing leaks in traps and other sources. In a study done in Canada on 30 boiler plants, savings from this measure ranged from 3-8% of the total gas consumption [15].

Improved Insulation of Steam Distribution Systems

Careful analysis of the use of existing insulation materials can often yield energy savings. Factors in the choice of materials include low thermal conductivity, dimensional stability under temperature change, resistance to water absorption and resistance to combustion. According to data from the U.S. Department of Energy's Steam Challenge Program, improving insulation of the existing stock of heat distribution systems would save an average of 3-13% with an average payback of 1.1 years [22].

Boiler Maintenance

A simple maintenance program to ensure that all components of a boiler are operating at peak performance can result in substantial savings. In the absence of a good maintenance system, burners and condensate return systems can wear or get out of adjustment. These factors can end up costing a steam system up to 20-30% of initial efficiency over 2-3 years. On average, the energy savings associated with improved boiler maintenance are estimated at 10% [3].

Reuse Condensate

Reusing hot condensate in boilers saves energy, reduces the need for treated boiler feed water, and reclaims water at up to 100^0C of sensible heat. Typically, fresh feed water must be treated to remove solids that might accumulate in the boiler; however, returning condensate to a boiler can substantially reduce the amount of purchased chemical required to accomplish this treatment. The fact that this measure can save substantial energy costs and purchased chemicals costs often makes building a return piping system attractive [15].

Leak Repair

Distribution pipes themselves often have leaks that (on average) go unnoticed without a program of regular inspection and maintenance. In addition to saving 3% of energy costs, having such a program can reduce the likelihood of having to repair major leaks, thus saving even more in the long term [22].

Preventive Maintenance

A general preventive maintenance (PM) program institutionalizes ongoing steam system checks, repairs, and upgrades to keep steam distribution systems operating at peak efficiency. General PM programs for steam distribution systems would incorporate many of the measures described above and typically lead to significant savings.

Other alternatives not considered for this paper in terms of Heat and Steam Distribution

Process Integration and Pinch Analysis: Process integration refers to the exploitation of potential synergies that are inherent in any system that consists of multiple components working together. In plants that have multiple heating and cooling demands, the use of process integration techniques may significantly improve plant energy efficiency.

Flue Gas Heat Recovery: Heat recovery from flue gas is a good opportunity for heat recovery in steam systems. Heat from flue gas can be used to preheat boiler feed water in an economizer. However, this is a common energy efficiency measure pre built into modern large boilers

Blowdown Steam Recovery: This system can be used for space heating and feed water preheating.

Steam Trap Maintenance: Steam traps have the function of removing condensed steam and non-condensable gases without losing any live steam. As these traps can vent significant amounts of steam if not properly monitored, a simple inspection and maintenance program can save significant amounts of energy for very little money. [3]

Introducing the energy efficiency measures described in section 2.6 is difficult without having an energy management system (section 2.6.1) in place to continually monitor and target performance. In Irish industry these systems are introduced through the sustainable energy authority of Ireland (SEAI). Section 2.7 shows why these systems are introduced from the SEAI perspective and what programs are used to implement energy management systems into Irish Industry.

2.7 Policies, Organisations and Performance of Energy Management in Ireland

The policies driving energy management in Ireland is our compliance with EU directives, to which we are legally bound to implement. The following are a list of policies implemented in Ireland in order to develop energy efficiencies in industry:

- Energy White Paper 2007 – Delivering a sustainable energy future for Ireland
- National Climate Change Strategy 2007-2012
- Kyoto Protocol 2005
- Electricty Regulation Act 1999
- National Development Plan 2007-2013
- The Green Paper 2006 - A European strategy for sustainable, competitive and secure energy

This National Climate Change Strategy 2007-2012 builds on the commitment to sustainable development set out towards 2016 and the National Development Plan 2007-2013 and is one of a number of interrelated Government initiatives that will address energy and climate change issues. These include the White Paper on Energy, the Bio-Energy Action Plan and the forthcoming Sustainable Transport Action Plan. Taken together, these measures will support environmental sustainability, underpin our competitive position and enable us to meet our global responsibilities [30]. In the Green Paper, the EU commission puts forward concrete proposals in six priority areas for implementing a european energy policy. Ranging from the completion of the internal market through to the implementation of a common external energy policy, these proposals are in place to help Europe to ensure a supply of energy which is secure, competitive and sustainable for decades [40].

However, these drivers are based more on national and government requirement and incentives unlike a pharmaceutical company which practices energy management to escalate its profit margins and reduce carbon emissions as part of their corporate responsibility. For this reason the author intends to only discuss the national programs towards energy saving (SEAI programs) that relate to energy saving in the pharmaceutical process.

2.7.1 Sustainable Energy Authority of Ireland (SEAI) Energy Management Schemes

The Sustainable Energy Authority of Ireland (SEAI), formerly the Irish Energy Centre, was set up by the government in 2002 as Ireland's national energy authority. SEAI and industry work together to reduce Ireland's energy consumption and CO_2 emissions, for this reason there is advantages for both parties. SEAI help reduce emissions and energy consumption nationally in order to be compliant EU directives and industry obtain large financial gains and incentives as well as global recognition for being more energy intensive about their practices. Programs for Energy Management in Ireland are coordinated by the SEAI, they provide services for Large Energy Users in Ireland through such programs as the Large Industry Energy Network (LIEN) and the Energy Agreement Programme (EAP).

Large Industry Energy Network (LIEN)

The LIEN is a voluntary membership program consisting of approximately 140 of Ireland's largest energy user companies that work together to develop and maintain robust energy management. The LIEN has continuously improved its energy performance since it was formed by SEAI, overall member companies reduced energy costs by €60 million in 2008 alone. Some have improved their energy efficiency by over 30% over the last decade. Regular workshops, seminars and site visits provide a forum through which members keep up to date on best practice and new technologies [28].

Energy Agreements Programme (EAP)

The Energy Agreements Programme (EAP), launched in May 2006, is a subset of the LIEN. The program requires a company to make a commitment to manage their energy use in a strategic and systematic way. In return, the EAP supports a company in implementing the EN16001 energy-management standard. This requires a company to pursue an aggressive programme of energy-efficiency actions and investment. The SEAI provide relationship support, advice, networking assistance and financial support for the initial three-year period of the agreement. 80 member companies of LIEN program have progressed to EAP membership in order to implement and achieve I.S. EN16001 accreditation [29].

I.S. EN16001:2009

The new I.S. EN 16001 (only introduced in 2009) standard represents the latest best practice in energy management. Ireland's Energy Management Standard I.S.393 (2005) was the original standard for the EAP and formed the basis for the introduction of the new I.S. EN16001 standard. A company that implements and maintains the I.S. EN16001 standard will continuously improve its energy performance year on year.

As seen previous in section 2.6.1, an Energy Management Standard specifies the requirements for establishing, implementing, maintaining and improving an energy management system. The I.S. EN16001 system takes into account legal obligations with which the organisation must comply and other requirements to which it may subscribe. It enables an organization to take a systematic approach to the continual improvement of its energy efficiency. This standard lays down requirements for continual improvement in the form of more efficient and more sustainable energy use, irrespective of the type of energy. This standard does not itself state specific performance criteria with respect to energy. This standard is applicable to any organization that wishes to ensure that it conforms to its stated energy policy and to demonstrate such conformance to others. This can be confirmed by self-evaluation and self declaration of conformance or by certification of the energy management system by an external organization [13]. I.S EN16001 forms the basis for the introduction of the new ISO50001 standard meaning achieving ISO accreditation may only involve minor alterations once the I.S. EN16001standard is implemented. The future ISO 50001 energy management standard will establish a framework for industrial plants, commercial facilities or entire organizations to manage energy.

2.7.2 SEAI Program Performance

Based on the 2008 LIEN annual report (most recent report published), the estimated total primary energy consumption (TPER) for LIEN membership was 26,600,000 MWh, representing a total estimated energy spend of €950 million. Through further roll out of the program an improvement of 5.2% was achieved in 2008 for industry, this translates into 1,620,000 MWh and €60 million [31]. Of the 5.2% savings the pharmaceutical industry accounted for 1%, this equates to energy saving of €11.5 million. Also, these savings improved operating efficiency by 4.53% in the pharmaceutical sector, this can be seen from figure 16 & 17.

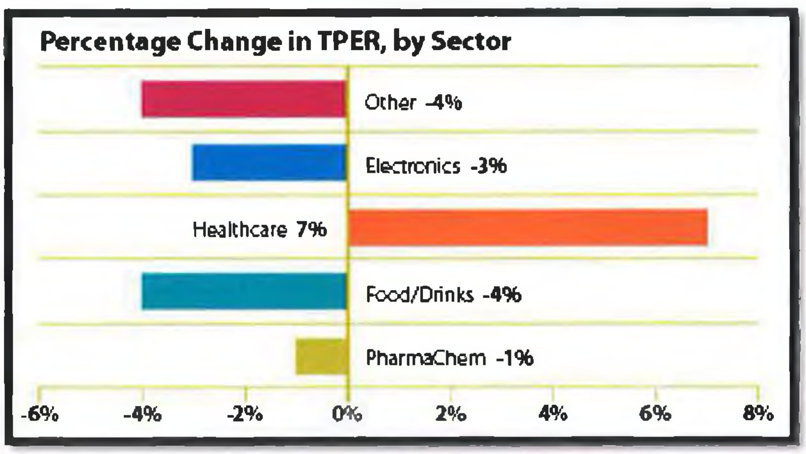

Figure 16: Breakdown of 5.2% TPER Improvement by Sector [31]

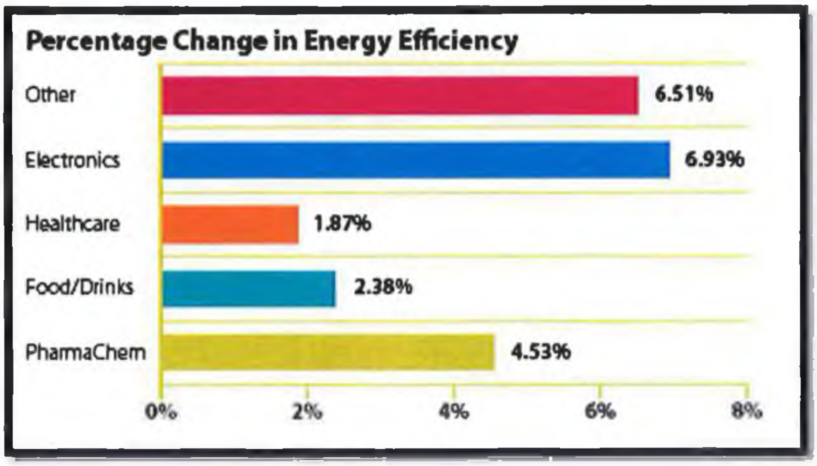

Figure 17: Operating Energy Efficiency Improvement [31]

The drivers of the energy efficiency change within the LIEN program and the Energy Agreement Program (The EAP is based on the IS393 standard, which was superseded by EN16001 in 2009) are broadly categorised as energy management system or an "other driver" (e.g. a business change, productivity influence, new product introduction, new capability or capacity requirement). Of the projects implemented in 2008, 80% were structured around implementing an Energy Management System, this accounted to 56% of the KWh savings in 2008. The remaining 20% were structured around other drivers accounting to 44% of the total KWh savings in 2008. Charts of the results can be seen from figures 18 and 19. From analysing the charts it identifies the impact of an energy management system attributing to 56% of energy savings for industry in 2008 through SEAI programs.

Figure 18: 2008 Project Breakdown [31]

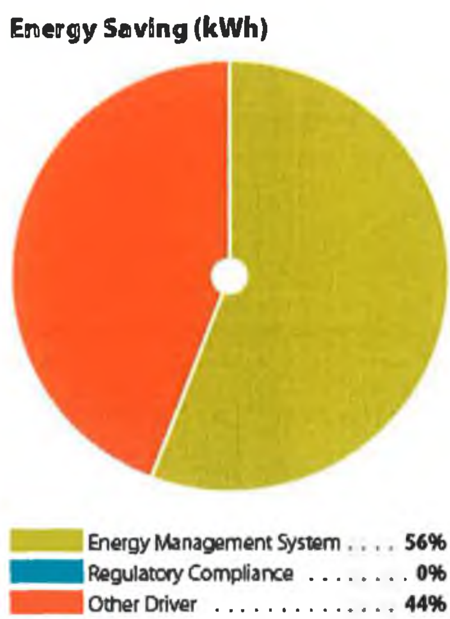

Figure 19: KWh Breakdown per Project [31]

In terms of better performance between the LIEN program and the Energy Agreement Program (EAP) the analysis indicates that EAP member companies made energy-efficiency gains of 6% whereas LIEN- only companies made gains of only 4.7% in 2008 [31]. This analysis indicates that the EAP members are outperforming LIEN- only members. This figure has likely increased further since the introduction of EN16001 in 2009 due to a higher standard of accreditation and more awareness amongst industry. Overall it is clear that by accepting membership to the EAP program energy efficiencies measures will be implemented into an organisation and by savings will be achieved.

2.7.3 Review of Irish Energy Saving Case Studies through EAP

This section analyses the energy performance of companies who committed to the EAP and implemented the IS393 energy management standard. The author uses IS393 energy management standard case studies as no I.S. EN16001 case studies have yet to be published through the SEAI (As IS393 formed the basis for I.S.EN16001 the author considers the case studies to be relevant). The case study companies include pharmaceutical and food based manufacturing facilities which can be seen in Appendix F and are named below:

- Abbott Pharmaceutical, Sligo [A]
- Glanbia Plc, Kilkenny [B]
- Schering-Plough, Cork [C]
- Wyeth, Dublin [D]

All the above companies achieved energy savings through the EAP membership and IS393 energy management standard implementation, these savings can be reviewed from Appendix F. The author analyses how through IS393 (EAP energy management standard from 2005-2009) they introduced the energy management system model, what techniques they introduced to achieve these savings and what are the best aspects of the IS393 energy management standard. A discussion on the main findings and correlations from the case studies can be seen below.

<u>*Drivers for Implementation*</u>

The drivers for implementation of the IS393 energy management standard are attributed to the rising costs in energy prices and a commitment to reduction of carbon emissions for all four of the case studies [A, B, C, D]. This finding is similar to that of the author in section 2.7

Identification of the energy users where energy saving techniques where focused

Case studies [A, D] highlighted gas as one of there biggest user. All four companies [A, B, C, D] targeted reductions in electricity usage, especially in the HVAC systems as it is one of the biggest energy users, as identified in from figure 3 and section 2.6.2. Water reductions where also achieved for both [A, D].

Efficiency measures implemented

Installation of VSD's to the HVAC systems where identified as an energy saving technique implemented for three of the case studies [A, B, D]. The introduction of Combined Heat and Power (CHP) system achieved substantial saving for case studies [B, D]. Two companies introduced shutdown management during shutdown periods and weekends to achieve savings as the facilities where using substantial energy quantities during inactive periods [A, D]. Properly sizing equipment and energy leak surveys where identified to achieve savings in case study [A].

Below outlines the aspects of the Energy Management System that where most effective towards enhancing energy performance in the case studies analysed.

Energy Management System Software (Monitoring and Targeting)

All four case studies [A, B, C, D] stated sophisticated monitoring and targeting (M&T) packages as essential for identifying energy saving opportunities . The system measured energy data and key profiles and feds this information into the budgetary process to allow costs to be assigned to various production areas. The Abbott facilities manager James Hughes said about there energy management system "*If I had to put the finger on any one thing that has had a significant and overarching effect on our energy, it would be this. This software captured much of the data for the energy audit and is a great help in identifying improvement opportunities*" [33].

Energy/Key Performance Indicators (EPI or KPI) (Targeting)

All four of the case studies [A, B, C, D] indicated that one of the pillars of sustained energy saving are the energy performance indicators (EPI). Through regular EPI analysis the companies ensured any variation in energy consumption was highlighted and explained. According to the environmental/energy services manager for Glanbia, John Finlay, indicators of performance are key, "*Without performance data, it would not be possible to drive forward efficient operation practices*" [32].

<u>Proper Training and Awareness</u>

Three case studies highlighted that most significant projects triggered by IS393 were not capital investments as much as the training of personnel so that they reduce energy usage in day-to-day operations [B, C, D]. The Glanbia Environmental Coordinator Audrey Mongan O'Shea outlines that sustained awareness and training is *"vital for maintaining momentum and driving continuous improvement forward"* [32].

<u>Ease of adoption into the a company management structure</u>

Case studies [A, C, D] all noted a key approach to energy management within there sites was the integration of the IS393 energy management standard, management structure, into the normal management structure of the companies. This enabled senior management to be on board from the start and proved to accelerate the implementation process.

<u>Energy savings through systems maturity and the introduction of savings by design</u>

It is highlighted in case studies [A, D] that more savings will be achieved in the long term through system maturity as energy management will become integrated into peoples day to day work responsibilities and activities leading to constant saving. Also, decision making over energy usage will be coordinated through systematic analysis leading to prioritisation of resources and better usage patterns.

Since implementing IS393 two case studies [B, C] highlighted they have become more strategically aware of the need to include energy efficiency and life cycle costing as key factors in equipment procurement, product development, and process/facility design. Whereas in the past selection was based purely on capital economics.

The case studies share commons trends throughout, all four stated that through the monitoring and targeting approach outlines by the IS393 energy management standard energy saving opportunities identified easily. KPI's enabled the companies to implement the energy opportunities and track there performance and drive forward in terms of efficient operation practices. Overall the case studies highlight, that by implementing an energy management standard it creates a management structure to understand all aspects of energy usage within an organisation which leads to energy savings being achieved on a consistent basis through monitoring and targeting, and saving through design. Mark Dullaghan, Wyeth engineering projects manager, sums this up from two quotes on the energy management situation in Wyeth's prior to implementing the IS393 energy management standard:

systems and compressed air systems which would all be heavy on site energy users.

I.S. EN16001 is the most current and efficient energy management program in Irish and international industry and presents an optimal platform to introduce the energy efficiency measures noted above and in section 2.6. This is proven from the case studies analysed in section 2.7.3, also these case studies used the crosscutting efficiencies identified previous such as VSD's, properly sizing, leak repairs in order to maximize energy savings. The I.S. EN16001 standard not only technically improves plant operations but integrates into company structure at management level and operates within cross-functional departments, meaning decision making on energy aspects is part of the regular business process and not a one off activity. This generates awareness and identifies saving opportunities from all aspects of a company on a recurring basis.

Chapter 3 analyses how the I.S. EN16001 energy management standard is implemented in GlaxoSmithKline (GSK), Cork. Through implementation an energy management system is integrated in the GSK Cork site.

Chapter 3 Case Study

3.1 Introduction

3.2 Overview of GlaxoSmithKline (GSK) and the Cork GSK Facility

3.3 GlaxoSmithKline (GSK) Energy Users

3.3.1 Electricity Users

3.3.2 Gas Users

3.4 GlaxoSmithKline (GSK) Energy Management System History

3.5 Implementing IS EN16001 in GlaxoSmithKline Pharmaceuticals

3.5.1 Energy Policy

3.5.2 Steps Involved to Implement EN16001

3.5.3 Implementation and Operation

3.5.4 Review of EMS by Top Management for Managing and Improving the EMS

3.7 Conclusion

3.1 Introduction

The EAP has produced positive results in terms of energy efficiency within the Irish pharmaceutical industry by adopting changes in major energy systems, improving energy performance through operational practices and management level support leading to reductions in energy usage [29].

In this chapter the author profiles how the I.S. EN16001 energy management standard model have been implemented in GlaxoSmithKline (GSK) Pharmaceuticals in Cork. As of 2007, GSK's annual energy expenditure was €7.4 million.

The Significant Energy Users (SEU's) are identified in terms of electricity and gas usage on the GSK Cork site and shows how enrolling in the SEAI Energy Agreement Program (EAP) to implement the I.S. EN16001 energy management standard developed a framework for monitoring and targeting GSK's energy usage and initiating a program for continual energy saving within the organisation at both a technical and management level.

3.2 Overview of GlaxoSmithKline (GSK) and the Cork GSK Facility

GlaxoSmithKline (GSK) is one of the pharmaceutical companies in the world and their business accounts for an estimated 7% of the world's pharmaceutical market. GSK produce medicines that treat major disease areas such as asthma, virus control, infections, mental health, diabetes and digestive conditions. In addition, they are a leader in the important area of vaccines and are developing new treatments for cancer. Some of GSK's more notable over-the-counter products include Gaviscon, Panadol, dental products such as Aquafresh and Sensodyne, smoking control products Nicorette/Niquitin and nutritional healthcare drinks such as Lucozade, Ribena and Horlicks.

Figure 20: GlaxoSmithKline Trademark Symbol

GSK have a leadership in four of the five largest therapeutic areas, anti-infectives, gastrointestinal/ metabolic, respiratory and central nervous system. Headquartered in London, it employs over 101,000 people worldwide and has an extensive global sales and marketing network with product supplied from 78 sites in 37 countries [1].

GlaxoSmithKline Cork was established in 1975. The production facility manufactures the active ingredients of medicinal compounds. The compounds made in the Cork facility can be seen from table 3, The Cork site is one of the primary strategic sites in GSK's global manufacturing and supply network. The 150-acre site, employ's approximately 300 staff and resides in one of the most picturesque harbours in the world.

Figure 21: GSK Cork Site and the surrounding Harbour

Products at GSK Cork		
Active Compounds	Product Name	Therapy Areas
Carvedilol	Coreg	Congestive Heart Failure
Paroxetine	Seroxat/Paxil	Depression
Topotecan	Hycamtin	Ovarian Cancer
Ropinirole	Requip	Parkinson's Disease
Abacavir	Trizivir	HIV
Dutasteride	Avolve	BPH

Table 3: Products Manufactured in GSK Cork Strategic Site [1]

GSK Cork has a highly automated manufacturing facility, as well as an R&D Pilot Plant with Pilot Plant Laboratories on site. In total, the site consists of 23 buildings (spanning 29,621 m^2) ranging from production buildings, maintenance workshops, environmental treatment facilities, laboratories, warehouses and administration offices. A more detailed breakdown can be seen from table 4.

GSK Cork Building Breakdown	
Production Buildings	7
R&D Buildings	2
Laboratory Buildings	3
Warehouses	2
Administration Buildings	3
Utility Buildings	6

Figure 22: GSK Cork Facility

Table 4: GSK Cork Building Breakdown

3.3 GlaxoSmithKline (GSK) Energy Users

Energy consumption in GSK can be accounted for through the use of electricity and gas. Water is also another related user (in terms of cost) but for the purposes of this study it is not assessed as it is not relevant to the I.S. EN16001 standard. Table 5 give a breakdown for the overall energy use for electricity and gas on the site in 2009 which accumulated to 268,047GJ for the site overall.

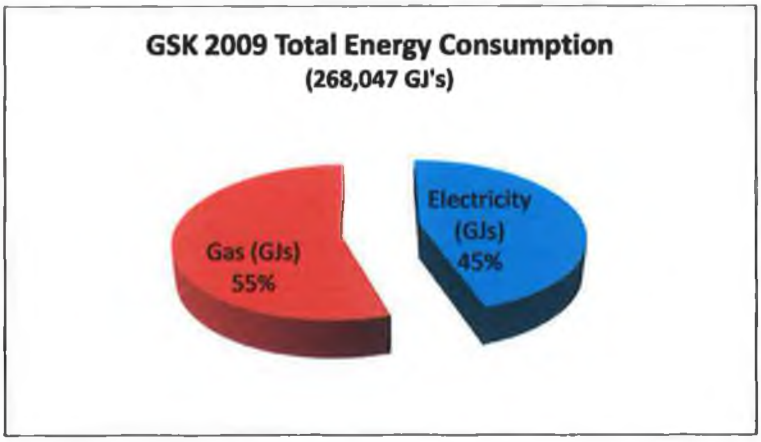

Table 5: Electricity and Gas Consumption for GSK in 2009

Gas (55%) was the biggest energy user in 2009 on the GSK Cork site. However, in the previous year electricity had the majority share of usage with 53%. The reason the bigger user has shifted is due to efficiency measures identified and implemented during 08/09, these measures where identified through two operational excellence events carried out within GSK analysing all aspects of energy usage on site and identifying energy saving projects, and Also GSK's commitment to the SEAI EAP (see section 2.7.1) in order to implement the IS393 energy management standard. Both Electricity and Gas users are outlined below for the GSK Cork site in section 3.3.1 and 3.3.2.

3.3.1 Electricity Users

As seen from table 5 electricity accounted for 45% of energy usage in 2009. There are 3 categories for electrical energy usage in the site, motors for utilities and processes, lighting within the site and general power (E.g. plug in equipment such as computers). The following is a breakdown of each user.

Motors

As seen from section 2.6 motors are used in nearly all major energy users in a pharmaceutical facility. Motors are used for HVAC fans, process vessel agitators, pumps, compressed air compressors, and refrigeration compressors. GSK currently has 1737 motors on site, these motors range from as little 1.1 KW for supply air fans to large 315 KW compressor motors. The majority of motors are used for HVAC and pumping, these account to 78% of the overall motor electrical consumption. Various process motors make up the remaining 22%, the breakdown and percentages can be seen from table 6 and 7.

Row Labels	Count of Motor Type
Agitator Motor (AGM)	184
Compressor Motor (CPM)	41
Fan Motor (FNM)	522
Hydraulic Unit Motor (HUM)	26
Mill Motor (MLM)	18
Pump Motor (PM)	836
Reactor Filter Motor (RFM)	9
Sieve Motor (SIM)	22
Vacumm Pump Motor (VPM)	79
Grand Total	**1737**

Table 6: Motor Breakdown for GSK Cork

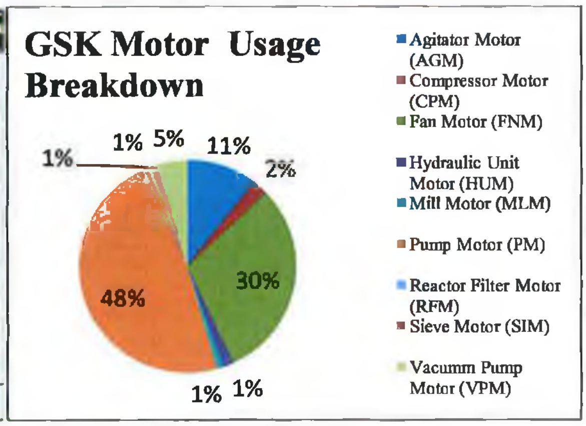

Table 7: Motor Type Percentage

It should be noted that not all 1737 motors are in operation 24/7. Process motors and pumping motors are only in operation if and when required. However, as of 2007 motor usage alone accounted for over 80% of electrical usage on site per annum [39]. Examples of the motor types used in GSK cork can be seen from figure 23, more examples can be seen in appendix D.

Figure 23: Examples of Motors on Site, Fan, Vacuum, Agitator and Compressor Motors [43]

Lighting

Lighting in GSK accounts for 2,421MWh at a given time as seen from table 8 [39]. This is the maximum load but is rarely ever realised as not all lighting in the site is on at the same time. Overall the site has 6,103 lighting units on site. From table 8 the lighting breakdown for the site by buildings. The main lighting fixture in the site are Ex-rated T8 fluorescent lighting used in process buildings, this accounts for 5321 lighting fixtures ranging from 600 – 1800 W.

The second highest light fixture used on site is the T5 fixtures which are used in administration. As seen from section 2.6.8 the T5 fixture is 40% more efficient than the T8 equivalent, however T5, are yet to attain an Ex-rating so they are not suitable for process buildings. Examples of T8 and T5 lighting fixtures in GSK can be seen from figure 24. The remaining lighting fixtures on site are made up of 88 sodium lights (SON) for warehouses and 97 spot lamps for office desk use. Average overall lighting consumption accounts for approximately 4.5% of the site electricity usage per annum [39].

Lamp	Type	Spot	Fluorescent					SON	Total		
	Size	35	T5	600	1200	1500	1800	400			
Lamp power W		35	14	18	36	58	70	400			
Circuit losses / lamp W			1.5	5	9.5	14	14	31			
Total lamp power W		35	15.5	23	45.5	72	84	431			
Building									No	kW	MWh
101	No.			162	816				978		
	kW			3.7	37.1					40.9	358
120	No.				174				174		
	kW				7.9					7.9	69
6001	No.			28	128				156		
	kW			0.6	5.8					6.5	57
7001	No.			58	32	382			472		
	kW			1.3	1.5	27.5				30.3	265
7002/7003	No.			8		188			196		
	kW			0.2	0.0	13.5				13.7	120
35	No.			116	44	228			388		
	kW			2.7	2.0	16.4				21.1	185
Restaurant and QC	No.			588	584				1,172		
Lab	kW			13.5	26.6					40.1	351
R&D Lab	No.		100	180	14				294		
	kW		1.6	4	1					6.3	55
Central milling	No.			134	122	48			304		
	kW			3.1	5.6	3.5				12.1	106
Warehouse and	No.			24	67	163			254		
Dispensary	kW			0.6	3.0	11.7				15.3	134
Building 36 Utilities	No.			238	46	138			422		
	kW			5.5	2.1	9.9				17.5	153
South Warehouse	No.			20	12	36	36	63	167		
	kW			0.5	0.5	2.6	3.0	27.2		33.8	296
Kaisan and tech Ops	No.	97	507	135	132	16			887		
	kW	3.4	7.9	3.1	6.0	1.2				21.5	188
EMC inc incinerators				62	32	130		15	239		
& solvent recovery	kW			1.4	1.5	9.4		6.465		18.7	82
			Total						6,103	286.0	2,421

Table 8: Lighting Breakdown for the GSK Site by Building [39]

Figure 24: T8 Process Lighting Fixture & T5 Office Lighting Fixture [43]

General Power

General power is defined as the electricity used on site for administration offices, workshops, laboratories, warehouses, contractors compound and the canteen. This mainly consists of plug in appliances such as computers, phones, printers, scanners, photocopiers, laboratory bench equipment, projectors, televisions, electronic storage units, fridges, workshop equipment and tools etc. For example, there is approximately 1045 active PC's and Laptops on site which accumulated together over a period of time is quite a substantial energy user. The average overall general power consumption accounts for approximately 8% of the site electricity usage per annum [39].

3.3.2 Gas Users

As seen from table 5 gas accounted for 55% of energy usage in 2009. Gas is used in two applications on the site. The first application is to provide fuel for the boilers in order to generate steam for the site. The second application is for the incinerators which are used to dispose of process and solvent waste generated on site. The following is a breakdown of the gas users on site.

Boilers

Steam is distributed to 15 site buildings on site for process and HVAC requirments. There are three boilers used on site used to generate steam. Two of the boilers are directly gas fuelled while the third boiler is a Waste Heat Boiler (WHB) which is fuelled by the waste heat generated from incineration. This means that the flue gas from the incineration process is passed through a boiler to utilise the waste heat in order to generate steam with no additional cost. The fuel used in this boiler is directly associated with incineration fuel requirements. Table 9 describes the boiler types and associated steam output on site.

Boiler Technical Identification No	Fuel	Design Output	Actual Output
		kg/hr	kg/hr
BO1931	Waste Heat Boiler	14,000	8,118
BO2002	Natural Gas	9,072	8,398
BO2003	Natural Gas	13,608	12,597
Site Steam Capacity		**36,680**	**29,995**

Table 9: Steam Boilers Description and Specification [39]

Currently Steam is supplied throughout the site via a common header. The three boilers are all connected to the header. BO1931 is the lead boiler on site as it is a WHB and should be maximised, BO2003 is the secondary boiler with BO2002 is used as emergency backup only when required. Figure 25 shows pictures of each of the three boilers, note on BO2002/03 the cream coloured gas supply line.

Figure 25: Boiler 2002, Boiler 2003, and Waste Heat Boiler 1931[43]

Incinerators

Incineration is the high temperature rapid combustion or burning of a substance in the presence of excess oxygen [44]. Incinerators on site are used to dispose of hazardous process waste and solvent waste. There are two active incinerators on the GSK site, one for non-salty waste streams and the other for salty waste streams. The incinerators are identified as Incinerator No.1 (IN1951) (Salty Waste) and Incinerator No.3 (IN1953) (Non-Salty Waste), these can be seen form figure 26. The incineration capacity can be seen from table 10 below. The Waste Heat Boiler (WHB) is interconnected to the non-salty waste incinerator as the salty waste stream leaves residues which cause inefficiencies in the WHB. In order to achieve optimal combustion each incinerator needs to reach a temperature of 1150^{O}C.

Incinerator	Waste Type	Burning Capacity (tonnes/annum)
IN1951 - No.1	Salty	6,000
IN1953 - No.3	Non-Salty	10,000
Overall site Incineration Capacity		**16,000**

Table 10: Incinerator Capacity Information [39]

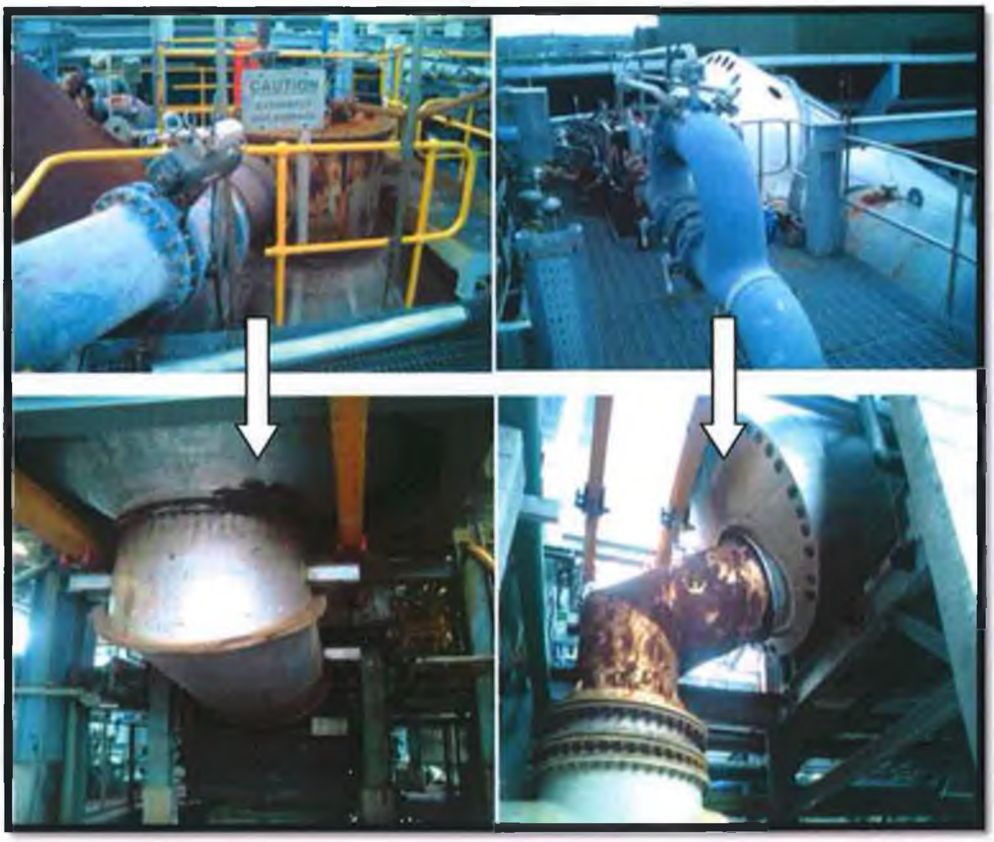

Figure 26: Incinerator No.3 & No. 1 Top and Discharge Images

3.4 GlaxoSmithKline (GSK) Energy Management System History

On the 08th January 2007 GlaxoSmithKline (GSK) Cork entered an agreement with SEAI to implement the I.S.393 Energy Management Standard. The agreement outlined the principles for participation in the Energy Agreement Programme over an initial 3-year period. GSK committed to the following actions and policies outlined by the I.S.393 standard during year one of the Agreement Period (May 2006 – May 2007) in order to maximise energy efficiency and reduce energy costs and related emissions. These included implementing:

1. [name], [position] of the senior management responsible
2. [name], [position] of personal assigned with the day-to-day responsibility
3. Commit to devoting adequate financial support to the EAP

GSK implemented these agreed criteria's over the initial 1 year period (some of these measures are described in section 3.5.2). GSK continued in their commitment to implement I.S.393 in year 2 and started integrating an energy management system into site facilities in order to enhance energy performance and achieve accreditation. Once informed of the impending publishing of the BSi EN16001(published in July 2009) GSK where advised by SEAI to keep implementing the energy management system as per I.S.393 and this will lead to achieving the BSi EN16001 accreditation once published. This was because the BSi EN16001 superseded the IS393 as part of the EAP, and became known in Ireland as I.S. EN16001 and also represented a better quality energy management system and a more internationally recognised accreditation. GSK is continually following the criteria for implementation of I.S. EN16001 since initially registering for EAP in January 2007 and is scheduled for I.S. EN16001 certification audit in December 2010 to achieve accreditation.

The following section 3.5, analyses how the criteria for I.S EN16001 is implemented in GSK, Cork

3.5 Implementing I.S. EN16001 in GlaxoSmithKline Pharmaceuticals, Cork

The I.S. EN16001:2009 Energy Management Standard has been developed to help organisations to improve their energy efficiency in a logical, controlled and systematic way, thereby saving energy and reducing costs. The standard is focused on promoting the analysis of energy usage data, and identifying the exact locations, times and underlying reasons behind current and past energy use, so that an organisation can accurately identify, understand and prioritise opportunities for improving energy efficiency [37].

The EMS system criteria above is documented as part of I.S. EN16001 through the generation of a site energy manual. The energy manual outlines how a company will meet the requirements of the energy management system it adheres to, the steps involved getting there, and how it will achieve continuous improvement in energy efficiency. How these steps where put in place and achieved for the GSK Cork site are analysed in sections 3.5.1-3.5.4.

3.5.1 Energy Policy (Plan)

One of the main criteria for I.S. EN16001 is the development of an energy policy. According to section 3.2 of the I.S. EN16001 standard, an energy policy states the organisations commitment for achieving improved energy performance and the top management shall ensure that the energy policy is adhered to [9]. This is done through 3 specific commitments:

1. To continually improve energy efficiency
2. To ensure the availability of information and of all necessary resources to achieve objectives and targets, and
3. To comply with all applicable requirements (legally or voluntarily agreed by the organization. [37]

GSK set about developing the site energy policy by following the structure identified in the I.S. EN16001 standard. This involved the site energy champion and site management team. They needed to define the scope and boundaries of the energy management system and tailor this to the scale of GSK Cork's energy usage. A framework then needed to be put in place for setting and reviewing energy objectives and targets, this ensured energy efficiency would be continually improved and resources available to achieve the targets. Once the framework was complete all applicable requirements either legal or voluntary related to energy aspects of the site needed to be reviewed and agreed to by the top management. Once these parameters where identified the GSK energy policy was drafted.

The policy was originally drafted by the site energy champion. The draft policy was regularly reviewed and edited through email interaction between the GSK site director, engineering director and energy champion until they had properly defined the GSK energy policy. The GSK Cork site energy policy can be seen in Appendix A.

Annually the energy champion presents the existing policy and any relevant issues to the site leadership team in order review and update. Section 3.5 aims to show how GSK set about implementing and maintaining the criteria agreed to in the site energy policy.

3.5.2 Steps Involved to Implement I.S. EN16001 (Do)

Integration of the energy management standard is designed to follow the same structured 'Plan, Do, Check, Act' approach common to all ISO management system standards. By adopting 'Plan, Do, Check, Act' technique the standard is readily integrated with other common international business standards such as ISO 9001 and ISO 14001 noted in section 2.6 of this paper. The following is an overview of each procedure:

Planning EMS: *(Plan)*

1. Formally identify and understand current energy usage by analysing your energy usage, factors and equipment.
2. Identify which opportunities for improvement can be realistically achieved, given any requirements for payback and the resources available.
3. Schedule a programme of work to ensure that the potential benefits identified in the opportunities for improvement will be realised.

Implementing EMS: *(Do)*

Next, implement a plan of work to realise the identified objectives and opportunities for improved energy efficiency.

Checking EMS: *(Check/Act)*

The organisation needs to monitor and measure the progress made in performance against the energy objectives and the requirements of the management system.

Review and act: *(Check/Act)*

The standard requires that top management review the EMS at planned intervals. The purpose of this is to ensure continuos improvement of the system and to ensure that the system, plans, programmes and personnel all operate in line with policy. The senior management team can use the performance statement as a means of assessing the progress achieved to date and schedule new or updated objectives and targets for the future. [38]

The following 7 steps show how GSK implemented these criteria's into the site and what systems are used to ensure these processes are being continually upheld.

Step 1: Identify the Past and Present Energy Usage on Site *(Plan)*

The first step was to identify the past and present energy usage on site. In order to achieve this GSK had to install an energy monitoring system for the site. GSK launched a project for implementation of the GSK Cork Energy Monitoring system.

The system installed is developed by Rockwell Automation, it is a web based energy management software called RSEnergyMetrix, this means the energy monitoring system can be accessed and reviewed from the GSK internet database. The software can collect data from a variety of remote devices (Voltmeter, Ammeter and Flowmeters) and place the data into a database. The software has a reporting engine that allows the user to view and generate chart data and run reports.

In order to ensure the energy monitoring system worked correctly GSK needed to install and commission remote devices such as ammeters and voltmeters for electrical metering and flow meters for gas, steam, refrigerant and compressed air metering. A lot of these meters already existed on the site but where never commissioned but also additional meters were retrofitted into the site. Once complete these where all linked to the GSK database and RSEnergyMetrix. The system was fully commissioned in 2009 throughout the site (i.e. each building or energy user). Overall electricity and gas usage metering for the site was available from 2007(i.e. electricity in and gas in at the mains).

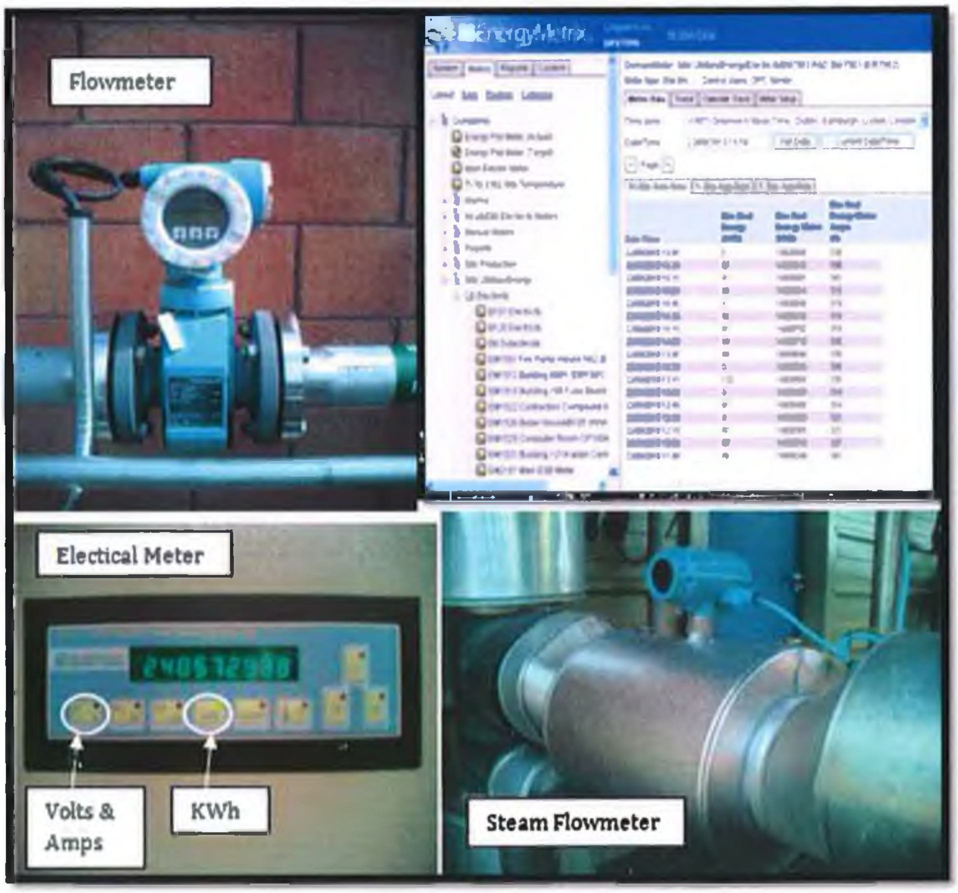

Figure 27: Energy Monitoring System & Energy Metering Devices

Figure 27 shows some examples of the metering devices used on site. The data from each meter is recorded at 15 minute intervals 24/7 and stored in a database. This information is then analysed using the RSEnergyMetrix seen above. The software can generate hourly, daily, monthly, annual reports and charts depending on the criteria and circumstance required. Using the RSEnergyMetrix energy metering software and usage information identified from audits carried out by energy consultants, GSK identified the past and present energy usage for 2006 and 2007 on site, also an estimate for energy usage in 2008. These can be seen from Table 11 on the following page:

Energy User	Year	Consumption	Unit	Unit Cost €/Unit	Annual Cost €
Electricity	2006	52,488,000	kWh	0.09	4,704,406
Gas	2006	47,800,254	kWh	0.033	1,572,009
Total		100,288,254	kWh		6,276,415

Energy User	Year	Consumption	Unit	Unit Cost €/Unit	Annual Cost €
Electricity	2007	52,663,589	kWh	0.10	5,266,359
Gas	2007	41,607,685	kWh	0.033	1,365,893
Total		94,271,274	kWh		6,632,252

[illegible]					
Energy User	Year	Consumption	Unit	Unit Cost €/Unit	Annual Cost €
Electricity	2008	51,386,225	kWh	0.11	5,652,485
Gas	2008	46,440,112	kWh	0.039	1,718,284
Total		97,826,337	kWh		7,463,649

Table 11: Overall Energy Usage for GSK Site 2006, 2007 and 2008

Once these estimates were completed, GSK assessed the energy usage situation and went about planning for improved efficiency. This is outlined in step 2.

Step 2: Identify the areas of significant energy usage (Plan)

In order to identify the areas of significant energy use GSK needed to generate an energy map of all the energy users on site to see where the energy was being used. In 2007, a UK based energy consultancy CMR where contracted to identify the Significant Energy Users (SEU's) on the GSK site and make recommendations for energy efficiency opportunities. From this information the energy map was developed. The initial energy map development was based on an extensive site survey and supported by detailed analysis and corroboration of data recorded for the sites various energy systems. The resultant tree diagram (energy map) identified the main site energy users for electricity and gas in terms of where the energy was going, and how much energy is being used. The 2008 energy map can be seen from table 12.

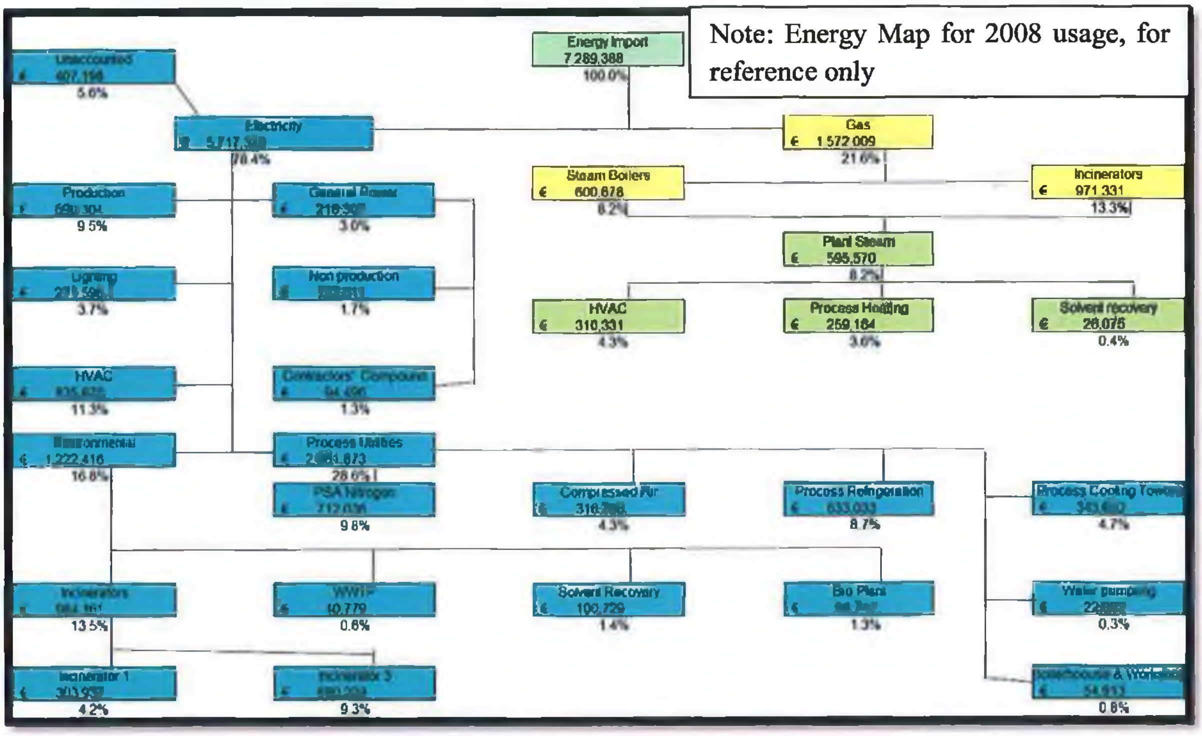

Table 12: GSK Cork Site Energy Breakdown [38]

From analysing the table 12 it can be seen the overall energy import is divided into the main energy users on site, electricity and gas. This is then further subdivided into the energy user for each energy source.

Electricity usage is subdivided into 6 categories, Production, HVAC, Environmental and Process Utilities all powered by motors and General Power, and Lighting. These categories are then subdivided again, where applicable, to show the area or equipment energy usage within that category. The same criteria was followed for gas but this is a lot smaller spread as gas is only used to fuel two site applications, the boilers for steam and incineration for waste disposal and steam. As the Waste Heat Boiler (WHB) is connected to incinerator No.3 (IN1953) plant steam is generated by both incinerations and the boilers.

Once this level of mapping was achieved GSK set about applying their metering down another level, (i.e. finding out the quantity of energy being used in each building so they can define the biggest users), this requires an efficient energy management system but will ensure GSK can analyse all energy aspects of the site from the top, down. The sankey diagram seen in table 13 shows an example of a building electricity usage map generated for the GSK site.

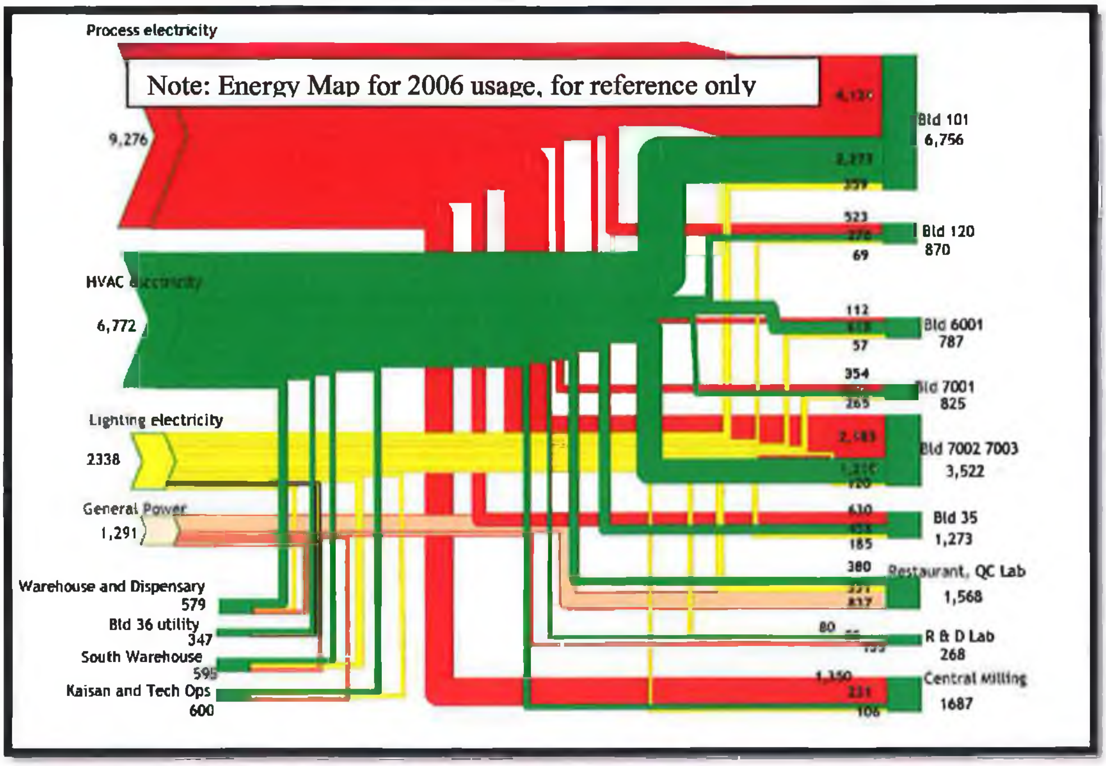

Table 13: Electrical Energy Mapping by Building (Units in MWh) [38]

The sankey diagram above categorizes electricity usage into four categories, process electricity, HVAC electricity, Lighting electricity and general power. The sankey diagram shows the energy distribution to different site buildings and the MWh usage associated. GSK have also developed sankey diagrams for the electricity system overview, Gas, Incinerators and steam distribution, and for site steam distribution [39].

Upon identifying the significant energy users within the site the potential energy opportunities were derived and assessed in order to reduce energy consumption.

Step 3: Identify opportunities for improvement (Plan/Do)

Based on the data and analysis carried out to determine the GSK Cork SEU's, GSK conducted internal events to determine opportunities for reducing energy usage instead of following the energy management standard criteria. GSK decided to adopt this approach as the energy management standard implementation process became quite time consuming and the GSK Cork site felt energy saving opportunities where passing them by. However, adopting there own approach proved to be the most effective procedure towards implementing energy saving projects in GSK Cork.

In order to generate a structure for identifying energy saving opportunities GSK organised two energy opportunity events. These events where co-ordinated and designed by the GSK Operational Excellence Team (OE) in order to evaluate GSK Corks energy status and accelerate the process for identifying energy saving opportunities. Both events analysed energy usage and project opportunities in a highly technical and economic manner as not to leave any stone unturned. These events where called the Baseline Event and the Kaizen Event.

Baseline Event

The initial event known as the "Baseline Event" was held in February 2009 and lasted for 3 working hour days. The event attendees consisted of 20 staff members from cross functional departments and different levels within the site, including engineering, technical development, OE, Operations Planning, Environmental, Health and Safety, Capital and Projects Engineering, Operations and external CMR energy consultants. The event goal was to review the current energy status within GSK and identify the quick wins in order achieve savings soon as possible. Table 14 shows the agenda for the event and how GSK identified short to medium term projects

Table 14: Baseline Event Energy Saving Agenda

From the baseline event GSK came to a common understanding of the energy usage in the Cork site. Also, savings targets where identified and short to medium term energy saving projects were identified and prioritised with the already in place ongoing projects in order to exploit quick energy savings. Some of these efficiency projects included, reducing utility setpoints, better electricity and nitrogen usage management, and chiller optimisation by reducing the chiller capacity. The baseline event enabled GSK to analyse there energy consumption and put a plan in place for that particular time. However, GSK needed to generate a long term savings plan in order to maximise the potential for energy saving on site. This was done through the second event known as the Kaizen Event.

<u>Kaizen Event</u>

The kaizen event was held in June 2009. The kaizen event attendees consisted of 41 staff members from cross functional departments including top management. The goal from the Kaizen event was outline specific energy reduction targets and identify a 3-4 year energy saving project schedule in order achieve these targets. The agenda for the kaizen event was to, review the key energy facts for GSK cork, identify strategic energy supply projects, identify energy usage reduction projects, analyse the level of the tiered metrics system (RSEnergyMetrix), outline the available resources for energy saving projects, and the hurdles that will need to be overcome. In order to achieve the agenda GSK implemented a 3 day event plan to cover each agenda issue, this can be seen from table 15.

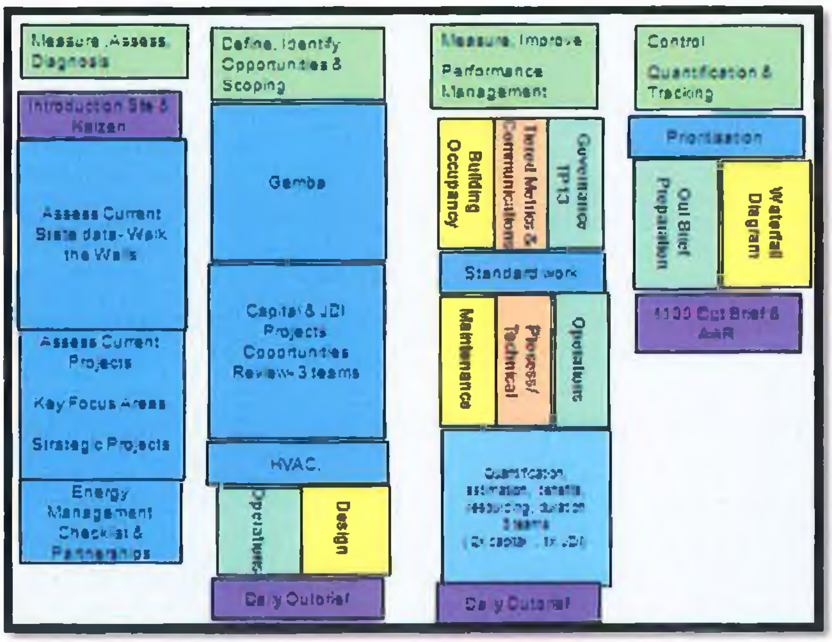

Table 15: Kaizen Event Energy Saving Agenda

The kaizen event identified a 3 year energy saving project plan for GSK. All the identified opportunities for potential energy savings where assessed before each opportunity was finalised for implementation (i.e. payback and energy reduction). GSK also identified some key issues towards energy management on site, these include limited staff awareness of site goals and limited building ownership at user level. These are analysed further in the following sections.

The base line and kaizen events proved to be very successful for GSK as they identified opportunities for the site in 2009 meaning accelerated energy savings could be achieved in the short term, while continually working on implementing an established energy management standard. Although, the GSK events are not sustainable towards implementing long term energy management system and continually reducing energy they did create a framework for implementing energy saving opportunities in GSK. The framework is described below.

<u>Development of the Waterfall Energy Saving Project Plan</u>

Using the identified opportunities from the Baseline and Kaizen events, GSK went about developing a framework in order to implement the energy saving projects. This was done through the development of a waterfall diagram listing all energy saving projects, there potential energy savings and cost savings and a timeframe to implement these projects. The waterfall diagram is split into a 3 year timeframe and represents GSK's energy saving project plan to achieve an overall energy reduction of 40%. The waterfall diagram for both energy and cost reduction can be seen from table 16 and 17 below:

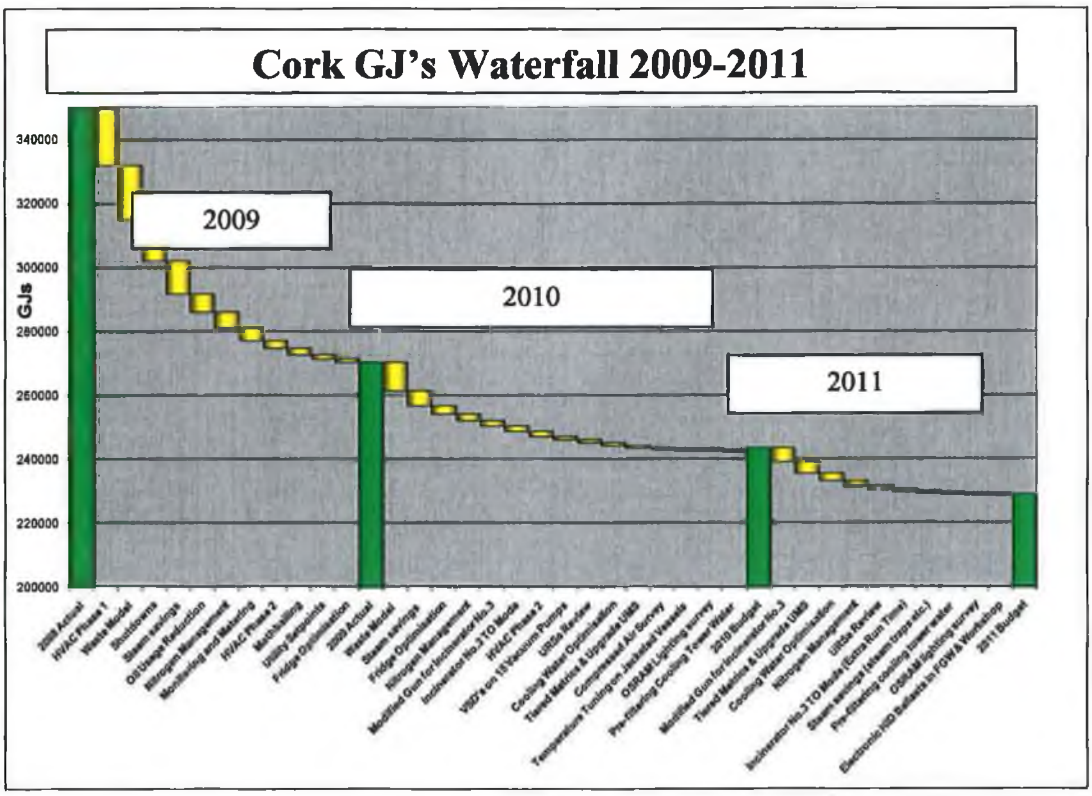

Table 16: Cork GJ's Waterfall 2009-2011

The green columns on the diagram represent the overall (Electricity and Gas) estimated energy expenditure for each year starting with the final site energy expenditure for 2008 (342,218 GJ's). The yellow columns represent the Gigajoule (GJ) saving over the year from the implementation of the corresponding efficiency project listed on the x-axis.

There were 10 energy saving projects accumulating to energy savings of 72,000 GJ (20,000,000 kWh's) in 2009. For 2010, 15 energy saving projects will be implemented accumulating to energy savings of 27,000 GJ (7,500,000 kWh's). For 2011, there will be 11 energy saving projects in order to realise energy savings of 13,000 GJ (3,620,000 kWh's).

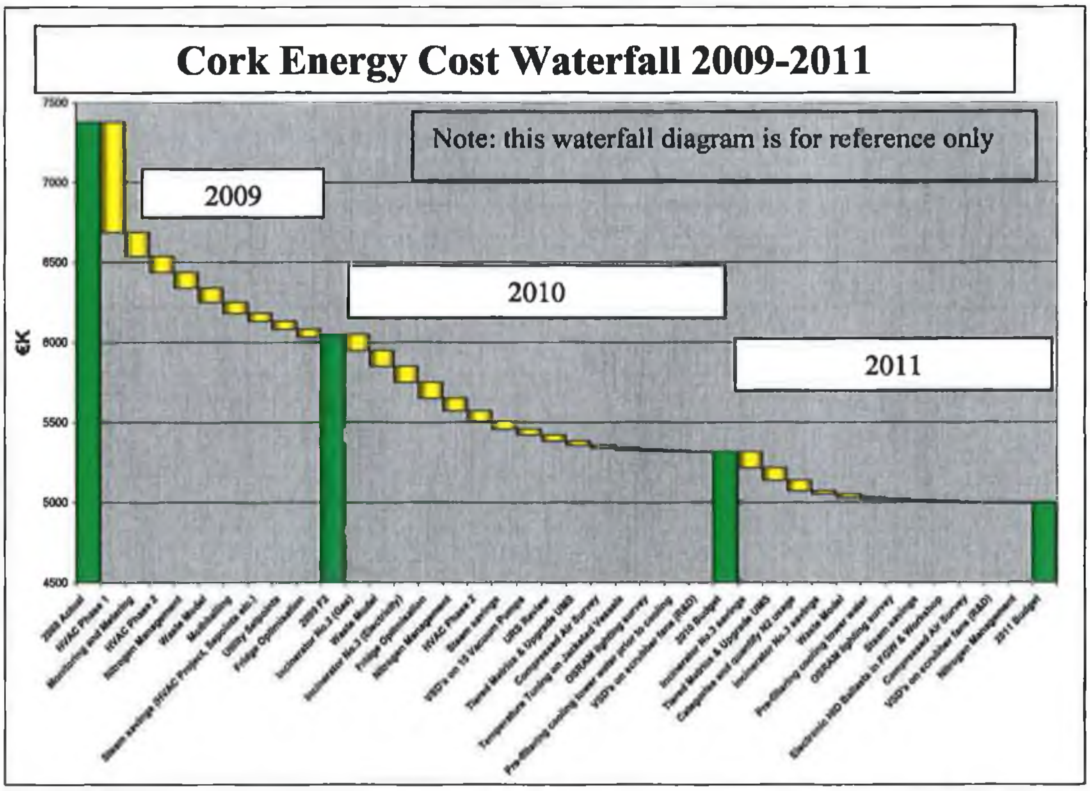

Table 17: Cork Energy Cost Waterfall 2009-2011 (€K =, 000)

From table 17 and 18 the potential cost saving of €2,437,000 million and 31,120,000 kWh's from project implementation are the identified energy and cost saving opportunities over the waterfall period. The most savings are identified in the initial year 2009, this is because the most obvious saving opportunities are identified initially and these tend to have the biggest savings. As the waterfall progresses further less saving potential is realised as it becomes more difficult to find saving opportunities.

Waterfall Projects Energy Saving Potential					
Year	Predicted Usage	No of Projects	GJ Saving	KWh Saving	Cost Saving €
2008	342,000	N/A	N/A	N/A	N/A
2009	270,000	11	72,000	20,000,000	1,400,000
2010	243,000	15	27,000	7,500,000	600,000
2011	230,000	10	13,000	3,620,000	437,000
Overall GJ, kWh & € Reduction			112,000 GJ's	31,120,000 kWh	€2,437,000 million

Table 18: Energy Saving in GJ, kWh and Euros

Monthly, the energy team and capital projects team assess the potential energy saving opportunities in the site, this ensures all possible saving potential is realised. Site circumstances change quite regularly due to manufacturing demand, leaving opportunities for savings on a continuous basis. These opportunities are stored on the register of opportunities for improvement within the site. Once an opportunity is assessed and confirmed by top management, it is inputted into the waterfall chart for implementation. This means the waterfall chart is a live document and is regularly updated in order to show all energy efficiency opportunities continuously.

Step 4: Predicting future energy usage (Do)

GSK predict energy usage for both electricity and gas in order to define energy performance from year to year. Different models are used to evaluate the two energy types as they operate under separate conditions.

Electricity

Electricity usage trends are quite constant within the GSK cork site, this is because manufacturing is ongoing in the site so the required electrical base load only fluctuates slightly, except for pre-planned site shutdown in summer and winter. Even if manufacturing increases it is easy to predict how it will affect the electrical load as data is available from previous timeframes when the increased manufacturing occurred. Using this information GSK predict a daily electricity usage trend chart for the year and also a cumulative electrical energy consumption rate chart in order to see if they are above or below energy performance and within the site electricity budget.

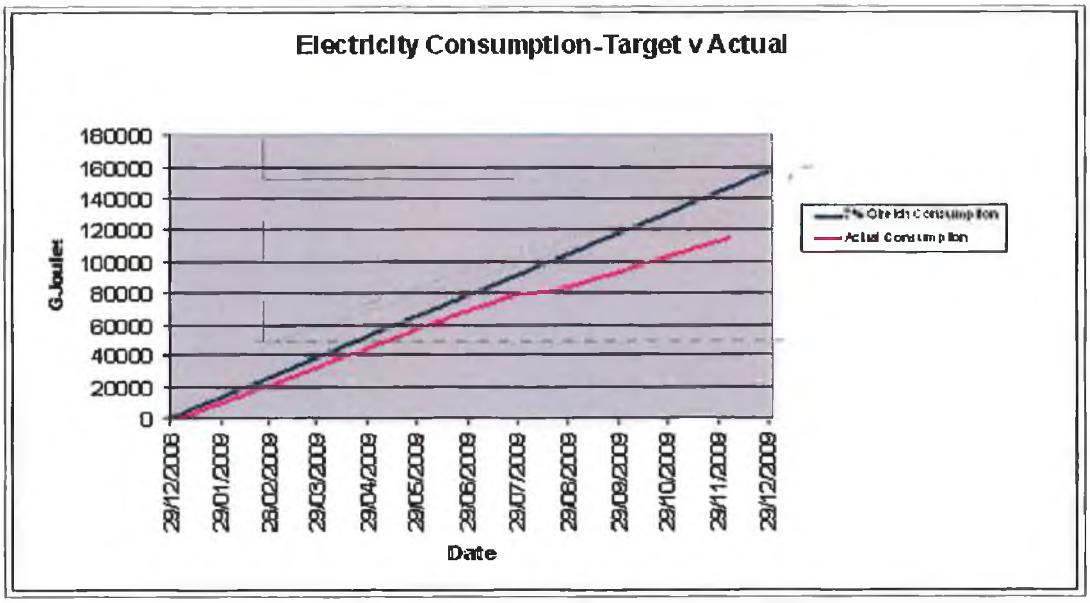

Table 19: Electricity Actual Consumption vs. Target Consumption 2009

Table 19 shows GSK's cumulative predicted electrical consumption chart for the 2009.The blue line highlights the cumulative target energy consumption set by GSK for the year. The pink line represents the actual cumulative electrical energy used for the year. Electricity consumption ran linearly under the target up to July, this reduced further due to shutdown and energy saving projects at the start of August and continued at this trend for the rest of the year. Overall this represented a 30,000 GJ better performance than the target consumption for 2009. GSK also analyse the daily usage trend chart in order to assess performance from various consumption standpoints.

Gas

Gas predictions are developed by analysing site production plans in order to estimate the annual waste volumes to be burned in the incinerators. By predicting the waste volume GSK can determine which incinerator will be used at a given time of year. Also the site steam demand is predicted depending on the time of year (i.e. less steam is required for HVAC in summer than winter). Ideally incinerator no.3 (IN1953) is utilised as often as possible as it has a larger capacity and is capable of producing steam from the Waste Heat Boiler (WHB). This reduces the amount of gas required for the boilers as the steam demand is substantially achieved through the incineration process.

A prediction model, designed in MS Excel, is used to input the predicted waste (salty or non-salty) quantities and steam demand for the year. From this data the site energy and environmental team plan a program of incineration to facilitate best usage of the gas fuelled equipment to burn waste while achieving the required steam output for the site. Once the program is developed the energy and environmental team can determine the quantities of gas required to meet the gas combustion program at different stages throughout the year.

This information is then used to predict a daily gas usage trend chart for the year and also a cumulative gas energy consumption rate chart in order to see if gas is are above or below energy performance and within gas budget.

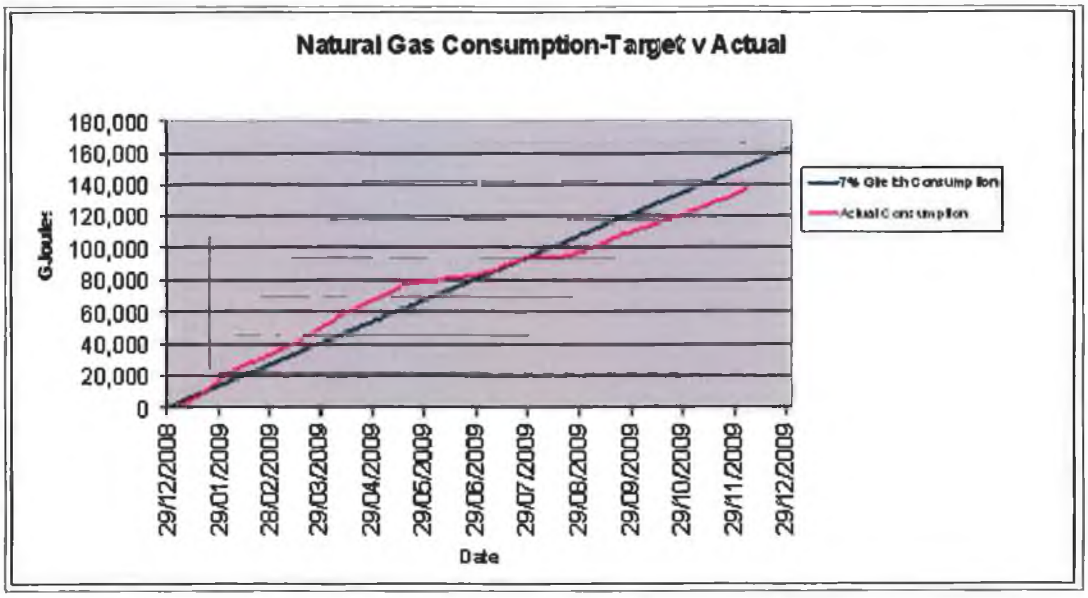

Table 20: Gas Actual Consumption vs. Target Consumption 2009

Table 20 shows GSK's cumulative predicted gas consumption chart for the 2009. It follows the same criteria as table 19 for electrical usage. Analysing table 20 shows GSK gas performance is over the target for the half of the year, performance again improved post shutdown improving overall site performance by approximately 10,000 GJ by the end of the year.

Both the electricity and gas daily usage trend charts for 2009 can be seen in Appendix B.

<u>Step 5: Identify personnel who have a significant impact on energy usage</u> *(Check/Act)*

The roles and responsibilities of all individuals with respect to energy usage must be clearly defined and documented as part of I.S. EN16001. This includes those who have either a direct or an indirect effect on energy usage, such as staff involved in operating processes and equipment, technical staff involved in maintenance or design engineers responsible for new processes or facilities. Table 21 highlights the categories of direct and indirect teams within GSK that have an effect on energy usage.

Team	Direct	Indirect
Capital & Project Engineering	X	
Commercial		X
Engineering Operations	X	
Environmental, Health & Safety	X	
Human Resources		X
Information Technology		X
Management	X	
Operational Excellence		X
Operations	X	
Operations Planning	X	
Procurement Agile		X
Quality	X	
R&D - Quality		X
R&D Pilot Plant	X	
Servers, Data Centres & Storage	X	
Technical Development	X	
Energy Contact Companies	**Direct**	**Indirect**
BOC	X	
Systems Optimisation Ltd	X	
Eirdata	X	

Table 21: Identification of Direct and Indirect Personal within GSK

Depending on the team involvement, be it direct or indirect, specific training requirements are carried out in order to enhance energy awareness and introduce energy efficient working techniques. Indirect users receive general energy awareness communication training, this involves regular notice board awareness on plant performance and how to best perform their role in the company in an energy efficient manner. Direct users will carry out training tailored to their role within GSK, this involves Standard Operating Procedures (SOP) on significant energy users best practice techniques within their task responsibilities and how to best perform their role in the company in an energy efficient manner.

GSK also promotes communication between the energy generator teams on site (i.e. engineering and maintenance) and the consumers on site (i.e. process engineers and operations) to ensure personnel who have a significant impact on energy usage operate as efficiently as possible. The engineering department generate all the energy intensive utilities on site such as steam, compressed air and nitrogen and ensure these utilities run as efficiently as possible. However, these utilities are consumed by the process engineering and operations teams for manufacturing processes and if not used correctly will negatively impact on energy usage on site (e.g. If the compressed air system generates compressed air as efficient as possible from engineering yet the process engineer leaves multiple valves open for long periods when not required, this leads to wasted energy). This concept is known as the Generator – Consumer usage within GSK. These teams are significant energy personnel which are targeted in order to promote better energy usage relations on site.

***Step 6: Identify Legal Obligations** (Check/Act)*

One of the clauses of I.S. EN 16001 is that GSK ensure they comply with all energy related legislation and other requirements which are applicable to their energy aspects, such as:

- National legal requirements
- Emission trading requirements
- Product energy-efficiency requirements
- Non-regulatory guidelines
- Voluntary agreements and codes of practice

These obligations are currently being identified for the GSK I.S. EN16001 audit. For this reason they are not discussed within the scope of this project.

***Step 7: Setting Goals and Targets** (Check/Act)*

EN16001 requires organisations to identify and document objectives and targets for improving energy efficiency at relevant operating levels. GSK Cork achieves this by identifying annual energy use and cost budgets, and challenging targets aligned with GSK targets. GSK set their goals and targets using the SMART model – **S**pecific, **M**easurable, **A**chievable, **R**ealistic and **T**arget-driven. Using the prediction trends indicated in step 4 of section 3.5.2, and the predicted energy reduction through project implementation GSK develop goals and targets for annual energy reduction. The energy management team identify realistic targets in terms of Gigajoule percentage reduction (for Gas & Electricity together) for each year based on previous performance and future project implementation. These targets are then graphically represented to assess performance throughout the year. This can be seen from table 22.

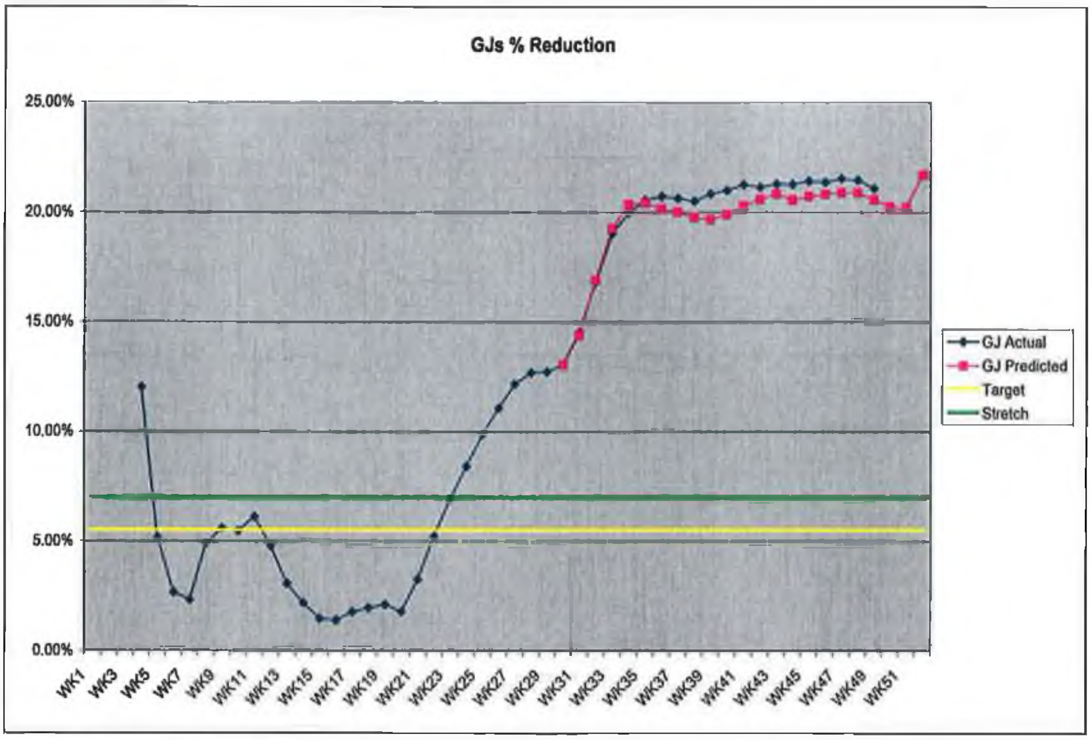

Table 22: GJ percentage target and performance in GSK for 2009

The yellow line represents the target improvement (6%) for the GSK cork site in 2009, table 22 shows a plot of the energy performance throughout 2009 (blue line). If the blue line moves above the yellow line the site is performing above target and if the blue line is under the yellow line the site is underperforming. How much above or below the target depends on the percentage figure on the y-axis. From table 22 it can be seen GSK's energy performance from week 5-week 21 is below the target reduction for the year, this however was expected due to the delayed arrival of energy saving projects coming online. Once the projects were online GSK started to move above the target performance line (yellow) and the actual energy performance for the year accumulated to 23% improvement on the previous year's energy consumption.

3.5.3 Implementation and Operation (Check/Act)

GSK currently has in place a system of resources to establish, implement, maintain and improve the energy management system. This system provides a structure to include skill sets, company organisation, available technology and financial resources.

One of the prime responsibilities of the site energy champion is to ensure that the energy management system activities are adequately resourced in line with the energy policy. This means identifying the roles and responsibility within GSK and ensuring awareness, training and competence is up to standard for continual improvement.

However, implementation is not only technically orientated but a strong communication system is required in order to continually assess site performance and daily activities affecting energy usage. This is carried out in GSK through the Performance Management System.

How these criteria's are implemented into GSK is described below:

Resources, Roles, Responsibility and Authority

For each job title GSK have that identified a list the roles and responsibilities in terms of the energy management system (EMS), starting with the top level of management and working through the rest of the organisation.

The Roles and Responsibilities of Organisation Directors and Top Management are:

- Establish the Energy Policy
- Designate an Energy Management Representative and members of the Energy team
- Ensure adequate resources are available for the EMS to be implemented and maintained

The Energy Management Representative and Energy team is responsible for:

- Ensuring that the Energy Management System (EMS) is implemented and maintained
- Reporting on the performance of the system at the management review
- Providing recommendations for improvement at the management review

Manufacturing Staff will be responsible for:

- Adhering to the energy-efficiency sections of the applicable standard operating procedures
- Going about there day to day activities in an energy efficient manner

Awareness, Training and Competence

GSK introduced the first site energy awareness programme in July 2010 for all staff and contractors to ensure that all personnel working on-site are kept informed of energy related issues including the sites energy policy and energy management programme of activities. This is carried out through a Site Energy Awareness Day – An annual day for raising site energy awareness is arranged in conjunction with SEAI to promote energy awareness in the home and within GSK. For the 2010 site energy awareness day, GSK targeted home energy awareness amongst the staff, as they will have more consideration for their home energy expenditure and have more of an incentive to participate in the site energy awareness day. As part of the energy awareness day 2010 an energy based questionnaire was deployed to test employee perceptions, behaviours and attitudes toward energy.

This was put in place due to the findings from the kaizen event showing that GSK have limited staff awareness of site goals. The findings are analysed further in chapter 5. GSK intend to hold a site energy awareness day annually in order to continually promote awareness amongst employees.

Training requirements for staff in GSK are analysed on an annual basis. Energy training programmes are carried out for all members of staff and for other persons working on behalf of the organisation who have a direct or indirect impact on energy use. Training is carried out based on the task/operation and individual responsibilities of each person.

Communication

GSK Cork undertakes regular internal communications with regard to its energy performance and energy management system. The internal site communications is designed to encourage all employees to participate in improving energy efficiency and reducing energy consumption. Site communications are planned and overseen by the energy management representative. The channels of communications utilised for the GSK Cork site is through performance management.

Performance Management

Performance management involves activities to ensure that goals are consistently being met in an effective and efficient manner. Metrics are used as a mechanism to control and coordinate the performance management process. The reason metrics are used is because they tier down from cooperate to site operational level and create a shared understanding amongst all stakeholders of the overall desired performance result and defines all individual / team roles in the process. GSK energy usage and associated cost is monitored and reported upon through the Rockwell RSEnergyMetrix monitoring and targeting information system (noted in section 3.5.2). Performance relative to the energy targets is regularly monitored and reported from RSEnergyMetrix at a site, functional and building level.

Figure 28: Energy Performance Management Review Board at Building Level

GSK have a tiered system of performance reviews in place whereby site level energy performance reviews are conducted by the site energy champion and attended by a cross functional team members responsible for energy usage on a monthly basis. Here key aspects of energy management are reviewed and variances from targets trigger actions to investigate and identify users driving variances from expected usage. Figure 28 shows a typical performance management review board at building level. Figure 29 shows a typical performance management review board at site level. The output of the reviews is cascaded to all teams on site through monthly briefs and team meetings.

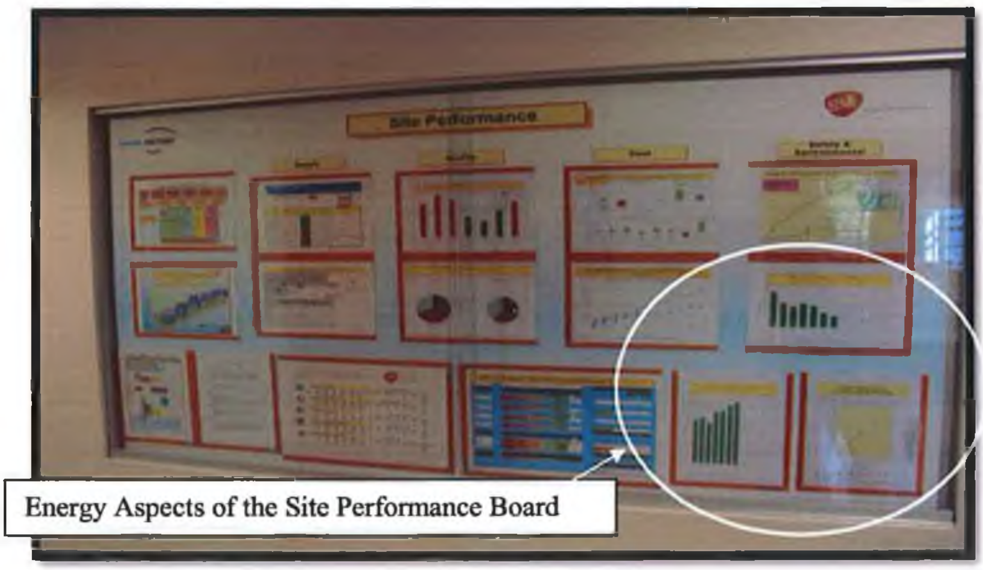

Figure 29: Performance Management Review Board at Site Level

At a functional level, the energy team track and report energy metrics on a daily /weekly basis to see if they aligns with site targets. Typically particular utilities or building level consumption is monitoring. These reviews are lead by middle management or team leads and engage with operational teams. Similar process of review and control applies at this level.

Operational Control

GSK have Standard Operational Procedures (SOP's) and controls in place to ensure that the level of energy performance is consistent with energy programmes, policies and targets. Operational controls within GSK include the specification, design, procurement, installation, operation and maintenance of significant energy utilising plant, facilities & equipment.

The information included in these documents includes the materials, quantities, operating ranges and limits, process safety considerations and energy efficient operating parameters set to ensure operational energy efficiency is maintained.

3.5.4 Review of EMS by Top Management for Managing and Improving the EMS (Check/Act)

The energy champion has the responsibility at GSK Cork to present to the Site Leadership Team at the beginning of each year a review of the previous year's performance in achieving the energy objectives and targets and outline the objectives for the coming year. The basis of the Energy Management Review is to define:

- Actions from the previous energy management review
- The status of the energy management programme and the extent to which energy objectives and targets have been met.
- Review GSK Cork's energy policy
- Summary of the energy performance of the GSK Cork site
- Results of energy assessments including the identification of energy aspects, the status of the implementation of improvements identified and the adequacy and effectiveness of the control measures implemented (waterfall chart framework).
- Projected energy consumption for the following period
- Recommendations for improvement
- Any other business.

Findings, conclusions and recommendations reached as a result of the energy presentation to the site leadership team and evaluation are recorded in documentary form outlining action items. This is carried out in the form of the minutes of the energy management review, which will be circulated to the relevant personnel. Another output from the management review is a summary performance statement that is established from the material in the energy management review presentation and the recorded minutes of the review.

3.7 Conclusion

It can clearly be seen GSK are implementing a solid energy management system around the Plan, Do, Check, act criteria of I.S. EN16001. By implementing the energy management system GSK are now very aware of the site Significant Energy Users (SEU's) in terms of electricity and gas. The installation and commissioning of the Rockwell RSEnergyMetrix enabled the site to identify and understand energy usage and past and present trends for the Cork site. This enabled GSK Cork to identify energy saving opportunities that can be realistically achieved on site and to develop a programme of projects to ensure that the potential opportunities are implemented on site.

However, there are inefficiencies in the Rockwell RSEnergyMetrix as some data meters tend to record escalated and inconsistent readings over random periods. This disturbs metering from a building and energy system aspect and leads to inaccurate result for actual consumption at building and energy system level. This inaccuracy is causing slowdown in GSK's plans to implement metering for every level of the plant (e.g., site level, building level, energy user level) and develop a more efficient energy management system. Also, the buildings owners that use these metrics may loose confidence in the monitoring system, this would act as a negative toward energy responsibility and awareness, and undermine the performance management system, making it non-productive towards driving energy consumption down. Until these meters are recalibrated GSK will not have a fully competent energy management system for all levels of plant energy usage.

The Baseline and Kaizen events proved to be extremely successful for GSK, for both benchmarking the site energy usage and formulating a framework for identifying and implementing energy saving projects. Due to the high intensity of the analysis carried out by cross-functional departments during the Baseline and Kaizen events GSK explored every aspect of energy usage on the Cork site. Thus, enabling GSK to identify short, medium and long term projects that could be implemented straight away, this accelerated energy saving through quick wins on the Cork site, prior having a full energy management system in place. Once complete development and accreditation of the GSK energy management system is achieved, GSK will have already have made substantial energy savings because of the advances made through the Baseline and Kaizen events. If GSK had not implemented the Baseline and Kaizen events energy saving potential might only have been realised in late 2010 meaning the energy savings achieved to date would not have been made.

In terms of communication, the GSK site performance management system creates great awareness amongst the site and promotes staff to operate in energy efficient manner continually. Through frequent monitoring by top management, middle management and manufacturing staff energy awareness is tired down through every staff level of GSK. However, this system is not fully rolled out to all buildings on site and it would be beneficial if more resources were put in place to develop this system, this would lead to increased energy savings from the ground – up through daily monitoring and awareness. This is the consumer concept from section 3.5.2 step 5 making sure energy is only used when required.

Chapter 4 Results and Analysis

4.1 Introduction

4.2 GSK Cork Site Energy Performance 2007-May 2010

4.5 Conclusion

4.1 Introduction

This chapter analyses the energy and cost saving results achieved by GSK to date through the implementation of I.S. EN16001 and the energy saving projects identified in the waterfall diagram. Introduction of the I.S. EN16001 and the waterfall chart have lead to accelerated saving due to the quick wins identified in the Baseline and Kaizen events, a target of 40% reduction was identified from improved energy performance, the author analyses whether these targets are achievable from the GSK performance to date.

4.2 GSK Cork Site Energy Performance 2007-Present

Since signing up to the SEAI energy agreement program GSK Cork have made massive inroads towards understanding the site energy usage and reducing overall energy consumption. Table 23 and 24 show the site energy performance since GSK first identified there past and presents (noted in section 3.5.2, step 1) energy usage in 2007. In table 23 the blue and red columns represent the electricity and gas individually for each year, the green column is a combination of both for total annual energy consumption. The purple column is the predicted/ target savings for each year identified in the waterfall energy saving diagram. This programme of work was implemented from the start of 2009. Information inputted for 2010 shows energy consumption up to the final week in May 2010. For 2011, only the waterfall chart target energy consumption is represented in the table.

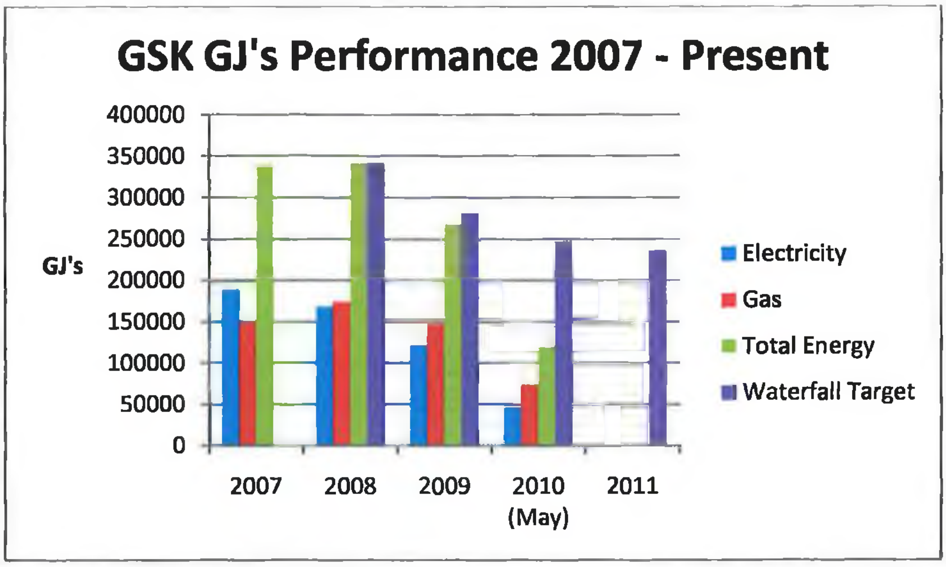

Table 23: GSK GJ's Performance 2007 – May 2010

	Actual	Actual	Actual % Reduction	Actual	Actual % Reduction
Energy User	**2007**	**2008**	**2008 vs. 2007**	**2009**	**2009 vs. 2008**
Unit	**(GJs)**	**(GJs)**	**%**	**(GJs)**	**%**
Electricity	189,437	168,341	-11	120,827	-28
Gas	149,776	173,877	16	147,220	-15
Total Energy	**339,213**	**342,218**	**1**	**268,047**	**-23**

Table 24: GSK GJ Metrics and Annual Percentage Performance

As 2007 and 2008 were identification periods for energy consumption it was not expected for GSK to improve the site energy performance. This was the case as they increased on 2007 usage by 1% for overall energy consumption. However, electricity reduced by 11% for 2008 but the increase in gas consumption to over 16% of the 2008 level lead to an increase in overall energy usage.

Upon introduction of 11 energy efficiency projects (can be seen the waterfall diagram) in 2009 GSK realised substanytial reductions for site energy consumption. In comparison from 2008 which was the baseline consumption for the waterfall chart GSK reduced their overall consumption by 23%.The 2009 electricity and gas consumption reduced by 28% and 15% respectively on 2008 usage. Overall the site reduced consumption by 74,171 GJ's in 2009. This reduction exceeded the site and waterfall chart reduction for the year by 2,171GJ's.

	Target for Year	Target % Reduction	Actual	Actual	Actual % Reduction (May)
Energy User	**2010**	**2010 vs. 2009**	**2009 (May)**	**2010 (May)**	**2010 vs. 2009**
Unit	**(GJs)**	**Target %**	**(GJs)**	**(GJs)**	**%**
Electricity	102,139	-15.4	57,091	46,034	-19.4
Gas	139,853	-5.0	79,170	73,277	-7.4
Total Energy	**241,992**	**-9.7**	**136,261**	**119,311**	**-12.4**

Table 25: GSK GJ Energy Performance up to 30th May 2010

Energy performance for 2010 can be seen from table 25. GSK have set targets to reduce the overall energy consumption by 9.7% for 2010 through the implementation of 15 energy efficiency projects and improved staff awareness. The 2010 performance is analysed by using metrics up to May to show almost half of the year. By comparing GSK energy usage by the end of May in 2009 and 2010 performance percentages can be identified. As of the end of May GSK are exceeding the 2010 target reduction by 2.7% overall. Electricity has reduced by 19.4% accumulating to a reduction of 11,057GJ's for the same period in 2009. Surprisingly, Gas is over performing by 2.4% of the 2010 target as over the initial cold period in 2010 gas consumption increased over the estimate due to site heating requirements. As of May 2010 GSK have reduced the overall site energy consumption by 12.4% (16,950 GJ's) on the same period 2009.

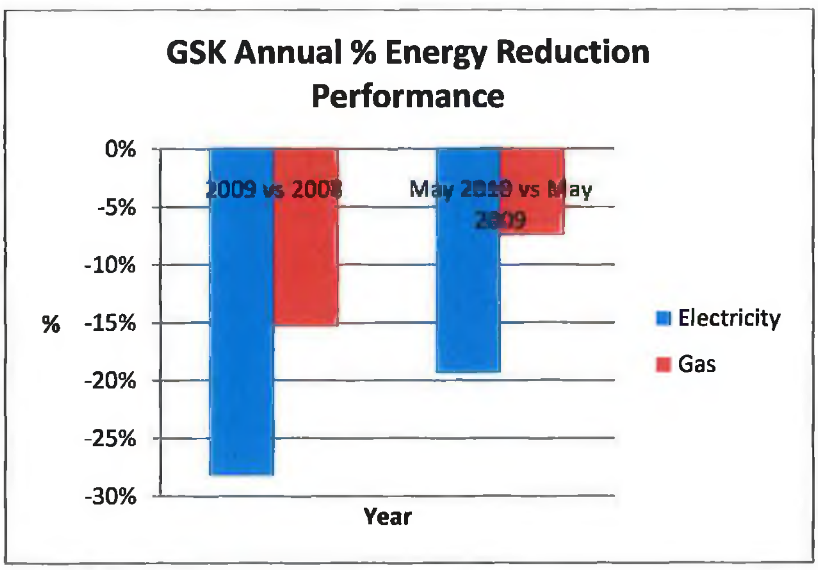

Table 26: GSK Annual % Energy Reduction Performance

Accumulating the yearly total energy percentage reductions for GSK, the site has already reduced the overall site consumption by 34% from January 2009 to May 2010. This can be seen from table

26 and 27. This means GSK need to reduce energy consumption by a further 6% to meet the 40% overall energy reduction target for 2011.

	Actual % Reduction	Actual % Reduction To date	Overall Energy % Reduction
Period	**2009 vs. 2008**	**May 2010 vs. May 2009**	**2008- May 2010**
Electricity	-28%	-19%	-48%
Gas	-15%	-7%	-23%
Total Energy	**-22%**	**-12%**	**-34%**

Table 27: GSK Energy % Reduction to Date

GSK have made substantial savings in terms of energy units but it is also important to identify the financial savings achieved through the energy measures implemented in GSK. By taking the GJ saving for 2008 and 2009 it can be converted into kWh. The GSK rate per kWh for electricity and gas is currently €0.14 and €0.04 respectively. These rates are similar to the industry rates identified in section 2.5.2 of chapter 2. Multiplying out the rates by the annual kWh savings for electricity and gas calculates the total financial savings made. This can be seen from table 28.

Year	2009	2009	2010 (May)	2010 (May)	kWh Unit Cost/kWh	2009	2010 (May)
Unit	**GJ's**	**kWh's**	**GJ's**	**kWh's**		**€**	**€**
Electricity	47,514	13,198,333	11,057	3,071,388	€0.14	€1,847,767	€429,994
Gas	26,657	7,404,722	5,893	1,636,944	€0.04	€296,189	€65,478
Total Savings	**74,171**	**20,603,055**	**16,950**	**4,708,332**		**€2,143,956**	**€495,472**
Overall € Saved Since 2008						**€2,639,428**	

Table 28: Financial Savings to Date

Overall the site has saved €2,639,428 million since the introduction of the I.S. EN16001 energy management system criteria, the baseline event, the kaizen event and the development of the waterfall framework for energy efficiency project implementation and also improved staff awareness and behaviour through training of EN16001 and better system management. Clearly it can be seen that electricity has produced far more savings than gas (€2,777,761 for Electricity and €361,667 for Gas) but this is because electricity is so much more expensive than gas. The actual kWh savings for each user are much closer together (16,269,721 kWh for Electricity and 9,041,666 kWh for Gas) but the price ratio of electricity to gas of 3.5:1 makes it far more practical for GSK to concentrate on electrical savings initially as larger financial savings are achieved from electricity savings.

Overall GSK have made substantial reductions in their energy usage and financial costs since the introduction of the I.S. EN16001 energy management system criteria to the Cork site and holding the baseline and kaizen events to achieve quick early energy saving wins. These saving have been made both on a technical basis to improve efficiencies and better awareness and energy practice throughout the site. Some of the technical practices implemented for energy saving in GSK Cork are described in section 5.2 and to identify the standard for awareness and behaviour within the GSK site a survey was carried out, results of the survey are described in section 5.3.

4.5 Conclusion

Implementation of the EN16001 energy management structure has produced overly accelerated energy and financial gains. By introducing a structured technique in order to monitor, target, identify and implement energy saving techniques into the energy management system, GSK has reduced its overall consumption from 91,121 GJ's (25,311,388 kWh's) from January 2009 to May 2010. This represents a financial saving of €2.64 million. However, it also highlights the potential wasted energy generated on site for the previous 15 years since energy management practice techniques originated in industry (Noted in figure 9 of section 2.5.1). During economic boom period companies didn't pay much attention to energy usage as energy was cheaper and high sales lead to high profit margins. Although, due to high economic activity companies had larger manufacturing quantities to meet the consumer demand meaning they operated at larger quantities for longer periods. This would increase energy expenditure to potentially equal current energy usage. If GSK had an energy management system in place during the boom period the profit margins could have been substantially more because manufacturing would have been more efficient and less energy intensive.

The savings achieved represent a 34% reduction in energy usage since January 2009. These savings could possibly represent the best savings GSK will ever achieve post energy management system implementation. The reason for this is because the most substantial savings are identified in the initial 1-2 year period as they are the most obvious saving opportunities that tend to have the biggest energy usage reductions. However, with future technology development energy saving opportunities could escalate in particular energy users leading to substantial energy saving. Also, by generating an independent power supply for the site (E.g. Wind Turbines) it would offset the cost of energy expenditure for GSK once the payback period is realised. An energy management system would still be relevant if an independent power supply was in place as it would assist in reducing site consumption to below the power supply generated, leaving additional power to be supplied to the grid.

Prioritising electricity savings over gas savings in GSK Cork elevated the financial savings substantially for the initial period. This means GSK could possibly reduce the energy consumption by the same kWh usage next year but if the savings are gas related it will only represent a 1/3 of savings financially that would have been achieved through electricity. As the waterfall energy savings plan progresses further less saving potential will realised as it becomes more difficult to find saving opportunities within the organisation.

Based on GSK's energy management performance to date it seems likely they will achieve the 40% targeted by the end of 2011. The effect of I.S. EN16001 and aggressive action towards energy reductions have been extremely positive for GSK to date but now the challenge is to implement the check/act criteria of the standard and maintain the energy management level achieved. This will involve maintaining the live status of the of the waterfall energy saving diagram so energy improvements are constantly being implemented.

Chapter 5 Discussion

5.1 Introduction

5.2 Technical Saving Measures

5.2.2 Electricity Saving Measures

5.2.3 Gas Saving Measures

5.3 Awareness and Behavioural Performance

5.4 Conclusion

5.1 Introduction

Savings are achieved from an energy management standard by improving efficiencies, creating awareness and better energy management within an organisation. In this chapter the author will discuss the some of the efficiency measures identified and incorporated within the GSK site and the savings achieved through these projects. These efficiency measures correspond with the opportunities for the pharmaceutical industry identified in the literature review section 2.6 and the case studies analysed in section 2.7.3 of chapter 2.

Technical efficiencies is one sure way of improving energy efficiency within an organisation but also awareness and behavioural techniques are very important for achieving savings at operational level. In order to access the awareness and behaviour towards energy saving amongst the GSK staff since the introduction of the energy management system structure a questionnaire was issued to all GSK staff. This is analysed in terms of GSK awareness and behavioural status to identify how energy management is perceived within the GSK Cork site, especially since it was identified from the kaizen event that energy awareness levels is a concern for GSK cork .

5.2 Technical Saving Measures

Technical and best practice techniques in order to achieve savings where applied in GSK for both electrical user and gas users. An overview of the some of the techniques for each user is described below in section 5.2.2 and 5.2.3. All energy saving techniques and measures described are inputted as projects on the waterfall energy saving plan of works (chapter 3, section 3.5.2, Table 16)

5.2.2 Electricity Saving Measures

As seen from chapter 3 section 3.3.1, there are 1737 motors on site. These motors are responsible for over 80% of electrical usage on site. Two efficiency measures applied by GSK are described below.

The first project was to reduce the air change rates in some of the main site HVAC systems and the second to reduce energy losses in the compressed air system.

HVAC Energy Reduction Project

GSK implemented a project around optimising the process building air change rates to reduce HVAC fan energy provisions. The GSK energy team identified that 13% of the overall plant electricity is used for building ventilation. This amounted to an operational cost of approximately €722,000 per annum for 63 HVAC systems. GSK identified that of the 63 HVAC systems, 78% of the costs (€566,340) are from 10 of the larger HVAC units. GSK analysed the Air Changes per Hour (ACPH) supplied to the areas associated with the 10 large HVAC units. The results showed Air Changes per Hour (ACPH) in these areas varied from 13-22 while the specification for these production areas is only 5-10 ACPH.

Figure 30: Eight of the Variable Speed Drive (VSD) Units Installed

In order to reduce the ACPH, GSK installed Variable Speed Drives (VSD's) systems to 25 fan motors within the 10 HVAC systems. The reason VSD's are used is because they reduce the fan speed to produce the required ACPH which will in turn decreases the power consumption. This is done by reducing the electrical frequency sent to the motors hence reducing the speed. Figure 30 shows eight of VSD units installed in building 1 on the GSK site.

Table 29 shows a breakdown of the saving achieved after installing the VSD's. GSK reduced the fan speed by over 80% for 18 of the fan motors and between 15%-61% for the remaining 7 fan motors. The original cost per annum of €560,340 reduced by 80.2% to €112,256 per annum. Savings were also made in the steam system, because with the reduction in ACPH less steam was required by the HVAC units. The steam savings accumulated to €127,000. Overall installation of the 25 VSD's to the fan motors delivered a cost saving of €581,084 per annum. The capital cost for the HVAC air energy reduction project was €462,344. This means payback was realised within 41.3 weeks.

Equipment Tag No.	Motor Size	Original Load at 50Hz	Original Cost pa.	Current Load	Post VSD Installation Cost pa.	% Decrease	Electricity Cost Saving
Unit	kW		€	kW	€	%	€
FNM-911A	75 KW	66.71	€79,070	6.72	€7,965	90%	€71,106
FNM-911B	75 KW	75.88	€89,939	6.23	€7,378	92%	€82,561
FNM-905A	37 KW	38.78	€45,963	1.85	€2,188	95%	€43,775
FNM-905B	37 KW	38.77	€45,954	1.89	€2,245	95%	€43,709
FNM-929	55 KW	43.34	€51,368	36.98	€43,826	15%	€7,542
FNM-2901	22 KW	12.81	€15,183	0.66	€788	95%	€14,395
FNM-2902	30KW	34.81	€41,262	1.76	€2,083	95%	€39,179
FNM-3203	15KW	10.34	€12,251	1.14	€1,349	89%	€10,902
FNM-3303	18.5KW	4.43	€5,252	1.90	€2,254	57%	€2,997
FNM-1224	11KW	8.55	€10,139	1.65	€1,953	81%	€8,186
FNM-1222	11KW	3.61	€4,278	1.91	€2,258	47%	€2,020
FNM-1203	11KW	5.30	€6,282	3.45	€4,085	35%	€2,197
FNM-1230	11KW	5.95	€7,047	1.14	€1,353	81%	€5,694
FNM-7002	18.5KW	14.48	€17,160	1.94	€2,305	87%	€14,856
FNM-7003	18.5KW	12.80	€15,167	1.92	€2,280	85%	€12,886
FNM-6011	18.5KW	14.92	€17,680	1.71	€2,022	89%	€15,658
FNM-6014	18.5KW	3.98	€4,716	1.53	€1,813	62%	€2,903
FNM-7706	30KW	14.97	€17,739	1.48	€1,752	90%	€15,987
FNM-7702	18.5KW	17.56	€20,812	1.68	€1,995	90%	€18,817
FNM-7709	22KW	4.89	€5,797	0.61	€728	87%	€5,069
FNM-7712	15KW	7.34	€8,694	0.91	€1,074	88%	€7,620
FNM-7814	18.5KW	12.80	€15,167	2.59	€3,070	80%	€12,097
FNM-7817	15KW	9.34	€11,074	4.89	€5,796	48%	€5,278
FNM-7822	15KW	10.33	€12,248	5.54	€6,567	46%	€5,680
FNM-7824	22KW	5.15	€6,099	2.64	€3,129	49%	€2,970
Total			€566,340		€112,256		€454,084
					Electricity Cost Saving		€454,084
					Steam Saving		€127,000
					Total Cost Saving p.a.		€581,084.00

Table 29: HVAC Energy Reduction Project Data & Savings

Due to the substantial savings achieved through the HVAC energy reduction project GSK have made it standard practice for all new motors installed on site to be VSD ready. GSK have also retrofitted VSD's to other Significant Energy Users (SEU's) on site such as compressors, other fan motors and approximately one quarter of the pumping motors on site. All agitator motors, mill motors and sieve motors on site already have VSD's installed as they are required for controlling the pharmaceutical production process. Overall GSK have approximately 626 VSD's installed, this represents 36% of the overall motors on site.

Energy Loss Survey Compressed Air Leakage

It was identified from literature review research that minimising compressed air leakage represented a common practice energy saving measure, especially because efficiency of compressed air systems is usually only 10% (see chapter 2, section 2.6.5). GSK contracted in a UK based company Monition, to carry out a compressed air leakage survey for the entire site using ultrasonic acoustic detectors. This involved surveying all actuated valves, regulators, line fittings, compressed air utility stations and manifolds on site. Monition carried out a survey in both June 2009 and June 2010. Figure 31 shows an example of a typical finding from the air leakage survey. From the highlighted section it is identified that compressed air is continually exhausting from the valve guard actuator. This leak annually wasted €336 of compressed air energy, the cost of repair was €73, meaning payback would be achieved within 11.3 weeks.

Image 79
Area : R&D BUILDING
Location : 2nd FLOOR / BAY 76 AREA GUARD ACTUATOR
Description : CONTINUALLY EXHAUSTING

Figure 31: Typical Compressed Air Leakage Finding from Air Leakage Survey

Table 30 shows the overall findings from the two surveys conducted. Overall there were 248 compressed air leakages identified. These leaks accumulated to €87,813 annually in wasted energy with only an €8,166 repair cost. These repairs have all been addressed within reason. It was identified that some leaks had low energy losses but required high investment to repair. From a financial it was not economical for GSK to repair these leaks as the energy loss was so low, meaning the payback would not be realised for some time. Upon completion of the compressed air leaks GSK have reduced the annual compressed air costs by over €75,000.

Year	Number of Leaks	Annual Cost for Fault	Estimated Cost of Repair
2009	160	€53,821	€6,941
2010	88	€33,992	€1,225
Total	**248**	**€87,813**	**€8,166**

Table 30: 2009 & 2010 Compressed Air Leakage Survey Results

5.2.3 Gas Saving Measures

As noted in chapter 3 section 3.3.2 gas is used to fuel the boilers to generate steam for the site along with the waste heat boiler (WHB) connected to incinerator no.3. A substantial amount of steam supplied to the site is generated from the WHB initially and the remaining steam requirement is met from boiler BO2003 and BO2002. Although WHB steam is considered free it still carries a cost through incineration gas requirements, initial capital cost and maintenance requirements. Also, BO2002 and BO2003 burn substantial gas quantities annually to generate steam energy. In order to minimise loss of energy through radiated heat GSK carried out a steam energy loss survey for the site. This is described below.

Energy Loss Survey for Steam

Boilers and steam distribution systems suffer major energy losses from lost radiated heat energy during distribution. Steam distribution lines are often left un-insulated at valves or fitting connections as they are more awkward to insulate, leading to poor workmanship on behalf of the installation crew. Also, insulation is removed by GSK staff to carry out regular maintenance checks and sometimes is not put back on correctly. In order to determine energy losses from radiant heat, GSK contracted Monition to carry out an energy loss survey for steam distribution systems for the entire site (this efficiency measure identified in chapter 2, section 2.6.9). The survey was carried out using a thermal imaging camera to identify exposed high temperature surface areas. Monition carried out a survey in both June 2009 and March 2010.

Figures 32-34, show 3 examples of typical findings from the steam system energy loss surveys. The highlighted sections on the figure show the area and the temperature of radiated heat waste. Table 31 gives a breakdown of the energy loss, cost of repair and payback for the 3 examples shown. The information required and how the energy loss, repair cost and payback period are calculated can be seen from the Monition case study example for steam energy loss in Appendix E.

Image No	Radiation heat loss from piping in Watts	Annual energy cost for fault (€)	Estimated Total Repair Cost (€)	Pay Back Time (Weeks)	Radiation heat loss from piping (GJ's)
50	664.5	€262	€110	22.3	21
53	1240.8	€488	€110	11.9	39.1
69	2065.4	€813	€117	7.6	65.1
Total	**3970.7**	**€1,563**	**€337**	**41.8**	**125.2**

Table 31: Steam Survey Example Findings

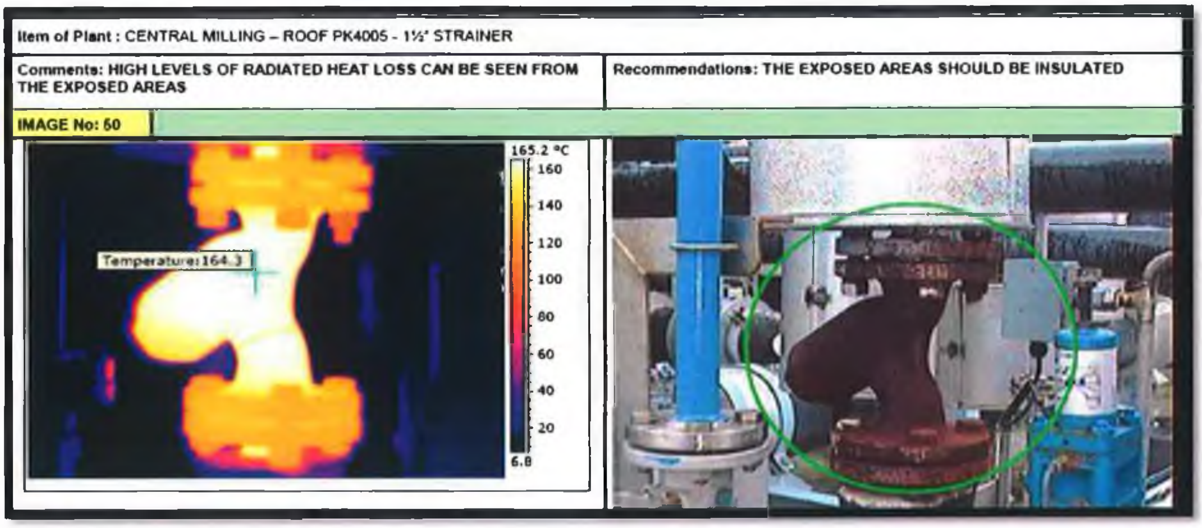

Figure 32: Exposed Strainer

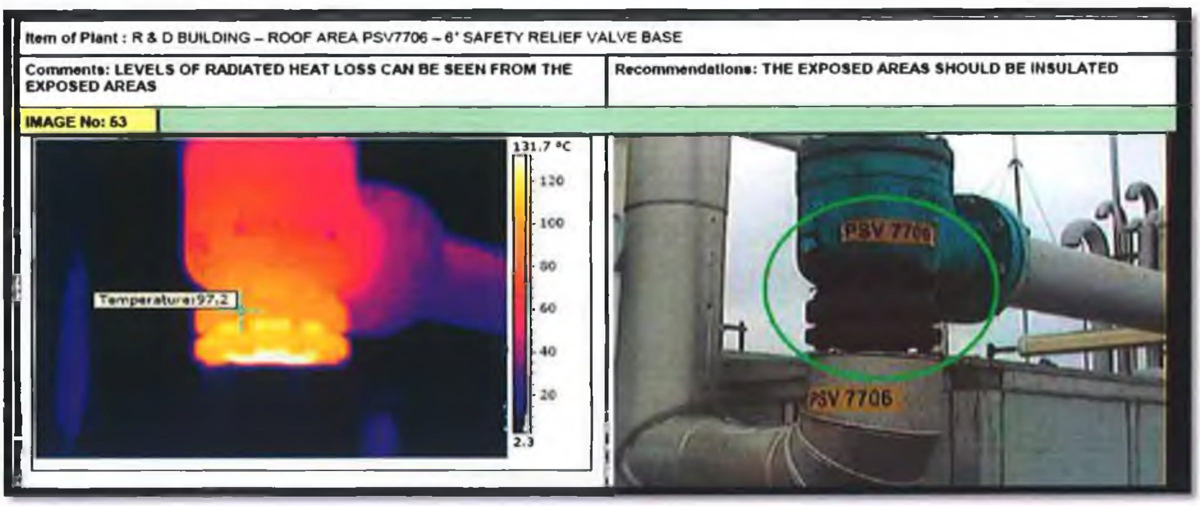

Figure 33: Exposed Pressure Safety Valve Connection

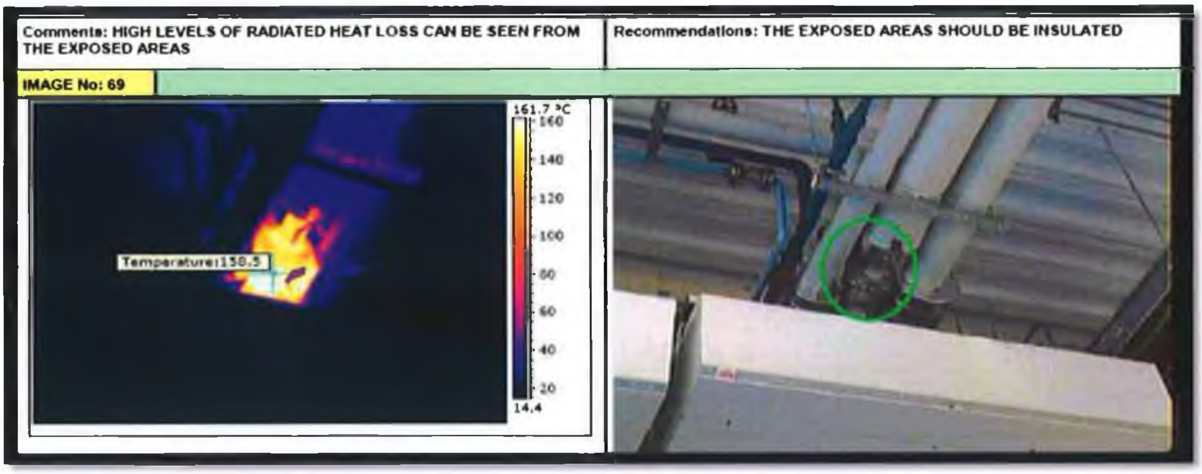

Figure 34: Exposed High Level Valve Connection

Table 32 shows the overall findings from the two surveys conducted. Overall there were 354 exposed areas identified. These heat losses accumulated to €182,533 annually in wasted heat energy. In order to repair all the exposed areas identified it would have cost €46,687. However, the price takes into account new insulation and labour costs for repair but for exposed areas at high level scaffold may be required also, this would significantly inflate the repair cost. Erecting scaffold may only be economical if multiple exposed areas are repaired from one scaffold, erecting a scaffold for an individual repair can prove expensive and push out the payback substantially.

Year	Number of exposed Areas	Annual Cost for Fault	Estimated Cost of Repair	Annual Wasted Energy (GJ's)
2009	217	€122,843	€30,315	9,817
2010	137	€59,690	€16,372	5,262
Total	**354**	**€182,533**	**€46,687**	**15,079**

Table 32: Steam System Radiated Heat Loss Survey Results

GSK carried out repairs to 327 of the exposed area identified. The remaining 27 exposed areas where deemed not economically viable for repair at the moment as they required scaffold access. The 27 remaining exposed area have been planned for repair within alternative projects that require scaffolds or hoists in the specific area of radiated heat loss. Overall implementation of the surveys and repairs has amounted to €124,978 in energy savings to date. These surveys are now scheduled annually as part of preventative maintenance techniques for ongoing steam systems checks, repairs and upgrades to keep the steam distribution systems operating at peak efficiency.

5.3 Awareness and Behavioural Performance

Although energy efficiency is a technical topic, the solutions are not all technological. Human factors such as attitude, knowledge, awareness and skill are significant energy aspects for most organisations. Well trained and aware staff can improve energy waste through changing their behaviour, managing their energy more appropriately and suggesting improved working methods or technical innovations.

It is very difficult to define how much energy is saved annually through awareness and behavioural practices. Instead it can be tested to see how knowledgeable the staff is toward energy management. It was identified from "Energy Management, Principles and Practice" book by Vilnis Vesma [37] that it is possible to assess staff energy awareness standards using a technique that allows a workforces energy profile to be plotted on a grid of behaviour against awareness from the results of a survey. A good score is achieved if staff score within the high-behaviour, high-awareness zone in the top right corner.

In July 2010 an energy based questionnaire compiling of 21 questions was deployed to test the GSK employee perceptions, behaviours and attitudes toward energy (the energy awareness questionnaire and results can be seen in appendix C). The questionnaire questions where developed by the GSK energy team and an SEAI consultant in order to assess the level of awareness within the company. The questions relate to both work and home energy aspects as it makes it more appealing to the employee to carry out the survey.

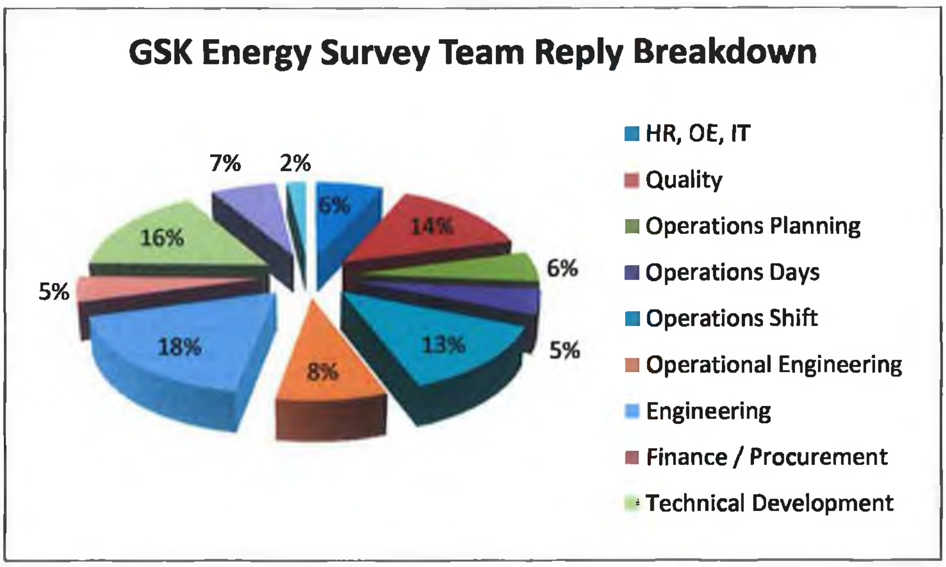

Table 33: GSK Energy Survey Team Reply Breakdown

The energy awareness survey was emailed to the 300 staff on the GSK Cork site and the total respondents to the survey were 221 staff. This was an excellent reply score of 74% of the GSK staff. A breakdown of the team percentage replies can be from table 33 above, the largest reply rates were received from the engineering, technical development, quality and operations shift teams. The reason for the higher response levels from these teams is because they are the 4 largest teams in GSK Cork.

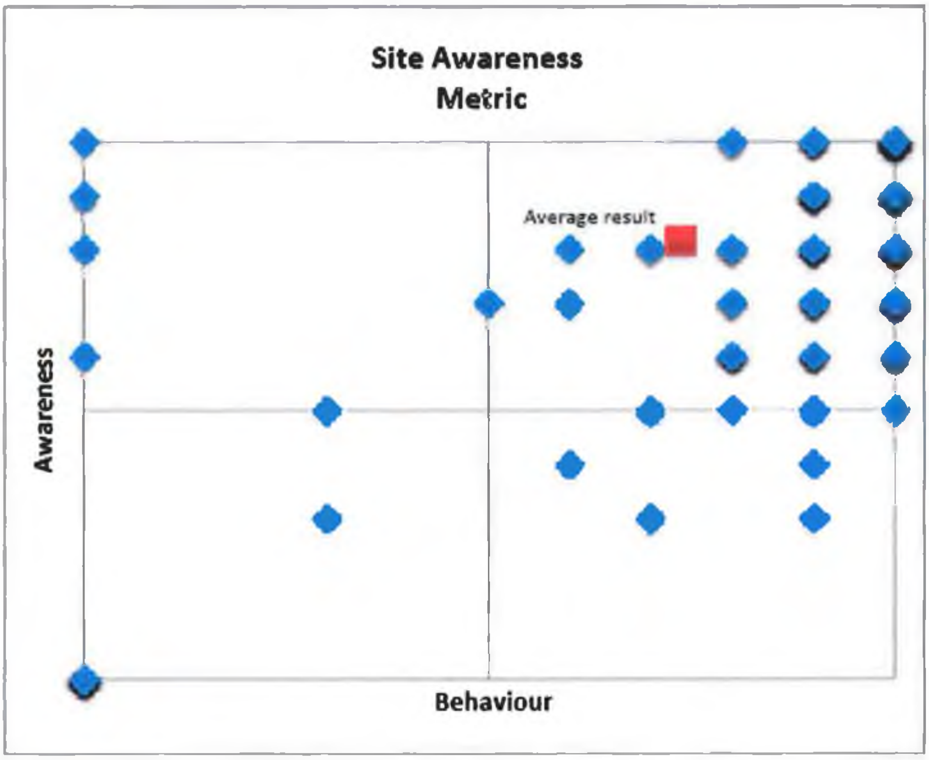

Table 34: Energy Awareness Survey Results

Table 34 above illustrates the grid performance of GSK's staff. A best practice score is in the upper right hand corner of the graph. GSK's average site score is located in this sector meaning energy is an important agenda amongst GSK personnel.

	Awareness	% of total	Behavioral	% of total	Total
Total Site Score	1629	74%	1804	82%	**78%**
Total Possible Score	2210	100%	2210	100%	

Table 35: Quantified Energy Awareness Survey Results

Table 35 shows that overall GSK scored a 78% results for awareness and behavioural aspects towards energy. This is a good result for GSK as this area was a concern from the findings made in the Kaizen event in June 2009. It shows that through GSK's improved energy performance, communication techniques, training initiatives and the site energy awareness day that they have raised the profile of energy awareness in the site.

However, it can be seen from the table 34 grid that some staff scored high for the awareness aspects (top left) but lower for behavioural aspects of energy (bottom right) and visa versa. Also, the results from questions 7, 10, 11 & 18 on the questionnaire

7. Are you aware of the energy policy in place within the organisation? (66% Yes/34% No)

10. Are you aware of the of any recent energy awareness activities undertaken by the organisation? (73% Yes/ 27% No)

11. Do you know how to communicate ideas for energy saving to the Energy Team? (45% Yes/55% No)

18. Do you try to identify how you can save energy at work? (77% Yes/23% No)

Show average and poor results for some important questions in the questionnaire, especially question 11 that 55% of the staff do not know how to communicate energy saving ideas to the GSK energy team. Question 7 shows there is substantial room for improvement in promoting the site energy policy, this is very important as the energy policy is key to achieving good results through the I.S. EN16001 energy management standard. GSK will need to generate more awareness around this aspect.

Considering the €2.64 million energy saving made in GSK since 2009 the results from question 10 showing 27% people are unaware of energy saving projects implemented on site is surprising. GSK may need to enhance the level performance management further within the site in order to make all personal aware of energy projects on site. The result of question 18 shows GSK need to create a better staff attitude for the 23% who do not try to identify savings in work, this could be done by enhancing training procedures or offering an incentives when for worthwhile energy saving ideas.

The results of the 4 questions analyses is alarming for GSK but may not be fault of the GSK staff. It does highlight to the GSK energy team that improved energy behavioural techniques need to be developed and trained to the staff to improve their energy knowledge and define how to communicate effectively with the GSK energy team. This training should include how and where GSK use their energy, and what employees can and should be doing to minimise consumption. This technique could prove very effective in terms of general power reductions because most staff involved in the process and engineering departments would have a good understanding of energy usage on site and go about their day to day activities in an energy efficient manner, but the more office and laboratory orientated staff might not have such strong energy awareness because it is not part of their daily work routine. Introducing training would promote better awareness within their work environment such as better lighting usage and to power off desk equipment when it is not required. These are minor saving but over a long period they could accumulate to substantial site energy savings.

Overall energy awareness and behaviour amongst the GSK staff is very strong but this can fade with time so it is important the GSK energy team hold regular awareness campaigns and training in order to maintain improve the site awareness and behavioural performance.

5.4 Conclusion

Overall energy efficiency practice is very much at the forefront of GSK Cork operations. Through technical efficiency measures GSK are substantially reducing energy consumption within the site. The energy team have a strong technical knowledge and are able to analyse the best possible savings at a given time, this is evident from targeting the HVAC systems for VSD installations initially as they account for 13% of overall electricity used on site. VSD efficiency measures are now being applied across all site motor usage.

The compressed air and thermal imaging surveys show GSK have good economical awareness in terms of selecting the best energy savings options. Upon realising that inefficiencies are occurring in the utility systems, GSK understood it is not always financially correct to carry out repair work as the payback period is substantially higher than the energy loss rate. Good budget management is a very important part of energy management as it ensures the resources are in place to target the most significant energy users initially and initiate the most productive energy saving measures so they are realised as soon as possible. The three energy projects described above account for 29.6% of the overall €2.64 million saved since the waterfall energy saving project plan was implemented in 2009.

From the survey results it was identified GSK Cork employees have good awareness and behavioural techniques in terms of energy management. Some key issues were identified from question 7, 10, 11 & 18, these issues need to be addressed through regular training and more energy awareness days in order to improve energy awareness further. Overall the I.S. EN16001 energy management system structure has implemented an excellent framework to achieve consistent energy savings from both technical and operational aspects.

Chapter 6 Conclusions & Recommendations

6.1 Introduction

6.2 Conclusion

6.2.1 The I.S. EN16001Energy Management Standard Performance

6.2.2 Drivers for Achieving Success in GSK

6.2.3 Issues that need to be addressed to improve the GSK Cork site EMS

6.3 Recommendations

6.1 Introduction

This chapter analyses the conclusions derived by the author from the aims and objectives set for this project. The energy and cost savings achieved through the introduction of the I.S. EN16001 energy management system structure have been positive but there was also independent input from GSK in order to accelerate the energy performance within the site. These issues are analysed in this chapter. The author also makes recommendations that could be introduced in order to further develop energy management performance for GSK.

6.2 Conclusions

In order to derive the conclusions the author needed to meet the objectives outlined in the chapter 1. These objectives were achieved from industry research carried out for chapter 2 and the analyses of the GSK I.S EN16001 implementation procedure in chapter 3. The author came to the following conclusion on the I.S. EN16001 energy management standard and its performance in GSK.

6.2.1 The I.S. EN16001 Energy Management Standard Performance

GSK have implemented a strong energy management system around the Plan, Do, Check, Act criteria of I.S. EN16001. Also, from the internal Baseline and Kaizen events GSK were able to identify quick energy saving wins, accelerating the overall I.S. EN16001 implementation process. Results of this can be identified from the €2.64 million energy savings made in 2009/2010.

Once the GSK EMS is fully implemented and accredited, it will mature and maintain the momentum generated during the development and implementation stages, meaning energy management will become integrated into every part of GSK energy activities, similar to that achieved in the Wyeth case study analysed in 2.7.3 and Appendix G. It is this aspect of the I.S. EN16001 energy management standard that offers the best benefits as it puts in place a structure for continuous energy saving for the long term.

However, in the short term, implementing the standard is quite a time consuming procedure and requires substantial resources. This leads to missed opportunities for energy saving as a company could spend 2-3 years putting the structure in place (metrics system, project planning, project implementation, documentation for the standard and communication procedures), without realising major savings. According to the SEAI EAP the energy management standard can be achieved within 12 months but this only seems probable if a company has substantial financial and personnel resources to target implementing the energy management standard effective immediately. The reality though, is that in the current economic climate most companies who implement the standard are trying to make quick savings, as they are under financial pressure. This was the case for GSK Cork who adopted there own procedures to accelerate achieving the energy savings through the baseline and kaizen events while also going about implementing the energy management standards.

This highlights the question, is it worthwhile implementing the I.S. EN16001 standard? The answer is yes, as it creates a strategic energy management system for monitoring, targeting, identifying projects, training staff, raising awareness and improving communication techniques that all serve to drive down energy usage continuously in the long term. However, in order to achieve quick savings and not miss energy saving opportunities in the short term, an internal approach such as the baseline and kaizen events held in GSK ensures all energy saving potential is realised straight away. An added benefit to this approach, is by the time the energy management standard comes online the energy usage base load will have been reduced substantially, meaning energy saving can start from a lower level. This shows that both these systems should be adopted when an organisation is trying to reduce there energy usage.

The situation also needs to be assessed to determine the circumstance if GSK had never implemented the I.S. EN16001 energy management standard. This would have represented a missed opportunity by GSK Cork, not only for the financial savings already achieved, but also for future production. As noted in section 4.5, during the previous economic boom energy expenditure was not an issue. This mindset has now changed in order to maximise profits in a competitive market. So by implementing the I.S.EN16001 energy management standard, GSK Cork have positioned there manufacturing facility to produce a quality product at a lower cost than previous timeframes when the increased utilisation occurs.

6.2.2 Drivers for achieving success in GSK

This section highlights some of the key drivers identified by the author that enhanced the energy management system performance and were vital towards achieving the energy and cost savings in GSK Cork.

Top Management

Top management support is a key driver for implementing I.S. EN16001 in GSK, this was also evident from the Schering plough case study analysed (see appendix G). Initially GSK Cork approached GSK corporate management with a view to introducing an energy management system. This proved to be extremely beneficial as top management understood that a formal energy management system could deliver the targets for resource efficiency, corporate responsibility and cutting greenhouse-gas emissions for GSK. This made it easier for GSK Cork to allocate budget funding to the projects required for the energy management system implementation. Top management support did not just occur from GSK corporate level but also from a site top management level. Achieving energy savings was made a key agenda for GSK Cork site in 2009. Without top management support to resource energy practices, such as implementing the energy management system, holding the baseline and kaizen events and implementing the waterfall energy saving projects plan, they could not have reduced the energy consumption by the 34% achieved to date. However, this top management support has turned out to be rewarded by GSK Cork as they have reduced the site budget requirement by €2.64 million. This means that top management support will continue as they realise directing resources towards the energy management system will continually achieve savings in the long term.

Metrics Recording System

Implementing an energy monitoring system is vital for identifying energy savings, this was highlighted from industry research in sections 2.6.1 and 2.7.3. The RSEnergyMetrix monitoring system installed in GSK, enabled the energy team to identify site energy usage for GSK Cork and develop the energy map (noted from table 12). From this map GSK identified the SEU's for the site and target the major areas of energy consumption. Without this information GSK could not have set reduction targets and evaluated the performance of energy reduction projects. However, improvements need to be made on the energy monitoring system for GSK to progress site performance. The meter recording inaccuracies (noted in section 3.7) are causing a slowdown in GSK's plans to implement metering for every level of the site and develop more challenging targets in order to reduce energy consumption.

Targeting Energy Reductions outside the Energy Management Standard

The Baseline and Kaizen events carried out by GSK have had a major impact on the energy reductions achieved in GSK Cork in the short term. These events enabled GSK to conduct in depth analyses of the site energy usage with cross functional teams throughout GSK Cork in order to explore all energy saving opportunities. As a result of these events, GSK accelerated the energy saving process of I.S EN16001 through implementing energy saving projects with quick payback periods. Also, the findings from these events formed the basis for implementing a plan of work (Do) for the GSK site, this was part of the I.S. EN16001 energy management standard requirements (section 3.5.2, step 2). If GSK had not carried out these events and continued solely towards achieving the energy management standard they might not have realised these opportunities until a later period, representing missed opportunities for energy and cost savings.

Prioritising Electricity Savings over Gas Savings

Prioritising electricity savings over gas savings in GSK Cork elevated the financial savings substantially for the initial period in 2009/2010 of the energy management system (noted in section 4.5). The price ratio of electricity (€0.14) to gas (€0.04) of 3.5:1 made it far more practical for GSK to concentrate on electrical savings initially as larger financial savings are achieved from reducing electricity rather than gas. By adopting this approach GSK maximised there energy cost saving potential straight away. If they had not targeted this approach, they might have only realised savings of €1.64 million rather than €2.64 million

A corporate decision has been made within GSK global that all energy savings for 2011 within GSK sites will be measured in CO^2 emissions. This is so GSK promote their corporate responsibility in trying to tackle climate change and reduce CO^2 emissions. The carbon savings ratio for CO^2 emissions reduction is similar to that of the price ratio above. For electricity, 1 kWh saved = 0.000535 tonnes of CO^2 emissions saved whereas for gas 1 kWh saved = 0.000184 tonnes of CO^2 emissions saved. This gives a ratio of approximately 3:1 for electricity savings versus gas savings for CO^2 emissions. So, prioritising electricity savings over gas savings would be more beneficial to maximise CO^2 emission reductions for the company.

6.2.3 Issues that need to be addressed to improve the GSK Cork site EMS

This section highlights some of the issues identified by the author that need to be addressed in order for GSK Cork to improve there energy management system.

Building Owner Resources and Communication

As part of the performance management communication scheme (section 3.5.3) GSK have appointed building owners to monitor, target and reduce energy usage at a building level throughout the site. This scheme offers good rewards in terms of developing awareness and better operational practice from an energy consumer aspect, but as of yet it has not been implemented on all the buildings on site. GSK need to resource the appointment of more building owners across the site to reduce energy consumption for buildings at site level, and promote better communication between the energy generators and energy consumers. This system is also flawed due to the inaccuracies in the RSEnergyMetrix monitoring system, until these meters are recalibrated the building owners will not have confidence in the metrics recorded, and this will only serve to undermine the performance management system.

The energy team also need to put more focus towards improving energy efficiency communication techniques on site. The performance management system is proven within GSK as it is used across different teams throughout the site. However, in terms of energy efficiency communication it has not been as successful, this is due to more resources being applied to implementing energy efficiency saving project rather than promoting energy communication within GSK. The energy awareness survey analysed in section 5.3 highlighted some issues of this happening in terms of staff not knowing how to communicate with the energy team. If the GSK energy team provide training for employees to understand how energy is monitored and used on site, it will develop more of an interest in reviewing the site communication boards to analyse site performance. This will encourage more activity around energy communication within GSK.

Identify a more Structured Energy Team

The energy team in GSK Cork currently consists of the site energy champion and a small number of staff from cross-functional teams on site. A more populated and structured energy team needs to be put in place. By doing this GSK can define clearer roles for the energy team and focus more attention on improving the current energy management system at both a building and system level throughout the site. This means either employing additional staff or transferring current staff to the energy team. Even though the GSK top management support the energy management system, it is very difficult for them to resource hiring additional staff to enhance the energy management system as the current economic climate is more focused on cutting back. The same criteria applies to transferring staff to the energy team as current team staff levels have already been reduced due to cut backs. This could prove to be an issue for the energy team as it could slow down progression of GSK energy management system and lead to potential energy saving opportunities being missed.

Introduction of Energy Performance Indicators (EPI)

It was identified from the case studies analysed in section 2.7.3 that all four case studies considered EPI's one of the pillars towards sustained energy saving. GSK have EPI's in place in terms of targeting but these are at a very high level and need to be introduced to individual buildings in order to correlate energy consumption for specific areas. The idea behind EPI's is to determine if the appropriate amount of energy is being consumed for the level of activity that is being carried out. For example, plotting the production output against the electricity used enables GSK to determine how much electrical energy is required to make a certain quantity of product. Through these correlations GSK can measure the relevant driving factors for consumption in an area and detect deviations from expected consumption. Also, if an energy saving project is introduced, GSK will be able to analyse the project performance as they should be able to produce the same quantity of product with less electrical energy. These correlations can be designed for most areas on site depending on the driving factors. If the GSK energy team design EPI's for each building in GSK Cork they can set targets for reducing energy consumption in all the different departments, no matter what activity that is being carried out.

In conclusion, implementing the I.S. EN16001 energy management standard criteria has been very positive and rewarding to date for the GSK Cork site. However, GSK have some issues to resolve in terms of metering and additional resources if they are going to maximise the energy management system potential in the long term. Once these issues are addressed, GSK will be able to apply the energy management system to every level of the site and set challenging targets to reduce energy consumption. If GSK do not sort out these issues the energy management system will not operate correctly, making it more and more difficult for GSK to achieve energy savings, which will lead dimensioning returns.

The author feels implementation of the I.S. EN16001 energy management standard is summed up perfectly by Mark Dullaghan and Ed Molyneaux from Wyeth Medica, Ireland.

"It's a lengthy process that requires input and commitment from many departments including engineering, training and EHS. Initiation is one thing, implementation is another, and while it is more challenging, it will be a worthwhile process" [42].

The following section is some brief recommendation made by the author in how GSK can further reduce there energy performance.

6.3 Recommendations

As seen from section 2.3, renegotiating energy rates with the supplier represents a good opportunity for reducing energy costs with no capital investment required. If the GSK procurement team renegotiated the energy prices there energy expenditure would reduce. The money saved from the energy procurement management could then be reinvested into energy saving projects.

Alternatively, GSK could become there own energy supplier. As seen from section 3.2, GSK own a 150-acre site that resides in the main channel to Cork harbour. This presents options for GSK in terms of generating an independent power supply from renewable energies such as wind energy or wave energy. Wind energy represents a better opportunity for GSK as it is a mature technology in Ireland and has proven results. This is not the case for wave energy, as it is considered a very new technology and would represent too much of a risk for GSK in terms of capital investment. Also, GSK already have the infrastructure in terms of land in which they could erect wind turbines on, they do not have any ownership over the ocean.

Combined Heat and Power (CHP) is another alternative (identified from section 2.7.3) but GSK currently do not have the infrastructure to utilise the waste heat for space heating. Also, wind energy represents a better option as the power generated would supply the current site utilities infrastructure, rather than altering the utilities infrastructure to accommodate utilising the waste heat from the CHP plant.

Upon achieving I.S. EN16001 accreditation it would be beneficial for GSK to try and implement the ISO14001 Environmental Management Standard (noted in section 2.6 & 3.5.2). The standard follows the same Plan, Do, Check, Act criteria making it very easy to retrofit into the GSK management system. GSK Cork have some strong links between environmental and energy consumption on site, especially in terms of incineration. For, example, by implementing the environmental management standard it could reduce the quantities of waste streams sent for incineration hence reducing gas requirements. If implemented the ISO14001 environmental management standard will complement the I.S. EN16001 energy management standard

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Appendix A

GSK Energy Policy

GlaxoSmithKline

GSK Cork
Energy Policy Statement

Energy Policy

GSK Cork recognises that management of energy consumption is an important part of its business activities. Responsible energy management contributes to operational efficiency and minimises the environmental impact of the business. Energy management is related to the existing Corporate Policy for Safety, Health and Environment but a separate policy is required to emphasise that energy is not just a technical issue but applicable to all of the organisation.

GSK Cork is committed to implementing a phased programme of work which manages opportunities and challenges associated with energy efficiency and sustainable environmental protection.

Policy

It is the policy of GSK Cork to:-

- Meet GSK company targets and objectives with respect to energy usage and the associated environmental impact
- Strive to maximise the energy efficiency of all business and manufacturing operations, facilities and assets including utility generation, conversion, transmission and at point of use
- As required, invest in new more energy efficient and reliable utility infrastructure and process equipment, through planned investment programmes
- Comply with applicable environmental regulation and develop opportunities to increase the proportion of renewable and sustainable energy used

Finbar Whyte
Cork Site Director

Implementation

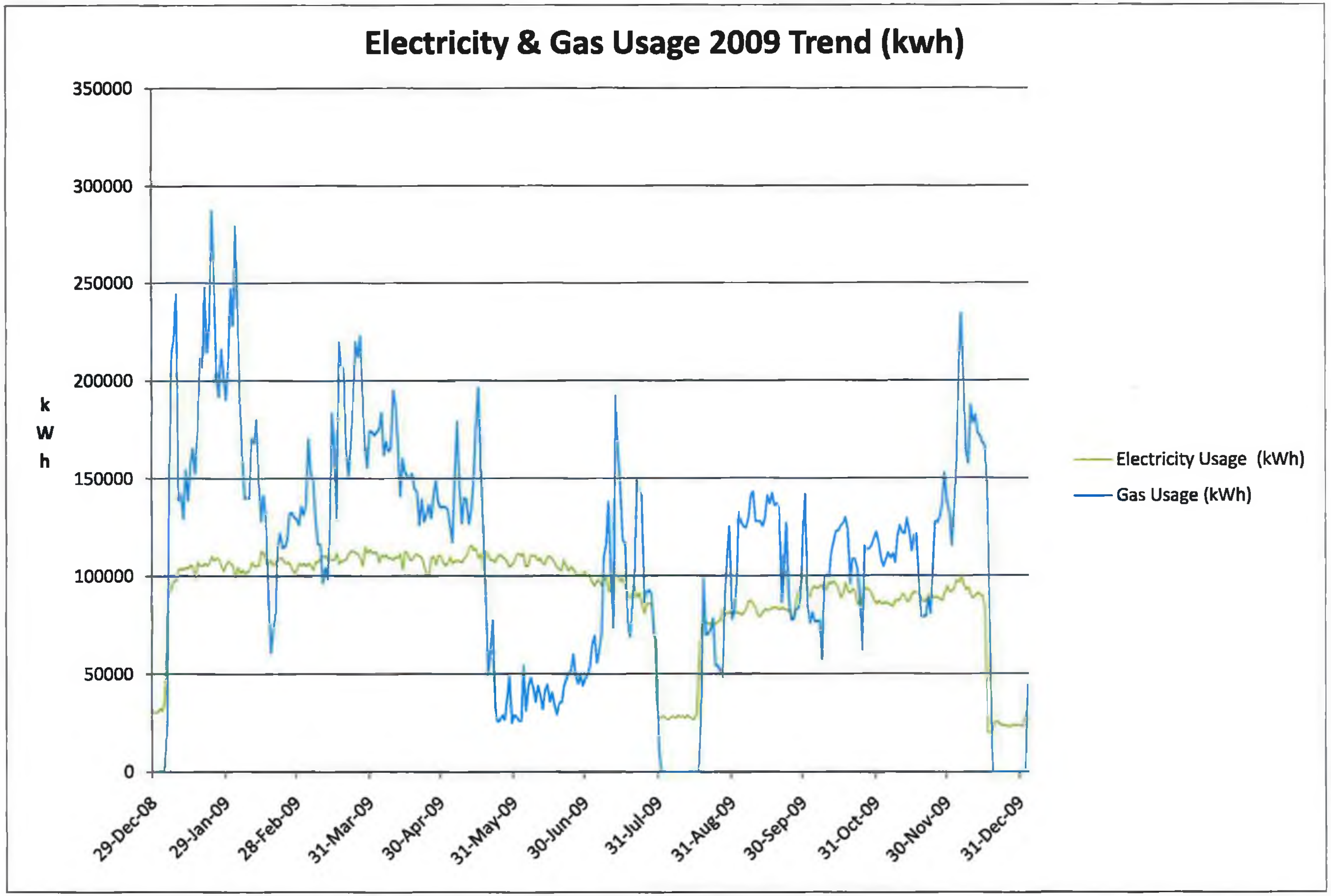
The primary responsibility for implementation of the Energy Policy rests with the management of GSK Cork, who will appoint a manager to develop and implement the policy and provide appropriate resources to allow effective implementation, and encourage all employees to participate in improving energy efficiency and reducing energy consumption.

GSK Cork will achieve the policy aims through:

- Appointing a site energy champion responsible for policy and local site plan implementation
- Setting annual use and cost budgets, and reduction targets aligned with GSK corporate targets
- Regular monitoring and reporting of energy consumption and cost
- Devolving responsibility and ownership for energy consumption at each building and operation on site
- Encouraging awareness and employee participation in improving energy efficiency and reducing energy consumption
- Sharing best practice on energy efficiency and energy consumption reduction
- Promoting the efficient use of energy for new and existing installations through a planned programme of projects and initiatives
- Adopting renewable energy and sustainable design principles
- Using an Energy Management System to sustain energy reduction and efficiency

Appendix B

GSK Electricity and Gas Daily Usage Trend Charts


Electricity & Gas Usage 2009 Trend (kwh)
350000
300000
250000
200000
150000
100000
50000
0
k
W
h
29-Dec-08
29-Jan-09
28-Feb-09
31-Mar-09
30-Apr-09
31-May-09
30-Jun-09
31-Jul-09
31-Aug-09
30-Sep-09
31-Oct-09
30-Nov-09
31-Dec-09
Electricity Usage (kWh)
Gas Usage (kWh)

Appendix C

GSK 2010 Energy Awareness Survey Questionnaire and Results

1. Which business function are you aligned to on site

	Response Total	Response Percent
HR, OE, IT	16	7%
Quality	33	15%
Operations Planning	14	6%
Operations Days	12	5%
Operations Shift	32	14%
Operational Engineering	20	9%
Engineering	41	19%
Finance / Procurement	11	5%
Technical Development	37	17%
EHS	15	7%
Research & Development	4	2%
Total Respondents		**221**

2. Are you aware of the environmental impact of energy use?

	Response Total	Response Percent
Yes	200	100%
No	1	0%
Total Respondents		**201**
(skipped this question)		20

3. Are you committed to saving energy?

	Response Total	Response Percent
Yes	195	97%
No	6	3%
Total Respondents		**201**
(skipped this question)		20

4. Are you aware of how to save energy at home?

	Response Total	Response Percent
Yes	188	94%
No	13	6%
Total Respondents		**201**
(skipped this question)		20

5. Do you know that there is grant assistance to help you save energy at home?

	Response Total	Response Percent
Yes	148	74%
No	53	26%
Total Respondents	**201**	
(skipped this question)	20	

6. Do you believe that management at this organisation are committed to energy management?

	Response Total	Response Percent
Yes	181	90%
No	20	10%
Total Respondents	**201**	
(skipped this question)	20	

7. Are you aware of an energy policy in place within this organisation?

	Response Total	Response Percent
Yes	133	66%
No	68	34%
Total Respondents	**201**	
(skipped this question)	20	

8. Do you have the opportunity to reduce energy usage at work?

	Response Total	Response Percent
Yes	170	85%
No	31	15%
Total Respondents	**201**	
(skipped this question)	20	

9. Do you practice energy saving techniques such as ensuring that equipment is only operated when required?

	Response Total	Response Percent
Yes	178	89%
No	23	11%
Total Respondents	**201**	
(skipped this question)	20	

10. Are you aware of any recent energy awareness activities undertaken by the organisation?

	Response Total	Response Percent
Yes	146	73%
No	55	27%
Total Respondents		201
(skipped this question)		20

11. Do you know how to communicate ideas for energy saving to the Energy Team?

	Response Total	Response Percent
Yes	90	45%
No	111	55%
Total Respondents		201
(skipped this question)		20

12. Do you try to save energy at home?

	Response Total	Response Percent
Yes	188	96%
No	7	4%
Total Respondents		195
(skipped this question)		26

13. Do you carry out energy saving practices such as turning off lights and equipment when not required?

	Response Total	Response Percent
Yes	191	98%
No	4	2%
Total Respondents		195
(skipped this question)		26

14. Would you be willing to change how you go about your day in order to reduce energy consumption?

	Response Total	Response Percent
Yes	184	94%
No	11	6%
Total Respondents		195
(skipped this question)		26

15. Do you try to limit the use of high-energy equipment such as tumble dryers, washing machines, etc.?

	Response Total	Response Percent
Yes	174	89%
No	21	11%
Total Respondents		**195**
(skipped this question)		26

16. Would you consider renewable/sustainable technologies in your home?

	Response Total	Response Percent
Yes	187	96%
No	8	4%
Total Respondents		**195**
(skipped this question)		26

17. Do you feel the company should consider renewable/sustainable technologies?

	Response Total	Response Percent
Yes	194	99%
No	1	1%
Total Respondents		**195**
(skipped this question)		26

18. Do you try to identify how you can save energy at work?

	Response Total	Response Percent
Yes	150	77%
No	45	23%
Total Respondents		**195**
(skipped this question)		26

19. Do you believe that taking steps to reduce the organisations energy consumption will benefit the environment?

	Response Total	Response Percent
Yes	189	97%
No	6	3%
Total Respondents		**195**
(skipped this question)		26

20. Would more information, competitions and the potential for reward motivate you to participate in energy saving initiatives?

	Response Total	Response Percent
Yes	**172**	**88%**
No	**23**	**12%**
Total Respondents		**195**
(skipped this question)		26

21. Do you believe that your actions can have an impact on the organisations energy use?

	Response Total	Response Percent
Yes	**175**	**90%**
No	**20**	**10%**
Total Respondents		**195**
(skipped this question)		26

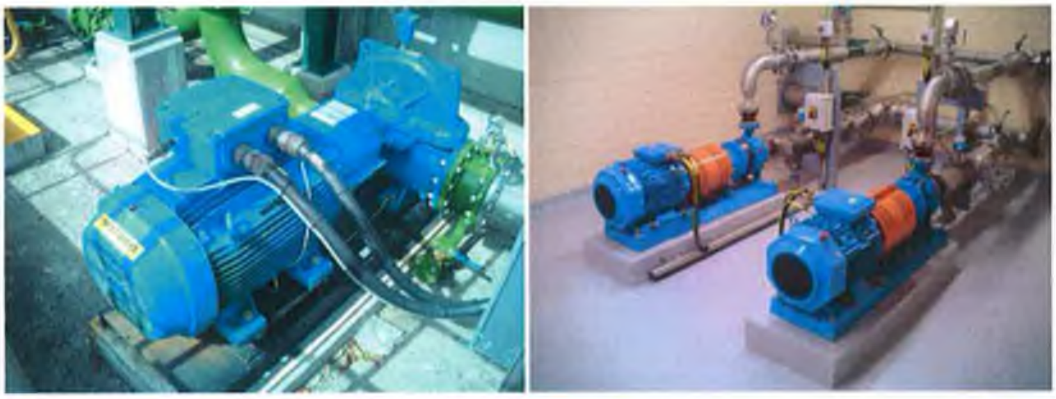
Appendix D

Site Images

Typical Air Handling Unit and Fan (HVAC System)

VSD MCC room plate and VSD Unit for an Agitator Motor

Typical Plant Air Compressor and Breathing Air Compressor



Typical Cooling Water Pump and Process Water Pumps

Tank Farm Pumps and Motors

GSK East Side Tank Farm

Un-insulated Refrigeration Distribution Line Filter and Pump

Nitrogen Pressure Swing Absorption (PSA) Plant and Gas Fuelled Boilers

Automated Valve Manifold Side End View and Front View (Compressed Air Users)

Purified Water Pump with High Purity Piping & Site Retention Ponds, Pipe Rack and Production Buildings

Salty Waste Incinerator Top and Bottom Views

Non Salty Waste Incinerator with Waste Heat Boiler

Appendix E

Monition Steam Survey Case Study Example

Information Required from GSK for Steam System Survey Calculations

Information Required for Steam system Calculations	Unit	Information
Which type of fuel do you use	N/A	Natural Gas
Annual Operating Hours For Boilers	N/A	8,400
Annual Fuel Use	kWh	16,331,814
Steam Generated per year	Tonnes	18,837
Steam Pressure	Bar (g)	6.8
Actual Unit Cost of Fuel	€	€1.17/Therm
Boiler feed water temperature	°C	86
Total Cost for steam generation per hr or yr (Estimation if unsure)	€	€512,574
Average electrical costs at site location	€	€0.14
Estimated Cost of insulation and labor per meter, valve and per flange	€	Varies depending on size
Your cost of labor per hour (Approximately)	€	€51.43

Case Study Attached

MONITION LTD
The advantage of knowledge

Gsk Energy Loss Survey

Steam Survey Case Example

The advantage of knowledge

Gsk - Steam Survey Case Example

Introduction

This reference document highlights the methodology behind the radiated heat energy loss survey of steam systems at GlaxoSmithKline. Whilst it is understood that there are many ways of calculating heat loss the process outlined in this document is the Gsk preferred method. Both the method and calculation used have been given to the Carbon Trust for ratification before its application.

Monition Ltd is always looking to improve upon its methods and quality of service delivery, therefore should any opportunities for improvement become evident then please contact Monition Ltd for collaboration of any advance. Any future improvement opportunities would be again confirmed with the Carbon Trust before being implemented into the Gsk method.

MONITION LTD
The advantage of knowledge

Case Example

The survey is undertaken with the use of a thermal imaging camera, digital imaging camera and where possible with assistance of site personnel for identification and confirmation of base data. The base data is recorded by a Monition site service engineer and a Thermal Imaging camera is used to capture the temperatures so the radiated heat can be obtained. The digital image is taken to help identify the location for repair work.

Base Data

During the survey process the following information is collected in order to help calculate the amount of energy loss (Watts);

- Mean Pipe Temperature taken from Thermal Image at each location
- Steam Pressure at each point
- Average Ambient Temperature (for outdoors the average is taken from the yearly average given by the met office unless stated by site)
- Average Wind Speed (zero is used indoors and for outdoors the average is taken from the yearly average given by the met office unless stated by site)
- Pipe Grade i.e. ANSI-Sch 40 (correcting the Emissivity value during survey to ensure actual temperatures are recorded correctly)
- Pipe Diameter at each point (for valve and flange it is the pipe diameter associated with each component)
- Estimated Area / Length Unlagged (Exposed or Worn). This is to help quantify the actual surface area unlagged, therefore non pipe work i.e. boiler hatches require reasonable estimation of surface area exposed

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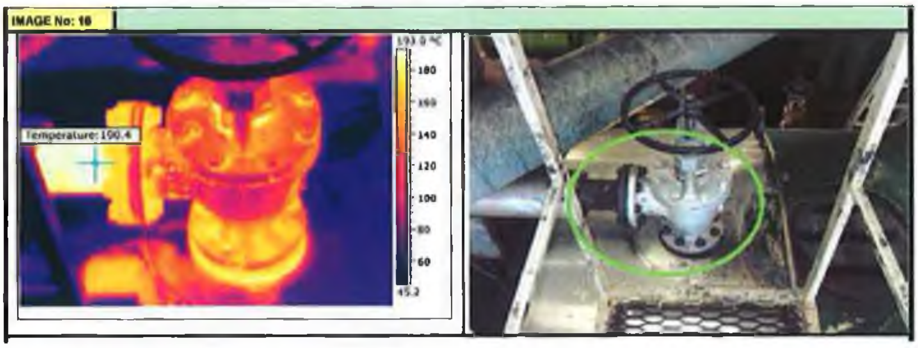
Case Example:



The information taken at this location is as follows;

- Pipe Temperature taken from Thermal Image (the Maximum is 190ºC as shown in the image but the average temperature on the pipe as calculated in imaging software is **173ºC)**
- Steam Pressure at each Point, **(10 Bar)**
- Average Ambient Temperature (in Boiler House **25ºC**)
- Average Wind Speed (inside, therefore **0 m/s**)
- Pipe Grade Schedule 40, Emissivity Value is set at 0.9 for this grade
- Pipe Diameter (**4 Inch)**
- Estimated Area / Length Unlagged (for the exposed pipe, valve and flange the surface area we have recorded is equivalent to **3m of unlagged 4 inch pipe work**)

Please Note: The surface areas typically associated with steam components is a follows;

Valve = 1 to 3m of equivalent straight piping (Note: Depending of Valve Type)
Flange = 0.3 to 1m of equivalent straight piping (Note: Depending of Flange Type)

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Energy Calculation

Monition Ltd uses the TLV software calculation to determine the energy loss at each location. The method outlined below is licensed to TLV. The product used is TLV engineering calculation SE-1 Version 3, 11320 Radiation Heat Loss from Piping.

The calculation is as follows;

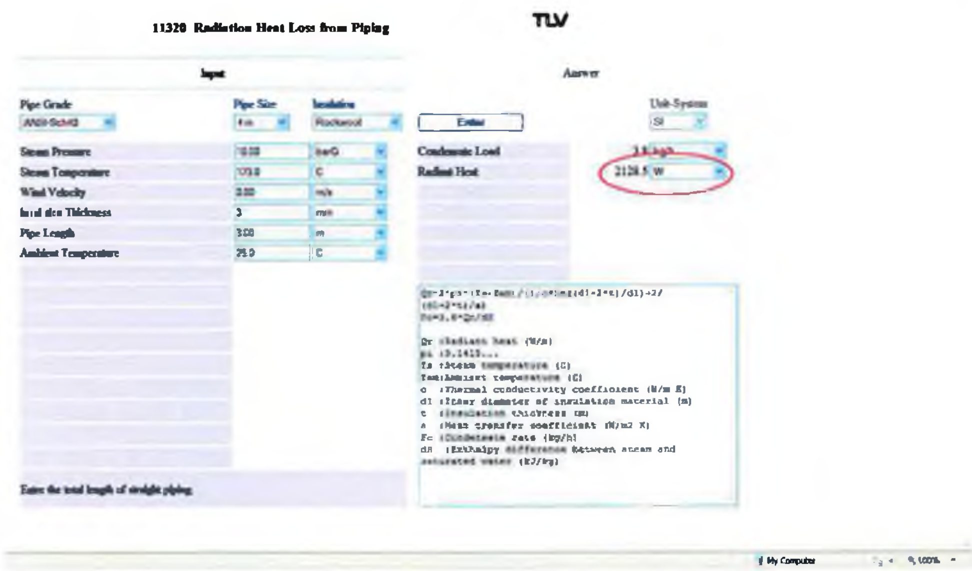
Qr =2*pi*(Ts-Tam)/ (1/c*ln ((d1+2*t)/d1) +2/ (d1+2*t)/a)

Qr: Radiant heat (W/m)
pi :3.1415...
Ts : Steam temperature (C)
Tam : Ambient temperature (C)
c :Thermal conductivity coefficient (W/m K)
d1 : Inner diameter of insulation material (m)
t :Insulation thickness (m)
a :Heat transfer coefficient (W/m2 K)

The base data is entered into the software and using the formula outlined above we can determine the Radiant Heat in Watts.

Case Example

The data is entered into the sheet as per the case example above and using the calculation outlined the Radiant Heat can be seen as **2128.5W**.



Cost Associated with Radiated Heat Loss

To determine the actual cost associated with radiant heat loss, we need to obtain the following values;

- Boiler Efficiency (Steam Generation Efficiency)
- Fuel Type
- The Cost of Fuel (Converted to KWh)
- Number of Operating Hours
- Repair Costs

Boiler Efficiency

Gsk have provided the information shown in table 1 for Boiler Efficiency. The figures are based on detailed surveys of over 80 boilers around the world. Therefore, based on the boiler type the percentage efficiency is selected for the calculation.

Table 1: Boiler Efficiency

Condensing Gas	**95%**
High efficiency modular	**89%**
Shell Boiler (hot water)	**89%**
Shell Boiler (steam)	**85%**
Reverse flame	**83%**
Cast Iron sectional	**79%**
Steam generator	**83%**
Water tube with economiser	**87%**

Case Example

For the case example, data was taken from a system heated by a Shell Boiler therefore the efficiency is **85%.**

Fuel (Type and Costs)

The fuel type and costs are obtained at each site. If the cost value is not given in KWh but therms, litres or other, then they are converted to £ per KWh based on the fuels calorific value.

Case Example

Table 2 below shows the chart used for the calculation. In the case study example the fuel used was Gas in therms converted to KWh with a cost of **£0.06 KWh**.

Note: That costs are determined in the local currency for each survey.

Table 2: Fuel Cost

FUEL COST PER CUBIC METRE OF GAS		PER CUBIC METRE IN LOCAL CURRENCY
ENERGY COST/KWH	0	
FUEL COST PER THERM OF GAS	1.8	PER THERM IN LOCAL CURRENCY
ENERGY COST/KWH	0.061433447	
FUEL COST PER LITRE OF HFO		PER LITRE IN LOCAL CURRENCY
ENERGY COST/KWH	0	
FUEL COST PER LITRE OF GAS OIL	0	PER LITRE IN LOCAL CURRENCY
ENERGY COST/KWH	0	
FUEL COST PER TONNE OF COAL	0	PER TONNE IN LOCAL CURRENCY
ENERGY COST/KWH	0	
FUEL COST PER LITRE OF LPG		PER LITRE IN LOCAL CURRENCY
ENERGY COST/KWH	0	
FUEL COST PER LITRE OF DIESEL		PER LITRE IN LOCAL CURRENCY
ENERGY COST/KWH	0	
FUEL COST PER LITRE OF LFO		PER LITRE IN LOCAL CURRENCY
ENERGY COST/KWH	0	

Cost Calculation

We have now determined the following information;

Case Study Base Data:
Radiated Heat Loss at Fault Location = **2128.5W**
Cost of Fuel in kWh = **£0.06**
Boiler Efficiency = **85%**
Number of Operational Hours = **8000 Hours** (*For this case example*)

Using the following information we now determine the cost per watt / per annum.

Therefore; Actual Fuel Cost accounting for the loss in Boiler Generation Deficiency,

Actual Cost £KWh = £KWh*(100%/85%) Note :(Shell Boiler)
Actual Cost £KWh = 0.071

Therefore, the Cost per KWh = 0.071 then the cost per KW each year equals the cost per hour multiplied by the number of operational hours in the year.

If site is operational for 8000 hours then the cost is;
£ per KW = 8000 x 0.071 = £568 KW/year

Therefore, to determine the cost per Watt we must divide the £ per KW by 1000;
Cost of a Watt Per Year = £568 / 1000 = **£0.568** W/year

Finally, to determine the cost of the radiated heat loss per year for each fault we can multiply the cost per watt per year against the number of watts lost due to radiated heat loss.

Case Example

Radiated Heat Loss at Fault Location = **2128.5W**
Cost of a Watt Per Year = **£0.568**

2128.5 x 0.568 = **£1208.99**

Repair Cost (ROI)

Note: To determine the return of investment (ROI) we simply estimate the repair cost at each location. So for the example if the repair cost is estimated at £200 then the ROI is as follow:

ROI = Repair Cost / (£Year / 52 Weeks)
ROI = £200 / (£1208.99 / 52)
ROI = 9 Weeks Payback

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Carbon Calculation

To determine the carbon footprint in Tonnes (tonnesCO2) we use the following formula which is provided by the Carbon Trust;

Amount of Carbon Dioxide produced is yielded as follows;

Carbon Footprint (KgCo2) = Carbon Emission Factor x KWh of fuel expended.

Carbon emission factors

The factors given below are taken from Annex A of UKETS(01)05 (Guidelines for the measurement and reporting of emissions in the UK Emissions Trading Scheme). These figures are consistent with the National Air Emission Inventory and with the carbon factors given in the generic PP3.02 (Underlying Climate Change Agreement for the [ ] sector).

Fuel		Carbon emission factors kg C/kWh	Carbon emission factors kg CO_2/kWh
Grid electricity	Delivered[1]	0.117	0.43
	Primary[2]	0.0453	0.1661
Natural gas		0.0518	0.19
Coal		0.0817	0.3
Coke		0.101[3]	0.37[3]
Petroleum coke		0.0927	0.34
Gas/diesel oil		0.068	0.25
Heavy fuel oil		0.0709	0.26
Petrol		0.0655	0.24
LPG		0.0573[4]	0.21[4]
Jet kerosene		0.0655	0.24
Ethane		0.0545	0.2
Naphtha		0.0709	0.26

[1] The carbon emission factor for delivered electricity should be used when taking consumption as read from the meter.
[2] The carbon emission factor for primary electricity should be used in calculations for Climate Change Agreements, where all energy use is reported in terms of primary energy.
[3] Climate Change Agreement participants should use 0.117 kg C/kWh (0.43 kg CO_2/kWh) for Coke.

In the Case example we are using natural Gas, therefore the KgCo2/kWh factor is 0.19 as shown in the chart.

KWh of fuel expended is determined from the total energy loss at each site. Therefore, if the total energy loss is 350,000 Watts for the whole site then the carbon footprint can be calculated as follows;

350,000 (j/s) x 3600 (sec/hour) x 8000 (Operational Hours)
= 10080000000000 watts usage per annum
= 2800000 kWh

Therefore, using the formula;
Carbon Footprint (KgCo2) = Carbon Emission Factor x KWh of fuel expended.
Carbon Footprint (KgCo2) = 0.19 Natural Gas x 2800000
Carbon Footprint (KgCo2) = 532000 (KgCo2) / 1000
Carbon Footprint (Tonnes) = 532

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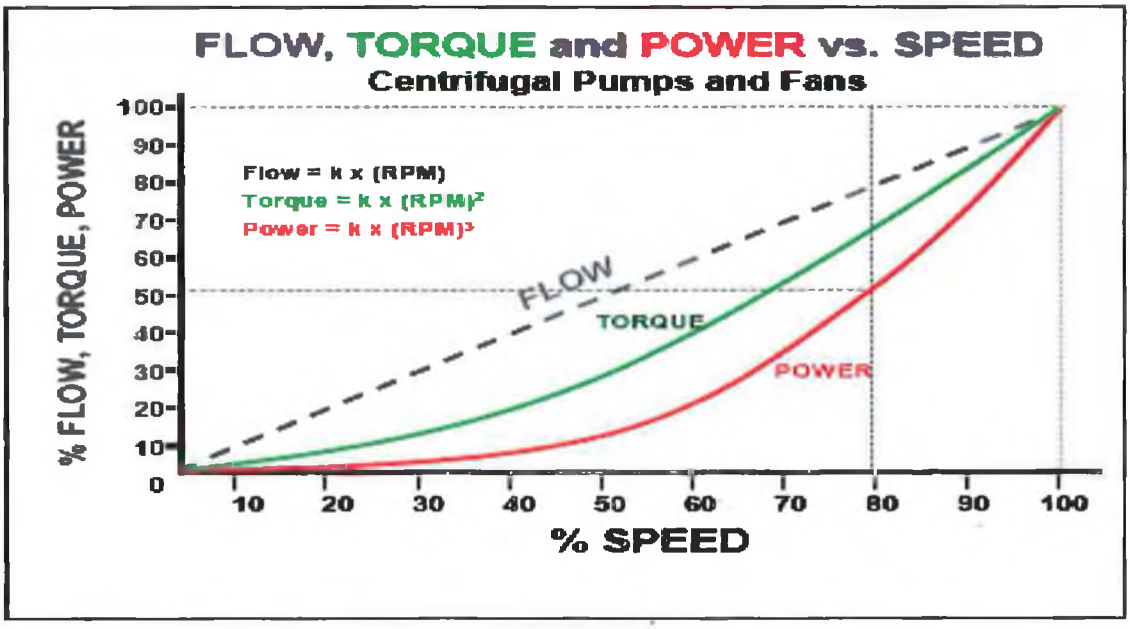
Appendix F

VSD Power Saving Graph



Using the flow, torque and Power vs. Speed graph above the potential power reduction for installing a VSD onto a motor can be identified.

For Example , the chart above shows that by reducing the motor speed to 80% (Flow) it will result in a 50% decrease in power consumption (where the dotted line intersects the red power curve).

This same concept applies for wherever the flow rate intersects the red power curve and horizontally crosses the % flow, torque, power line on the y-axis

Appendix G

IS393 Energy Management Standard Case Studies

Abbott prescribes energy success

Abbott Ireland Pharmaceutical Operations (AIPO) is a first-of-its-kind Abbott operation, designed to manufacture the active ingredients for both small molecules and drugs, which support the therapeutic areas of cardiology, neurology, oncology and urology. The plant spans over 130,000 square feet and currently employs over 100 people.

The AIPO facility in Sligo has driven down electricity and fuel-oil use significantly in the two years since it established baseline energy-use figures for its SEI Energy Agreement.

Energy and related achievements include:

- Certified to IS393 in January 2008 and achieved first annual re-certification.
- Reduced total electricity use from 9.5 MWh in 2006 to 7.82 MWh in 2008.
- Reduced kerosene consumption by one- third, from 1.374 million litres to 0.918 million litres (2006-08).
- Halved water consumption (2006-08).

The site runs 24x7 and maintains conditioned environments for pharmaceutical production. The industry's quality-assurance standards have remained the energy-management team's overriding concern, but AIPO has achieved significant energy savings and was certified to IS393 in January 2008. The site has just completed its first annual re-certification.

Site energy use in late 2007, when AIPO was working towards IS393, was around €1.4 million, dominated by HVAC, which accounted for almost three-quarters of total energy costs.

There are four main buildings on the Sligo site: an admin and laboratory building; the active pharmaceutical ingredient (API) building; a second drug production building; and the utilities building supplying energy to the site. Production runs 24 hours a day, five days a week.

Twin boilers burn Kerosene to deliver steam to the other buildings for HVAC and production, plus additional steam energy to produce hot glycol for production and for use in distillation. On a smaller scale, electricity is used to produce chilled glycol for HVAC and production. Both steam and chilled glycol are circulated 24 hours a day, seven days a week.

During the Review of Energy Aspects required by Abbott for IS393, an energy audit found that the facility was still drawing approximately 70% of peak electrical power and using around 70% of peak fuel oil when the plant was not in production and when most people were not present.

The search for early wins

An important facilitator for the energy team at AIPO has been the energy management system software.

'If I had to put a finger on any one thing that has had a very significant and overarching effect on our energy use, it would be this,' says James Hughes, Facilities Manager and Energy Team Leader. 'This software captured much of the data for the energy audit and is a great help in identifying improvement opportunities.'

From an energy-management viewpoint, the way forward seemed clear. The primary recommendation in the IS393 energy audit was for an early focus on HVAC systems – not only the exploration of HVAC load reductions during non-production periods, but also the 'right-sizing' of utilities to supply the energy demand.

As with other cleanroom environments, pharmaceutical production requires conditioned spaces to be formally validated to ensure that product quality cannot be compromised in any way. Once established, conditions tend to be difficult to change.

Quality takes precedence

'There may be obvious routes to follow from an engineering perspective, but we have to look at processes from a QA [quality assurance] standpoint,' says Dermot Fennelly, AIPO's Supply Chain and Facilities Manager.

'While there has been some progress in reducing HVAC energy demand, for instance by simply turning off air conditioning in non-production areas after hours, there is still plenty of room for energy reductions on the demand side.

'We have had much greater success to date tackling the supply side, which was where the low-hanging fruit was to be found.'

Tuning the supply side

The big wins to date under the IS393 regime have been:

- Right-sizing the two steam boilers – both boilers were found to be oversized for the energy loads being delivered; installing burners of a more appropriate size is delivering around 30% savings on fuel.
- Variable-speed drives on motors – Pump Smart systems were installed site-wide, saving approx. 8% of the electrical base load.
- Similarly, a new compressor installed with variable-speed drive is saving about 4% of the electrical base load.
- Using excess capacity from process chillers to provide chilled water for HVAC systems – so successful has this been that HVAC chillers have been turned off for a large part of the year. Summer 2009 will show if HVAC chillers can be turned off all year round.
- Fixing leaks in compressed-air systems – outdoor tubing installations were being degraded by sunlight. Much of the site has now been re-tubed using stainless steel to repair leaks and prevent future problems.

In AIPO's most recent energy review, for 2008, total electricity use had fallen from 9.5 MWh in 2006 (the baseline year for the SEI Energy Agreement) to 7.82 MWh. Kerosene consumption fell by a far larger proportion, from 1.374 million litres to 0.918 million litres, a reduction of almost exactly one-third. Over the same period water consumption was halved.

The figures also show that HVAC's share of total energy use on site has been reduced with some success, from 78% in 2007 to 68% in 2008. At the same time, product production's share has now more than doubled, from 6.8% to 14.2% (see the two pie charts for comparison).

Energy gets its own agenda

Before the IS393 certification process, AIPO had an informal but active energy-management team. 'We were doing energy management anyway and IS393 fitted our strategy,' says Fennelly. 'IS393 has formalised energy management at AIPO and it has certainly proved very effective as a cost-containment system, allowing us to off set a lot of energy cost fluctuations.'

James Hughes would not go so far as to claim that AIPO has fully established an energy culture across the company as yet. The initial emphasis was on infrastructure changes. Recently, there has been more stress on smaller, operational changes. The facility has a 'very energised' energy-management team that is able to prioritise and act on suggestions. And there is now an energy-saving suggestion box on the company's intranet.

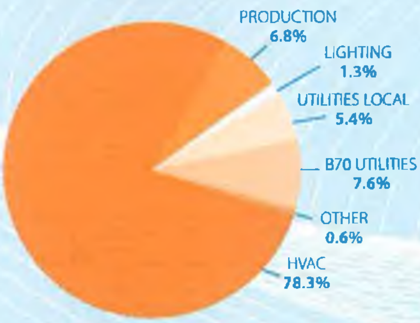
'IS393 implementation has formalised energy management at AIPO. Energy is now a routine item on management meeting agendas,' says Hughes. Energy performance indicators are now prepared on a monthly basis and form part of the overall site KPI review.

Ensuring a sustainable future

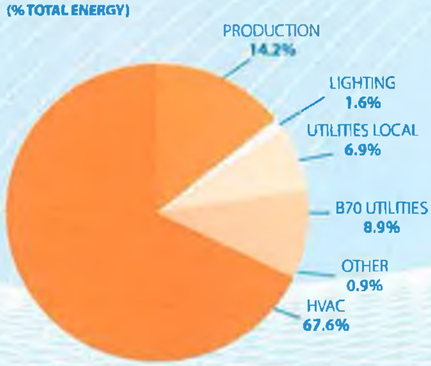
Fennelly believes that advances made through IS393 will turn out to be long-held gains that will improve the sustainability of the Sligo facility over time, rather than short-term reactions to rising energy costs. This is because decisions have been rooted in systematic analysis and the prioritisation of resources.

Other Abbott sites in Ireland are now following Sligo's lead by working towards IS393 certification. That is strong testimony to the energy-efficiency improvements that flowed from IS393 at the Sligo site.

AIPO ENERGY ASPECTS 2007 (% TOTAL ENERGY)



AIPO ENERGY ASPECTS 2008 (% TOTAL ENERGY)



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NDP National Development Plan 2007-2013
SEI is funded by the Irish Government under the National Development Plan 2007-2013 with programmes part financed by the European Union.

Glanbia Gets The Recipe Right

GLANBIA plc is a leading international dairy foods and nutritional ingredients group, headquartered in Ireland. It has operations in Ireland, Europe and the USA, and international joint ventures in the UK, USA and Nigeria.

'Sustained awareness is vital for maintaining momentum and driving continuous improvement forward'

The cost of energy and climate change

Glanbia Ingredients, Ballyragget is the largest multi-purpose, integrated dairy site in Europe. It processes a broad range of dairy ingredients. As energy represents 40% of controllable costs, fuel prices and energy efficiency are crucial to the future competitiveness of Glanbia Ingredients. Also, in the context of environmental climate change, Glanbia Ingredients constantly seeks to reduce carbon emission levels.

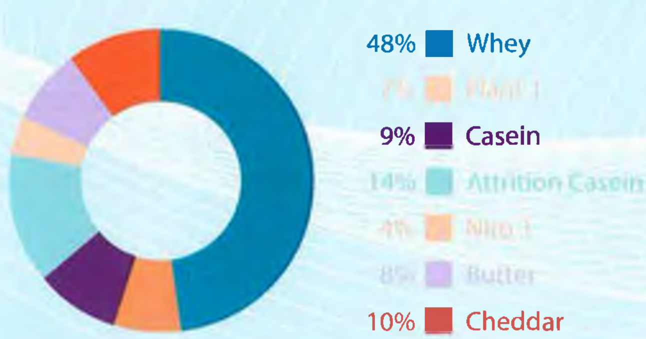
The primary source of energy at Ballyragget is natural gas, as the combined heat and power (CHP) plant produces electricity and steam for the site.

Applying the solution

To tackle these issues, Glanbia:

- signed up to Sustainable Energy Ireland's (SEI's) Energy Agreements Programme in May 2006
- committed to undertaking a fundamental review of energy use by implementing a strategic and systematic approach to energy management
- decided to implement a structured energy-management system – IS393 – at the facility in line with best practice, to improve competitiveness and minimise environmental impact
- was the first Irish-owned company to have achieved accreditation to the IS393 Energy Management System in May 2007

Electrical Usage per Plant KWh: 2006



Counting the benefits

- Glanbia is an active member of SEI's Large Industry Energy Network (LIEN) which reports annually on energy usage and reduction of consumption and emissions using an Energy Performance Index (EPI). The target for 2006 was 62. Glanbia achieved an EPI of 59.11, which outperformed the target.
- Driven by a culture of efficiency in all aspects of operations at the facility, the energy management system engages personnel across all departments, using quantitative data and information.
- In 2006 the amount of energy used per processed 1,000 litres of milk decreased, thus showing an increase In overall energy efficiency across the site.

Identifying the big energy users

Around 60 GWh of electricity and 225 GWh of steam are produced annually by the onsite CHP plant. A further 3 GWh of electricity is imported from the national grid, while supplementary steam requirements are provided by natural-gas-fired steam boilers. The largest single user of electricity onsite is the refrigeration plant, which generates chilled water for a number of processes. The most energy-intensive

process is whey processing, where the bulk of evaporation and drying takes place. It accounts for 48% of energy consumption.

A sophisticated monitoring and targeting (M&T) package is used. The system measures energy data and key profiles, and feeds these into the budgetary process to allow costs to be assigned to various production areas.

To gain further understanding of the energy breakdown, a quantitative analysis of the data was required. Usage profiles over time were assessed and baseline consumption patterns established. Big energy users could then be identified and their impact on the consumption profile better understood.

Mapping the flow of energy

An energy-flow model for the plant was developed during the early stages of the implementation process. In a top-down approach, all significant energy flows were mapped, from the utilities to the end users, in a series of dynamic energy-flow diagrams. Niall Weldon, a Glanbia graduate engineer, mapped and generated these diagrams. This involved analysing the PIDs (piping and instrumentation diagrams), breaking the plant down to a user-friendly PFD (process flow diagram) and, with these, carrying out a mass and energy balance around each process. From this work the big energy users were identified and a strategy and register of opportunities were developed.

The resulting spreadsheet-based flow sheets facilitated active interaction with the processes and their associated energy flows. Any energy implications arising from alterations in production processes are automatically predicted through energy usage data. This allows current processes to be optimised.

The register of opportunities forms the basis for the energy services programme. It will ensure that the most energy-efficient modes of operation are implemented. In addition, the systematic approach ensures that any process improvements are recorded and clearly documented.

EPIs for production-related processes are negotiated with stakeholders after efficiency improvements have been made – for example, a 4.6% reduction in energy consumption has been negotiated with whey production managers for the coming year. EPIs are analysed weekly to ensure that any variation in energy consumption is highlighted and explained. The EPIs are normalised against any variations in production and are reviewed regularly.

In addition, a strategic plan for continuous monitoring of energy profiles was formed. This ensures that efficient plant operation is sustained.

Commenting on the energy plan, John Finlay, the site's Environmental/Energy Services Manager, said quantitative indicators of performance were the key. Without performance data, he added, it would not be possible to drive forward efficient operation practices.

Bright sparks

Energy efficiency means reducing costs and carbon dioxide emissions. It also raises employees' awareness of energy-saving opportunities at home as well as in the workplace. It quickly became apparent that awareness and communication at every level of the organisation were essential for a fully integrated energy-management system. Glanbia Ingredients, Ballyragget, Environmental Coordinator Audrey Mongan O'Shea says sustained awareness is "vital for maintaining momentum and driving continuous improvement forward". The energy team has run a number of campaigns to raise energy awareness at the plant, such as energy awareness weeks, an energy quiz, photo competitions, energy booklets and the 'Bright Sparks' initiative.

Saving by design

The energy-management system ensures that energy-efficient design is now at the forefront in all new projects at Glanbia. Lifecycle economics are considered when any energy-consuming device is bought, whereas in the past equipment selection was based purely on capital economics. For instance, a boiler's attributes (TDS control and blow-down, VSDs on combustion air fans, condensate return, treatment facilities and the installation of an economiser) are being fully explored before any investment decision is made. This lifecycle approach is also adopted when process operations are examined; for example, a process coming online in the near future is currently being reviewed with the aim of reducing water consumption.

The Night Watchman energy initiative was taken onboard by the IT Department, and is applicable to lots of companies. Glanbia computers are automatically turned off outside normal operating hours. The switching back on of these units is staggered through the morning so that the peak morning electrical load is controlled and personnel begin the day's work with computers working at greater efficiency.

According to Glanbia Ingredients Ireland CEO Jim Bergin, "We are very proud to have achieved the IS393. The systems which the environmental team have evolved to achieve this accreditation enable the business to improve energy efficiency, thereby reducing costs. This is particularly relevant in the context of dramatic energy price increases and the impact of climate change."

> 'Quantitative indicators of performance were the key. Without performance data it would not have been possible to drive forward efficient operation practices'

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Sustainable Energy Ireland | Energy Agreements

Schering-Plough Cork plant is global flagship

Schering-Plough (Brinny) is a subsidiary of Schering-Plough Corporation (USA), a global, science-centred, health-care company with leading prescription, consumer and animal health products. The company, located on a 26-acre site near Innishannon, Co Cork, has a staff of 570. It produces a range of biotechnology-derived pharmaceutical products. The Brinny plant is the main site for producing these products, which are marketed worldwide by the Schering-Plough corporation. The site was certified to the IS393 Energy Management Standard in December 2008.

The implementation of the IS393 energy management standard helped achieve:

- sustained energy savings
- informed decision-making
- integrated energy management with shared responsibility
- a structured approach in line with the company's Right First Time methodology
- the surpassing of corporate energy - management standards

Excellence rewarded

The company rewards excellence in energy and environment performance and is committed to good corporate citizenship. Schering-Plough (Brinny) has been a member of Sustainable Energy Ireland's (SEI) Large Industry Energy Network since the late 1990s. It was one of the first companies to join SEI's Energy Agreements programme.

The Brinny plant had already achieved ISO14001 certification for environmental management. The next logical step was to reinforce its commitment to energy management by implementing Ireland's energy-management standard IS393.

Need to control energy use

The Brinny site combines manufacturing, laboratories, warehousing, utilities and administration. Significant energy-using plant includes:

- three natural-gas boilers, chillers and fans for HVAC and process cooling
- compressed-air generation for the manufacturing processes and instrumentation.

HVAC chillers and fans account for two-thirds of the electrical energy use.

Since the energy bill is over €6m, controlling energy use is a high priority for senior management.

The corporate drivers

The main motives for implementing IS393 were:

- the rising cost of energy and the need to reduce its impact on operating costs
- the company's global Level II standard for energy management, required for all plants

Schering-Plough internationally also has an ambitious target for cutting greenhouse-gas emissions: 5% absolute reduction of 2002 CO_2 levels by 2012.

These efforts are intended to provide value to customers, employees, shareholders and the local community, and further reinforce the company vision: "To earn trust, every day."

"IS393 provided the ideal solution for us. It suited the company's ethos and built on existing systems. Structures were already in place to accommodate such a standard and it aligned perfectly with our 'Right First Time' methodology,"

says Stephen Sisk, the Energy Process Engineer.

Leading in best practice

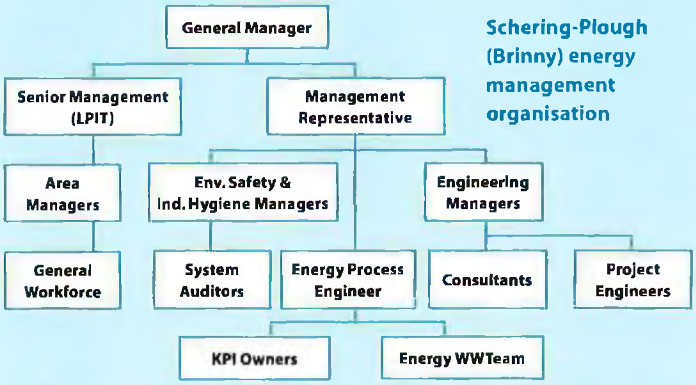
Senior management was on board from the start. They knew that a formal energy-management system could deliver the energy savings called for by their ambitious agendas for resource efficiency, corporate responsibility and cutting greenhouse-gas emissions. They allocated the time and resources required to implement IS393. At the outset, the Energy Process Engineer was appointed to lead the energy-efficiency effort.

The top-level goals for IS393 were to:

- demonstrate best practice in energy management
- be a leader within the Schering-Plough group

Although structures were already in place to implement IS393, a gap analysis of energy-management activity was required to identify focus areas for implementation.

Energy consultants then carried out audits to identify any remaining gaps in energy management and opportunities to improve energy efficiency. The energy team developed a plan to address gaps, prioritise opportunities and implement the system. The SEI-appointed Agreement Support Manager (ASM) assisted them throughout the process.



Schering-Plough (Brinny) energy management organisation

Energy Management Stakeholder Categorisation

Category description	Example
Direct high impact	Utilities operator, Energy Process Engineer
Influencer	Supervisors, Process engineers
Leaders	Area managers
Projects and Procurement	Project engineers, Purchasing
Indirect impact	Security, Cleaners
General	General workforce, incl. Contractors
Maintenance crafts	Mechanical, Electrical and Instrument
Service companies	Chillers, Boiler, HVAC, Air compressor
Technical support	Validation, Quality, Tech. transfer

Integrated energy management

A key approach to energy management at the site is its integration into the normal management structure of the plant. In this way energy management decision making is part of the business process and not a bolt-on activity. The energy team itself consists of people from cross-functional departments and levels within the facility, including finance, operations, production, procurement, engineering and environmental health & safety.

Schering-Plough recognises that lasting change can only be brought about by a change in the energy culture within the company. To help achieve this they developed a series of categories to describe the influence of stakeholders on energy use and their interaction with the energy management system. From groups with 'Direct high impact' to those with 'General' influence, every role within the company was categorised and roles, responsibilities and training assigned.

Training is a significant part of implementing IS393 at the facility. This ranges from general awareness training through to training on technologies and work areas such as laboratories and offices. Specific training is also delivered to the category groups identified in the table, with courses covering "Energy Aspects for Influencers" amongst many others.

Tracking performance

With IS393, the energy management process is standardised so that improvements are sustained over time. One of the pillars of sustained energy savings are the Key Performance Indicators (KPIs). At the Brinny plant these are developed and agreed with stakeholders, and ownership of the KPIs is taken on by specified individuals within the organisation structure (see organisation structure above). This is crucial to ensure that targets are met. To date the plant has focused more on overall indicators, but plans to develop KPIs for other important technologies and processes.

Energy savings

IS393 is paying dividends for Schering-Plough. The savings achieved in 2008 were:

Electrical: 582,492 kWh
Gas: 1,502,578 kWh

Major projects with measurable savings, triggered by the increased focus on energy as a result of IS393 in 2008 are shown in the table. However, further un-metered savings were achieved from projects such as fixing steam leaks and ensuring equipment is off, outside of production hours.

Metered energy savings as 2008

Description	System	Savings (kWh p.a.)
Shutdown of a standby boiler (gas)	Steam	1,400,000
Shutdown fermentation extension and services when not required (elec)	HVAC	266,212
Control space heating in administration building (elec)	Boilers	225,760
Insulate steam valves and fittings in boiler house area (gas)	Steam	102,578
Reduce compressed air leaks (elec)	Compressed Air	90,520

Direct benefits

Through its certified IS393 energy management system, Schering-Plough aims to continuously improve the efficient use of energy to manufacture its products and operate its facilities at the Brinny plant. The implementation of IS393 has proved to be a highly successful strategy. Stephen Sisk adds

"The plant has surpassed the requirements of our corporate directives with a system that satisfies our corporate standard requirements."

The direct benefits of IS393 are:

- sustained energy savings;
- shared responsibility through a cross functional energy team;
- informed decision making;
- structured approach in line with the company's Right First Time methodology.

Since implementing IS393 the site has also become more strategically aware of the need to include energy efficiency and life cycle costing as key factors in equipment procurement, product development, and process/facility design. A strategic 'energy efficient design' methodology is now being applied to a new facility design under consideration.

With an ISO international energy management standard in the pipeline, Stephen Sisk is delighted with the achievement.

"Schering-Plough Brinny is in an excellent position within the organisation to offer advice to other company plants embarking on system implementation."

With this in mind, Brinny is leading the way and is already liaising with corporate management to produce international guidance on how to incorporate energy issues into new projects and apply project lifecycle analysis.

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SUSTAINABLE ENERGY IRELAND | Energy Agreements

CASE STUDY/17
WYETH

IS393 energises Wyeth energy efficiency

Wyeth, the multinational healthcare group, is the largest pharmaceutical employer in Ireland. It has five facilities, employing over 3,000 employees.

The Wyeth Medica Ireland (WMI) campus at Newbridge, Co. Kildare, where operations occupy 22 hectares, took the lead among Wyeth's Irish facilities to pursue best practice in energy efficiency by using the IS393 Energy-Management System. The company was also under pressure to reduce growing energy costs for the site to maintain cost competitiveness.

Wyeth arrived in Newbridge in 1992. Since then it has tripled the size of its site – to more than 1 million sq ft – and seen employment grow from 50 to over 1,300 staff.

Significant Energy Management achievements in 2008:

- Energy Management System certified to IS393:2005 (June 2008).
- New site energy lead appointed (October 2008).
- Equipment shut-down at weekends.
- Installation of variable speed drive on HVAC supporting selected production equipment (enables out-of-hours set back of system to lower limits).
- 2008 Energy Calendar developed based on energy art competition run with local school.

Global operations on a single site

The facility is a global and regional supplier of products and a key manufacturing base for new and innovative therapies emerging from Wyeth's R&D pipeline. Operations therefore extend across a range of formulation activities, from the blending of raw materials, granulation, drying and coating processes to packaging and distribution.

Production facilities, for instance, include packaging and processing buildings, solvent-recovery plant, CHP plant and laboratories. Other facilities are: warehousing of raw materials/intermediates/finished goods, external materials storage, services including steam, compressed air, nitrogen, cooling water and process water, wastewater pre-treatment plant (WWTP), waste management centre, oils/fats/grease (OFG) wastewater treatment plant, engineering workshops, and an administration building with canteen.

Structures in place

WMI already had a dedicated corporate energy department supporting the Newbridge facility before its managing director signed an agreement with SEI in 2008 to put a certified energy-management system in place. As part of its environmental commitment, the company had already achieved ISO 14001.

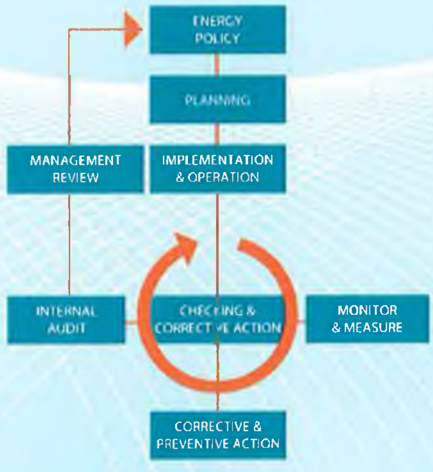
However, there was no formal approach to energy management across the site. As engineering project manager Mark Dullaghan recalls: `We were implementing projects without knowing what our significant aspects were. There was also an ad hoc, reactive approach to energy management, with meetings convened when energy bills ran high.´

The implementation of a certified system to IS393 was seen as an effective tool for co-ordinating these energy-reduction efforts and ensuring that gains would be sustained over time.

Building on environmental management systems

The fact that the IS393 standard was formulated along the lines of ISO 14001 – already in place at Newbridge – with its familiar 'Plan-Do-Check-Act' model, suited the energy team at Wyeth. After agreement with SEI and with a supporting relationship established, the team worked with Environment, Health and Safety staff at Newbridge to update the ISO 14001 procedures. According to EHS Manager Ed Molyneaux `This required additional procedures, including check sheets and training programmes to be developed in order to meet IS393 requirements´.

Figure 01:
The Energy Aspects Review



There would also be a cross-benefit with WMI's need to maintain an Integrated Pollution Prevention Control (IPPC) licence, which requires periodic audits of energy efficiency onsite to identify opportunities for energy-use reduction and efficiency. In addition, IPPC requires identification of opportunities for water reduction, including recycling and reuse.

Phased implementation

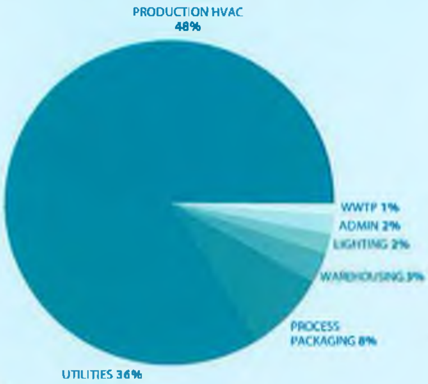
Implementation of the IS393 process at Newbridge was in two phases: phase one was concerned with updating ISO 14001 to meet IS393 and conducting internal EHS audits to include evaluation of opportunities; phase two implemented the remaining stages in association with consultants.

Energy-usage figures were available for the SEI-appointed external consultant who carried out a gap analysis, and a bottom-up approach identified equipment with significant energy usage. Opportunities for improvement were then identified through an energy aspects review (see Figure 1).

A critical factor in implementation, says Mr Dullaghan, was the development of key performance indicators (KPIs) and an associated energy-monitoring process. Three KPIs were developed:

- Reduce natural gas consumption by 3.3% – 4022 MWh
- Reduce electrical consumption by 2% – 1215 MWh
- Reduce water consumption by 2% – 6945 m³

Figure 02:
A breakdown of the site's energy use



Energy-saving projects

The most significant projects triggered by IS393 were not capital investments so much as the training of personnel so that they reduce energy usage in day-to-day operations. Switching off equipment during shutdowns and weekend periods, for instance, saved 800,000 kWh.

The most dramatic saving was a 16% decrease in water usage, after monitoring of the site's water mass balance revealed a significant leak.

The most notable energy-saving capital investment at Newbridge in recent years remains the pre-IS393 combined heat & power (CHP) plant installed in 2004, which has been producing energy savings of around €750,000 a year.

In parallel with IS393, WMI has obtained grants from SEI's Industrial Best Practice Initiative for building projects. A more energy-efficient pharmaceutical R&D facility is forecast to reduce CO_2 emissions by over 1750 tonnes a year and water by 2200 m³ a year.

Employees play major role

According to Ed Molyneaux 'Under the IS393 regime, all employees have been made responsible for promoting a culture of energy awareness at Newbridge. They can contribute to plant energy saving by ensuring that any ideas/opportunities are reported to the site Energy Management Committee. In addition to staff training, the system is promoted via leaflets in the canteen, presentations during energy awareness days and email communications'.

'When the system is mature, energy management should become integrated into people's day-to-day work responsibilities and activities,' says Mr Dullaghan. 'This will lead to savings in costs and reinforce the site's responsibility to protection of the environment.'

He does not doubt that the benefits of IS393 certification have outweighed the costs and reports that the process has given WMI a new perspective on the Newbridge site's energy profile. 'Implementation of an energy-management system is an effective tool to co-ordinate the sustained reduction of energy usage at a site and also to bring awareness of an energy-management programme to front-of-mind for management and employees.'

The company holds that a mature and established environmental management system enables a smoother transition to the implementation of an energy-management system. Mark Dullaghan and Ed Molyneaux conclude: 'It's a lengthy process that requires input and commitment from many departments including engineering, training and EHS. Initiation is one thing, implementation is another, and while it is more challenging, it will be a worthwhile process.'

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