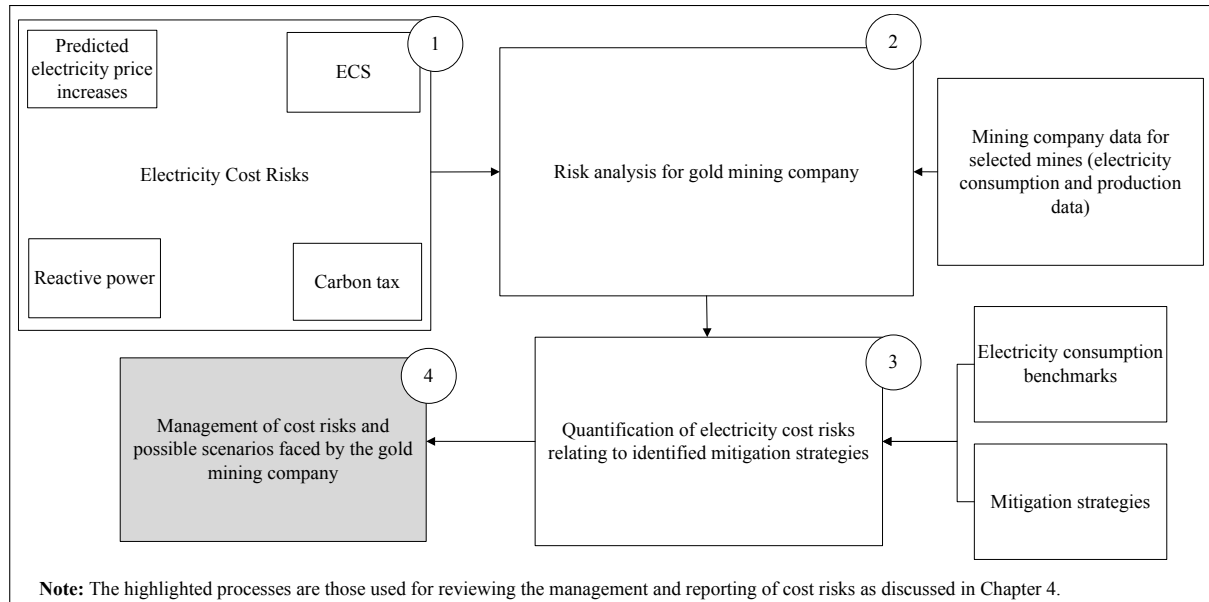


Chapter 4 : Implemented risk management



4.1 Introduction

In Chapter 3, methodologies for individual service electricity reduction were developed and potential projects identified. Benchmarked data of each mine's electricity cost risk differs in electricity intensity, operational size and profit contribution. The combined effect of the cost risks for each mine will influence operational planning of the mining company. It is thus crucial that the electricity consumption of each mine and the company as a whole must be managed, reported and maintained.

It was also concluded from Chapter 3 that benchmarking can be used to identify potential mitigation, but each project must be individually maintained and controlled to obtain savings as a whole. Presented data showed the annual electricity consumption and installed capacities provide a good indication or starting point. To quantify and identify possible solutions, the hourly daily profile of the selected service must be reviewed or investigated to obtain the relationship between production and electricity usage.

The following chapter will discuss the derived methodologies and processes developed and implemented on the mines of the selected mining company, to manage and reduce the future cost risks of the mining company.

4.2 Electricity management and reporting

4.2.1 Electricity management

To manage electricity from one central point, companies have established Energy Management Systems (EMS) to improve or organise the electricity improvement of a industry or company [1]. It has been proven that an energy cost reduction of 10% in the first year of implementation can be achieved with an EMS system based on ISO 50001 standards [2]. The ISO 50001 management standard was released in 2011, and contains a set of energy management standards which can be incorporated with existing ISO standards to help consumers to reduce their electricity consumption [3], [4].

A EMS would enforce a systematic approach to possible existing energy savings strategies and then managing it according to the Plan-Do-Check-Act (PDCA) cycle of the ISO 50001 standards. The PDCA cycle of the ISO 50001 energy management standard has also been proven successful in South African industries [1], [5].

4.2.2 Limitations of available management systems

EMSs have been implemented in several industries [6]. A study has been presented with savings of 25% resulting from an implemented energy management system [7]. The case study was for the manufacturing industry with the presented specific consumption reduction strategies not being applicable to the mining industry. There is also very limited information regarding the implementation of an EMS on a South African gold mining company. While there are studies available which provide guidelines for the development of an energy management system specific to industries [8–10], the information provided is general and for use as a guideline only. No specific modelling equations are provided to quantify electricity reduction for certain electricity consuming loads or services on a gold mine.

The available commercial solutions are limited to single plants and mines and do not incorporate global reporting mechanisms for management and control. This can be attributed to the mines having several different SCADA interfaces and network standards. The available commercial products focuses on monitoring and reporting [11], [12]. However, this only covers the two first cycles (*Plan, Do*) of the ISO 50001 process and clear goals and mitigation strategies must be provided to manage electricity accordingly. For the available commercial electricity reporting services, the reports are not clearly defined and not designated for certain personnel or departments [12].

If a mining company would like to invest in the development of a solution that would provide measurement to all the large consuming services, it would be a very costly and

resource intensive project. This is due to production interruption caused by the measuring equipment installations and the cost involved for the both the purchasing and installation of the measuring equipment and communication systems.

The presented strategies in Chapter 3 provide the mine with the ability to investigate and quantify mitigation strategies without installation of an new EMS. It is recommended that an ISO 50001 compliant EMS must be installed or incorporated into the existing DSM or Eskom reporting systems. This will provide sustainability and the additional benefits of the ISO standards helping to reduce electricity consumption will be achieved. The installation of the EMS could be performed in parallel with the identified DSM projects and measuring equipment should be included in the infrastructure when reviewing DSM projects.

For this study, a management and reporting system was developed which utilises existing SCADA and electricity data from previously implemented projects and incorporates the data in different types of reports. Using these reports, the data is analysed according to the presented electricity cost risks and available DSM strategies. The mitigation strategies are then communicated to the mine with the potential electricity reductions.

This developed system provides the advantage of identifying opportunities from existing electricity bills and production data providing targeted benchmarks. The reporting process and management process ensures sustainable savings. The developed management system can be used by any South African gold mines, even those without an existing electricity management system or monitoring and reporting capabilities.

The goal of the developed system is to ensure sustainability through reporting and monitoring of existing electricity savings projects. From the reported data, possible mitigation strategies are identified. Cost risk mitigation and impacts are used to create awareness to induce behavioural changes.

Behavioural changes are usually quick to implement, and are not as costly as new projects. Several studies are available on behavioural changes resulting in electricity efficiency [13]. The following section will describe the derived management and reporting system.

4.2.3 Development of an electricity management system

The ISO 50001 PDCA cycle was reviewed and incorporated into this study. The implemented and derived PDCA methodology, reporting and risk management system for this study is illustrated in Figure 4.1. The *Plan* step in Figure 4.1 is seen as the first step, consisting of all the preliminary required information as discussed and illustrated in Chapter 2 and Chapter 3. The *Do* step is the actual implementation of the mitigation strategies derived in the Plan step. *Check* is represented by the reporting system and information presented

to the mine company. *Act* is the management and methodology development to update the existing systems or investigate new potential.

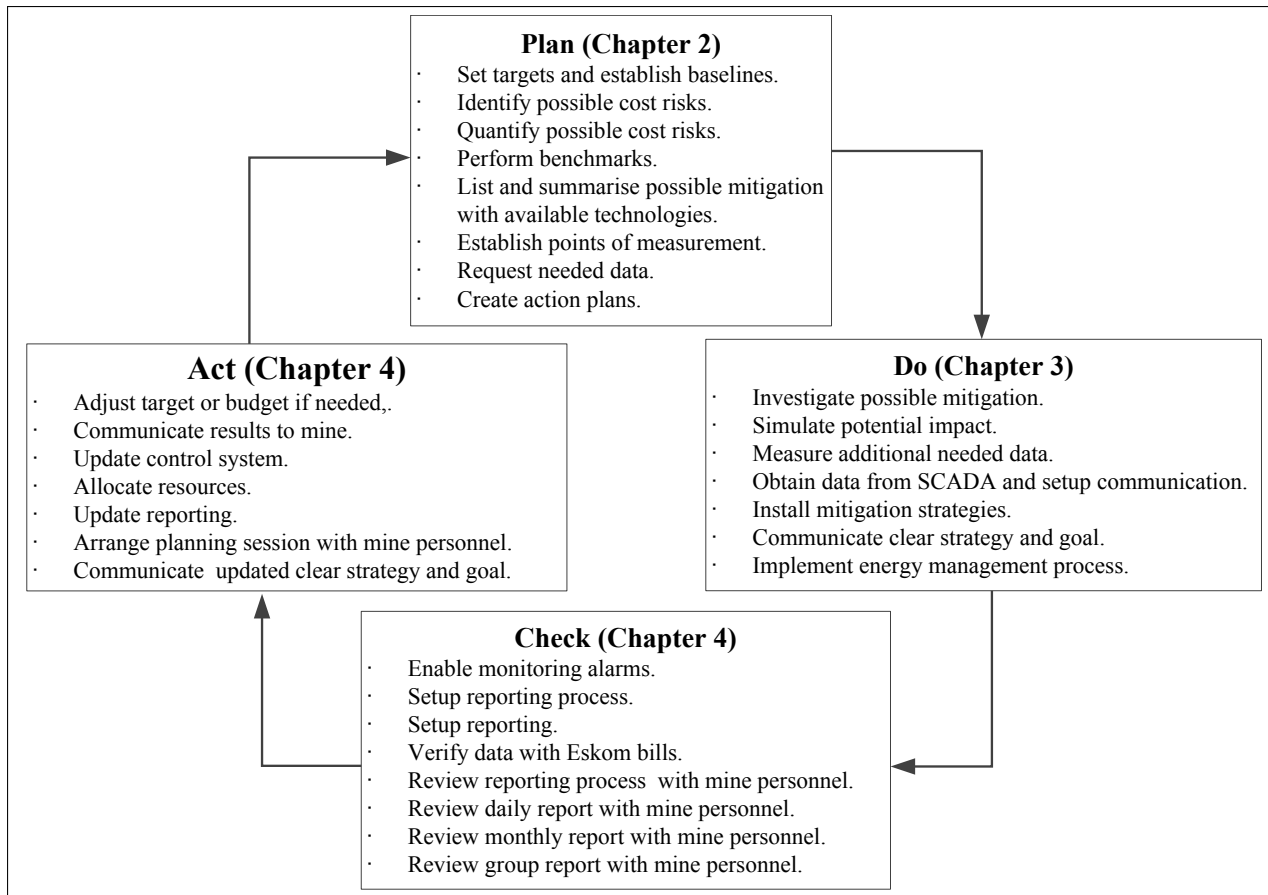


Figure 4.1: PDCA cycle with the assigned task for the reporting system implemented.

The derived risks were incorporated and used in the management reporting process as mitigation. The reporting structure and data collection also incorporates the PDCA cycle and is illustrated in Figure 4.2. Data is received from an existing SCADA or mine-specific electricity monitoring system. The data is sent to a central database, whereafter the data is arranged, modelled and reported according to a specific report or mine standard. The reports are sent out to specific mine personnel. The report will be reviewed and verified, where after meetings will be held to review the savings and derive mitigation strategies. If need be, the baseline and control parameter will be updated.

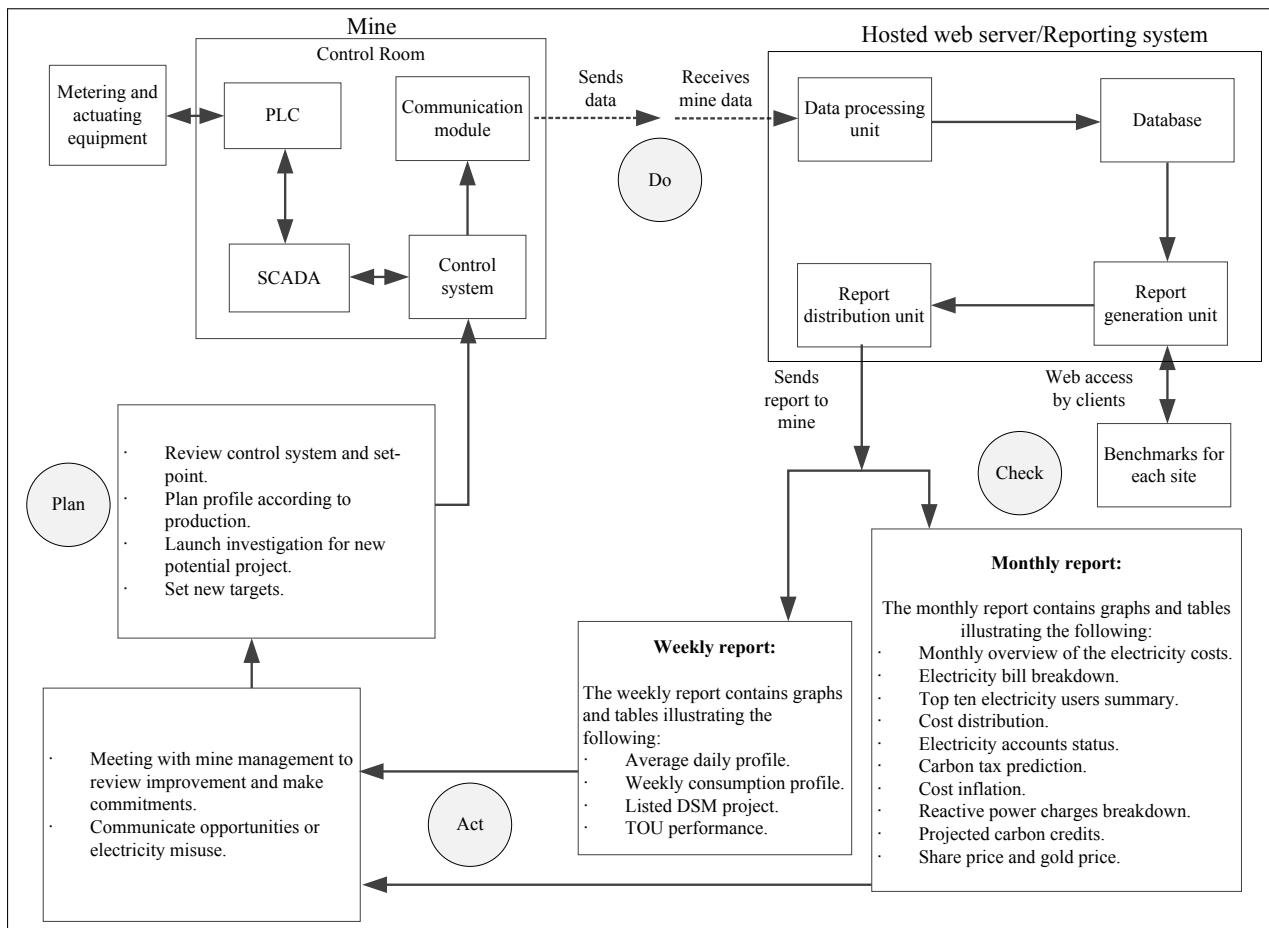


Figure 4.2: Data management and reporting methodology implemented for this study.

The advantages of monitoring and reporting electricity usage on South African mines have been proven [14]; through monitoring and daily reports, compressed air leaks were identified and fixed, protecting the mine against estimated compressed air losses of R70 000 a month. This malfunctioning of compressed air equipment was also identified in the presented case study. For the reporting and management of the mine data, the following requirements were met:

- The data was obtained on a daily basis from the mine's SCADA, power monitoring equipment used by the mine and the monthly Eskom electricity bill.
- The received power data from the installed monitoring equipment was validated against the applicable Eskom bills to ensure correctness.
- If no data was available, the data loss was indicated on the system.
- The data was processed weekly on an automated system.
- The reports compiled were reviewed by personnel responsible for generating the reports to ensure correctness.
- The reports were provided to the correct mine personnel.

- The provided reports were discussed with senior mine management responsible for electricity management, as well as mine managers for each reported mine.

The derived management system and associated reporting system offers a management solution which includes the following:

- electricity reporting,
- electricity management,
- identification of opportunities for further electricity savings,
- identification of risks,
- monthly reporting,
- DR management, and
- optimal benchmarked targets for improvement.

4.3 Implemented reporting and management system

For the management of electricity, the derived electricity cost risks and mitigation strategies were made available through monthly reports. The developed reporting methodology for this study provides reporting for the appropriate personnel with necessary technical or financial information, quantifying influential elements on the large electricity consuming services. There are three main report types, namely daily, weekly and monthly reports. Each report has a specific objective and advantage to managing electricity and is detailed below.

Daily report

The daily report is DSM project specific and provides the project target and performance achieved for the day and for the month to date. This provides the mine with the ability to review their electricity consumption on the reported services on a daily basis. The daily electricity reference and actual consumption profile are provided. The accumulated cost savings are also shown on the daily report indicating missed opportunities. The report is used by the mine personnel responsible for the project (e.g electrical foreman, project engineer). Cumulatively the daily report information is also presented in the weekly report. Therefore only weekly report will be discussed in detail, later in this chapter.

Weekly report

The weekly report provides the electricity profile on all mining services for the mine. This provides the mine with the ability to monitor all the DSM projects in one report on a weekly basis. All the selected incoming data of the mine is incorporated with a projected usage baseline or budget. The weekly report can be used with ECS management for correct allocation management or rephasing of electricity. As the reports are sent out every week, there is enough time for the report personnel to verify the correctness of the report through data analysis.

Monthly report

The monthly report illustrates the electricity consumption of all the relevant mining shafts or sites. The monthly report is sent out once a month and is used in planning and providing electricity targets for the month. Where the weekly and daily reports are used to manage the electricity for each mine, the month report is used by the electricity manager to ensure that all the electricity cost risks are addressed for the mining company as a whole, and to manage resources accordingly. A key requirement for the ISO 50001 management process is getting the commitment from management [5]. The monthly reports incorporates the key results and information requested by the mine management to manage the electricity costs.

The following sections will discuss the reported items of the weekly and monthly reports with the results obtained.

4.3.1 Weekly report

An example of a weekly report that was sent out to Mine H is attached in Appendix E. The first page illustrates the measured electricity consumption elements with the baseline and the actual consumed data. The potential and implemented projects are listed to provide information regarding potential opportunities. Mine H was selected being a highly profitable mine and having several DSM project implemented on. This will indicate the additional advantage that will be provided by the reporting methodology.

Daily consumption profiles and the baseline were established for the selected individual services. The mine manages the electricity consumption ensuring that the electricity consumption is below the target or budgets provided. The power consumption targets for Mine H are illustrated in Table 4.1.

Component	Month to date		
	Actual (kWh)	Baseline (kWh)	%
Mine H	9 067 183	8 926 185	100%
-Compressors	2 485 234	2 480 101	28%
-Mining	1 706 520	1 550 943	17%
-Pumping	1 097 359	908 700	10%
-Refrigeration	1 622 863	1 722 551	19%
-Fans	1 552 744	1 567 925	18%
-General	199 854	159 250	2%
-Decline pumping	104 163	106 374	1%
-Hoisting	598 788	616 601	7%

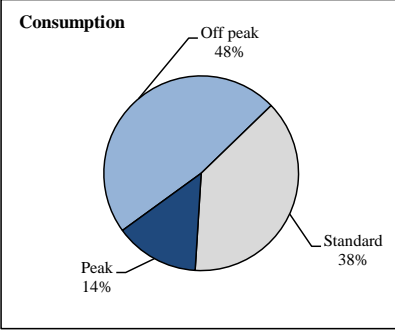


Table 4.1: Summary of the power consumption for the main mining services and overall power consumption.

The following section will illustrate the cost risks according to the derived model in Chapter 2 and the mitigation strategies of Chapter 3. The total daily electricity consumed for each of the services is presented at the start of the report. This enables the engineering manager to compare the present consumption to that of the targeted baseline.

The monthly total power tracking is used to ensure that the power consumption management is working correctly and that the consumption is below the budget/baseline. Figure 4.3 illustrates the graphs of total power consumption, used to monitor the consumption on a weekly basis. The effects of the mine strikes of September 2013 can clearly be noted.

During the strikes, the mine responded correctly by switching off unused power-consuming services such as cooling and compressed air, as illustrated in Figure 4.4. From the analysed data, it should be noted that large services can be switched off in the case of a high electrical cost risk situation such as ECS. However, the mining service (electricity supplied to underground and surface works) in Figure 4.5 does not indicate a reduction of electricity during the mine strikes. This indicates the potential of installing infrastructure which could aid the mine in reducing their mining-service electricity consumption during non-production periods.

One study proved that for South African platinum mines, 80% of the electricity consumed is for non-production related services [15]. From the weekly report, it was found that more than 65% was still required during the strike periods of Mine H. This indicates that there is a great need to isolate and control non-productive related electrical loads on a mine.

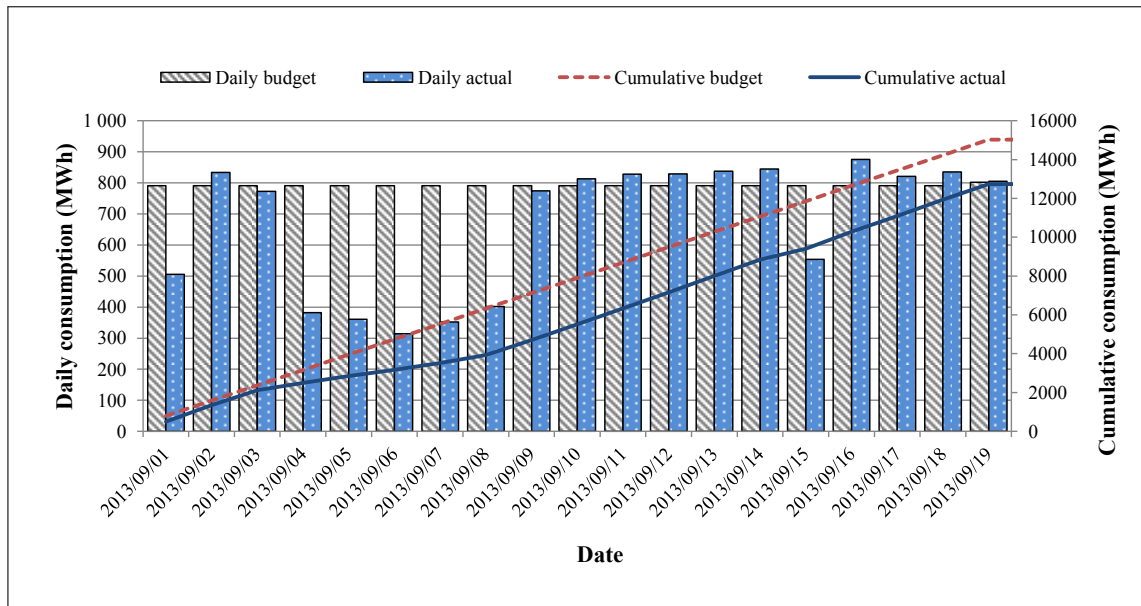


Figure 4.3: Total power consumption of Mine H for September 2013.

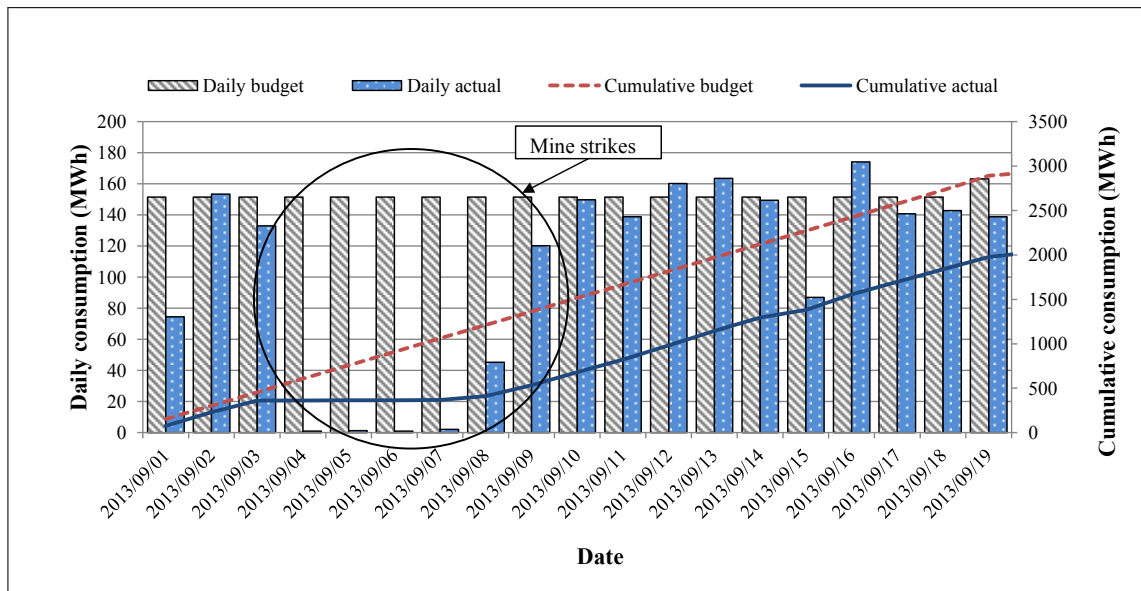


Figure 4.4: Cooling system power consumption of Mine H for September 2013.

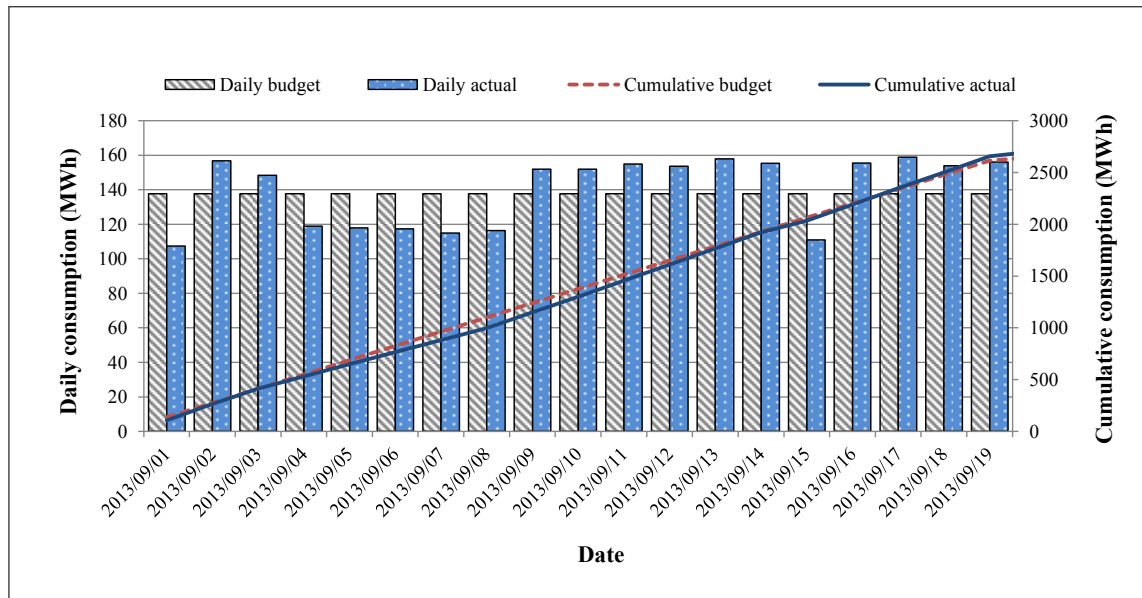


Figure 4.5: Mining power consumption of Mine H for September 2013.

The daily average consumption profiles of the services listed in Table 4.1 are also illustrated in the weekly report. The daily average profiles provide insight into potential high TOU charges and could aid in managing the maximum demand. The TOU charges are also expressed in the amount of electricity used in the three consumption periods and the related costs. The indicated TOU cost is used to create awareness among mine personnel and to indicate the cost risk involved for each service.

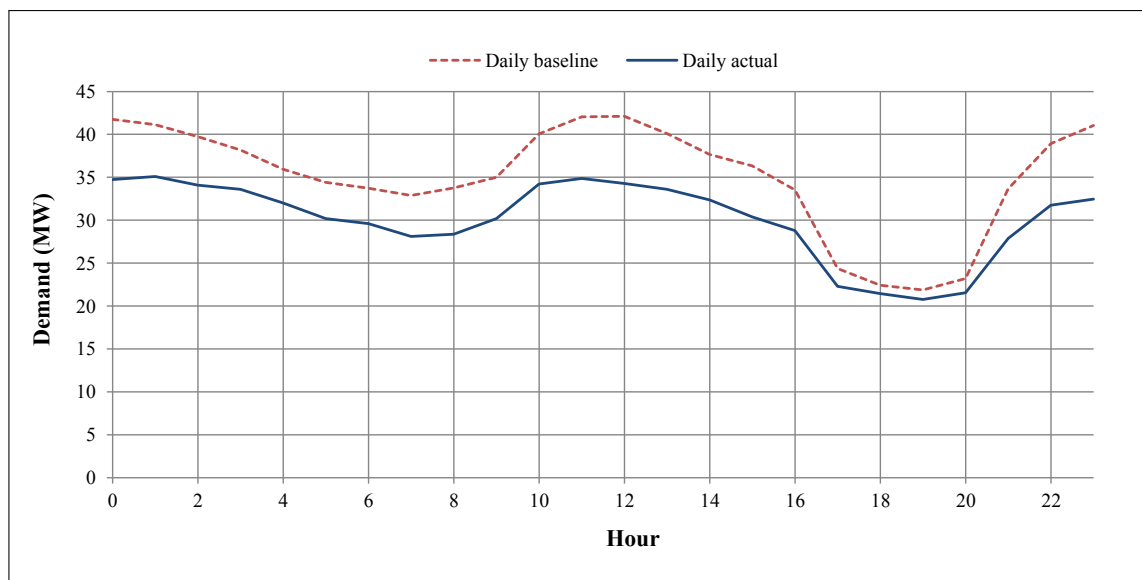


Figure 4.6: Total-to-date power consumption for Mine H for September 2013.

Figures 4.6, 4.7 and 4.8 illustrate the total and main services average daily profiles. The total, cooling system, hoisting, compressor and pumping daily profiles clearly indicate an optimised load profile due to DSM projects that have been implemented. The average daily mining profile does not indicate a load shift profile but rather a higher demand for certain

periods of the day. This provides an opportunity of isolating loads for DSM projects and performing load shift on the mining service. The hoisting profile shows that the average daily load managed is not according to the provided baseline and this was communicated to the mine.

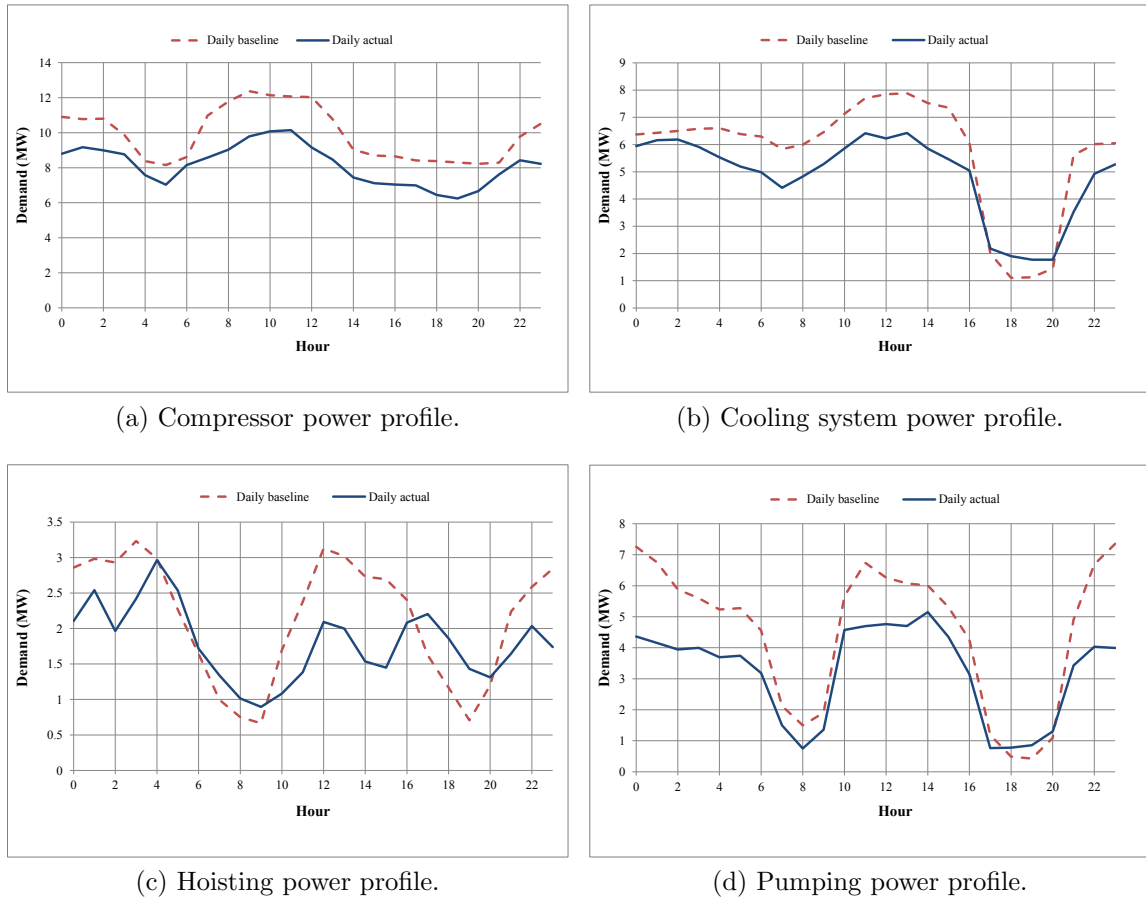


Figure 4.7: Main selected services with daily average baseline value and usage.

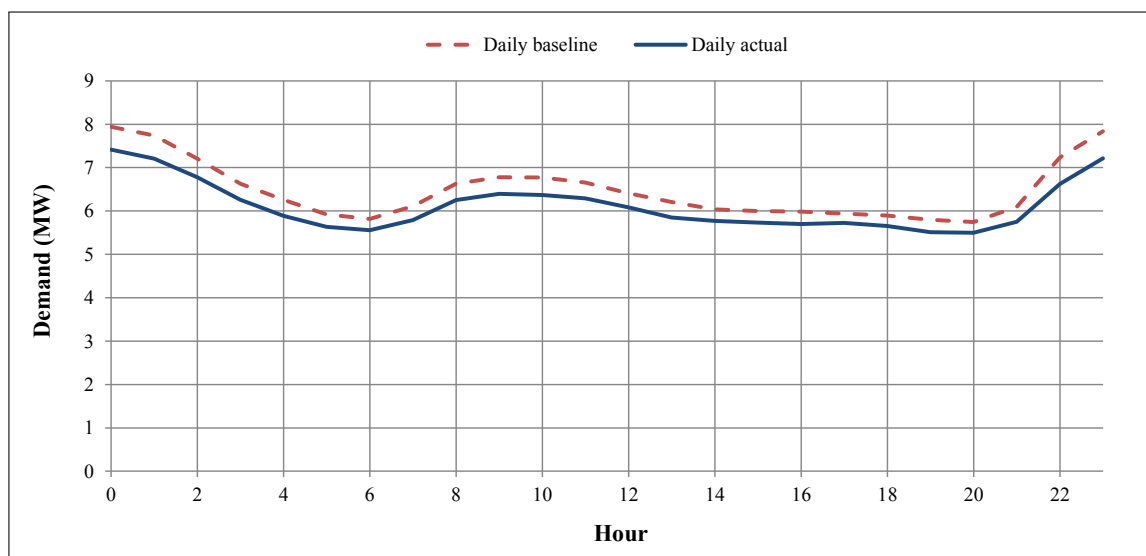


Figure 4.8: Mining power consumption profile for Mine H for September 2013.

In the weekly report shown in Appendix E, the daily budgets are still shown as the financial

budget and not as the updated baselines. During this study the weekly budgets have been updated, illustrating continual improvement of the PDCA cycle.

The baseline for the illustrated graphs of Mine H was selected at the start of August 2013. The first reports were sent out at the end June 2013. With the awareness created by the report and without any additional infrastructure added to the mine, the hoisting electricity profile of mine was improved. This is accredited to the reporting system and informing the mine of the additional load shift potential by updating the winding profile to optimally shift load in the evening.

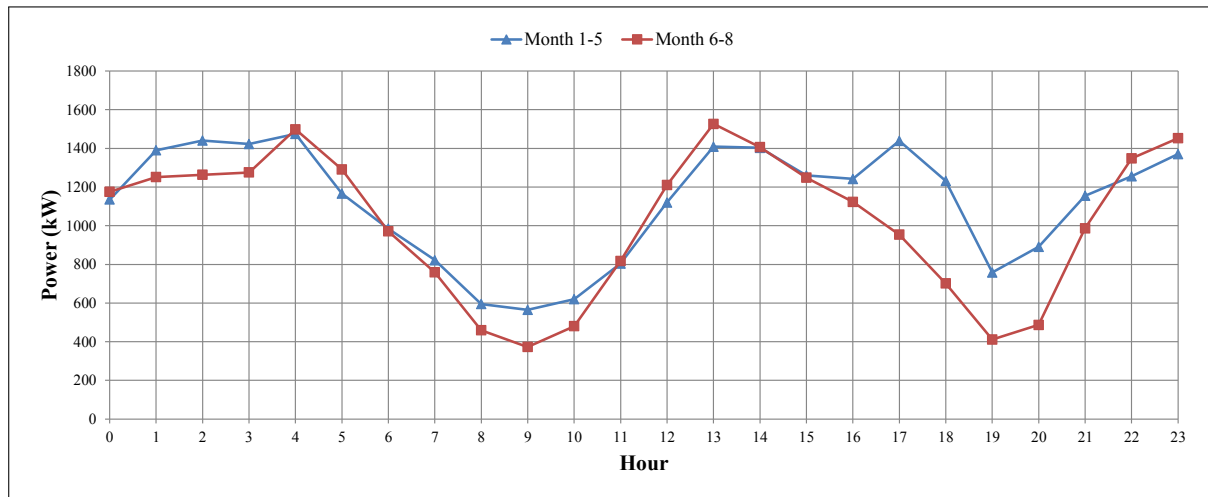


Figure 4.9: Illustration of the improved load profile resulting from management reporting.

Figure 4.9 illustrates the load shift profile of January to May 2013 and the updated load shift profile for June to August 2013. This indicates the benefits obtained from the reporting and management procedure. The improved load shift resulted in additional electricity cost savings of R11 295 at the end of August 2013. The mine has been informed of the possible improvement on the other measured services of the mines.

4.3.2 Monthly report

Monthly reports are sent out on a monthly basis and report on all the mines of the mining company. In the monthly report, electricity usage and cost risks for the company are listed. The electricity manager for the mining company will then use the monthly report to verify the electricity usage and mitigation strategies. The monthly report which was sent out to the mine is illustrated in Appendix F.

The following points are presented in the monthly report for the control and mitigation of electricity costs:

TOU structure: The TOU structure highlights the higher electricity costs for the related

periods and is used to provide insight into the related costs.

Monthly overview of costs: The monthly overview provides an indication of how well the electricity is managed. Electricity reduction goals could also be included in the overview. The monthly budget overview is illustrated with a yearly profile illustrating the high electrical costs experienced in the high demand seasons.

Cost and usage breakdown: The breakdown of the electricity bills is shown to provide the mining company with an indication of their usage profile and reactive power charges. The top ten electricity consuming mines are also shown to illustrate the effect of each mine's consumption in relation to the others.

Electricity accounts history: The list of available electricity accounts indicates the amount of data received and acts as a validation point, where missing data is indicated in grey. The mines that are consuming more than the allocated budgets are also highlighted in red. This provides an indication of where electricity management strategies should be implemented.

PCP/ECS penalties: The potential ECS penalties are indicated as zero. This is mainly due to the baseline that has been chosen, which was negotiated between the mine and Eskom in 2007. It is assumed that if the ECS is approved, a new baseline will be negotiated and the risk strategy updated. By still incorporating the ECS in the reporting system, it provides the mining company with the advantage to act quickly if the ECS is approved.

Carbon tax: The potential carbon tax is illustrated with the latest updates from the budget speech. The potential carbon tax is illustrated to create awareness and aid in allocated resources for the expected increase.

Price inflation: The price inflation of the past and future electricity costs is illustrated. The price inflation will provide an indication of how important electricity will have to be managed compared to other mining operational costs.

Reactive power: The reactive power charges for the sites are indicated. This will provide an indication for potential investment and if reactive power charges were to be charged throughout the year. This indicates which mines should install power factor corrective capacitive banks first.

Opportunities for the mining company: In the opportunity section, the potential CERs are indicated. The indicated CERs are estimates for the identified potential projects which are still awaiting final UNFCCC approval.

Gold price, shares and exchange rate: With the reviewed cost risks and present electricity costs, the mining company can review the potential future electricity cost in

relation to the gold price. By indicating the exchange rate, share price and the gold price, the report can be used several financial or management departments in the mining company.

4.3.3 Benchmark reporting and management

In Chapter 3 annual electrical consumption and production benchmarks were used to identify potential projects. As discussed, benchmarking on a monthly basis will provide better insight into optimal production and electricity relationships, creating the ability to manage electricity on a monthly basis according to the benchmarked results. The electricity intensity in terms of production and electricity consumption could provide more details in a best-case operational usage. The benchmarked services of the mining company are illustrated in Figures 4.10 to 4.12. During this study, the benchmarking reporting was performed on a monthly basis and the data was provided on-line or with a spreadsheet application (Microsoft Excel¹).

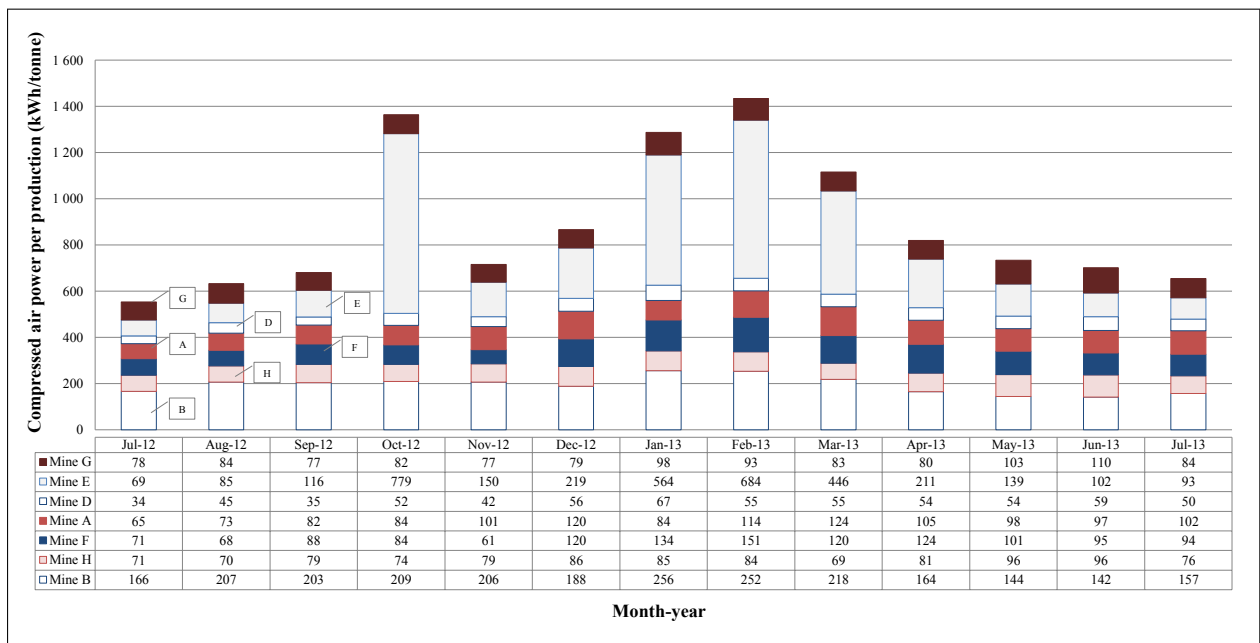


Figure 4.10: Benchmarking used in mine monitoring: Compressed air.

¹Microsoft Excel software, information available at <http://office.microsoft.com/en-za/excel/>

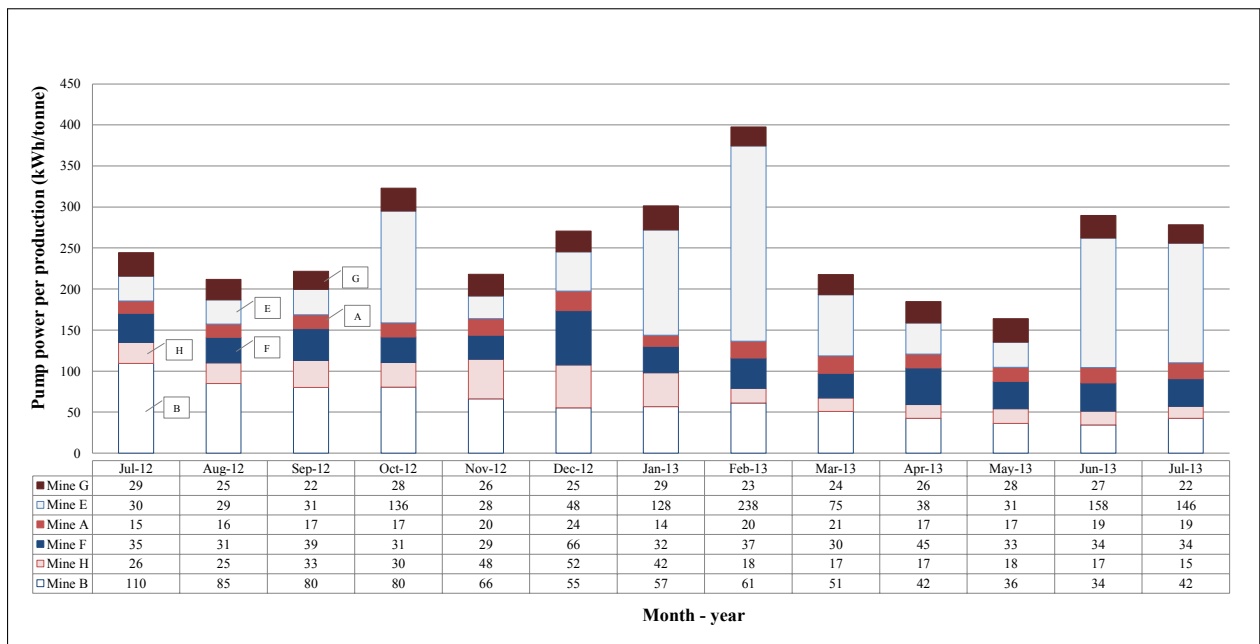


Figure 4.11: Benchmarking used in mine monitoring: Pumping.

From the pumping benchmarked data, the clear reduction in pumping intensity should be noted for Mine B. This is due to a new pumping station that was installed and due to the production increase. Mine B is steadily closing down and only the high profitable sections are being mined.

From the benchmarked data, the well-performing mines can be distinguished from the other mines. However, details such as dates and reasons must be logged for the abnormal consumption, which could be used for data analysis influencing future decisions. Mine E was very electricity intensive in January and February as well as the high demand seasons compared to the other months. Mine E is the largest electricity consuming mine in the company but also has the capacity as the largest producer.

The high electricity intensity profile for Mine E is mainly due to the labour force strikes and low production during that period. The electricity consumption of Mine E should be closely monitored in non-production periods to ensure optimal use of electricity.

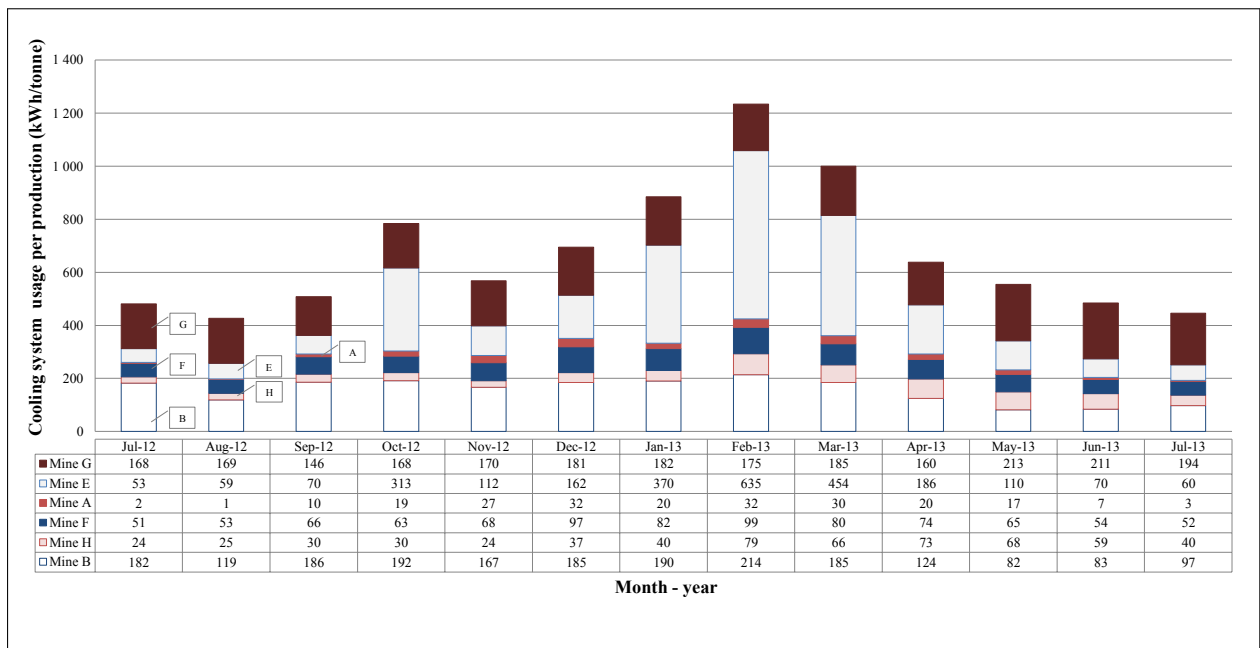


Figure 4.12: Benchmarking used in mine monitoring: Cooling system.

The relationship between production and electricity usage can be found for the main selected services - pumping electricity consumption in relation to production can be seen in Figure 4.13. As seen in the weekly reports, certain electricity consuming services such as mining do to correspond to low production days. There are many contributing factors for the variance in production which cannot be controlled; if it is assumed that the production is as optimal as possible, the lowest possible electricity average can be calculated for the related service. The lowest consuming electricity average for the producing month should provide a good target for electricity in relation to production and should aid in planning for high-risk scenarios by providing an indication for mitigation.

Figure 4.14 provides the predicated optimal production and worst-case electricity consumption resulting in the same number of tonnes milled. The optimal case is calculated by identifying the month with the highest production and with the lowest electricity usage in a year. The relationship is then applied to the other months to obtain the best-case production profile. As noted in Figure 4.14, a mine with thee closely grouped optimal and worst-case electricity profiles provides an indication of the small variance in electricity consumption related to production.

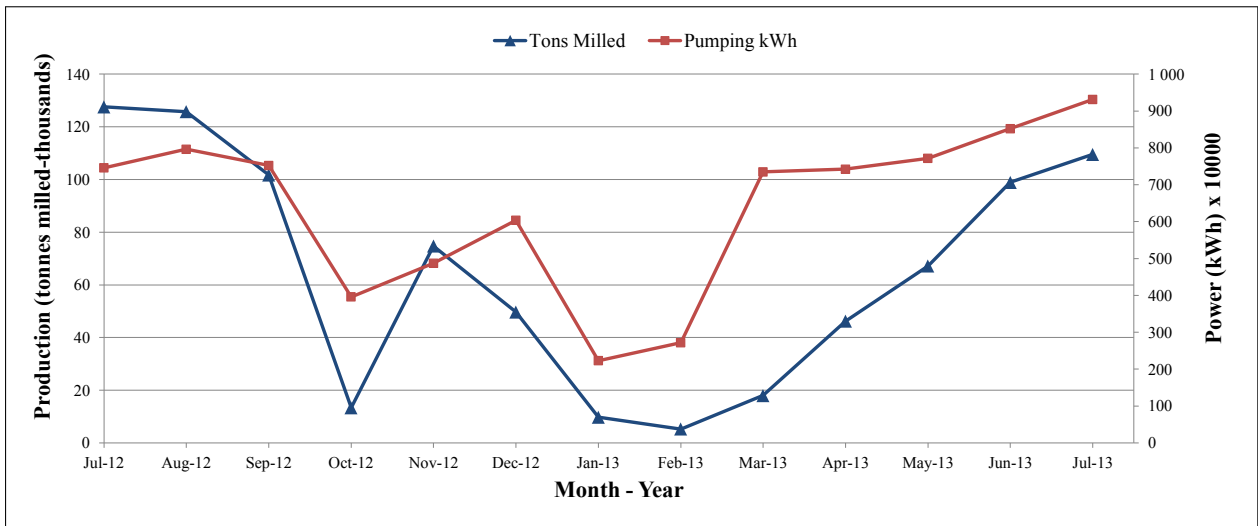


Figure 4.13: Relationship between production and electricity consumption - Mine E.

The optimal electricity profile was compared to the actual profile and a potential improvement was calculated and is shown in Tables 4.2 and 4.3. A large percentage improvement will indicate how much electricity is used in relation to low production. This is seen in Mine E and the relevant mine strikes where there was little production in comparison to the amount of compressed air supplied. The potential improvement indication is a better representation of utilised compressed air for production in comparison to the annual benchmarks.

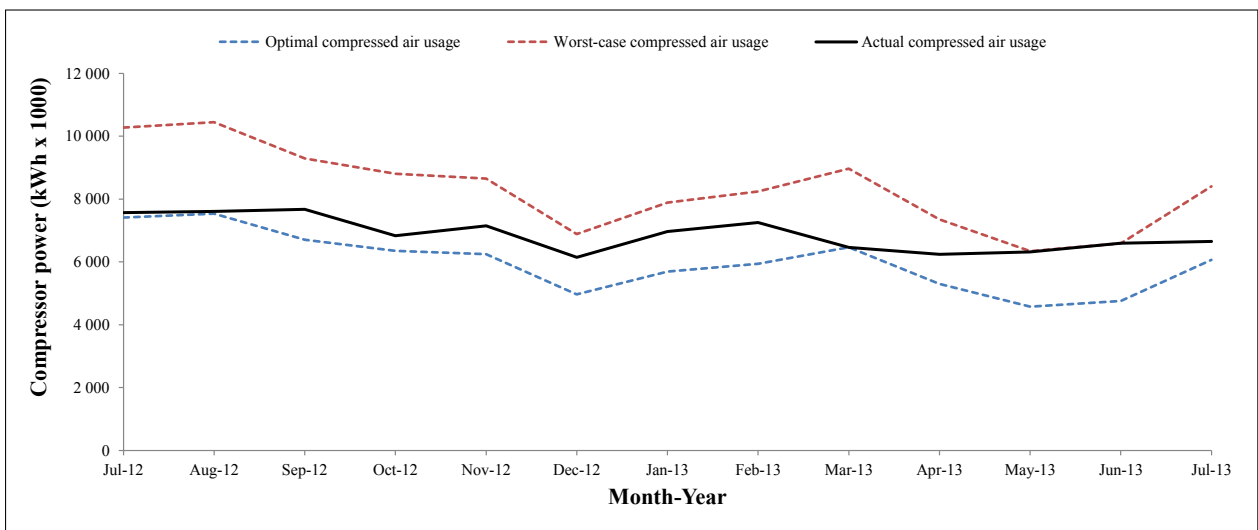


Figure 4.14: Optimal and worst-case compressed air power consumption in relation to production.

Table 4.2 indicates the potential improvement for the main services but only for the summer months as it was noted that the cooling system consumption was much lower in the winter due to the lower cooling requirements. As seen in Table 4.3, the percentage improvement is much higher.

Mine Name:	Pumping: Percentage improvement in (kWh)	Cooling: Percentage improvement in (kWh)	Compressed air: Percentage improvement in (kWh)
Mine B	28%	44%	24%
Mine H	25%	17%	13%
Mine F	##	3%	37%
Mine A	15%	36%	31%
Mine D	37%	##	32%
Mine E	40%	31%	51%
Mine G	17%	19%	11%
##: Data loss			

Table 4.2: Percentage improvement in relation to electricity consumption and services (summer only).

Mine Name:	Pumping: Percentage improvement in (kWh)	Cooling: Percentage improvement in (kWh)	Compressed air: Percentage improvement in (kWh)
Mine B	28%	44%	24%
Mine H	25%	50%	13%
Mine F	##	24%	37%
Mine A	15%	94%	31%
Mine D	37%	##	32%
Mine E	40%	48%	51%
Mine G	17%	31%	11%
##: Data loss			

Table 4.3: Percentage improvement in relation to electricity consumption and services.

Mine H provides a good indication of having a lower potential improvement on all the services. This correlates to the benchmarked data of Chapter 3 where Mine H was identified as one of the lowest electricity-intensive mines when compared to the others. The best-case scenario also indicates the extent to which the service is related to production. The percentage also indicates if a mine is a constant producer or if there are a large number of production interruptions.

The potential electricity reduction for each service was quantified in relation to the mine power and the total electricity of all the selected mines. The potential reduction for the selected mines in relation to each service is listed in Table 4.4. It should be noted that in relation to production and utilising electricity optimally for the presented services, the total electricity could be reduced by 17%.

Mine Name	Pumping			Cooling			Compressed air		
	% Reduction service power	% Reduction shaft power	% Reduction total power	% Reduction service power	% Reduction shaft power	% Reduction total power	% Reduction service power	% Reduction shaft power	% Reduction total power
Mine B	28%	2%	0.2%	44%	9%	0.9%	24%	7%	0.6%
Mine H	25%	3%	0.7%	17%	2%	0.5%	13%	3%	0.7%
Mine F	##	##	##	3%	1%	0.1%	37%	17%	1.3%
Mine A	15%	2%	0.3%	36%	2%	0.3%	31%	12%	1.7%
Mine D	37%	5%	0.4%	##	##	##	32%	9%	0.7%
Mine E	40%	5%	2.1%	31%	4%	1.7%	51%	9%	3.9%
Mine G	17%	1%	0.0%	19%	4%	0.2%	11%	3%	0.2%
##: Data loss									

Table 4.4: Percentage improvement for each mine and total electricity reduction.

4.4 Conclusion

In this chapter, the implemented reporting and management system were discussed. Examples of weekly and monthly reports were shown to illustrate the effectiveness and benefits obtained from the reporting system. The benefits of the reporting and electricity management system was indicated with the improvement of the load shifting profile of Mine H's hoisting service and the identification of other potential electricity cost-savings projects.

The monthly benchmarked production and electricity relationship for the main services was listed. The importance of production monitoring was highlighted. The benchmarks also provided the possible optimal electricity usage profile which can be used as a baseline or goal. The optimal usage could also aid in the modelling of the non-profitable production point for the electricity tariff increases. This will provide the best-case scenario for electricity reduction and what the expected cost impact will be from the cost risks if electricity usage was optimal.

For the installed projects indicated in Chapter 3, a maintenance contract was established which ensures additional sustainability of electrical savings for the projects. It is recommended that future commissioned projects are also accompanied by a maintenance plan or agreement.

Whilst implementing the reporting system the selected mining company requested to become ISO 50001 compliant. The baseline has been established for monitored projects and mines, new reviewed baselines must be updated for certain identified projects. The next step for the mine company is to appoint dedicated personnel and to undertake a commitment for electricity reduction on identified projects.

The developed DSM identification methodology and risk quantification provides insight into

the cost risks. From the presented data, the mine is provided with an approach derived for the main services that could be used. With the study, clear production and electricity consuming targets were set for the mining company. From the benefits of the reporting and electricity cost risk management system, the mining company has indicated the interest of purchasing additional monitoring software and investing in further reporting development.

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