A STUDY OF DEMAND SIDE MANAGEMENT POTENTIAL IN SOUTH AFRICAN INDUSTRIES

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ABSTRACT

This paper looks at the potential for demand side management (DSM) in nine industries in South Africa. The DSM potential of the industries was assessed through audits and by examining the load profiles of the industries. The DSM options considered were either an improvement in energy efficiency or the shifting of electricity use to outside of the Eskom peak. DSM options that would negatively affect production were not considered. The paper introduces the study, explains why certain industries were selected as case studies and briefly summarises the findings at each site.

1. INTRODUCTION

DSM is receiving increasing attention from both Eskom and the National Electricity Regulator (NER). Demand for electricity has increased by about 1000MW per annum in recent years. The 2003/4 National Integrated Resource Plan (NIRP) predicts that at the current rate of increase of demand additional peaking plant will be needed in 2008 and additional base load plant in 2010 [1]. Due to the lead time needed to develop new generating plant it will become difficult to meet electricity demand in years to come.

Demand side management is a way of reducing demand and therefore delaying the time when new generation capacity is needed. DSM measures allow customers to use electricity less intensively or at times which do not coincide with unavoidable peak demand. The 2003/4 NIRP forecast of future electricity demand includes a forecast reduction in demand from DSM measures in the industrial sector that would improve motor efficiency, lighting efficiency, compressed air efficiency and the use of variable speed drives (VSDs). The NIRP includes an annual displacement target of 57MW in the industrial and mining sub-sectors resulting from energy efficiency and load management DSM options.

Industry and mining used a total of 112TWh of electricity in 2005, this was 46 percent of the electricity sold in South Africa during that year [2]. In contrast only 44.5 MW's of DSM interventions were contracted in the industrial sector during 2005. The industrial sector has a large demand for electricity and very little realisation of its DSM potential.

The purpose of this work was to identify industries and processes within these industries that should be targeted for DSM interventions.

As only a limited number of audits could be carried out during this study it was necessary to establish which industries showed the greatest potential for DSM and should receive audits. The study was therefore completed in two phases.

During the first phase industrial sub sectors including mining were ranked based on the overall energy they consume, the peakyness of their load profile, the potential for DSM savings from retrofits in existing or new plants and the likely cost and technical ease with which DSM measures could be implemented.

During the second phase the audits were carried out and meters were installed. Metered data was used to establish typical load profiles for these industries and to establish the likely result of DSM interventions.

The industrial sub sectors considered during this study were food and beverages, textiles, wood and wood products, chemicals, iron and steel, non – ferrous metals, non-metallic minerals and mining (both gold, Platinum and other).

2. INDUSTRIAL ASSESSMENTS – CHOSEN INDUSTRIES

The purpose of this initial study was to establish which industries to target with detailed energy assessments. As only a limited number of assessments could be conducted, it was important to establish how to maximise the return on the invested efforts and resources. The aim was thus, to develop a ranking of industries based on their potential for energy savings from DSM interventions.

The following criteria were considered:

1. Electricity consumption and potential DSM savings from retrofits at existing plants.
2. Electricity consumption and potential DSM savings at new plants.
3. Potential DSM interventions in each industry.
4. The costs of a suite of DSM interventions in each industry.
5. The technical ease with which DSM may be implemented in each industry.

The potential for DSM savings in the different industrial sectors was evaluated based on these criteria using aggregated values sourced from local and international studies. An assumption of consumption by end-uses (motors, process heat, lighting etc.) as a percentage of total consumption in the different industries was needed for this. The assumptions used were taken from the US Department of Energy's Energy Information Administration [3] and the British Department of Trade and Industry [4]. Mining assumptions were taken from the South African Department of Mineral and Energy's Integrated Energy Plan [5].

DSM measures were applied to the various 'end uses' of electricity within each industry. From these a shortlist of industries to target with energy audits and data gathering was suggested. Industry and mining are referred to collectively as industry. The ranking of each industry in terms of its currently and future electricity use and DSM potential can be seen in Table 1 and Table 2.

Table 1: Ranking of industries and potential DSM savings based on current electricity consumption

	Electricity use		DSM potential	
	Rank	% of total	Rank	GWh saved
Iron and Steel	1	22.91	2	2 289
Precious and non ferrous metals	2	16.55	10	184
Gold mining	3	15.36	1	2 311
Chemicals	4	12.54	4	1 370
Wood and wood products	5	8.18	3	1 458
Platinum mining	6	6.13	5	927
Non-metallic minerals	7	5.02	8	524
Rest of man	8	4.12	7	542
Food, beverages and Tobacco	9	3.20	6	605
Coal mining	10	2.52	9	381
Copper mining	11	0.88	11	133
Rest of mining	12	0.80	12	121
Diamond mining	13	0.60	13	91
Textile, cloth and leather	14	0.38	14	67
Iron ore mining	15	0.32	15	48
Rest of basic metals	16	0.18	18	13
Chrome mining	17	0.16	16	24
Manganese mining	18	0.13	17	19
Asbestos mining	19	0.02	19	3

Table 2: Ranking of industries and potential DSM savings based on future electricity consumption

	Electricity use		DSM potential	
	Rank	% of total	Rank	GWh saved
Iron and Steel	1	22.91	2	2 289
Precious and non ferrous metals	2	16.55	10	184
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Rest of basic metals	16	0.18	18	13
Chrome mining	17	0.16	16	24
Manganese mining	18	0.13	17	19
Asbestos mining	19	0.02	19	3

Table 3 ranks industries in terms of the likely payback period and ease of implementation

	Payback period	Rank	Ease of implementation	Rank
Wood and wood products	2.2	7	1.9	1
Textiles	2.6	4	2.7	9
Rest of man	2.6		2.5	8
Rest of basic metals	2.8	2	2	2
Other mining	2.4	5	2.4	6
Non metallic minerals	2.9	1	2.3	4
Non ferrous metals	2.6	4	2.7	11
Iron and Steel	2.3	6	2.2	3
Gold mining	2.4	5	2.4	5
Food & beverages	2.4	5	2.7	10
Chemicals	2.7	3	2.5	7

The outcome of the first phase of the study in terms of industries to target is summarized in Table 3 below. The table includes a column for the number of audits recommended in each sub-sector when gold mining is included and when gold mining is excluded from the study. The actual number of audits undertaken in each sub-sector during the second phase of the study is shown in the last column in Table 3.

Table 4: Number of audits suggested and carried out in each sub-sector

Sector	With gold mining	Without gold mining	Actual number of Audits
	Number of audits		
Gold mining	2	0	1
Iron and steel	2	3	1
Wood and wood products	1	2	1
Chemicals	1	2	1
Platinum mining	1	1	1
Food and beverages	1	1	2
Non-metallic minerals	1	1	2
Coal mining	1	0	0
Non ferrous metals	0	0	0

3. AUDITS AT CHOSEN INDUSTRIES

Ten sites were chosen for audits. The sites chosen were felt to have processes and patterns of energy use that would be representative of the subsectors into which they fell. At one of the sites it was not possible to complete the study due to production problems they were experiencing, leaving a total of nine sites audited.

At each site tours were taken through the factory in order to understand the production processes, energy use and special constraints and problems. Conversations were held with managers, superintendents, foremen, technicians and artisans.

An emphasis of the study was on installing meters in order to determine load profiles and where possible establish a profile for a typical weekday, Saturday and Sunday. Total demand as well as some of the larger end users were monitored at each site.

Meter points were chosen based on the information from the tours and discussions. Readings were taken over a period of at least three months, in some cases readings were available over a year and it was possible to develop pre-winter, winter and post winter profiles. Monitoring of electricity end uses was also done to determine the existence of seasonal variations in energy use or other relationships.

A brief description of each factory follows, including the DSM potential found at each site. The results presented from the study include options for improving energy efficiency and options for shifting load.

3.1 NON-METALLIC MINERALS: BRICK MAKING

The brick making factory has a maximum demand of 1650 KVA and makes both high quality face bricks and run of kiln bricks. It produces about 85 million bricks a year. The brick factory has two main sections, preparation and making where the clay is moulded into bricks and the kilns where the bricks are fired. The largest energy users are the kilns. These are fired on heavy furnace oil or coal fines. The kilns run 24 hours a day 7 days a week and are the production bottleneck. Preparation and making runs according to a shift timetable, mostly between 7:00am and 18:30pm.

The factory offers limited opportunities for improved energy efficiency through better drive belts, more efficient motors and lighting. It would also be possible to pre-heat the HFO used in the kilns with heat exchangers using heat from the kilns. Heating the HFO is currently being done with electric heaters.

There is potential to easily shift 700 kW out of peak times at this factory. This is possible as preparation and making has sufficient capacity to be shut down at peak times without affecting production quality or quantity. Figure 1 below shows the average profile of the factory in April 2005. The profile is shown over a two day period as the factory schedules night shifts which alter the profile for 48 hours. The profiles show clearly when preparation and making is active and the increase in energy use during these times.

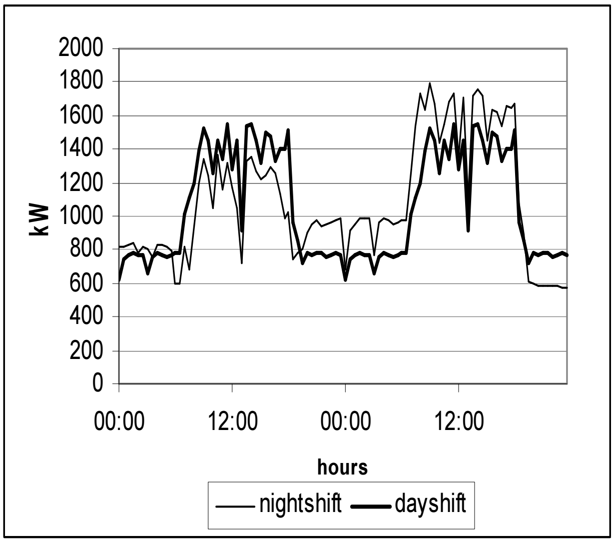

Figure 1: Typical dayshift and nightshift profiles during April 2005

3.2 NON-METALLIC MINERALS: CEMENT

Maximum demand at the cement mill is about 7300 kVA. The mill produces about 550 thousand tons of cement each year. The largest energy users are the kilns which are fired with coal. Electricity is used for motors to turn the kilns and drive fans, crushers, kilns, conveyors and compressors. The kilns run 24 hours a day 7 days a week and as with brick making are the bottleneck in process. The plant is on a tariff which offers cheaper electricity during off peak times. Management at the cement mill are highly aware of energy costs and have implemented effective measures to reduce electrical loads at times of peak demand. Crushers only run at standard and off-peak times, the raw mills and finishing mills only run in off-peak times.

The potential for further improvements in energy efficiency and peak shifting is limited without major changes in the production processes. At present off peak demand is about 7000kW, peak demand is as low as 1500kW, they are currently shifting about 5500kW out of peak periods.

There is limited opportunity to improve motor efficiency as motors are often specialized and required to work in an extremely dusty environment. There is the possibility of reducing the lighting load which was estimated to be around 400kW by about 100kW, but larger savings may be made by ensuring that lights not needed during the day are turned off.

Figure 2 below shows the average weekday, Saturday and Sunday profile during October 2004. The weekday profile shows how demand is being shifted at peak times and during standard times into the off peak periods.

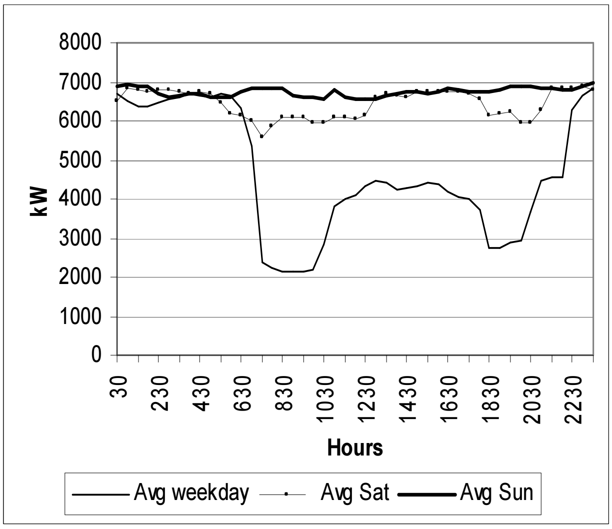

Figure 2: Average weekday, Saturday and Sunday profiles during October 2004

3.3 WOOD AND WOOD PRODUCTS: PAPER MILL

In this sub-sector a paper mill was studied which uses both soft and hard wood to make paper. The mill produces around 340 thousand tons of paper a year. Paper machines, digesters and other specialized equipment run continuously 24 hours a day 7 days a week. The de-barker, wood chippers, water treatment plant and waste plant do not need to run continuously as they have excess production capacity.

The mill uses energy in the form of coal, wood, gas and electricity. Coal, gas and black liquor are used to raise steam for process heating and to generate electricity. Sasol gas is used for firing the lime kilns. Maximum electricity demand is around 55MW they currently have the capacity to generate 20MW of electricity from steam on site.

The mill has potential to improve its energy efficiency by improving lighting efficiency and using high efficiency motors and by better use and maintenance of compressed air systems. There are good opportunities for shifting load in the plants that do not need to run continuously. Shutting the debarking plant and wood yard down during peak times would shift 2600kW. Storage facilities for pulp produced from waste paper by the waste plant would allow 2000kW to be shifted. The pumps in the water treatment plant have excess capacity there is also a large unaccounted loss of water and problems with silting of pumps if they are allowed to remain stationary. For this reason pumps in the waste treatment pant are kept running. If these problems were addressed, pumps could be stopped during peak times, and 1500kW saved or shifted.

In 2002 a study showed that, due to economies of scale, it is cheaper for the mill to import electricity from ESKOM than to generate its own. In a pulp mill however, the excess heat can be used for process heat. At present steam generated at 62 bar goes through high pressure reducing valves (with a capacity of 135 tons/hour) and is reduced to 11 bar. This is a huge waste of high quality energy. With the existing steam supply it would be possible to generate an additional 10 MW of electricity at all times.

A further source of energy that is currently not being utilized is the bark from the pine logs. At present bark is dumped in landfill or sold as compost.

3.4 FOOD AND BEVERAGES: FRUIT JUICE AND JUICE CONCENTRATE

The juice plant produces concentrated juice and canned sparkling juice. Maximum demand is around 3700kVA. The pant has four main sections, these are juice preparation, packaging, storage and distribution. The greatest users of energy at the factory are cooling, heating and compressed air. The deep freeze plant, refrigeration plant and air compressors make up almost half of the maximum demand.

Production takes place all year round 24 hours a day 7 days a week, although the period of maximum demand is between January and June. The largest variation in demand during the day occurs in the bottling and canning plant which did not operate 24 hours over weekends.

There are opportunities to improve the energy efficiency of lighting and motors at this plant. Both offer small opportunities for savings. Improving lighting efficiency would save 37kW, improving motor efficiency would save 134.49MWh each year. Other areas where efficiency could be improved lay in the use of variable speed drives, fixing compressed air leaks and shading refrigeration condensers. There is potential to shut down deep freeze compressors during peak times, this would shift 100kW.

Figure 3 shows the average pre-winter and winter profiles for weedays, Saturdays and Sundays. It shows how demand is steady during the day, decreasing over weekends.

Demand is higher in this plant in the pre-winter months due to the seasonal harvesting of fruit.

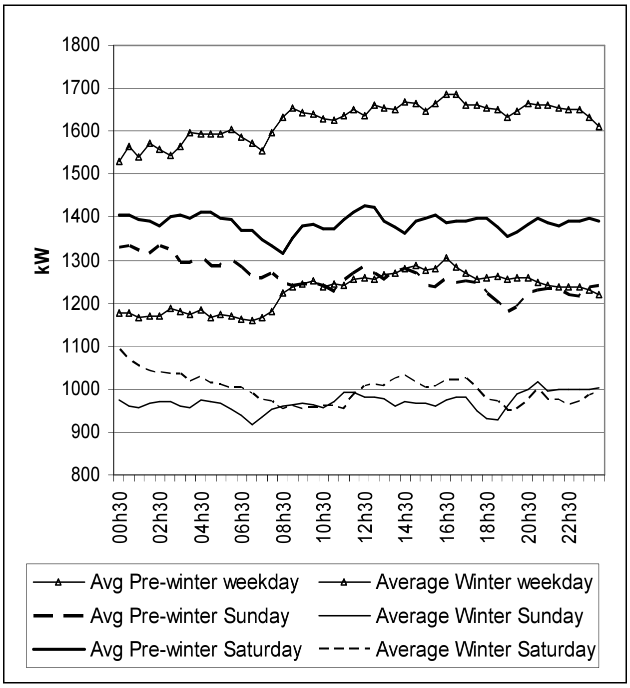

Figure 3: Average weekday, Saturday and Sunday profiles for winter and pre-winter

3.5 FOOD AND BEVERAGES: BREWERY

The brewery produces about 13% of beer in South Africa. Maximum demand is around 6000kVA. The main sections at the brewery are raw materials handling, brewing, fermenting, maturation, packaging, storage and distribution. Again Refrigeration, compressed air and the production of CO2 account for almost half of the maximum demand of which refrigeration is 25%.

Brewing takes place 24 hours a day 7 days a week according to a schedule. Bottling or canning does not run continuously. There is a dip in demand over weekends when three of the four bottling lines are shut down between 6am on Saturday and 6am on Monday. Beer can not be stored for long periods and demand at the plant is higher in summer when demand for beer is greatest.

The brewery has done a lot to improve its energy efficiency and runs many awareness campaigns. There were however still opportunities to improve energy efficiency in the brewery by running compressor motors at a higher load factors, attending to damaged insulation and improving the energy efficiency of lighting and motors. It was estimated that improving the energy efficiency of lighting would result in a 24 hour saving of 120kW and improving motor efficiency a saving of 134MWh.

It may be possible to shift packaging load, from weekdays into weekends, but it is not possible to shift packaging load away from peak periods due to the time required to heat up cleaning and sterilizing equipment.

Both food and beverage plants had waste water treatment facilities. In both cases it would be possible to use the methane bi-product from the waste treatment plants for either heat or combined heat and power (CHP). The brewery produces on average between 3400 and 4300MJ of methane per hour which is currently being captured and flared. The methane could be used in a CHP plant running a micro turbine or reciprocating engine. It is estimated that a CHP plant at the brewery could drop at least 750kW off peak demand (the brewery is currently using electrode boilers) or generate up to 290kW continuously. At the fruit juice plant the waste water is stored and treated in open dams and the methane released directly into the atmosphere.

Figure 4 below shows the average pre-winter and winter profiles at the brewery for weedays, Saturdays and Sundays. Demand is relatively steady during the day, decreasing over weekends when the packaging lines are shut down.

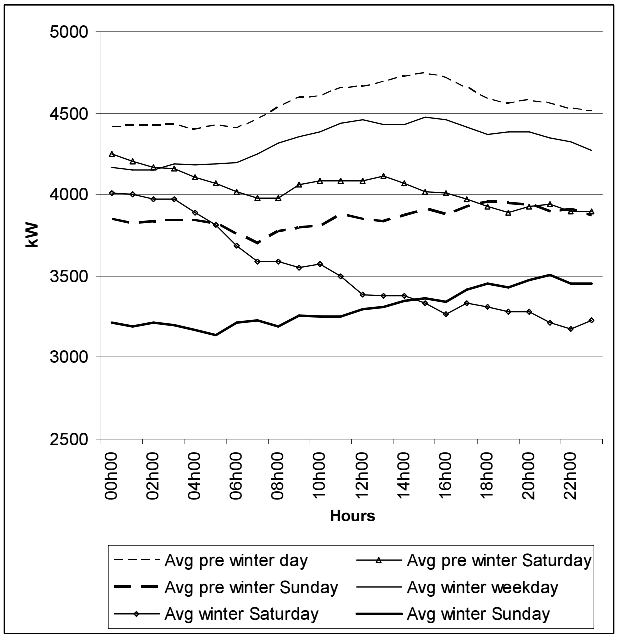

Figure 4: Average weekday, Saturday and Sunday profiles for winter and pre-winter

3.6 CHEMICALS

The chemical plant studied had typical processes for the chemical industry, but it was felt that the plant was not typical in terms of its layout and production schedule. Production was carried out in batches to fill orders. At certain times production took place 24 hours a day, 7 days a week, at others not.

Because of the nature of the product the production plants were widespread. This made it difficult, with limited resources, to investigate in much detail the potential for improving energy efficiency. There were a large number of motors present, and using high efficiency motors would give savings. Lighting load was large and lighting consisted mainly of mercury vapour lamps and incandescent lamps, here again it is possible to make large savings.

There are clear opportunities for moving substantial electrical loads away from peak demand times. It is estimated that it would be possible to shift 1000kW out of peak times. It may also be possible to replace existing electric ovens, used for drying, with steam ovens or ovens fired on LPG. Electric ovens are currently used as they are quicker and easier to start up.

Figure 5 below shows the average weekday, Saturday and Sunday profiles at the plant during the month of October 2004. The weekday profile shows how demand increased during the day on weekdays and drops off over weekends.

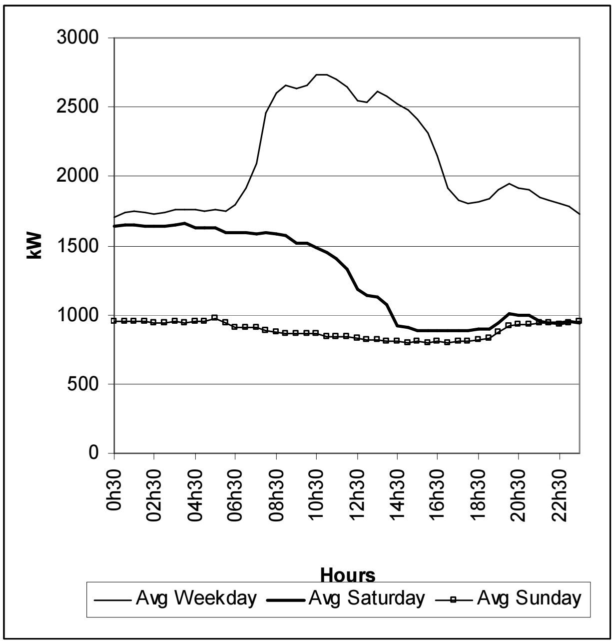

Figure 5: Average weekday, Saturday and Sunday profiles for October 2004

3.7 IRON AND STEEL: STEEL MILL

The Iron and Steel mill visited produces approximately 13% of South Africas total steel production. Maximum demand appeared to be around 220MVA. At the mill there are several large electric motors, ladle furnaces and an electric arc furnace.

The Iron and steel plant included in the study uses a continuous process with no storage at any stage and it is therefore not possible to shift major loads out of peak periods. Production takes place 24 hours a day 7 days a week, there is a 2 hour shutdown for maintenance every fifth week. It is however possible to achieve large savings through energy efficiency measures. There is scope for improving lighting efficiency and motor efficiency by making use of high efficiency motors and using variable speed drives (VSD's) with fans and pumps or turning off equipment such as pumps when they are not needed.

It is estimated that improving lighting efficiency could result in savings of 12GWh per year.

Figure 6 below represents a typical day of electricity demand at the mill. Demand does not vary significantly over a 24 hour period, and remains constant over weekends. No seasonal variation in demand could be determined.

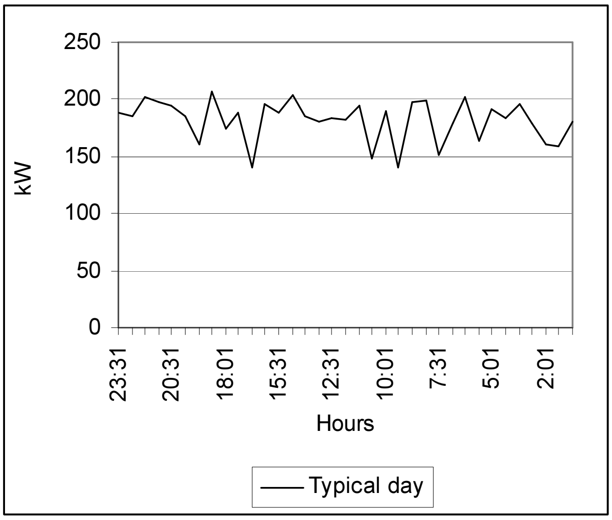

Figure 6: Typical day

3.8 GOLD MINING

The gold mine audited produces about 20 percent of the gold produced in South Africa during 2005 . It produces 1g of gold for every 105kg of rock mined. The rock is mined at an average depth of 2750m. The mine has two vertical hoisting shafts, two service shafts, a sub shaft and a surface gold plant. The large energy users on the mine are compressed air (19%), fans (12%), pumps (35%), gold plant (12%), Rock winders (9%), fridge plant (5%) and hostels (4%).

The mine has some existing load shifting systems in place, it is currently shifting pumping and cooling load to off peak times, but there is scope for more. At the moment, they are shifting thirty percent of their pumping load, this could be improved upon. It is estimated that the mine could shift 17% of pumping load during the morning peak and 89% during the evening peak. Manufacturing ice at off peak times for cooling could shift 2MW in the morning peak and 6MW in the evening. Rock winding is also an area where peak savings could be made.

Energy efficiency measures include replacing the 60W incandescents underground with CFL's. It is estimated that this could save 4MW of the 20MW lighting load. Other options for improving energy efficiency include improving fan and motor efficiency by using variable speed drives and v-belts and using the compressor intercooler water to preheat water for the hostels.

Figure 7 shows the average weekday, Saturday and Sunday profile for the mine during July 2005. There are large variations in energy use visible in the average progiles. The variations in energy use lie mainly in the fridge and ice pant, compressor loads and pumping loads.

Figure 7: Average weekedy, Saturday and Sunday profile during July 2005

3.9 PLATINUM MINING

The platinum mine included in the study contributes 12% of South Africa's refined platinum. The demand for platinum world wide is increasing. The large energy users at the mine are cooling, ventilation, transportation of ore with rock winders and man winders and milling. There are several large compressors, fans and pumps.

Energy efficiency measures which could be introduced include replacing incandecents with CFL's. It is not known how large the lighting demand is, but due to the extent of these mines, savings would be significant. Motor efficiency could be improved by replacing belts with toothed belts, using high efficiency motors and VSD's. Compressed air is transported in a large reticulation network throughout the mine, it is estimated that better maintenance and system upgrades could improve the efficiency by 10% (about 814MWh).

There is potential to shift load out of peak times by controlling and scheduling pumping and rock winders.

Figure 8 shows the large variations in demand at the mine over the average weekday, Saturday and Sunday during July 2005. The greatest use of electricity is made between 8:00 and 16:00 on weekdays.

Figure 8: Average weekedy, Saturday and Sunday profile during July 2005

4. DIFFICULTIES EXPERIENCED

Some difficulties were experienced during the study. These were mainly due to the size of some of the sites. At the larger sites it was not possible with the limited resources and time available to study the entire site in detail. And for example at the platinum mining site where the electrical infrastructure was spread out over a large area and remote communication with meters was not possible it was difficult and time consuming to obtain the data from the meters. Problems with the wiring of installed meters were experienced on two sites which resulted in the discarding of erroneous data. Meters could only be installed or wiring changed when the plant or section of plant was shut down.

5. CONCLUSION

It is apparent from this study that in most of the industries visited it is possible to improve energy efficiency and to shift load. Very few sites considered energy efficiency as important when purchasing equipment and only one site had an employee dedicated to improving or monitoring energy efficiency. Very few of the sites actively practiced any form of load shifting to avoid using electricity during peak times. At one of the sites load shifting was being successfully implemented and large savings were being achieved.

There is large scope for DSM projects in the industrial sector. At the nine sites visited through standard interventions it is possible to improve energy efficiency and shift up to 39MW out of peak time.

5.5 REFERENCES

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5.7 AUTHOR(S)

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Presenter:
The paper is presented by Ajay Trikam.

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