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1 Introduction

This book is the first of a set of three being published by the ENERGYWISE Plastics project. The intention is to offer advice on energy efficiency within the polymer industry. The three books come under the main title of *A Practical Guide to Energy Managemen*t and are aimed at firstly managers, secondly processors, and finally the management of facilities and utilities.

The ENERGYWISE Plastics project is partly funded by the Leonardo programme which supports the development of skills and training. It funds work placements for trainees, workers and staff, and supports European projects to discuss common issues or develop training materials, courses and frameworks. Leonardo is part of the European Commission's Lifelong Learning Programme.

1.1 The Need for Energy Reduction

The European plastics industry is one of the most important sectors in the European Union (EU), with according to EuPC, about 1.6 million people working in 50,000 companies, with an aggregate production of almost 40 million tonnes, representing a value of some €280 billion and applications in a vast variety of industries . However, the sector is mainly dominated by small and medium enterprises (SME) that are coming under increasing pressure from low wage economies as well as increases in EU enforced legislation and a rise in the price of energy and raw materials. While global demand for plastics materials has continued to grow, profit margins of European producers have suffered due to increased expenses for raw materials and energy. Due to the uncertain global economic climate and market pressures on key customer sectors, the main focus of many processors is process optimisation and cost reduction rather than business expansion.

There are many reasons for wanting to improve your energy efficiency, however, the most compelling reason for the plastics processing industry is that wasting energy costs money and this is reflected in the bottom line. With rising energy costs, soaring raw material prices and the impacts of climate change, the need to monitor and reduce energy consumption is more important than ever before. As with most industries, controlling costs is critical to sustainability and profitability. However, energy costs can be controlled and often reduced, by implementing measures that do not require significant investment. In many cases improvements can be made for low or no cost, by making slight changes to the way a process or equipment is operated to optimise its performance. Energy efficiency offers short- and long-term benefits and by increasing the efficiency of a business the bottom line can be strengthened. It will be the ability of businesses to make rational and informed decisions about the use of energy on site that will play an increasingly important role in helping to manage the new challenges in a changing business climate.

According to the *European 2008 Environment Policy Review – Annex 1*, 'energy use (including transport) accounts for 80% of all greenhouse gas emissions in the European 15'.

Following agreement at the European Council in 2007, the EU is committed to:

- Achieving at least a 20% reduction in its greenhouse gas emissions by 2020
- An increase in the use of renewable energy, to 20% of all energy consumed
- A 20% increase in energy efficiency
- An increase in the use of bio-fuels, to 10% of all fuel used in transport

Energy efficiency and energy management have never been more important themes than now. With the advent of the climate change levy within the UK, companies have found an increasing burden (or incentive!) on them to reduce energy consumption and improve manufacturing processes, without significantly adding to financial burden. In reality of course, there are three major drivers for the increased concern with energy – security of supply, legislation and cost.

1.2 The ENERGYWISE Plastics Project

The ENERGYWISE Plastics Project has an objective to develop an elearning platform and training materials for those working with the plastics industry to learn and understand how to manage and reduce their energy consumption. The project uses a 'blended learning' approach, offering interactive on-line modules and supporting 'hard-copy' resources, focusing on the needs of SME. The course has three entry points and is aimed at different levels/grades of staff within an organisation:

1. Management
2. Processing/operational staff

2 Understanding Energy

2.1 Introduction

According to the *European 2008 Environment Policy Review – Annex 1* - 'energy use (including transport) accounts for 80% of all greenhouse gas emissions in the European 15.

Following agreement at the European Council in 2007, the European Union (EU) is committed to:

- Achieving at least a 20% reduction in its greenhouse gas emissions by 2020 compared to 1990, or 30% if other developed nations agree to take similar action
- An increase in the use of renewable energy, to 20% of all energy consumed. This is a binding target. However, the plan allows flexibility in how each country contributes to the overall EU target
- A 20% increase in energy efficiency
- An increase in the use of bio-fuels, to 10% of all fuel used in transport

The European Energy Market is, at best, complicated and with many disparate issues. Whilst we may be subject to a multitude of European Directives, Requirements and Laws, the European market, it can be argued, is dominated by 'National Interest' and legal requirements which often differs from country to country, even within the 'European 27 (EU-27)'. With the increasing challenges faced by climate change, an increased dependency on energy imports (and associated issues of transport and most importantly, international relations) and higher energy prices, the EU-27 faces a common challenge – or opportunity – to develop energy efficient technology.

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Although there is an increasing pressure on businesses in all sectors to improve their environmental performance, many small-to-medium enterprises (SME) still have a low awareness of obligations with regards to reducing their 'carbon footprint'. A European wide survey carried out by the ENER-PLAST project in 2009 revealed that of the 262 companies questioned:

- 40% were unaware of existing legislation regarding energy
- 61% of companies do not have an energy manager
- 94% believe that their home country should harmonise legislation with the EU
- 63% report that profit is their main driver for energy reduction

Energy prices have seen an exponential increase in recent years, with security of supply one of the main issues. There are many reasons for the uncertainty of supply (and of prices), from natural to man made issues, including conflicts around the world. Developing nations such as Brazil, China and India, and to some extent, Russia, have seen grosas domestic product growth rates between 8% and 10%, together with the associated increase in demand for raw materials and meeting the needs of an increasing population. Even allowing for the global recession of 2008-2010, energy prices have continued to remain volatile, as security of supply is by no means assured.

Energy accounts for 80% of all greenhouse gas emissions within the EU. Determined to fight against climate change, the EU is committed to reducing its own emissions by at least 20% by 2020, as detailed in the *Action Plan for Energy Efficiency (2007 – 2012)*. 'The Commission considers the biggest energy savings are to be made in the following sectors: residential and commercial buildings (tertiary), with savings potentials estimated at 27% and 30%, respectively, the manufacturing industry, with the potential for a 25% reduction, and transport, with the potential for a 26% reduction in energy consumption.' [1]

There are a number of commitments which many European Government's have signed up to, one of which is the Kyoto Agreement (countries that agree to the Kyoto Protocol will reduce greenhouse gas emissions that contribute to global warming by 5.2% below 1990 levels. The target date for the initial agreement is 2012). As the European Environment Agency reports, 'the European Union's greenhouse gas inventory report, shows that emissions have not only continued their downward trend in 2008, but have also picked up apace. The EU-27's emissions stood 11.3% below their 1990 levels, while EU-15 achieved a reduction of 6.9% compared to Kyoto base-year levels'. The report continues 'the EU-27's emissions have been declining steadily since 2003 to reach 4,940 billion tonnes of CO_2 equivalents in 2008. Compared to the 2007 emissions, this represents a reduction of 99 million tonnes or 2%. With the

3 Energy Management

The following chapter concentrates on the management of energy consumption and the tools that can be used to assist in this task. The latest concept of ‘degree days’ will be discussed and how to make use of this information will be considered, illustrating the text with real examples. Important short- and long-term measures will be discussed along with a suggested action plan including the importance of training. Finally measurement, without which no control can be achieved, will be addressed and again real examples will be used to show how to get the best results from the different techniques such as half-hour data and automated monitoring and control.

3.1 Degree days

3.1.1 Introduction

Essentially this subject focuses upon quantifying, monitoring and controlling the amount of energy used for heating any controlled set of buildings, offices, or factory complex. The cost of this energy is readily obtained but how do we determine if the heating system is under control, or whether we are using more energy than is necessary for the task. Additionally, when we make changes how do we monitor any improvements that we may make? What happens if the weather becomes warmer and less energy is used as a natural course of events? Any changes that have been made will then be lost because of the change in demand for heating within the building.

Using degree days enables a comparison to be made between any changes that have been implemented, eliminates weather factors thus helping to observe trends in energy usage and assists with the budgeting of expenditure on heating energy.

3.1.2 Definition of Degree Days

Different types of degree days can be obtained and used for a variety of applications. There are ‘heating’ degree days, ‘cooling’ degree days, and ‘growing’ degree days, and the names give a good indication of their potential usage. Whilst all are of interest and can assist in the objective of reducing energy consumption, it simplifies matters to limit this section to a definition of heating degree days.

Degree days (heating) are a means of quantifying the expected demand for heating of, for example a building, dependent upon the prevailing weather conditions. Thus, a high figure for degree days would imply a high demand for heating energy, and a low figure would mean less demand. Obviously the nature of the building, its insulation efficiency, occupancy, and heating efficiency will all influence the energy demand. However, degree days are based upon different levels of, what are known as base temperatures. The base temperature being the temperature at which the building does not require any additional heating beyond what is supplied by its occupants and their computers and so on. Obviously all buildings are different but it has been found that certain base temperatures can be used to cover most buildings. This is discussed more fully in the next section.

Degree days are in fact the summation of the temperature difference below the base temperature multiplied by the time at that temperature. Thus, if the temperature remained constant at 14.5 °C for a whole day then the degree days, on a base temperature of 15.5 °C, would be one degree multiplied by one day, effectively one degree day. In reality the actual ambient temperature will vary considerable during the course of a day but this can be accommodated by taking temperature readings every hour, multiplying the difference below base temperature by one twenty-fourth and then adding the 24 results to give the degree day for that day. These degree days can then be added over the course of a month and a figure arrived at for degree days for that month. The monthly degree days are in fact the most commonly quoted and used figure.

An excellent and more detailed definition of degree days can be found by going to the website *Degreedays.net* and then the 'knol' by Martin Bromley. [1]

3.1.3 Obtaining Degree Day data

Historical degree day data can be obtained from a variety of sources, but before discussing the sources it is important to understand some of the variants that can occur in the type of data that is available.

3.1.3.1 Base Temperature

One of the most common base temperatures used is 15.5 °C (60 °F) which applies fairly

4 Cost of Ownership

4.1 Concept

Total cost of ownership (TCO) is a financial estimate. Its purpose is to help consumers and enterprise managers determine direct and indirect costs of a product or system. It is a management accounting concept that can be used in full cost accounting or even ecological economics where it includes social costs.

TCO when incorporated in any financial benefit analysis, provides a cost basis for determining the economic value of that investment. Examples include: return on investment, internal rate of return, economic value added, return on information technology, and rapid economic justification.

A TCO analysis includes total cost of acquisition and operating costs. An enterprise may use it as a product/process comparison tool. TCO directly relates to an enterprise's asset and/or related system's total costs across all projects and processes, thus giving a picture of the profitability over time.

TCO analysis was popularised by the Gartner Group in 1987. The root of this concept dates back at least to the first quarter of the twentieth century. It has since been developed in a number of different methodologies and software tools. TCO tries to offer a statement on the financial impact of deploying any technology product over its life cycle, for example the incorporation of a variable speed drive to an injection machine.

Many times, using TCO analysis has shown that there is a difference between the price of something and its long-term cost.

4.2 How to Calculate Total Cost of Ownership

The TCO concept is widely used in the software and transportation industries and can be easily applied to the plastics industry. For example, the TCO defines the cost of owning a production machine from the time of purchase by the owner, through its operation and maintenance to the time it leaves the possession of the owner. Comparative TCO studies between various models help managers choose a machine to fit their needs and budget.

Some of the key data elements used to calculate the cost of ownership for a production machine include:

- Depreciation costs: Allocation of the cost of tangible assets to periods in which the assets are used. Generally the cost is allocated, as depreciation expense, among the periods in which the asset is expected to be used. Such expense is recognised by businesses for financial reporting and tax purposes. Methods of computing depreciation may vary by asset for the same business. Methods and lives may be specified by the accounting and/or tax rules of a country. Several standard methods of computing depreciation expense may be used, including fixed percentage, straight line, and declining balance methods. Depreciation expense generally begins when the asset is placed in service.

- Energy costs: The biggest part of the operation cost in the plastic industry and the one in which big differences can be made by choosing energy efficient equipment that saves energy during its whole life cycle.

- Financing: is the science of fund management. It deals with how money is spent and budgeted. Finance is one of the most important aspects of business management and includes decisions related to the use and acquisition of funds for the enterprise.

- Maintenance and repairs costs: Maintenance, repair, and operations (MRO) involves fixing any sort of mechanical or electrical device should it become out of order or broken (known as repair, unscheduled or casualty maintenance). It also includes performing routine actions which keep the device in working order (known as scheduled maintenance) or prevents trouble from arising (preventive maintenance). MRO may be defined as, 'All actions which have the objective of retaining or restoring an item in or to a state in which it can perform its required function. The actions include the combination of all technical and corresponding administrative, managerial, and supervision actions.'

- Opportunity costs: This is the cost related to the next-best choice available to someone who has picked between several mutually exclusive choices. It is a key concept in economics. It has been described as expressing 'the basic relationship between scarcity and choice.' The notion of opportunity cost plays a crucial part in ensuring that scarce resources are used efficiently. For example, an organisation that invests money in acquiring a new asset instead of spending that money on maintaining its existing asset portfolio incurs the increased risk of failure of its existing assets. The opportunity cost of the decision to acquire a new asset is

5 Leadership and Awareness

The success of an energy management programme within an organisation depends upon an union between technology and management. Technology alone cannot achieve optimal savings, but coupled with operational and management practices can lead to significant savings. The key attributes to a successful energy management programme include:

- Commitment from top-level management
- Development of management strategies
- Clearly stated goals on energy efficiency
- Communication of goals, tactics and achievements throughout all levels of the organisation
- Delegation of responsibility and accountability to the appropriate personnel
- Sustained tracking and assessment of energy use and technology application
- Continuous investigation of potential energy reduction projects
- Application of business investment models to energy projects
- Establishment of an internal recognition and reward programme for achieving energy goals

Energy management is highly cost-effective but it is important to remember that it is not a one-off exercise, to be effective it must be an ongoing process.

This section will help you to assess the current state of energy management in your organisation and give you advice about how to review your own effectiveness, define where you are at the moment and where you want to get to.

5.1 The Advantages of Energy Efficiency

There are many reasons why an organisation should take energy efficiency seriously, from improving the economic health to helping to reducing damage to the environment. Many measures can also bring substantial benefits in terms of employee comfort through improved heating, insulation and the avoidance of cold spots. This can reduce staff turnover and improve productivity. Attention to energy efficiency can often highlight deficiencies in other areas such as maintenance, process yield and quality, therefore giving significant additional productivity benefits.

Additionally, an increasing amount of regulations and directives at both a national and European level is being applied to drive improvements in energy efficiency. It is not just a matter of operating efficiently; it can also be a factor in operating legally.

5.2 Energy Awareness Survey

Before embarking on an energy management programme, an awareness survey should be conducted within the company and repeated at regular intervals to measure change.

By allocating scores to the responses for the questions given in **Figure 3.7** one will obtain an 'energy awareness score'. This provides a measure of how you are performing in managing energy usage. The maximum score available is 16.

The energy awareness survey will help you learn about your organisation's knowledge and commitment to reducing energy consumption.

5.3 Effective Implementation

Fundamental to the effective implementation of an energy efficiency programme is good management. Like any resource that an organisation employs, energy will only be used efficiently if it is managed properly. Good energy management saves energy in itself, but is also necessary for getting the most out of technical energy saving measures. A report published by the 'UK Energy Efficiency Best Practice Programme' entitled 'Maintaining the momentum – Sustaining energy management' found that there are six critical factors for successful energy management:

- Top-level commitment
- Leadership
- Company awareness