

**AN AUTOMATED IT APPLICATION FOR
ENSURING SUSTAINABLE SAVINGS
WITH LOAD SHIFT SYSTEMS**

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Abstract

In this project, an Information Technology (IT) application was developed that processes and analyses data that is generated by systems that manage the electrical power consumption of large energy consumers.

Because of the volume of this data, and the time usually consumed in processing it manually, (for example, by using Excel spreadsheets) an automated system was required that does the processing as well as the analysis.

The name “REMS Sentinel” was given to this application. It is divided into two parts, one of which has already been implemented on a number of gold mines.

The first part processes each day’s data from the Energy Management System (EMS) and then transfers only the most important information to a remote central database. The processed data can then be viewed on a web page, or on a cell phone through a specially designed Wireless Application Protocol (WAP) web site.

The second part of *REMS Sentinel* then uses the processed data to generate reports by means of which the previous day’s performance of the EMS can be monitored.

The need for such an automated data processing system has arisen from the advent of Eskom’s Demand Side Management (DSM) program. The purpose of this is to reduce the energy consumption of large energy users during peak hours each day.

The Real-time Energy Management System (REMS) was designed to contribute to the solution of this problem. REMS uses real-time simulation and control parameters to schedule the consumption of energy during peak hours.

However, REMS generates a large amount of data whilst controlling, for example, mine equipment in real time. This data is used to calculate the load that was shifted during peak hours, and to calculate the money that was saved during each month. Previously, these calculations were carried out manually, which resulted in huge time delays.

REMS Sentinel solved this problem and enables one operator to monitor several installations simultaneously.

Samevatting

In hierdie projek is 'n Informasietegnologie (IT) stelsel ontwerp. Hierdie stelsel verwerk en analiseer data wat deur ander stelsels gegenereer word, wat die elektriese energieverbruik van groot energieverbruikers beheer.

Omdat sulke stelsels gewoonlik aansienlik baie data genereer, en die handprosessering daarvan geruime tyd opneem (deur bv, Excel te gebruik), het daar 'n behoefte ontstaan vir 'n outomatiese stelsel om die verwerking en analiseering van sulke data te hanteer.

Om hierdie behoefte te bevredig is daar 'n stelsel ontwerp met die naam "*REMS Sentinel*". Hierdie stelsel bestaan uit twee programme, waarvan die een deel alreeds op verskeie goudmyne geïmplementeer is.

Lsg. deel prosesseer daaglik die data van die Energiebestuursstelsel (EBS), en die verwerkte data word dan na 'n afgeleë gesentraliseerde databasis oorgedra. Hierdie verwerkte data kan dan deur 'n webtuiste, of deur 'n spesiaal ontwerpte "Wireless Application Protocol (WAP)" webtuiste op 'n selfoon gelees word.

Die tweede deel van *REMS Sentinel* gebruik dan die data om verslae te genereer waarmee die prestasie van die EBS geëvalueer kan word.

Die behoefte van hierdie stelsel het te voorskyn gekom a.g.v. die ontstaan van Eskom se "Demand Side Management (DSM)" program. Hierdie program se doel is om die hoeveelheid elektriese energie wat deur groot energieverbruikers gebruik word in die piek tye van elke dag, te verminder.

'n Stelsel met die naam "Real-time Energy Management System (REMS)" is ontwerp om 'n bydra te lewer tot die oplossing van hierdie probleem. Deur gebruik te maak van intydse simulاسie en kontrole parameters, kan die energie verbruik van groot energieverbruikers geskeduleer word.

Hierdie REMS stelsel genereer egter 'n groot hoeveelheid data terwyl dit, byvoorbeeld, myntoerusting beheer. Hierdie data word gebruik om die las geskuif, en Rand besparing, vir die betrokke myn te bepaal.

Om 'n stelsel soos REMS te monitor vereis dat die data intyd verwerk moet word. Hierdie data moes tot op hede met die hand verwerk word, en het dus baie tyd geverg. *REMS Sentinel* het hierdie probleem opgelos en gee nou die operateur van die stelsel die voordeel om meervoudige myne op dieselfde tyd te monitor.

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Abbreviations

AMR	Automated Meter Reading
ASP	Active Server Pages
BDE	Borland Database Engine
CLR	Common Language Runtime
CLX	Cross-Platform Components
COM	Component Object Modelling
CSV	Comma Separated Values
DNS	Domain Name Service
DSL	Digital Subscriber Line
DSM	Demand Side Management
EMS	Energy Management System
ESCO	Energy Services Company
GSM	Global System for Mobile communications
GUI	Graphical User Interface
HTML	Hyper Text Mark-up Language
IIS	Internet Information Server
ISP	Internet Service Provider
IT	Information Technology
Kbps	Kilo bits per second
kHz	kilo Hertz
LAN	Local Area Network
Mbps	Mega bits per second

ms	milliseconds
MSC	Mobile Services Switching
ODBC	Open Database Connectivity
OLE	Object Linking and Embedding
OOP	Object Orientated Programming
PHP	Hypertext Pre Processor
PLC	Programmable Logic Controller
REMS	Real Time Energy Management System
RSL	REMS Sentinel Local
RSR	REMS Sentinel Remote
RTP	Real Time Pricing
SCADA	Supervisory Control And Data-Acquisition Systems
SIM	Subscriber Identity Module
SQL	Structured Query Language
TCP/IP	Transmission Control Protocol over Internet Protocol
TDMA	Time Division Multiple Access
WAN	Wide Area Network
WAP	Wireless Application Protocol
WWW	World Wide Web
XHTML	Extended HTML

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CHAPTER 1 INTRODUCTION

1.1 Background and literature review

1.1.1 Eskom's electricity demand problem

South Africa is one of the world's most important mining countries. Because of the number of deep level mines in South Africa, the mining industry is also one of the largest consumers of electricity in this country.

The mining sector in Southern Africa consumed 23% of the total electrical power produced in 1996[1]. This led to a number of problems that motivated Eskom, which is South Africa's primary electricity utility, to invest in studies that would reduce the electrical power demand from large energy consumers, for example, deep level mines. Lane conducted one such study in 1996 [2] and obtained the following result:

A 27% peak load reduction can be achieved on a typical South African deep level mine. This reduction can be achieved by scheduling electrical systems.

If one assumes that this is realistic, the potential savings that can be achieved on such a deep level mine by the scheduling of electrical equipment, can be estimated.

30% of a typical deep level mine's electrical bill is due to the electrical power usage during peak billing hours. This is not because more electrical power is being used, but because the cost of an electrical power unit can be 8 times more during peak hours, than during the lowest price period.

When we assume that 30% of a deep level mine's electrical bill is related to the peak demand hours, then this implies that an 8% cost reduction in the electricity

bill can be achieved if electrical systems are scheduled, as suggested by Lane [2].

On average, South African gold and platinum mine consumed 26 GWh of electrical power in the year 2000 [1]. At an average cost per electrical unit of 10c/kWh, it can be estimated that the gold and platinum mines in Southern Africa incurred an electrical bill of R 2.6 billion in 2000.

Taking into account that 65% of all South African mine are deep level mines, then in the year 2000 nearly R135 million could have been saved if electrical systems had been scheduled.

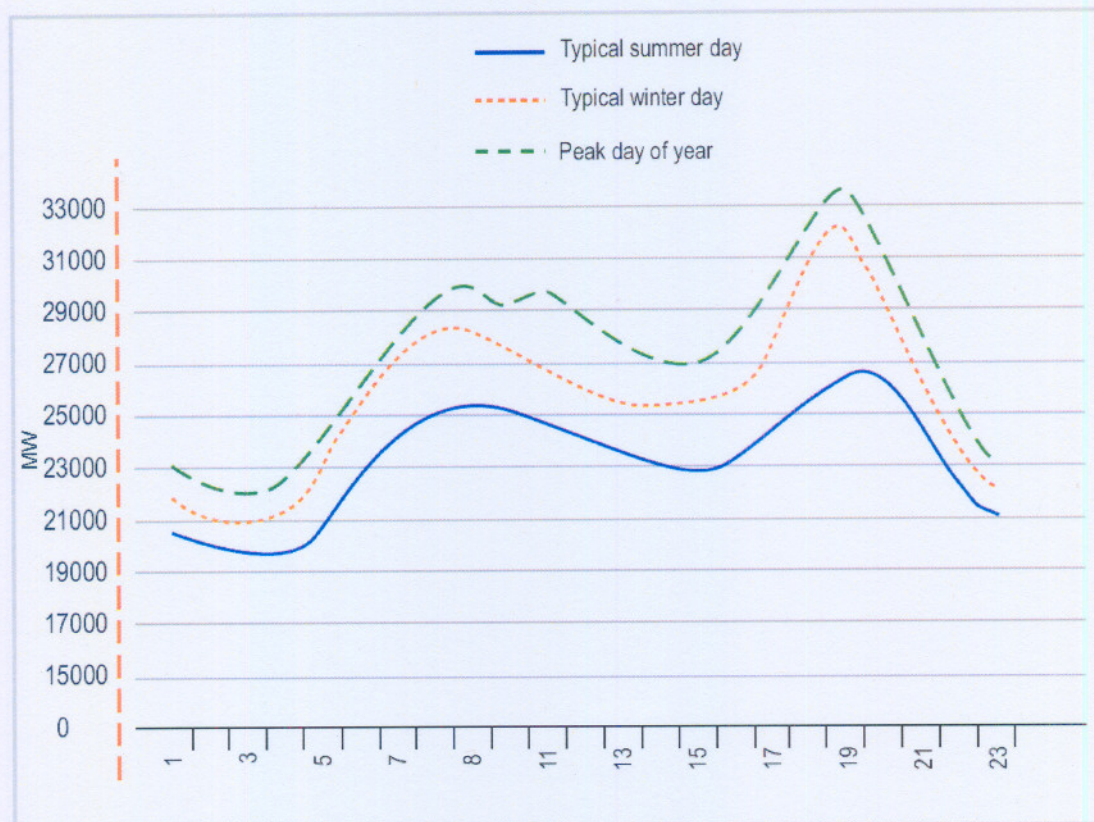


Figure 1.1: Different electricity demand trends in MW

Electrical power suppliers found that the demand followed certain trends that varied according to: (see Figure 1.1 [3]):

- ***The specific time of the day.*** In each day there are two periods during which consumers use more electricity than during the rest of the day. The first of these is between 07:00 and 10:00 in the morning, and the second from 18:00 to 20:00 in the afternoon. These peaks are largely caused by domestic consumers, for cooking and space heating.
- ***The season of the year.*** More electricity is consumed during the winter months due to the heating that is required. This is not only applicable to the residential sector, but also to the commercial sector.
- ***The type of day.*** Days are categorised as weekdays, Saturdays, Sundays, and public holidays. Each of these days experience the two peaks discussed earlier, but they are more prominent during weekdays.

The sharp rise in consumption during peak times can be at least partly attributed to the success of the RDP domestic electrification programme, but it causes serious problems for Eskom.

The lowest cost electricity generating plant that Eskom has at its disposal are termed “Base Load stations”. These are the coal-fired, “six-pack” 6 x 600 MW stations that run 24 hours per day. They are extremely costly to stop and re-start and therefore provide what is termed the “base load”.

However, during peak times these stations cannot supply all the power required, and consequently Eskom’s smaller, more costly, power stations are brought on line. Because their operating costs are much higher than that of the base load stations, a unit of electricity costs far more during peak times than during the rest of the day.

Eskom has an obligation to supply sufficient electricity for all its customers’ needs. Before the projected peak demand exceeds the current installed capacity,

Eskom will have to build additional power plants. These are, however, very expensive as compared with the current stations (estimates range from R32 to R40 billion for a 4000 MW station). For this reason Eskom is understandably anxious to postpone the day that new capacity has to be ordered as much as possible. This is the background to Eskom's initiation of the DSM program.

1.1.2 The need for load shifting

As mentioned above, Eskom seeks a reduction in peak demand. One approach is to promote the consumption of less electricity at all times, which is Energy Efficiency. Because this approach is not always possible, an alternative approach is to encourage large electrical power consumers to use more electricity during the non-peak hours of the day, and thus being able to use less during the peak hours of the day.

This concept is known as 'Load Shifting'. This does not necessarily mean that *less* electricity is being consumed, but rather that less is consumed during a specific hour, and more during another. The objective of Eskom's Demand Side Management (DSM) division is therefore to assist their customers to consume less power during peak hours but more during non-peak hours.

Figure 1.2 shows the typical daily electrical power demand profile for South Africa, and the peak hours are clearly visible [4].

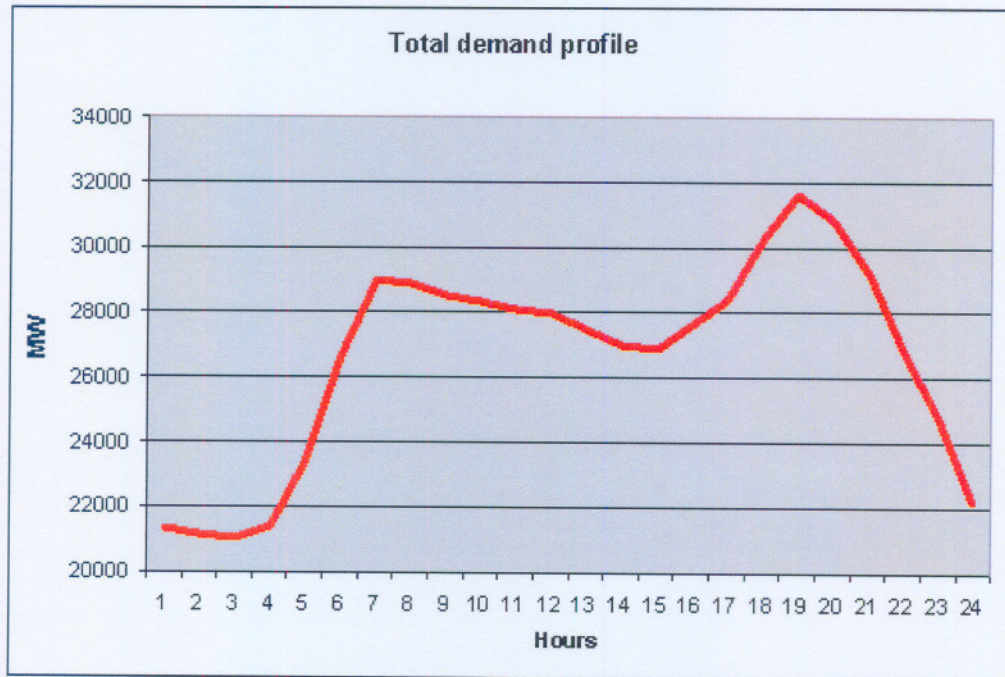


Figure 1.2: Total electrical power user demand (Year 2000)

In order to encourage clients to reduce their electricity consumption during peak hours, Eskom introduced Real Time Pricing (RTP) in January 1999.

RTP is an electrical power tariff profile that applies only to certain industrial electrical power consumers. The price for each hour of each day is determined by the cost prediction of Eskom. If Eskom predicts that the cost of producing electrical power for a certain hour is high, then the RTP price for that hour would be high. Conversely, if the cost of producing the electrical power demand for that hour is low, then the RTP price for that hour would be low. It is therefore cost reflective pricing, which is fair to all consumers.

In general, the RTP price for peak hours was very high, thus urging electrical power consumers to use less power during those hours, and more during the cheaper hours. This provides an economic incentive to the user to 'shift load'.

It is important to note that the introduction of the RTP price profile by itself did not shift load. Load could only be shifted if the industries to whom the RTP applied, reacted to the RTP.

Per definition an Energy Services Company (ESCO) is a company that develops, installs and finances projects designed to improve energy efficiency and maintenance costs for facilities over a five to ten year period [5].

These companies came to birth due to the funding system that Eskom launched that sponsors the following:

- Companies that successfully respond to RTP themselves;
- Companies that initiate successful responses to RTP in other companies.

ESCO's fall into the second group.

The ESCO industry in the USA is about 20 years old. Its beginnings can be traced back to late-1970s oil crises. The opportunity was created by high-energy costs, and ESCO's created a service to reduce the energy costs of clients. Currently the ESCO industry in North America facilitates an investment of about \$2 billion annually in energy efficiency [6].

ESCO's in South Africa help Eskom in its objective of load shifting, therefore they qualify for part of the funding provided by Eskom.

1.1.3 A Typical Energy Management System (EMS)

In order to appreciate the function of the IT system that was developed as a part of this project, it is first necessary to describe work that an ESCO does and the typical data that it would have to handle.

In this section the work done by an ESCO on a typical deep level mine is discussed, looking at, in particular, the electricity used for the pumping of water.

To shift load (and hence to save the mine energy costs) requires operational changes, since the operational schedule on a mine will have to be changed from its current one.

However, mines will only change their operations if there is a very high level of confidence that these changes will not, in any way, affect the safety and production of the mine. In order to gain the confidence of the mine, it must first be proven beyond any doubt that there will be no negative influence as a result of any changes to the load pattern proposed by the EMS system.

This can only be achieved if the fully-integrated operation of the mine can be simulated in exact detail and extensively verified through the previous years' detailed operational data.

When building the simulation model for the mine operations, each and every element in the mining process has to be simulated in exact detail. For each element a mathematical model must be built which accurately represents that specific component. The model for the component is verified to ensure that it reacts in exactly the same way as the real component on the mine.

All the simulated components are then combined into one integration model, which represents the integrated operation of the complete mine. The full control system is then integrated with this to arrive at a "real life" simulation of the mine.

The fully integrated dynamic system and control model for the mine is extensively verified with detailed measured data. The necessary update of the integrated model is done until perfect verification proves to the client's satisfaction that a successful computer model of the mine has been achieved.

Only after this verification process can it be said with certainty that the simulation model correctly represents the integrated operation on the mine. Figure 1.3 shows the pumping simulation model for a typical mine.

Once the simulation model is complete and the confidence of the client is obtained, the model is integrated with the Supervisory Control And Data-Acquisition Systems (SCADA) control system of the mine.

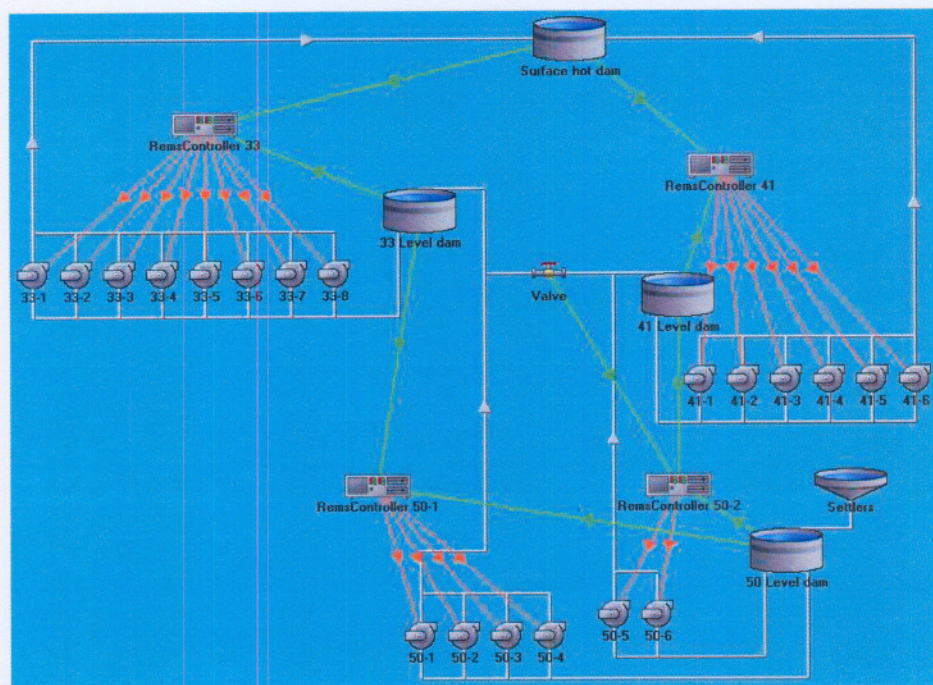


Figure 1.3: Simulation model of the pumping processes for a typical mine.

Other daily varying influences on the final electricity bill, which must *inter alia* be included in such a system include: varying weather data (only when the cooling systems is also scheduled), maintenance schedules as well as the electricity price for that specific day, (if the mine's electricity tariff is on RTP).

The electricity price, as well as the weather forecast for the day, is automatically sent to the simulation model via the Internet from Eskom and the Weather Bureau respectively.

The user supplies the model with constraints including upper/lower limits for the dams, the equipment on/off limits, any other constraints and the maintenance schedule for the next day.

All this information is then also integrated into the system before the EMS can optimise operations for minimum energy cost and maximum load shift.

A dynamic optimisation procedure is then integrated with all the aforementioned to arrive at the optimum schedule of all the elements to ensure minimum energy cost and maximum load shift, but taking into account all the safety, health operation, maintenance or other constraints.

The optimised solution then interacts with the SCADA system on the mine and controls the operations via Programmable Logic Controllers (PLC's).

1.2 The need for this study

1.2.1 Monitoring load shifting

When an ESCO signs a contract with Eskom, they undertake to shift load consistently. Furthermore, they specify the amount that they will be shifting out of peak periods. Since the ESCO received the funding from Eskom on the basis of the contracted load shifting, they must ensure that this actually takes place, otherwise penalties have to be paid to Eskom

A method of continuously monitoring the relevant electricity consumption on the mine was therefore needed. REMS was developed to provide a remote energy management facility which can obtain load shift. This is done by scheduling, for example, the water pumping system so that optimised pumping takes place during peak hours.

Because the payment of penalties for non-performance is at stake, a means must be found to identify what is a permissible shortfall of the promised load shift, and what is not. Generally speaking, all so-called "Acts of God" are termed *condonable*, which means no penalties have to be paid. This term is applied when neither the mine nor the ESCO can be blamed for an incident which causes a lesser than contractually agreed load shift.

To ensure that the correct load is shifted on the mine, several procedures can be followed. One of these would be to physically monitor the status and actions of

REMS by sitting in front of the computer. Another procedure would be to monitor REMS through the use of a network connection. When this is done, the operator can see in real-time what is happening on the mine.

Unfortunately, most mines do not have a direct Internet connection and thus a dialup connection must be used. This is very expensive and therefore not a very efficient way of monitoring the mine. On the other hand, by the implementation of a database, the system could be monitored continuously. This is discussed in the next section.

1.2.2 Improving the sustainability of load shifting

In order to reduce costs as well as improve efficiency, it was decided to design a system that could gather data automatically.

The current REMS system as installed on a typical mine logs data into a database, and in Comma Separated Values (CSV) files. From these files the load shifted can be calculated for the previous day. Other important operational information is also logged. This includes, i.a. which pumps were available throughout the day, as well as which pumps were broken. If the load shifted during the previous day was less than contracted, the operator can look at the other data logged by REMS. If, for example, one of the pumps was out of order, then this would constitute a *condonable* reason for the lack of performance and no penalties would have to be paid.

Since this data is logged at two or three minute intervals, it amounts to an enormous amount of data that is being logged every day.

The sustainability of load shifting depends on the correct load being shifted as well as making sure that it is being done consistently. To improve this, a means was necessary to monitor this performance of REMS by using the data logged to see where the system can perform better, and accordingly change the system.

1.2.3 *Problem Statement*

In the past all of the logged data was manipulated in a spreadsheet program (such as Microsoft's Excel package), to do the necessary calculations for the previous day.

The man hours required by the ESCO's staff to carry out these calculations on data logged during one day was about two hours. This is a quarter of a working day, and this applied to only one mine.

As the number of mines being monitored increased, the amount of time needed to calculate the load shifted the previous day increased accordingly. This led to a time delay before the ESCO could determine whether the correct load was indeed shifted. These delays sometimes were as long as a few days.

The purpose of this project was therefore *to develop a solution that could not only do all the calculations faster and more efficiently, but also would do them automatically*. These calculations include the load shifted, financial savings, time REMS was on schedule, and statistics on all the pumps within the mine.

1.3 **Overview of this document**

The rest of this document consists of four parts: a literature study, the design of a new Data Management System; the validation of the system; and a conclusion.

Literature Study

Prior to embarking on the development of such a system, the author researched what other people have done in this field, and how they did it.

Specific components would be required to allow the proposed system to function and fulfil all its requirements. All of these different types of components were studied and the advantages and disadvantages of each were identified. Reasons for using a particular component were given.

Lastly, the preliminary design specifications are also given. This provides the detail on how, and with what components, the new system was designed.

The Design of this system

The research culminated in the design of the system. All detail is included, as well as all logical concepts.

The system is explained in sections relating certain processes that need to take place in order to achieve the specified goal. Each section contains a brief description of the concept and the rest of that section is the detailed design.

The Validation of the new system

As with all software, different versions were launched and tested in practice. Whilst this software was in use, various so-called bugs appeared and needed to be fixed. Other very useful information was acquired during this phase.

The system has since been implemented on several mines and the results obtained in this fashion were compared with the manually calculated results.

Conclusion/Recommendation

Finally, a conclusion was drawn on the effectiveness of this newly designed system. Comparative results were used to draw a logical conclusion on how effective the system was. Recommendations were made on possible future work.

CHAPTER 2 LITERATURE STUDY

2.1 Introduction

A literature survey was conducted to establish whether a system such as the one envisaged already exists, and what other researchers have done to solve similar problems. Also, the various tools and sub-systems that could be used for this project were researched extensively.

2.2 Existing systems

US Pat. No 6701298 to Jutsen describes a system and method for energy management where data relating to the energy usage and other related activities is collected with an automated data processing device.

This data is analysed and the results are used to make recommendations on the effectiveness of the energy management [7].

The pros and cons of US Pat. 6701298 compared to a system that is required are:

Pros:

- ❖ The system improves the energy management system by giving suggestions to improve it.

Cons:

- ❖ A system is not needed that improves the energy management system, but rather one that could give *information on the performance*, thus improving the sustainability of the system.

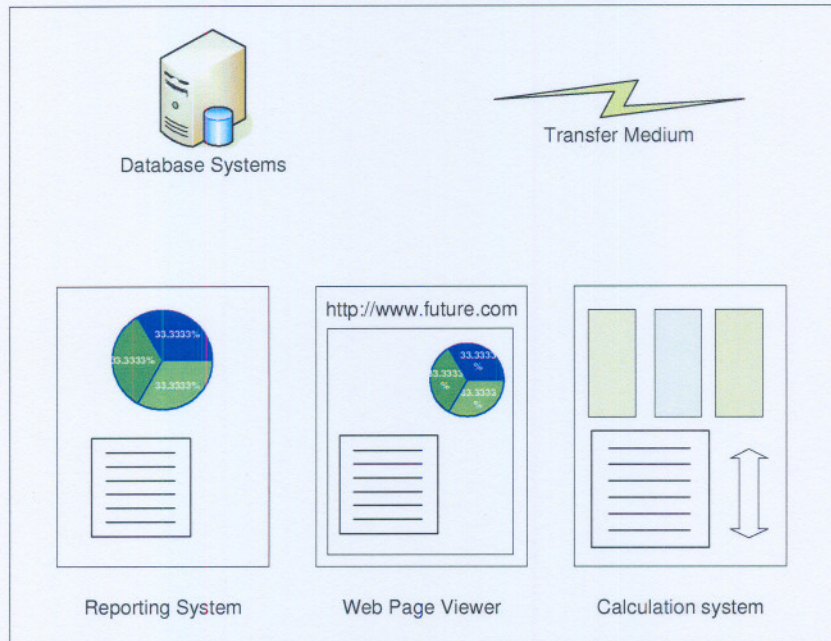


Figure 2.1: The five key components required for the system.

System components for such a system would include the following:

- A database system to store the calculated and analysed data.
- A data transferring medium to transfer the calculated and analysed data to a central storage point.
- A reporting application to generate reports.
- A web page to view this information on the internet.
- An application to calculate and analyse the data generated by the energy management system.

Taking all these requirements into consideration, an in depth look was needed into certain components to design such a system. These components include the compiler, database, communication, and web page language. All these components will be necessary to design and deliver the required system.

Once the exchange has been completed, the local computer will send the users username and password to the ISP. On a successful authentication, the user will have a connection to the Internet and will be able to browse the Internet, download mail, etc.

This information has been obtained from references [21][22][23][24].

Digital Subscriber Line (DSL)

DSL is a very high-speed communication system that uses the same wires as the telephone system [25]. The normal copper wires that the telephone system uses have the capacity to carry more than the normal phone conversations. They can manage a much higher bandwidth or a higher range of frequencies required by phone conversations [26].

The extra capacity that these telephone lines provide is used by the DSL communication system to transfer extra information without disturbing normal telephone conversations [26].

By limiting the frequencies that are carried over these copper wires, the telephone system can pack a large amount of wires into a very small space, without worrying about interference between these lines. A system that needs to transfer digital data rather than analogue data can use much more of the line's capacity.[26].

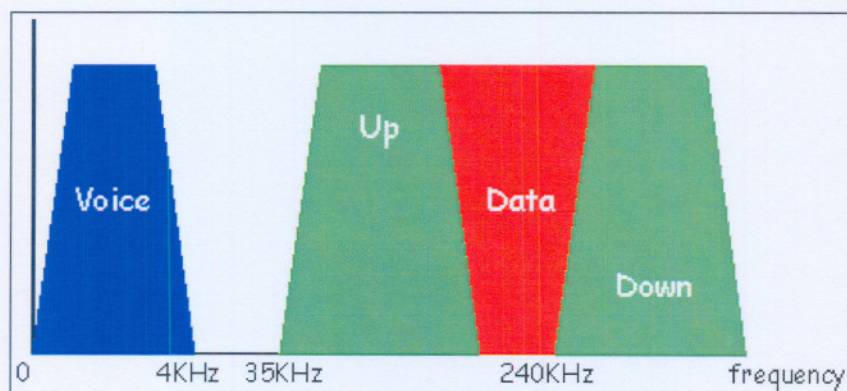


Figure 2.2: DSL frequency allocation [27]

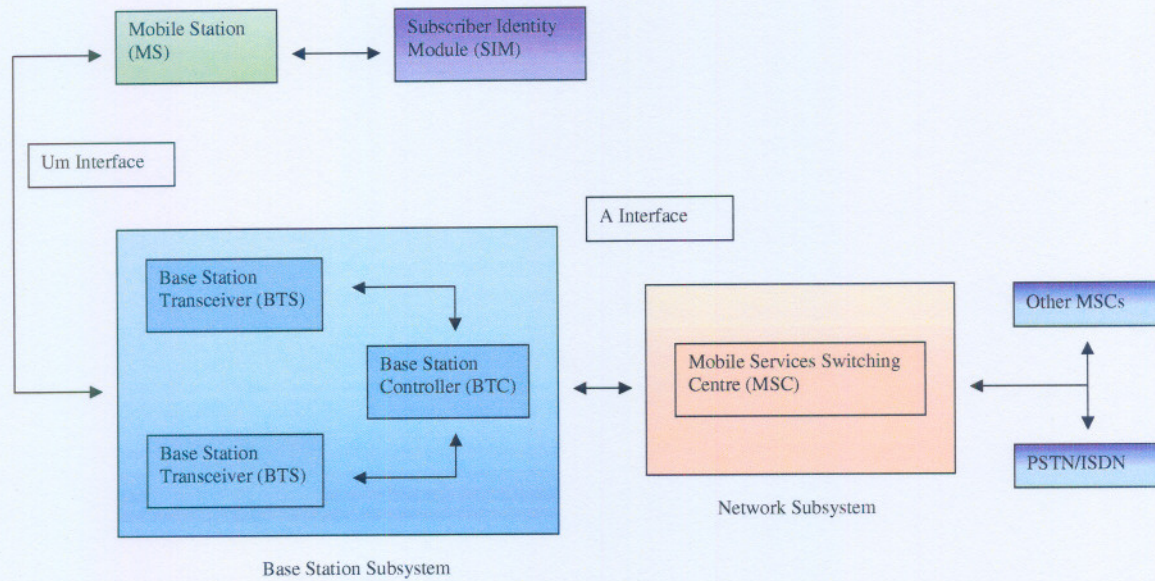


Figure 2.3: Simplified GSM network

The Mobile Station and the Base Station Subsystem communicate across the “Um” interface, which is also known as the air interface or the radio link. The Base Station Subsystem and the network subsystem communicate over the “A” interface, which is managed by the Base Station Controller [32].

GSM operates in the 900 MHz frequency band (890 MHz – 960 MHz) in Europe, Asia and Africa. In the Americas the GSM system operates in the 1.9 GHz frequency range [28][30][31]. GSM has a connection speed of 9.6 kbps.

operating system as well as the Microsoft Windows operating system, and it can be acquired at no charge.

The ASP system simply cannot be used for the system because ASP.Net requires Windows and because of the use of a Linux Mandrake computer on this project.

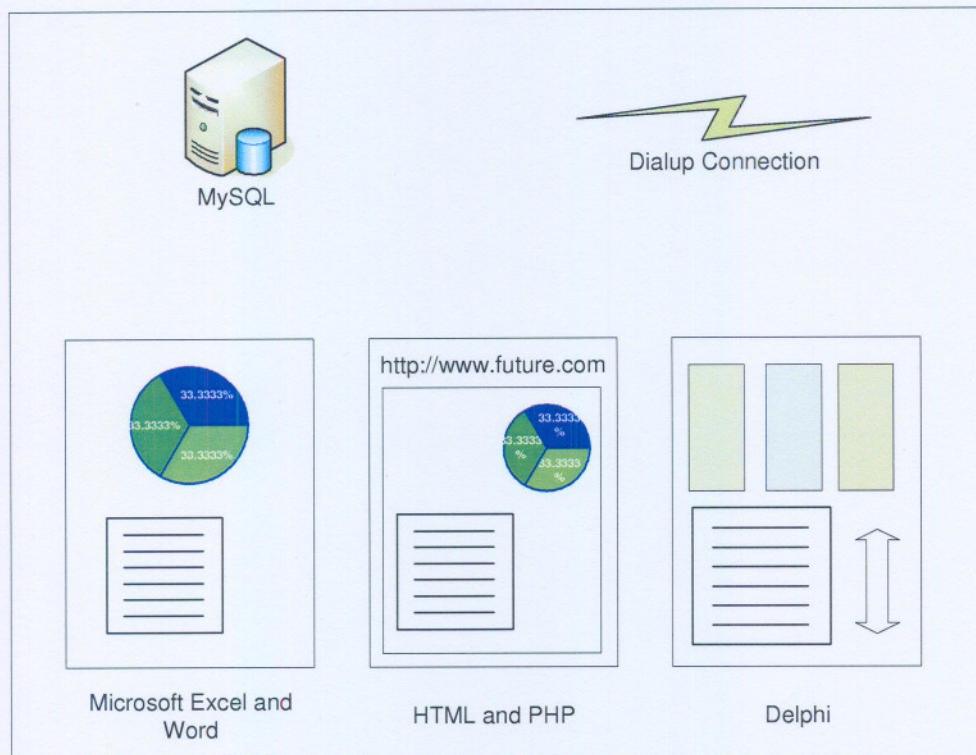


Figure 2.5: Five major components selected

Figure 2.5 depicts the five major components that were selected for the new proposed system.

MySQL will be used for the data storage system. Dialup will be the communication interface that will be used to transfer the data and information to and from the databases. HTML and PHP will be used for the webpage to view the results. The main application will be written in the development package

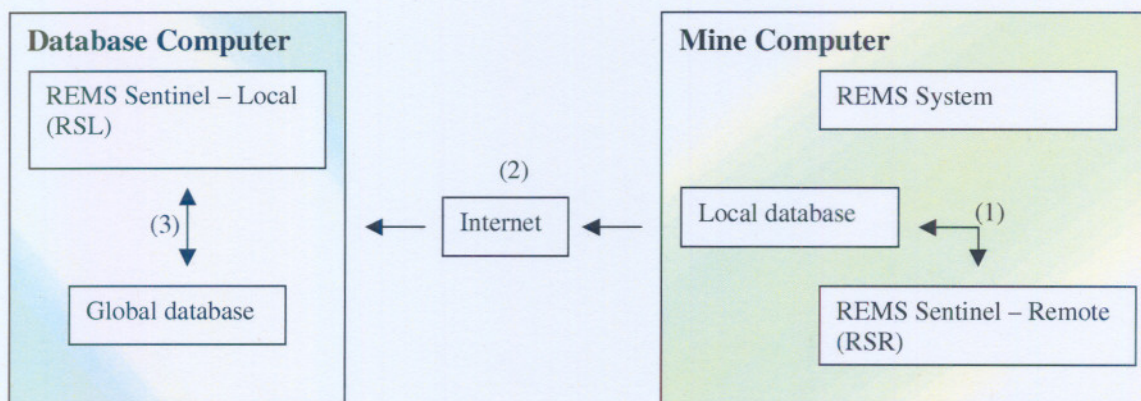


Figure 3.1: Operational environment of *REMS Sentinel*

From Figure 3.1 it can be seen that the following components listed below are essential for the operation of *REMS Sentinel*:

- 1.) A Local MySQL database, where the information can be stored by the REMS system, and on which *REMS Sentinel - Remote* (RSR), then performs certain processes;
- 2.) Methods for RSR to connect to the Internet in order to ultimately connect to the central database, from where it will transfer the processed data;
- 3.) A global database where the processed information can be stored via the Internet, and which *REMS Sentinel - Local* (RSL) uses to generate reports.

3.2.2 Software design requirements

As is the case for all software design, there are certain elements that have to be carefully attended to for the software to be successful and fulfil its purpose.

3.3 Design procedure

This new system must be designed in a specific order. For example, RSL cannot be designed before RSR. This is because RSL needs the data that RSR calculates, before it can generate any report.

In this section the design procedure will be explained as well as how the different components were developed.

In Figure 3.2 a simple flow diagram is given that shows the design procedure that was used to develop the *REMS Sentinel*.

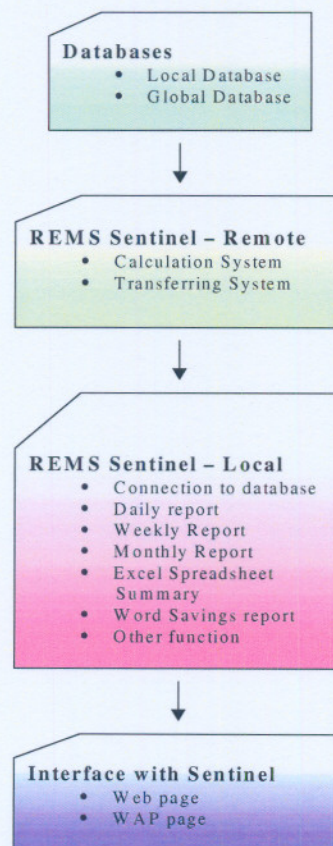


Figure 3.2: Design Procedure

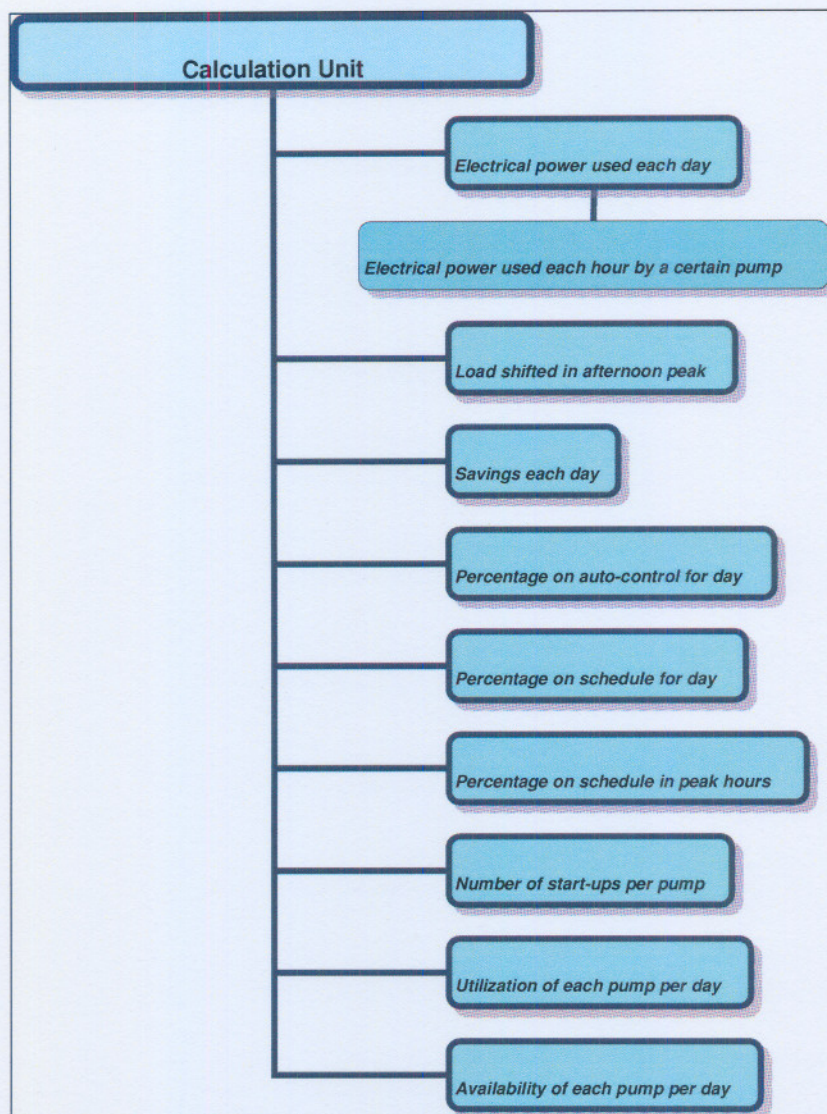


Figure 3.5: The calculation order of the calculation unit

Below is an in-depth description of each calculation unit.

Electrical power used each hour by a certain pump

To calculate the electrical power used during each hour, the individual electrical power consumption of each pump in the mine pumping system is required.

for the pumping of water during off-peak periods, in order to switch them off during the evening peak.

This completes the calculation system. All this is done once on each day, and the processed data is then handled by the transferring system.

Transferring System

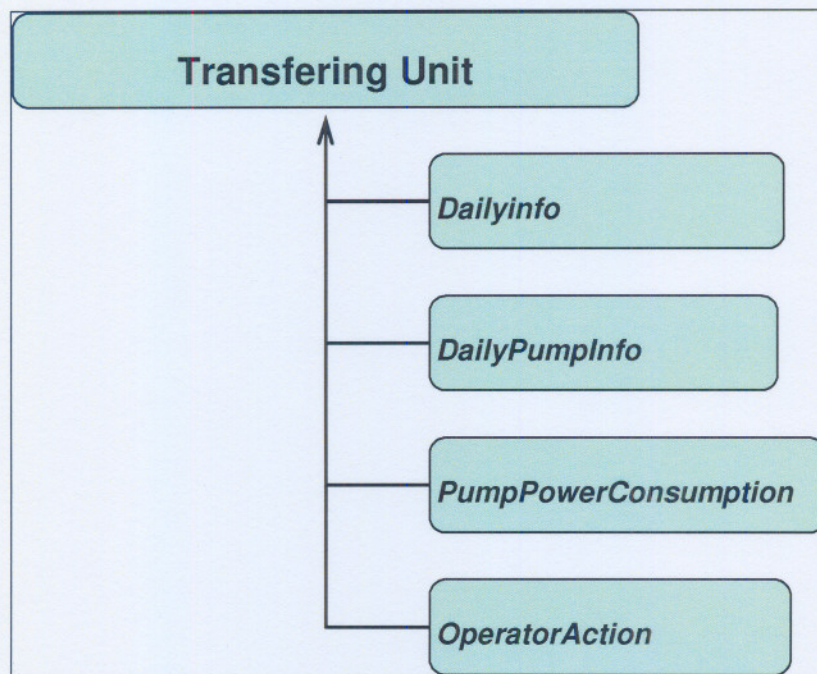


Figure 3.6: Transferring unit

Figure 3.6 depicts the transferring unit's structure. This figure shows the order in which the specific table data will be transferred.

A connection is made to the global database and the data is selected and then transferred. After this, the data that was transferred is marked in the local database so that it is not transferred again.

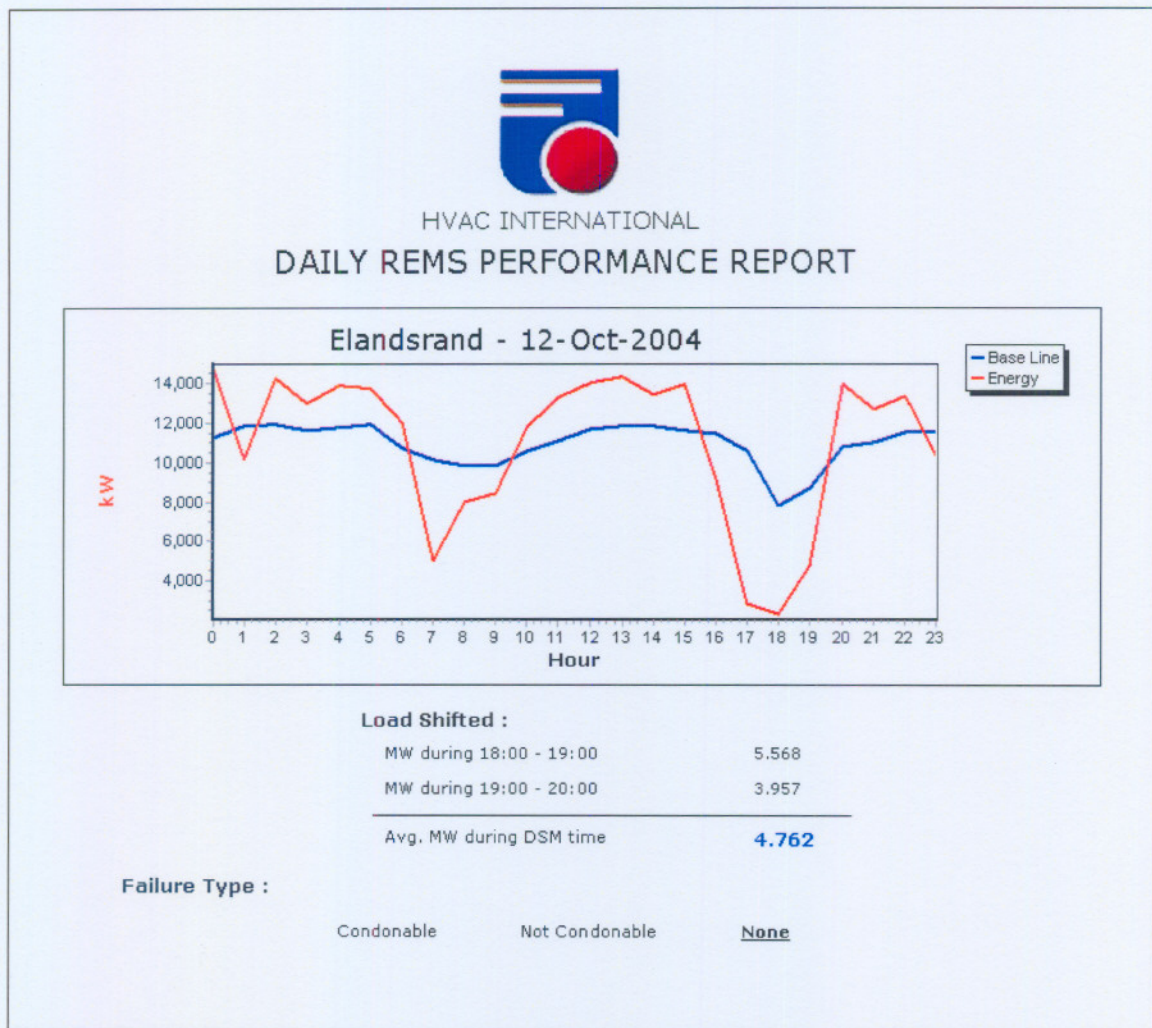


Figure 3.7: Daily report for Elandsrand mine on 12 October 2004

Weekly Report

The weekly reports primarily consist of two types of reports. The first report is the “sustainability report”, and the second the “statistical report”.

The “sustainability report” consists of data regarding the status of REMS. Figure 3.8 shows a typical sustainability report for Elandsrand mine from the 3rd to the 11th October 2004. The percentage on schedule could be so low because the pump operator still have the ability to put a pump on manual as this overrides the control by REMS. If the pump is suppose to be off, but the pump



HVAC INTERNATIONAL

REMS Sustainability Report

Elandsrand

From : 3-Oct-2004

To : 11-Oct-2004

		% on Auto Control	% on Schedule	% on Schedule(peak periods)
Total Period :		92.07	19.33	31.57
Date	Day	% on Auto Control	% on Schedule	% on Schedule(peak periods)
3-Oct-2004	Sunday	92.35	21.11	36.67
4-Oct-2004	Monday	99.86	25.28	36.67
5-Oct-2004	Tuesday	100.00	18.61	36.67
6-Oct-2004	Wednesday	92.91	18.94	36.00
7-Oct-2004	Thursday	100.00	21.50	34.67
8-Oct-2004	Friday	100.00	18.78	34.00
9-Oct-2004	Saturday	89.98	17.63	35.33
10-Oct-2004	Sunday	78.46	18.36	31.50
11-Oct-2004	Monday	75.09	13.75	2.67

Figure 3.8: Sustainable report for Elandsrand mine (3rd to 11th of October 2004)



HVAC INTERNATIONAL

REMS Statistical Report

Elandsrand

From : 3-Oct-2004

To : 11-Oct-2004

Pump	Start-Ups	Utilization (%)	Availability (%)
P100-1	50	16.04	100.00
P100-4	96	35.29	100.00
P100-5	93	32.74	100.00
P100-3	57	72.14	100.00
P75-1	96	43.50	100.00
P75-2	0	0.00	100.00
P75-3	95	54.01	100.00
P75-4	1	0.02	100.00
P75-5	95	45.17	100.00
P75-6	92	58.57	100.00
P52-1	109	53.95	100.00
P52-2	3	2.49	0.00
P52-3	106	58.09	100.00
P52-4	105	58.01	100.00
P52-5	106	55.04	100.00
P29-1	72	52.79	100.00
P29-2	0	0.00	100.00
P29-3	58	32.24	100.00
P29-4	72	57.31	100.00
P29-5	69	51.84	100.00

Figure 3.9: Statistical report for Elandsrand mine (3rd to 11th of October 2004)

The information was selected and transferred to the report template from the “*dailypumpinfo*” table in the global database. The statistical data from the week for each pump can be seen.

Monthly Report

The user can chose to generate one of two possible monthly reports. The first is the general Monthly Load Shifted and Savings Report. This report can be seen in Figure 3.10.



Figure 3.10: Monthly load shifted and savings

them, the application checks whether the current data that has been selected was *condonable*, and if so, then that day's load shifted is not added to the total.

The selected day's load shifted is then added together, and the average is calculated. This is then displayed for the user to see, as seen in Figure 3.11.

Calculate Load Shifted

Start Date: 2004/10/01

Stop Date: 2004/10/15

Inc Condonable days
 Exc Condonable days

Total: 22.24 Avg: 1.59

Calculate

Figure 3.11: Calculating the current total and average load shifted.

Check daily data

There are certain reports that must be generated for Eskom. At the end of each month these reports confirm the actual load shifted, and the savings for that month. Before these reports can be generated, the user/operator must make sure that all the correct reasons for the *condonable* days have been provided, and that all days that are *condonable* are marked as such.

The user specifies the month and the year. The application will then select all the days in that specific month that occur in the data base, and display them as seen in Figure 3.12.

The user can then see what the current status is of every day of the month. If he suspects that the data for any day is incorrect, he can refer to the daily report generation tool, and amend that day's information.

Date	Load Shifted	Condonable	Reason
1-Oct-2004	3.024	0	
2-Oct-2004	3.704	0	
3-Oct-2004	-1.236	1	Breakdown
4-Oct-2004	2.923	0	
5-Oct-2004	1.914	0	
6-Oct-2004	-0.744	1	Breakdown
7-Oct-2004	2.399	0	
8-Oct-2004	1.522	0	
9-Oct-2004	2.230	0	
10-Oct-2004	1.559	0	
11-Oct-2004	-0.816	1	Breakdown
12-Oct-2004	3.050	0	
13-Oct-2004	1.229	0	
14-Oct-2004	1.483	0	
15-Oct-2004	1.895	0	

Figure 3.12: Check daily data for Tshepong mine for October 2004

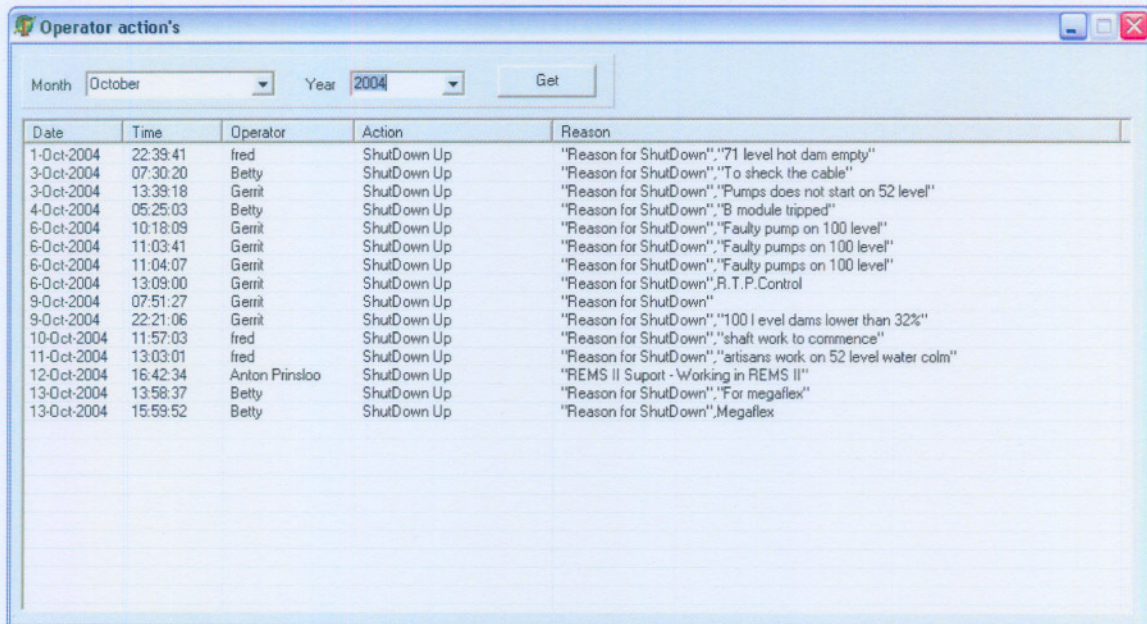
Check operator action

Before a day's missed load shifted can be classified as *condonable*, the user/operator must have a very good reason. Commonly the user/operator would give the specific mine a telephone call, and asks the operator if anything went wrong on that day. If it was an "Act of God", then that day's load shift was *condonable*. (If, however, a missed load shift opportunity was *not condonable*, then that means that the penalty clause of the Eskom contract will come into effect).

Furthermore, the user can use the function available in the application to see what operator actions were logged into the database. In Figure 3.13, for example, details of all the operator actions for the month of October 2004 for Elandsrand mine are given.

The user specifies the month and year of which he/she wants to see the operator actions.

The application then selects the data from the “*operatoraction*” table in the local database. This is then displayed for the user to see, as shown in Figure 3.13.



Date	Time	Operator	Action	Reason
1-Oct-2004	22:39:41	fred	ShutDown Up	"Reason for ShutDown": "71 level hot dam empty"
3-Oct-2004	07:30:20	Betty	ShutDown Up	"Reason for ShutDown": "To check the cable"
3-Oct-2004	13:39:18	Gerrit	ShutDown Up	"Reason for ShutDown": "Pumps does not start on 52 level"
4-Oct-2004	05:25:03	Betty	ShutDown Up	"Reason for ShutDown": "B module tripped"
6-Oct-2004	10:18:09	Gerrit	ShutDown Up	"Reason for ShutDown": "Faulty pump on 100 level"
6-Oct-2004	11:03:41	Gerrit	ShutDown Up	"Reason for ShutDown": "Faulty pumps on 100 level"
6-Oct-2004	11:04:07	Gerrit	ShutDown Up	"Reason for ShutDown": "Faulty pumps on 100 level"
6-Oct-2004	13:09:00	Gerrit	ShutDown Up	"Reason for ShutDown": "R.T.P.Control"
9-Oct-2004	07:51:27	Gerrit	ShutDown Up	"Reason for ShutDown": ""
9-Oct-2004	22:21:06	Gerrit	ShutDown Up	"Reason for ShutDown": "100 l evel dams lower than 32%"
10-Oct-2004	11:57:03	fred	ShutDown Up	"Reason for ShutDown": "shaft work to commence"
11-Oct-2004	13:03:01	fred	ShutDown Up	"Reason for ShutDown": "artisans work on 52 level water colm"
12-Oct-2004	16:42:34	Anton Prinsloo	ShutDown Up	"REMS II Suport - Working in REMS II"
13-Oct-2004	13:58:37	Betty	ShutDown Up	"Reason for ShutDown": "For megaflex"
13-Oct-2004	15:59:52	Betty	ShutDown Up	"Reason for ShutDown": "Megaflex"

Figure 3.13: Operator actions for Elandsrand in October 2004.

3.5 User interface with Sentinel

REMS Sentinel also provides web pages to other persons, e.g. management, that would like to see certain information concerning their mine. These persons can contact the REMS team so that they can be given access to the website. Such access to data will only be given to mines for which they are responsible.

There are two options for the user to use. The one is a normal web page that can be viewed with the use of a computer and the Internet. The second requires a Cell phone with Extended Hyper Text Mark-up Language (XHTML) browsing capabilities.

3.5.1 *REMS Sentinel* Web page

Appendix C contains 4 figures representing the *REMS Sentinel* Web page. The Web page is split into 2 main parts. The first part contains the Savings pages,

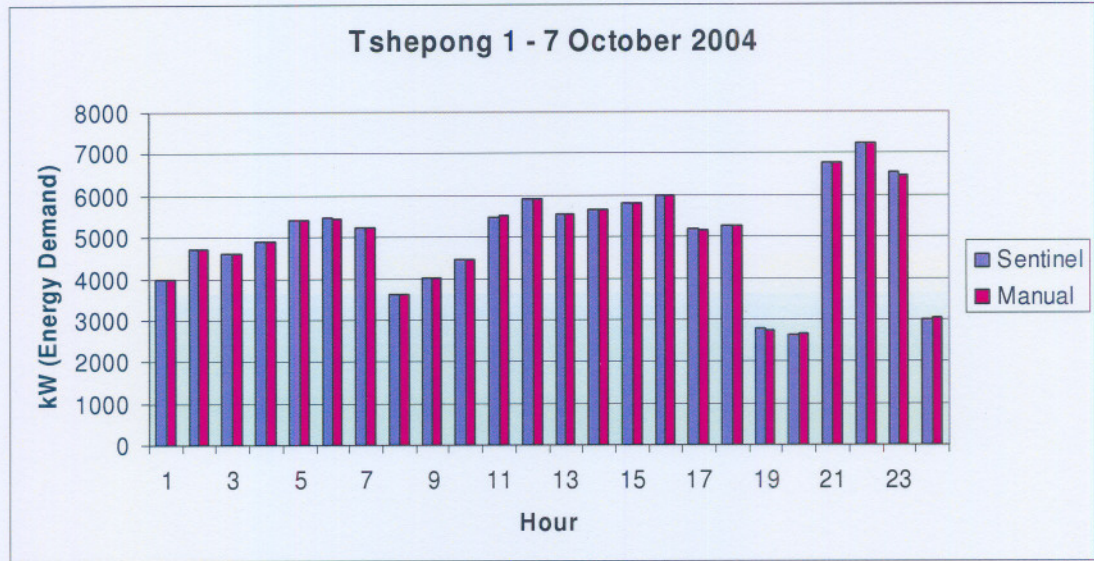


Figure 4.1: Average weekly energy demand for Tshepong’s clear water pumping system (1st to 7th October 2004)

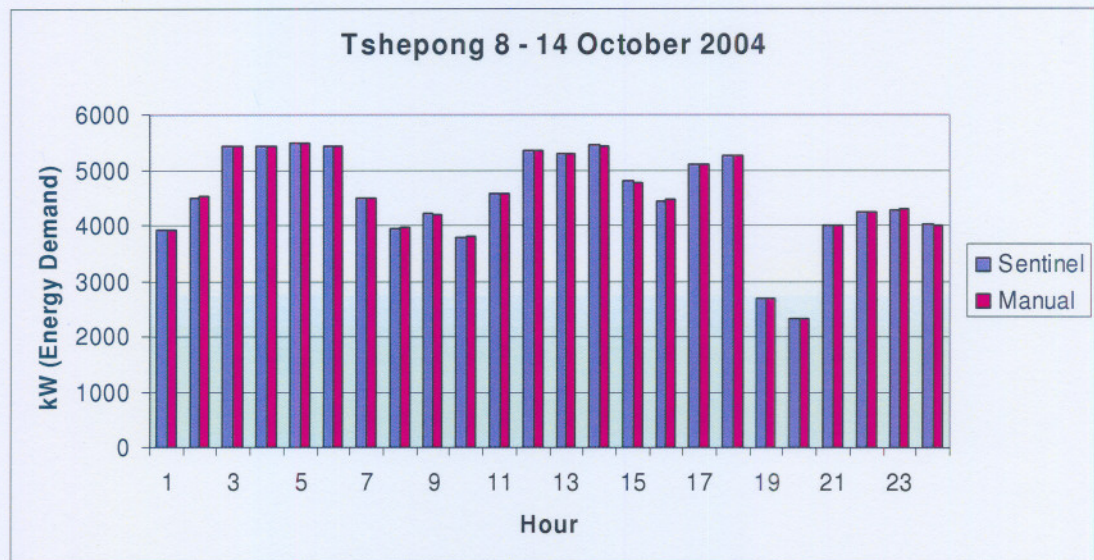


Figure 4.2: Average weekly energy demand for Tshepong’s clear water pumping system (8th to 14th October 2004)

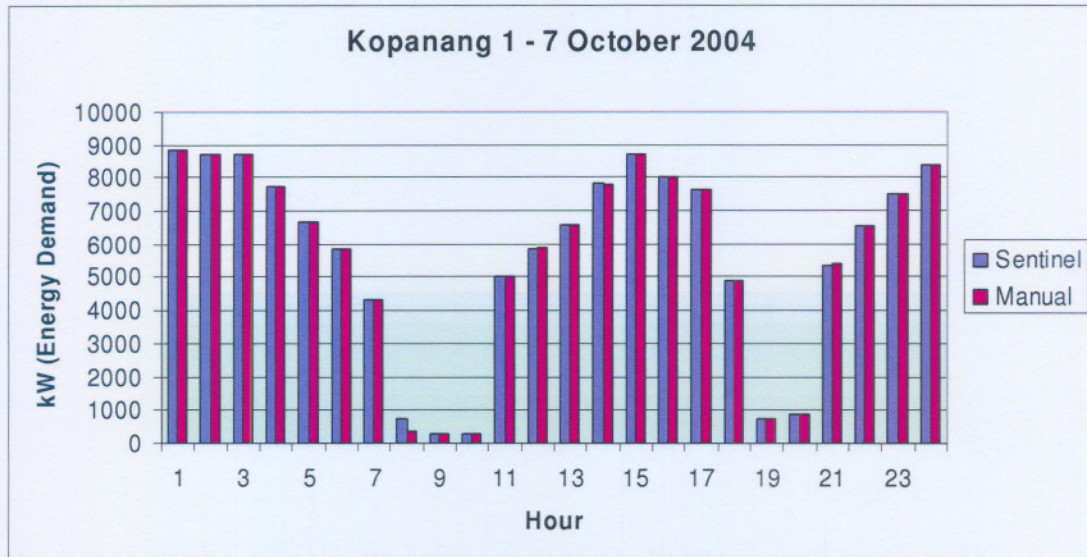


Figure 4.3: Average weekly energy demand for Kopanang’s clear water pumping system (1st to 7th October 2004)

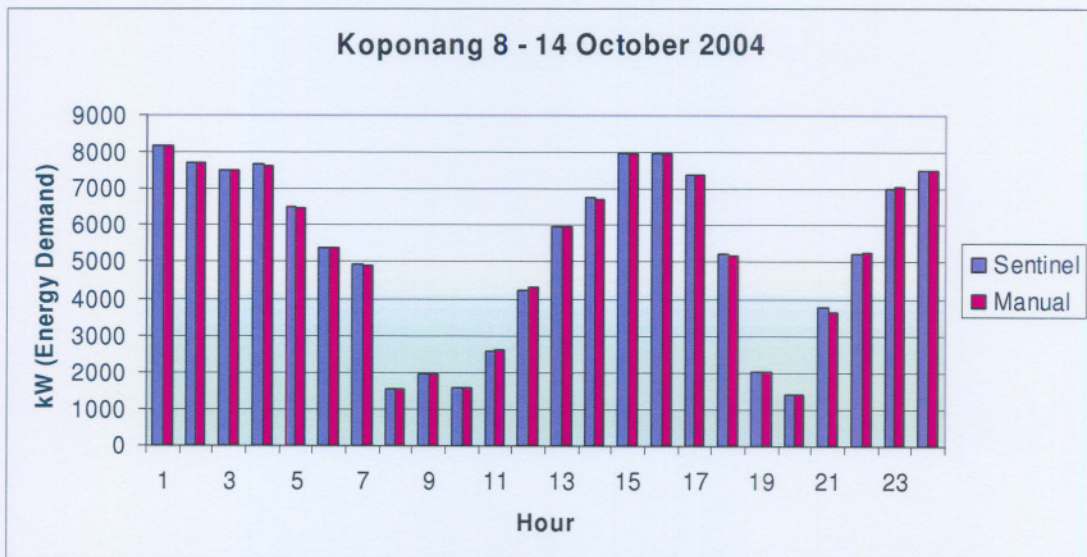


Figure 4.4: Average weekly energy demand for Kopanang’s clear water pumping system (8th to 14th October 2004)

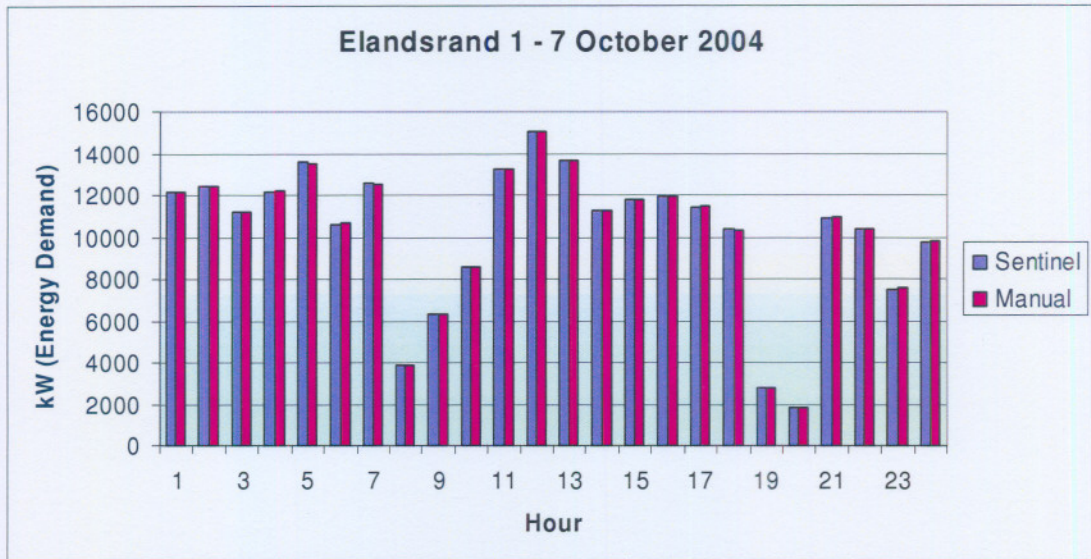


Figure 4.5: Average weekly energy demand for Elandsrand’s clear water pumping system (1st to 7th October 2004)

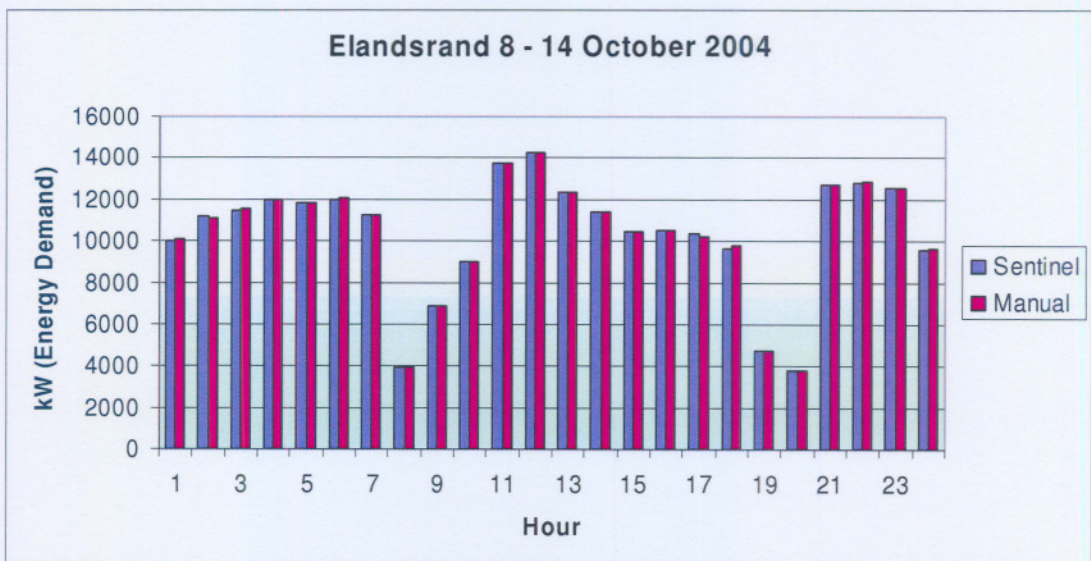


Figure 4.6: Average weekly energy demand for Elandsrand’s clear water pumping system (8th to 14th October 2004)

APPENDICES

Appendix A: Monthly Cost Savings Report

MONTHLY SAVINGS ON THE CLEAR WATER PUMPS
AT ELANDSRAND MINE FOR OCTOBER 2004



HVAC International



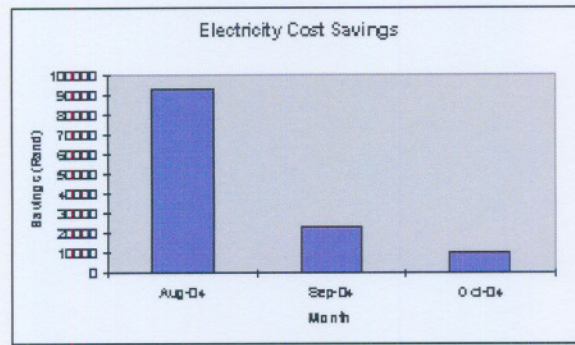
15-Oct-2004

Month	Measured (R)	Accumulative Net savings (R)	Unrealised potential (R)
Aug-2004	92854.37	92854.37	0
Sep-2004	23144.74	115999.11	0
Oct-2004	10634.17	126633.28	0
Total	126633.28	126633.28	0

Table I: Monthly Savings

Calculations:

- Accumulative Net saving : Measured saving
- Unrealised potential: This additional saving could have been achieved if the control response was 100%



HVAC International's service

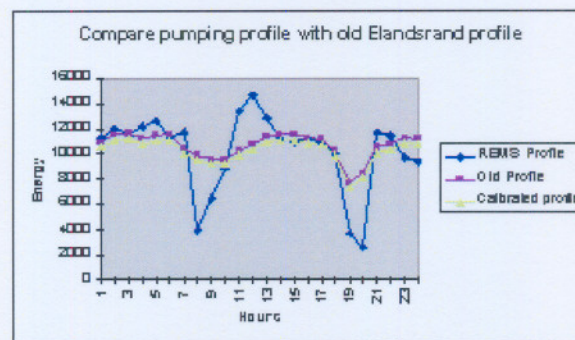
- Sustainable load shifting through pumpings scheduling and control.
- Continues investigations and implementations to obtain additional electricity cost savings.
- Monthly cost savings reports.

REMS Performance

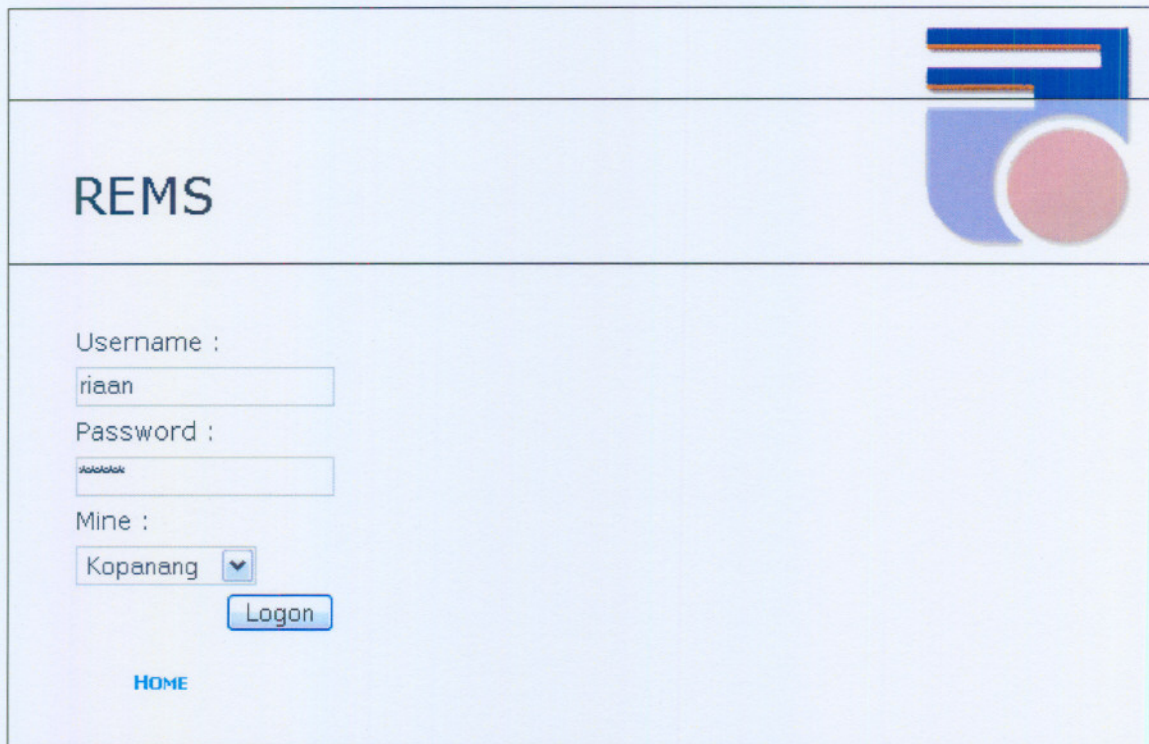
October 2004

Load promised : 3 MW

Actual load shifted : 4.980 MW



Appendix C: REMS Sentinel Web Page



The image shows a screenshot of the REMS Sentinel Web Page login interface. The page is divided into three horizontal sections. The top section is empty. The middle section contains the text "REMS" on the left and a logo on the right. The logo consists of a blue square with a white circle inside, and a red circle to the right of the blue square. The bottom section contains the login form. The form has four input fields: "Username :" with the value "riaan", "Password :" with masked characters, "Mine :" with a dropdown menu showing "Kopanang", and a "Logon" button. Below the form is a "HOME" link.

REMS

Username :

Password :

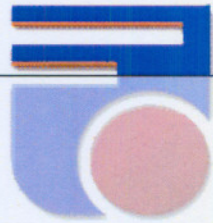
Mine :
 ▼

[HOME](#)

Figure C.1: *REMS Sentinel* Web page login



Figure C.2: *REMS Sentinel* Web page - option page

LOGOUT 

REMS

Elandsrand

Day : ▾

Month : ▾

Year : ▾

[DAILY SAVINGS](#)

[WEEKLY SAVINGS](#)

[BACK](#)

Montly Savings (R/c)

Date	Savings(R/c)
01 Oct 2004	R 1186.36
02 Oct 2004	R 515.08
03 Oct 2004	R 0
04 Oct 2004	R 865.46
05 Oct 2004	R 1766.15
06 Oct 2004	R 1056.01
07 Oct 2004	R 802.97
08 Oct 2004	R 1253.01
09 Oct 2004	R 225.95
10 Oct 2004	R 0
11 Oct 2004	R 323.26
12 Oct 2004	R 1354.53
13 Oct 2004	R 1285.4
14 Oct 2004	R 844.37
15 Oct 2004	R 438.39
Total	R 11916.94
Avg	R 794.46

Figure C.3: *REMS Sentinel* Web page – savings page

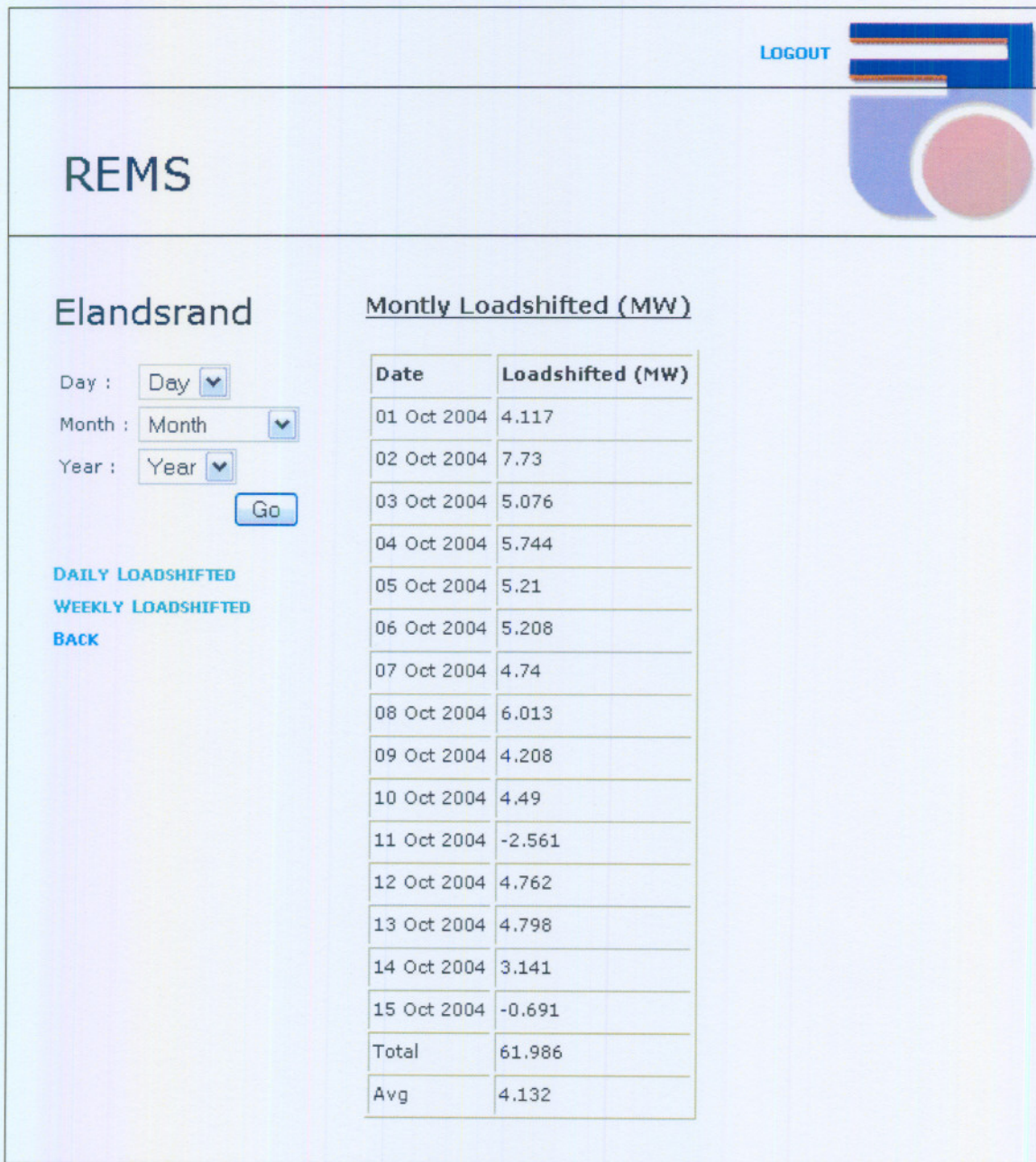
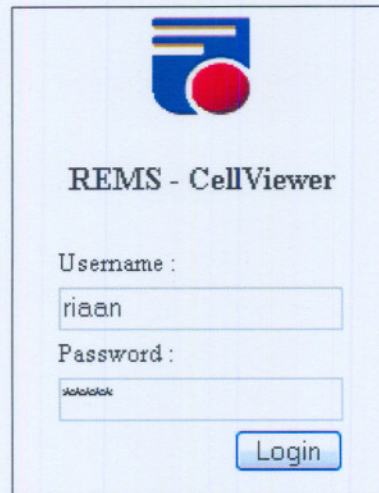


Figure C.4: *REMS Sentinel* Web Page – Load shifted page

Appendix D: REMS Sentinel Cell phone Web page



The image shows a login form for 'REMS - CellViewer'. At the top is a logo consisting of a blue square with three horizontal lines and a red circle. Below the logo, the text 'REMS - CellViewer' is displayed. The form includes a 'Username :' label followed by a text input field containing 'riaan'. Below that is a 'Password :' label followed by a password input field with masked characters. A 'Login' button is positioned at the bottom right of the form.

Figure D.1: *REMS Sentinel* Cell phone web page – Login



The image shows a mine selection form. It features a label 'Select a Mine :'. Below the label is a dropdown menu with 'Kopanang' selected and a downward arrow. A 'Go' button is located below the dropdown menu.

Figure D.2: *REMS Sentinel* Cell phone web page – Mine selection

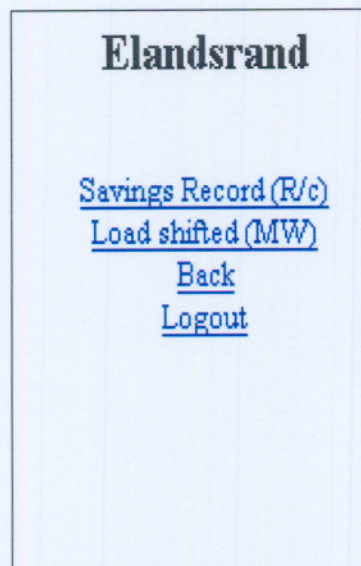


Figure D.3: *REMS Sentinel* Cell phone web page – Option



Figure D.4: *REMS Sentinel* Cell phone web page – Savings page

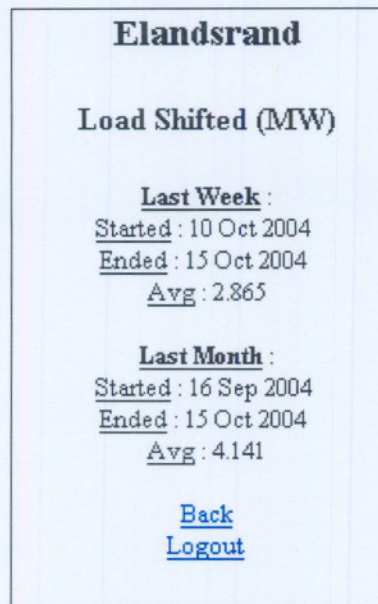


Figure D.5: *REMS Sentinel* Cell phone web page – Load shift page