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NATIONAL CLEANER PRODUCTION CENTRE SA

NCPC
national cleaner production centre
South Africa

CONTRACT REPORT

IN PLANT ASSESSMENT REPORT OF PREMIER FOODS PRETORIA WHEAT MILL (PTY) LTD

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IN PLANT ASSESSMENT REPORT OF PREMIER FOODS - PRETORIA WHEAT MILL (PTY) LTD

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28 September 2007

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EXECUTIVE SUMMARY

Premier Foods Pretoria Wheat Mill runs a dry wheat milling process, whose primary outputs are flour and bran. The organisation receives wheat from various local and international sources, and supplies a variety of customers in the food and wholesale/retail sectors.

The objectives of the In Plant Assessment were to further investigate opportunities for improvement and/or optimisation identified during the Quick-scan, which would be of benefit from both a financial and an environmental impact perspective.

The plant is highly automated and efficiently run. Opportunities for improvement with regards energy usage were selected in the following areas:

1. The Compressed air system
2. Packaging Oven

Although substantial potential for saving through electrical energy management were identified during the Quick-scan, this could not be further invest aged as a result of time constraints and delays experienced in the purchase and installation of measuring instrumentation, by suppliers to Premier Foods.

Practicable Energy Savings identified for the compressed air system and packaging oven are summarised in the ensuing tables:

Summary Oven Savings	
Energy Saved/annum through reduction of operating temperature	R 9 893.86
Cost of implementation	R 5 000.00
Pay back Period	6 months
Potential savings by installing insulation blanket @ 80% efficiency	R 2 987.19
Cost of insulation	R 200.00
Payback period	1 months
Total Annual Savings	R 12 881.05

Compressed Air System Savings	
Annual cost of leakage losses	R 6 510.77
Savings per annum if losses are reduced to 10 %	R 4 624.68
Investment required	R 0
Payback Period	0 months
Annual cost of blowing down trucks with compressed air	R 284.70
Savings through using hand held electrical blower	R 142.35
Investment required	R 195.00
Payback Period	16 months
Total Savings per annum	R 4 767.02

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1. PREFACE

This Cleaner Production IPA Report for PREMIER FOODS PRETORIA WHEAT MILL (PTY) LTD (SA), was performed as part of an awareness and pilot NCP project out by the South African National Cleaner Production Centre (NCPC - SA). The NCPC was established in 2002 within the framework of UNIDO/UNEP[1] Cleaner Production Centres

The programme has been designed for the needs of companies ready to analyze and optimize their internal business processes with a view to developing Cleaner Production (CP) techniques and to implement Environmentally Sound Technologies. This will allow the companies to reduce both their operating costs and improve their environmental performance, thus increasing their productivity and competitiveness. The project provides opportunities for staff training and technical consulting. It is targeted at executives and technically skilled employees (such as managers with a special brief for environmental affairs).

Further information can be found on the internet www.ncpc.co.za. Before a company is analyzed in detail, a *Quick-Scan* is usually conducted. The Quick-Scan is a short analysis which assesses the quality of the crucial processes, material- and energy flows in order to identify the *potentials* for CP. i.e. with the Quick-Scan the process areas with good optimising potentials are found and a possible focus for further analysis can be defined. On the basis of the Quick Scan, the company will decide whether or not and in which process areas an in-depth analysis (the CP Assessment) shall be conducted.

2. PROCEDURE

Premier Foods declared an interest in conducting an In Plant Assessment (IPA) based on the findings of a QuickScan performed at the company's premises in Waltloo, Pretoria. The findings of the QuickScan were presented to Premier Foods, and it was subsequently agreed to commence with the IPA.

The QuickScan indicated CP potential in the following areas:

[1] UNIDO – United Nations Industrial Development Organisation
UNEP – United Nations Environment Programme

1. Electrical energy usage and trends
2. Electrical maximum demand trends
3. Lighting requirements in the mill plant
4. Packaging area oven
5. Compressed air system design and trends

The following areas of focus were selected for more detailed scrutiny:

1. Packaging area oven
2. Compressed air system design and trends

Although the CP potential for electrical energy and maximum demand showed the most CP potential, time constraints as well as delays experienced by Premier Foods in obtaining measuring instrumentation which they had ordered prevented a comprehensive assessment of electrical energy usage and maximum demand trends.

The following persons participated in the IPA exercise.

Table 2-1: IPA Participants

Name	Organisation	Designation
P. Kritzinger	Premier Foods	Head Miller
C. Kortman	Premier Foods	Maintenance Engineer
A. Ebrahim	Environmental Science Associates	Lead Consultant
S. Moletsane	Tsebo Consulting	Professional Consultant
T. Mutshatshi	Naledzi Environmental Consulting	Professional Consultant
M. Ram Reddi	National Cleaner Production Centre	Project Manager
Dr J. Fresner	Stenum Consulting	CP Specialist
Dr T.Burki	Energy Ecology Policy Consulting	CP Specialist

Subsequent to the identification of potential areas for implementation of CP, further information was requested from the organisation, research into the selected areas/processes was conducted and follow up visits were undertaken to collect data and assess specific areas and activities.

3. SHORT ANALYSIS

3.1 The Enterprise

Premier Foods Pretoria Wheat mill (hereafter referred to as the plant) was established in 1994. The plant produces various grades of wheat flour (hereafter referred to as flour) through the dry milling of wheat grain. The plant runs 24 hours a day, 365 days a year. Supplying flour to Premier Foods bakeries and various customers including Famous Brands (Debonnairs Pizza), Romans Pizza, Kellogs, Natural Brands, Wholesalers and Retailing Chains (e.g. Pick'n Pay, Shoprite, Checkers e.tc.)

The plant receives wheat from both domestic and foreign suppliers. Wheat is transported to the premises by rail and road truck. Imported wheat is shipped by sea to local ports and then trucked to the site. The wheat is initially stored in onsite bulk silos by AgriSA, and transferred to the plants own silos on demand.

The main products from the milling process are flour and bran. Approximately 90 000 tonnes per annum of wheat is milled producing approximately 72 000 tonnes of flour and 18 000 tonnes of bran.

Various grades of flour are produced through the milling and blending of different wheat varieties as required by customers. Additives such as Vitamin supplementation, fats (for pizza/pastry manufacture) and sodium bicarbonate (for self raising flour) are blended into the product as required. Bran is sold in bulk to various buyers mostly for use as animal feed.

The plant is located in an established industrial area in the North East of Pretoria. The immediate area is neither environmentally nor socio-economically sensitive, however there are residential suburbs on the north and south borders of the Waltloo industrial area.

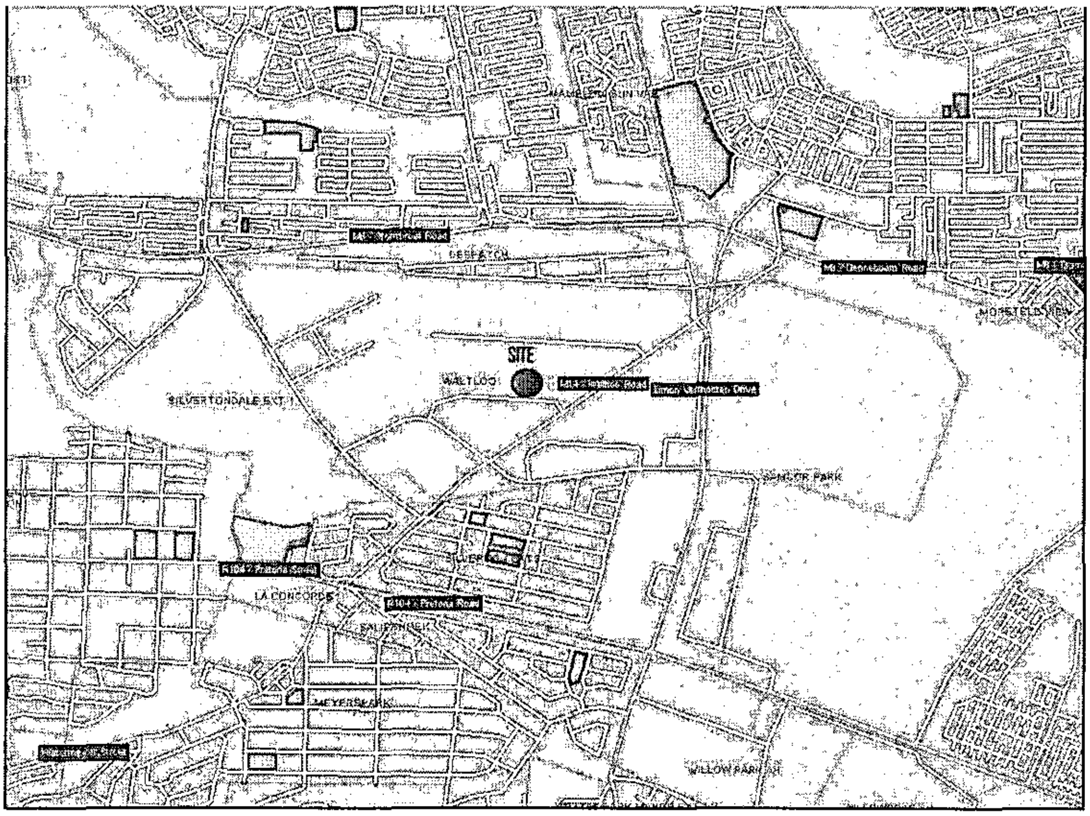

Figure 3-1: Locality Map

3.2 Manufacturing Processes

3.2.1 Overview

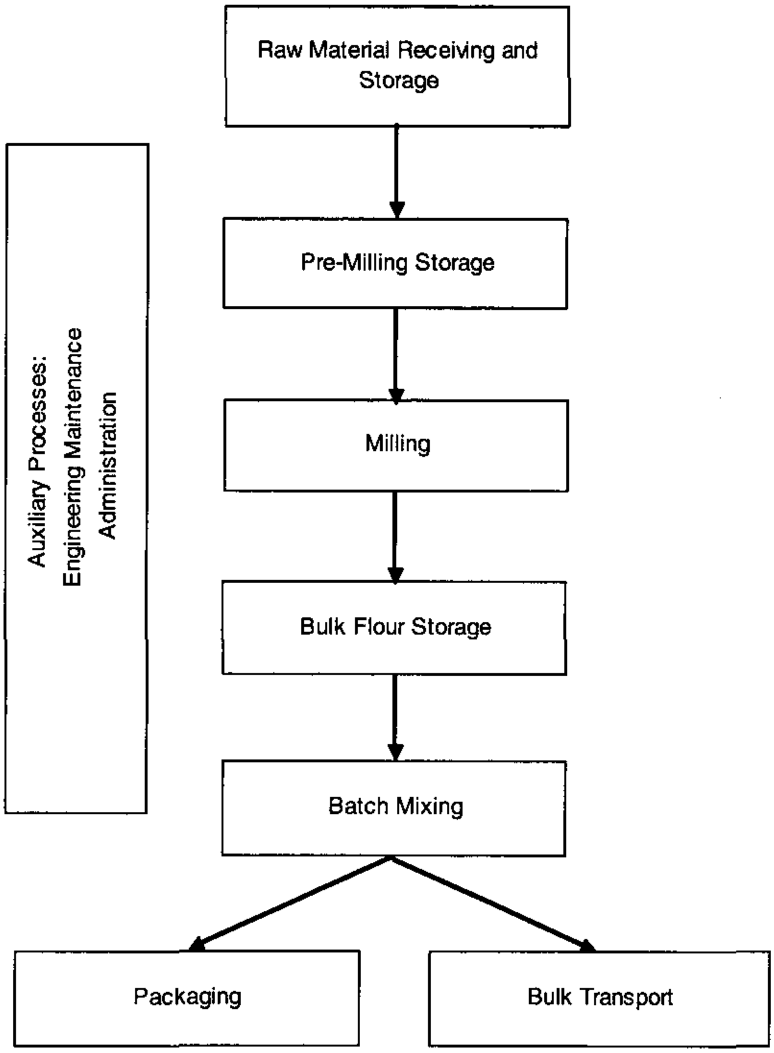

Figure 3-2: Plant Overview

The focus of the IPA requires the individual processes to be discussed in general terms only. The essential stages of the manufacturing process will briefly be explained in the ensuing sections.

3.2.2 Raw Material Receiving and Pre-Milling Storage

Wheat is received by rail and road truck. The trucks pass over a weighbridge before and after offloading. The wheat is offloaded manually from trucks but tipped from rail trucks. The grain falls the through a chute onto a belt conveyor system that carries the wheat to a bucket conveyance system which subsequently deposits the wheat into bulk silos (referred to as Raw Wheat Storage Bins). The site has 10 grain silos altogether with a total storage capacity of 15 000 tonnes.

Foreign matter is separated from the wheat by means of screening and magnetic separation. Large screens (+10mm gauge) are used to remove material larger than the wheat grains such as leaves, sticks and stones, while small screens (-3mm gauge) are used to remove smaller particles such as sand and small seed. The total mass of foreign matter removed is minimal, and is either passed through a hammer mill and pneumatically conveyed to the bran silos or disposed of as general waste.

Dust and Suspended particles are extracted from the system via an aspiration system. It was noted that the aspiration system extracts from the conveyance system as well as the silos and distribution systems above the silos, consequently the system is running as long as there is transfer of grain in some section of the offloading and storage sections. The systems extracts from all points simultaneously.

The moisture content of the wheat is measured and water is added to condition the wheat to the desired target moisture by means of an inline spray system with remote fixed flow rate control. "Conditioning" is the adjustment of the moisture level of the grain to facilitate maximum separation of bran from endosperm. A manually operated system is then used to fine tune the moisture input.

At present tap water is used for moisture addition; however the plant will in the future install a water purification plant. This plant will incorporate fungicides and bactericides into the conditioning water to mitigate fungal and bacterial infection. From time to time wheat is received with elevated fungal and bacterial counts, which in turn result in high counts in the flour produced, the installation is intended to ensure that fungal and bacterial counts in flour produced meet customer expectations at all times. The wheat is fumigated periodically to prevent/control pest infestation.

Wheat is transferred from the raw wheat storage bins to the dirty wheat storage bins on demand from the plant. Up to this stage in the supply chain, the wheat still belongs to the supplier; the ownership is transferred only when the wheat is transferred to the dirty wheat storage bins.

3.2.3 Milling

Wheat from the storage bins is elevated to the top of the mill via bucket conveyors, from where it is gravity fed through the ensuing screening, crushing and separation machinery. The wheat is then passed through several cleaning mechanisms which remove foreign matter by means of size screening and density separation using air classification. The material removed (mostly organic material such as sticks, maize, grass seeds etc) is hammer milled and transferred to the bran silos.

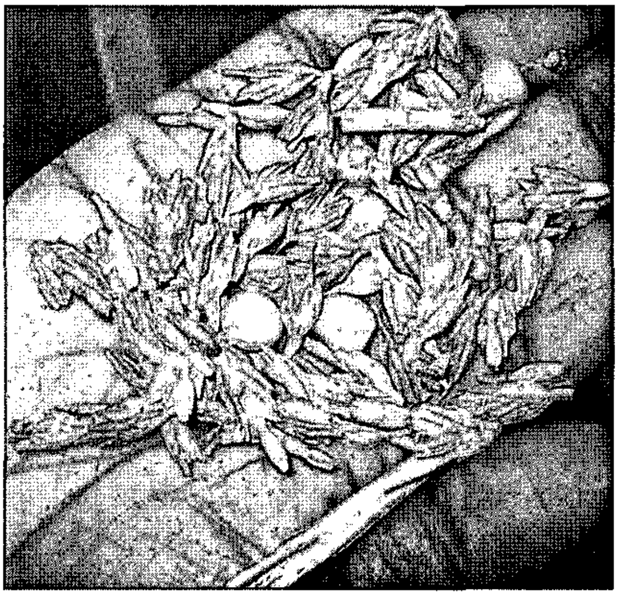

Figure 3-3: Non Wheat material separated from raw material

The objective of the milling section is separate the endosperm from the bran. The cleaned wheat is ground in rolling mills be means of cast iron rollers. The wheat is passed through several grinding stages. At each stage a portion of flour is extracted and the remaining bran with residual endosperm attached is passed on to the next grinding stage. The flour is separated from the bran by sifting (size screening). The extraction efficiency is dependant on the quality of flour required. The higher the proportion of bran allowed in the flour the higher extraction efficiency i.e. more flour is produced per tonne of wheat milled due to the higher percentage of bran in the flour. The output bran and flour are pneumatically transferred to their respective holding silos.

3.2.4 Bulk Storage, Batch Mixing and Packaging

Various grades and varieties of packed flour are produced by mixing different proportions of the bulk flour produced from the milling of different cultivars of wheat milled. The quantities of ingredient flour are controlled via batch weighers and fed through to final holding bins after mixing. The final bins discharge into bulk truck containers for transport to the various customers. Alternatively flour is packages in individual packs via an automated packing system. The flour is packed in paper bags, or laminated aluminium foil bags which are heat sealed. The small units are assembled into larger units which are subsequently wrapped in polyethylene packaging, and subsequently passed through an oven to set the plastic wrap.

3.2.5 Environmentally Relevant Substances

There are no substances of environmental significance incorporated into the product. There are small quantities of hazardous waste produced by the facility mainly from maintenance activity these include fluorescent tubes, used oil, and lead-acid batteries from the forklifts, for example.

3.2.6 Energy management

The most significant source of energy is electricity. Ancillary sources of energy include diesel fuel for road and rail trucking, and lead acid batteries for forklifts. The use of electricity and potential for improvement are covered in the ensuing section of this report. At present energy consumption is not continuously monitored and assessed. The introduction of an energy management system to track energy usage and costs and identify any trends or assignable variation is a potential source of improvement for Premier Foods.

4. DETAILED ASSESSMENT PHASE

4.1 Register of CP aspects and evaluation of significant processes

4.1.1 Energy provision – Electrical energy

Electricity is the primary source of energy for the plant. The plant sources electricity in 3-phase at 380kV stepped down from 11kV grid source. With the exception of bills issued by the Tshwane Metro Council electricity usage is not monitored on a continuous basis. The average consumption of electricity is 78kWH/tonne of wheat milled based on data derived from electricity bills for the months September 2005 to August 2006. The average peak half hourly demand is 1227kVA.

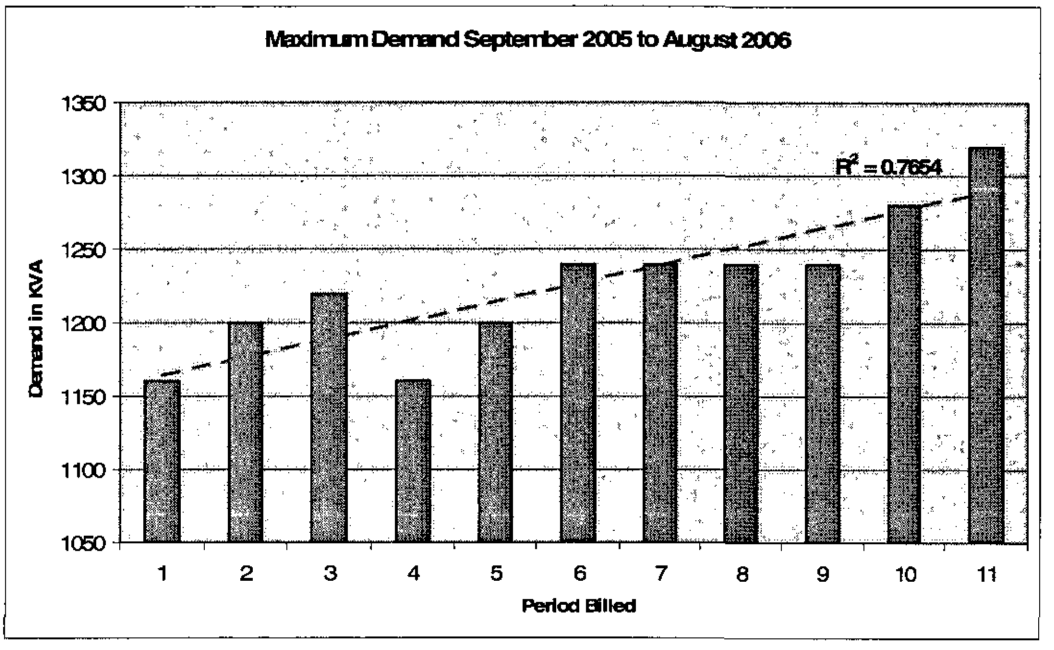

Figure 4-1: Maximum Demand Sept '05 to Aug '06

Table 4-1: Maximum Demand Sept '05 to Aug '06			
Billing period	Start	End	Demand (KVA)
1	2005/08/27	2005/09/21	1160
2	2005/09/22	2005/10/24	1200
3	2005/10/25	2005/11/16	1220
4	2005/11/17	2005/12/20	1160
5	*2005/12/21*	*2006/01/26*	1200
6	2006/01/27	2006/03/07	1240
7	2006/03/08	2006/03/24	1240
8	2006/04/25	2006/05/19	1240
9	2006/05/20	2006/06/23	1240
10	2006/06/24	2006/07/21	1280
11	2006/07/22	2006/08/18	1320
Average			**1227**

From figure **Error! Reference source not found.**, it can be observed that the maximum demand appears to be steadily increasing over the duration of measurement. This is supported by the relatively high correlation co-efficient for the linear trend line inserted to illustrate the increasing consumption. The installation of an online monitoring system would assist in identifying the demand fluctuation patterns and thus facilitate the improved management of peak demand.

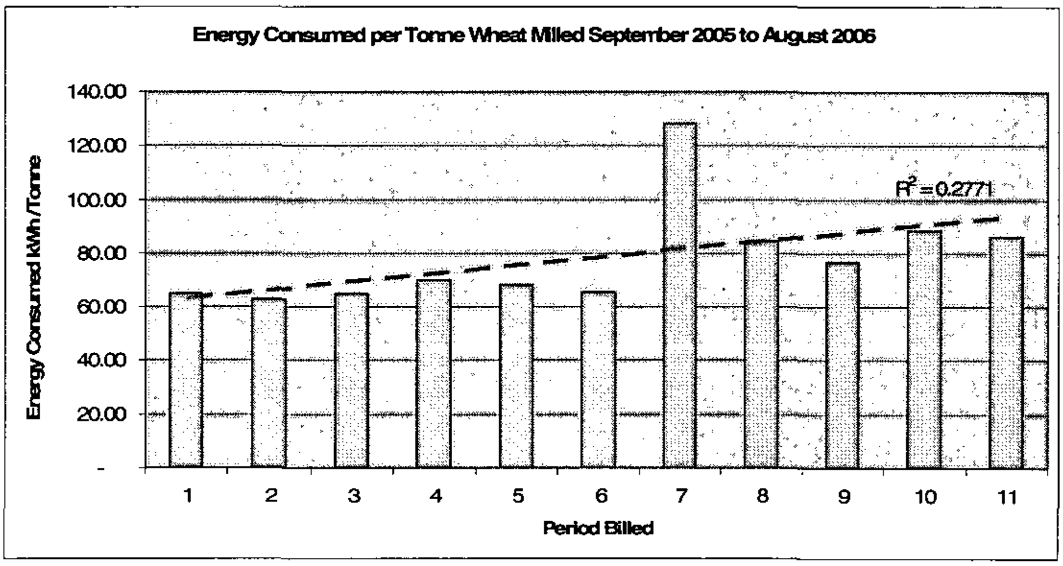

Figure 4-2: Electrical Energy Consumption Sept '05 to Aug '06

Table 4-2: Electrical Energy Usage Sept '05 to Aug '06

Billing period	Start	End	Energy (kWh)	Number of Days billed	Energy (per day)	Energy (per hour)	Energy per tonne of wheat milled
1	2005/08/27	2005/09/21	414000	26.00	15,923	663.46	65.05
2	2005/09/22	2005/10/24	508000	33.00	15,394	641.41	62.88
3	2005/10/25	2005/11/16	366000	23.00	15,913	663.04	65.00
4	2005/11/17	2005/12/20	582000	34.00	17,118	713.24	69.93
5	2005/12/21	2006/01/26	618000	37.00	16,703	695.95	68.23
6	2006/01/27	2006/03/07	642000	40.00	16,050	668.75	65.56
7	2006/03/08	2006/03/24	534000	17.00	31,412	1,308.82	128.32
8	2006/04/25	2006/05/19	518000	25.00	20,720	863.33	84.64
9	2006/05/20	2006/06/23	656000	35.00	18,743	780.95	76.56
10	2006/06/24	2006/07/21	606000	28.00	21,643	901.79	88.41
11	2006/07/22	2006/08/18	592000	28.00	21,143	880.95	86.37
Average			**548727.27**		**19,160**	**798**	**78.3**

From figure **Error! Reference source not found.**, it can be observed that the electrical energy consumption appears to be steadily increasing over the duration of measurement.

N.B. The energy usage per tonne of wheat milled is calculated based on the following information provided by the company:

1. Milling capacity: 12 tonne/hr
2. Plant Availability: 85%
3. Operating schedule: 24 hr/day, 365 day/year

It is thus assumed that an average of 224 tonnes/day of wheat is milled. It appears that the specific electricity consumption is steadily rising, with one significant isolated spike in period 7, this however coincides with the shortest billing period thus should be treated with caution.

The correlation co-efficient for an assumed linear increase in energy consumption is fairly low. However it is suspected that this is due to the spike exhibited in period. If period 7 energy consumption is replaced by a value equal to the average consumption for the entire then it is noted that a linear increasing trend with a much higher correlation is observed thus implying that there is indeed an increasing trend in energy consumption see **Error! Reference source not found.**.

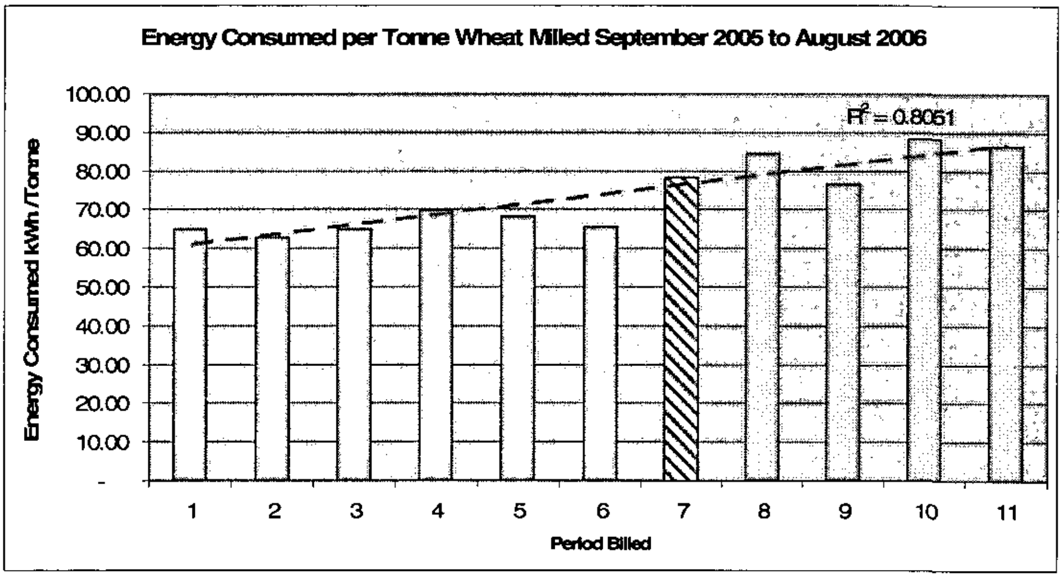

Figure 4-3: Adjusted Electrical Energy Consumption Sept '05 to Aug '06

Table 4-3: Electrical Energy Usage Sept '05 to Aug '06

Billing period	Start	End	Energy (per day)	Energy (per hour)	Energy per tonne of wheat milled
1	2005/08/27	2005/09/21	15,923	663.46	65.05
2	2005/09/22	2005/10/24	15,394	641.41	62.88
3	2005/10/25	2005/11/16	15,913	663.04	65.00
4	2005/11/17	2005/12/20	17,118	713.24	69.93
5	2005/12/21	2006/01/26	16,703	695.95	68.23
6	2006/01/27	2006/03/07	16,050	668.75	65.56
7	2006/03/08	2006/03/24	*19,160**	*798.34**	*78.27**
8	2006/04/25	2006/05/19	20,720	863.33	84.64
9	2006/05/20	2006/06/23	18,743	780.95	76.56
10	2006/06/24	2006/07/21	21,643	901.79	88.41
11	2006/07/22	2006/08/18	21,143	880.95	86.37

** value for period 7 replaced by average consumption for the year.*

It would appear that the bulk of energy consumption may be attributed to pneumatic transport and separation/classification systems. A detailed assessment of these systems may reveal potential for improvement. The aspiration network for the wheat receiving and storage facilities in particular may yield potential for improvement. It was noted that the aspiration system for wheat offloading is not regulated offloading activity but rather by aspiration needs elsewhere in the system. This is a prime example of a system that could be controlled automatically using position sensing or motion detection from the offloading bay or chutes.

Lighting within the plant building was on during the audit; however there is significant incidence of daylight through the windows. It is recommended that the adequacy of daylight and the management of artificial lighting systems be investigated. The Environmental Regulations for Workplaces, 1987 (GNR 2281) as promulgated in terms of , in terms of section 35 of the Machinery and Occupational Safety Act, 1983 (Act 6 of 1983) set the Minimum average values of maintained illuminance for flour milling at 150 lux. It is recommended that the illuminance provided by natural lighting be monitored with a view to reducing dependence on artificial lighting. In the event that natural illuminance is found to be adequate, the following strategies could be considered fo lighting management:

1. The use of illuminance dependant switches to automatically switch lights on or off at a prescribed minimum illuminance level.
2. The use of motion sensing devices to switch on lights upon entry to a room, and switch off lights when there is no movement in a room, this could be especially effective since the factory is highly automated. Note that such devices could also feed a signal to the PLC network and be used to inform operators and plant management of activity in different areas of the plant.

4.1.2 Energy provision – Process Heat

With the exception of heat for thermo-setting packaging material, there is no heat supplied to the process. The oven used for setting the wrapping package wrapping in the packaging section should be investigated for potential improvement. It takes the oven approximately 1 hour to reach operating temperature. The oven nameplate indicates a temperature of 250°C (it is assumed that this is the operating temperature) and current rating of 50A (380V), and is thus a significant energy user. The long warm-up period implies that the oven must be switched on an hour before commencement of packing and also that it cannot be switched off during product changes. Note that a changeover from brown to white flour may take as long as 1½ due to the stringent cleaning requirements for preventing cross contamination of the white flour.

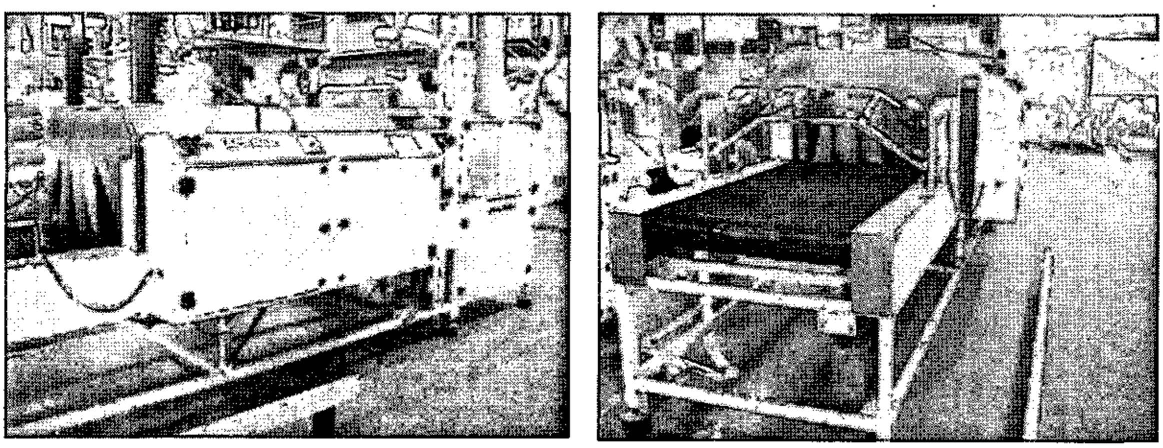

Figure 4-4: Packaging Oven

4.1.3 Energy provision – Compressed Air

The plant has 2 air compressors. Only one of these is operated at any time, with the other compressor off, on standby. Only one compressor has a nameplate. The nameplate indicates a rating of 7 bar, 10m^3/min, and power rating of 64kW. The compressed air is generated at 7 bar passed through an air dryer and then to a header tank at which point the pressure is approximately 6.5 bar. The header tank has a capacity of 0.925m^3 and a design rating of 8bar. The compressed air demand is not monitored thus it could not be immediately determined what the plant demand is nor the nature of the compressor's real-time response patterns. This may be a potential area for improvement as well, and an assessment of the demand and response of the systems may be used to optimise the system design. Compressed air demand patterns can be monitored using an online flow meter which would record flow patterns over a period of time (generally 7 days), the data thus generated would be used to determine the optimum compressed air system design parameters. Improved compressed air system design can improve energy efficiency significantly, with savings of up to 40% being achieved with Ingersoll Rands IntelliFlow system analysis and redesign associated therewith. The system can be installed for one week (or other representative period). In addition to evaluating identifying potential improvement of efficiency, this system can be used to measure the amount of compressed air lost through leakages and unplanned compressed air consumption.

Typically energy losses result from continuous running of the compressor due to inadequate reservoir capacity and pressure. Depending on the outcome of demand side flow monitoring exercise the compressed air system could be improved by resizing the reservoir not only to increase the buffer capacity but possibly to re-evaluate the compressor system and explore options for increasing the pressure supply such that the compressor would work on a cyclic basis whereby the compressor would fill the reservoir to a given pressure and then switch off while the reservoir supplies air to the plant, until a pre-determined pressure drop is reached at which stage the compressor would be restarted. The advantages of this are:

- Energy saving through reduced running time
- Maintenance savings and compressor life extension due to reduced running hours
- The use of a variable speed drive to control start-up currents, and also enable the compressor motor to start-up at load hence controlling peak demand as well as preventing mechanical wear at start-up.

Typically the introduction of a VFD driven system with pressure regulated "on-off" control would be best implemented with a hybrid permanent magnet motor which is more robust than an induction motor insofar as repeated start-stop operations are concerned. These motors are bearingless, and shaft mountable. The stators are can be replaced infield in the unlikely event of stator failure. Consequently, these motors are generally more maintenance friendly and have high availability.

The overall outcome of such a system lends itself to savings through improved energy efficiency, reduced maintenance cost and improved availability.

No obvious leaks of compressed air were observed during the plant visits, however temporary (or permanent) installation of an online flow meter can be used to identify and quantify compressed air leakages or unplanned usage. This may be a stand alone system installed for a period as described above, or an online system feeding a signal to the plants control system network, providing real-time data that can be monitored and stored via the SCADA system.

The primary uses of compressed air in the plant are reportedly:

- Reverse pulse filter units
- Instrumentation
- Pneumatic piston positioners for various equipment
- Compressed air is also used to remove product adhering to internal machinery surfaces (for example the combinatory) through pulsing or air hammer.

Instrumentation generally requires compressed air at between 1.5 and 2.0 bars, standard practice in this regard is fit pressure regulation devices at the point of use which serve the dual purpose pressure reduction and condensate removal. It is recommended that the entire compressed air circuit be inspected to ensure that all regulation devices are set to the required settings and that a periodic inspection procedure is developed to confirm the settings.

The compressors are located outside the building in a shaded open area, this is ideal in terms of efficiency related to intake air parameters.

4.1.4 Working Methods

Generally employees were observed to be wearing personal protective clothing. Regular safety awareness meetings are conducted and training is provided on a periodic basis. The working areas observed throughout the mill were immaculately clean.

4.2 Selection of Assessment focus

The IPA focused on the following areas:

1. Compressed Air System

2. Packaging Oven

The QuickScan shows that the largest potential for savings rests with the management of electrical energy usage and maximum demand; however, due time constraints as well as delays experienced by Premier Foods in obtaining measuring instrumentation, which were ordered but could not be installed due to inherent faults, a comprehensive assessment of electrical energy usage and maximum demand trends could not be undertaken.

5. CP OPTIONS GENERATION AND IMPLMENTATION

5.1 Compressed Air

Initial qualitative assessment of the compressed air system indicated that potential for improvement in the energy efficiency of the system should be further evaluated. Several CP Options were contemplated and the following activities were undertaken:

- Empirical quantification of air leakage
- In plant compressed air leak audit
- Intelligent Air Survey

The outcomes of these activities were used to inform the feasibility analysis for each CP option and are summarised in Table 5-1.

Table 5-1: Summary of Compressed Air CP Options Generated

	Description of CP Option	Directly Implemented[2]	Technical Feasibility	Economic Viability	Environmental Evaluation	Implementation Decision	Investment (R)	Savings (R)
1.	Replace current compressors with automated self contained system	Neg	Pos	Neg	n.a	Neg	n.a	4393
2.	Install control system and VFD to optimise compressor speed	Neg	Pos	Neg	n.a	Neg	70 000	4393
3.	Increase header capacity	Neg	Pos	Neut	Neut	Neg	n.a	n.a
4.	Conduct leak audit and repair leaks identified	Pos	Pos	Pos	Pos	Pos	0	4624.68
5.	Audit pneumatic seals and repair/replace	Pos	Pos[β]	Pos	Pos	Pos	n.a	n.a
6.	Replace blow lines for cleaning trucks with hand held cleaning blowers	Neg	Pos	Pos	Pos	Pos	300	284.70

5.1.1 Quantification of Air Leakage

It is practically inevitable that a compressed air reticulation system, especially one that is complex and wide spread, will have leaks. In practice it is rare that all leaks can be prevented. It is often difficult to locate compressed air leaks in a working system unless the system, as the conventional and most practical method is for the auditor to use his/her ears as the sensing instrumentation.

The total compressed air leakage from the plant was estimated by filling the air receiver, with all machinery shut down, and monitoring the pressure drop with time. It is assumed that all compressed air lost during this time was due to leakage as management confirmed that most of the plant was shutdown, and that machinery that was running did not require compressed air. The results of this exercise are shown in table Table 5-2: Leak Test Results

[β] pneumatic seal rings for mill roller piston actuators scarcely available

Table 5-2: Leak Test Results

Time	Pressure
0	4.7
5	3.5
10	3.2
15	3
25	2.8
35	2.5
40	2.2
50	2
60	1.8

The results are shown graphically in **Error! Reference source not found.**.

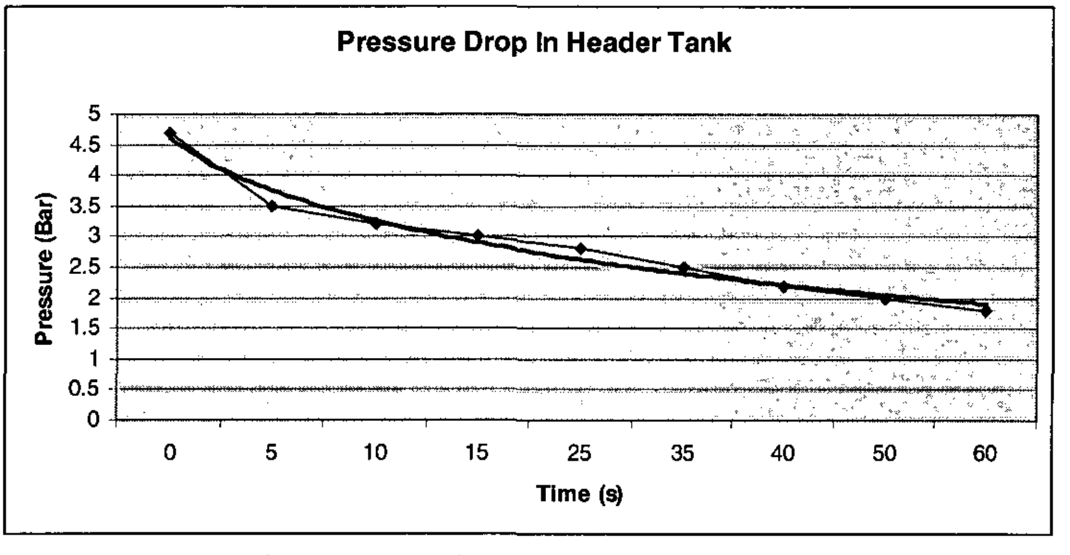

Figure 5-1: Results of Leakage Experiment

In order to calculate the rate of air loss the following assumptions were made:

- the compressed air is a perfect gas
- the expansion of the air inside the receiver as pressure falls is isothermal

These assumptions imply that the product of pressure and specific volume remains constant as the air in the receiver expands.

The rate of air loss is calculated using the first two points on the curve This produces a conservative estimate of leakage as the actual leakage would be a little higher for at a constant operating pressure of about 6.3 Bar. The loss rate at 6.3 bar was not monitored as the compressor online at the time of the experiment delivered on 4.8 Bar at the receiver.

Table 5-3: Compressed Air Losses and Savings

Leak rate	0.611 m^3/min
average system flow rate	1.77 m^3/min
% losses	35%
Current annual energy cost	R 18,861
Annual cost of losses	R 6511
Savings per annum if losses are reduced to 10 %	R 4 624.68
Investment required	0
Payback Period	0

5.1.2 Compressed Air Leak Audit

Initially an audit of the system was undertaken by the IPA team to identify leaks in the compresses air system. At the time of the audit several wheat transport machinery was still running, thus making it very difficult to hear leaks in many parts of the plant.

Numerous leaks were however identified at the mills. These leaks all emanated from shaft seals for pneumatic pistons used to position mill rollers. 5 significantly audible leaking positioners were identified, in the absence of plant noise it is expected that more leaks may have been identified.

From the observation of pressure drop in the receiver during the exercise conducted to calculate the overall leakage rate, it was immediately obvious that a significant amount of air was being lost from the system. In order to effectively identify leaks in the plant, the audit should be done in relative silence with all the machinery off. It could not be established with certainty if the plant would be shut down within the time frames allowed for the IPA. As an alternative and potentially more effective methodology it proposed to plant management that the audit be conducted by plant employees, instead of the IPA team. Effectively workers across the plant (i.e. operators, cleaners, artisans etc) were instructed to note any leaks that the observe during the execution of their duties. The observation should be recorded and passed on to the maintenance department which then collates the information and integrates this into the maintenance schedule.

This should result in a much wider effort as well contribute towards the inculcating of cleaner production principles in the workforce through participation in the project.

5.1.3 Automated Compressor System and

Results of the Intelligent Air survey conducted, showed that a plant could potentially achieve a further 23% annual saving on energy cost associated with the generating compressed air. This represents a sum R4393/annum which is small in comparison to the typical cost of installing a variable frequency drive and control unit to regulate the compressors. A typical installation for a 64KW rated compressor would be in the region of R70 000 making the payback period approximately 16 years. Plant management indicated that investment would only be considered for payback periods not exceeding 1 year.

A comprehensive report on the Intelligent Air survey conducted is contained in Appendix 1.

5.1.4 Truck cleaning with compressed air

Bilk tanker trucks are filled through flexible chutes, for bulk transportation of flour to various customers and bakeries. Small amounts of flour fall on the trucks during the transfer process and during the installation and removes of the chutes. The amount of product lost, although not measured, was observed to be minimal. Compressed air is used to blow flour off the tankers before they roll out. Given that compressed air requires significant amounts of energy, and is costly, to generate it was suggested that the compressed air blowers be replaced by hand held electrical fan blowers. This process is not undertaken on a regular basis as the use of tankers depends on what orders are put through. It is thus not immediately possible to quantify the cost however an electrical blower is viewed favourably as purchase cost is in the region of R280. The hoses are approximately 6mm diameter thus consuming approximately 7.2KW. Assuming 5 trucks per day are cleaned for an average of 60 Seconds each, implies a saving of R284.70 per year. Consequently a payback period of 1 year approximately.

5.2 Shrink Wrap Oven

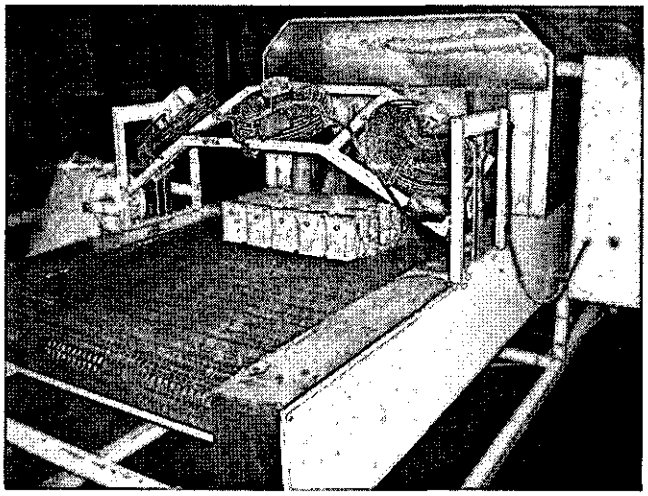

Figure 5-2: Shrink Wrap Oven

Initial qualitative assessment of the heating oven indicated that potential for improvement in the energy efficiency of the system should be further evaluated. Several CP Options were contemplated and the following activities were undertaken:

- Reducing the operating temperature of the oven
- Insulating the outer surfaces

The outcomes of these activities were used to inform the feasibility analysis for each CP option.

Table 5-4: Summary of Shrink Wrap Oven CP Options Generated

Description of CP Option		Directly Implemented[2]	Technical Feasibility	Economic Viability	Environmental Evaluation	Implementation Decision	Investment (R)	Savings (R)
1.	Reduce operating temperature	Pos	Pos	Pos	Pos	Pos	0	9,893.86
2.	Reduce Grate Speed[Y]	Pos	Pos	Pos	Pos	Pos	5000	9,893.86
3.	Insulating the outer surfaces	Pos	Pos	Neut	Pos	Neg	n.a.	3,733.99
4.	Turn Fans away from oven	Pos	Pos	Pos	Pos	Pos	n.a	n.a

[Y] undertaken in combination with option 1

It was observed that oven operates at a constant temperature setting of 200℃. Literature review however indicates that the shrink wrapping process can be conducted at temperatures as low as 120℃ using Low Density Polyethylene (LDPE) shrink wrap. An investigation of the possibility of reducing the oven temperature was thus undertaken.

The following observations were made:

1. The maximum packaging rate of 60 bales per hour[Ψ]
2. It takes 30 seconds for a bale to go through the oven
3. For every minute at the maximum packaging rate the oven is idle for 30sec of each minute.
4. The oven grate is driven via a variable speed torque converter
5. At a steady temperature of 200℃ the oven's elec trical current demand is 33A.

The observations above lead to the following potential options for reducing the oven operating temperature:

1. Reduce the oven grate speed to maximise heat exposure time
2. Determine an optimal temperature setting for the oven

In order to reduce the grate speed the torque converter was brought to its lowest setting. It was observed that the grate speed did not change substantially as a result of this adjustment, and it was proposed by the plant engineer the torque converter be replaced by variable speed drive which could be used to determine the minimum practical speed to run the grate without causing congestion. Once the minimal speed is obtained the minimum temperature setting can be obtained.

In the absence of the variable speed ability on the grate a brief test to reduce the temperature was undertaken to determine if the temperature could be reduced at the current operating speed. The temperature setting was initially reduced to 150℃. At this temperature it was observed the packaging was did not wrap around the bales adequately. Although pictures were taken, plant management requested that no pictures showing any premier food logos or brands be distributed, hence the photos are not integrated into the report.

[Ψ] although the machine operator and supervisor indicated that a maximum of 45 bales can be achieved, bales were produced at the rate of 1 bale per minute at the time of the exercise.

The temperature setting at 180℃ with the torque converter at minimum speed produced adequate shrink wrapping.

It can immediately be inferred from the preceding comments and observations that there is still substantial potential for improvement of energy usage by the oven. The width of a bale is approximately 60cm. The length of the oven is approximately 1.2m. Consequently up to 3 bales at a time can pass through the oven. Refer to Table 5-5: Potential Oven Savings from temperature reduction for a summary of the potential savings to be had.

Table 5-5: Potential Oven Savings from temperature reduction

Parameter	Units
Supply Voltage (3Φ)	380V
Current Oven Setting	200℃
Current At 200℃	33 Amps
Power Consumption	22 kW
Heating Length	1200 mm
Heating Time	30 sec
Current Grate Speed	40 mm/sec
Package Width	600 mm
Package Interval	60 sec
Minimum Grate Speed	10 mm/sec
Maximum Heating Time	120 sec
Proposed Temperature	120℃
Current At 120℃	19.8 Amps
Power Consumption	13 kW
Power Saved	9 kW
% Power Saved	40%
Energy Saved/Annum	76107kWh
Energy Saved/Annum	R9,893.86
Cost of installing new motor and gearbox	R 5 000
Payback period	6 months

Note these potential savings are based on the assumption that the wrapping temperature can be reduced to 120℃. If higher temperatures are required then correspondingly lower savings will be achieved.

The torque converter driving the grate will have to be exchanged for a low speed gear box. If this can be done internally without having to purchase new equipment then the payback is period will be zero. If the material must be purchased then the installation cost is conservatively estimated at R 5 000, resulting in a payback period of approximately 6 months.

5.2.1 Heat Insulation

Although the oven has built in heat insulation to prevent heat loss from external surfaces, the external temperature was measured at 52℃. Assuming an overall heat transfer co-efficient for the stainless steel surface to be W/m^{2}K, the heat loss and potential annual savings are shown in Table 5-6: Heat Loss from Oven Surface.

Table 5-6: Heat Loss from Oven Surface	
Parameter	
thermal transmittance coefficient steel	46 W/m^{2}K
surface area	2.64 m^2
Surface temperature	52℃
Air temperature	25℃
heat loss rate	3 kW
total heat loss per annum	28,723 kWh
cost	R 3 734
Potential savings by installing insulation blanket @ 80% efficiency	R2 987.19
Cost of insulation	R 200.00
Payback period	1 months

5.2.2 Heat Loss through Infiltration

It is expected that the majority of heat lost from the oven is through the exit of hot air from the oven. Two factors contribute to the heat loss through infiltration:

1. The curtains at the at the entrance and exit to the oven do not close as wee as they could see **Error! Reference source not found.**.
2. The fans for cooling the shrink-wrapped bales face toward the oven. See **Error! Reference source not found.**

The oven is partially closed at each end by a set curtains. Although is not practicably possible to completely close off the oven entrance and exits, the loss of hot air could be reduced by replacing the curtains with more effective curtain that have overlapping flaps.

The fans can easily be turned away from the oven by adjusting the angle in the opposite direct ion using the locating nuts that hold the fan frame to the supporting frame. See **Error! Reference source not found.**.

It is difficult to determine the potential savings without non-empirically as the air flow rates are not known and cannot be easily measured. Although the potential for savings is apparent.

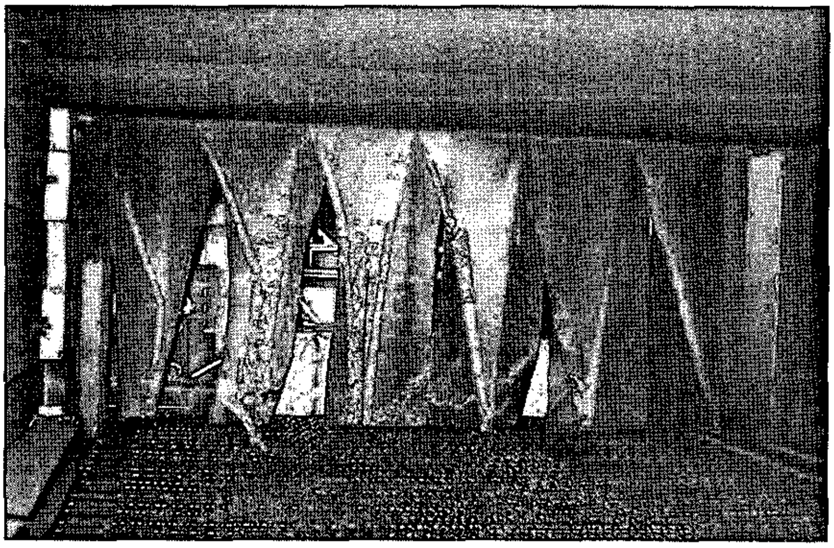

Figure 5-3: Oven Curtains - view from inside oven

6. SUSTAINING CLEANER PRODUCTION ACTIVITIES

The continued implementation if a cleaner production methodology is only achievable through the participation of employees at various levels in the organisation. The most significant potential for improvement lies in the monitoring and management of electrical energy consumption and maximum demand. It is recommended that the an energy management plan be formulated to address this issue. This plan should ideally incorporate:

- Identification continuous monitoring and periodic reporting of energy usage and maximum demand
- An awareness programme to educate and involve employees with respect to energy management

- An assessment of existing high energy users with a view to identifying potential for improvement

7. REFERNCES

IRAS 2002 - Guide to the Selection and Installation of Compressed Air Services. Ingersoll Rand Air Solutions. CPN8823127.