Industrial Energy Efficiency Project in South Africa

Introduction and Implementation of an Energy Management System

Case Study Report

Company name	RHODES FOOD GROUP (PTY) LTD.
Sector	Agri-processing (FMCG) – Food manufacturer.
Year joined IEE Project	2012
Year of interventions	2014-2015
Contact person	Wikus Otto, Engineering/Energy Manager. +27 21 710-9218
Systems of intervention	EnMS

1. BACKGROUND

1.1 Company profile

Rhodes Food Group (RFG) is a diversified food business that prides itself on delivering quality products and outstanding service. While its head office is situated in the Franschhoek Valley, the Group has operations in the Western Cape, Gauteng, Limpopo and Swaziland. The Group's product range includes canned deciduous fruit, citrus and pineapples; canned vegetables; tomato products; jams; juice concentrates and purees; prepared meals; pies and pastries and a range of dairy products. Rhodes Food Group markets its products under its own brands and is a well-established supplier of private label products locally and internationally.

1.2 Plant profile

The Rhodes Food Group complex in Groot Drakenstein is located in Pniel Road near Franshhoek outside Cape Town. The complex comprises of Ready Meals, Cannery, Dairy, RFG Head Office and the Ayreshire Stud Farm as well as Services Departments. An ISO 9001:2008 system is in place as well as HACCP (Food Safety).

Ready Meals Western Cape has 200 permanent employees, and up to 100 seasonal employees with a Factory of 5,000 m2 under roof. They produce over 300,000 ready meals per week (approximately 100 tons of product). They have an exclusive national supply agreement with Woolworths. The Dairy (including bottling plant and cheesery) has 32 permanent employees, and 20 seasonal employees with a Factory of 2,000m2 under roof. The daily intake of milk is approximately 28,000 l milk. . They are the exclusive supplier of Ayrshire milk and cream to Woolworths for Western Cape and Eastern Cape. The Ayrshire Stud Farm has 16 permanent employees, and 13 seasonal employees. There are 104 ha's of owned land and 500 cows in milk. They produces approximately 10,000 l milk per day for the Dairy and are one of SA's top award winning Ayrshire herds with approximately 1,000 head.

Figure 2. Overview of the RFG Groot Drakenstein Complex

Figure 1. Satellite view of the RFG Ready Meals and Dairy buildings.

1.3 Nature of challenges

Rising energy prices have resulted in a negative impact in associated utility costs. The main energy sources are Electricity with an annual cost of R7,5 million, Coal at R2,2 million and LPG at R0.5 million. Thus, Rhodes Food Group was motivated to identify areas where savings could be made, but lacked insight in to how this could be achieved. In February 2014, with assistance from the IEE project, Rhodes Food Group embarked on the Energy Management Systems (EnMS) implementation process. Rhodes Food Group initially had limited sub-metering for the departments, and although they are a large user, found it difficult to identify savings. Their divisions also operate quite separately and their industry has been under a lot of pressure from retailers on their environmental performance and offering cost savings.

2. OVERVIEW SUMMARY

2.1 IEE capacity building programme

Participation in the IEE programme enabled RFG's Engineering/Energy Manager, Wikus Otto, to develop EnMS expertise through the EnMS Advanced Level programme. Energy Awareness and skill were also developed by members of RFG's technical and maintenance staff by attending a variety of IEE courses and more being interested in attending additional courses. Two senior staff, part of the Energy Team at RFG (Bennie Gordon and Robert Sudell) attended the EnMS 2 Day training, which developed their EnMS expertise.
Two RFG Maintenance Staff members are to attend the EnMS 2 day Training. Operational Managers are to be looked at attending in the future – possibly on site. Two RFG Staff members are also to attend 1 day Steam Systems Optimisation Training. Following this they will evaluate if they attend the 2 day training. The RFG Energy Team is also interested in senior Maintenance staff attending training on refrigeration (once it is available). The necessary technical and advisory support was also provided by Resource Innovations with the 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.

3. KEY ACHIEVEMENTS

Key Outcomes/Results table

Implementation Period	**2014/15**
Total Number of projects	**13**
Monetary savings in ZAR	**R 3,481,329**

Energy savings in kWh	**602,611kWh (Elec) + 2,911,192kWh (Fuel) = 3,513,803kWh**
Total investment made ZAR	**R 844,800**
Payback time period in years	**0.24 years**
GHG Emission Reduction (tonne CO_2)[1]	**1,514**

4. THE APPROACH

Rhodes Food Group requested funding from UNIDO[2] to implement an EnMS in October 2013 as part of the IEE programme. The funding to implement the EnMS was approved and implementation commenced in February 2014.

An energy assessment previously carried out in January 2013 by Resource Innovations Africa (Pty) Ltd. was incorporated into the planning component of the EnMS. 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, 18% reduction in coal costs and a reduction in CO_2 emissions. Savings in excess of R 4,000,000 per annum were identified.

Table 5. Ready Meals Monthly Electrical Balance

Machine / System	Electricity (kWh)	%	Theoretical Demand	%
Admin	11,170	3.0%	47	7.6%
Refrigeration	207,387	55.3%	285	46.5%
Services	54,163	14.4%	74	12.1%
High care	34,719	9.3%	111	18.1%
Low care	40,884	10.9%	56	9.2%
Flour	510	0.1%	1	0.1%
Lighting	26,353	7.0%	39	6.3%
Total	**375,185**	**100.0%**	**613**	**100.0%**

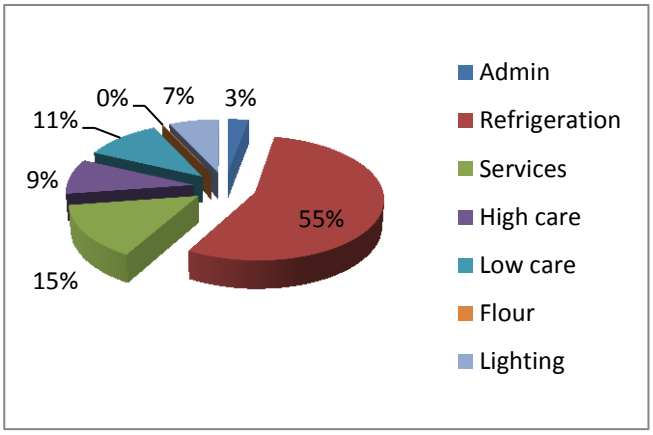


Figure 3. Ready Meals Monthly Electrical Consumption Pie Chart

Table 6. Dairy Monthly Electrical Balance

Machine / System	Electricity (kWh)	%	Theoretical Demand	%
Admin	3,542	3.0%	14	5.8%
High care	518	0.4%	2	0.8%
Cheese	4,967	4.2%	18	7.5%
Services	1,487	1.2%	6	2.5%
Refrigeration	79,270	66.3	121	50.2%
Milk receiving	1,857	1.6%	9	3.9%
Low care	14,407	12.0	51	21.3%
Lighting	13,532	11.3	19	8.0%
Total	**119,580**	**100.0**	**241**	**100.0%**

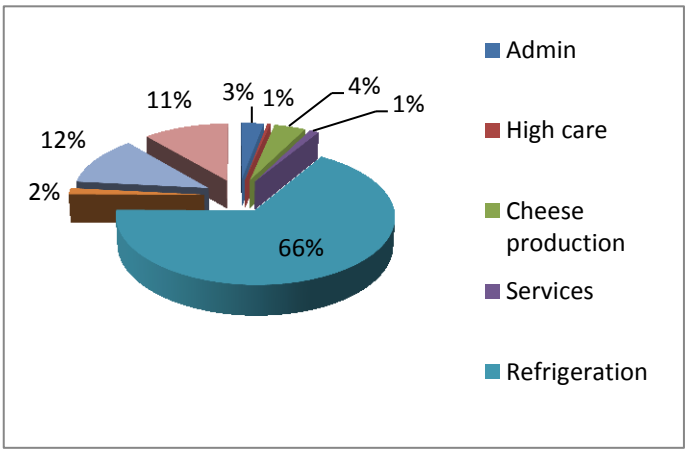


Figure 4. Dairy Monthly Electrical consumption Pie Chart

[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] United Nations Industrial Development Organisation.

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

- The Energy Policy was signed by the Managing Director committed Rhodes Food Group to reduce electricity consumption by 10% by December 2016. See the signed policy in the appendices.

- The Scope for EnMS implementation was defined as purchased electricity, Coal, LPG (Gas), as well as water for the Groot Drakenstein complex. Diesel was excluded as it is used by an external third party primarily off the site.

- In the Boundary statement, Ready Meals Western Cape, Dairy, Ayrshire Stud Farm and the Services Departments were included. The following were excluded: Cannery (as it is in the process of being moved) as well as the RFG Head Office (as it is part of a different division).

- A Non-Disclosure Agreement has been signed between the consultant implementing the EnMS and RFG.

- RFG has put a legal register in place as part of their ISO 50001 implementation (this also supports their ISO 9001 and HACCP systems). Legislation relevant to energy is included in this. Documentation control procedures for energy management have been developed at RFG.

- From the baseline period (October 2012 – September 2013) to the assessment year, the Ready Meals plant had a decrease in production volumes of 17%, while the total electrical energy consumption for the plant decreased by 9%. The Energy Performance Indicator (EnPI) of Electrical Consumption (kWh) divided by Cooling Degree Days (CDD) changed from 15,705 pre-intervention to 10,098 post intervention, a 35.7% decrease. Using the EnPI Tool[3] comparing 2013 against the 2012 baseline year, **Energy Savings of 4.4% (153,333kWh)** were recorded. This was determined using one department verification[4] methodology from the plant. The sum of the individual projects carried out was far more than the savings recorded in only the Ready Meals Plant, Primarily because much of it was achieved on centralised services and prior to accurate metering being in place.

- It was determined that Cooling Degree Days (CDD) was the driver on energy consumption, achieving a good correlation when compared with regression analysis[5]. Production (units) and Heating Degree Days (HDD) had some correlation, but were not regarded as significant drivers.

- It was determined from the initial energy assessment the Significant Energy Uses (SEU's) of the EnMS were Refrigeration and Lighting (for electrical energy) and Boiler (for fuel energy). It was discovered that the existing sub-metering installed was inadequate for the purposes of the EnMS implementation.

- Important input was provided from the Operations staff as well as Engineering on the data inputs. It was realised there was an initial discrepancy with dates – production was being reported on the week ending and electricity on week start dates.

- The Ready Meals department displayed the best R squared of the departments, as there is fairly regular production and good data collection. The baseline year for the RFG EnMS was a 47 week period from 4 November 2012 to 29 September 2013. The period evaluated corresponded to these dates in 3 November 2012 to 5 October 2013. The baseline consumption was 3,631,939kWh with Production volumes of 11,229,086 units.

- The monthly base load at Ready meals (with zero production) based on the data provided was fairly high at 66,441kWh (87% of the weekly average). This did decrease by 4,538kWh (6.8%) in 2013. The base load is

[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 0.82 was achieved in 2012/13 and 0.79 in 2013/14. Note that an R squared of 0.75 and higher is viewed as having a good statistical correlation.

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].

- The energy efficiency projects accounted for most of the savings achieved. Most of these were 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. 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 33 projects identified. These opportunities were spread out over three financial years, and were estimated to provide savings totalling 1,364,989 kWh (Electricity) + 3,093,628 kWh (Fuel) = 4,458,617kWh (21.4% of annual baseline consumption) and requiring investment of R4,2 million. These plans provided significant redundancy to enable RFG to achieve the targeted 10% reduction in energy consumption by December 2016.

ELECTRICITY TARIFF REVIEW

Tariff change to TOU	
Cost Savings	R 2,317,492
Energy Savings	-
Cost of Project	Zero capex
Payback Period	0 years
Kg CO_2 Savings	-

The previous RFG tariff from Groot Drakentein was a standard consumption (kWh) and maximum demand (kVA) tariff. Options were reviewed by RFG and changed to a Time of Use (TOU) tariff in July 2013. There were no capex requirements. The savings provided immediate payback and significant reduction in electricity costs.

Being a 24 hour operation, RFG were able to derive significant benefit from the lower off-peak tariff as well as the lower kVA charges.

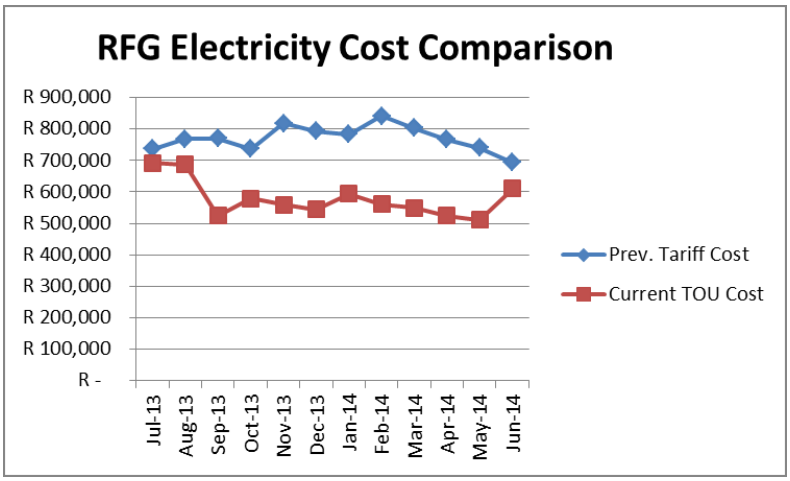


Figure 5. RFG Electricity cost comparison July 2013 - June 2014

[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.

LIGHTING RETROFITS + DAYLIGHT SENSORS

Lighting Retrofit + Daylight Sensor Savings	
Cost Savings	R 426,761
Energy Savings	456,559 kWh
Cost of Project	R282,598 (Incl. Eskom rebate)
Payback Period	0.7 years
tCO_2 Savings	444 Tonnes

Lighting retrofits were carried out at Ready Meals and the Dairy Farm as part of the Eskom IDM project. Older technology fluorescent and HID lamps were replaced with more efficient newer technology. The Eskom rebate contribution of R203,181 was significant in reducing the cost of the project. This project was completed in January 2014.

There were also daylight sensors installed I various areas, which was completed in February 2015. Cost savings in excess of R426,000 were achieved through these projects.

Figure 7. Outside loading bay lights left on

Figure 6. Workshop lights left on

RETURN ALL THE CONDENSATE TO THE BOILER

Returning condensate Savings	
Cost Savings	R 100,000
Energy Savings	593,712kWh
Cost of Project	R 100,000
Payback Period	1 year
tCO_2 Savings	189.8 Tonnes

The condensate lost to drain was calculated using the make-up water meter readings and it was found to be 35%. Returning 50% of the total (assuming flash steam and steam injection is not recovered) condensate fed to the boiler will reduce the boilers fuel required because of the heat content. An added advantage is the fact that the water is relatively pure and does not require chemical treatment. One return pipe was recommended for the high pressure steam traps and one for the pumped (low pressure applications) condensate will ensure that the high pressure system does not put unnecessary back pressure onto the low pressure system.

Coolag completed the installation of insulated condensate return pipes in January 2014.

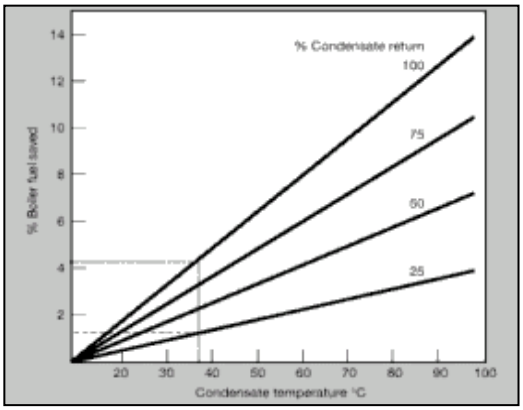


Figure 8. Condensate return payback calculator

IMPROVE MONITORING BOILER EFFICIENCY AND COMBUSTION - 4 TONNE

Improve Monitoring Boiler Efficiency	
Cost Savings	R 113,690
Energy Savings	578,218kWh
Cost of Project	R 150,000
Payback Period	1.3 years
tCO_2 Savings	184.9 Tonnes

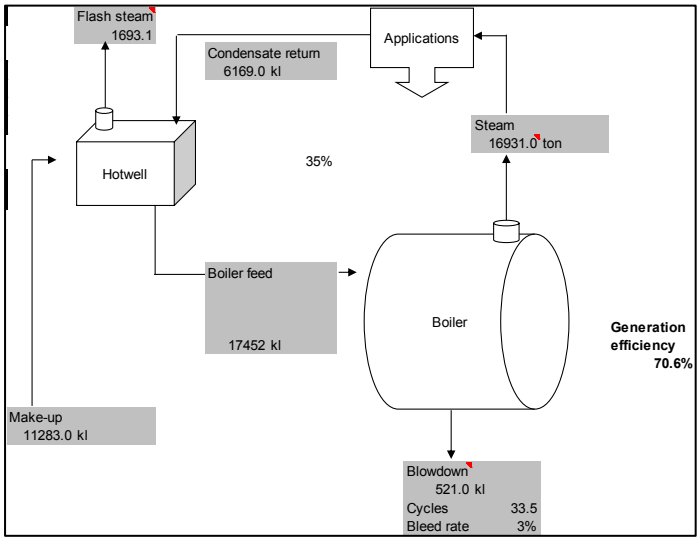
Due to changes at the plant the larger 7.2 tonne (Cannery) boiler was only used as a backup from June 2013. The smaller 4 tonne (Juice) boiler was automated with an Oxygen Trim Controller to improve efficiency.

By monitoring the two water meters and TDS blow-down flow-rate, the boilers overall generation efficiency, as well as the condensate return, can be accurately calculated over period of time. In addition, a flue gas analyser has been purchased by RFG that O2 and temperature readings in the stack can be taken and calculated stack losses.

The implementation of a oxygen trim controller will improve combustion efficiency through optimising the air-fuel mixture. A 5% reduction in boiler fuel is expected. CAL Automation completed the installation of an oxygen trim controller in January 2014.

Table 1. Steam System Efficiency Calculator

Expected flash loss	**10%**	
Boiler TDS	**3350**	**ppm**
Feed TDS	**100**	**ppm**
Boiler feed	**17,452**	**kl**
Fuel used	**2,602,405**	**kg**
Hotwell make-up	**11283**	kl
Assumptions (modify if necessary)		
Flash steam loss (2 bar)	**10%**	
Fuel energy (Coal)	**24.1**	**MJ / kg**
Steam enthalpy (8 bar)	**2,780**	**kJ/kg**
Condensate enthalpy (80oC)	164.8	kJ/kg
Boiler efficiency	**70.6%**	
Lost condensate	**53.6%**	9068.9



CONVERT FROM STEAM INJECTION TO HEAT EXCHANGERS

Improve Monitoring Boiler Efficiency	
Cost Savings	R 117,000
Energy Savings	466,359kWh
Cost of Project	R 110,000
Payback Period	0.9 years
tCO_2 Savings	149.1 Tonnes

The Dairy utilises direct stem injection for pasteurisers and CIP. The Dairy pasteuriser passes 10,000 litres of milk / hour and the calculated steam flow-rate required to raise the temperature from 50 - 90ºC equates to 837.4 kg of steam / hour. The Dairy Plant Room recently had heat exchanges installed to recover heat from the CIP and pasteurisers. CIP coil heats up water from 15 - 84ºC in a 1,000 litre tank

1,000 kg x 4.187 kJ/kgºC x 69ºC = 144.5 kg of steam / hour

12 h/day x 144.5 kg/h = 1,733 kg/day of steam which the boiler will not have to heat for make-up water. This equates to 632.5 tonnes steam per annum, or a 4.5% reduction in the fuel bill per annum. The water savings has not been included.

Figure 9. Milk pasteuriser with steam injection

Although converting the steam injection system to a heat exchanger makes it possible to return the condensate by means of installing a condensate return pump and an insulated condensate return pipe, it is too far from the boiler to make the project viable.

The installation was completed in September 2014.

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 later in 2015.

The EnMS Communication Strategy was planned, but knowledge of the EnMS system has largely been restricted to the Energy Team and Maintenance staff with the publicising of the Energy Policy internally. RFG 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 RFG on 20+24 October 2014. The process audit methodology was employed to ascertain the EnMS implementation status. The audit covered the all elements of the energy management system - Planning, Implementation and Operation as well as Checking and Management Review. It focused on the refrigeration and boiler systems, as the significant energy users - with specific reference to operational control, system documentation and records. The Audit results had a total of twenty two findings (CPAR's[7]) were raised. These are monitored as part of RFG's Internal QA system.

7. FUTURE PROJECTS:

- An application for MCEP[8] funding to fund a number of capital intensive energy efficiency projects has been submitted and the outcome is awaited.
- Solar PV is being investigated to be installed at the Groot Drakenstein facility and a Power Purchase Agreement (PPA) is being considered.
- A project to recover waste heat from the Ammonia refrigeration plant is being scoped for later in 2015.
- Replacement of the existing coal boiler with a biomass (wood chip) is being investigated.
- Shared learning within the broader RFG Group is planned during 2015/2016, which will hopefully see significant improvements in efficiency.

[7] Corrective and Preventative Action Request

[8] 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.

8. LESSONS LEARNED:

- More accurate and accessible and consolidated data for monitoring and measurement is crucial to the success and ongoing implementation of the EnMS at RFG.
- 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 RFG are believed to have been due to this.
- 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 each Department can take up responsibility for continuous energy performance improvement.