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Report

Energy Saving Action Plan

Narrabri Mine

Narrabri Coal Operations Pty Ltd

11 August 2014

Rev 4 (Final)

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Report Details

Energy Saving Action Plan - Narrabri Mine

Filename: 12593 Narrabri Mine Energy Saving Action Plan Rev 4.docx

Job #: J0130067 Folder #: F12593

Revision: 4 (Final)

Date: 11 August 2014

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EXECUTIVE SUMMARY

A summary of the all the opportunities that were viable is described in the table below:

Description of opportunity	Electricity savings	LPG savings GJ p.a.	Diesel Cost Savings $ p.a.	Energy cost savings $ p.a.	Other cost savings (e.g. maintenance) $ p.a.	Total cost savings $ p.a.	Capital cost $ total (ex GST)	Simple Payback (years)
Air Compressor	**$ p.a**							
Efficiency Upgrade	-2,220	0	~$733,000	-$333,000	~$300,000	$400,000	$600,000	1.5
Heat recovery	0	888	0.00	$37,068	0	$37,068	$20,000	0.5
Ventilation	**MWh p.a**							
Main ventilation fan, 3 fans at lower speed	2,015	0	0	$280,000	0	$280,000	$0	0
Auxiliary ventilation fans replacement	1,182	0	0	$165,000	$300,000 once off	$165,000	$705,000	2.5
Water pumping	**MWh p.a**							
Dam SB1 water transfer pump replacement	30	0		$4,050	$0	$4,050	$22,355	5.5
RO time shifting	0	0	0	$39,000	$0	$39,000	unsure	?
Investigation of pipe size	13-182	0	0	$2,000-$25,000	$0	$2,000-$25,000	unsure	?
Emulsion leaks on the Longwall	**MWh p.a**							
Leakage cost summary	680	0	0	$45,730	$133,720	$179,445	unsure	?
Drift conveyor slowdown	**MWh p.a**							
Slow down to 75% of full speed when belts are unloaded	458	0	0	$52,678	0	$52,678	$0	0
Lighting	**MWh p.a**							
Lighting upgrade	196	0	0	$27,494	0	$0	$560,290	20.4
CSG generation	**MWh p.a**							
Installing electricity generating equipment is now not possible due to energy for recovery of solution								N/A
TOTAL*		**888**	**0**	**$380,097**	**$4,315,680**	**$5,401,283**	**$1,397,654**	**1.7**

In addition, there are a number of low cost opportunities that could be implemented (e.g. fitting timers, motion sensors and energy saving tip stickers where relevant) in the office areas, and bath house. Although the savings are relatively small, simple initiatives will reinforce to staff the need to constantly look for energy saving opportunities at the mine.

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APPENDICES

1. INTRODUCTION

Advitech Pty Limited (Advitech) was engaged by Narrabri Coal Operations Pty Ltd, a wholly owned subsidiary of Whitehaven Coal Limited (Whitehaven), to prepare an Energy Saving Action Plan (ESAP) for the Narrabri Mine. The specific request was that the ESAP include a Level 3 Energy Audit.

It should be noted that this report was prepared by Advitech Pty Limited for Narrabri Coal Operations Pty Ltd ("the customer") in accordance with the scope of work and specific requirements agreed between Advitech and the customer. This report was prepared with background information, terms of reference and assumptions agreed with the customer. The report is not intended for use by any other individual or organisation and as such, Advitech will not accept liability for use of the information contained in this report, other than that which was intended at the time of writing.

2. BACKGROUND AND OBJECTIVES

Narrabri Mine is located approximately 30km south-south-east of Narrabri and 10km north-north-west of Baan Baa. The Mine Site covers an area of approximately 5,298 ha the majority of which is located on land owned by Narrabri Mine.

Project Approval (PA) 05_0102 for the Narrabri Mine (Stage 1) was granted by the Minister for Planning in 2007, which permitted the mining and rail transportation of up to 2.5 million tonnes per year of run-of-mine (ROM) coal for a period of 21 years. Works for Stage 1 began in 2008. Stage 2 operations were subsequently approved by the Minister for Planning in July 2010, via PA 08_0144, which provides for the extraction of up to 8 Mt pa of coal utilising Longwall mining methods.

The project comprises a coal mine with underground facilities currently consisting of development panels, Longwall unit, continuous miners, ventilation fans, conveyors, water pumps and ancillary services as well as surface facilities consisting of administration offices, a bathhouse, workshops, coal stockpile areas, coal crushing, rail load out train loader, surface ventilation fans and surface water pumps. The site currently employs 190 full time staff and 108 contractors.

Opportunities to minimise energy consumption and greenhouse gas (GHG) emissions across the site have been a central consideration to the design and engineering of the mine development and wherever practicable energy efficiency measures have been implemented into the mine's infrastructure and operations philosophy.

The Stage 1 Approval required the preparation of an ESAP and in August 2011 Narrabri Mine updated the ESAP as a condition of consent for the Stage 2 Approval (Clause 30). Specifically the consent required:

> *Energy Savings Action Plan*
>
> *30. The Proponent shall revise the Energy Savings Action Plan for the Stage 1 project to encompass all proposed mine activities and potential impacts associated with energy management for the site (Stages 1 and 2) and subsequently implement this revised version of the Energy Savings Action Plan to the satisfaction of the Director-General. This plan must:*
>
> > *(a) be prepared in consultation with DECCW;*
> >
> > *(b) be prepared in accordance with the Guidelines for Energy Savings Action Plans (DEUS, 2005), or **its latest version;***
> >
> > *(c) be submitted to the Director-General for approval prior to 30 June 2011;*
> >
> > *and*

> *(d) include a program to monitor the effectiveness of measures to reduce energy use on site.*

The 2011 ESAP was an update of the original plan prepared in 2008. The plans were prepared in accordance with the Guidelines for Energy Savings Action Plans, produced by DEUS in October 2005, and with the associated Guide Notes, as well as in accord with the Federal Energy Efficiency Opportunities Act, 2006.

Within the 2011 ESAP (p.17), Narrabri Mine proposed to:

> *Conduct an external Level 2 or Level 3 Energy audit to identify the next stage of energy efficiency actions following the start-up of near full scale production.*

Additional commitment to undertaking a Level 3 Energy Audit is found in the mines *Greenhouse Gas Minimisation Plan (GGMP) Stage 2 Longwall Project* (June 2012) which has been prepared under Condition 32 of PA 08_0144. The Greenhouse Gas Management Plan acknowledges that:

> *Until the site is operation at approximately 5 to 6 Mtpa, it is difficult to set baseline energy benchmark or even to accurately quantify the true magnitude of the improvement projects already implemented. The conduct of the Level 3 Energy Audit of the mine would be a major milestone in establishing both the benchmark position for energy consumption, additional detailed improvement opportunities and measurement methodologies to capture the quantitative impact of each energy efficiency project undertaken in the future.*

Narrabri Mine Environmental Officer reports that since March 2013, the mine was operating at full production.

3. METHODOLOGY

3.1 ESAP

This revision of the Narrabri Mine ESAP is also prepared in accordance with the Guidelines for Energy Savings Action Plans (October 2005) and with the Federal Energy Efficiency Opportunities Act, 2006. Accordingly, the ESAP includes:

1. Baseline energy determination;
2. Management review;
3. Technical review (Level 3 Energy Audit);
4. Determination of management action and objectives;
5. Plan for implementation.

3.2 Level 3 Energy Audit

The requirements of a Level 3 Energy Audit are described in *AS/NZS 3598:2000 Energy Audits.* A level 3 Energy Audit:

> *"provides a detailed analysis of energy usage, the savings that can be made, and the cost of achieving those savings"*

A level 3 audit is expected to provide a firm estimate of savings and costs with accuracy figures within ±10 % for cost and benefits.

The tasks required to be undertaken, and the deliverables for a Level 3 audit, are detailed in Clause 13.2.1, 13.2.2 and 13.2.3 of *AS/NZS 3598:2000* and are summarised in Table 1.

Table 1: Summary of Level 3 Energy Audit Content

Requirements of a Level 3 Energy Audit
▪ Verbal Report
▪ Full Analysis and report
▪ Metering
▪ Formal presentation to senior managers
▪ Provision of an itemised and prioritised list of recommendations to reduce energy consumption
▪ Detailed recommendations that will allow design and documentation to proceed
▪ Analysis of 24 months bills and comparison with benchmark
▪ Preparation of monthly or seasonal energy consumption profiles
▪ Preparation of energy consumption targets and indicators
▪ Site visit and commenting on major wastes
▪ Tariff analysis
▪ Listing of major uses
▪ Model of energy use
▪ Daily load curves for site
▪ Daily load curves for major plant
▪ Measurement of light levels
▪ Monitoring of temperature and other key parameters
▪ Detailing key aspects of building fabric

Source: AS/NZS 3598:2000 Appendix C

3.2.1 Data Limitations

Narrabri Mine report that full production was achieved during March 2013. Thus, 24 months of data, as required for a Level 3 Energy Audit, representative of full production is not available for the site. While 24 months of data is presented in this audit, baseline levels are calculated from data available while the mine was in full production.

4. MANAGEMENT REVIEW

4.1 Energy Management Review Process

The Energy Management Review is a structured assessment of the systems the organisation has in place for managing energy. The previously conducted Management Review, has been reviewed as part of the ESAP update.

The management review was conducted by Advitech personnel and was carried out in a meeting on 17 April 2013. Attendees included Narrabri Mine's:

- Steve Farrar — Environmental Officer;
- Robert Gow — Manager of Electrical Engineering; and
- Jonathan Pogson — Electrical Engineer.

The purpose of the meeting was to update Narrabri Mine on the ESAP process and to ensure that continued support for energy improvements initiatives is maintained.

4.2 Management Review

Table 2 details the results of the management review update utilising the template provided in the *Guidelines for Energy Saving Action Plans* (DEUS 2005).

Narrabri Mine has identified improvements in the area of Energy Supply Management since the 2011 review. Improvements in this area relate to:

- Formalisation of energy procurement processes; and
- Assessment of alternative energy supply opportunities.

Table 2: Management Review

Review Area	Rating				
	Low	**Moderate**	**Minimum Sustainable**	**Industry Leader**	**Best Practice**
Senior management commitment	• No activity / absent	• Informal management practices	• Executive-level approved energy efficiency policy • Performance against this policy is publicly reported • Major facilities have sub-targets	• Business practices are routinely audited • Business practices are publicly reported	• Organisation can demonstrate that energy management is ingrained into corporate culture
Understanding of energy savings potential	• No activity / absent	• Informal management practices	• Energy audit undertaken to inform improvements in operating and maintenance procedures and capital works	• Cost-effective energy efficiency opportunities are routinely implemented • Energy efficient operation and maintenance procedures in place	• All innovation measures implemented
Energy targets and key performance indicators	• No activity / absent	• Informal management practices	• Energy KPIs established and tracked monthly • Internal benchmarking of similar facilities where applicable	• Energy KPIs are included in job descriptions	• Energy KPIs are benchmarked against world best practice performance and in top quartile
Energy metering and monitoring	• No activity / absent	• Informal management practices	• Monitoring of energy use for all sites against baseline • Monitoring enables access to metering data for major energy users	• Sub-metering installed throughout site • Results reported and tracked at regular management meetings	• All energy consumption sub-metered • Regular board level reporting of energy consumption
Energy management reporting	• No activity / absent	• Informal management practices	• Organisation reports on all savings opportunities including those with long payback periods • Plans and time-frames for implementation are also reported	• Business practices are routinely audited • Business practices are publicly reported	• Organisation can demonstrate that energy management is ingrained into corporate culture
Energy supply management	• No activity / absent	• Informal management practices	• Formal processes in place for energy procurement • Alternative energy supply options are assessed	• Product life cycles studies are carried out	• Organisation acts on product life cycle measures to reduce cradle to grave impacts
Operating and maintenance procedures	• No activity / absent	• Informal management practices	• Operating and maintenance procedures have been included in energy audit/assessment • Energy efficiency improvements will include operating procedures and training	• Product life cycles studies are carried out	• Organisation acts on product life cycle measures to reduce cradle to grave impacts
Accountabilities for energy management	• No activity / absent	• Informal management practices	• An executive-level manager is accountable for energy management • Energy management team coordinates energy management activities	• Energy KPIs are included in job descriptions	• Energy KPIs are benchmarked against world best practice performance and in top quartile
Training and awareness procedures	• No activity / absent	• Informal management practices	• Basic energy-awareness activities are in place • Energy management training is provided to operations and maintenance teams	• Business practices are routinely audited • Business practices are publicly reported	• Organisation can demonstrate that energy management is ingrained into corporate culture

4.3 Energy Management Actions

The 2011 ESAP was produced prior to the commencement of Longwall mining at the mine. However, several management actions were proposed to occur prior to this time. **Table 3** provides an update of the status of the proposed actions from the 2011 ESAP.

Table 3: Status of Energy Management Actions from 2011 ESAP

	Energy Management Improvement Actions (2011 ESAP)	Status and Comments	Planned Completion Date	Responsible
1	*Assign responsibilities for energy usage and management by functional areas across the site*	Completed 30 June 2009	Complete	N/A
2	*Add energy management to the agenda for site management meetings where progress and implementation of this Action Plan will be discussed*	Add energy management slide to Technical Services Presentation for monthly meetings.	Before next monthly meeting	Steve Farrar
3	*Develop and report monthly site-based reports of electrical energy usage for the different areas across the site using On site SCADA / Energy Metering system. Report at monthly meetings*	JP to implement kWh/tonne mined or washed through CHPP.	Before July 2014	Jonathon Pogson Steve Farrar
4	*Develop and report on energy targets for the different areas across the site*	Not yet carried out. Set targets when SCADA reporting is implemented.	SCADA, KPIs by May 2014, review in May 2014 (12 months since full production). See Table 4	Jonathon Pogson
5	*Monitor and report on the Key Performance Indicator for energy use across the site operations*	Level 3 Energy Audit developed KPI based on full production scenario of 11.29kWh/tonne mined. Revise target when at full production for 1 year.	May 2014 See Table 4	Steve Farrar
6	*Develop comprehensive guidelines for energy management and include as part of standard operation and maintenance procedures*	Completion of this step is dependent upon the install and operation of relevant metering, and understanding variability of KPIs which can then be used to set the standard/KPI. Revise target when at full production for 1 year.	May 2014 See Table 4	Steve Farrar
8	*Optimise pick length on Longwall mining equipment to maximise energy efficiency and minimise coal fines*	Completed:1 January 2011	Completed	N/A

	Energy Management Improvement Actions (2011 ESAP)	Status and Comments	Planned Completion Date	Responsible
9	*Establish a Site Energy Management Committee to routinely review and report on energy management initiatives and ensure compliance with formal reporting conditions for both ESAP and EEO*	First meeting in conjunction with current Energy Audit	Complete - 1st meeting held 30 July 2013. Plan to meet every 12 months.	Steve Farrar
10	*Conduct an external Level 2 or Level 3 Energy audit to identify the next stage of energy efficiency actions following the start up of near full scale production*	Completed as part of current ESAP - June 2013	Complete	N/A
11	*Develop generic energy efficiency training modules for relevant staff to ensure energy efficiency awareness is raised and ownership for energy efficiency improvement is spread throughout the organisation*	Not yet carried out Issue Tool Box Talk as done at open cuts, Danny Young to provide examples.	Before July 2014 Transfer to 2014 Management Activities (Table 4)	Danny Young
12	*Establish an energy efficiency improvement suggestions scheme for mine personnel to capture and reward energy efficiency initiatives from staff*	Use existing improvement form 'WHC_FRM_NAR_IMPROVEMENT SUGGESTION'. Need to communicate to personnel that committee established and opportunities can be reported. Also need to communicate that Josh Martin is an additional contact for UG personnel.	June 2014 Transfer to 2014 Management Activities (Table 4)	Steve Farrar

Table 4 summarises the energy saving actions proposed during the kick off meeting for the 2013 Audit for Narrabri Mine. It is apparent in Table 4 that the generation of automated reports from SCADA and the provision of this information to management is a key area for energy management improvement and is the basis of improvement in four review areas:

- Reviewing energy metering and monitoring;
- Understanding of energy savings potential;
- Providing a baseline for energy management reporting; and
- Setting energy targets and KPIs.

The SCADA reports are especially important as Narrabri Mine KPIs are currently based on limited data due to the recent commencement of full production. Section 5.7, highlights the necessity to review SCADA data in relation to KPI suitability (along with trends) as more full production data becomes available.

Table 4: Energy Management Actions for 2013

Review Area	Energy Management Improvement Actions	Responsibility	Planned Completion Date	Actual Completion Date
Senior management commitment	Include the commercial manager in energy management team meetings	Steve Farrar	July 2013	30 July 2013
Understanding of energy savings potential	Energy Audit inclusions • Compressed air; • Ventilation system; • Water - pumping and what goes in; • Hydraulic bypass and leaks on Longwall face; • Gas drainage system	Level 3 Energy Audit by Advitech	July 2013	July 2013
Energy targets and KPIs	Establish energy KPI's for each operational area over time ▪ Improve functionality of SCADA system	Jonathon Pogson	Recalculation of annual KPI in May 2014 will be based on 12 months of 'real' data	N/A
Energy metering and monitoring	Improve functionality of SCADA system to management system ▪ Ongoing. information should at a minimum allow for the calculation of KPI - kWh/tonne mined/washed	Jonathon Pogson	July 2014	N/A
Energy management reporting	Generate automated report from SCADA and provide to management,	Jonathon Pogson	July 2014	N/A
	Investigate diesel and LPG use reporting and resolution ▪ Is there potential for daily or equipment level data collection and reporting ▪ Consider development of specific diesel and/ or LPG KPIs	Jonathon Pogson	July 2014	N/A

Review Area	Energy Management Improvement Actions	Responsibility	Planned Completion Date	Actual Completion Date
Energy supply management	Continue with energy brokerage negotiation when contract expires	Dean Lawrence (Commercial manager)	As needed	Ongoing
Operating and maintenance procedures	Investigate energy management procedures ▪ Use tool box talk to inform work force of following initiatives	Steve Farrar	July 2014	N/A
	Use of energy efficient lighting ▪ Capital ~$95k, payback in <3 yrs. Engage L&S to undertake an audit of typical conveyor installations (i.e. MG103 belt (moveable) and trunk belt (fixed)) to identify efficiency opportunities. Replace identified lights as per maintenance schedule.	Robert Gow	Audit completed before December 2013	N/A
	Installation of sky lights and PV cells in workshops ▪ PV cells/timers installed on outside lights and main car park. Investigate options for motion detectors/sky lights for stores/workshop. Must maintain minimum lighting at all times.	Steve Farrar	July 2014	N/A
	Installation off instantaneous hot water systems in bath houses	Construction Project Manager	Complete	2010
	Installation of VVVF drives on conveyors (except small ones underground) for softer start	Construction Project Manager	Complete	2009
	Use of VVVF drives on larger pumps. No plan for VVF on small pumps	Construction Project Manager	Complete	2010
	Installation of Solar Lighting use in bottom car park	Site Civil Engineer	Complete	2012

Review Area	Energy Management Improvement Actions	Responsibility	Planned Completion Date	Actual Completion Date
	Air Conditioning Upgrade for main Administration Building ▪ Install 3-pipe AC system to allow heating/cooling in different areas as this cannot be done currently. ▪ NCO recently purchased bar heaters as some offices are colder than others. Investigate costs further. Could also result in boosting workforce morale.	Jonathon Pogson	Ongoing	N/A
Accountabilities for energy management	Include the commercial manager in energy management team meetings	Steve Farrar	July 2013	30 July 2013
Training and awareness procedures	Toolbox talks and investigate energy management options communicated with relevant staff ▪ Aim to raise awareness and ownership for energy efficiency improvements	Steve Farrar Danny Young to provide examples	July 2014	N/A
	Establish an energy efficiency improvement suggestions scheme for mine personnel to capture and reward energy efficiency initiatives from staff ▪ Use existing 'WHC_FRM_NAR_IMPROVEMENT SUGGESTION' form. ▪ Communicate to personnel that committee established and opportunities can be reported. ▪ Communicate that Josh Martin is an additional contact for UG personnel	Steve Farrar	Before July 2014 (From 2011 ESAP)	N/A

5. BASELINE ENERGY USE

5.1 Projected Energy Usage

Narrabri Mine's previous ESAP (2011) documented energy use (electricity) for the site for the construction period between 2008 and 2011. The ESAP also projected electricity use for the site for the remaining construction and operational periods until June 2014. **Table 5** updates the previous ESAP data and projections with the audited data from April 2012 to March 2013.

Table 5: Projected and Audited Energy Use from 2008 to 2013

Parameter	Projected Electricity Usage					Current Data
Year	1July 2008 - 30 June 2009	1 July 2009 - 30 June 2010	1 July 2010 - 30 June 2011	1 July 2011 - 30 June 2012*	1 July 2012 - 30 June 2013	1 June 2012 30 May 2013
Electricity Use (GWh pa)	28.429	22.733	27.245	162.53 *(19.95)*	163.59	48.2
Diesel Use (kL)						2,514
LPG Use (kL)						32
Total Energy (GJ)						271,641
GHG Emissions (tCO2e)	30,294	24,225	29,032	173,189	174,323	
Production State	Construction	Construction	Construction	Construction	Commissioning	Full Production from March 2013
Production (tonnes)	0	111	232,983	1,863,705 *(220,542)*	5,381,605	3,676,806
KPI (kwh/tonne)	-	204,800	1,169	87.21 *(90.4)*	30.4	13.12

* Italicised text reflect real data for the 2011 – 2012 financial year.

Source of base table: Narrabri Mine Energy Savings Action Plan (5 August 2011)

Worthy of noting that in **Table 5** the projected energy use for Narrabri Mine 2012 to 2013 is vastly greater than the current real data. The projected data calculations of the 2011 ESAP assumed full production for the entire period whereas the current data (shaded grey) includes real data whereby full production operations are only represented in the period March 2013 to May 2013 and data subsequently extrapolated to represent an annual consumption. This discrepancy is further discussed in **Section 6.1**.

5.2 Energy Baseline Reporting Period

Baseline energy consumption was provided for the 24 months April 2011 to March 2013. Note that only data from March 2013 is reflective of a full production operational period. Section 3.2.1 comments on data limitations associated with the baseline reporting period.

Table 6 provides a summary of the baseline energy use at Narrabri Mine for the twelve month period between June 2012 to May 2013. The information is shown graphically in Figure 1 and Figure 2 which provide a breakdown of energy use by gigajoules and cost ($), respectively. Note that only March 2013 to May 2013 represent full production on site.

Table 6: Energy Baseline: Reporting Period June 2012 to May 2013

Energy Type	MWh pa	GJ pa	%	Energy Cost $ pa	GHG tCO_2-e pa	Cost $/GJ
Electricity	48,257	173,727	64%	$ 6,636,525	43,432	$ 38.20
LPG	-	841	0.3%	$ 35,539	50	$ 42.23
Diesel	-	97,073	35.7%	$ 3,260,901	6,747	$ 33.59
Total	**48,257**	**271,641**	**100%**	**$ 9,932,965**	**50,229**	

Notes to Table 6

1. Costs exclude GST

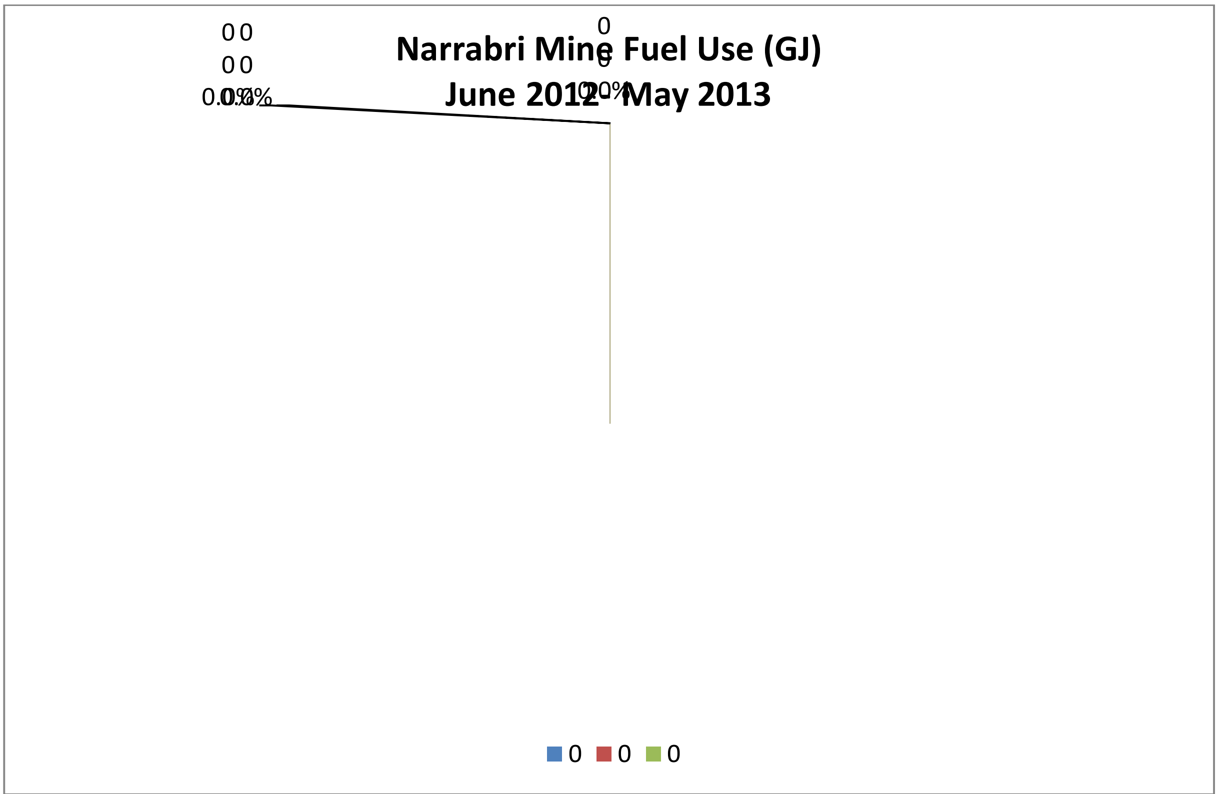

Figure 1: Narrabri Mine Energy (GJ) Split (June 2012 to May 2013)

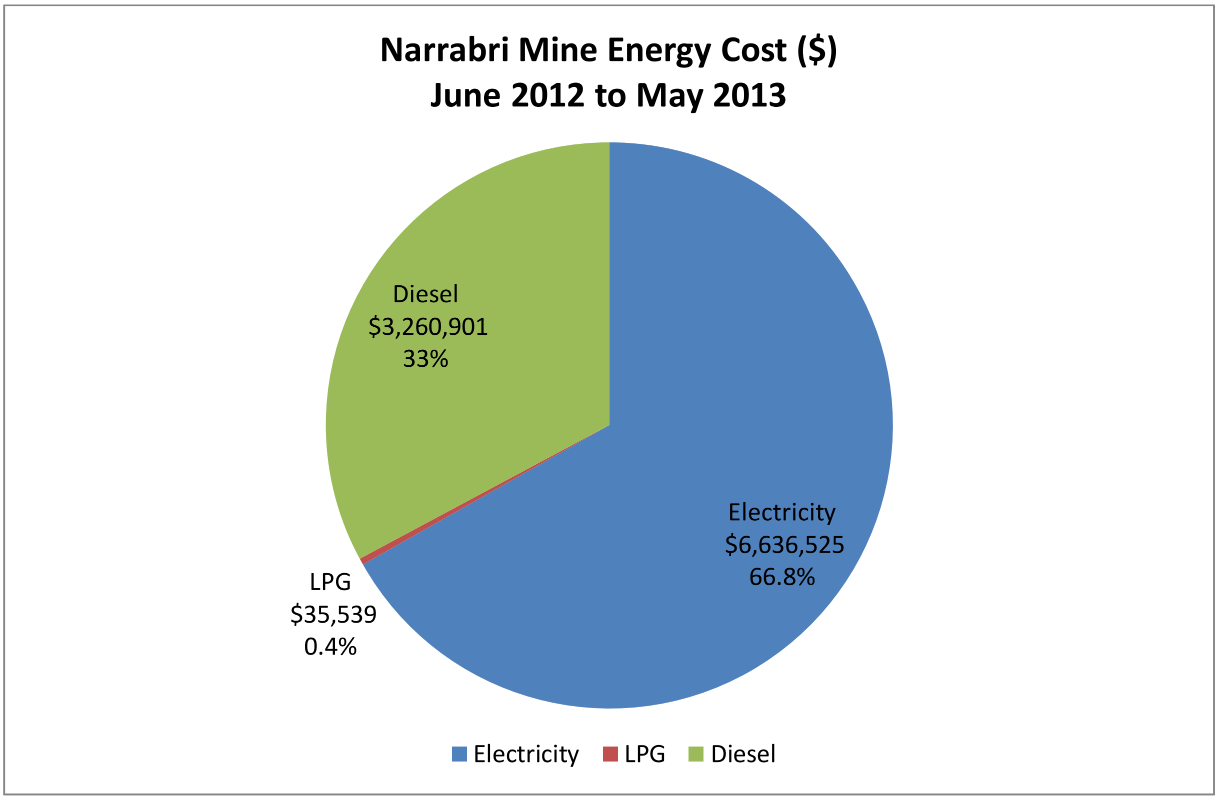

Figure 2: Narrabri Mine Energy ($) Split

Table 7 provides the energy baseline based on 3 months of data (March 2013 to May 2013) of full production at the mine. Extrapolation of the electricity use data from this period estimates an annual electricity consumption of 59,262 MWh.

Table 7: Energy Baseline: Full Production Reporting Period March 2013 to May 2013

Energy Type	MWh pa	GJ	%	Energy Cost $	GHG tCO2	Cost $/GJ
Electricity	14,813	53,327	68.5%	$ 1,987,470	13,331.81	$ 37
LPG	-	154	0.2%	$ 6,856	9	$ 44
Diesel	-	24,405	31.3%	$ 819,838	1,696	$ 34
Total	**14,813**	**77,887**	**100%**	**$ 2,814,164**	**15,037**	

Notes to Table 6

1. Costs exclude GST

Figure 3 represents the energy usage split for this full production period, and as expected the diesel usage proportion has dropped compared to the electricity usage on site.

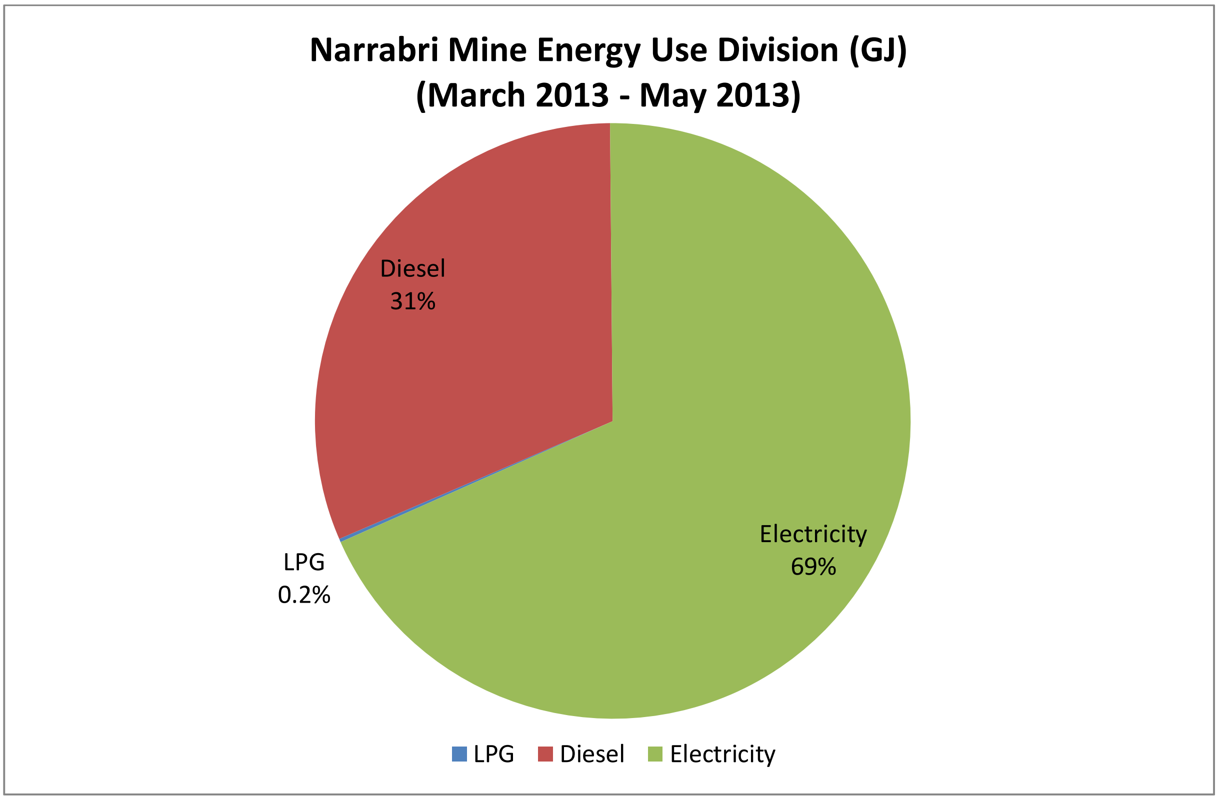

Figure 3: Narrabri Mine Energy (GJ) Split - Full Production Data (March to May2013)

5.3 Electricity Data Analysis

Narrabri Mine has one electricity connection point via National Meter Identifier (NMI) 4001202550. Origin energy supplied 30 minute interval profile data for the meter allowing analysis of electricity use over time for the Narrabri Mine site.

5.3.1 Tariff Analysis

Narrabri Mine currently pays an average price of 13.7 c/kWh (exc. GST) for electricity. Advitech propose to use 14 c/kWh for future energy prices in payback calculations.

The site has a moderate KVA demand cost which varies with the time of use and which makes it important to maintain a good power factor to minimise the maximum demand. See Section 7.3 for more information about Narrabri Mine's Power Factor.

The average electricity price of 13.7 c/kWh excluding GST is reasonable for customers of this size in a country area but is probably 20% higher than metropolitan areas including the Hunter Valley.

The major points from the tariff review are (based on the February 2013 account):

- The network charges are the lowest published tariff (Sub Transmission 3 Rate Demand).
- 14.8% of electricity is consumed in off peak periods, 29.9% in shoulder periods and 55.3% in peak periods.
- Energy (including carbon) accounts for 47% of the total bill, network charges for 40% and other charges (mainly environmental) the remaining 13%.
- Off peak rates are approximately 6 c/kWh lower than peak and shoulder rates which should encourage Narrabri Mine to operate as much equipment on off peak hours as possible.

It is beyond the scope of this review to verify the reasonableness of Essential Energy's network pricing.

5.3.2 Annual Comparison of Electricity Usage

The Annual Electricity Consumption of Narrabri Mine for the 24 month period between April 2011 and May 2013 is presented in **Figure 4**. The consistently increasing usage over the period represents the increasing production activities of the mine as it moved through the development, commissioning to full production operations: Note that only March to May 2013 represents steady state operations. Analysis of consumption trends of larger intervals will be useful when more full production usage data is available, this will help to better describe full operation variability and if there are any regular trends (though there is expected to be no seasonal differences in Narrabri Mine's operation).

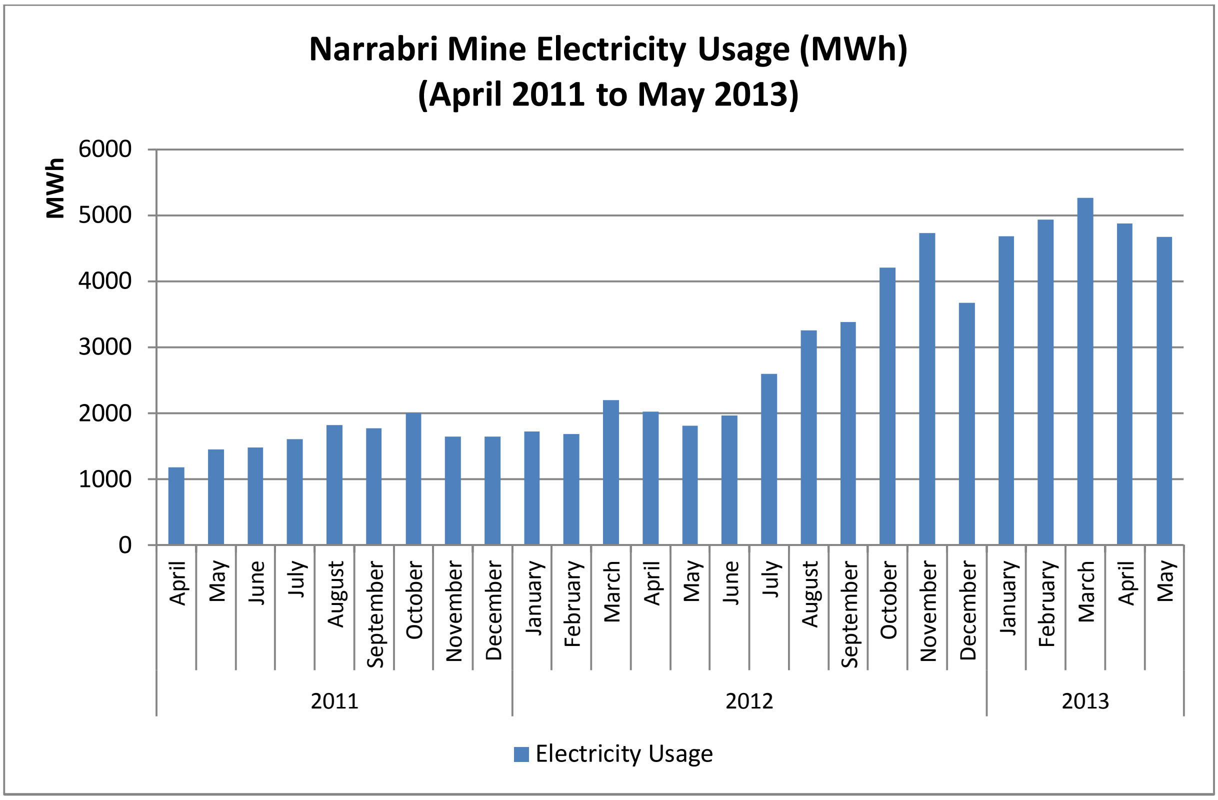

Figure 4: Narrabri Mine Electricity Consumption 2011 to 2013

Figure 5 provides a further analysis of electricity consumption throughout the 24 months between April 2011 to May 2013, highlighting periods of usage (Peak, Shoulder and Off Peak) and allowing comparison of usage by month and year. A consistent pattern of consumption during peak, shoulder and off peak periods can be seen.

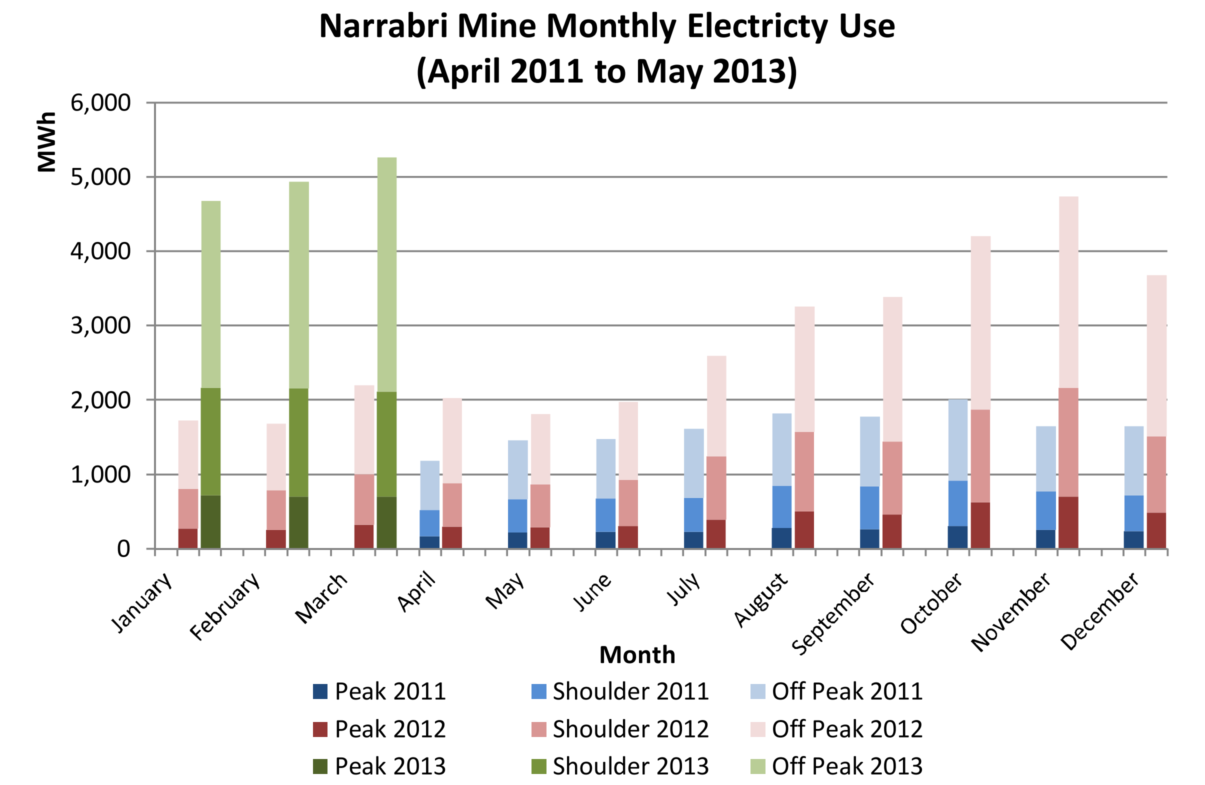

Figure 5: Narrabri Mine Electricity Consumption 2011 to 2013 by Month and Period

5.3.3 Monthly Analysis of Electricity Consumption

Monthly analysis has been carried out only on March 2013 data to represent full production usage. See **Figure 6**. Downtime (presumably for maintenance) can be noted when electricity demand drops below 4,000KVA, this occurred on the following dates of March: 5, 12, 15, 22, 26,

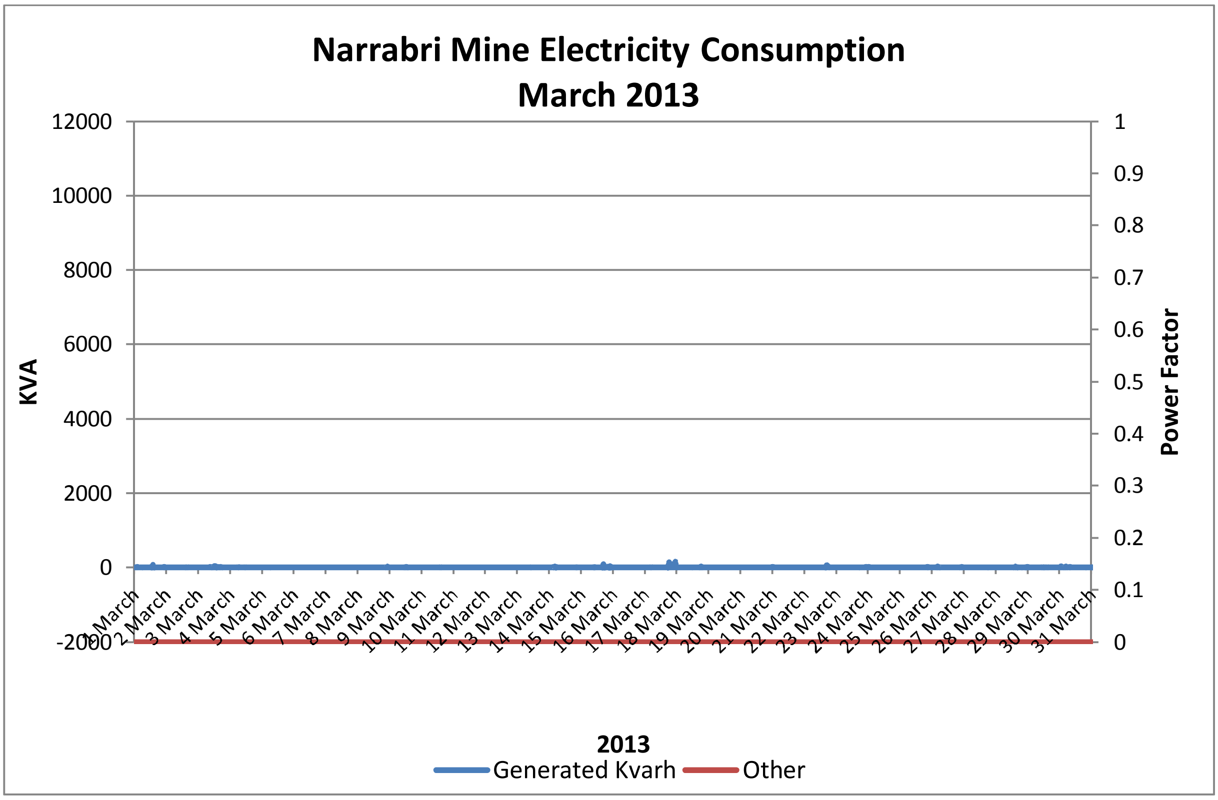

Figure 6: Narrabri Mine Monthly Electricity Consumption for March 2013

5.3.4 Analysis of Weekly and Daily Electricity Data

Figure 7 shows the weekly electricity consumption profile for Monday March 2013 to Sunday 10 March 2013. Figure 8 shows a daily profile within March when the mine is at full production, and lastly Figure 9 shows average weekly consumption during the full production period.

It should be noted that there is a substantial amount of variability in the week (between 3,500-11,000 KVA), most of which occurs in the daily profile (on the day selected, 5,500-10,000KVA) which indicates that most variability occurs within the daily profile (which is usually harder to attenuate than if the variability was by exception, for example once a week or several times a month). The profile of the average weekly profile in the full production period shows Tuesdays scheduled downtime for maintenance, but other than this no strong daily cycles.

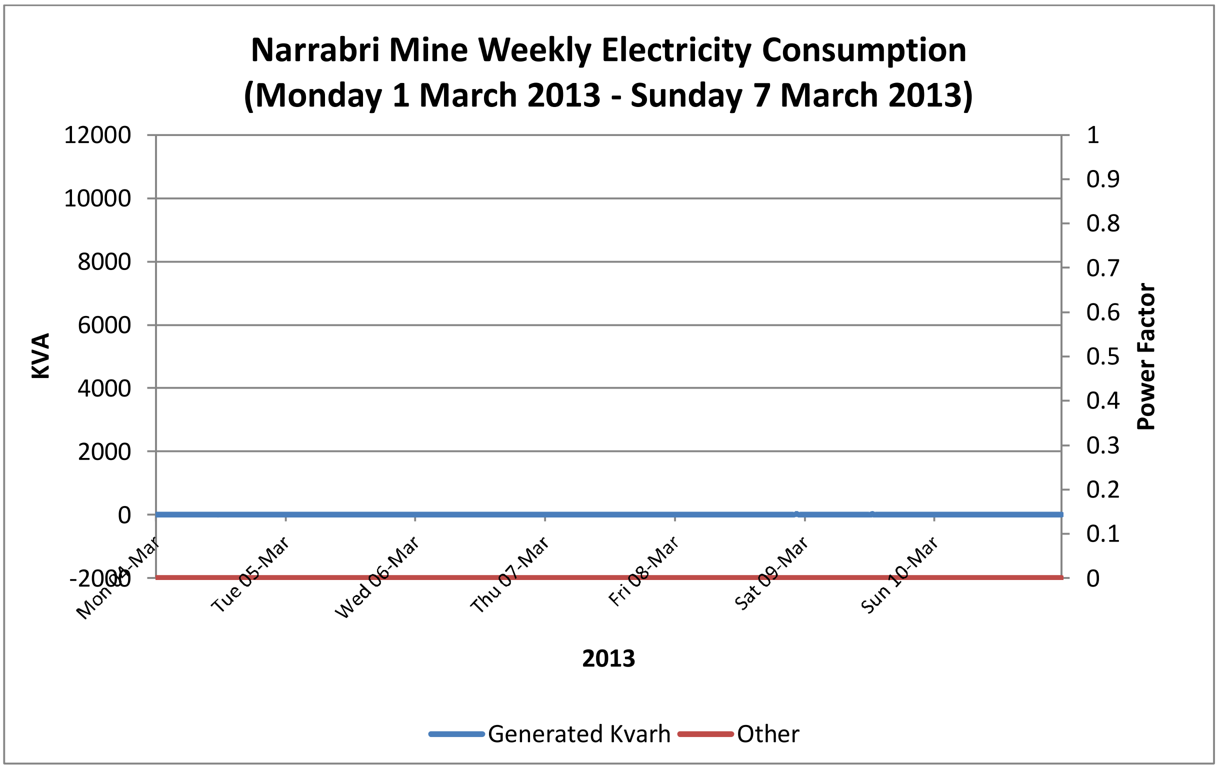

Figure 7: Weekly Electricity Consumption 4 March to 10 March 2013

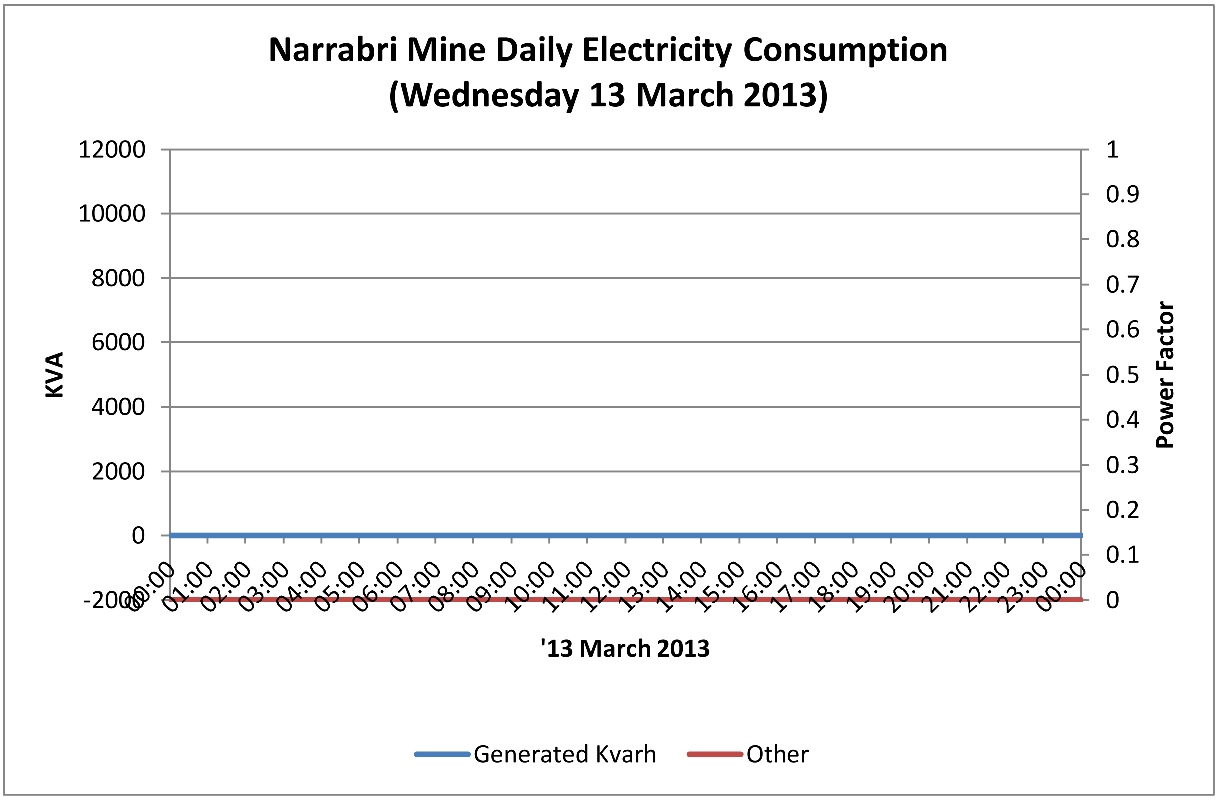

Figure 8: Narrabri Mine Daily Electricity Consumption 13 March 2013

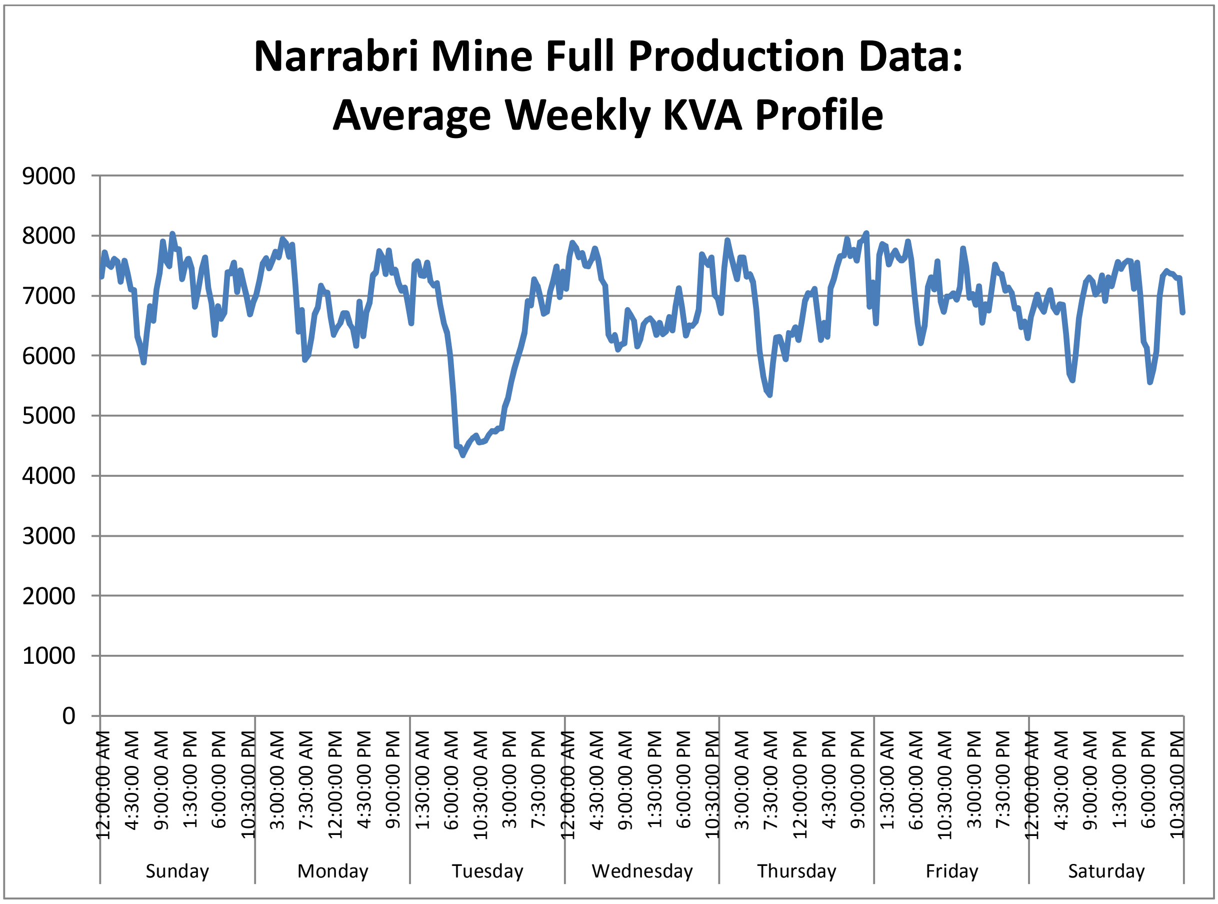

Figure 9: Weekly profile of average KVA during full production

5.4 LPG Consumption

LPG consumption at Narrabri Mine for the period May 2011 to May 2013 is presented in **Figure 10**. Detailed analysis of usage on site of LPG is not possible as data relates to monthly purchase quantities rather than daily usage.

LPG is used at Narrabri Mine for the sole purpose of bath house water heating. Consumption over the 23 month period has been variable although there is a slight trend for increased purchase of LPG during winter periods which may relate to the expected increased use of hot water in the bathhouse at this time of year, or may relate to additional personnel on site during construction and commissioning. LPG consumption would appear to have trended down since September 2012 and reached a stable usage state since the commencement of full production in March 2013.

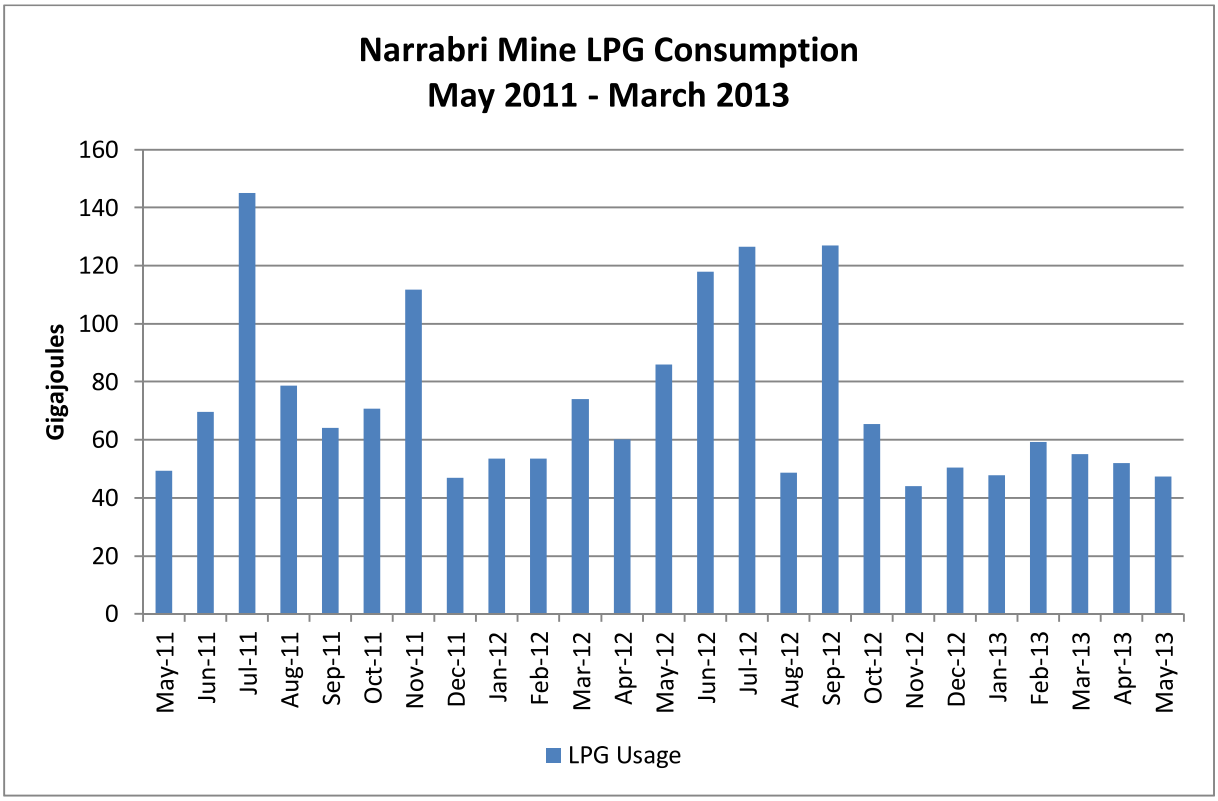

Figure 10: Narrabri Mine LPG Consumption

5.4.1 LPG Tariff

LPG is charged according to the monthly variations in the Saudi Contract Price. LPG Companies routinely fail to correctly pass through decreases in prices with the result that LPG prices always tend to creep upwards. Hence LPG contracts should be negotiated at least every two to three years. Conversion to LNG or CSG should be investigated when these fuels are more commonly available.

5.5 Diesel Fuel Use

The 2011 ESAP reported diesel use for 2010 – 2011 and stated that diesel use during the construction of the mine was relatively high due to the number of non-routine activities associated with earth moving, drilling and running of diesel generators. There was an expectation that diesel use would reduce as the mine moved from establishment mode to full production mode (from March 2013). On current data (to May 2013) it is difficult to confirm if this is the case, although certainly there appears to be a trend towards reduced diesel usage (see **Figure 11**).

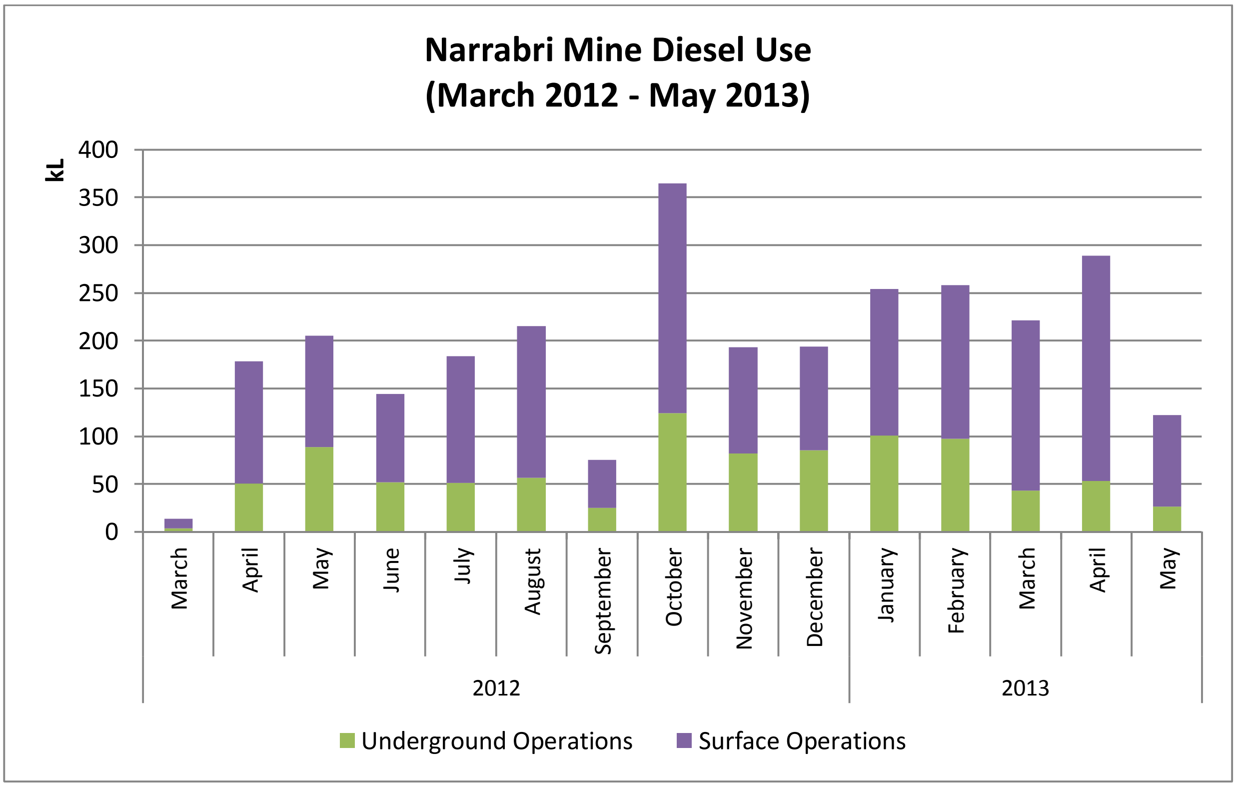

Figure 11: Narrabri Mine Diesel Use (March 2012 to March 2013)

For the 12 month period between June 2012 and May 2013, diesel use constitutes 35.7% of the total site energy usage covering both surface and underground operations (see **Figure 12**. The surface operations component of the diesel usage is the dominant usage consuming 68% of diesel on the site (see **Figure 13**).

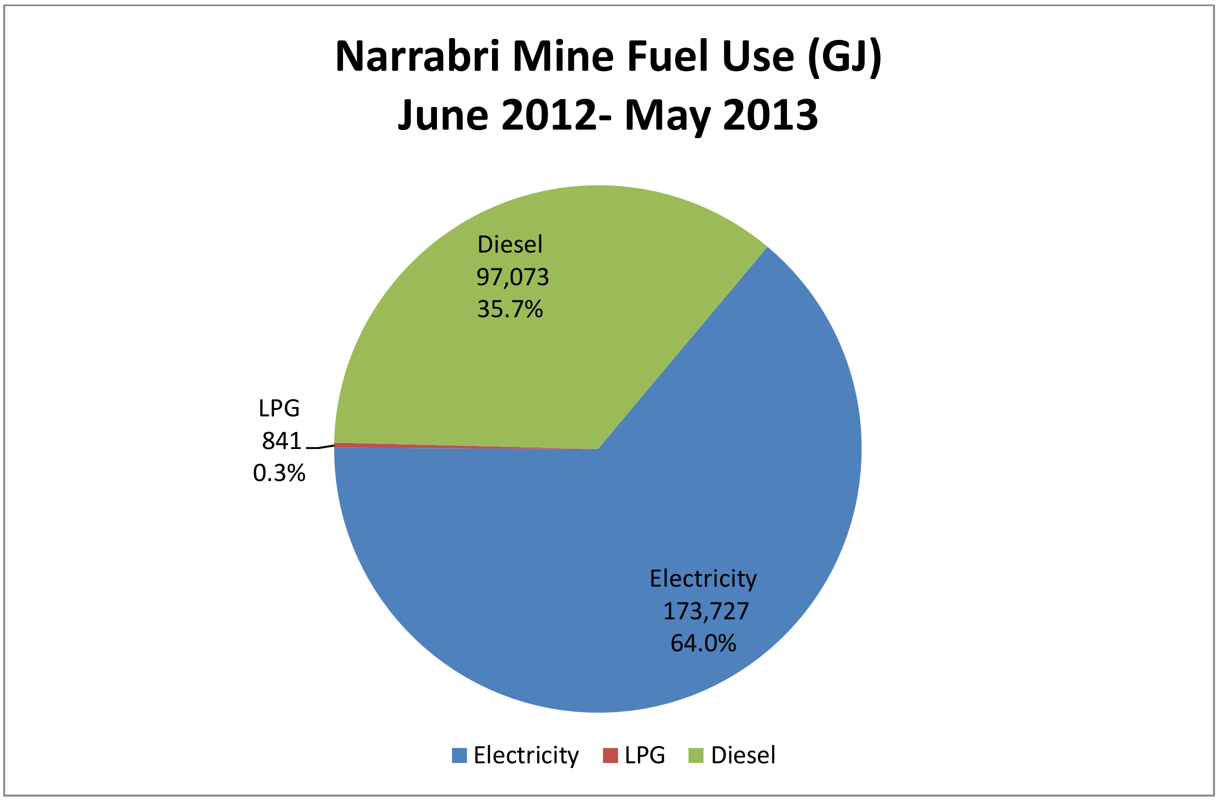

Figure 12: Narrabri Mine Fuel Use Breakdown (GJ)

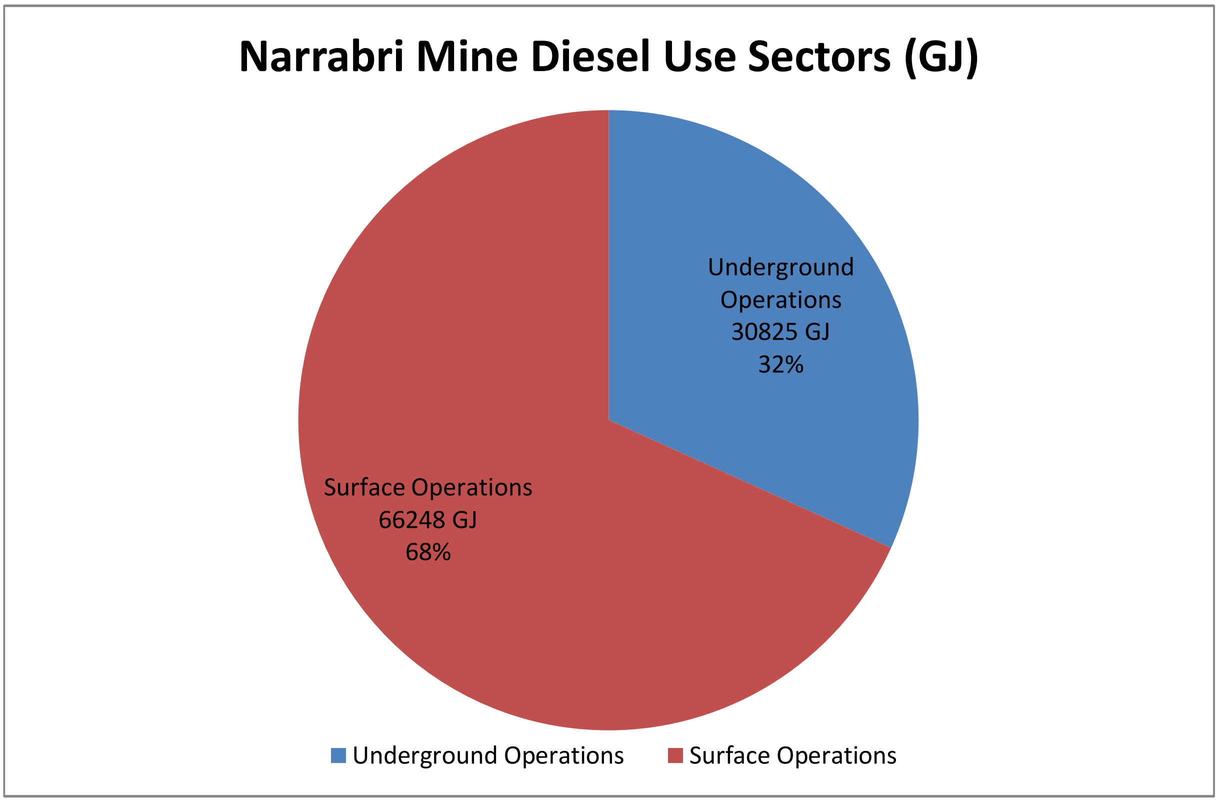

Figure 13: Narrabri Mine Diesel Use Sectors (March 2013 to May 2013)

Analysis of usage since full production started (March 2013 to May 2013) indicates that underground use of diesel is reduced: Underground diesel use constitutes only 19% of the diesel use. The reduction would be consistent with the commentary of the 2011 ESAP relating to reduced diesel use as the mine comes into full production (See **Figure 14**).

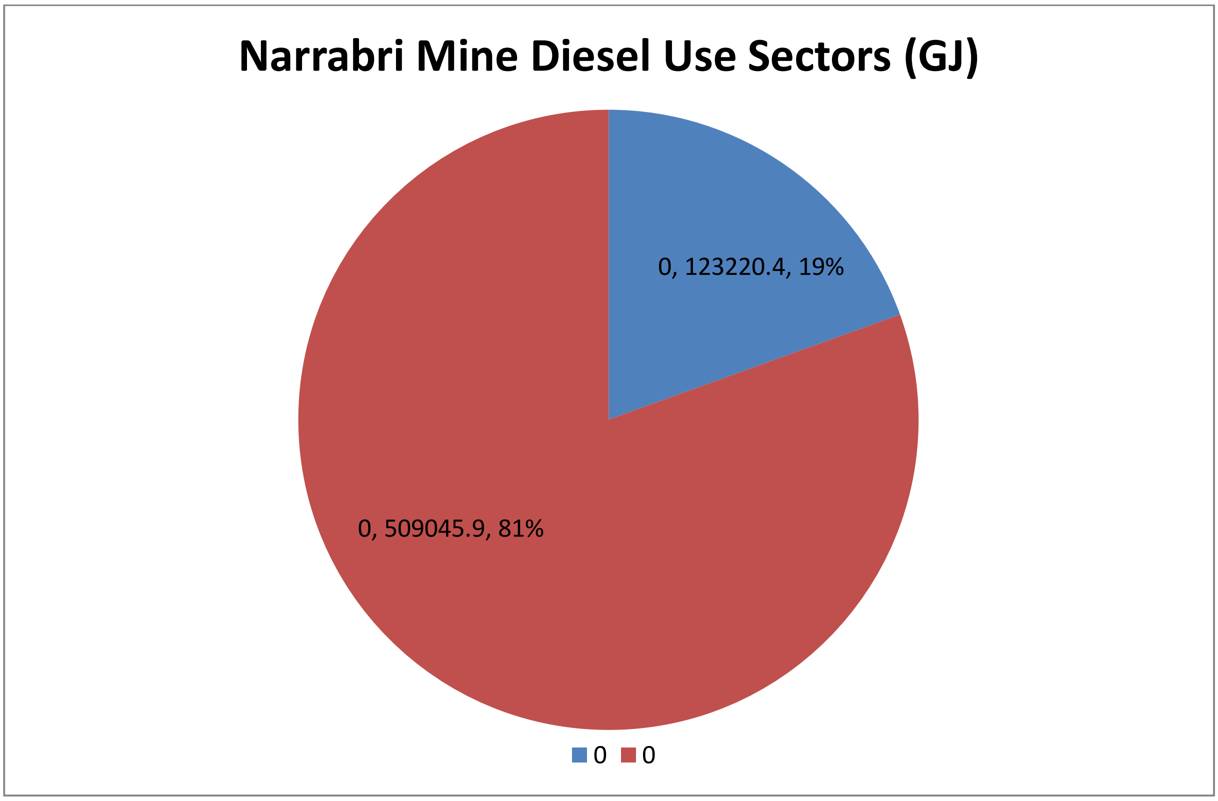

Figure 14: Narrabri Mine diesel use breakdown based on full production data

Underground diesel usage is not recorded at the equipment level. Diesel is transported underground in a 3,000L pod which is parked (13 c/t in C heading of the mains) and used during the shift. It is brought out and refilled when required. The fuel transported in the pod is recorded as 'OPS' (underground operations) on Narrabri Mine's diesel fuel reconciliation sheet. Diesel use underground is for Load Haul Dump (LHD) vehicles and personnel transporters along with one grader.

Dozer use and gas drainage works, such as civil works, generators and excavations are the dominant consumers of diesel on the surface.

Figure 15 presents the breakdown of diesel use for surface operations at Narrabri Mine.

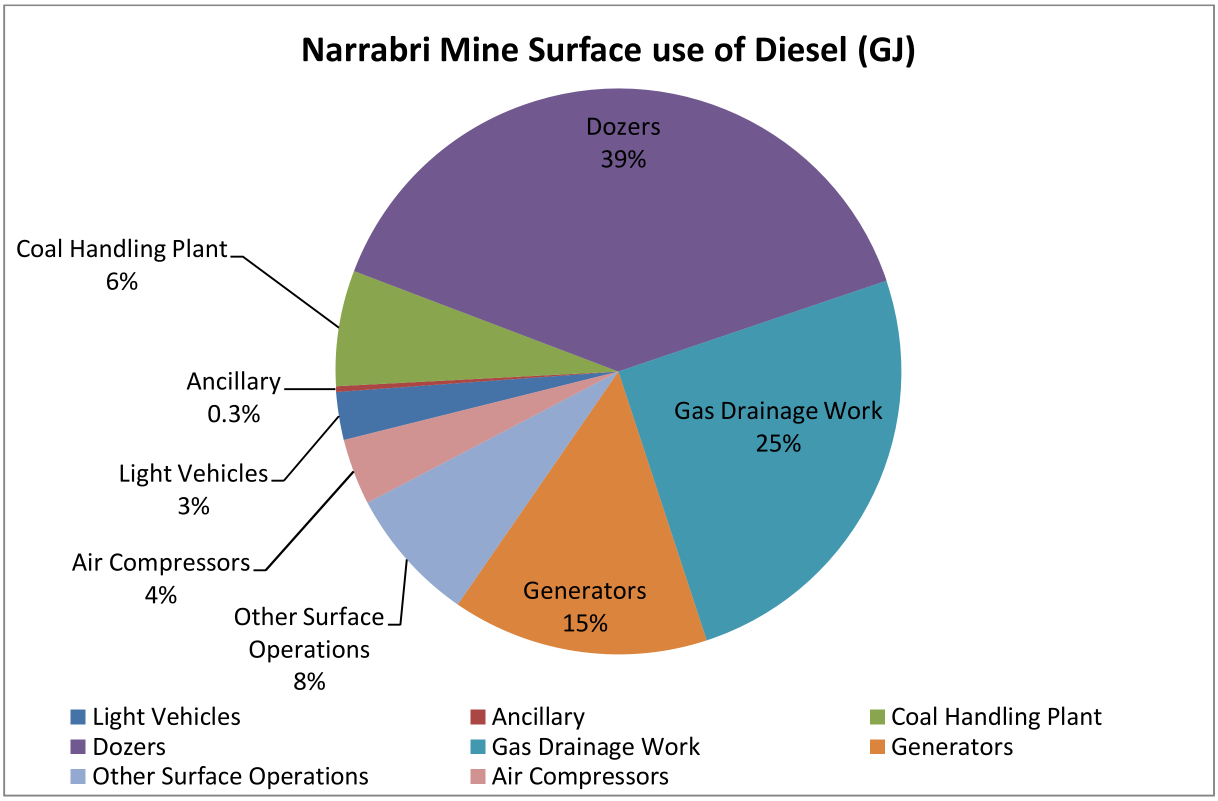

Figure 15: Narrabri Mine Surface Operations Use of Diesel Fuel (June 2012 to May 2013)

5.6 Drivers of Energy Use Change

While there are direct costs associated with energy use, and these are calculated for each opportunity identified in this report, although it should be noted that there are other drivers that support or enhance the opportunities.
These are:

- Increasing energy price: it is forecasted to increase 10% per annum until it will be approximately double current prices by 2020 (though this is not adjusted for inflation/CPI increase)
- Carbon accounting legislative requirements: with or without the Australian Carbon Pricing Mechanism, there is still a requirement to report greenhouse gas emissions through the National Greenhouse and Energy Reporting (NGER) program
- Public accountability: by monitoring and improving energy use (and other onsite resources) this shows good practice in environmental and business leadership and responsibility for resources which support the local community.

Any opportunities identified in this report need to be considered for appropriateness, as some may have external influences (such as safety or planning) that may override the opportunity cost or enhance the prospect.

Opportunities should also be individually considered, as some projects may reduce the savings and effectiveness of others, especially as multiple solutions may affect identical processes and activities.

5.7 Key Performance Indicators (KPI's)

5.7.1 Data Constraints

Narrabri Mine is a new operation with only energy and production figures for March 2013 representing steady state operations. As such, at this point it is pertinent to present only a monthly figure for the amount of energy per tonne of coal produced. Data collection over time will determine variability in energy use and production due to environmental or other factors which may deem an annual KPI as more relevant.

The current ESAP has required a significant amount of engineering assessment of energy flows due to some limited processing of SCADA data. Narrabri Mine are currently developing the full functionality of the SCADA system which will allow tracking of energy use and link directly to energy management. Currently, Narrabri Mine has SCADA systems and sensors installed on most pieces of equipment, but retrieval of data from the SCADA database needs to be determined and programmed, and this needs to be considered for each piece of equipment and embedded in a summary of system performance and energy usage. This will form automatic SCADA reports that can be used to track performance and energy usage.

It is further recommended that Narrabri Mine management develop an energy reporting format that can be incorporated into the management reporting system enabling both maintenance of existing levels of efficiency and verification of improvements through energy savings initiatives.

5.7.2 Production and Development of Energy KPIs

Quantities of coal mined, for the 12 months (April 2012 to March 2013), is represented in **Figure 16** which shows a steady increase in production over the twelve months. Coal mined for the twelve month period between April 2012 and March 2013 was 2,986,527 tonnes however, March to May 2013 is reported to be the only period of full production with a total of 1,311,545 tonnes of coal mined from the Longwall and development components of the mine.

5.7.2.1 Total energy used per tonne of coal mined

The GJ of energy used (electricity, diesel and LPG) per tonne of coal mined (Longwall and Development area) has reduced as the mine has transformed from build to commission to current full production. The energy used during the 12 month period from June 2012 to May 2013 equated to 0.07 GJ/tonne. However, only March to May equates to full production the energy used per tonne of coal during this period is 0.06 GJ/tonne. (See **Figure 16**).

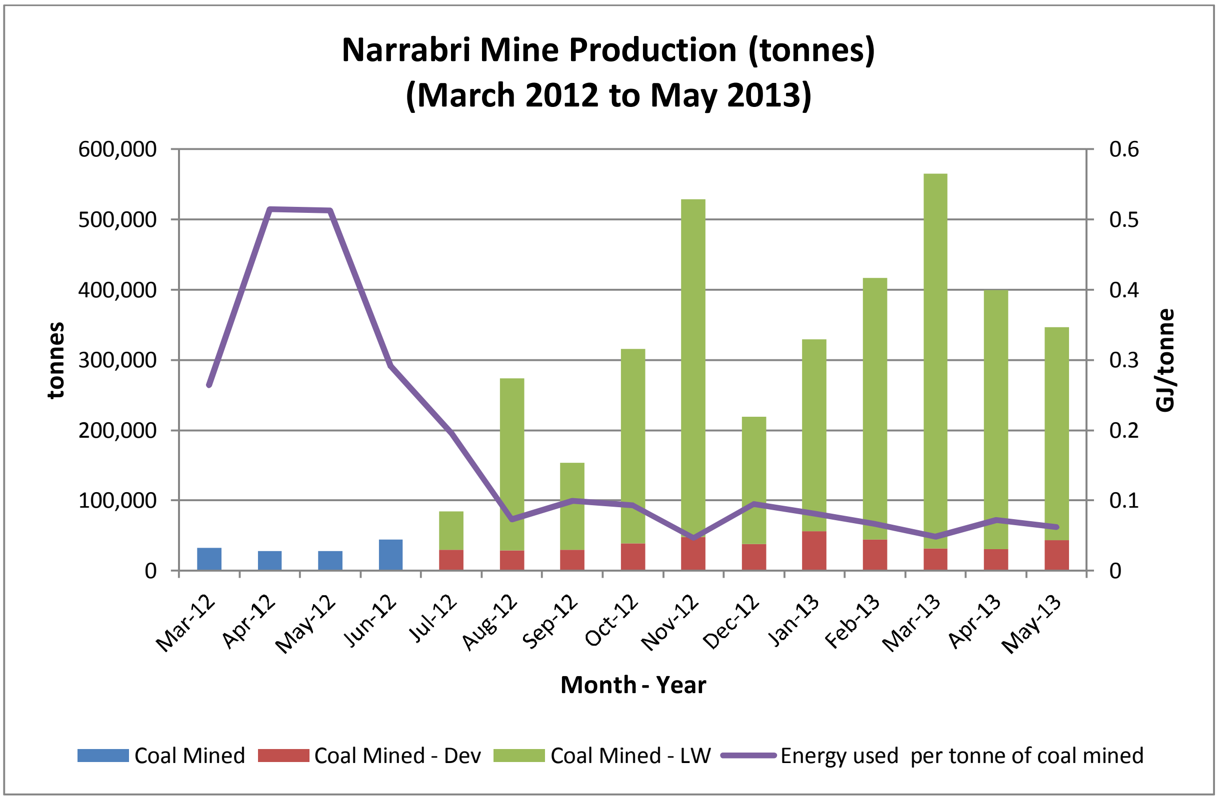

Figure 16: Narrabri Mine Production (April 2012 to March 2013)

The primary source of energy on the site is electricity, and thus the KPI has also been reviewed based on energy use from electricity. **Figure 17** compares the tonnes of coal mined to the amount of electricity consumed. For the year between June 2012 and May 2013, 13.12 kWh per tonne of coal was required. The amount of electricity used during the full production period of March to May 2013, was 11.29 kWh/tonne.

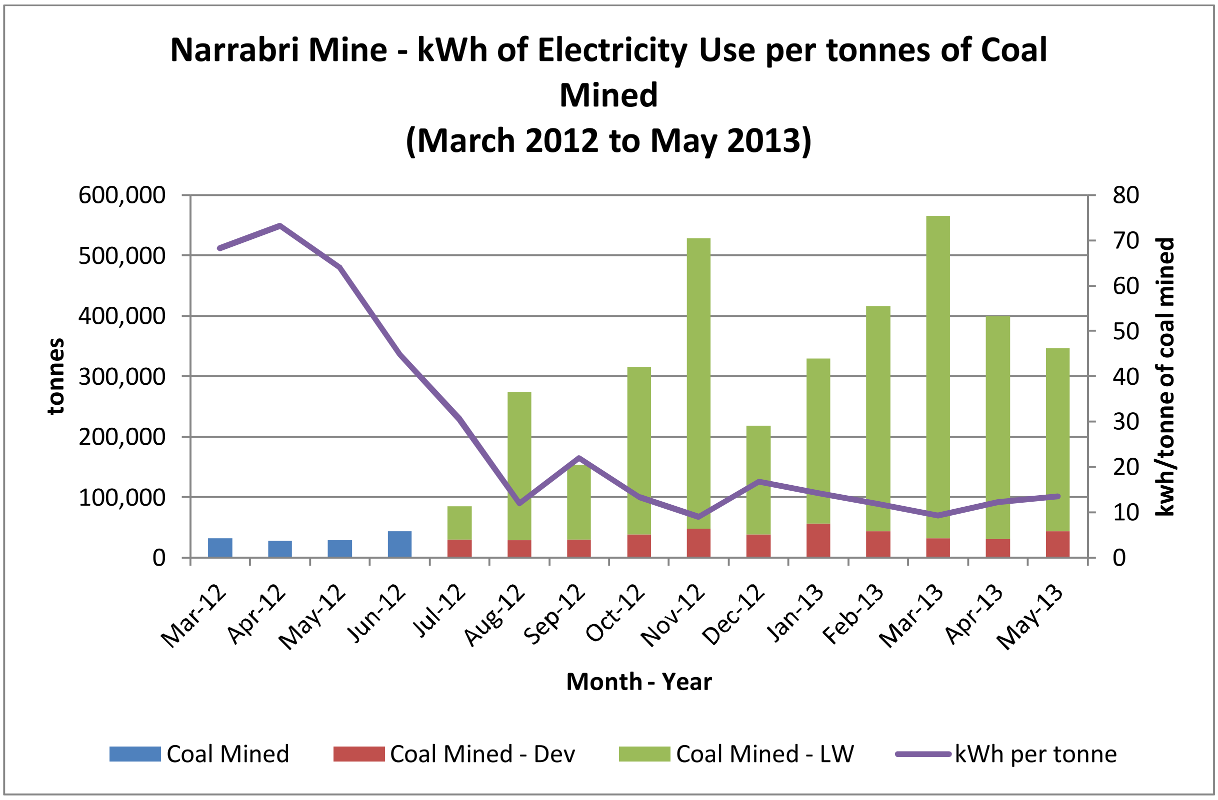

Figure 17: Electricity Consumption per tonnes of coal produced (March 2012 to May 2013)

As more full production energy consumption and coal production data becomes available, KPI's will be able to be refined and, as such, will become a valuable reporting tool for measuring energy efficiency. Potential KPIs may relate specifically to the Coal Handling and Preparation Plant (CHPP) and saleable washed coal.

5.7.3 Benchmarks

Narrabri Mine KPI compared to a Central Queensland underground operation is presented in Table 8. The KPI of the year from June 2012 to May 2013 is obviously not representative of the true full production state as operations did not commence full production until March 2013. Calculation of the KPI based on the three months of full production data (March to May 2013) KPI against the Central Queensland Underground shows Narrabri Mine to have a favourable KPI which may be due to two factors:

- Comparison against an ageing mine site;
- Applications of newer and improved technology; and
- More stringent regulatory requirements during the development approval process.

Monitoring of the KPI as the mine continues full production is imperative to assess the accuracy of this scoping KPI.

Table 8: Narrabri Mine Key Performance Indicators

	Narrabri Mine March - May2013	Narrabri Mine June 2012 - May 2013	Central Qu. Mine 2012 (Lower Production Level)	Central Qu. Mine 2012 (Upper Production Level	Lower Hunter Mine July 2007
Coal Mined (Mt)	1.3	3.7	4.0[1]	5.7[1]	_
Total Energy Use (GJ)	77,887	271,641	501,400[2]	501,400[2]	_
Electricity Use (kWh)	43,327	173,727	NA	NA	_
kWh/tonne coal mined	11.29	13.2	NA	NA	12.5
GJ/tonne coal mined	0.05	0.08	0.12	0.09	_

Notes to Table 8:
[1] Estimated production based on production limits provided by approval
[2] Based on mine EEO Report

In addition, KPIs have been calculated for the CHPP, where efficiency is measured by the amount of energy used per tonne of output from the CHPP. For Narrabri Mine, the output from the CHPP was 2.6 Mt and the energy used in the CHPP was calculated to be 30,566 GJ. The KPI is calculated to be 0.012 GJ/ tonne of output from CHPP.

The addition of more data on which to base these early assessments will strengthen the reliability of the information presented in this report as a basis of comparison for future assessments.

6. DETAILED TECHNICAL REVIEW OF SITE ENERGY USE

6.1 Electricity Use Breakdown

The mine site contains a wide range of machinery for mining purposes, and this machinery in turn uses many electric motors and other electrical devices, including ventilation fans and compressors. There is also a small fleet of mobile equipment on the mine site. Appendix I provides a detailed breakdown of individual equipment including; the hours of operation, duty and, annual energy usage. This information is summarised into estimated power usage for functional units in Table 9 and presented graphically in Figure 18.

The data presented in Table 9 is for 2012-2013 is based on SCADA data of many major pieces of equipment. Details of measured equipment are provided in Appendix III. Table 9 also presents the predicted Stage 2 Energy Usage from the 2011 ESAP. The discrepancy between projected use and the extrapolated/measured data is great. Projected data sourced from the 2011 ESAP has been based on design estimates of the site. The extrapolated data uses the real energy consumption totals and short term measurements for many pieces of equipment. These are then extrapolated out to the 12 month period.

Estimates of electricity usage for Administration are based on the 2011 ESAP and should be confirmed by measurement.

Table 9: Estimated Power Usage by Functional Unit

Functional Unit	Design Stage 2 Energy Use (MWh pa)[1]	Measured and Design Energy Use (MWh pa)
Administration[3]	1,010.79	1,010.79
Coal Preparation Plant	17,387.00	3,261.80
Conveyers	27,322.00	13,927.91
Development Panels 1 to 3	22,228.00	9,872.43
Fan Site Nitrogen Inertisation	5,256.00	2,334.46
Gas Drainage Plant	4,554.00	878.47
Longwall Mining System	46,411.00	18,523.87
Main Ventilation Fans	17,871.00	7,937.16
Namoi R Pipeline Pump	716	317.66
Train Load-out System	336	149.73
Water Pumping	1,340.00	429.05
Water Treatment	1,075.00	477.79
Workshop	2,592.00	1,151.67
Additional[2]	5,193.37	2,078.14
Total	**153,292.16**	**62,350.91**

Notes to Table 9:

[1] From 2011 ESAP

[2] Additional usage calculated from old model: 3.5% difference between Equipment model provided in Appendix 1 and Annual Total presented in Table 16 of ESAP.

[3] Administration usage assumed to be unchanged from 2011 ESAP

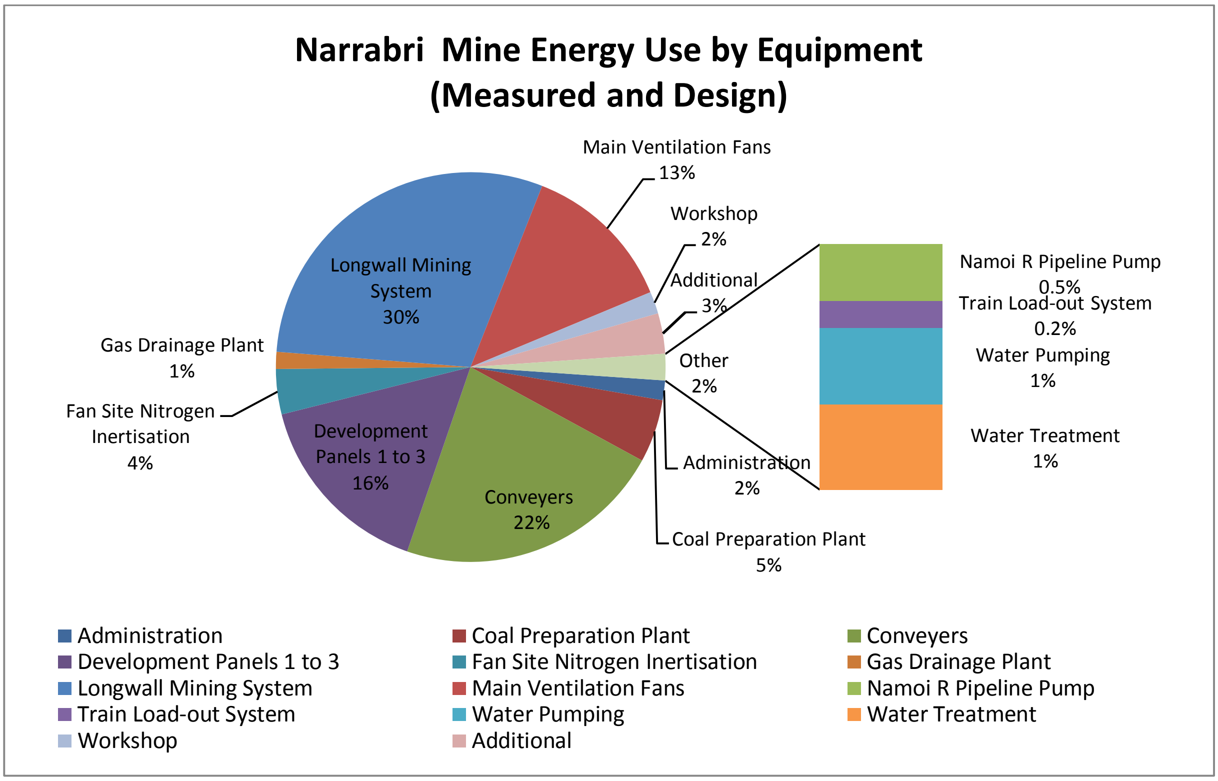

Figure 18: Narrabri Mine Electricity Usage by Functional Area

In **Figure 18**, above, it should be noted that the differences in predicted design energy breakdown when compared to current measured energy breakdown were:"

- Conveyors used a greater proportion than estimated: 17.8% was estimated and 22.3% was measured;
- Coal Preparation Plant used a smaller proportion than estimated: 11.3% was estimated and 5.2% was measured;
- Main Ventilation Fans used a greater proportion than estimated: 11.7% was estimated,12.7% was measured; and
- Gas drainage has a smaller proportion than estimated: 3% was estimated, and 1.4% was measured.

7. ENERGY SAVING OPPORTUNITIES AND ACTIONS

7.1 Demand Management

Demand management would ensure the most efficient equipment is used for specific tasks. Evaluation of the application of compressed air and reverse osmosis (RO) water may identify whether use can be reduced at the point of application, thereby offering energy and cost savings to Narrabri Mine. Systems of work for specific tasks may reflect a cultural precedence rather than practices that offer the best energy management or energy savings: e.g. If compressed air is used for cleaning any equipment/areas, a broom or leaf blower may function the same and reduce energy demand as high pressure is not required.

7.2 Office Areas and Staff Amenities

In addition to the lighting reduction discussed in **Section 7.15**, office areas represent a low cost opportunity for management to demonstrate commitment to energy management. Although the savings are relatively small, simple initiatives will reinforce to staff the need to constantly look for energy saving opportunities in the mine.

Examples in the office are:

- Fitting timers to hot and cold water units, printers, photocopiers and air conditioners to automatically shut down outside of office hours (e.g. 6 pm to 5 am weekdays and on weekends);
- Fitting motion sensors to lights in rooms used infrequently;
- Ensuring computers go to power save mode; and
- Fitting stickers on switches to remind staff to turn off lights and other equipment.

The mine crib room and bathroom are also ideal places to demonstrate to staff energy commitment by fitting energy saving lighting and movement sensors.

7.3 Power Factor Correction

A preliminary review of the power factor correction at Narrabri Mine was completed. The review of the data identified; that as the mine has developed, the power factor has improved to an average of 0.97 for the first five months of 2013 (Average maximum monthly electrical consumption 11000 kVA). This power factor is regarded as being very good.

An analysis was completed to determine what savings could be achieved by increasing the power factor by 0.01. Based on an average electricity price of $3.38/kVA, a saving of approximately $1,150 per month was identified ($13,800 per annum).

Advitech obtained advice from Capacitor Technologies who indicated that a power factor of 0.98 is targeted for new installations. Capacitor Technologies indicated that capital cost for any upgrade to an existing 11 kV Power Factor Correction Installation would be in the region of $100,000 to $200,000.

This would equate to a payback period of 7 – 14 years. This is generally considered an unattractive payback period, therefore further detail of power factor improvement opportunity was not sought. Should demand charges substantially increase or equipment cost substantially decrease, this may be worthwhile revisiting (probably in the order of 5 years time or greater).

7.4 Voltage Optimisation and System Loss Reduction

The power reticulation system of Narrabri Mine was reviewed to determine if it was appropriate to carry out further analysis on the power system. A brief analysis of the main underground feeds was completed. Single Line Diagram NHE.00.02.Rev.10 shows three underground feeds:

- Two 300mm^2; and
- One x 150mm^2.

Assumptions relating to the system were made based on the current mining activity and current equipment list. Assumptions were:

- Feeds were on average 1km long;
- Total installed power was estimated to be 21,000 kW (1100 Amps @ 11kV);
- Average duty was estimated to be 0.6; and
- All loads could be applied to the system at one time.

Based on the above it was assumed that each 300mm^2 cable would transmit 440 amps. The cable losses were assumed to be 0.203 mV/A.m.

Estimates for the cable loss were based on the following:

- Cable Loss x Current x Distance = Voltage Drop
  - (0.203/1000) x 440 x 1000 = 90 V (Less than 1%)

Based on a combined electricity price of $0.14/kWh, this equates to a cost of:

- Voltage Drop x Duty x Hours Per Year x Electricity Price = Electricity Cost Per Annum
  - 90 x 0.6 x 8736 x 0.14 = $66,000 Per Annum

It is expected that to halve this voltage drop and as such save approximately $33,000 per annum, the infrastructure cost per cable run would be in the region of $500,000 equating to a payback of greater than 14 years.

The infrastructure cost assumes a 300 mm^2 cable with a run of 1 km @ $350/m plus approximately $150,000 in substation/distribution control board (DCB) upgrades required to install an additional cable run.

Based on the above information, this is a generally unattractive payback; therefore no further detail of this opportunity was required.

Note: AS/NZS 3000 states that the maximum voltage drop shall not exceed 5%, so Narrabri Mine can be confident that their losses would be at this level or less.

7.5 Air Compressor

7.5.1 Air Compressor Efficiency

CAPS energy efficiency services were commissioned by Advitech to investigate the air compressor efficiency at Narrabri Mine.

CAPS found that Narrabri Mine has 4 air compressors in operation. 2 air compressors fuelled by diesel, and 2 powered by electricity. Estimated annual energy cost of the four compressors is $1,143,000 with the electrical compressors contributing $410,000 (36%) of the total and the remaining $733,000 (64%) by the diesel compressors. Total estimated annual costs (including equipment hire) of running the four compressors on this system was $1,466,000 with the diesel compressors contributing approximately 70% of these costs.

The two electrical compressors are operating at a high level of supply efficiency at 6.5 kW/m^3/min due to them running fully loaded for a majority of the audit period. Efficiency of the diesel compressors could not be determined as power and pressure data was not able to be logged.

Due to the inability to accurately determine the amount of air being generated by the diesel compressors on site the actual system Demand Profile, including all four compressors, cannot be accurately determined. With the two electrical compressors consistently providing approximately 54 m^3/min of air to the system the two diesel air compressors would be providing up to an additional 60 m^3/min depending on air requirement in the system.

The most appropriate future compressor setup for this system to achieve a design capacity of 120 m^3/min (4000 cfm) utilising the two existing electrical compressors is the installation of two new electrical compressors with maximum capacity of 60 m^3/min. At 100% load two compressors would consume in the vicinity of 450 kW of power which equates to a maximum of $550,000 in annual energy costs. This is compared with annual costs in excess of $1.1M for the two diesel compressors. This setup is based upon the assumption that the four compressors have the capacity to maintain system pressure at 700 kPa.

The exact amount of savings available cannot be determined due to inability to determine actual air demand in the system. However, savings in excess of $400,000 per year could be achieved by replacement of the diesel compressors with similar sized electrical compressors. It is expected that any upgrades would achieve a simple payback of less than 1.5 years. It would appear that the majority of the energy savings are from reductions in equipment hiring costs rather than in direct fuel savings.

Further investigation would be required to determine the actual type and size of any replacement compressors. For example two stage compressors or centrifugal compressors are generally 5% to 10% more energy efficient than single stage screw compressors when operating at high loads however centrifugal compressors need to be located in a relatively clean environment which may prove challenging at a mine site.

Note: Many other factors should be taken into consideration when deciding which option best suits the needs of the site and the application (such as air compressor planned relocation etc.). It is also possible that other options may be preferable considering other factors not identified from the CAPS study.

7.5.2 Air Compressor – Heat Recovery for Bathhouse

Whilst approximately 90% of the energy input to compressors is lost as heat, it is usually at a relatively low grade for process work. It is, however, commonly at temperatures suitable for building services and other applications. Recovering this heat can prove highly cost-effective, reducing overall energy bills and also benefitting the environment.

Figure 19: Total heat recovery process flow diagram

Based upon the diagram above up to 200 kW of energy would be available for use in a heat recovery system based upon the two electrical compressors operating at 100% load. This represents approximately 66 L/min taken from 10°C to 55°C, which should service 6+ bathrooms (Rinnai instantaneous rate 32 L/min enough to cover 3+ bathroom home). In addition if the diesel air compressors are replaced with electric equivalent, then this would also produce additional energy for the heat recovery system effectively doubling the heat output of the system (approximately 130 L/min total, from 10°C to 55°C, servicing 12+ bathrooms).

This heat recovery opportunity may be sufficient to replace all LPG use onsite (for bathhouse use). If so, it may be worthwhile co-locating the air compressors next to the bathhouse to reduce losses, though generally these will be small (10W/m is lost using 40mm insulation, assuming 40°C temperature differential.
(losses taken from tables: http://www.engineeringtoolbox.com/heat-loss-insulated-pipes-d_1151.html).

This would be equivalent to 1300W lost across 130m (which is the approximate distance from the workshop to bathhouse) representing 0.5% of total energy.

The cost to add the optional extra of the heat recovery unit with a new system is approximately $10,000. If the air compressors are purchased and installed based on the above efficiency opportunity (with a payback of 1.5 years), then these additional system would save all LPG use for the bath house, estimated at $37,068 per annum, assuming 2 units costing $20,000, even with additional piping costs (less than $17,068) this would payback in less than a year.

A detailed review of the demand side of the proposed heat recovery system would need to be undertaken to understand and determine project feasibility before implementation.

7.6 Ventilation Motor Optimisation

Narrabri Mine currently has 3 main ventilation fans installed in parallel. These fans were designed and installed by Howden Australia (Howdens) and are of the type MCV150 2550 with an installed power of 850 kW each. The ventilation system has been designed to require approximately 340 m^3/s at a static collar pressure of - 2600 Pa. The fans are currently configured to have two (2) fans running at a combined power of approximately 1,200 kW.

Howdens were requested to examine the fans to confirm if this is the most power efficient configuration. Howdens identified that for the current flow and pressure requirements, an indicative total shaft power saving of 230 kW could be achieved by operating all three fans at a reduced speed to match the duty. Fan curves representing the current and proposed configuration are presented in **Appendix II**.

Narrabri Mine have reported that they only operate two of the three fans with the third fan maintained in a non-running standby condition. By utilising all three fans, it is expected that the running maintenance of the fans will increase by 50%, though this will eliminate standby maintenance which will avoid degradation through lack of use of fan components (such as bearings).

It is expected that this change could be implemented by Narrabri Mine using internal staff, skills and equipment. Based on a combined electricity cost of 14c/kWh, this equates to a saving of $280,000 per annum (Note: For the purposes of the calculations, it has been assumed that the air density is 1.2 kg/m^3). Narrabri Mine anticipates that all three fans will be required for mine ventilation within the next 2-3 years as the mine workings progress to the west.

7.7 Auxiliary Ventilation Motors

Narrabri Mine currently has 3 auxiliary ventilation fans installed. These fans were designed by Flakt Woods and are the 21 m^3/s model with an installed power of 150 kW each. Based on the information provided by Narrabri Mine and for the purposes of the analysis, it has been assumed that Narrabri Mine require a minimum 14.5 m^3/s and maximum of 18.5 m^3/s from their auxiliary fans to ventilate the development headings. It is understood that Narrabri Mine run a maximum duct length of 300 m of 760 mm diameter and a minimum duct length of 50 m. It is understood that these fans have a maximum efficiency of approximately 60%.

Flakt Woods were requested to examine the fan to confirm what options exist for improving their efficiency. Flakt Woods provided a suitable fan curve for analysis. The Flakt Woods fan was examined to determine the power requirements from the existing operation based on a minimum ventilation rate of 14.5 m^3/s and a maximum of 18.5 m^3/s. (**Table 10**).

Table 10: Flakt Woods Fan

Duct Length (m)	VIV Position	Flow Rate (m^3/s)	Pressure (kPa)	Power (kW)	Efficiency (%)	Average Power (kW)
50	4th Position	15.8	1.1	110	16	
100	4th Position	15.2	1.8	112	27	111
100	Fully Open	18.5	2.7	148	34	
200	Fully Open	16.1	4.4	146	49	147
300	Fully Open	14.6	5.3	145	53	146
					Total	**139**

AirEng were requested to provide a concept for an alternative fan with options for improved efficiency. AirEng proposed their own fan 'MAF23 Hurricane' with 160 kW installed power. This fan is understood to have a maximum efficiency of approximately 65%.

The MAF23 fan was examined to determine the savings from the replacement of the Flakt Woods fan. This has been based on a preferred ventilation rate of 14.5 m^3/s (**Table 11**).

Table 11: MAF23 Fan

Duct Length (m)	VIV Position	Flow Rate (m^3/s)	Pressure (kPa)	Power (kW)	Efficiency (%)	Average Power (kW)
50	3rd Position	17.2	1.1	105	18	
100	3rd Position	16.5	2.2	115	32	110
200	3rd Position	15.3	3.8	120	48	118
200	2nd Position	16.3	4.3	136	52	
300	2nd Position	15	5.7	142	60	139
					Total	**125**

The MAF23 fan was also examined to determine the savings from the use of a variable speed drive. This has been based on a preferred ventilation rate of 14.5 m^3/s (**Table 12**).

Table 12: MAF23 Fan with VSD

Duct Length (m)	VIV Position	Flow Rate (m^3/s)	Pressure (kPa)	Power (kW) (Estimated)	Efficiency (%)	Average Power (kW)
50	N/A	14.5	0.8	54	21	
100	N/A	14.5	1.7	68	36	61
200	N/A	14.5	3.5	93	55	81
300	N/A	14.5	5.3	128	60	111
					Total	**89**

Note: All values are approximate based on estimated duct losses and leakage.

Assuming a linear development rate, the average power consumption is:

- Flakt Woods Fan – 139 kW
- AirEng MAF23 – 133 kW
- AirEng MAF23 fitted with variable speed drive – 89 kW

Based on a combined electricity price of $0.14/kwh and assuming the fan runs 90% of the year, this equates to a potential saving of:

- Replacing Flakt Woods Fans with AirEng Fans - $15,000 per annum per fan
- Replacing Flakt Woods Fans with AirEng Fans with variable speed drive - $55,000 per annum per fan

The cost of a replacement AirEng fan with a variable speed drive is in the order of $235,000. It is expected that the existing fan could be sold for approximately $100,000. This equates to a payback period of less than 2.3 years.

It is understood that the AirEng fan is larger than the Flakt Woods fan with a width of 1.75 m and a length of 5.3 m (sled mounted fan).

For the purposes of the calculations, it has been assumed that the air density is 1.2 kg/m^3.

If variable speed drives were utilised for the Auxiliary Ventilation Fans, it is expected that additional savings would be available from the Main Fans through the reduced development heading ventilation requirements. I.e. the main ventilation would only be required to ventilate based on an auxiliary fan setting of 14.5 m^3/s rather than up to 18.5 m^3/s. This option has not been explored as the effects of the ventilation change on the complete system are understandably complicated.

7.8 Water Pumps

7.8.1 Reverse Osmosis (RO) Downtime

The Reverse Osmosis (RO) plant is integral to maintaining water quality and supplying treated water to various locations about the site. The RO facility currently consumes 910 MW.hr per year. The RO plant currently consumes approximately 85% of the total WTP system energy consumption.

Analysis of supplied daily RO SCADA information suggests that the facility is operated almost exclusively during peak and shoulder periods. Based on February and March RO production information only 27% of all available off-peak hours is being used by the RO facility. Potential opportunity exists for Narrabri Mine to shift RO operating hours into off-peak power pricing periods. Off-peak energy pricing is approximately 39% cheaper than peak and off-peak periods. It is theoretically possible to save up to $39,000 per year be maximising load shifting to off-peak power periods.

Based on present information, the current RO plant is not fully automated and requires the attendance of on-site contractors to instigate regular calibration, testing and fault rectification (if required). The potential to alter the current working regime of the RO plant is very much reliant on examination of mandatory manning requirements, automation requirements and operational risk assessment.

At the time of writing this report the following is noted about the RO plant:

- The RO plant can technically be started-up and shut-down remotely but at the moment, it is not linked to the SCADA system. Based on discussion with PALL, the WTP supplier, the RO is currently manually started and shut-down through the HMI (Human Machine Interface).
- The RO can 'park' itself into a safe mode during the following scenarios; low tank level, high tank level, treated water dam level high and critical RO process alarms. If RO SCADA enhancements are implemented, any of those scenarios will send an alert to the SCADA.
- The on-site attendance procedure is as follows; when there is something wrong with the RO system such as a too-high/low-pressure or critical process alarms, an operator intervention is required. When such an event happens overnight or during the weekend when there is no operator on site, the RO system sits in a 'parked' safe mode until an operator comes to rectify the fault.
- The following activities are completed by the on-site contractor:
  - Monitoring of the feed dam results and analysing of those results to ensure water is of suitable quality for the WTP;
  - Cleaning of the membrane (Codeline elements of the RO). The membrane cleaning frequency is unclear. PALL has not advised on membrane cleaning frequency.
  - Calibration of the RO system. It is unclear when this needs to be undertaken and how often.
  - Taking of RO permeate water sample. It is unclear when this needs to be undertaken and how often.

7.9 Pumps and Motors without VSD and with Variable Run Time

The application of variable speed drives on some equipment which currently function without VSD was investigated, though all opportunities have now already been taken advantage of (VSDs now installed), or the duty cycle or equipment does not suit the VSD addition.

7.10 Dam SB1 Water Transfer Pump

The existing pump transfers water from dam SB1 to Pond A1. The pump is not well suited for the intended application as the pump discharge outlet is throttled by a valve. Based on site discussions the current throttling valve position is 50%. The throttled valve is required to ensure adequate backpressure on the pump discharge to maintain it within the recommended pump operating range. The existing pump is a 22 kW Sykes HH100 pump which was installed in April 2009. The pump motor has variable VVVF drive and is speed limited to within a range of 1400-1800 rpm. Based on SCADA records, the total run time for the pump is 23,605 hours which averages out to be 66% duty or 15.7 hours a day.

According to the pump supplier, it is not recommended to operate the pump outside the recommended pump operating range (e.g. operating at lower speeds etc.). The current throttling of the discharge line is not reflective of good engineering practice and will result in unnecessary energy losses.

Based upon preliminary fluid flow modelling of the water transfer circuit, speed adjustment of the pump to 1400 rpm, it is estimated that the pressure drop across the throttling valve is in the order of 240 kPa for anticipated discharge flow of approximately 27 L/s. For the reported back pressure requirement of 350 kPa, this cross-references satisfactorily with the available pump curve. The equivalent energy loss across the valve while the pump is in operation is estimated at 6.5 kW.

A more appropriate selection of pump may remove the requirement of valve throttle. Based on available information, it is estimated that a pump with a discharge of 30 L/s at duty pressure of 150 kPa should suffice. The existing pump operating point is estimated at 26 L/s at 350 kPa duty pressure.

Preliminary calculation suggests that a new pump (appropriate for the application at hand) should deliver approximately a 50% reduction in energy consumption relative to existing set-up. This equates to approximately 29.6 MW.hr/yr or $4,050 per annum saving. The cost for the new pump (CP100i Sykes Auto-Prime pump directly coupled to a 7.5kW WEG electric motor suitable for VFD) is $22,355 resulting in a simple payback of 5.5 years. Potentially this payback period may be reduced by reusing the current VSD (which may save $1,500 - $2,500) and also selling the decommissioned pump may reduce the payback further.

7.11 Size confirmation in A1 water transfer pipe

Based on PID information between pump Dam A1 #1 and the Reclaim Water Tank, piping diameters vary between 90 mm and 200 mm. Based on current information this pump operates 24/7 with a motor capacity of 75 kW.

Assuming that the PID information expressed in PID 43167785_0400_ME_2801_4 Rev 5-ME-2801 is correct, energy savings should be expected by replacing 90 mm piping diameter with larger diameter bore pipes (e.g. 200 mm).

For a nominal water flow of 20 L/s and length of pipe comparison of 100 meters, estimated current pipe friction energy losses equate to approximately 13.5 MW.hr per year. This represents a power cost saving of approximately $1,800 per annum assuming an energy cost of $0.14/kW.hr. This represents approximately 2% loss through the system due to pipe size constriction. Since the power is a squared relationship, if the flowrate is closer to 40 L/s, this would equate to 180MWh, which is over 30% loss through the system ($24,000 worth of losses). Therefore this flowrate and pressure of the system and obviously pipe diameter should be ascertained.

7.12 Emulsion Bypass and Leaks on Longwall Face

Emulsion leaks and bypass on the Longwall face were investigated as this was identified in the previous ESAP (2011), and would cover a large amount of energy consumption. If this consumption is monitored and controlled well this may lead to large energy savings. It is important to note that there are approximately 30,000 hoses and 3,000 valves on the Longwall unit alone, so reducing leaks and bypass may be extremely difficult.

7.12.1 Leakage estimation of emulsion

The amount of current leaks on the Longwall face was recorded to be 72,000L of emulsion concentrate in 233 days, which represents an annual figure of approximately 113,000L. When made up in ratios of 3% emulsion to 97% water this represents 3,759,657L total emulsion. Narrabri Mine used the tank levels and pump volumes reported to SCADA and emulsion delivery tracking to determine that approximately 7L/min is being lost due to leakage on the Longwall face.

7.12.2 Leakage and bypass estimation

Trials were completed by Narrabri Mine by stopping Longwall equipment and observing the activity of the pumps loading and unloading to maintain pressure settings. This work to maintain pressure was taken to be the total leakage and bypass rate from the Longwall

From SCADA data of the pumps to maintain pressure, it was found that the duty cycle in these trials was approximately 41% of a single 250 kW pump, which relates to an average of 103.5kW.
Estimating this to an annual figure using run times of 18 hours a day, and 7 days a week, 360 days a year results in 679,749 kWh, which when using the average delivered electricity cost of 14c/kWh is equivalent to $95,165 per annum.

After discussions with Peter Van De Ven of Narrabri Mine, he identified that it would be most useful to create a bypass and leakage cost summary to assist with raising awareness of the maintenance issues, and justifying increasing expenditure of scheduling (where this is identified to reduce bypass or leakage). Peter asked that the emulsion costs be included in this cost summary. The emulsion concentrate is $2.40/L and is made up at about 3% concentrate to 97% water. The water cost is taken from total water processed at the WTP from February 01 2013 to 31 March 2013, and calculated electricity cost based on time of use, pro-rated over the whole year. This results in a water cost of $2.02 per kL produced.

Peter identified that a ‘good’ bypass and leakage rate is 80 – 100 L/min, and that a ‘bad’ bypass and leakage rate is 300L/min or above. The leakage cost summary is provided in **Table 13**.

Table 13: Emulsion Leakage Cost Summary*

Items	Good 80L/min	Current 154L/min	Bad 300L/min
Pump electricity cost	$49,436	$95,165	$185,386
Emulsion fluid cost	$140,620	$270,695	$527,330
Water leakage estimate	1,953 kL	3,760 kL	7,324 kL
Cost of water leakage	$3,938	$7,580	$14,766
Therefore total difference:	$193,995 1,953 kL	$373,440 3,760 kL	$727,480 7,324 kL

*Emulsion Leakage (L/min) includes loss plus bypass

The cost of bypass and leakages currently equates to $373,440 and 3,760kL per year, so it is important to monitor this, and reduce this where possible.

7.13 Drift Conveyor Opportunities

There are potential energy and cost savings for Narrabri Mine by reducing speed of the drift conveyor drives when the belts are empty. Trials were undertaken by Narrabri Mine to estimate the approximate savings of implementing such a system. Belts were reduced to 75% of total speed when unloaded to observe the reduction in energy consumption. Narrabri Mine found the following results:

- Loaded belt normal speed runs at around 60% of maximum power use (approx. 4000 t/h);
- Empty belt normal speed runs at around 11% (of maximum power use); and
- Empty belt at 75% of normal speed runs at around 9% (of maximum power use).

From early discussions run speed of between 20% and 55% resulted in belt shudder (when using steel belts, which has maintenance benefits over fabric belts). Therefore a slowdown speed nominated was to be above this threshold.

The identification of the fraction of time this slowdown could be implemented was analysed by using SCADA data and identifying when belt speed was over 80% of maximum recorded speed, and current was below 75% of maximum current.

The expected power and cost savings for speed reductions for Drift Conveyor Drive #1 and Drive #2 are presented in Table 14. Analysis of SCADA data found no data for Drive #3, though from discussion with the site, it is understood that this drive is indeed working in parallel with the other 2 drives. Therefore we have estimated the consumption by the average of the other 2 drives. While this may not represent real usage it will broadly cover a closer magnitude of consumption than omission of this drive.

Cost savings are based on an energy cost of $115/MWh. The total estimated saving for Drive #1, #2 and #3 is $52,678 per year.

There is very little cost in implementing this opportunity, simple reprogramming of PLC and SCADA and linking feedback between conveyors so belts always accept loads at full speed. This work could be carried out by Narrabri Mine staff.

Table 14: Drift Conveyor Speed Reduction Opportunity

Drift Conveyor	Slowdown opportunity (%)	Expected saving per year (MWh)	Expected saving per year ($)
Drive #1	49%	141	$16,202
Drive #2	54%	165	$18,917
Drive #3	*~52%*	*153*	*$17,559*

7.14 Gas Drainage System

Currently Narrabri Mine operate liquid sealed vacuum pumps for coal gas drainage purposes. No energy efficiency opportunities were identified with coal drainage vacuum pumps.

7.15 Lighting

Narrabri Mine lighting is a small component of the overall site use, but the simple function of the equipment and better alternatives available, have made some opportunities very attractive.

While Advitech has omitted high pressure sodium lights (apart from high power) from this analysis as they are quite efficient in terms of lumens/W and therefore appropriate for general visibility, they are a light that human eyesight does not respond well to, in fact side by side with a lux meter they may appear to produce many more lumens, though people will still state that the high pressure sodium is dimmer. The opposite effect is true with induction lighting. This effect is due to the wavelength of light being produced. While high pressure sodium is in the lower end of the visible spectrum human eyes seem to register the same lumens as lower, and induction is towards the high end of the visible spectrum (blue) and therefore people register this light as apparently brighter for the same lumens. Also properties of other lighting equipment such as LED being far more directional and suited to task lighting than other lighting sources should be considered for lighting suitability.

Any upgrade of Narrabri Mine lighting must consider the proximity of the Siding Springs Observatory and the impact of light pollution on astronomical investigations. The use of directional/shielded/full cut off lighting types as well as spectral range should be considered in the implementation of lighting opportunities.

The main opportunities were high powered lights, and single T8s with magnetic ballast changed over to T5s with electronic ballast. See Table 15 for further detail.

Table 15: Lighting opportunities with a short payback period

Area	No.	Watts	Type	Hours/ day	kWh/ year	Type	Post kWh	Post saving	Capital cost	ESC	ESC value	Capital inc ESCs	Simple payback
Product Pad	10	2000	Metal Halide	12	87600	500W LED	21900	$7,542	$18,000	657	$13,140	$4,860	0.6
Stores Hardstand	12	1000	High Pressure Sodium	12	52560	250W LED	13140	$4,525	$14,400	394	$7,884	$6,516	1.4
Stores Hardstand	8	400	High Pressure Sodium	12	14016	MH 250W	1006	$603	$2,400	53	$1,051	$1,349	2.2
WTP Switchroom	2	36	Single Fluro	12	315	14W single T5	123	$22	$64	2	$39	$25	1.2
WTP	4	400	High Pressure Sodium	12	7008	MH 250W	4380	$302	$1,200	26	$526	$674	2.2
Bathhouse/Undermanagers office/Hallway/First Aid Room	75	36	Twin Fluro*	24	47304	28 twin T5	36792	$1,591	$6,600	105	$2,102	$4,498	2.8
66kV Switchyard	5	400	High Pressure Sodium	12	8760	MH 250W	5475	$377	$1,500	33	$657	$843	2.2
Tanks at Box Cut	6	400	High Pressure Sodium	12	10512	MH 250W	6570	$453	$1,800	39	$788	$1,012	2.2
Store/Workshop	39	400	Mercury Vapour	12	68328	MH 250W	42705	$2,941	$11,700	256	$5,125	$6,575	2.2
Trunkbelt	100	36	Twin Fluro*	24	63072	28 twin T5	49056	$2,121	$8,800	140	$2,803	$5,997	2.8
Driveages	240	36	Twin Fluro*	24	151373	28 twin T5	117734	$5,090	$21,120	336	$6,728	$14,392	2.8
Switch area	20	36	Twin Fluro*	24	12614	28 twin T5	9811	$424	$1,760	28	$561	$1,199	2.8
15ct Pump Station	20	36	Twin Fluro*	24	12614	28 twin T5	9811	$424	$1,760	28	$561	$1,199	2.8
CPP Rejects Conveyor CV702 Lighting	3	400	Eco40-400M/SS	12	5256	250W Metal Halide	3285	$226	$900	33	$657	$243	1.1
PCI Product Conveyor CV803 Lighting	3	400	Eco40-400M/SS	12	5256	250W Metal Halide	3285	$226	$900	33	$657	$243	1.1
Product Transfer Station ST801 Lighting 2	8	400	Eco40-400M/SS	12	14016	250W Metal Halide	8760	$603	$2,400	88	$1,752	$648	1.1
CPP Plant Feed Floor Lighting	1	250	Eco15-250M/SS	12	1095	200W Metal Halide	876	$25	$200	9	$175	$25	1.0

Prices in **Table 15** reflect general commercial/industrial approximate prices in Advitech's experience. Narrabri Mine has sourced a quotation from their preferred supplier and has found prices to far exceed this to an extent where this opportunity is no longer attractive, the lump sum cost and payback is shown in the opportunity summary table.

7.16 Coal Seam Gas Flaring and Generation opportunities

After significant investigation this opportunity was found to be impractical due to the heat requirements to recover the amine solution post-stripping exceeding the energy content of the entire gas stream.

The gas drainage plant produces significant volumes of methane mixed with carbon dioxide and traces of other gases. The following table shows the approximate volumes, concentrations and energy content (data is from the 2012 Greenhouse Gas Minimisation Plan).

Table 16: Gas Drainage Plant Characteristics

Flows				
Pre Drainage				
Total (m^3/hr)		5,928		
CH4 content (m^3/hr)				592
Goaf				
Total (m^3/hr)		913		
CH4 content (m^3/hr)				251
	Total Gas (m^3/hr):	6,841	Total CH4 (m^3/hr):	843
		Total % CH4 average:		12.32%
		Total energy (kW/hr):		8,664
		Power gen potential (kW/hr):		3,466

Originally, a power generation plant was sized to produce the following electrical capacity which would be equivalent to around 35% of the site's consumption.

Table 17: Original Power Generation Plant Savings (now impractical)

Power Generation		**Assumptions**
Energy Generation (kWh pa)	27,656,022	Assumes 95% availability for 350 days pa
Energy Cost ($ pa)	$3,125,131	Assumes 11.3 c/kWh average energy price
Demand reduction ($)	$83,176	Assumes reduction in 6 out of 12 months
Potential Saving ($ pa)	$3,158,307	CO_2 removal plant additional operating cost $30k-70k and requires heat recovery for amine recovery ($50k included here)
Estimated capital cost ($)	$14,500,000	Assumes $1,650 per kWe installed (average of $800-$2,500 per kWe installed – OEH cogen estimates) including CO_2 removal, does not include any modification of gas collection system to generators.
CO_2 Removal Equipment ($)	$9,075,440 ($8M USD)	Cost of equipment provided by Huntsman.
CO_2 Removal ($ pa)	>$50,000	Assumed cost of operation
Payback (years)	N/A	

While engine suppliers in Australia have little knowledge of CO_2 removal equipment for electricity generation, it is quite common in other industry sectors. Engine suppliers usually require a methane content of at least 25%, which in this case results in a reduction of CO_2 by at least 50%.

In an attempt to feed the operating heat load required to recover the amine solution, waste heat from the electricity generation process should be used. The problem then arises from the energy required for CO_2 stripping solution recovery.

The heat energy requirement estimated by Huntsman is 12MW. While this may be able to be reduced by optimising the process, this may only reduce the requirement by around 10%. This requirement results in eliminating the opportunity as it exceeds the energy content of the entire gas stream, which is approximately of 8.6MW.

While there may be some other sources of heat (such as from the air compressors) this would still not be sufficient as these are a few hundred kW rather than a few MW (therefore an order of magnitude away). It is not recommended to pursue this option unless other waste heat sources or higher methane gas is identified.

8. REFERENCES

1. Department of Energy Utilities and Sustainability 2005 Guidelines for Energy Saving Action Plans, DEUS
2. AS/NZS 3598:2000 Energy Audits.

Appendix I

Electrical Equipment on Site

Category	Functional Area for Electricity Usage	Electricity Usage Equipment	~ kW	Number of Units	Duty	Hours per day	Days per year	Annual MWh	Measured/Design Annual MWh (per unit)	Source data	Adjusted Duty	Adjusted MWh per unit
Workshop	Workshop	Air Compressor #1	185	1	80%	24	365	1,296.0	1296	design	44%	720
Workshop	Workshop	Air Compressor #2	185	1	80%	24	365	1,296	1296	design	44%	720
Water Pumping	Water Pumping	Fire Pump #1	75	1	5%	24	365	33	33	design	3%	18
Water Pumping	Water Pumping	Fire Pump #2	75	1	5%	24	365	33	33	design	3%	18
Water Pumping	Water Pumping	Dam A1 Pump #1	75	1	80%	24	365	526	526	design	44%	292
Water Pumping	Water Pumping	Dam A1 Pump #2	7.5	1	80%	24	365	526	53	design	44%	29
Water Pumping	Water Pumping	Box Cut Pump #1	75	1	80%	3	365	66	66	design	44%	37
Water Pumping	Water Pumping	Box Cut Pump #2	75	1	80%	3	365	66	66	design	44%	37
Water Pumping	Water Pumping	Dam B1 Filtered Water Pump 1	37	1	80%	3	365	32	32	design	44%	18
Water Pumping	Water Pumping	Dam B1 Filtered Water Pump 2	37	1	80%	3	365	32	32	design	44%	18
Water Pumping	Water Pumping	Dam D Transfer Pump	30	1	80%	3	365	26	26	design	44%	15
Water Treatment	Water Treatment	MF AP4 A Feed Pump	15	1	80%	24	365	105	105	design	44%	58
Water Treatment	Water Treatment	MF AP4 A Flush Pump	15	1	80%	24	365	105	105	design	44%	58
Water Treatment	Water Treatment	MF AP4 B Feed Pump	15	1	80%	24	365	105	105	design	44%	58
Water Treatment	Water Treatment	MF AP4 B Flush Pump	15	1	80%	24	365	105	105	design	44%	58
Water Treatment	Water Treatment	RO A LP Feed Pump	18.5	1	80%	24	365	130	130	design	44%	72
Water Treatment	Water Treatment	RO A Stage 1 Pump	45	1	80%	24	365	315	315	design	44%	175
Water Treatment	Water Treatment	Feed Pump A -1	15	1	80%	24	365	105	105	design	44%	58
Water Treatment	Water Treatment	Feed Pump B -2	15	1	80%	24	365	105	105	design	44%	58
Coal Preparation Plant	Bypass Coal 1,200 tph Crushing Plant	Breaker 1/1 Drive (Breaker shaft)	150	1	10%	2	365	11	11	design	6%	6
Coal Preparation Plant	Bypass Coal 1,200 tph Crushing Plant	Feeder 1/1 Drive (Feeder Chain)	150	1	10%	2	365	11	11	design	6%	6
Coal Preparation Plant	Bypass Coal 1,200 tph Crushing Plant	Conveyor 1/1 Drive (Primary Belt)	150	1	10%	2	365	11	11	design	6%	6
Coal Preparation Plant	Bypass Coal 1,200 tph Crushing Plant	Crusher 1/1 Drive (Tertiary Crusher)	220	1	10%	2	365	16	16	design	6%	9
Coal Preparation Plant	Bypass Coal 1,200 tph Crushing Plant	Conveyor 2 Drive 2A (Secondary Belt)	150	1	10%	2	365	11	11	design	6%	6
Coal Preparation Plant	Bypass Coal 1,200 tph Crushing Plant	Conveyor 2 Drive 2B (Secondary Belt)	150	1	10%	2	365	11	11	design	6%	6
Train Load Out	Train Loadout System	Reclaim Conveyor Drive	500	1	80%	5	52	104	104	design	44%	58
Train Load Out	Train Loadout System	Reclaim Tunnel Vent Fan	30	1	80%	24	365	210	210	design	44%	117
Train Load Out	Train Loadout System	TLO No.1 Hydraulic Power Pack	55	1	80%	5	52	11	11	design	44%	6
Train Load Out	Train Loadout System	TLO No.2 Hydraulic Power Pack	55	1	80%	5	52	11	11	design	44%	6
Conveyors	Drift Belt Conveyor	No 1 Motor	1000	1	30%	24	365	2628	1806	measured	21%	1806
Conveyors	Drift Belt Conveyor	No 2 Motor	1000	1	30%	24	365	2628	1809	measured	21%	1809
Conveyors	Drift Belt Conveyor	No 3 Motor	1000	1	30%	24	365	2628	1840	measured	21%	1840
Conveyors	Drift Belt Conveyor	Product Skyline	315	1	30%	24	365	828	227	measured	8%	227
Conveyors	Drift Belt Conveyor	Tripper Supply	30	1	30%	24	365	79	18	measured	7%	18
Conveyors	Main West Trunk A Belt Conveyor	No 1 Motor	630	1	30%	24	365	1,656	1656	design	17%	920
Conveyors	Main West Trunk A Belt Conveyor	No 2 Motor	630	1	30%	24	36500%	1,656	1656	design	17%	920
Conveyors	Main West Trunk A Belt Conveyor	No 3 Motor	630	1	30%	24	365	1,656	1656	design	17%	920
Conveyors	Main West Trunk B Belt Conveyor	No 1 Motor	630	1	30%	24	365	1,656	1656	design	17%	920
Conveyors	Main West Trunk B Belt Conveyor	No 2 Motor	630	1	30%	24	365	1,656	1656	design	17%	920
Conveyors	Main West Trunk B Belt Conveyor	No 3 Motor	630	1	30%	24	365	1,656	1656	design	17%	920
Conveyors	LW Main Gate Belt Conveyor	No 1 Motor	630	1	30%	24	365	1,656	1656	design	17%	920
Conveyors	LW Main Gate Belt Conveyor	No 2 Motor	630	1	30%	24	365	1,656	1656	design	17%	920
Conveyors	LW Main Gate Belt Conveyor	No 3 Motor	630	1	30%	24	365	1,656	1656	design	17%	920
Conveyors	Development Main Gate Belt Conveyors	No 1 Motor	630	1	30%	24	365	1,656	1656	design	17%	920
Conveyors	Temporary Conveyors	Drive	250	1	30%	24	365	657	657	design	17%	365
Conveyors	Temporary Conveyors	Drive	250	1	30%	24	365	657	657	design	17%	365
Conveyors	Temporary Conveyors	Drive	250	1	30%	24	365	657	657	design	17%	365

Category	Functional Area for Electricity Usage	Electricity Usage Equipment	~ kW	Number of Units	Duty	Hours per day	Days per year	Annual MWh	Measured/Design Annual MWh (per unit)	Source data	Adjusted Duty	Adjusted MWh per unit
Development Panel 1 to 3	Development Panels 1 to 3	No 1 Cutter (12CM12-40D Continuous Miner)	170	3	80%	24	365	3574	3574	design	44%	1986
Development Panel 1 to 3	Development Panels 1 to 3	No 2 Cutter (12CM12-40D Continuous Miner)	170	3	80%	24	365	3574	3574	design	44%	1986
Development Panel 1 to 3	Development Panels 1 to 3	No 1 Traction (12CM12-40D Continuous Miner)	60	3	80%	24	365	1261	1261	design	44%	701
Development Panel 1 to 3	Development Panels 1 to 3	No 2 Traction (12CM12-40D Continuous Miner)	60	3	80%	24	365	1261	1261	design	44%	701
Development Panel 1 to 3	Development Panels 1 to 3	No 1 Conveyor (12CM12-40D Continuous Miner)	45	3	80%	24	365	946	946	design	44%	526
Development Panel 1 to 3	Development Panels 1 to 3	No 2 Conveyor (12CM12-40D Continuous Miner)	45	3	80%	24	365	946	946	design	44%	526
Development Panel 1 to 3	Development Panels 1 to 3	Main Pump (12CM12-40D Continuous Miner)	45	3	80%	24	365	946	946	design	44%	526
Development Panel 1 to 3	Development Panels 1 to 3	Drill Pump (12CM12-40D Continuous Miner)	45	3	80%	24	365	946	946	design	44%	526
Development Panel 1 to 3	Development Panels 1 to 3	No 1 Traction (10SC32BC shuttle car)	85	3	80%	24	365	1787	1787	design	44%	993
Development Panel 1 to 3	Development Panels 1 to 3	No 2 Traction (10SC32BC shuttle car)	85	3	80%	24	365	1787	1787	design	44%	993
Development Panel 1 to 3	Development Panels 1 to 3	No 1 Conveyor (10SC32BC shuttle car)	23	3	80%	24	365	484	484	design	44%	269
Development Panel 1 to 3	Development Panels 1 to 3	No 2 Conveyor (10SC32BC shuttle car)	23	3	80%	24	365	484	484	design	44%	269
Development Panel 1 to 3	Development Panels 1 to 3	Pump (10SC32BC shuttle car)	15	3	80%	24	365	315	315	design	44%	175
Development Panel 1 to 3	Development Panels 1 to 3	Breaker (BF14 Breaker Feeder)	90	3	80%	3	365	237	237	design	44%	131
Development Panel 1 to 3	Development Panels 1 to 3	Hydraulic Pump (BF14 Breaker Feeder)	90	3	80%	3	365	237	237	design	44%	131
Development Panel 1 to 3	Development Panels 1 to 3	MB2337 Water Pump (Panel Water Pump Pod)	110	3	80%	3	365	289	289	design	44%	161
Development Panel 1 to 3	Development Panels 1 to 3	Motor (Auxiliary Ventilation Fan)	150	3	80%	24	365	3,154	3154	design	44%	1752
Main Ventilation Fans	Main Ventilation Fans	Fan Motor No 1	850	1	80%	24	365	5,957	5957	design	44%	3310
Main Ventilation Fans	Main Ventilation Fans	Fan Motor No 2	850	1	80%	24	365	5,957	5957	design	44%	3310
Main Ventilation Fans	Main Ventilation Fans	Fan Motor No 3	850	1	80%	24	365	5,957	5957	design	44%	3310
Gas Drainage Plants	Gas Drainage Plant	Vacuum Pump Motor No 1	315	1	55%	24	365	1,518	293	measured	11%	293
Gas Drainage Plants	Gas Drainage Plant	Vacuum Pump Motor No 2	315	1	55%	24	365	1,518	293	measured	11%	293
Gas Drainage Plants	Gas Drainage Plant	Vacuum Pump Motor No 3	315	1	55%	24	365	1,518	293	measured	11%	293
Coal Preparation Plant	Coal Handling and Preparation Plant	Reclaim Tunnel Fan	75	1	80%	24	365	526	526	design	44%	292
Coal Preparation Plant	Coal Handling and Preparation Plant	Reclaim Tunnel 1 Sump Pump	22	1	80%	24	365	154	154	design	44%	86
Coal Preparation Plant	Coal Handling and Preparation Plant	Reclaim Conveyor 1	110	1	80%	24	365	771	22	measured	2%	22
Coal Preparation Plant	Coal Handling and Preparation Plant	Reclaim Tunnel 2 Sump Pump	22	1	80%	24	365	154	154	design	44%	86
Coal Preparation Plant	Coal Handling and Preparation Plant	Reclaim Conveyor 2	110	1	80%	24	365	771	26	measured	3%	26
Coal Preparation Plant	Coal Handling and Preparation Plant	Rotary Breaker	110	1	80%	24	365	771	38	measured	4%	38
Coal Preparation Plant	Coal Handling and Preparation Plant	Plant Feed Conveyor	110	1	80%	24	365	771	39	measured	4%	39
Coal Preparation Plant	Coal Handling and Preparation Plant	Dry Sizing Screen	55	1	80%	24	365	385	385	design	44%	214
Coal Preparation Plant	Coal Handling and Preparation Plant	Bath Feed Pump	185	1	80%	24	365	1,296	97	measured	6%	97
Coal Preparation Plant	Coal Handling and Preparation Plant	Bath Correct Medium Pump	90	1	80%	24	365	631	41	measured	5%	41
Coal Preparation Plant	Coal Handling and Preparation Plant	Dense Medium Bath	18.5	1	80%	24	365	130	130	design	44%	72
Coal Preparation Plant	Coal Handling and Preparation Plant	Bath Product Screen	22	1	80%	24	365	154	8	measured	4%	8
Coal Preparation Plant	Coal Handling and Preparation Plant	Bath Reject Screen	22	1	80%	24	365	154	5	measured	3%	5
Coal Preparation Plant	Coal Handling and Preparation Plant	Bath Product Sizer	185	1	80%	24	365	1,296	1296	design	44%	720

Category	Functional Area for Electricity Usage	Electricity Usage Equipment	~ kW	Number of Units	Duty	Hours per day	Days per year	Annual MWh	Measured/Design Annual MWh (per unit)	Source data	Adjusted Duty	Adjusted MWh per unit
Coal Preparation Plant	Coal Handling and Preparation Plant	Bath Product Feed Feeder	15	1	80%	24	365	105	105	design	44%	58
Coal Preparation Plant	Coal Handling and Preparation Plant	Product Screen	55	1	80%	24	365	385	13	measured	3%	13
Coal Preparation Plant	Coal Handling and Preparation Plant	DMC Feed Pump	250	1	80%	24	365	1,752	88	measured	4%	88
Coal Preparation Plant	Coal Handling and Preparation Plant	Correct Medium Pump	55	1	80%	24	365	385	21	measured	4%	21
Coal Preparation Plant	Coal Handling and Preparation Plant	Centrifuge Main Drive	55	1	80%	24	365	385	385	design	44%	214
Coal Preparation Plant	Coal Handling and Preparation Plant	Centrifuge Main Drive	55	1	80%	24	365	385	385	design	44%	214
Coal Preparation Plant	Coal Handling and Preparation Plant	Dilute Medium Pump	75	1	80%	24	365	526	26	measured	4%	26
Coal Preparation Plant	Coal Handling and Preparation Plant	Magnetite Addition Pump	30	1	80%	24	365	210	210	design	44%	117
Coal Preparation Plant	Coal Handling and Preparation Plant	CPP Area Sump Pump	30	1	80%	24	365	210	210	design	44%	117
Coal Preparation Plant	Coal Handling and Preparation Plant	Fines Product Pump	75	1	80%	24	365	526	526	design	44%	292
Coal Preparation Plant	Coal Handling and Preparation Plant	Filter Press Wash Water Pump	55	1	80%	24	365	385	385	design	44%	214
Coal Preparation Plant	Coal Handling and Preparation Plant	Clarified Water Pump	90	1	80%	24	365	631	631	design	44%	350
Coal Preparation Plant	Coal Handling and Preparation Plant	CPP Air Compressor	45	1	80%	24	365	315	315	design	44%	175
Coal Preparation Plant	Coal Handling and Preparation Plant	Rotary Breaker Reject Conveyor	15	1	80%	24	365	105	105	design	44%	58
Coal Preparation Plant	Coal Handling and Preparation Plant	CPP Rejects Conveyor	55	1	80%	24	365	385	10	measured	2%	10
Coal Preparation Plant	Coal Handling and Preparation Plant	Thermal Product Conveyor	185	1	80%	24	365	1,296	47	measured	3%	47
Coal Preparation Plant	Coal Handling and Preparation Plant	Thermal Product Skyline Conveyor	110	1	80%	24	365	771	18	measured	2%	18
Coal Preparation Plant	Coal Handling and Preparation Plant	Thermal Product Skyline Tripper	30	1	80%	24	365	210	210	design	44%	117
Coal Preparation Plant	Coal Handling and Preparation Plant	PCI Product Conveyor	55	1	80%	24	365	385	15	measured	3%	15
Longwall Mining System	Longwall Mining System	Tail-Gate Drive	1200	1	55%	24	365	5,782	5782	design	31%	3213
Longwall Mining System	Longwall Mining System	Main-Gate Drive	1200	1	55%	24	365	5,782	5782	design	31%	3213
Longwall Mining System	Longwall Mining System	Crusher	500	1	55%	24	365	2,409	2409	design	31%	1339
Longwall Mining System	Longwall Mining System	BSL	500	1	55%	24	365	2,409	2409	design	31%	1339
Longwall Mining System	Longwall Mining System	Dust-Scrubber	37	1	55%	24	365	178	178	design	31%	99
Longwall Mining System	Longwall Mining System	Main-Gate Ranging Arm/Cutter	860	1	55%	24	365	4,143	1370	measured	18%	1370
Longwall Mining System	Longwall Mining System	Tail-Gate Ranging Arm/Cutter	860	1	55%	24	365	4,143	1369	measured	18%	1369
Longwall Mining System	Longwall Mining System	Main-Gate Haulage	150	1	55%	24	365	723	723	design	31%	402
Longwall Mining System	Longwall Mining System	Tail-Gate Haulage	150	1	55%	24	365	723	723	design	31%	402
Longwall Mining System	Longwall Mining System	Hydraulic Pump	75	1	55%	24	365	361	361	design	31%	201
Longwall Mining System	Longwall Mining System	Lump Breaker	200	1	55%	24	365	964	964	design	31%	535
Longwall Mining System	Longwall Mining System	Main Emulsion Hydraulic Pump #1	250	1	55%	24	365	1,205	415	measured	19%	415
Longwall Mining System	Longwall Mining System	Main Emulsion Hydraulic Pump #2	250	1	55%	24	365	1,205	398	measured	18%	398
Longwall Mining System	Longwall Mining System	Main Emulsion Hydraulic Pump #3	250	1	55%	24	365	1,205	410	measured	19%	410
Longwall Mining System	Longwall Mining System	Main Emulsion Hydraulic Pump #4	250	1	55%	24	365	1,205	391	measured	18%	391
Longwall Mining System	Longwall Mining System	Water Booster Pump & High-Pressure Emulsion Hydraulic Pump #1	250	1	55%	24	365	1,205	448	measured	20%	448
Longwall Mining System	Longwall Mining System	Water Booster Pump & High-Pressure Emulsion Hydraulic Pump #2	250	1	55%	24	365	1,205	1	measured	0%	1
Longwall Mining System	Longwall Mining System	Tail-Gate Drive	1200	1	55%	24	365	5,782	5782	design	31%	3213
Longwall Mining System	Longwall Mining System	Main-Gate Drive	1200	1	55%	24	365	5,782	5782	design	31%	3213
Fan Site Nitrogen Inertisation	Fan Site Nitrogen Inertisation	Compressor #1	250	1	80%	24	365	1,752	1752	design	44%	974
Fan Site Nitrogen Inertisation	Fan Site Nitrogen Inertisation	Compressor #2	250	1	80%	24	365	1,752	1752	design	44%	974
Fan Site Nitrogen Inertisation	Fan Site Nitrogen Inertisation	Compressor #3	250	1	80%	24	365	1,752	1752	design	44%	974
Namoi R. Pipeline Pump	Namoi River Pipeline Pumping	Raw Water Pump NR1A	90	1	80%	24	250	432	432	design	44%	240
Namoi R. Pipeline Pump	Namoi River Pipeline Pumping	Namoi River Pump NR2	22	1	80%	24	250	106	106	design	44%	59
Namoi R. Pipeline Pump	Namoi River Pipeline Pumping	Namoi Alluvial Bore Pump NR3	37	1	80%	24	250	178	178	design	44%	99
Water Pumping	Underground Pump Station (15 c/t)	Pump 1 (90kW, VVVF, PLC controlled, automatic)	90	1	9%	24	365	71	71	design	5%	40
Water Pumping	Underground Pump Station (15 c/t)	Pump 2 (90kW, VVVF, PLC controlled, automatic)	90	1	0%	24	365	0	0	design	0%	0
Water Pumping	Underground Pump Station (15 c/t)	Pump 3 (90kW, VVVF, PLC controlled, automatic)	90	1	4%	24	365	28	28	design	2%	16

Appendix II

Ventilation Opportunity

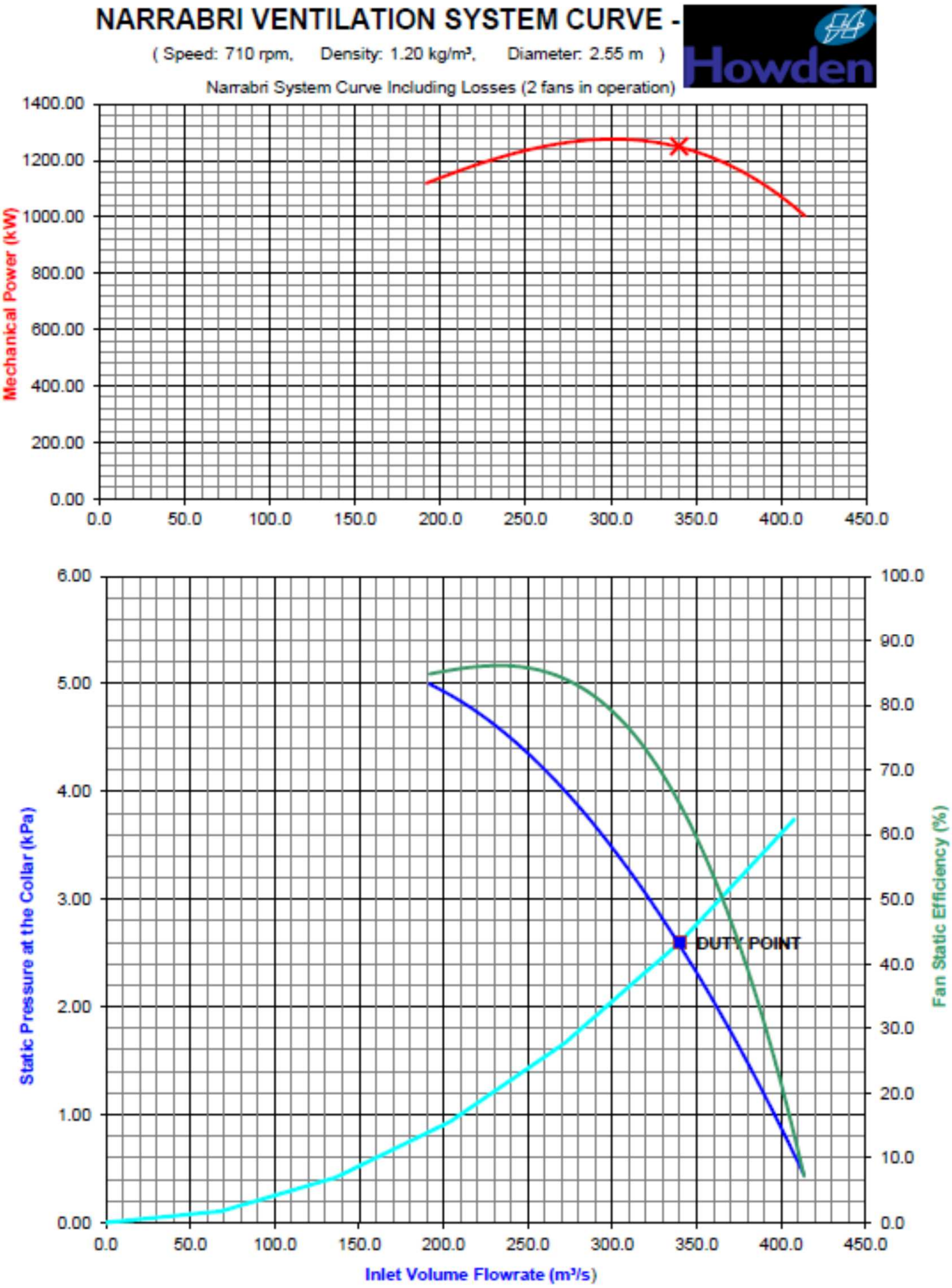

Chart 1 – Existing Configuration, Two Fan Operation Fan Efficiency Approximately 65%

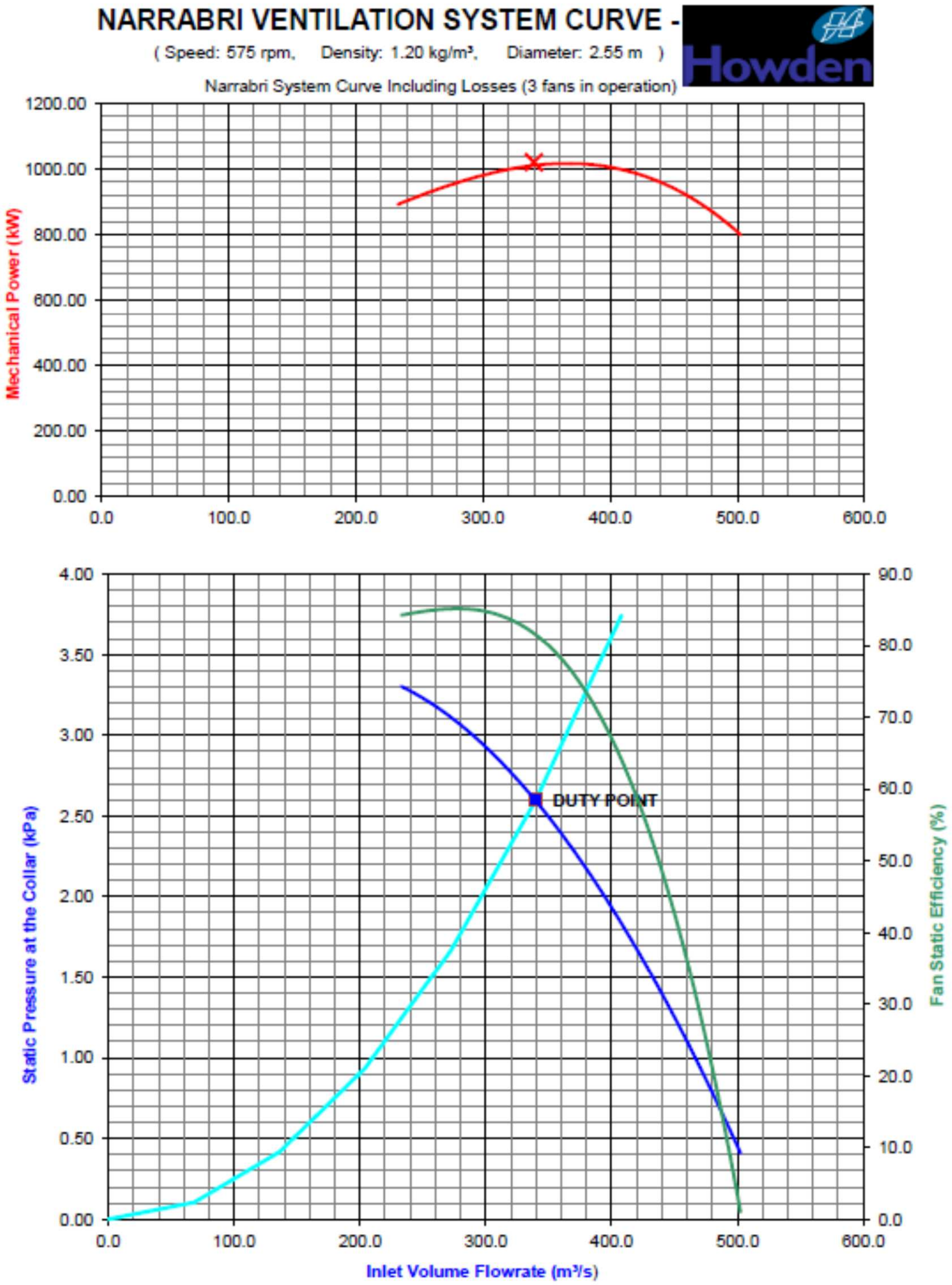

Chart 2 - Proposed Configuration – Three Fan Operation Fan Efficiency Approximately 80%

Appendix III

Measured Energy Use based on SCADA Data

Functional Area for Electricity Usage	Electricity Usage Equipment	~ kW	Number of Units	Measured Duty cycle
Drift Belt Conveyor	No 1 Motor	1000	1	21%
Drift Belt Conveyor	No 2 Motor	1000	1	21%
Drift Belt Conveyor	No 3 Motor	1000	1	21%
Drift Belt Conveyor	Product Skyline	315	1	8%
Drift Belt Conveyor	Tripper Supply	30	1	7%
Gas Drainage Plant	Vacuum Pump Motor No 1	315	1	10.6%
Gas Drainage Plant	Vacuum Pump Motor No 2	315	1	10.6%
Gas Drainage Plant	Vacuum Pump Motor No 3	315	1	10.6%
Coal Handling and Preparation Plant	Reclaim Conveyor 1	110	1	2.3%
Coal Handling and Preparation Plant	Reclaim Conveyor 2	110	1	2.7%
Coal Handling and Preparation Plant	Rotary Breaker	110	1	4.0%
Coal Handling and Preparation Plant	Plant Feed Conveyor	110	1	4.0%
Coal Handling and Preparation Plant	Bath Feed Pump	185	1	6.0%
Coal Handling and Preparation Plant	Bath Correct Medium Pump	90	1	5.2%
Coal Handling and Preparation Plant	Bath Product Screen	22	1	4.1%
Coal Handling and Preparation Plant	Bath Reject Screen	22	1	2.8%
Coal Handling and Preparation Plant	Product Screen	55	1	2.8%
Coal Handling and Preparation Plant	DMC Feed Pump	250	1	4.0%
Coal Handling and Preparation Plant	Correct Medium Pump	55	1	4.4%
Coal Handling and Preparation Plant	Dilute Medium Pump	75	1	3.9%
Coal Handling and Preparation Plant	CPP Rejects Conveyor	55	1	2.1%
Coal Handling and Preparation Plant	Thermal Product Conveyor	185	1	2.9%
Coal Handling and Preparation Plant	Thermal Product Skyline Conveyor	110	1	1.8%
Coal Handling and Preparation Plant	PCI Product Conveyor	55	1	3.0%
Longwall Mining System	Main-Gate Ranging Arm/Cutter	860	1	18%
Longwall Mining System	Tail-Gate Ranging Arm/Cutter	860	1	18%
Longwall Mining System	Main Emulsion Hydraulic Pump #1	250	1	19%
Longwall Mining System	Main Emulsion Hydraulic Pump #2	250	1	18%
Longwall Mining System	Main Emulsion Hydraulic Pump #3	250	1	19%
Longwall Mining System	Main Emulsion Hydraulic Pump #4	250	1	18%
Longwall Mining System	Water Booster Pump & High-Pressure Emulsion Hydraulic Pump #1	250	1	20%
Longwall Mining System	Water Booster Pump & High-Pressure Emulsion Hydraulic Pump #2	250	1	0%