By implementing demand side management (DSM) measures on the rock winders the electrical power demand during the peak periods (18h00 to 20h00, weekdays) can be reduced and thus assist to create an overall power reduction in the national demand.

Measurement and verification (M&V) is needed to determine the impact of the project. M&V is an independent, impartial process that answers the following questions:

• What was actually done/installed during the DSM project?
• What was the actual impact of the DSM project?

This paper will focus on an M&V methodology for rock winder load management.

To reduce the electrical demand of the rock winders during peak hours the electrical load is shifted outside the peak period, this is done by switching the winder motors off during the peak periods. To measure and verify the impact of this newly installed hoisting schedule a baseline model needs to be determined first. The objective of the baseline model is to provide a prediction of what the electricity use would have been if the DSM measure was not implemented by the Energy Service Company (ESCo). The impact is then determined by subtracting the actual profile from the baseline profile.

**Winder operation**

The basic operation of a rock winder system is to transport reef and waste from the different underground mining levels to the surface. The following components need to be defined to understand the winding process:

• **Skip** – a bucket in which the rock is transported.
• **Winder rope** – used to pull the bucket up or down.
• **Winder pulley** – a pulley that guides the rope up and down the shaft.
• **Winder motors** – drives the winding operation.
• **Skip feeder** – a cone like structure that loads the skip with rock.

To make the transport process easier the rocks needs to be blasted into smaller pieces. The smaller rocks are then transported to the underground silos via a mining train. Then 20 tons of rocks are loaded onto the skips via the skip feeder and this loading process takes about two to five minutes. This is then where the winding process starts.

The winder motors winds the one end of the rope and at the same time it rewinds the other end of the rope. With this winding operation we get that the one skip at the one end of the rope moves up, and at the same time the other skip at the other end of the rope moves down. The skips can reach a speed of up to 15 m/s.

When the skip arrives at the surface of the shaft, the rock is automatically thrown onto a conveyer belt that transports the ore to the gold plant.

**Determining the baseline**

**Characterisation**

In order to determine the baseline (a model of what the electricity demand would have been if the proposed DSM activities were not implemented) and calculate the impacts for the project, it was necessary to quantify the following variable in half hourly intervals: the actual total rock winder load (kW) prior to implementation.

The above mentioned parameter must be quantified again after the implementation of the DSM activities to determine the impact.

Before implementation there was no form of automated metering installed on the rock winder motors targeted by the DSM intervention for load shifting. The M&V team was provided with data supplied by the ESCo and the baseline was developed by using the data supplied.

The ESCo used data for a two month period to compile a preliminary baseline (feasibility study). Fig. 2 below shows the pre-implementation load profile (baseline), as calculated by the ESCo, and the expected
post implementation load profile (optimised profile). The proposed load shift can clearly be seen from the post implementation load profile.

In Fig. 2 it can be seen that the load will be reduced during the evening peak period and distributed to other periods of the day. However this calculations made by the ESCo should then be measured and verified by the M&V team.

**Baseline adjustments**

Baseline adjustments will be needed when the DSM project is expanded to include other parts of the rock winder motor system not included in the scope of the current DSM project.

**Periodical recalculation**

Every time a performance tracking report is submitted the baselines (weekday, Saturday and Sunday profiles) will be recalculated for each day of the month. This is done so that the baseline electricity profiles for the rock winder system takes load growth into account. In this way the baselines remain accurate even when more rock is hoisted in one month and less in another. For the period under consideration the baseline will be recalculated (when developing

**Demand baseline**

The baseline was developed from the data obtained for the pre-implementation period. The baseline profile consists of the average half hourly kW values for a weekday, Saturday and Sunday. The demand baseline for the rock winder system for each day type is provided in Fig. 4. However the ESCo intend to do load shifting only on weekdays and not on weekends.

The demand baseline profile data provided in Fig. 4 will thus be used to describe the pre-implementation conditions of the rock winder motor system’s electricity use. This baseline profile will remain unchanged (except for the periodical re-calculation) throughout the savings determination unless baseline adjustments become necessary.

Out of the demand baseline profiles it can be seen that there is 3,75 MW available for shifting between 18h00 and 20h00 on weekdays, which means there is enough capacity available to shift a load of 3,3 MW in Eskom’s peak period of between 18h00 and 20h00.

**Electricity consumption baseline**

The daily energy consumption baseline value is obtained by adding all the half hourly kW values over the 24-hour period and by dividing the sum of all these values by two. The electricity consumption baseline can thus readily be calculated from the demand baseline profile by subtracting the actual energy consumption from the daily baseline.

**Statistical analysis**

A statistical analysis was performed on the baselines above. The weekday baseline for the rock winders is shown in Fig. 5 along with the upper- and lower confidence limits. These limits provide a 95% certainty bandwidth within which the baseline values will be 95% of the time.

If the average kW value over the 24-hour period along with the corresponding confidence interval (for 95% certainty) averaged over each hour is considered, it is seen that the confidence interval is on average 15% of the weekday baseline value. It can thus be said that the baseline provides a relatively accurate representation of the pre-implementation operation of the rock winder system.

We are thus confident that the weekday baseline provide an accurate representation of the pre-implementation operational conditions and will be sufficient for the determination of the project impacts after implementation.

**Savings calculations**

Steps for the savings calculations

After the implementation was done, the savings was calculated with the formula:

\[
\text{Impact} = \text{baseline} - \text{actual} \pm \text{adjustments}
\]
The following steps were followed to determine the impact:

Step 1: Gather the 30 minute post-implementation data for one month.

Step 2: Calculate the total kWh per day used for every day from the actual (post-implementation) data.

Step 3: Calculate the ratio between the pre and post implementation daily kWh for each day.

Step 4: Adjust the baseline by multiplying with the ratio calculated in step 3 for each day.

Step 5: Determine an average weekday profile for the actual and the baseline.

Step 6: The savings can now be calculated by subtracting the actual profile from the baseline profile.

Results

A three month performance assessment period was used to determine the performance of this project. The ESCO was contracted to save on average 3.3 MW over a year. The impact during the evening peak was 2.7 MW in the 1st month, 1.1 MW in the 2nd month and 0.9 MW in the 3rd month. On average the impact during the evening peak for these three months was 1.6 MW which gives a under performance of 1.4 MW on average.

However during the performance assessment period there were a lot of maintenance on the winders and the winders were forced to work during peak hours to catch up the back log of rocks that needs to be hoisted to the surface.

Thus by doing the savings calculations again and by taking into consideration that the rock winders were forced to work during peak times due to unforeseen events outside the control of the ESCo; the savings was then recalculated and the maintenance days were ignored in the savings calculations.

The following results were obtained: 3.1 MW, 2.8 MW and 3.2 MW respectively, giving an average of 3 MW. Thus it could be said that this project is working but due to unforeseen events outside the control of the ESCo the target was not reach during the performance period.

Conclusion

To conclude; the M&V method described in this paper to M&V a winder load management project was a success therefore this method can be used on other winder load management projects.

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