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Moolarben Coal Energy Savings Action Plan

Felix Resources Limited

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Energy Savings
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Prepared For:

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EXECUTIVE SUMMARY

Stage 1 Approval of the Moolarben Coal Project (MCP) was granted by the NSW Minister for Planning on 6 September 2007 as a Major Project under Part 3A of the Environmental Planning & Assessment Act 1979 (EPA Act) (Stage 1 Approval). The requirements for this approval include the development of an Energy Saving Action Plan (ESAP). The MCP is a Joint Venture, with Felix Resources having an 80% share of ownership.

Stage 1 of the Moolarben Coal Mines (MCM) project involves the construction of a 10MTpa open cut coal mine approximately 40 km north-east of the Mudgee township. The coal mine will use a substantial amount of energy in the production of black coal in open-cut and underground operations. Preparing an Energy Saving Action Plan for a greenfield site where the detailed design and equipment selection has not been finalised in many areas provided an opportunity to explore and specify equipment, designs and procedures that are cost effective and energy efficient from day one.

This Technical Review has attempted to audit the proposed equipment and processes to identify potential improvements in energy performance. While the exact numbers and type of mining equipment to be used are still to be finalised, it appears that both diesel and electricity will both be significant contributors to the overall energy consumption at the site.

As the MCM is not operational, it is not possible to obtain actual energy consumption data nor is it possible to specify Key Performance Indicators (KPI's). In the absence of site specific data, Felix Resources' Ashton mine was analysed in an attempt to understand and estimate future baseline energy use and KPIs for the larger Moolarben coal mine.

Management policies for the MCM are still in their infancy. Consequently, the Management Review focussed on the Management policies in place for Felix Resources. This review revealed a few opportunities for improvement regarding the organisations Energy Management System. Mines sites owned by Felix Resources operate with a significant amount of autonomy so this finding has provided an opportunity for MCM to develop its own Energy Management System. There is the potential for this to be adopted by other Felix Resources sites where appropriate.

The commitment of Senior Management to the review process bodes well for a successful process of implementation leading to significant benefits to MCM, both commercially and environmentally.

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Energy Management Review – 4 July 2008

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Technical Review

1. INTRODUCTION

Advitech Pty Limited was engaged by Moolarben Coal Mines (MCM) to prepare an Energy Saving Action Plan (ESAP) for the approved Stage 1 of the Moolarben Coal Project at Mudgee, NSW in accordance with its Project Approval 05_0117 (Schedule 3, Condition 62) granted by the Minister for Planning, NSW Department of Planning (DoP).

The Moolarben Coal Project (MCP) area is located 40 kilometres north-east of Mudgee and 25 kilometres east of Gulgong. It covers an area of about 11,000 Ha (110 sq km) comprising rural land, private and public lands and some public infrastructure. The MCP comprises integrated open cut and underground mines as well as coal handling, washing, rail loading facilities and associated infrastructure.

The project development necessitates a staged approval process. The Approved Stage 1 includes Open Cut Pits O/C1, 2 & 3, Underground Mine U/G4 and associated infrastructure and materials handling plant. This report relates to Stage 1 of the Moolarben Coal Project.

Advitech has audited the proposed energy systems using the guidelines and templates recommended by the NSW Department of Environment and Climate Change (DECC). These guidelines and templates were developed by the former NSW Department of Energy, Utilities and Sustainability (DEUS) and are referred to throughout this document. The findings and recommendations for energy reductions are summarised in this report.

The objectives of the ESAP are to:

- Ensure compliance with the project approval conditions;
- Minimise the mine's greenhouse gas emissions;
- Propose opportunities to investigate in order to reduce energy consumption; and
- Ensure annual reporting of greenhouse gas emissions and tracking of energy saving opportunities.

This Energy Savings Action Plan (ESAP) will be reviewed in four years in accordance with the DEUS Guidelines. Progress each year regarding actions within this ESAP will be reported in MCM's Annual Environmental Management Report (AEMR).

It should be noted that this report was prepared by Advitech Pty Limited for MCM in accordance with the scope of work and specific requirements agreed between Advitech and MCM. 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. METHODOLOGY

Workshops with representatives of MCM and Advitech were conducted in July 2008, involving management team meetings and the project team. Proposed equipment lists and specifications were examined for usefulness in providing energy-related data. Information was also obtained from company management and operational personnel regarding the policies and procedures to be implemented.

3. BASELINE ENERGY USE

A baseline energy audit is normally undertaken as part of the Energy Savings Action Plan. This was unable to be undertaken as the MCP is a greenfield site. The Company will undertake a Baseline Energy Audit following twelve months of coal production.

4. MANAGEMENT REVIEW

4.1 DEUS Management Team Review Template

A facilitated management meeting was held on 4 July 2008 at Advitech's offices.

The management team used the DEUS ESAP Template to rate various categories of current energy management performance. Rating the MCM management team specifically was difficult as the team is yet to be finalised and management systems are still in their infancy. Consequently, the Energy Management Systems in place for Felix Resources were rated as a minimum for MCM.

As can be seen in **Figure 1**, the review of Energy Management indicated performance is currently in the moderate category with "informal management systems" the normal practice. A copy of the DEUS ESAP Template 2 report has been included in **Appendix 1**.

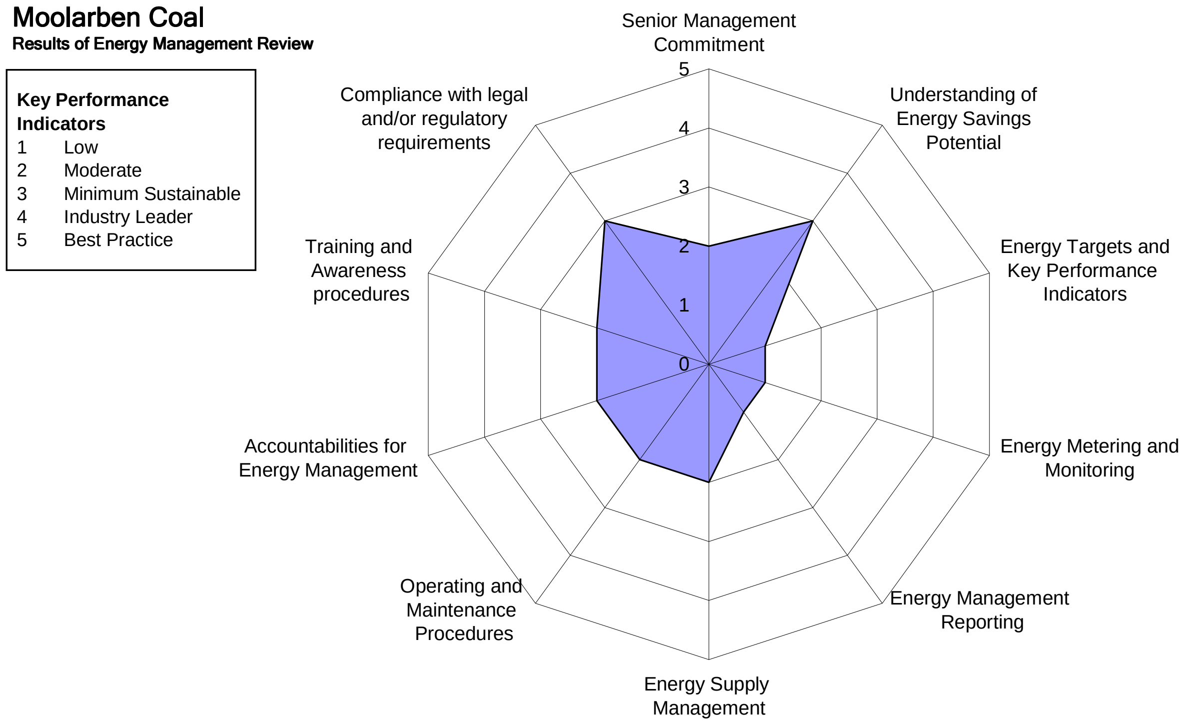

Figure 1: Results of Energy Management Review

Actions to assist MCM establish a general Energy Management System are noted in **Table 1** which again is based on the DEUS ESAP template. These actions include a commitment to form an Energy Management Forum for MCM to aid the ongoing management of energy use and performance.

It will not be possible to commence some actions until the mine has commenced the construction phase scheduled for the 1st quarter of 2009. Many actions will not be able to be completed until the first half of 2010, when the operation of the mine is scheduled to commence.

The existing MCM Management Team is committed to achieving Level 3 compliance (Minimum Sustainable) within two years of commissioning the mine by following the action plan detailed in **Table 1** below. MCM commits to the actions presented in **Table 1.**

Prior to this date MCM will undertake an audit on actual energy usage for the MCP following twelve months of normal operations to verify if the opportunities already identified have been implemented and are effective and to look for further energy saving opportunities.

Table 1: Energy Management Actions (DEUS Template 3) for MCM

Energy Management Action	Management Review Area	Responsibility	Start Date	Completion Date
Investigate corporate policies with respect to energy savings. Example - are targets set and reported on website?	Senior management Commitment	General Manager	04 Jul 08	30 Dec 09
Include energy efficiency information in tender specifications. Target efficiency. Ongoing measurement of energy efficiency.	Understanding of energy savings potential	General Manager	04 Jul 08	30 Jun 09
Target to be set following the start of production.	Energy targets and key performance indicators	General Manager	04 Jul 08	31 June 11
Investigate how to monitor diesel consumption, energy consumption. Include monitoring options in tender specifications.	Energy metering and monitoring	Contracts Manager	04 Jul 08	30 Dec 09
Comply with EEO and NGER legislation.	Energy Management reporting	General Manager	04 Jul 08	31 Dec 09
Include energy efficiency/green energy options in energy procurement specifications. Consider setting minimum target for energy from renewable sources.	Energy supply management	Contracts Manager	04 Jul 08	30 Jun 10
Include maintenance procedures in tender specifications.	Operating and maintenance procedures	Contracts Manager	04 Jul 08	30 Dec 09
Investigate corporate policy for energy management. Develop appropriate policy and processes for energy management. Develop responsibilities and accountabilities for ensuring that energy management is happening.	Accountabilities for energy management	ECRM	04 Jul 08	30 Feb 09
Include energy efficiency awareness in induction procedures, and ongoing training. E.g. Toolbox talks, radar.	Training and awareness procedures	ECRM, Engineering Manager	04 Jul 08	31 Dec 09

Continue awareness of legislative requirements. Include regulatory requirements in Energy Management System.	Compliance with legal and/or regulatory requirements	ECRM	04 Jul 08	31 June 09
Develop maintenance procedures.	Operating and maintenance procedures	Contracts Manager	04 Jul 08	31 Dec 10
Develop an Energy Management System	Accountabilities for energy management	ECRM	24 Nov 08	31 Dec 09

Notes to Table 1:

1. ECRM – Environment and Community Relations Manager (or delegate)
2. The completion dates are all dependent on the mine commencing construction in the first quarter of 2009 and subsequent operations in early 2010.
3. Responsible Officers may change depending on how the MCM team develops over time. Roles and Responsibilities will be outlined in the Energy Management System

4.2 Development of an Energy Savings Culture

4.2.1 Present Culture

The present corporate culture at Felix Resources embodies a strong focus on production and safety. Felix Resources commitment to an environmentally aware culture has been demonstrated by the participation of the Company in the Australian Government's "Greenhouse Challenge Plus" program.

The identification of energy savings opportunities provides the impetus for the Moolarben Coal Project, to develop an Energy Management System and to establish responsibilities relating to energy management.

4.2.2 Development of an Energy Management System

An Energy Management System will be developed by MCM (see **Table 1**) with the overall objective to understand and gain control over the use of energy. The system will consist of a number of planned actions to achieve this objective and will form part of the overall Safety, Health, Environment and Community Management System (SHECMS).

4.2.3 Energy Management Reporting

Advitech's interviews with the MCM management team have provided evidence of an understanding of Energy Management Reporting. In most cases (as demonstrated by Template No. 2 of the DEUS ESAP) this has been informally put into practice. To some extent, as noted above, the focus on establishing the mine as a viable business has been the primary priority. Reporting systems will be finalised as the management team is established and operational protocols are confirmed.

The most obvious cause of lack of focus on energy efficiency in any organisation is the difficulty in detecting any change in energy performance particularly when there are changes to production levels. The only solution to this difficulty is to put in place an effective energy reporting system. This will form part of the Energy Management System.

Such a reporting system should produce timely, targeted reports to each level of the organisation as well as to external stakeholders. To this end an effective foundation for monitoring and reporting both electricity and diesel usage is being developed for the mine. Production reports will be generated through the Supervisory Control and Data Acquisition (SCADA) system. These reports will be compared to power consumption which will enable KPI assessment. Similarly, the use of fuel tracking and on-board equipment monitoring will allow the efficiency of diesel fuel use to be monitored, reported and managed.

Reports from energy measurement systems will provide verification for actions taken as part of this review and will enable more accurate assessment of longer term energy saving proposals.

4.2.4 On Site Energy Forum

MCM will spend approximately $5.5M per annum for electricity and in excess of $40 - 50M per annum for diesel (depending on fuel cost and rebates) for the MCP when it is in full production in coming years. An effective Energy Management System has the capacity to influence downwards both quantity and cost. To ensure success, the system needs a focal point or forum to drive economically achievable best practice in energy efficiency. This could take the form of a single person (i.e. an Energy Co-ordinator or Manager), or a Committee (Energy Forum) where "Energy Champions" are assigned from key departments or operational areas.

MCM has decided to form an Energy Management Forum. The primary role of the Forum will be to manage and monitor current energy needs and to develop a future strategy embracing opportunities to improve energy performance. The role would involve communication with management, staff, external stakeholders as well as implementation of the opportunities identified in this Review. The role would also require a sound understanding of construction activities, infrastructure operations, machinery, and energy demands to enable identification of opportunities moving forward.

The Energy Management Forum will have clear accountabilities, objectives and goals, and have access to adequate resources to achieve those objectives. Initially the Forum will meet monthly. The first meeting of the Energy Management Forum will be scheduled to take place during the first quarter of construction.

5. TECHNICAL REVIEW

The Technical Review document is included as **Appendix II** to this report. It should be noted that this review has been undertaken in line with the MCP being a greenfield site. The Technical Review has been formulated on the Company's experience with the Ashton Mine (a smaller open cut and underground mining operation).

The following table lists opportunities that were identified during the Technical Review and at a brainstorming workshop conducted with MCM representatives. MCM commits to the actions presented in **Table 2**.

Table 2: Energy Opportunities for MCM

Area	Opportunity	Responsible Officer	Completion Date
Diesel fuel alternatives	Further investigate the potential use of hybrid diesel/LNG engines for mining fleet.	General Manager	31 Jun 2009
Diesel fuel alternatives	Investigate the potential use of biodiesel blends as an alternate fuel for Moolarben.	General Manager	31 Dec 2010
Diesel fuel efficiency	Install, use and monitor payload information to ensure that maximum efficiency of the haulage trucks is consistently achieved.	Engineering Manager	30 Jun 2010
Diesel fuel efficiency	Ensure operators are trained to understand the importance of energy efficiency and the use of specific equipment.	General Manager	31 Dec 2010
Diesel fuel efficiency	Implement a fuel monitoring and database management system to track diesel use for major equipment at Moolarben Mine.	Engineering Manager	31 Dec 2010
Energy Efficiency - Supply	Investigate the efficiencies of the specified transformers and look at cost/benefits of upgraded equipment.	Engineering Manager	31 June 2009
Coal Prep Plant	Moolarben Coal will specify the use of energy efficiency equipment and will ensure that pumps are sized correctly for the production throughput of the CPP	Engineering Manager	31 June 2009
Conveyors	Investigate the use of a SCADA system that can monitor and remotely control conveyors and other equipment to identify unloaded equipment and shut them down when safe and practical to do so.	Engineering Manager	31 June 2010
Hot Water Supply to Bath House	Investigate the installation of heat pump hot water systems instead of standard electric hot water systems. As the bath house will consist of hired relocatable buildings for the first 12 months it would not be practical to install high efficiency equipment until a permanent facility has been established.	Engineering Manager	31 June 2010
Heating of Bath House	Investigate the installation of heat pump air conditioning systems boosted by gas heaters instead of standard electric heaters and incorporate timers and/or control systems. As the bath house will consist of hired relocatable buildings for the first 12 months it would not be practical to install high efficiency equipment until a permanent facility has been established.	Engineering Manager	31 June 2010
Surface Facility Lighting	Install high efficiency lights with photo-sensors and timers.	Engineering Manager	31 June 2010
Surface Facility Lighting	The investigation and analysis of LED lighting applications should be continued as capital prices for this technology continue to fall.	Engineering Manager	31 June 2010
AC Variable Speed Drives (VSDs)	The investigation and analysis of potential applications of variable speed drives should be continued.	Engineering Manager	31 June 2010

Area	Opportunity	Responsible Officer	Completion Date
AC Variable Speed Drives (VSDs)	A procedure should be developed to identify unloaded motors and then install control systems and/or VSDs to minimise the energy wasted in keeping unloaded motors spinning.	Engineering Manager	31 June 2010
Air compressors	Investigate further cost/benefits of single stage VSD versus two stage air compressors depending on projected mine air consumption.	Engineering Manager	31 June 2010
Re-use of waste heat	Investigate the practicality of reclaiming waste heat from the air compressors to provide hot water and heating for the surface facilities once the type and location of the air compressors is known.	Engineering Manager	31 June 2010

Notes to Table 2:

1. The completion dates are all dependent on the mine commencing operation in the first quarter of 2010.
2. Responsible Officers may change depending on how the MCM team develops over time. Roles and Responsibilities will be identified in the Energy Management System

6. RECOMMENDATIONS

6.1 Energy Saving Action Plan

MCM management has committed to investigate each of the opportunities identified in this report. Many are already in progress as part of the normal process of selecting the best equipment for the project. Other items such as staff training cannot be commenced until the mine starts operating.

Progress on actioning of these opportunities will be reported in Annual Environmental Management Reports (AEMR).

Progressing these opportunities listed in **Table 2** is in addition to, and will be enhanced by, establishing an Energy Management System as detailed by the actions and responsibilities listed in **Table 1**.

6.2 Greenhouse Reporting

The DoP Project Approval Condition requires MCM to report annually in the AEMR the total amount of greenhouse gas emissions from the MCP and the effectiveness of the measures implemented under the ESAP.

The Environment and Community Relations Manager has the responsibility to “report annually on progress with the energy management System to DoP as part of Annual Environment Management Report”.

The reporting of the effectiveness of measures implemented under the ESAP will be greatly enhanced by the installation of sub-metering systems, SCADA monitoring systems, monthly reporting of energy KPI and other initiatives proposed in this ESAP.

7. CONCLUSION

Advitech has prepared a first pass Energy Savings Action Plan for the greenfield site – Moolarben Coal Project.

The review has identified a number of areas that can be implemented by MCM management initially which would give benefits both financially and environmentally as well as areas that may give future benefits.

The report also identifies Management's commitment to undertake an audit following twelve months of operation of the Moolarben Coal Mine.

8. REFERENCES

The following information was used in the preparation of this report:

1. Department of Energy Utilities and Sustainability (DEUS), 2006, Guidelines for Energy Saving Action Plans.
2. Templates, tools and conversion factors provided by DEUS (now incorporated in the Department of Environment and Climate Change – DECC)
3. Rheem Hot Water Manual, 1997

Appendix I

Energy Management
Review - 4 July 2008

Results of the Energy Management Review (Template 2) for Moolarben Mine

Organisation: Moolarben Coal Pty Ltd

Management Team

Edwina White	Environment and Community Relations Manager
Ian Callow	Project manager
Malcolm Burling	Engineering Manager
Brian Cullen	
Henry Angelucci	Electrical Engineer

Key Areas

		Low	Moderate	Minimum Sustainable	Industry Leader	Best Practice
A	Senior management Commitment		X			
B	Understanding of energy savings potential		X			
C	Energy targets and key performance indicators		X			
D	Energy metering and monitoring		X			
E	Energy management reporting		X			
F	Energy supply management		X			
G	Operating and maintenance procedures		X			
H	Accountabilities for energy management	X				
I	Training and awareness procedures		X			
J	Compliance with legal and/or regulatory requirements			X		

Figure 1: Energy Management Review (DEUS Template 2) based on using existing Energy Management Systems in place for Felix Resources as a minimum for Moolarben Coal Mines

Appendix II

Technical Review

TECHNICAL REVIEW

1. PROJECTED MOOLARBEN ENERGY USE

The Moolarben Coal Project (MCP) has a staged implementation: where construction will commence in the first quarter of 2009 with the development of open cut coal mining and a coal preparation plant (CPP), and then beginning open cut coal production during 2010 and underground coal development 2011[1].

The projected energy use from these activities is shown in **Table A1** and **Figure A1** below. The figures are based on information supplied by the Moolarben Coal Mines (MCM) management team. This information included a schedule of equipment to be used in the operation, and estimates of energy use based on the experience at the Ashton Mine.

Table A1: Projected Annual Electrical and Diesel Energy Use at MCM

	Unit	Energy GJ	Projected unit Cost	Projected unit Cost $/GJ	Projected annual cost	Emission factor	GHG Emissions tCO2-e
Electricity (MWh)	74,375	267,750	$80/MWh	22.2	$ 5,950,000	0.2950	78,990
Diesel (kL)	39,085	1,508,680	$1.30/L	33.7	$ 50,810,500	0.0752	113,450
Totals		**1,776,430**			**$ 56,760,500**		**192,440**

It is noted that the projected unit cost of both electricity and diesel will vary depending on the supplier agreements reached by MCM, market prices, and other influences, and are used throughout this document as indicators only.

The equivalent information supplied to Advitech for the Ashton mine for the 2006/07 year is shown in **Table A2**.

Table A2: Electrical and Diesel Energy Use at Ashton Mine 2006/07

	Unit	GJ	Approx. unit Cost	Approx. unit Cost $/GJ	Annual Cost	Emission factor	GHG Emissions tCO2-e
Electricity (MWh)	23,660	85,190	$80/MWh	22.2	$ 1,893,040	0.2950	25,130
Diesel (kL)	10,745	414,760	$1.30/L	33.7	$ 13,968,500	0.0752	31,190
Totals		**499,950**			**$ 15,861,540**		**56,320**

It is evident that the use of diesel associated with the open cut mine operations at the MCP will be a major contributor to the overall energy consumption for the mine. The projected energy use is

[1] Timing of the operations may vary depending on construction timeframes.

dependent on the staging of development of the mine. It is expected that initially the Open Cut Mine will be developed, followed by the development of the Underground Mine in 2011[1]. The underground coal mine will use significantly more electrical energy than the open cut mining operation, while the open cut mines will consume significantly more diesel fuel. The energy consumption of the coal handling preparation plant will also be affected by the staged development. The expected impact of the staged development of the mine on energy consumption is illustrated in **Figure A1**.

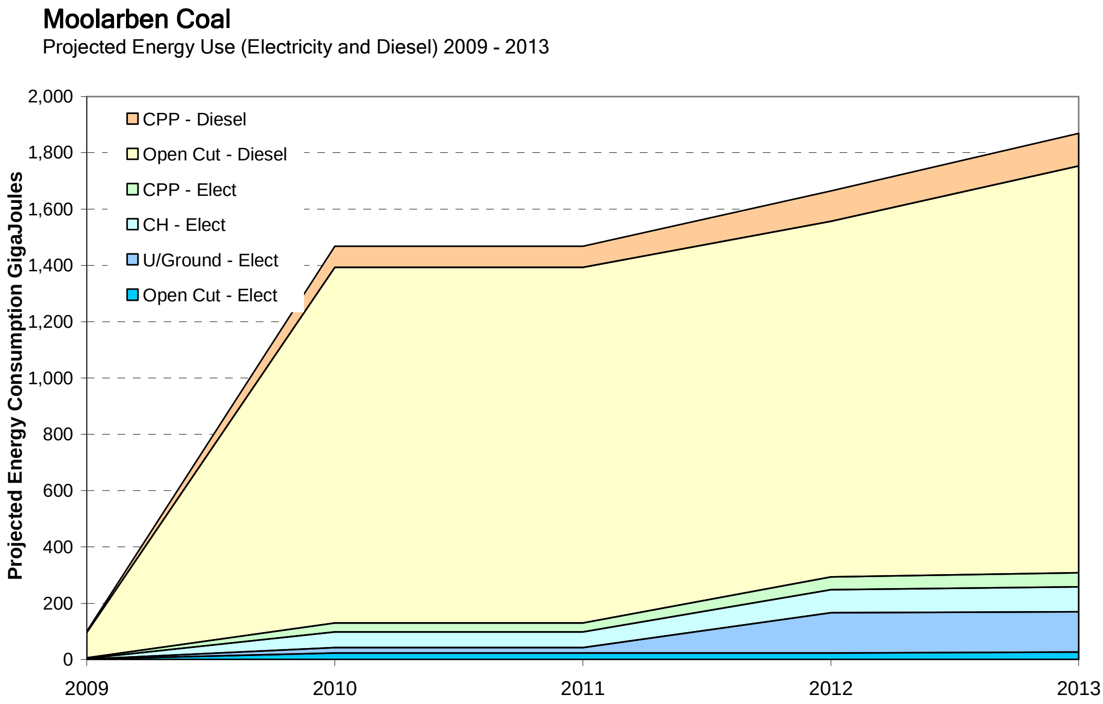

Figure A1: Projected Energy Use – Moolarben Coal 2009 – 2013

1.1 Development of Energy Key Performance Indicators

Key Performance Indicators (KPIs) are applicable at an industry level, enterprise level, and an operational level[2]. Key Performance Indicators can be developed for the mining activities which are either:

a) Externally focussed, and provide the ultimate measures of performance against higher level objectives; or

b) Internally focussed, which are diagnostic and are useful in formulating and measuring the performance of control strategies.

MCM will be required to identify a range of indicators to provide information for reporting purposes, and to assist in the management of energy efficiency of their operations. A number of KPIs may be required to understand the energy efficiency of various operations undertaken by MCM. For example, separate KPIs may be determined for the operation of the open cut pits, underground mining, and coal preparation plant.

[2] R. Mark and R. Worrall, *Greenhouse Gas Key Performance Indicators for Australian Coal Mines*, Proceedings of the Fifth International Conference on Greenhouse Gas Control Technologies..

For the purposes of energy management, the KPIs developed may be based on the Run of Mine (ROM) tonnes to give an intensity measure, or based on production tonnes (i.e. saleable product) to give an efficiency measure.

- **Intensity Measures** are useful for determining the intensity of the mining process. They include energy consumed by the mining operation, but exclude the energy associated with processing, waste and wash plant.
- **Efficiency Measures** – used to determine the efficiency of the entire operation including all aspects of mining and processing.

Based on the projected annual energy consumption for MCM, it is possible to estimate the value of the intensity KPI for energy consumption per unit of production. The calculated KPIs are shown in **Table 3.**

Table A3: Estimate of KPIs for Moolarben Coal Mine

Operation	Tonnes ROM Coal per annum	GJ per annum	KPI: GJ/tonne ROM Coal
Open cut - GJ/tonne	8,000,000	1,508,680	0.189
Underground - GJ/tonne	4,000,000	267,750	0.067
TOTAL	**12,000,000**	**1,776,430**	**0.148**

These estimated figures compare favourably to the KPI for energy consumption at Ashton Mine (based on consumption data from Ashton Mine) which is illustrated in **Figure A2.** The chart shows the actual overall energy per tonne of saleable coal achieved by Ashton for the 2006 and 2007 financial years. It is estimated that the saleable coal from the MCP open cut and underground operations will be about 80% of the ROM coal figure, giving a KPI of approximately 0.185 GJ/tonne saleable coal.

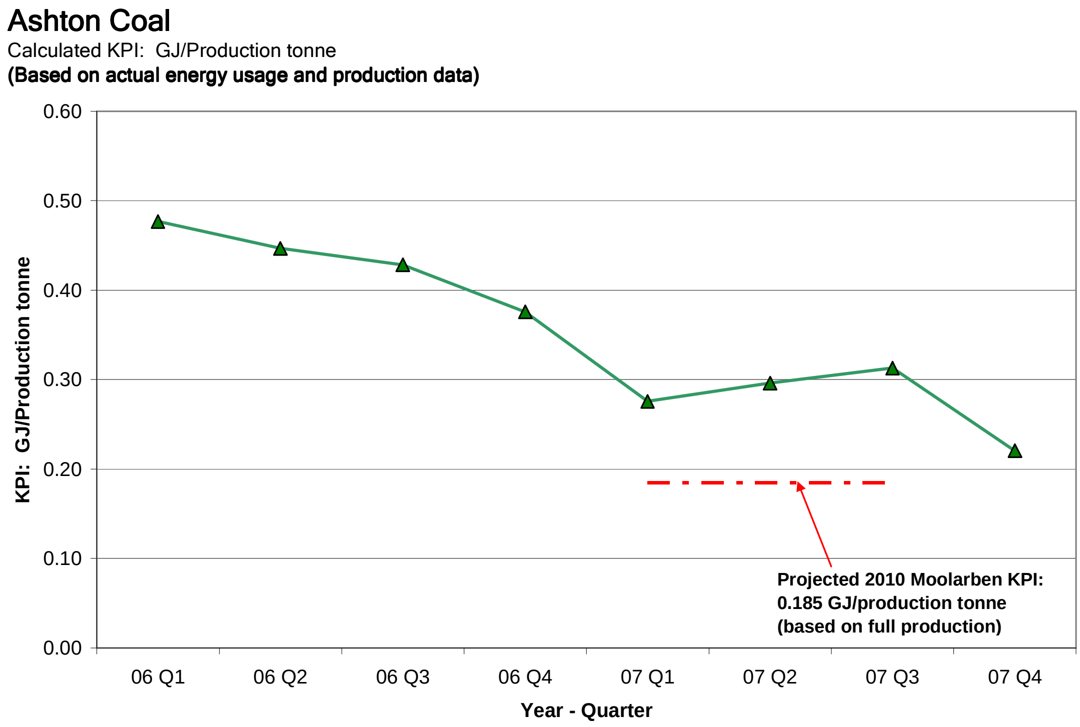

Figure A2: Calculated KPI GJ/ production tonne for Ashton, showing projected KPI for MCM

In Figure A2, it is evident that the energy efficiency of the Ashton Mine improved as the underground coal mine completed its development stage in the first quarter of 2007, and contributed to the production output.

It is likely that MCM will require increased energy in the initial stages of the mine development related to the development activities. It is noted that the actual energy consumption KPI that can be achieved by MCM will be dependent on the geological conditions, and will need to be determined following development of the mine. Some of the geological factors that may affect the KPI include the ratio of overburden to coal, the quality of the coal seam, and the ease of access for equipment.

2. DIESEL

MCM intends to use a fleet of diesel powered vehicles for open-cut mining operations. The fleet consists of vehicles and equipment designed to remove overburden, and for coal excavation and transport requirements.

At full production, the expected fleet consists of approximately 70 vehicles, including 4 x 600 tonne excavators, 16 x 240 tonne overburden removal trucks, and 8 x 240 tonne coal trucks. The major diesel users are shown in **Figure A3**.

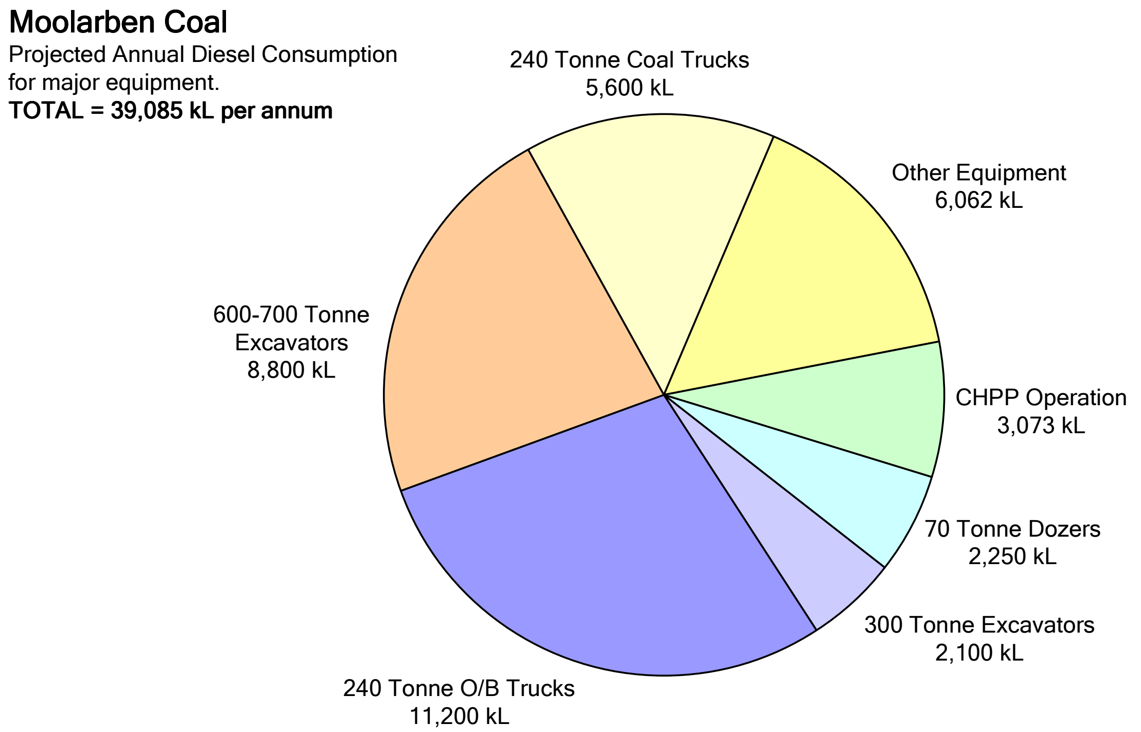

Figure A3: Projected Diesel Consumption for major equipment

KPI's will be developed to measure fuel consumption and the efficiency of the equipment. It is expected an overall KPI for fuel consumption per tonnes of run-of-mine (ROM) coal produced will be used. It should also be possible to monitor the fuel consumption and efficiency of specific groups of equipment, for example excavators and overburden removal trucks.

From the available figures, an estimate of the diesel energy consumption per tonne of clean coal produced by open cut mining operations at MCM will be approximately 195 MJ/Production tonne (equivalent to 4.9 Litres of Diesel per ROM tonne). This figure will be dependent on the amount and characteristics of the overburden to be removed. An additional KPI to consider would be energy consumption for the ROM tonnes, and for the movement of overburden i.e. MJ/BCM. BCM refers to the bank cubic metres, and includes the coal, inclusions and overburden.

The factors that will affect the production efficiency in relation to the diesel include:

- Equipment design and specifications;
- Fuel Type;
- Operational factors, including distance, payload and driver characteristics;
- Management and Monitoring; and
- Maintenance procedures and scheduling

The following subsections analyse MCM's current plans. Possible opportunities for reducing energy consumption and energy costs are also explored through analysing alternatives and operational practices and protocols potentially available to MCM.

2.1 Equipment Design and Specifications

MCM will specify equipment that will maximise the payload and efficiency of the operation. For example, large 240 tonne overburden and payload haulage trucks will be used to minimise the total number of trucks required for the fleet, and to give an increased efficiency of coal production with respect to diesel usage. MCM will purchase new equipment that meets the current standards for the mining industry. MCM intends to use diesel powered hydraulic excavators with a bucket size of around 35 cubic metres. The size of the excavators has been sized to maximise recovery and minimise equipment numbers thereby reducing fuel consumption.

MCM has specified the use of diesel powered excavators for the mining operation. The reason for the choice of this excavator type over an electrically-powered dragline relates to the specific terrain and mining distances of the MCM mine site.

2.2 Fuel Type

MCM is planning to introduce a fleet of diesel vehicles and equipment. As part of the technical review for the ESAP, currently available technologies for fuels used for open cut mining equipment were reviewed. Liquid Natural Gas (LNG) and Biodiesel were evaluated as potential alternate fuels to produce energy savings. This is explored below.

LNG/Diesel Hybrid Engines

There are currently no open cut coal mines in Australia that are running a LNG/Diesel Fleet. Proven case studies of fleets using LNG exist, however these fleets have different characteristics in terms of operating times, engine power and payload requirements. Examples are the fleets used by SITA Environmental Solutions and Murray Goulburn. It is noted that the size and power of the engines required by MCM are significantly greater than those described in the case studies.
LNG represents a significant opportunity for cost reduction, and a potential opportunity for emissions reduction. However the emissions reduction depends heavily on fugitive emissions and the assumption of no loss, or very low loss, of LNG through the refuelling cycle[3].

The approximate financial and greenhouse benefits of using LNG are described in **Table A4** and **Table A5** below. It is noted that the greenhouse gas refers to the end-of-pipe emissions, and that fuel prices are indicative only.

Table A4: Summary of Costs for Diesel and LNG fuel

	Diesel	LNG
Assume fuel consumption of 1,500,000 GJ Annually		
Energy Cost $/GJ	($1.30 per litre @ 0.0386 GJ/litre)	
	$33.68 / GJ	$14.00 / GJ
Annual Cost	$50.8 M	$18.1 M

[3] CSIRO, **Comparison of Transport Fuels,** Final Report to the Australian Greenhouse Office on the stage 2 study of life-cycle emissions analysis of alternative fuels for heavy vehicles.

Table A5: Summary of GHG Emissions for Diesel and LNG fuel

	Diesel	LNG
Assume fuel consumption of 1,500,000 GJ Annually		
Emission Factor, tCO2-e/GJ	0.075	0.067
Annual GHG, tC02-e	113,450	91,600

The use of LNG represents a potential cost saving of $32.7M per annum, depending on specifics of market price and available technologies. In terms of greenhouse gas emissions, LNG offers a relative saving of about 20% based on end-of-pipe emissions. This figure is dependent upon fugitive emissions. While these savings opportunities are significant for both cost and emissions, there are risks relating to the infrastructure and technology in using this fuel.

The use of LNG requires significant infrastructure due to the nature of the fuel which is cooled to less than -160°C and then stored in cryogenic vessels. Currently the infrastructure does not exist in the regional area of the MCP (although it is noted that Kleenheat expects that LNG infrastructure will be introduced to NSW by 2010). In the absence of existing infrastructure it is not currently possible to perform a small scale trial of the technology; however this may be investigated in the future.

The use of LNG as a hybrid fuel with diesel requires a non-standard engine. Generally these hybrid engines are able to run on either the LNG/Diesel hybrid mix, or with just diesel. An opportunity may exist to specify the hybrid engine, and retrofit the required LNG tanks at a later date as infrastructure is built. The effect on payloads, if any, will need to be considered. MCM will also need to consider OH&S and Coal Mines Health and Safety Regulations and any additional requirements of the Department of Primary industries for use of LNG as an alternate fuel.

While LNG represents a potential cost and environmental opportunity to MCM, there are significant risks associated with the implementation of this fuel in terms of technology and infrastructure. The emerging technologies and applicability of LNG as an alternative fuel for the coal mining fleet should be monitored over the short to medium term.

Opportunity: Further investigate the potential use of hybrid diesel/LNG engines for mining fleet in the future.

Biodiesel

Biodiesel is a renewable fuel source that offers improved emissions over standard diesel. In practice, biodiesel is blended with diesel in ratios ranging from 5 – 20%. There is evidence that biodiesel has been trialled in open cut mine vehicles, although there is currently no widespread use of the fuel in the mining industry. The results of these trials have yet to be made public. Currently there is no formal support of the manufacturers such as Caterpillar, Cummins and MTU-Detroit to use the biodiesel in their engines. In addition, the applicability of a Biodiesel blend to the relatively cool-climate of the MCP would need to be assessed.

Biodiesel represents a potential environmental opportunity to MCM, however there are risks associated with the implementation of this fuel in terms of technology. The emerging technologies and applicability of biodiesel as an alternative fuel for the coal mining fleet should be monitored over the short to medium term.

The NGA Factor book shows the Biodiesel from Canola has a full cycle emission factor of 62.5 kg CO_{2e}/GJ which is 16.9% less than the 75.2 kg CO_{2e}/GJ quoted for Automotive Diesel.

Opportunity: Investigate the potential use of biodiesel blends as an alternate fuel for Moolarben

2.3 Operational Factors

The amount of fuel required for the mining operation will be determined by the following operational factors:

- Haulage grades;
- Haulage distances;
- Idle time;
- Payload distributions; and
- Driver characteristics.

Minimising the distances between the mining, crushing and loading facilities will assist in the overall efficiency of the mining operation. These factors are taken into account as good mining practice.

The efficiency of the haulage operation is also dependent on the ability to achieve the maximum payload within a reasonably close tolerance. To achieve this objective, sophisticated measurement and monitoring of haulage trucks will be used by MCM to ensure the efficiency of the operation. For example, the excavator will be able to tell the truck how much volume it will be getting.

Opportunity: Install, use and monitor payload information to ensure that maximum efficiency of the haulage trucks is consistently achieved.

The energy efficiency of equipment can be related to the way in which it is operated. For mining equipment this can include gear selection, idling performance, and especially in the case of excavators, technique. Monitoring of fuel efficiency will help to identify operational issues, such as poor maintenance, degrading performance, and inefficient operation.

Opportunity: Ensure operators are trained to understand the importance of energy efficiency and the use of specific equipment.

Management and Monitoring

The ability to monitor fuel usage across the MCM's fleet of mining equipment will assist in the management of diesel use. MCM is investigating installing a fuel management system, such as the Banlaw FuelTrack system, which will assist the mine management in monitoring the fuel efficiency of each vehicle. MCM will have an electronic database whereby an electronic system will automatically record the fuel use and hours operated of equipment, tank monitoring and when machines go to refuel. The fuel tracking and database system will become key components of a system to establish energy baselines and opportunities for improvement for diesel at the mine site.

Opportunity: Implement a fuel monitoring and database management system to track diesel use for major equipment for the MCP.

2.4 Diesel Energy Measurement, Monitoring and KPIs

The ongoing identification of energy savings actions relating to diesel consumption, and the implementation of those actions will require measurement and monitoring.

a) Data Reporting

It is recommended that MCM management develop a diesel energy reporting format which can be incorporated into the management reporting system enabling both maintenance of existing levels of efficiency and verification of improvements through energy savings initiatives.

b) Diesel Consumption Data

To be able to allocate total diesel consumption to major pieces of equipment will require monitoring of the fuel consumption for major items of equipment, and an overall management of diesel fuel on the site.

c) Development of Diesel KPI

Diesel use is dominated by the equipment used in the open cut mines. The diesel consumption achieved by the Ashton open cut mining operations can provide a broad indication of the KPIs that may be able to be achieved by MCM. In this example, a KPI of diesel consumption in kL versus production tonnes is used. A chart showing the variation of KPI over time for the Ashton Mine is shown in **Figure A4** below. As data becomes more consistently available from MCM, KPIs specific to the mine will be able to be refined and will become a valuable reporting tool for measuring diesel efficiency.

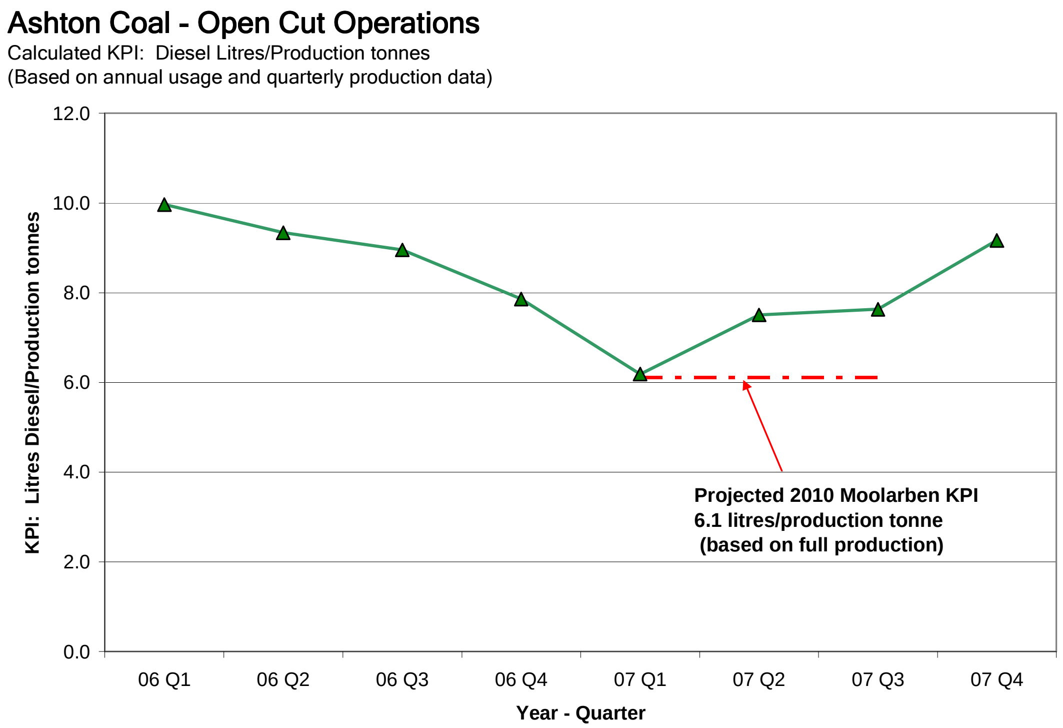

Figure A4: Ashton historic KPI performance, Diesel kL/ Production tonne – Open Cut operations

A diesel consumption KPI of 6.1 litres per tonne of saleable coal has been estimated for MCM based on saleable production being 80% of the ROM tonnes from the open cut mine, and estimates of equipment and fuel usage. The actual KPI that will be able to be achieved by MCM will depend on factors including geography and geology. It is envisaged that MCP will set target KPIs and record monthly progress of KPIs for diesel consumption once adequate monitoring systems are in place.

3. ELECTRICAL ENERGY

The following subsections analyse the opportunities available in terms of electricity consumption. This section explores the potential opportunities to reduce electrical energy consumption and cost through identifying alternatives and management activities to improve energy efficiency.

3.1 Bulk Electricity Supply

Power will be supplied to the MCP at 66 kV from the existing Country Energy Ulan Switchyard. The 66 kV power line will be run adjacent to the road and rail corridor to the Coal Handling facilities where a 66/11 kV substation will be constructed. The main metering enclosure will be within this high voltage substation.

3.2 Cost of Supply

Supply costs consist of two major parts: network or delivery charges which are regulated, and energy charges which are competitively sourced from the market. With a projected total maximum demand of approximately 15 MW and metering at high voltage in the privately owned main substation, it is likely that Country Energy will calculate an individual Cost Reflective Network Tariff for MCP. These tariffs are normally lower than the published network tariff prices.

The last twelve months has seen volatility in the wholesale contract electricity price with market prices ranging from $43 per MWh to $77 per MWh. This is illustrated in **Figure A5**.

At the time of preparing this report, future retail contract prices are considered to be relatively low at a price of $50 per MWh. Given that the MCM's price has not been locked in, and including distribution, network tariff and other market charges, Advitech has used an average projected price for Calendar Year 2009 of $80 per MWh (excluding GST but including all network and market charges), for all cost and payback calculations.

Figure A5: Wholesale NSW Electricity Prices

3.3 Internal Supply Arrangement

The incoming supply will be transformed to 11 kV for distribution around the site by means of two 66/11 kV transformers. The 11 kV distribution system will feed approximately 9 smaller substation transformers with output ratings either 1 kV or 415 V.

3.4 Transformer Efficiency

Although there are minimum standards for the efficiency of new transformers it is known that there is a wide range in efficiencies within some manufacturer's ranges and between manufacturers. The evaluation method for determining the optimum transformer for a job will depend on the shape of the customer load, i.e. percentage of time at various load levels.

What normally happens from a customer perspective is that a dollar value is calculated for the no-load and load-loss per kW in present value terms. This is determined from the cost of energy and the loading pattern etc. This then signals to the manufacturer how to determine the best option in terms of capital cost versus losses and allows the customer to simply evaluate tender responses.
The following table from Hitachi demonstrates the potential savings.

Table A6: Typical Transformer Efficiencies

Type	No-Load Loss (W)	Load Loss (W)
Amorphous Transformer	245	2,800
Silicon steel plate transformer (Super high-efficiency type)	495	3,115
Silicon steel plate transformer (Based on JEM1474)	896	5,702
Silicon steel plate transformer (Standard low-loss type)	1,110	5,910
Silicon steel plate transformer (25 years ago)	2,370	6,410

*Typical example of 3-phase, 500 kVA and 50Hz

A load loss reduction of 2.6 kW represents a potential saving of 0.5% and would hence translate to annual saving of $30,000 per annum at full mine production.

Opportunity: Investigate the efficiencies of the specified transformers and look at cost/benefits of upgraded equipment.

3.5 Power Factor Correction

The MCP will have power factor correction equipment fitted from commencement which will aim to achieve a power factor of 0.95 (0.9 minimum).

3.6 Typical Peak Day Load Profiles

The Open Cut and CPP operations of the MCP are expected to operate 24 hours per day for seven to ten day cycles separated by a 24 hour maintenance shutdown. It is suggested that MCP conduct the maintenance periods during weekdays rather than weekends, if possible, in order to reduce costs by avoiding peak and shoulder charges. This would also benefit the NSW grid by lowering demand in peak periods.

Initially most of the energy will be consumed by the CPP. It is expected that the CPP will be run relatively continuously, even in the initial stages of the mine to ensure continuity of supply.

It is expected that a typical daily load profile will be relatively flat. Little variation is expected between the winter and summer seasons.

3.7 Major Plant Items

Figure A6 shows the expected consumption of electricity according to the maximum demand rating of the proposed equipment.

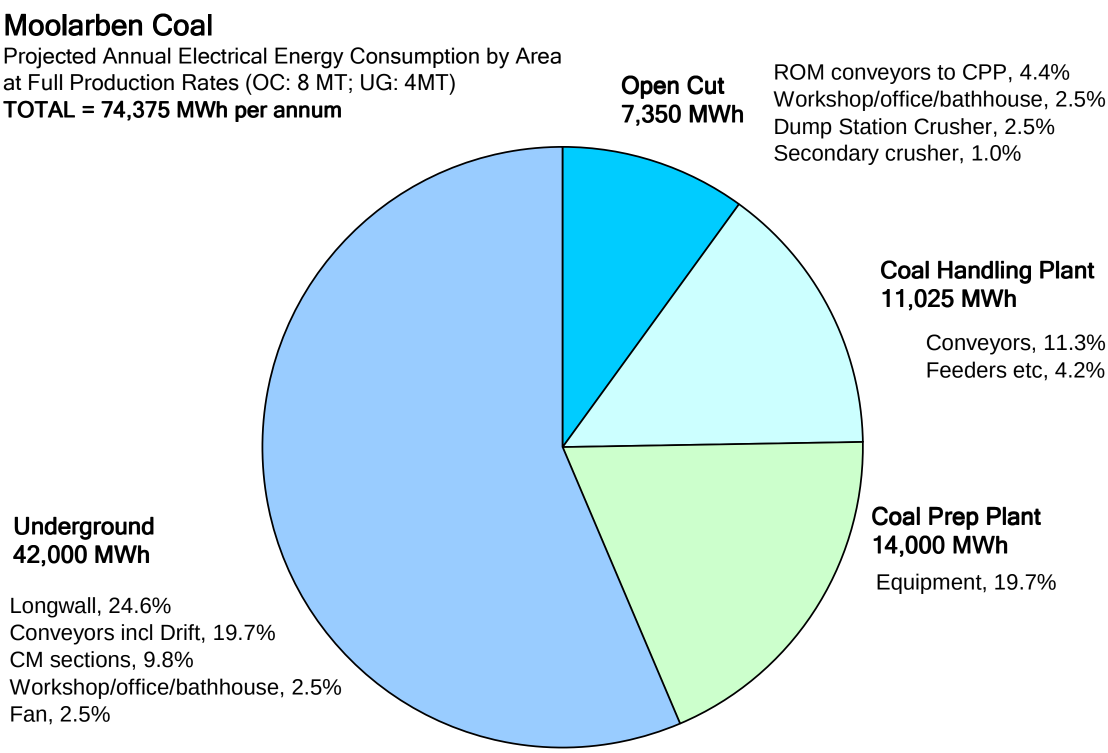

Figure A6: Expected Electrical Demand by Equipment

3.8 Underground Machinery

A significant portion of the sites energy consumption will be attributed to mining equipment used in the underground mine. This equipment is not due to be commissioned until 2011. Unfortunately there appears to be little opportunity for energy reductions in the main mining equipment such as the longwall miner and conveyors. These will be the latest technology specialist equipment that cannot be easily modified. Opportunities for energy reductions exist in optimising usage patterns and through maintenance programs, which generally correspond to compliance to mine operating standards and optimising production as per the mine plan.

3.9 Coal Preparation Plant (CPP)

The CPP is the next major area for electrical energy consumption. The CPP uses specialised equipment to crush coal to an acceptable size, and "wash" the coal to remove impurities. Operations include separation and de-watering of the coal. The CPP utilises a number of pieces of equipment such as conveyors, pumps, agitators and cyclones to achieve the operation.

The energy efficiency of the CPP will primarily be determined by the efficiency of the equipment used in the plant. Case studies show that the efficiency of coal prep plants can be improved by ensuring that the sizing of pumps and conveyors and other equipment are appropriate for the throughput of the plant[4]. For example, Bulga Coal Handling and Preparation Plant replaced 25 motors with higher efficiency alternatives to achieve an annual saving of 220 MWh.

Opportunity: Moolarben Coal will specify the use of energy efficiency equipment and will ensure that pumps are sized correctly for the production throughput of the CPP

3.10 Coal Handling Plant - Conveyor Systems

Conveyor systems will constitute the next largest group of energy using equipment. Mine management have been diligent in specifying conveyor systems that are not oversized, have minimum thickness belts and with low friction rollers.

The main conveyors will have two drive motors and there is an opportunity to shutdown one motor at low loads. This is discussed further in **Section 3.18**, Unloaded Motors.

There is also potential to turn off some conveyors when not in use for extended periods. Unfortunately mining regulations that require conveyors to be manually inspected prior to restarting after a short period restrict the opportunity to shutdown conveyors repeatedly for brief periods.

Opportunity: A SCADA system that can monitor and remotely control conveyors and other equipment could be used to identify unloaded equipment and shut them down when safe and practical to do so.

3.11 Water Pumping

It is recommended that water pumps specified for the MCP are controlled surface pumps fitted with Variable Speed Drives to maintain adequate flows and pressures to underground and above ground facilities. These actual units have not been specified at the time of writing this report however the mine

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[4] Office of Industrial Technologies Energy efficiency and Renewable Energy, U.S. Department of Energy, "**Optimized Pump Systems Save Coal Preparation Plant Money and Energy**", http://www1.eere.energy.gov/industry/bestpractices/pdfs/peabody1.pdf

engineering staff understand the importance of specifying correctly sized pumps and motors to optimise energy efficiency.

Four main water pumps for the CPP are likely to be high voltage motors because of their large capacity. High voltage motors are inherently more efficient than lower voltage motors due to lower I^2R losses.

3.12 ACARP Project C1604 Electrical Efficiency in Coal Processing

The Australian Coal Association Research Program (ACARP) published a report by Tony James in March 2008 that investigates the potential for energy efficiency in coal processing plants (i.e. Coal Prep Plants and Coal Handling Plants). The results are based on work at a small to medium sized coal processing plant. This section attempts to summarise the key elements that may be of benefit to MCP, however the application of the alternatives will depend on the coal processing configuration that will work best for the type of coals mined, the product required and the tailings/reject management. It is further noted that some of these applications would not be suitable for MCM as the coal processing plant is larger than the sizes specified in this report.

Efficiency of Various Coal Preparation Methods

Table A7 shows the comparison of power consumption per tonne of ROM coal, kWh/tonne for different processing units. Included in Appendix A are the simple models that were used for the power calculations. These are basic minimal models and it can be expected that there may be some increase in kWh/tonne in actual plants, when ancillary equipment is included e.g. floor sumps etc.

Table A7: Power Consumption DMB/DMC/Spirals/Flotation

Coal Preparation Method	DMB	DMC	Spirals	Flotation
Electricity Consumption (kWh/tonne)	0.72	1.1	2.8	6.6

The table confirms what most people would expect: that the larger the coal particle processed the greater the electrical efficiency.

- The DMB (Dense Medium Bath) is generally constrained to larger particles (range 65x 16mm). The method is effective and power efficient.
- DMC (Dense Medium Cyclone) method of processing coal is effective and power efficient (range 50x 0.5mm). The majority of coal processed in Australia is processed using DMC's.
- It can be seen from the Spirals power requirement that as the coal particle size is reduced in size the power consumption to process increases dramatically.
- Flotation continues the increase in power consumption as size decreases. With Flotation the electrical power requirements of current dewatering systems are a major contributor. If a method of drying requiring less power were used it could halve the power required by flotation product.

Efficiency of Various Size of Coal Preparation Equipment

Table A8 shows how energy efficiency of coal preparation equipment improves with increasing size of the equipment.

Table A8: Power Consumption vs. Module Capacity

Method	M:C ratio	450 tph	600 tph	800 tph	Average
DMB				0.72	0.72
DMC	2.7/1	1.15	1.06	0.94	1.05
DMC	3.6/1	1.16	1.06	1.00	1.07
Spiral		2.91	2.65	2.78	2.78
Flotation		7.06	6.41	6.28	6.58

Table A8 confirms that from an energy perspective the trend to larger modules in coal processing plants improves the electrical efficiency. This is attributed to the higher efficiency in larger pumps.

In comparing the power consumption versus the module capacity, there are two areas of non linearity:

- DMC 600 tph for two different medium to coal ratios.
- Spiral 600 tph to 800 tph.
- These are both attributed to the general nature of these pump power calculations, and the quantum level steps between pump sizes and their efficiencies.

Electrical Power in Coal Handling Plants

Table A9 compares the electrical efficiency of two common Raw Coal Sizing and Crushing Systems, a Rotary Breaker and a Chain Feeder Breaker:

- The Rotary Breaker Model consists of a Bin with a vibrating feeder (15kW), a Conveyor (55kW) feeding the Rotary Breaker (55kW).
  - Total Power 125 kW.
  - Capacity 1200 tph at 140 mm top size.
- The Feeder Breaker Model consists of a Chain Feeder 75 kW, and a Breaker 110 kW.
  - Total Power 185 kW.
  - Capacity 750 tph at 250 mm top size.

Table A9: Power Consumption vs. Reduction Method

Coal Reduction Method	kW	Tph	kWh/tonne	Annual Cost*
Rotary Breaker	125	1200	0.10	$40,000
Feeder Breaker	185	750	0.25	$98,400

* Calculated for a 4 million tonnes per annum processing plant.

To quantify the difference, consider a 4 million tonnes per annum processing plant, with the cost of electricity at 10 cents per kWh. The reduction in electrical power cost would be $60,000 per year or 1.5 cents per tonne by using a Rotary Breaker in place of a Feeder Breaker. If a life cycle operating cost comparison was employed the reduction in power and maintenance costs may offset the higher initial cost of the Rotary Breaker.

The other typical Raw Coal System utilises sizers in place of the rotary breaker or feeder breaker. The existing sizers currently in manufacture vary in kW capacity dramatically. One option is a large connected motor running at 50% capacity with the ability to handle surge or harder material. The other option uses a smaller motor, which operates at near full power and bypasses harder material. A realistic comparison of these units would require trends of power and tonnages to allow a fair comparison.

From the above comparison the Rotary Breaker is more energy efficient than the Feeder Breaker configuration.

Note 1: In the above example the Rotary Breaker has reduced it's product to 140 mm top size and the Feeder Breaker has reduced it's product to 250 mm. This again presents greater efficiency with less work further required to achieve the normal 50 mm top size.

Note 2: The selection of the sizing or reduction equipment will depend on the ROM coal characteristics; hard coals with slab like breakage may not be suitable in a rotary breaker and require the selection of a sizer or crusher. The selection of the correct equipment has to consider the physical characteristics of the coal along with other considerations not just power consumption.

The other basic design comparison is the use of vibratory feeders as compared with a chain feeder. Again the power consumption (or costs) and maintenance costs are dramatically less.

Demand Management

The ACARP report examines a number of areas where electrical energy savings can be achieved such as pumping efficiency, air compressors and lighting. The majority of these are discussed elsewhere in this report.

Cogeneration is not feasible for the MCP due to the low methane content of the coal seams being mined.

However Demand Management is an area that can potentially save MCM significant amounts of money and reduce the maximum demand on the NSW grid. Typical examples quoted by the ACARP report include ensuring that three large energy using processes such as train loading, train unloading and return water pumping do not occur simultaneously. Another potential demand management initiative was to ensure that the irrigation control system does not operate when the coal crushing system is operating.

Performance Indicators

Some typical performance indicators for a coal processing plant, published in the ACARP report are shown in **Table A10**. These figures are indicative for a coal preparation plant processing approximately 3 MT of ROM coal each year. The ability to apply sub-meters to the high-energy using equipment, if practical, would allow MCM to develop specific performance indicators for the CPP similar to the energy intensity indicators shown below.

Table A10: Power Consumption vs. Reduction Method

Application of Energy	Connected Load kW	Energy Consumed kW	Energy Consumed kWh (indicative)	Energy Intensity kW/hr
Pumping	3,154	2,365	14,400,000	5.00
Conveyors	862	646	3,940,000	1.37
Crushing	406	304	1,860,000	0.65
Services	279	209	1,280,000	0.45
Lighting	100	100	470,000	0.17
TOTAL	4,800	3,625	21.970.000	7.70

3.13 Hot Water Supply to Bath House

The energy source for hot water for the mine bath house had not been specified at the time of writing this report. With the assistance of manufacturers, Advitech has prepared an analysis of water heating options to assist MCM in selecting a hot water system. The analysis is based upon the following assumptions:

- At full production, MCM will employ around 320 people including staff and operations personnel
- Almost all operations personnel are expected to use the showers;
- Operations staff will work around a 2 - 3 shifts per day basis
- Assuming there are approximately 100 operations personnel per 3 shifts;
- Total hot water use is 4,250 L over a 20 minute peak period; and
- Total of 12,750 L per day with a temperature rise of 50 degrees Celsius.

It is noted that this is a preliminary investigation, and the actual work patterns, number of personnel and hot water requirements will be finalised at a later date.

There is no natural gas available in the vicinity so a comparison has been made of the relative costs and benefits of electric, heat pump and LPG systems. Unfortunately, traditional flat plate solar hot water systems cannot be installed in inland NSW above an elevation of 400 metres, due to the risk of breakage of the equipment associated with the cold temperatures. For this reason an analysis of solar systems has not been undertaken. New generation evacuated tube solar systems claim to be able to operate in these colder climates but the suppliers are currently unable to provide sufficient technical data including running cost estimates to be able to undertake a comparative analysis.

Table A11 shows that significant energy and greenhouse gas reductions could be achieved by specifying a LPG hot water system. The high running costs of LPG however lead to a net increase in expense, making economic justification difficult. However a Rheem Heat Pump hot water system coupled with electric boosters could give a reasonable pay back and still reduce energy and greenhouse gas emissions significantly compared to a standard electric hot water system (up to 164 tonnes CO_2 pa).

A more cost-effective and efficient solution may be able to be achieved by customising the design of a heat pump hot water system for the specific applications, rather than using an “off-the-shelf” product. Advitech recommends that MCM contact a specialist for the design of such a system.

Table A11: Hot water system comparison

Type	Max. 20 mins delivery (L at 50°C rise)	Annual energy cost	Capital cost	Payback (years)	Greenhouse gas (tonnes p.a.)
Rheem Electric	4250	$ 25,130	$ 21,600	Base case	275
Rheem Heat Pump	4250	$ 10,175	$ 45,290	1.6	111
Rheem Gas Storage	4540	$ 28,579	$ 26,500	N/A	89
Rheem Gas Instant.	5280	$ 26,358	$ 38,380	N/A	82

Notes:

1. Rheem Heat Pump running cost estimated with COP of 3.8, plus 15% of time when electric hot water systems will be required to boost heat pump.
2. Traditional flat plate solar systems are not suitable due to cold temperatures freezing the water causing collector breakages.
3. There are five months of the year when the mean minimum temperatures falls below 7 degrees Celsius.
4. Energy required per day supplied by manufacturers.
5. All prices exclude GST.
6. LPG price based on 55 cents per litre delivered price.
7. Electricity price based on estimated market price of 7.2 cents per kilowatt hour, plus expected increase of 1.8 cents per kilowatt hour.
8. The capital cost of the Heat Pump includes an estimated financial benefit of $20,930 from creation of REC’s.

It may be possible to interrupt supply to the heaters for a limited period to avoid peak load periods in summer afternoons and winter evenings.

Opportunity: Investigate the installation of heat pump hot water systems instead of standard electric hot water systems.

3.14 Heating of Bath House

No heating systems for the bath house or other surface facilities have been proposed at this time. Underground mine bath houses traditionally are set at 30°C to provide drying for the wet clothes that are hung in mesh steel lockers.

Advitech’s previous analysis of a similar underground mine bath house revealed that, in theory, reverse cycle air conditioners are more cost effective and greenhouse friendly than electric fan heaters, however experience at other mines has shown that they cannot maintain a reasonable temperature and that the fan heaters are required to supplement the air conditioners in cold conditions. Although marginally more expensive to run, gas heating is much less expensive to install and offers good greenhouse gas savings. Greenhouse gas emission savings equivalent to up to 84 tonnes of CO_2 per annum have been identified.

Whether gas or electric fan heaters are chosen as the back up for the air conditioners it is recommended they be fitted with a timer so that they operate only for short periods just prior to shift changeover during cold periods.

It is common practice in mine bath houses to specify wall mounted exhaust fans at a high level which are effectively removing the humidity and heat supplied by the heating system. If this system is adopted a timer is recommended to control the operation of the exhaust fans so that they operate only as long as required to remove excess moisture. This time will vary from season to season and will require fine tuning after experience.

Heat retention could also be greatly improved if the bath house entrances were fitted with a simple air lock to prevent warm air from escaping every time the door is opened.

Opportunity: Investigate the installation of heat pump air conditioning systems boosted by gas heaters instead of standard electric heaters and incorporate timers and/or control systems.

3.15 Surface Facility Lighting

The cost of providing surface lighting of buildings is expected to represent less than 1% of total energy use. However the CPP, bathhouse and workshop areas will require lighting 24 hours per day and it is common practice in mines to leave lights on even when natural daylight is sufficient or there is no one in the vicinity.

MCM management are encouraged to use the most advanced lighting systems as possible as it is a relatively inexpensive but highly visible and effective method of demonstrating to staff the management commitment to energy saving. Hopefully this will encourage staff to think about energy saving in general and turn off equipment when not required.

Typical suggestions for energy efficiency improvements in lighting design include:

- Use of natural daylight whenever possible. E.g. Installing skylights;
- Orientation of shaded windows on the northern side of buildings;
- Use of photo-sensors to turn lights off at predetermined Lux levels;
- Use of movement detectors to turn lights off in areas where no one is present; and
- Selection of appropriate lights. E.g. T5 fluorescents with electronic ballasts, rather than T8.

For example, a recent previous Advitech energy comparison undertaken for an underground mine showed that for 100 standard 36 W double T8 fluorescent tubes energy savings of 250% and payback periods of less than one year are possible by installing the more efficient T5 lights and simple control systems. Greenhouse gas savings of 30 tonnes per annum are possible.

Table A12: Lighting system comparison

Type	Annual energy cost	Capital cost	Payback (years)	Greenhouse gas (tCO_{2-e} pa)
Total T8	$ 5,620	$ 4,950	Base case	62
Total T5	$ 4,371	$ 5,940	0.8	48
Total T5 plus sensors	$ 2,185	$ 6,940	0.6	24

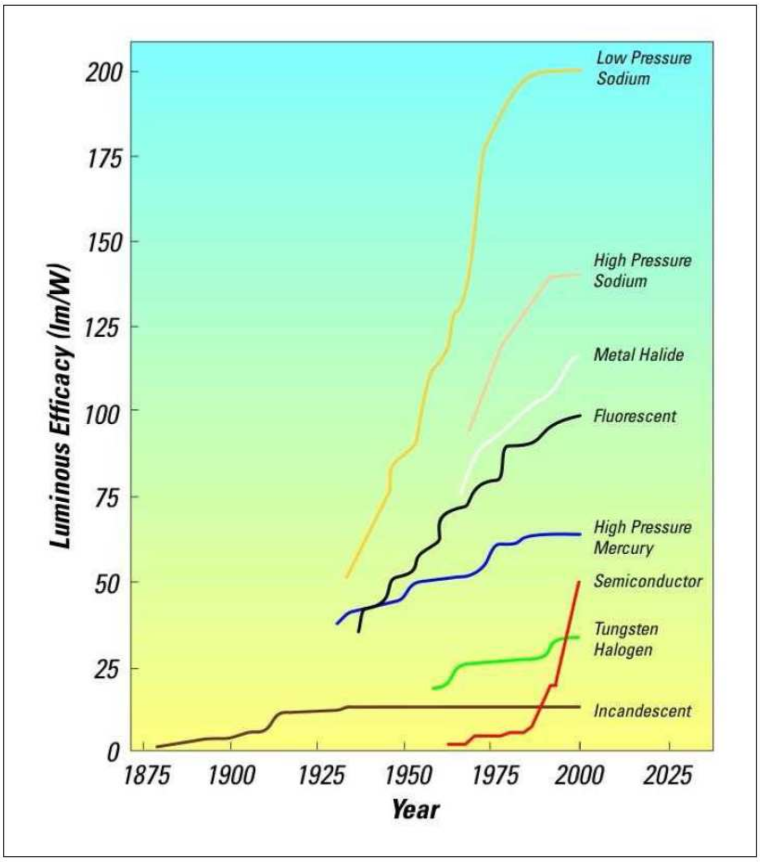
Opportunity: Install high efficiency lights with photo-sensors and timers.

The CPP will require high intensity discharge lighting. Current management thinking is to install high pressure sodium 150 W wall mounted lights. These are approximately 20% more efficient than the equivalent mercury vapour or metal halide lamps but suffer from poorer colour rendition. **Figure A7** shows the efficiencies of various types of industrial lighting.

It should be noted that in high usage areas the new generation LED lights that are progressively becoming available should be investigated when their cost becomes reasonable. LED lights generally offer substantial advantages over conventional lights with respect to much longer life and as much as 50% savings of the energy consumption. An LED supplier (Maser Group) quoted an equivalent Model LED wall mounted light would use 100 W (a 46% reduction from the high pressure sodium lamp) but noted that the overall lumen intensity was considerably lower and the price would be around $750 each. Even allowing for an expected life three times longer than the sodium lamps the $40 per annum electricity saving per lamp would probably not justify the increased capital expenditure.

Opportunity: The investigation and analysis of LED lighting applications should be continued as capital prices for this technology continue to fall.

Efficacies for lamps



(Ref. http://www.cs.cdu.edu.au/homepages/jmitroy/sph244/Lecture04.pdf)

Figure A7: Efficiencies of Industrial Lighting Systems

3.16 AC Variable Speed Drives (VSDs)

It has been well documented that both productivity and energy consumption can be improved by using variable speed drives on applications such as pumps, compressors and fans. By adjusting the motor speed in proportion to the load, the VSD can reduce energy costs by as much as 30% if the fan or pump speed is reduced by, say 15%.

Several drives are already proposed to be fitted with VSDs and Advitech's assessment is that generally the company has been diligent in identifying VSD opportunities. Further opportunities may exist where the cost effectiveness has now become attractive in light of increasing electricity prices.

Opportunity: The investigation and analysis of potential applications of variable speed drives should be continued.

3.17 High Efficiency AC Motors

In 2006 the Australian Government introduced mandatory Minimum Energy Performance Standards (MEPS) for motors smaller than 185 kW. This should mean that all motors ordered for the MCP will automatically have higher efficiency and lower running losses. However MCM are advised to check carefully since there has been several cases reported where equipment imported from overseas has been supplied with non MEPS compliant motors.

MCM should also be aware that "the typical efficiency of a worm gear box ranges between 50-90%, depending on the gear ratio. If a manufacturer put an electrical motor on a 50% energy efficient gear box, that's 50% of the energy consumption lost straight away"[5].

Energy losses in specifying incorrectly sized or inappropriate types of fans or pumps can also lead to energy wastage of up to 50%.

3.18 Unloaded Motors

As discussed previously, it will be difficult in a continuously operating mine to identify motors that continue to operate after their loading has been removed. Company staff have indicated that such situations may exist in areas associated with conveyors. It should be possible to use SCADA logging (where motor input current is monitored) to identify motors that spend a portion of their time idling. Further investigation of this matter is warranted.

For example if some conveyors have two drive motors for periods of high loads it should be possible to manually or automatically switch one motor off when the load decreases.

Opportunity: A procedure should be developed to identify unloaded motors and then install control systems and/or VSDs to minimise the energy wasted in keeping unloaded motors spinning.

3.19 Compressed Air

MCM has not specified an air compressor system at this stage. In similar underground mines air compression generally contributes around 2% of the total final energy consumed with typically three 125 kW compressors installed.

A recent previous compressed air report for a similar underground mine found substantial energy savings could be achieved by installing a two stage compressor rather than a single stage compressor (even if it was VSD controlled). Although the VSD controlled compressor is more efficient at low loads, the two stage machines are much more efficient at higher loads so the decision on which to buy will depend on how long the mine will take to ramp up production and compressed air consumption.

Comparing single stage and two stage 250 kW compressors operating at 1500 CFM (42.5 m^3/min), the two stage compressor would operate approximately 232,000 kWh per annum more efficiently, saving the mine 228 tonnes per annum of CO_2.

Opportunity: Investigate further cost/benefits of single stage VSD versus two stage air compressors depending on projected mine air consumption.

A recommended strategy for MCM would be to install a VSD controlled air compressor first to allow for the progressive increase in load as the mine expands. When the VSD machine is bearing full load a second fixed speed compressor could be installed along with a control system to ensure that the fixed speed machine operates as a base load unit and the VSD compressor acts to top up the required air.

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[5] www.manmonthly.com.au/articles/MEPS-explained-at-NMW-2008-seminar, accessed July 2008.

A two stage compressor type should then be chosen as the base load machine provided that reliability and cost issues are satisfied.

The CPP will also require air compressors but they will not be large energy users. Typically a 22 kW machine will supply instrument air 24 hours per day and a larger 90 kW compressor will supply compressed air for around 12 hours per week for "blowing the sumps" or agitating the magnetite slurry. The larger compressor will be switched off when not required.

MCM are encouraged to consider using a blower instead of an air compressor for this type of use as the pressure actually required is likely to be less than 400 kPa. Reducing the output pressure of an air compressor from 700 kPa to 300 kPa will result in an energy saving of approximately 32%.

3.20 Heat Recovery from Air Compressors

The large air compressors for the underground mine should be more than capable of supplying hot water and possibly heating to the surface facilities such as the bath house if they are positioned within 100 metres. Up to 81°C hot water is available by installing air/water heat exchangers to replace the usual fan driven air/air cooler fitted to most air compressors.

From the previous section on the bath house the proposed capacity of the hot water systems totalled only 72 kW.

A typical Atlas Copco GA315 VSD 315 kW input air compressors can supply up to 195 kW of hot water continuously at full load so should be more than capable of supplying the bath house demand. This could potentially save up to 275 tonnes per annum of CO_2.

Opportunity: Investigate the practicality of reclaiming waste heat from the air compressors to provide hot water and heating for the surface facilities once the type and location of the air compressors is known.

3.21 Energy Measurement, Monitoring and KPIs

The ongoing identification of energy savings actions, and the implementation of those actions will require measurement and monitoring of both electrical and diesel energy consumption.

a) Data Restraints

The absence of sub-metering or SCADA systems for electricity at the Ashton Mine has necessitated a significant amount of engineering assessment of energy flows which has then been extrapolated to the proposed MCP situation. It is recommended that MCM management develop an energy reporting format which can be incorporated into the management reporting system enabling both maintenance of existing levels of efficiency and verification of improvements through energy savings initiatives.

b) Energy Data

To be able to allocate total energy consumption to major pieces of equipment or facilities will require sub-metering of electricity at various points around the site. Advitech has recommended a number of proposed locations for sub metering including surface and underground facilities.

c) Development of Electrical Energy KPI

Historic data of the electrical energy consumed by the Ashton Mine can provide a broad indication of the KPIs that may be able to be achieved by MCM. In this example, a KPI of electrical energy consumption in kWh versus production tonnes is used. A chart showing the variation of KPI over time for the Ashton Mine is shown in **Figure A8** below. (The decrease in the electrical energy KPI in March 2007 is associated with the completion of the development stage of the underground coal mine, and an increase in capacity of coal handling facilities).

As data becomes more consistently available from MCM, KPIs specific to the mine will be able to be refined and will become a valuable reporting tool for measuring energy efficiency.

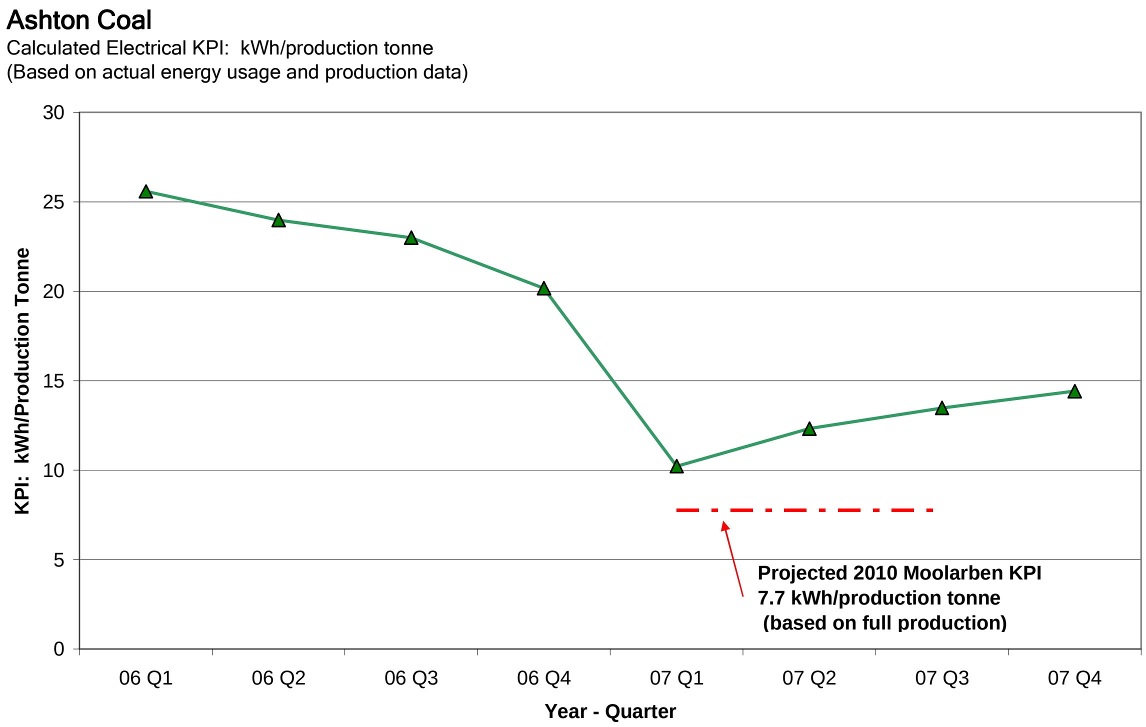

Figure A8: Ashton historic KPI performance, kWh/tonne

An energy KPI of 7.7 kWh per tonne of saleable coal has been estimated for MCM based on saleable production being 80% of the ROM tonnes, for both the Open Cut and Underground mines. The actual KPI that will be able to be achieved by MCM will depend on factors including geography and geology. It is envisaged that MCM will set target KPIs and record monthly progress of KPIs for the open cut, the underground mine and the CPP once adequate monitoring systems are in place.

4. CONCLUSION

The technical review of MCM's anticipated energy requirements indicates several key areas in which MCM has the potential to achieve energy savings. In general the following actions are required:

- Specifying energy efficient equipment from the initial stage of the project;
- Selecting equipment to maximise efficiency and ensure that throughput rates are closely matched;
- Installing measurement and monitoring equipment (including on-board computers for diesel consumption and sub-metering of electrical systems) that will supply adequate information for the ongoing monitoring of energy consumption;
- Developing key performance indicators for both the intensity and efficiency of the various operations at the Moolarben mine site; and
- Ongoing investigation of developing technologies.

MCM management were understandably reluctant to commit to baseline energy consumption or KPIs until the mine was in operation at a reasonably steady state. It is expected that MCM will set target KPIs and record monthly progress of KPIs for the open cut, the underground mine and the CPP once adequate monitoring systems are in place.