Industrial Energy Efficiency Project in South Africa

Case Study – ESO Interventions

Company name	DURBANVILLE HILLS WINERY
Sector	AGRO - PROCESSING
Year joined IEE Project	2012
Year of interventions	2013 - 15
Contact person	REHAN EMMENIS
System of intervention	LIGHTING, COMPRESSED AIR, REFRIGERATION, PUMPS, HOT WATER

1 BACKGROUND

1.1 Company profile

Durbanville Hills is one of the premier wine making estates in South Africa and is operated by Distell Corporation. The business comprises farming and wine making and is part of the Primary production section of Distell.

Distell Group Limited is South Africa's leading producer and marketer of fine wines, spirits, ciders and ready-to-drinks (RTDs). The Group is listed on JSE (Johannesburg Stock Exchange) Limited. Distell employs over 4 200 people and has an annual turnover in excess of R7.9 billion.

Their products are carefully crafted during a two-phased production process. The Primary Production division is responsible for the raw material procurement, distillation, winemaking and blending. The Secondary Production division is responsible for blending and bottling.

Figure 1: Street views of Durbanville Hills

Figure 2: Satellite view of Durbanville Hills

1.2 The IEE Project - Capacity Building Programme (based on ISO 500001 and ESO)

The IEE Project introduced the Durbanville Hills, Cape Town plant to the new industrial energy efficiency concepts of Energy Management Systems (EnMS) and Energy Systems Optimization (ESO). Durbanville Hills then approached the NCPC in order to participate in the of the IEE Project SME's energy assessment component which involved the plant being assessed by one of the UNIDO trained system optimisation expert consultants.

Recognizing the value of the IEE Project, as well as the value-addition of having a trained system optimisation expert complete an energy assessment of the plant, the Durbanville Hills assessment took place in February 2013. The structure of the IEE Project capacity building programme (both the EnMS and ESO components) are beneficial to enterprises as they not only focus on technical aspects but also provide companies with a clear understanding on how to efficiently manage energy in an holistic and systematic manner.

The plant, subsequently had the benefit of an in depth investigation into the various energy systems which contributed to the overall energy cost. This involved investigation of the Refrigeration, Compressed Air, Pumps, Fans, Water Heating and Lighting. Maintenance staff and management of the plant were provided with findings and recommendations in order to help guide them in the implementation process to ensure good results and achieve consistent savings.

1.3 Project Description

This case study shows how the IEE Project has supported Durbanville Hills in mitigating the challenge of rising energy prices, increasing the reliability of its operations and enhancing the plant's competitiveness and efficiency as well as generating considerable financial, economic and environmental returns.

The IEE Project has empowered the Durbanville Hills plant engineering team and maintenance staff with the ESO expertise through this process and has provided them with the necessary technical and advisory support throughout the implementation and installation of this specific Systems Optimization initiative.

The profitability analysis shown in Table 2 below; demonstrates that improvements and investments in industrial energy efficiency through the implementation of ESO measures, designed to not impact negatively on productivity levels, would also provide a sustainable business model to increase and enhance the enterprise's competitiveness.

1.4 Plant profile

The Durbanville Hills plant is typical of many small wineries in that it has an extremely seasonal variation in energy usage with two distinct discernible seasons. The Electricity consumption varies considerably from season to season as the harvesting & wine making process requires a specific energy usage split which tends to be different from that of the storage season.

Harvesting and Production Season;

The biggest consumer during the wine making season tends to be refrigeration and the chilled water plant together with compressed air which is consumed by the 'bag' presses used to crush the grapes and extract the juice. There are many other processes which take place such as stalk removal, filtration, blending etc. which all add to the high consumption during this period. For example, significant energy users during this time are the mobile pumps which are used to move wine from tank to tank during blending. Lighting also come into the energy consumption mix as the operational hours tend to carry on long into the night. Grapes are mostly harvested during the day and delivered to the winery as they are loaded by the farmers.

Storage Season;

During this season, the chilled water plant is generally shut down and the compressed air system is only used to operate the various valves which allow mixing and blending between tanks. Some refrigeration of Glycol using the Ammonia system is still required for the cold stabilisation process where temperatures below zero are required.

The diagram below demonstrates the extreme difference in energy consumption of the plant during Harvest Season (January, February, March, April) and the 'Off' Season (May to December)

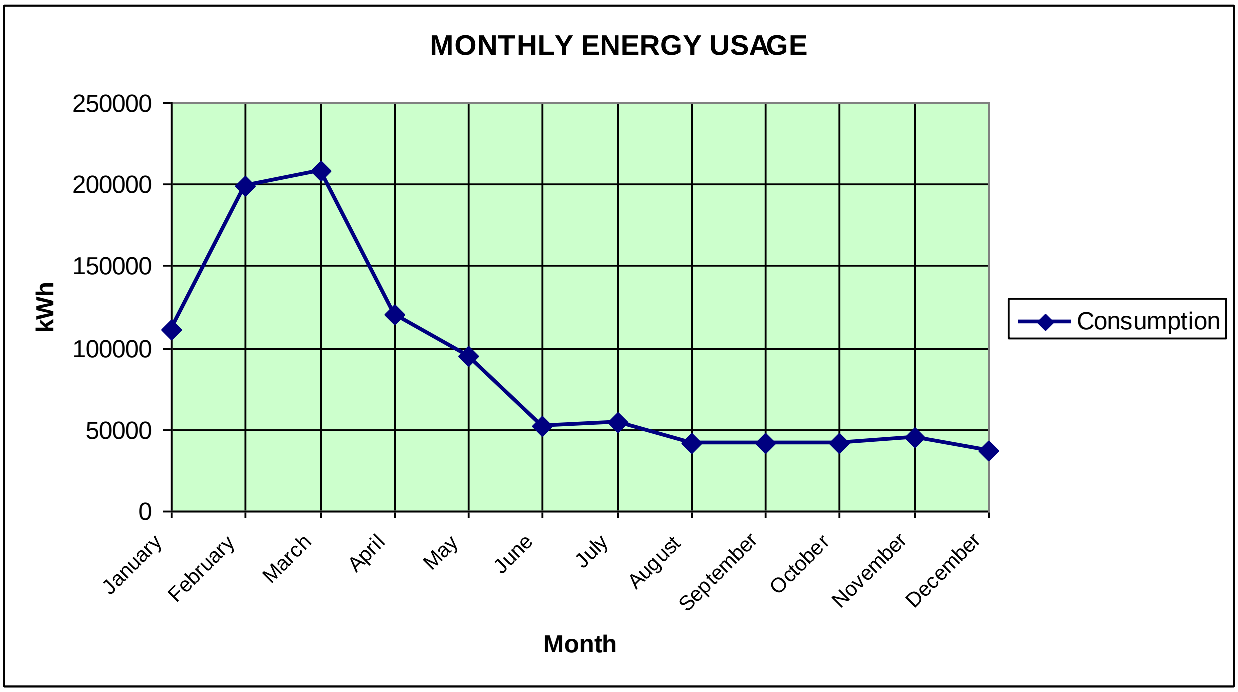


Figure 3: Graph showing electricity consumption per month

2 OVERVIEW OF IMPLEMENTATION

2.1 Assessment Description

The site assessment followed a well proven methodology where the energy consumption billing and patterns of use are first analysed followed by the consultant completing a walk-through of the plant to identify what are generally known as the Significant Energy Users (SEU's).

Once these have been identified the breakdown of the plant energy consumption is calculated and the potential benefits of system optimisation are appraised for 'Easiest', 'Most Beneficial', Biggest Savings', 'High and Low Cost' etc.

A measuring and analysis programme is then conducted in order to put more accurate values to the optimisation projects and their cost savings potential.

The approach included:

- Walk-through & survey of the plant
- Analysis of energy consumption and costs
- Analysis of energy consumption performance of various systems
- Identification of energy saving opportunities
- Report for action and implementation

The Table 1 below shows the breakdown of the plant in terms of energy consumption calculated by the consultant and this was used to target those systems which would offer the best energy savings opportunities.

Table 1: Break down of electricity consumption by plant

Equipment	Estimated Electricity Usage (kWh/month)	%	Nameplate Rating Demand (KVA)	%
Refrigeration and Chilled Water	111 024	42.7	467	34
Pumps and Motors	70 838	27.3	616	44
Compressed Air	37 267	14.3	155	11
Lighting	24 759	9.5	69	5
Fridges and Air conditioners	7 890	3.0	24	2.5
Cooking and Kitchen	4 598	1.8	47	3
Administration	3 360	1.3	8	0.5
Total per Month (Average)	259 736	100	1 387	100

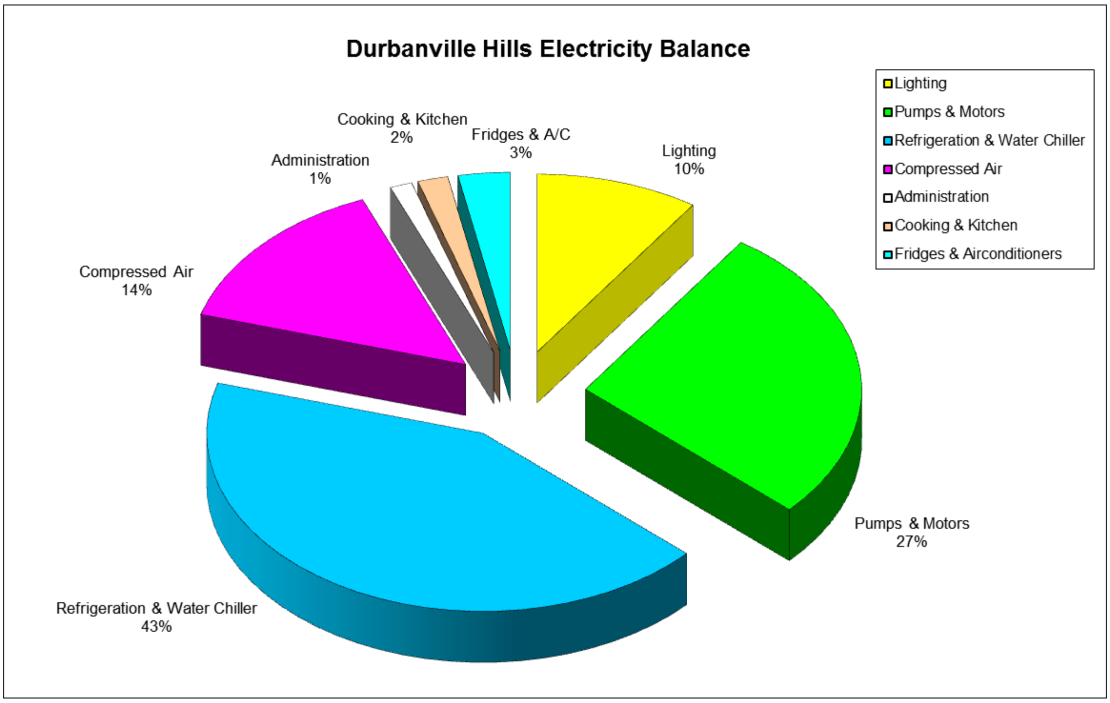


Figure 4: Breakdown of electricity usage

During the site assessment, the following direct energy saving initiatives were identified and presented to the Durbanville Hills management. The initiatives listed in Table 1 below are the main areas noted; however, other indirect savings opportunities were also identified and discussed.

Table 2: Savings Opportunities Identified

No.	Energy Minimisation Opportunities	Estimated Savings (kWh / Year)	Estimated Savings (ZAR / Year)	Estimated Investment (ZAR)	Estimated Payback Period (Years)
1	Demand Management	0	R 71 000	0	Immediate
2	Chilled Water Plant	198 000	R 154 000	R 150 000	1 year
3	Lighting	110 000	R 86 000	R 150 000	2 years
4	Compressed Air System	40 000	R 31 000	Management	Immediate
Electricity Savings		348 000	R 342 000	R 300 000	N/A

As a result of the engagement with the IEE Project, the following initiatives have been developed and put into place at Durbanville Hills, Cape Town;

1) Installation of daylight lighting and automatic switching using Lux level sensors
2) Re-setting of compressed air pressure set points
3) Installation of pressure control systems to chilled water circulation pumps
4) Automatic switching off of mash cooler pumps when no product was available
5) Sequencing of the 3 x Ammonia plant compressors dependent on load
6) Timing the hot water geysers to only run during ‘Off Peak’ times

The above projects have become part of an ongoing process at the plant and the savings seen to date have given rise to enthusiasm on the part of management with the resulting 'buy in' driving the implementation of the more expensive initiatives.

Recent electricity billing information, for the period since the assessment and some implementation took place, was received from the plant and a comparison was drawn to the previous year before any of the interventions took place.

(This had to be compared to the production tonnage during the harvest season so as to allow the comparison to be accurate)

3 KEY ACHIEVEMENTS

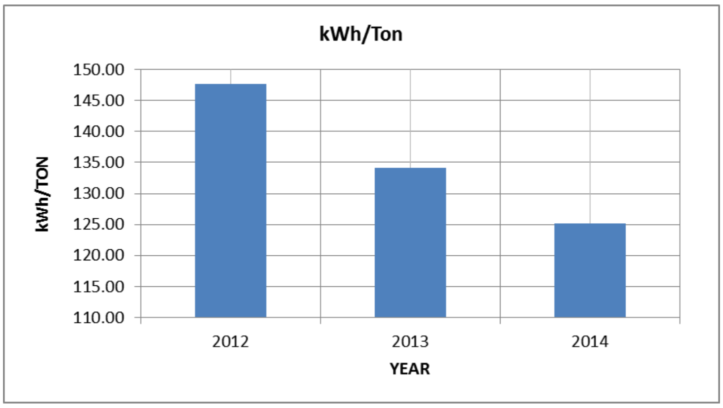
Implementation Period	2012 to 2015
Total Number of projects implemented at the plant	6
Energy Intensity Savings (kWh/TON/year)	15.26% (147.68 to 125.14)
Electricity Cost savings (ZAR/TON)	R 155.19 to R 97.61
Total investment made to date (ZAR)	Not available
Payback time period in years	Not available
GHG Emission per TON production (ton CO2/year/TON)	103.37 to 87.60

NOTE:

The savings made are best shown in terms of energy intensity as the production variation can distort the effect of any electricity and cost savings.

Table 3: Electricity Consumption and kWh per Ton produced

Month	2012 (kWh)	2013 (kWh)	2014 (kWh)	2015 (kWh)
January	111 561	132 989	47 566	51 801
February	198 918	140 625	87 772	107 639
March	208 524	206 567	206 707	202 452
April	120 873	185 847	230 840	
May	95 473	136 151	180 633	
June	52 067	63 421	91 386	
July	53 978	58 169	57 558	
August	41 561	63 078	61 376	
September	41 886	62 550	56 360	
October	41 184	51 269	58 074	
November	44 856	52 454	58 879	
December	37 042	59 080	51 688	
Average	87 327	101 017	99 070	
TOTAL	**1 047 923**	**1 212 200**	**1 188 839**	**361 892**
TONS	**7 096**	**9 000**	**9 500**	**8 000**
kWh/Ton	**147.68**	**134.69**	**125.14**	**45.24**
Reduction		**8.80%**	**15.26%**	



4 DESCRIPTION OF INTERVENTIONS

4.1 Chilled Water System

One of the highest energy consumers, and also one of the most critical, especially during the harvest season, is the chilled water system which is used to cool down the grape 'mash' and also the tanks as the wine is fermented. It is critical that sufficient chilled water is available especially when fermenting, as the temperature can easily rise uncontrollably, with a resultant deterioration in product quality. It was important that the operation of the system was not compromised in any way whilst still managing to reduce the energy consumption.

4.1.1 System description

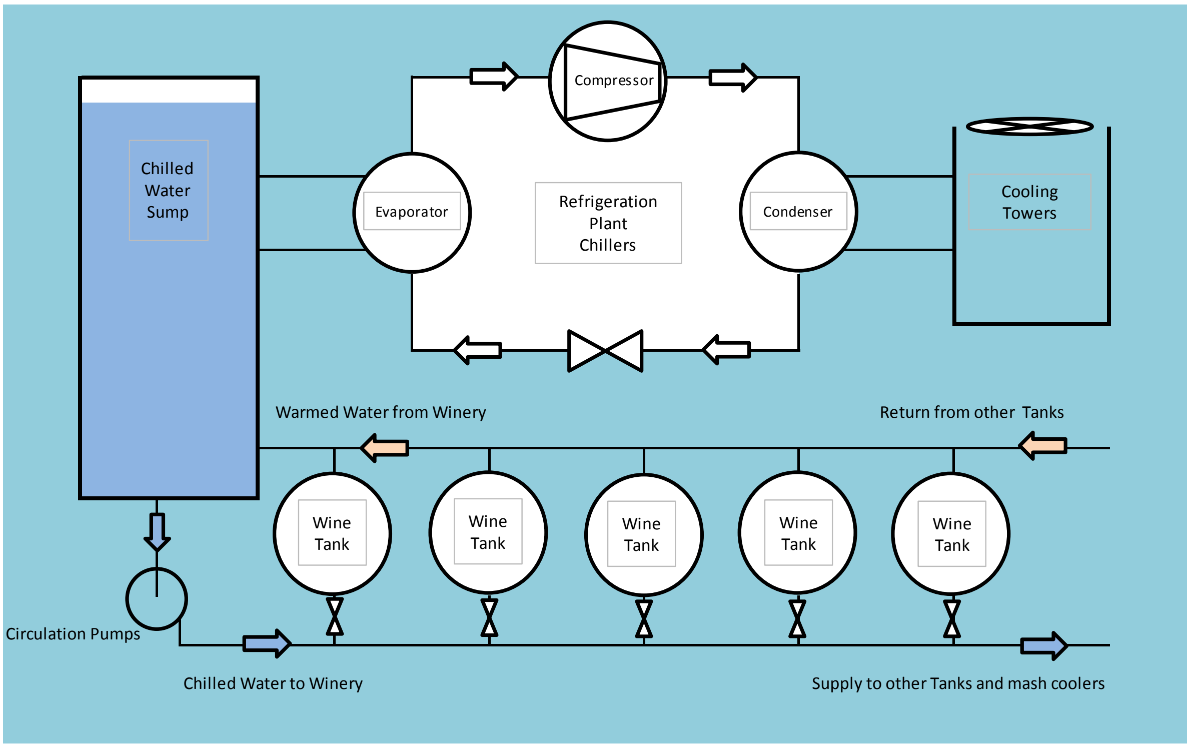


Figure 5: Layout of the chilled water plant and supply system

The areas noted for intervention were the refrigeration compressors, the circulation pumps and the cooling tower fans.

It was also hoped that the temperature of the chilled water could be raised from the current set point of 4°C up to 7°C, however this was discussed with the winemaker and determined to be not viable as the control of the wine fermentation in the tanks could be compromised.

4.1.2 System Optimisation

1) Circulation Pump Control

Control over the operation of the circulation pumps was introduced in the form of automatic switching when product was available or unavailable at the mash coolers, and also pressure control which reduced or increased the number of pumps running as required by the demand of the system.

As tanks require cooling, the valve at that tank is opened by the winemaker resulting in a drop in pressure requiring additional pumps to commence running. Similarly, closing the tank valves increases the system pressure allowing the number of pumps running to be reduced.

2) Refrigeration Compressor Sequencing

The number of refrigeration compressors running is also pressure controlled which gives a good indication of the demand for refrigerant. As the pressure increases the number of compressors running is reduced to the point where the pressure reaches the set point required. This allows the system to automatically operate with the supply matching the demand.

3) Cooling Tower Fans

The cooling tower fans are to be the next initiative to be implemented as it was noted that especially during the night, the condensers required less cooling as the ambient air temperature dropped. VSD drives are to be installed at these fans which will be controlled by the cooling requirement measured by the condenser demand and temperature difference measured.

4.1.3 General System observations

It was difficult to accurately measure the savings achieved by the interventions listed above, however, the maintenance staff reported that the pump and compressor management control was operating correctly, and as anticipated, these units were not running continuously any more and instead the numbers of compressors and pumps running was definitely reduced at any particular time of observation.

The chilled water was kept available at the required temperature and the winemakers were satisfied that the intervention had not compromised the product quality.

4.2 Compressed Air System

The compressed air system is a critical component of the plant as it is used for both the bag presses (4) and also all the pneumatics and valves. The bag presses use large volumes of low pressure air whilst the valves and pneumatics require at least 6.5 bar pressure in order to operate correctly.

4.2.1 System description

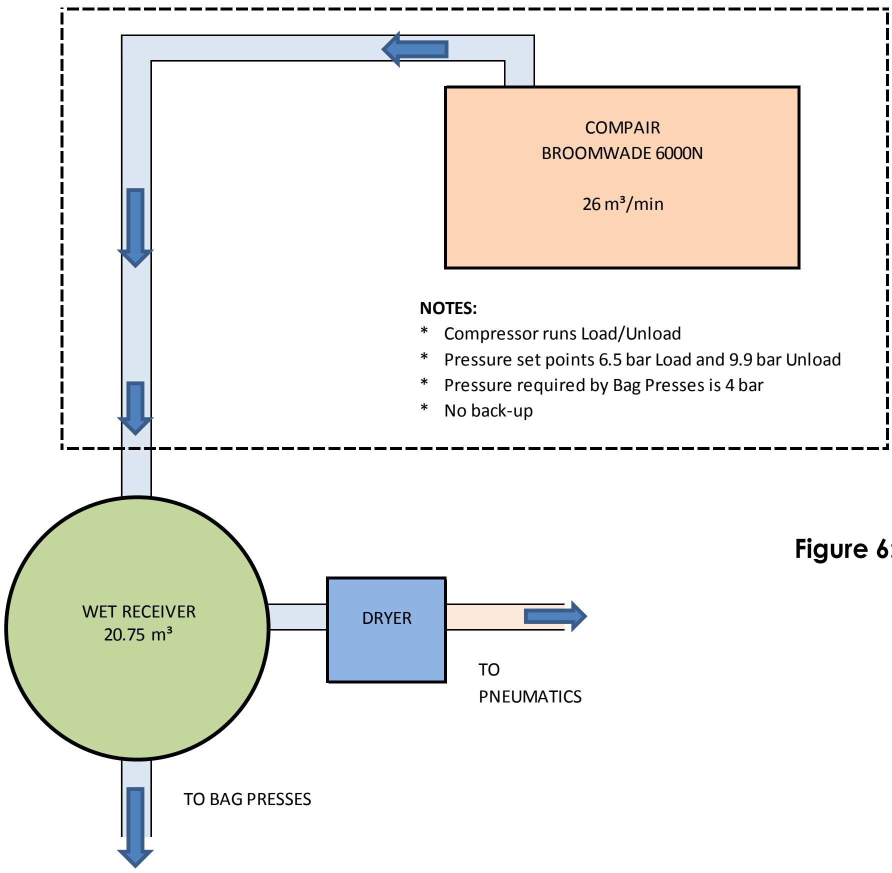


Figure 6: Schematic of compressed air system

4.2.2 System Optimisation

The areas noted for optimisation focussed on better matching the supply and demand requirements of the plant. The pressure variations required the compressor to be able to supply large volumes of low pressure together with smaller flows of higher pressure. Since there was a large capacity receiver it was recommended to lower the Loading pressure set point from the existing 8.5 bar to the minimum for the pneumatics of 6.5 bar.

It was determined that the large size of the receiver would allow a slow deterioration of pressure from the 9.9 bar Unload set-point. This would then allow the compressor to not only Unload but to actually switch off for a period until the lower set point was reached and it then started up again.

Previous Operation;

At 9.9 bar the compressor Unloaded, then it ran Unloaded for a period of approximately 20 mins whilst the pressure dropped to 8.5 bar at which point it would Load again.

During this Unloaded period the power drawn was approximately 60% of the Full Load Power of 150 kW = 90 kW. If this time period was averaged during the Harvest Season, then for every hour of operation the compressor would run at Full Load Power for 40 mins and 20 mins at Unloaded Power. This equated to an amount of 99 kWh from Full Load and 30 kWh for the Unloaded period.

The intervention of reducing the Load pressure set-point to 6.5 bar, allowed the compressor to shut down completely and not run at Unloaded Power.

4.2.3 Results of Intervention

Since there are 2 distinct periods that the compressor is used, the calculated savings were split into the 2 periods.

Harvest Season Savings

Average operational hours during Harvest Time (3 months)	=	18 hours per day
Compressor Loaded time	=	12 hours per day
Compressor Unloaded time	=	6 hours per day
Total Unloaded time	=	540 hours
Unloaded Power	=	30 kW
Saved Energy during Harvest Season	**=**	**16 200 kWh per year**

Off Season Savings

Average Operational ours during Off-Season (9 months)	=	8 hours per day
Compressor Loaded time	=	5 hours per day
Compressor Unloaded time	=	3 hours per day
Total Unloaded time	=	810 hours
Unloaded Power	=	30 kW
Saved Energy during Off Season	**=**	**24 300 kWh per year**

TOTAL YEARLY SAVINGS **=** **40 500 kWh**

4.2.4 General System observations

It was difficult to accurately measure the savings achieved by the interventions listed above, however, it the plant maintenance staff reported that it could clearly be seen that the air compressor was definitely switching off completely for fairly long periods and not just running Unloaded as previously.

The compressed air supply was still sufficient to supply all the requirements and the large receiver tank definitely helped in reducing the running time and hence the operating costs.

4.3 Lighting

The lighting is an important part of the operation as the tank areas tend to be fairly dark and require good lighting for the blending operations and general wine making. In general the existing lighting was produced by the 74 x 400W High Bay lamps.

There were also a large number of other types of light, predominately 1200mm double tube T8 type fluorescent, and 126 x Halogen downlighters.

Figure 7: Typical Tank store showing original 400W High Bay lamps

4.3.1 System Optimisation

The first section of lighting that was optimised was the 400W High Bay lamps. Two intervention projects were completed resulting in excellent lighting with minimum energy consumption.

1) Installation of daylight panels in the roof of the tank stores
2) Installation of a light sensitive switching system which read the Lux levels in the store and automatically switches on the High By lights if required

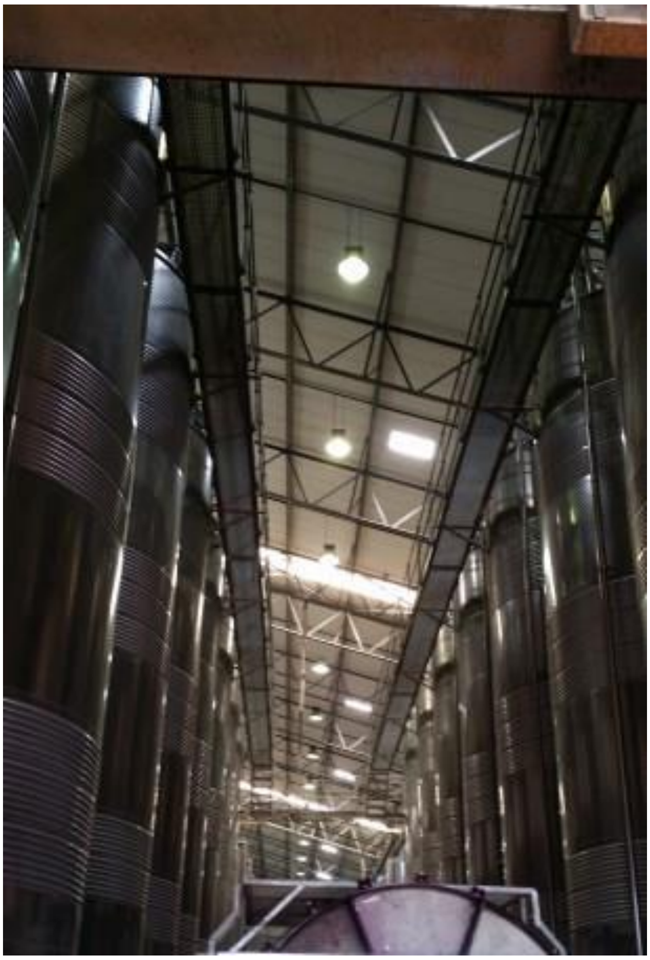


Figure 8: Tank Store showing lights switched off on left and on at right

The above pictures show quite clearly that the daylight panels inserted are providing better illumination than the original High Bay lamps. In fact the effect of the High Bay lights being switched on was not noticeable.

The cost of the panel installation was very low compared to installing energy efficient lights, and since the harvest season when the tank stores are most busy is during Summer, the benefits were most noticeable during that time.

Figure 9: Diagram showing installation of daylight sensing light system

4.3.2 Results of Intervention

The Harvest season of 3 months being during Summer, allowed for the High Bay lights to remain switched off for on average 10 hours per day. During the Off-Season they can remain off for on average 7 hours per day

Number of lamps	=	74
Power per lamp	=	0.4 kW
Hours of operation normally	=	24 hrs per day
Energy consumption of 400W lamp operation	=	710 kWh per day
Energy consumption of lamps per year	=	260 000 kWh
	=	R 202 000 per year

Hours switched off after intervention	=	2 300
Hours of operation after intervention	=	6 400
Energy consumption savings	=	2 300 x 0.4 kW x 74
	=	68 000 kWh per year
	=	**R 53 000 per year**

4.3.3 General System observations

It was difficult to accurately measure the savings achieved by the interventions listed above, due to the numerous lighting circuits involved, however, the consultant could clearly see that the illumination produced by the daylight panels was in fact better than that produced by the 400W High Bay lamps.

The daylight sensor control was operating well and the manual switch together with the data logging system allowed excellent management control of the lighting in the tank stores.

The workers were happy with the Lux levels and productivity was not affected.

Further interventions to replace firstly the 50W Halogen downlighters with LED versions are now planned due to the success of this first intervention.

It is anticipated that a further **42 000 kWh** of indirect savings can be saved with energy efficient lighting retro fit replacements.

4.4 Water Heating (Demand Management)

There are a number of electrically heated geysers throughout the plant and 5 of these have been identified and fitted with timer controls.

Due to the plant being on a time of use tariff, it was possible to schedule the geyser element heating to periods of lowest cost, ie during the 'Off Peak' periods.

4.4.1 Results of Intervention

By managing the Times of Use, the best possible result (ie lowest cost) can be achieved within the tariff constraints.

As can be seen from the diagram, the 'Peak' periods are for a fairly short time between 07:00 and 10:00 and again from 18:00 to 20:00. These periods are charged at very high rates especially during the 'High' season.

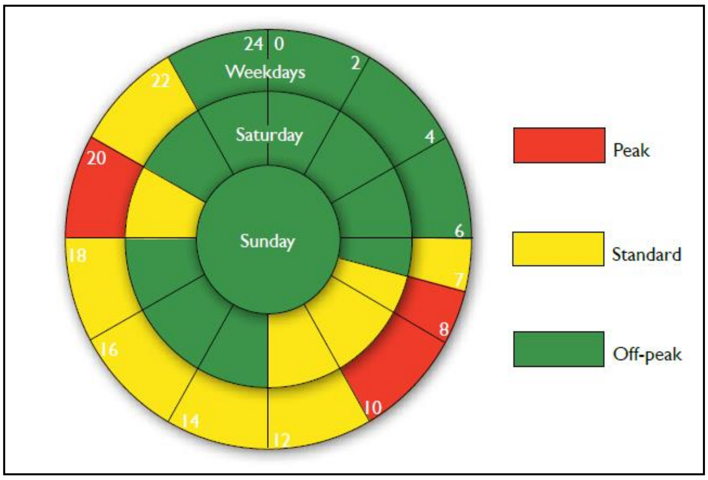


Figure 10: Diagram showing Time of Use Time periods

Seasons are:

Low Season -	September to May (Summer)
High Season -	June to August (Winter)

Low Season:		**High Season:**	
Standard Time -	R 0.53 /kWh	Standard Time -	R 0.71 /kWh
Off Peak Time -	R 0.33 /kWh	Off Peak Time -	R 0.38 /kWh
Peak Time -	R 0.76 /kWh	Peak Time -	R 2.33 /kWh

Example:

The energy consumption of the 5 geysers is approximately 15 kW. A load of 15 kW moved from 'Peak' time to 'Off-Peak' time will result in the following;

Power used	=	15 kW
Hours used per month	=	216 hrs
Cost per month during 'Peak' time (High Season)	=	R 22 600
Cost per month during 'Off-Peak' time (High Season)	=	R 1 200

If this load is moved every day during the year the savings would be;

Savings during High Season	=	R 64 000 per year
Savings during Low Season	=	R 7 000 per year
Total Savings per year (5 x geysers)	**=**	**R 71 000**

4.4.2 General Observations

The savings achieved by this intervention could then be estimated using the time set on the timers and working with the tariff rates from Eskom.

Further interventions to install timers on all the rest of the geysers throughout the plant as well as the restaurant would potentially achieve a further savings R 142 000 per year. It is estimated that there are a further 10 geysers throughout the site but this would have to be confirmed.

There is also the potential to install heat pumps to replace the electrical element heating but this would incur fairly high investment with a 3 year return. The management decided against this option at this time.

4 HIGHLIGHTS OF ESO INTERVENTIONS

NOTE:

The Interventions implemented at the plant were in most part 'Indirect' savings projects as they were not directly as per the assessment recommendations. The company noted the areas where the best results could be achieved and then took the recommendations on board and instituted their own interventions as they thought best.

No.	System	Savings (kWh / Year)	Savings (ZAR / Year)	Investment (ZAR)	GHG Emission Reduction (Kg CO2/year)	Payback (yrs)
1	Demand Management	0	R 71 000	R 0	0	Immediate
2	Chilled Water Plant	198 000	R 154 000	R 150 000	178 000	1 year
3	Lighting	110 000	R 86 000	R 50 000	99 000	0.5 years
4	Compressed Air System	40 000	R 31 000	R 0	36 000	Immediate

5 FUTURE INTERVENTIONS

Since there were a number of systems that could potentially benefit from similar interventions, a list of recommendations was prepared for management which included the following;

- It was proposed to install VSDs on all of the cooling tower fans and on the rest of the circulation pumps feeding the tanks stores with chilled water
- The VSD's would be installed in the refrigeration room and on the cooling towers so would therefore have to be IP55 rated so that dust and moisture did not affect performance
- By locating the cooling tower VSD drives close to the fans, various harmonics and other EMC phenomena would be better mitigated
- The VSD's would work in conjunction with the chiller control systems and the demand requirements could then be better matched by the fans and pumps
- The solution would be autonomous and would have a fail-safe breaker that would revert the system back to its current operation method of direct online

6 BENEFITS & LESSONS LEARNED

The energy and financial savings achieved by the interventions made at the Durbanville Hills plant proved to be even better than was hoped for.

Installations of the next recommended interventions are now planned, where it is anticipated that further energy savings will be achieved.

The IEE Project assisted Durbanville Hills in analysing the plant's energy consumption in a systematic and holistic manner, thereby helping the cellar engineers to optimize processes throughout the various energy intensive systems.

The main lessons learned and steps followed by Durbanville Hills resulted in the following:

- Management commitment was shown to be the key to success. It was thanks to the buy-in of the high-level management team that resource allocation was made available

- Durbanville Hills made energy a priority. The energy team showed that the intervention projects completed allowed a better understanding of the process requirements and the benefits of ESO implementation

- The engineers in the plant were assisted technically with respect to ESO methodologies implementation. (In order to maintain the progress of the interventions it is always key for the plant to raise employee awareness at all levels on energy matters and the benefits of energy efficiency)

- It is recommended that an EnMS (Energy Management System) be put in place at the cellar as this will limit the risk of improvements being linked to, and supported by, a single person rather than by the company culture

- Constant monitoring of any interventions, and then reporting to top management on the achievements and challenges encountered, helps reinforce the commitment and provide security with respect to the effectiveness of the decisions taken