A SUCCESSFUL DSM PROJECT IMPLEMENTED ON THE REFRIGERATION PLANT AT KOPANANG GOLD MINE

Prof E H Mathews *, Dr M Kleingeld *, D L W Krueger **
* North-West University and Consultant to HVACI , ** Private Consultant
P O Box 2156, Faerie Glen 4, 0043

ABSTRACT

This paper describes a DSM project carried out during the latter part of 2005 at Kopanang Gold Mine. This is, to our knowledge, the first time that a mine refrigeration plant has been controlled to minimise electricity costs and reduce load during the evening peak time. Predicted and contracted load reduction was 2.9 MW and the actual measured and verified results were 3,5 MW.

1. INTRODUCTION

The advent of Eskom's DSM programme made it possible for large electricity users to reduce their electricity costs by reducing some of their load in peak consumption hours. In this way, they can avoid the high costs of electricity during peak hours. In the MegaFlex Tariff structure, a unit of electricity during the peak period can cost up to eight times that of the off-peak prices.

The mining industry of South Africa consumes approximately 23% of all electrical power generated in the country [1]. Refrigeration plants of hot, deep level mines are responsible for a large proportion of this usage.

HVAC International first focussed their attention on the mines' water pumping systems, since these provided large opportunities for load shift projects. However, it soon became evident that on all of the mines where load shift projects were carried out on the clear water pumping systems, additional opportunities existed to shift or reduce load and to save the mine money.

It will be appreciated that load reduction on refrigeration plants is a different kettle of fish to that on pumping systems, due to the high cooling demand in the mine. The underground environmental conditions of a mine (as achieved primarily by the fridge plant*), lies at the very heart of its productive capability. For this reason, no compromises or risks are acceptable when proposing load reduction projects.

For the automation process of the fridge plants, the plants must be shut down completely. The only period for doing so, is in the winter season of every year. This is done because the dry bulb temperature is lower in the winter than during the summer and these lower air temperatures can be used to cool down the mine sufficiently, instead of the Fridge Plants, without limiting the productivity.

It is essential that no delays from ESKOM, as well as from the subcontractors, must occur for the commissioning period of the Fridge Plant (FP). The implementation of the DSM project on the Kopanang FP was on a tight schedule because of the delay from ESKOM to give financial support. With this taken into account, and by enough help and manpower from the mine, the project was, however, delivered on time.

We are therefore justifiably proud to be able to present the completion of a successful project in this important operational area.

2. DEVELOPING A TOOL FOR THIS DSM APPLICATION

A patented simulation tool, developed specifically for fridge plant control, was used to perform simulations on a detailed mathematical model of the FP circuit.

Mathematical equations are used to model the FP circuit of the mine as accurately as possible. The component models link inputs to the basic variables of the system. These are based on the simplified fundamental principles combined with correlation coefficients derived from discrete empirical data**.**

The models are fully component-based and allow simulation of a wide range of operational conditions. The calculation of the energy consumption of each component is included in each model. The correlation coefficients for a specific make and model of equipment can be derived from data obtained during measurements or from the manufacturer's data sheets.

Figure 1 shows the basic flow sheet of the Kopanang FP circuit.

* Although the more correct nomenclature would be "Refrigeration plant", the words "fridge plant" are used in this paper because that is the more commonly used designation.

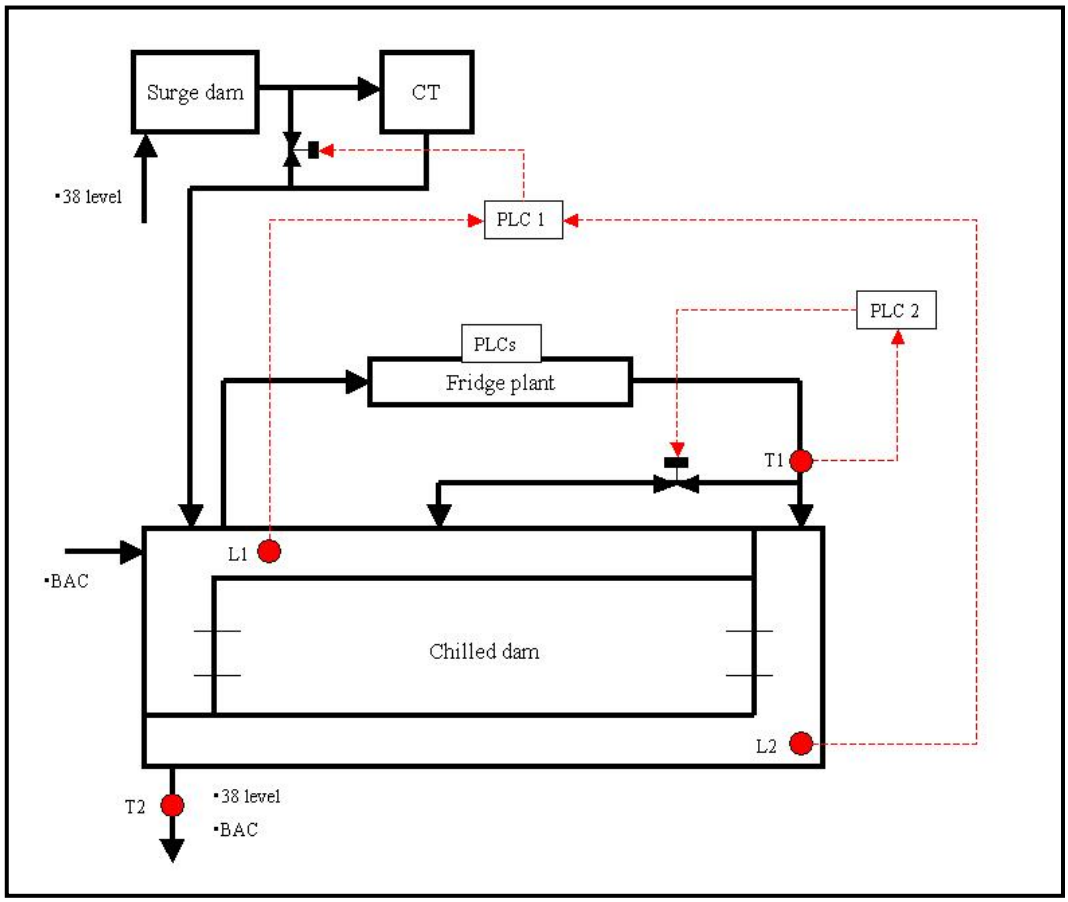

Figure 1: Basic flowsheet of Kopanang refrigeration plant circuit

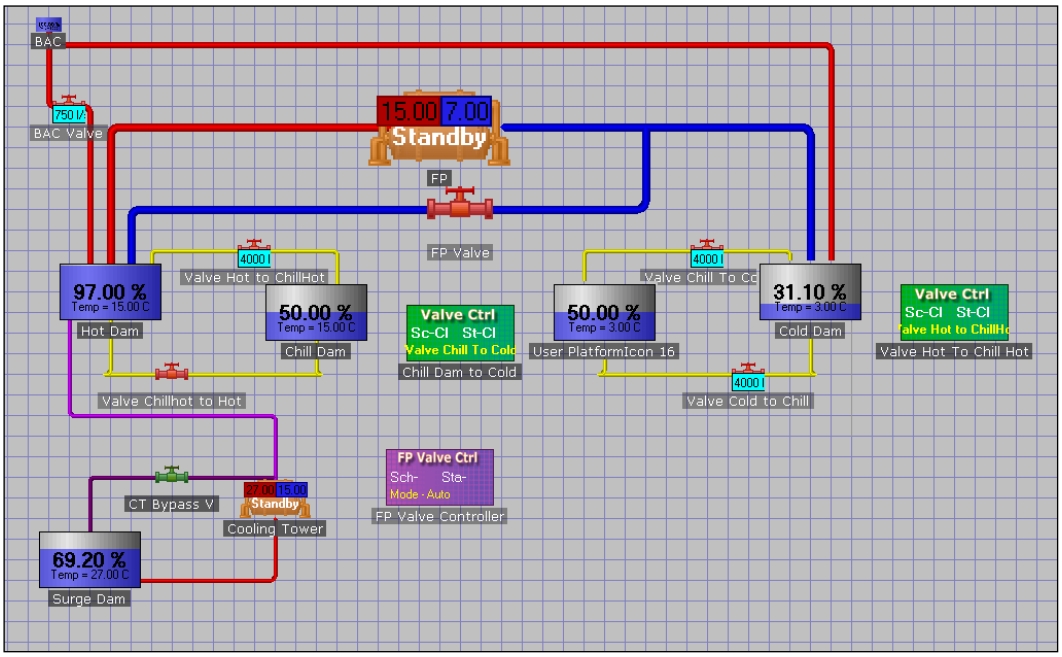

Figure 2: Model of the refrigeration plant circuit in the simulation package

Figure 2 shows the details of the valves and equipment as it is built up in the simulation software package.

Once the simulation model of the system has been completed, this creates the opportunity to build an optimisation engine. The output of such an optimisation process is a component scheduler, which is an operation schedule for every controllable component in the system.

Since energy consumption figures and costs are inherent elements of the simulation model, the optimised operations schedule will result in an overall least cost of electricity.

The operation of the fridge plant controller and its relation to other components can be seen in Figure 3.

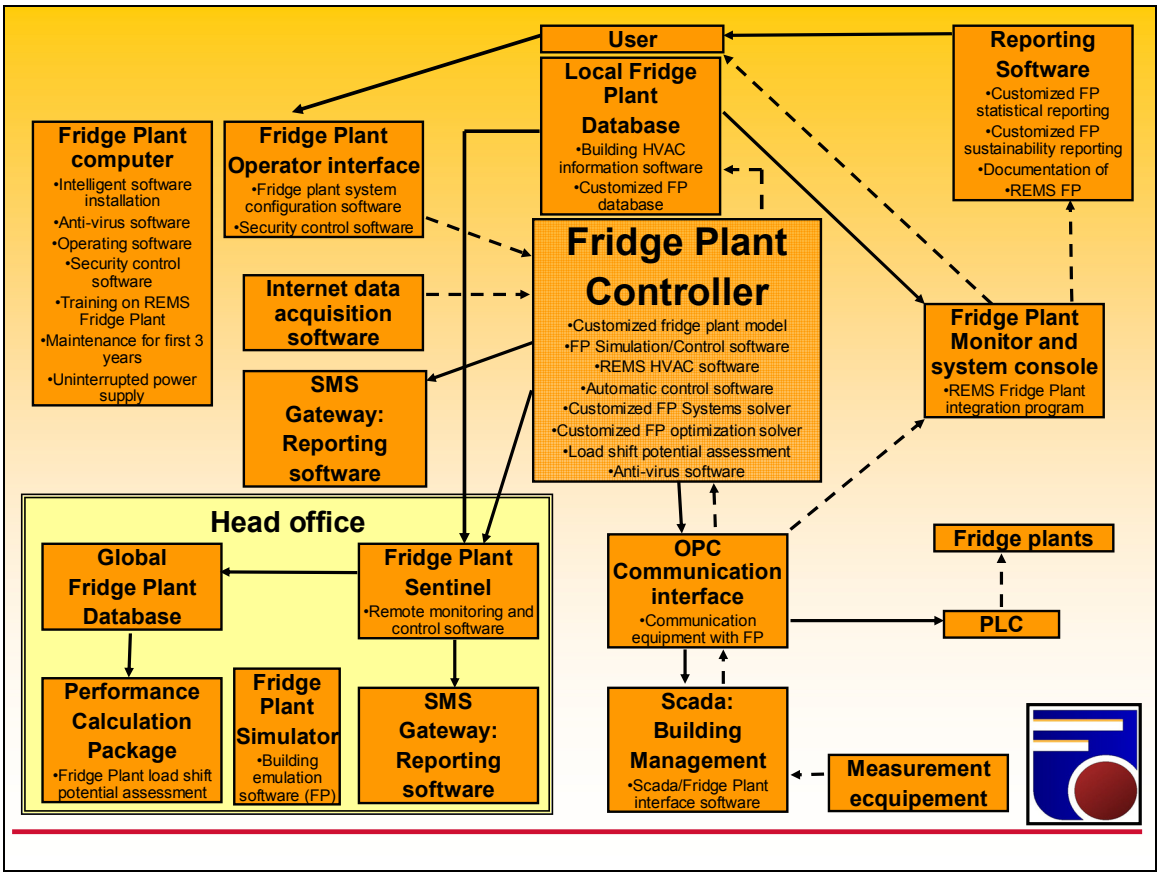

Figure 3: The fridge plant controller configuration

The fridge plant controller will optimise the use of cold water storage capacity and changing inlet temperatures of the fridge plants at evening peak time. This can only be achieved by optimum control of all six plants to ensure that the correct environmental conditions are met.

It controls all the motors and valves through the SCADA, which is connected to the relevant mine systems by means of communication hardware and software.

The fridge controller unit will typically be located in the client's control room, where it is connected to the Supervisory Control and Data Acquisition (SCADA) system.

A duplicate of the controller software is situated in HVAC International's control room in Pretoria; from where each installed remotely controlled system can be monitored. This unit has an identical display as that in the mine's control room. Figure 4 shows a typical display on this Viewer.

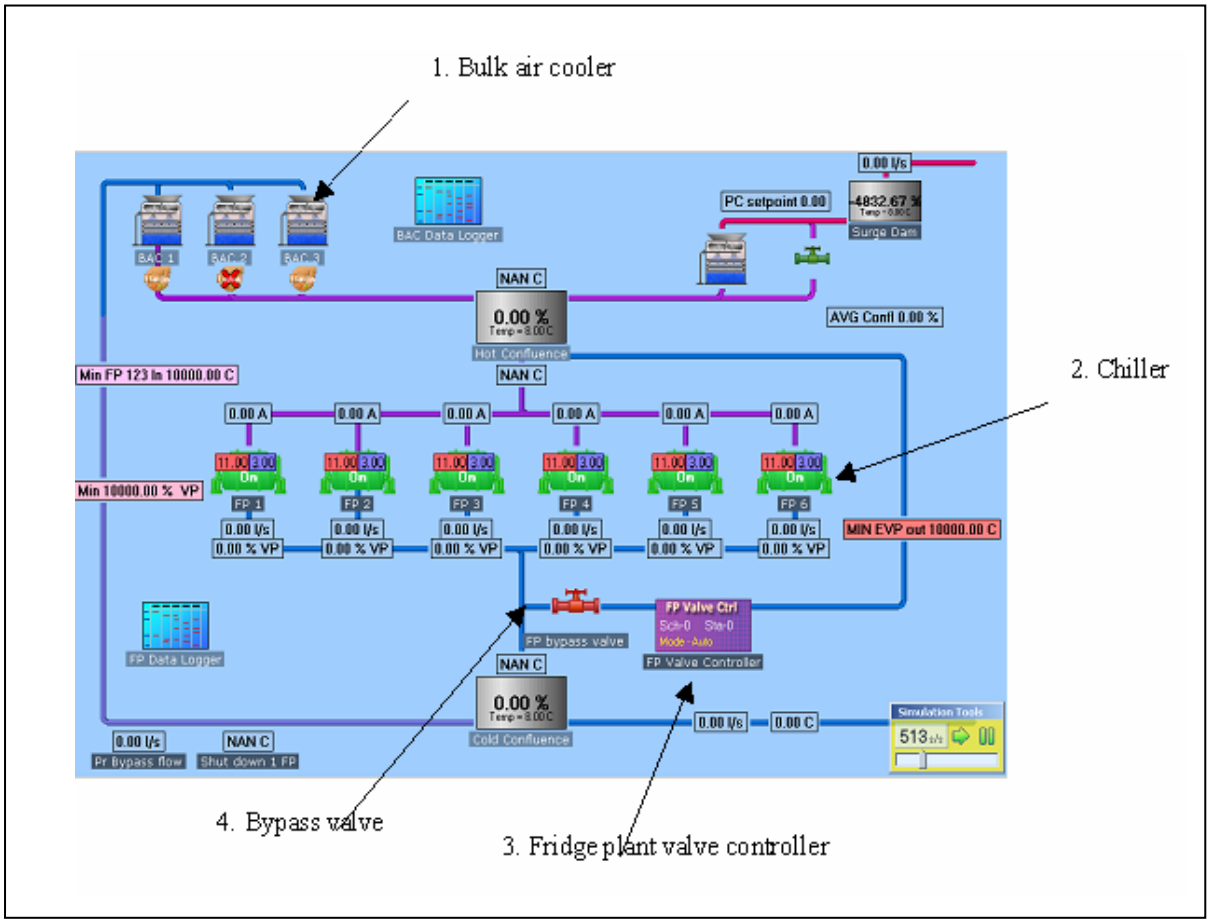

Figure 4: Viewer of the refrigeration plant controller at Kopanang mine

Operational data from November and December 2005 are shown in the Figures 5 and 6. These are determined through the daily profile of all the fridge plants running. Figure 5 shows the load reduction results for the fridge plant for a typical day. The temperature profiles for the incoming and outgoing water are shown in Figure 6:

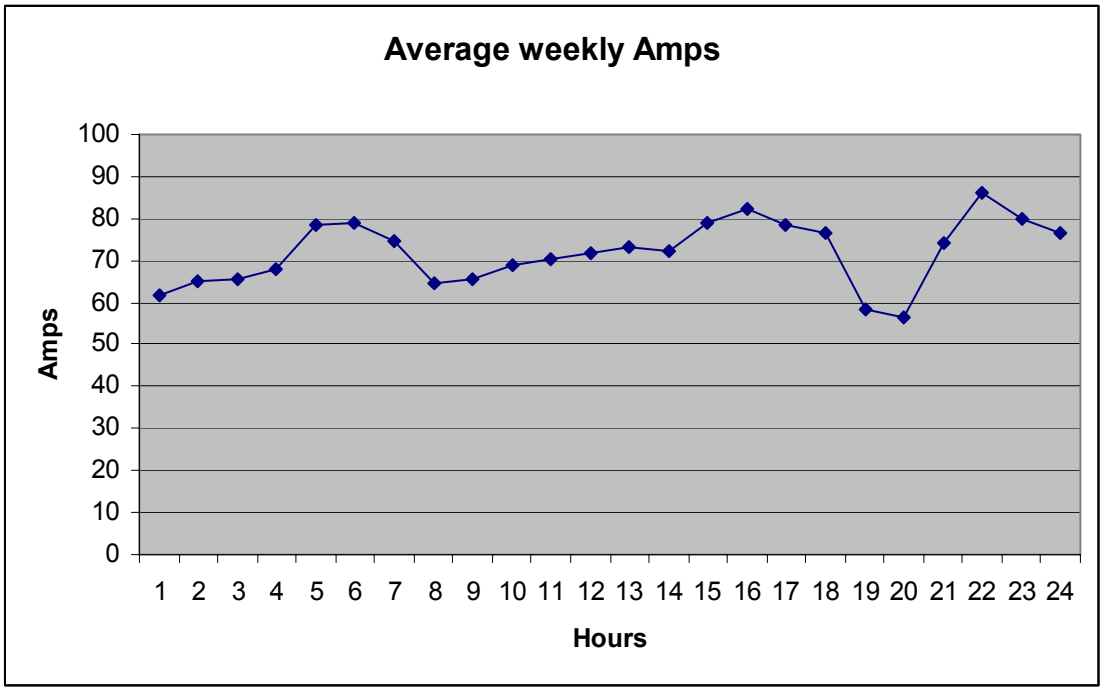

Figure 5: Average weekly electrical current used for the period 12 – 16 December 2005

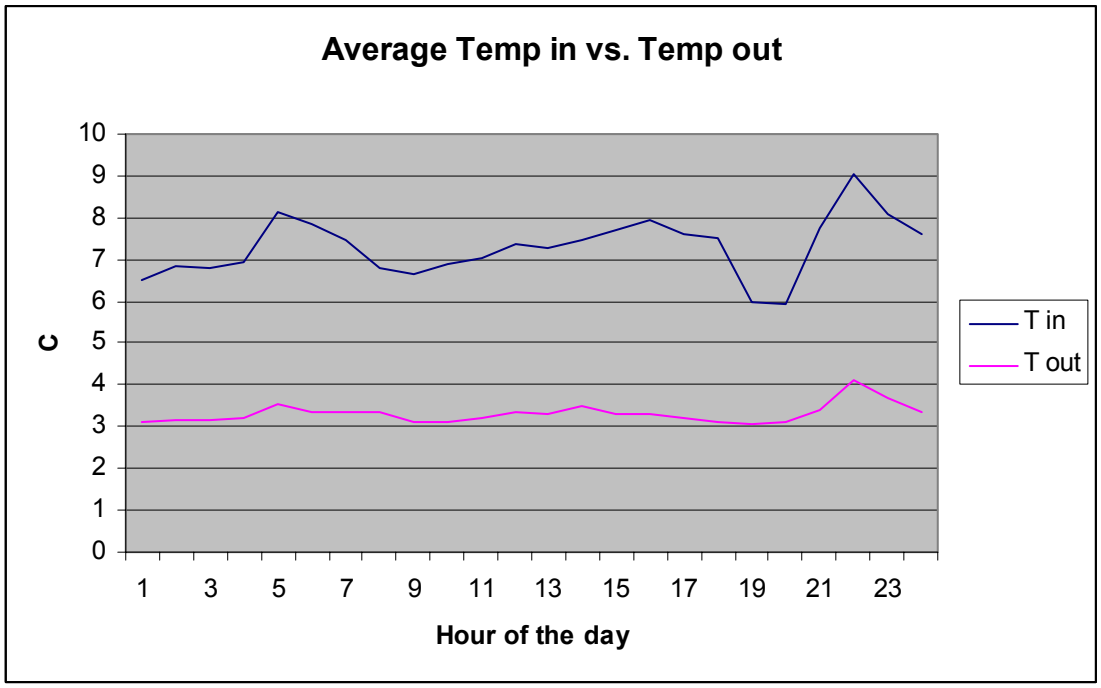

Figure 6: Average temperature profiles of Kopanang fridge plant

As seen in the Figure 6, the influence on the outlet temperatures of the Fridge Plants by changing the inlet temperature is negligible. Therefore no negative effect is caused to the mine workers or productivity of the mine by implementing the new control system for Fridge Plants.

3. RESULTS ACHIEVED

The typical weekly power consumption profile after the intervention, as compared with the baseline, is shown in Figure 7:

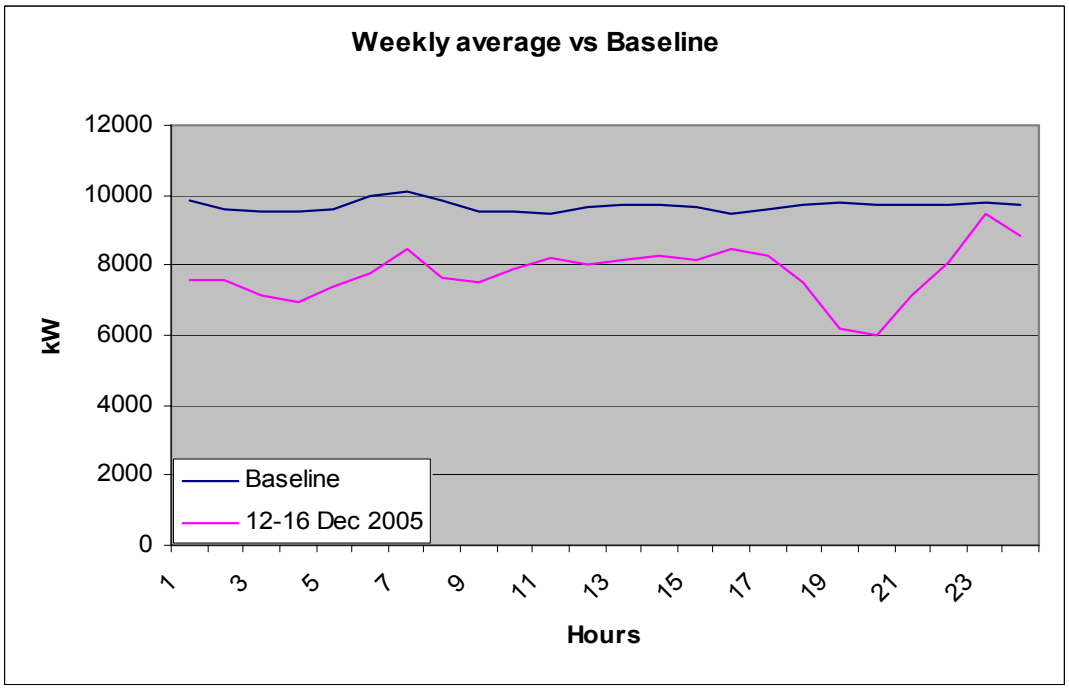

Figure 7: New power consumption profile versus the baseline profile

The daily load reduction for a typical week is shown in the Table 1 below.

Table 1: Daily load reduction for a typical week

Mon(12/12)	Tues(13/12)	Wed(14/12)	Thurs(15/12)	Fri(16/12)	**Average**
3.51	4.09	3.71	3.64	3.55	3.70

This shows that the average peak load reduction for this week is 3,7 MW.

4. CONCLUSION

The fridge plant project at Kopanang has shown that it is possible to reduce the load on a typical mine refrigeration plant, and to maintain this load reduction during the ESKOM evening peak reliably and consistently.

5. REFERENCES

[1] Preliminary Energy Outlook for South Africa, Energy Research Institute, Dept of Mechanical Engineering, University of Cape Town, Private Bag, Rondebosch 7701, October 2001.

6. AUTHORS

Principal Author: Prof Edward Mathews holds a PhD in Mechanical Engineering. He and his research group have won 23 awards for their work on energy efficiency, including an award from the British Association for the Advancement of Science.

Co-Author 1*:* Dr Marius Kleingeld holds a PhD in Mechanical Engineering. He has 13 years experience in energy efficiency and modelling. He is currently Managing Director of HVAC International, and Professor in the Department of Engineering, NWU.

Co-Author 2: Dieter Krueger holds B Sc (Chem Eng) and M Sc (Mech Eng) degrees. He was the Director of the CSIR's Division of Energy Technology until 1996 and is currently an Independent Consultant in Energy Management as well as part-time lecturer in Energy Systems at North-West University.

Presenter: The paper is presented by Prof Mathews.