Industrial Energy Efficiency Project in South Africa

Introduction and Implementation of an Energy Management System and Energy Systems Interventions

Company name	**POLYOAK PACKAGING (PTY) LTD**
Sector	**Plastic packaging manufacturer - injection and blow moulded rigid plastic**
Year joined IEE Project	**2012**
Year of interventions	**2013**
Contact person	**Andre Treurnich, Maintenance/Energy Manager. +27 21 710-9218**
Systems of intervention	**EnMS** **Cooling** **Heating**

1. BACKGROUND

1.1 Company profile

Polyoak Packaging, founded in 1976, is a privately owned plastic packaging manufacturer specialising in the design and manufacture of injection and blow moulded rigid plastic packaging for the dairy, beverage, apparel and industrial sectors in Southern Africa. The Polyoak group have manufacturing operations and distribution centres are in Cape Town, Durban, Johannesburg, East London and Namibia. Polyoak Packaging is one of the leading rigid plastic packaging suppliers in Southern Africa.

1.2 Plant profile

The Polyoak Cape Town plant has 1,134 employees with a factory floorspace of 109,850 m2 and is located in Waterford Road in the suburb of Diep River in Cape Town. The plant comprises of 7 buildings with 10 production departments of Visconti, Blowpack, Tubs 1, Tubs 2, Tubs 4, Dairy, Pet 1, Pet 2, Preforms, African Closures. The following ISO systems are in place: ISO 9000 and ISO 22000 (group accreditation of manufacturing plants). They are also working towards compliance in ISO 17025, ISO 18000, ISO 14000.

Figure 2. Satellite view of POLYOAK PACKAGING

Figure 1. Front view of POLYOAK PACKAGING

1.3 Nature of challenges

Rising electricity prices resulted in a negative impact in associated utility costs. Electricity is the primary energy source with an annual cost of R35 million. Thus, Polyoak was motivated to identify areas where savings could be made, but lacked insight in to how this could be achieved. In July 2012, with assistance from the IEE project, Polyoak Packaging embarked on the Energy Management Systems (EnMS) implementation process in earnest. Polyoak also agreed to be a demonstration plant for UNIDO EnMS Expert level training course. Polyoak had limited sub-metering for the departments and being a very large user found it difficult to identify savings. Departments also often operated autonomously e.g. with pump operations. The designated Energy Manager had limited capacity and Departments had yet to identify specific people to address EnMS implementation.

2. OVERVIEW OF IMPLEMENTATION

2.1 IEE capacity building programme

Participation in the IEE programme enabled Polyoak's Maintenance/Energy Manager, Andre Treurnich, to develop EnMS expertise through the EnMS Expert Level programme. Energy Awareness and skill were also developed in 4 members of Polyoaks' technical and maintenance staff by attending a variety of IEE courses and more being interested in attending additional courses. ESO expertise was also offered in assessing Polyoak's pumping systems. The necessary technical and advisory support was also provided which resulted in a customised Energy Management System being implemented as well as various Systems initiatives being carried out. As a result, significant savings have been achieved without significant financial investment required.

3. KEY ACHIEVEMENTS

Key Outcomes/Results table

Implementation Period	**2013**
Total Number of projects	**3**
Monetary savings in ZAR	**R 2,925,931**
Energy savings in kWh	**3,112,693 kWh**
Total investment made ZAR	**R 262,133**
Payback time period in years	**0.1 years**
GHG Emission Reduction (tonne CO_2)[1]	**2,978**

4. THE APPROACH

Polyoak participated in EnMS as a Host Plant[2] in July 2012 as part of the IEE programme. The EnMS concept was introduced and implemented over the period of over a year.

An energy assessment that formed part of the planning component of the EnMS was conducted between the 6th and 7th November 2012 by DMC Resource Innovations CC. The methodology included compiling detailed electrical energy balance and identifying opportunities for increased optimisation. Areas for resource saving identified included a 25% reduction in electrical energy costs and a 10% reduction in CO_2 emissions. Savings in excess of R 3,000,000 per annum were identified. The following describes various components of the EnMS implementation in more detail.

[1] SA Grid kWh to CO_2 Conversion Factor set at 0.957 as per the 'Journal of Energy in South Africa' – Vol 22 No 4; November 2011.
[2] The IEE Project defines a Host Plant as any South African industrial plant that agrees to accommodate project related events at its facilities.

Table 1. Overview of Energy Applications

Machine / System	Monthly Electricity (kWh)	%	Theoretical Demand	%
Compressed Air	645,057	17.1%	887	12.0%
Cooling	1,015,744	26.9%	1,502	20.3%
Heating	687,699	18.2%	1,642	22.2%
Motors	1,277,869	33.9%	3,175	42.9%
Lighting	147,856	3.9%	203	2.7%
Total	**3,774,225**	**100.0%**	**7,409**	**100.0%**

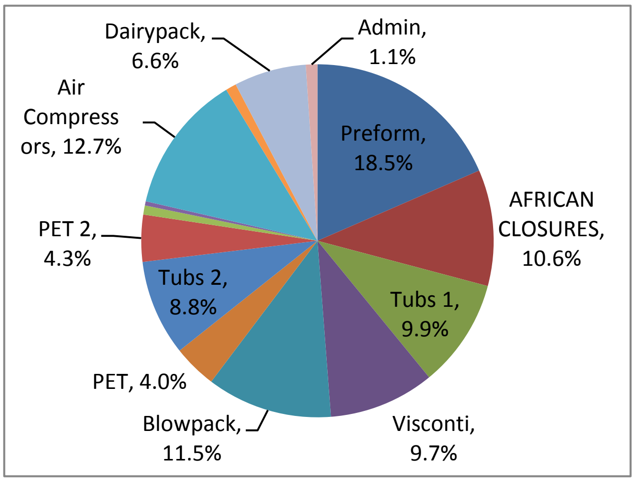

Figure 3. Pie Chart of Consumption of Departments

The following describes various components of the EnMS implementation in more detail.

- The Energy Policy signed by the Managing Director committed Polyoak to reduce electricity consumption by 15% by December 2015. The scope for EnMS implementation was defined as purchased electricity for the Cape Town facility. In the boundary statement, the following was excluded: LPG (Gas) due to very small volumes used in only in Printing Burners and Diesel for Transport as it is not consumed on site and is also small volumes.

- Polyoak has an existing legal register as part of their ISO 9001 and 22000 systems. Legislation specifically relevant to energy has yet to be added. Documentation control procedures for energy management have not been specifically developed at Polyoak. The existing ISO systems have references to energy, which would need to be integrated should Polyoak apply for certification (currently not pursuing).

- During the period investigated (2012-2013), the overall plant had an 18% increase in the annual production volumes, while the total electrical energy consumption for the plant only increased by 1.4%. The Energy Performance Indicator (EnPI) of Electrical Consumption (kWh) divided by Production (Kg's) changed from 1.61 pre-intervention to 1.36 post intervention, a 15.6% decrease. Using the EnPI Tool[3] comparing 2013 against the 2012 baseline year, **Energy Savings of 7.73% (3,112,693kWh)** were recorded. This was determined using option C of whole facility verification[4] methodology from the overall plant level. The sum of the individual projects carried out was far less than the savings believed to have been achieved, due to behaviour change being one of the primary sources of savings – which are difficult to measure.

- It was determined that production was the driver on energy consumption, achieving a very good correlation when compared with regression analysis[5]. Heating Degree days has a reasonable correlation, while Cooling Degree days did not provide a very good correlation and was not regarded as a significant driver.

- Initially it was determined that Energy Applications should function as the Significant Energy Uses (SEU's) of the EnMS. Due to the difficulties of metering the various motors etc. throughout the plant, this was changed to use Production Departments as the SEUs. It was discovered that only three of the ten production departments had adequate sub-metering installed during the period to be interrogated in detail – Preforms, Tubs and African Closures (AC). These departments account for approximately 50% of electrical consumption and production volumes. There were production increases in these departments of 11.6% for the period while electricity usage decreased by 0.6%. The average EnPI (kWh/Kg's) for the year assessed against the baseline decreased by 10.4% with the EnPI tool recording the Energy Savings of 8.92%, due to baseline adjustments.

[3] Energy Performance Indicator Tool developed by Georgia Tech Research Corporation (EnPI Tool v 3.02 - June 2013).
[4] EVO 2012. International Performance and Verification Protocol, EVO 10000 – 1:2012, Efficiency Valuation Organisation.
[5] An R squared of 0.88 was achieved in 2012 and 0.79 in 2013. Note that an R squared of 0.75 and higher is viewed as having a good statistical correlation.

- The Preforms department displayed the best R squared of the departments, as there is regular production. The R Squared varied significantly for both Tubs and African Closures for the years analysed.

- The baseline year for the Polyoak EnMS was 2012 (49 week period from 7 January to 9 December 2012). The period evaluated corresponded to these dates in 2013. The baseline consumption was 36,671,623kWh with Production volumes of 23,885,742 Kg's.

- The monthly base load at Polyoak (with zero production) based on the data provided was reasonably high at 404,482kWh (54% of the weekly average). This did decrease by 17,739kWh (4.6%) in 2013. The base load is recommended not to exceed 30% to 40% of the total load in a plant with controlled energy use. Any site with values that are very different needs to investigate the causes[6].

- With the rapid growth in Production volumes, the future (expected) energy use at Polyoak is anticipated to rise slowly, but to be well lower than the production growth rate.

- Operational Control accounted for approximately 7% of the optimisations savings identified in the initial energy assessment. Critical Operating Parameters were developed for SEU's as part of the EnMS. Although there were Standard Operating Procedures (SOP's) these were usually more focussed on production, rather than operational and maintenance criteria. They were also controlled by departmental staff and not the centralised maintenance team who initially were tasked with implementing the EnMS. Items such as Hydraulic Motors (Temperature set points on oil), Extruder heating (Temperature), Cooling system (Pressure, Temperature Lift and Refrigerant Pressure Gauges) were put in place. Maintenance criteria for SEUs was also established for the various SEU's as well as the frequency of maintenance.

6. SELECTED ENERGY SYSTEM OPTIMISATION INTERVENTIONS

The Energy Performance Opportunities (EPO's) database became the action plan for the EnMS implementation. Investments, savings and payback as well as dates and responsibility were assigned to the 14 projects identified. These were divided up into opportunities not requiring significant investment, were estimated to provide savings totalling 4,534,085kWh (10% of annual baseline consumption) and requiring investment of R1,6 million. Projects requiring larger investment and further investigation or feasibility were estimated to provide savings totalling 14,644,110kWh (15% of annual consumption) and requiring investment in excess of R4 million. With total savings estimated to exceed 25%, these plans provided significant redundancy to enable Polyoak to achieve the targeted 15% reduction in energy consumption.

COOLING TOWER FAN AND PUMP OPTIMISATION

Cooling Fan and Pump Savings/2013	
Cost Savings	R 389,488
Energy Savings	414,349 kWh
Cost of Project	Zero capex
Payback Period	0 years
Kg CO_2 Savings	396,532 Kg

The Cooling Tower Fans and Pumps in two departments, Dairy PET and Preforms were optimised in the 2013 calendar year. This involved the retrofitting of Variable Speed Drives (VSD's) to the fans of the cooling towers and pumps of the chillers of these two departments. As these units were rented, there were no capex requirements. The savings provided immediate payback and a 59% reduction in electrical consumption of the units from 699,152kWh to 284,803kWh. Recently an additional department, PET2, has had VSD's fitted which is hoped will realise similar savings.

Figure 4. Cooling Fan and Pump VSD Controller in Dairy PET Department.

[6] Kent,R; What's your process energy fingerprint?; Tangram Technology Ltd.; Plastics Technology Issue: March 2009; http://www.ptonline.com/articles/whats-your-process-energy-fingerprint.

COOLING RECIRCULATION SYSTEM OPTIMISATION

AC1 Cooling Recirculation System Optimisation Savings/2013	
Cost Savings	R 96,200
Energy Savings	102,340kWh
Cost of Project	R260 000
Payback Period	2.7 years
Kg CO_2 Savings	97,940Kg

Figure 5. Upgraded AC1 recirculation pumps.

The recirculation pump systems at Polyoak (other than the PET line) were not designed to operate in parallel, although usually most of the recirculation pumps (including the reserve pumps) are in full time operation. During June 2013 the Cooling Recirculation System piping and pumps were optimised in the African Closures (AC1) Department and Preforms was carried out in January 2014. This corrected the pumps in parallel on a system designed for a single pump. Performance improved as a result of decreased operating pressures / head, which ultimately decreased the specific energy usage (kWh / Ml pumped) by an estimated 15%. It also enabled departments to be independent of each other and have greater control of their cooling requirements.

In addition to this a detailed Pump System Assessment was carried out as part of the Pump System Optimisation expert training in February 2013 on the Dairypak and Petpak department's cooling recirculation systems. It was noted that Energy Baseline (Pumps only) for the Dairypak system was between 375 and 378 kWh / Ml water recirculated when the pumps are run in isolation for pumps 1 and 2 respectively. If both pumps were running the energy intensity increased to 535 kWh / M l (42.6% increase). A number of recommendations were made with savings in excess of R400,000 identified.

INSULATION JACKET FOR BARREL EXTRUDER

Figure 6. Barrel extruder insulation jacket.

The surface temperatures of the barrel extruder cover plates were 100-180°C translating to high potential energy loss (518-1,400W/m), and the hot cover plates could also lead to safety risks in terms of burn injuries. In September 2013, Ruan le Roux conducted a trial of insulating ofe of the extruder barrels in the Visconti department. Trial results show a 1.2% reduction in power drawn in addition the surface temperature of the insulation jacket reduced significantly. Due to the positive outcome of the trial, it is now planned to roll out the installation of insulation jackets to all barrel extruders.

Barrel Extruder Savings per machine/2013	
Cost Savings	R13,908 /year
Energy Savings	14,796 kWh
Cost of Project	R2,133
Payback Period	0.2 years
Kg CO_2 Savings	14,158 Kg

Other EnMS activities

Staff training on basic energy awareness is planned to be included in company induction of all new employees. Induction processes already provide information regarding general energy efficiency and this is to be expanded. The 'Polyoak School' (Polyoak's inhouse training facility) also offers employees classes relating to energy, which they can add to their 'passport' of courses passed. This is planned to take place later in 2014.

The **communication tools** were not used as effectively as they could have been in Polyoak. The EnMS Communication Strategy was planned, but knowledge of the EnMS system has largely been restricted to the Maintenance staff and publicising of the Energy Policy internally. Polyoak made a decision that it would not communicate externally initially regarding the EnMS implementation. This decision would be re-considered once the system was more established.

Design and procurement process changes have started to be implemented, including procurement criteria for assessing energy use - primarily of new equipment and planned upgrading projects.

An **Internal EnMS Audit** was held at Polyoak as the Host Plant for the IEE EnMS Expert Level training on 6 August 2013. The process audit methodology was employed to ascertain the EnMS implementation status. The audit covered the four key elements of the energy management system - Management Commitment, Planning, Implementation and Operation as well as Checking and Management Review. It focused on the compressed air system, a significant energy user - with specific reference to operational control, system documentation and records. The Audit results had a total of four findings, two Major Non-Conformances and two Minor Non-Conformances.

7. FUTURE PROJECTS:

- An application for MCEP[7] funding to fund a number of capital intensive energy efficiency projects has been submitted and the outcome is awaited.
- A Compressed Air Leak detection survey is scheduled to start in February 2014 as a leak detector has recently been purchased and a system of tagging and tracking established.
- A more energy efficient 40 bar compressor replacement is planned.
- Cooling Piping reconfiguration is planned for a number of departments based on the Pump assessment carried out. This involves optimising process configurations and reviewing simultaneous pump operation.
- Energy Awareness Training is to be started in 2014 and is described under staff training in section 6.

8. LESSONS LEARNED:

- Formalised training can help to address people's resistance to change. Skills required for implementing EE projects are often not available – with which training can also assist.
- Behavioural change has a huge impact on energy use – from top management down to lowest worker. Much of the improvements achieved at Polyoak are believed to have been due to this.
- Measurement / metering is critical, to enable accurate analysis of SEU's and to better inform future implementation.
- Providing adequate resources and support of Energy Manager is vital for the continuity of the EnMS. The EnMS needs to penetrate the organisation further and ownership expanded in roles and responsibilities, such that the Departments themselves take up responsibility for continuous energy performance improvement.

[7] Manufacturing Competitiveness Enhancement Programme (MCEP) consists of Industrial financing loan facilities managed by the IDC; and, Production incentive grants administered by the Department of Trade and Industry.