Energy Use Benchmarks for Open Cut Coal Mines

D Cooke[1] and C Randall[2]

OVERVIEW

Energy studies have been undertaken at a number of open coal mines in the Hunter valley.

A range of energy efficiency benchmarks and targets have been established, which, when applied across coal mines, will assist in leading to a significant improvement in energy efficiency in the coal mining industry in NSW, thereby leading to an improvement in environmental performance.

Typically, energy efficiency improvements of 20 per cent and higher appear possible at many mines leading to a commensurate reduction in this controllable operating cost, i.e. energy. On the basis that annual energy costs and net profit are similar for many mines, a reduction in energy costs by 20 per cent will lead to increase of 20 per cent in net profit.

The major energy benchmarks and performance targets are:

Overburden removal (mine total energy)
Mines with draglines

Unit	Benchmark Level	Target Level
MJ/BCM	18.6	14.0
Cents/BCM	19.0	14.9

On an energy basis, this represents a possible improvement of 24.7 per cent over current best practice. On a cost basis, this represents a possible improvement of 21.6 per cent over current best practice. For mines currently performing above the current best level, the possible improvement would be greater.

Mines without draglines

Unit	Benchmark Level	Target Level
MJ/BCM	26.3	19.8
Cents/BCM	24.2	19.4

On an energy basis, this represents a possible improvement of 24.7 per cent over current best practice. On a cost basis, this represents a possible improvement of 19.8 per cent over current best practice. For mines currently performing above the current best level, the possible improvement would be greater.

Other benchmarks have been established for draglines, shovels, drills, transport systems and coal washing and handling.

BACKGROUND

In April 1994, Shortland Electricity and Pacific Power developed a joint initiative directed to the coal industry to support the broad marketing objectives of::

- raising customer perception of the commercial and environmental responsibility of the industry in regard to supply and use of energy;
- increasing customer understanding of the benefits of energy efficiency and specifically of the benefits of efficient and effective use of electricity; and
- achieving increased energy efficient uses of energy.

The fundamental objective of the study was to produce credible and meaningful information for coal mine management and the electricity industry that would result in increased energy productivity for mine establishment.

The guiding principle for this approach was that there are commercial benefits for Pacific Power, Shortland Electricity and its customers to be gained from the study. Better energy management practices and adoption of efficient electrical technologies benefit the coal producer while it was expected that an energy assessment would identify opportunities for the electricity industry. Importantly, there was and is an ongoing opportunity for Shortland Electricity to improve mine management's understanding of electricity usage and the relevant technologies for various mining processes.

The study has been undertaken as a joint exercise by Denis Cooke & Associates Pty. Limited (Denis Cooke) and C Randall & Associates Pty. Limited (Cohn Randall).

INTRODUCTION

Energy in Australia is cheap by world standards. However, for the mine operator it still represents some significant controllable operating costs

In order to control energy costs, management of mines has in general to date focussed on the unit cost of energy, ie per litre of diesel or per kWh of electricity and maximum demand charges and on the stated energy consumption of new equipment.

With few exceptions, the monitoring of the actual efficiency of utilisation of energy is not common in the coal industry.

To achieve better control of energy costs, monitoring of energy consumption and measurement of efficiency is necessary.

From the monitoring work undertaken during the study it is apparent that energy efficiency data can be used as a management tool to improve overall mine performance as well as to reduce energy consumption and thus lower operating costs.

ENERGY CONSUMPTION IN MINES

Energy is consumed in each mining, transport and processing operation and the quantity consumed and its efficient utilisation is a function of a multitude of factors.

1 Managing Director, Denis Cooke & Associates Pty Ltd, Carlingford NSW

2 Managing Director, C Randall & Associates Pty Ltd, Newcastle NSW

In mining operations, the main factors that influence energy consumption include: the equipment design; machine matching; explosives factor and the degree of fragmentation; drilling patterns; bench heights; floor conditions; dip of the working floors; shovel/truck loading system; and shift system.

In transport of materials, the main factors affecting energy consumption include: equipment design; gradients; payloads; and required delivery rates.

In coal preparation, the main factors that influence energy consumption include: plant design; plant processes and flow for coarse and fine coals; ROM size distribution; ROM coal quality especially the reject percentage; moisture content of ROM and clean coal; and material balance.

A significant observation during the course of the study was the variability of operator practice in relation to electric shovels. Shovels driven by skilled operators were smooth compared to erratic movements with significant shocks for less skilled operators. From these observations, we concluded that the impact of high energy consumption is not only the high direct energy cost but the impact of higher maintenance costs some time in the future due to the transmission of that energy through the system to the machine.

In addition, a basic engineering principle of maintenance of equipment is that the greater the energy efficiency, the lower the maintenance and repair costs due to lower deleterious energy impacts on the machinery. Typical deleterious impacts on the machinery would include vibration, shock, high temperature, harmonics, and excessive mechanical stress.

BENCHMARKING

Benchmarking can best be described as an on-going systematic process to seek out and introduce international best practice by comparing an organisation's performance against competitors and best-in-class examples. It can help an organisation identify gaps in its performance and identify opportunities for improved work practices and procedures. It also assists companies to identify the practices driving the best performers, and to develop a strategy for achieving and sustaining international levels of performance.

Benchmarking is also a vehicle for driving cultural change. It is a strategic response by organisations to an increasingly competitive international environment. It fosters and institutionalises an external focus within an organisation, enabling the organisation to develop a strategy geared to its competitive environment

Energy performance

For the mining industry, the amount of energy used in relation to BCM, ROM coal and product coal can provide a valuable performance indicator by which the overall efficiency of the operations may be measured.

From the mines studied so far, it is apparent that there are many factors which affect the energy efficiency outcome. The factors include the type of equipment used, for example electric and/or diesel powered equipment and the relative fuel intensity, operational methods, for example shovel and truck matching and the mining conditions, for example the overburden ratio to name but one factor in each case.

Notwithstanding these variables, the study has found that the energy used at each mine site in relation to the total amount of overburden removed, ROM coal and total amount of clean coal may be used as a performance indicator. Whilst comparison across the industry is possible, comparisons need to be considered in the light of the particular site variables as mentioned above. For example, a particular site may have a high overburden ratio, in which case the overall energy use in relation to BCM moved would be expected to be higher than another site which has a much lower overburden ratio, other factors remaining similar.

Methodology

To establish energy use benchmarks, the energy consumption for each mine and for various areas at each mine site were measured and related to production of BCM, tonnes ROM coal and tonnes clean coal using statistical techniques. Load survey data was used from Shortland Electricity, extensive use was made of any in-house metering transducers where available, and where not available portable metering equipment was installed to collect load consumption data.

Information from the transducers and/or portable meters was down loaded through a data logger to a PC to establish load profiles for various areas throughout the mine site (as allowed by the areas monitored by the transducers). Subsequently this information was down loaded to spreadsheets and compared with Shortland Electricity information.

Additionally, short load surveys were taken at the mine sites of the workshop, administration/office and bath house loads and individual motor loads of all conveyors and machines operating through the coal preparation plant areas where possible.

Extensive use was made of historical production data, energy consumption and costs to produce historical trends of energy usage and costs in relation to bank cubic metres, raw coal and clean coal produced.

For diesel fuel, historical cost and consumption data was used with historical production data to produce historical trends of energy usage and costs in relation to bank cubic metres, raw coal and clean coal produced. At one mine site, it was asserted that on board data logging of diesel fuel usage was in place, at least for the major haulage trucks. However, it was found that this was not the case. As a result, no direct measurement of diesel fuel usage was possible. Fuel and operating cost comparisons of diesel fuel in comparison with electricity were derived from data in the McCoy Truck Study, (Smith, 1993) carried out in the USA, and published fuel consumption data from the Caterpillar and Detroit diesel engine manufacturers making allowances for drive train efficiencies where necessary.

Cost comparisons used the actual excise free diesel price paid by the mine(s) and the actual electricity price paid by the mine(s).

In undertaking cost comparisons of this type, some difficulties arise as follows.

The excise free diesel fuel price paid by individual mines will differ depending on purchasing volume discounts and/or supply arrangements. Some mines elect to purchase diesel at an outlet provided and maintained on the mine site by a supplier. The mine pays a higher price than those mines which manage and store their diesel fuel on site, but pays only as the fuel is transferred to the fuel tanks on each vehicle.

To overcome this difficulty, an adjustment to the diesel price paid was necessary to ensure fair comparison with other mine sites.

In addition, in making energy and cost comparisons, some mines elect to use subcontractors for part of the operations. For example, some mines use sub~contractors to provide haulage services on the mine site. For energy comparisons across mine sites, all energy use in the mining operation has been included.

Energy efficiency benchmarks

To establish energy efficiency benchmarks, the achieved energy performance for each mine for each activity has been examined by:

1. looking for consistently achievable best performance in a particular area, and
2. analysing the opportunities which exist at each mine to improve on the achieved energy performance and calculating the effect which implementation would have on the achieved energy performance.

It is recognised that the mines included within the study represent a small sample and that as a result the energy benchmarks established in this report may be regarded as conservative. Often a mine may have special circumstances which will cause the achieved energy efficiency benchmark to differ from the established benchmarks. Before applying the benchmarks to another mine, the particular operations of that mine require understanding so that any special circumstances may be factored into the whole energy picture.

Two distinct energy benchmarks have been established for the total operations of a mine: (I) mines which use a dragline for overburden removal; (ii) mines which do not use a dragline.

Energy efficiency benchmarks have now been established for open cut mining and coal preparation and handling processes based on the studies conducted at a number of Hunter Valley opencut operations. These energy benchmark figures have been determined as follows.

Each mine has been analysed for a theoretically achievable optimum energy efficiency level based on identified projects and optimum fuel consumption for diesel and electricity usage.

For draglines and shovels, 93 per cent of the observed consistently achievable energy consumption levels have been taken as an energy benchmark to allow for a seven per cent improvement in machine energy performance through fine tuning and improved operations.

For washeries and conveyors, it was assumed that efficiency improvements would be achieved through maximum direct feed to washeries, switching off inefficient modules, and not running unloaded conveyors. Other improvements were considered to be undertaken including modifications to bathhouse heating systems.

The energy efficiency benchmarks established are as follows:

Overburden removal (mine total energy)

Mines with draglines

Unit	Benchmark Level	Target Level
MJ/BCM	18.6	14.0
Cents/BCM	19.0	14.9

On an energy basis, this represents a possible improvement of 24.7 per cent over current best practice. On a cost basis, this represents a possible improvement of 21.6 per cent over current best practice. For mines currently performing above the current best level, the possible improvement would be greater.

Mines without draglines

Unit	Benchmark Level	Target Level
MJ/BCM	26.3	19.8
Cents/BCM	24.2	19.4

On an energy basis, this represents a possible improvement of 24.7 per cent over current best practice. On a cost basis, this represents a possible improvement of 21.6 per cent over current best practice. For mines currently performing above the current best level, the possible improvement would be greater.

Overburden removal - shovels

Overburden removal - draglines

Energy target levels represent a possible improvement of about seven to eight per cent over current benchmarks.

Overburden drilling - electric drills

Overburden drilling - diesel drills

Coal preparation

Coal transport - stacking handling

Coal transport - conveying

For the above operations, the determined energy target levels represent a possible improvement of about ten per cent over current benchmarks.

Coal transport - diesel powered truck

Benchmarks have been established using figures taken from USA McCoy Truck Study. In comparison with Australian mines, the figures represent a possible significant improvement of 30 per cent and higher in many instances.

Mine dewatering - water pumping

Benchmarks for water pumping do not have great significance because of the variables which will effect the actual energy level.

FINDINGS

Arising from the study, in addition to establishing benchmarks for the various processes, notable findings were made which are outlined as follows: -

Energy efficiency benchmarks as management tools

Energy efficiency benchmarks for each operation in the production of coal have been developed in the course of this study.

Through appropriate monitoring equipment, energy consumption can be captured simply and easily related to the current benchmarks for the particular operation. Management can then with rapid turnaround of shift by shift energy efficiency factors 'empower' operators with information that is sufficiently quick and easy to understand and gives them an opportunity to assess the reasons for major divergence and if possible make corrections. The development of energy data for provision to operators on an on-line basis is theoretically possible hut currently no software and hardware exists to provide this data. This could be a possible future development.

Where the problem is more structural than operational, management can focus on the issues which are creating the divergent energy efficiency. Sustained high energy consumption above the benchmark can result in long-term maintenance problems and the possible shortening of the plant-or equipment's economic life.

In the recent study commissioned by the Department of Primary Industries and Energy tided 'An International Comparison of Performance Indicators for the Australian Coal Industry' (Department of Primary Industries and Energy, 1994) the suitability of selected performance indicators was discussed at length. The categories of performance indicators included in the brief were:

- Labour productivity;
- Safety performance; and
- Capital utilisation.

From the work undertaken in this study, energy performance indicators for the different operational areas in the coal mine, eg washery, drilling, shovel operations, stacking etc, will form useful efficiency indicators for areas which previously would have been considered too complex or having too many variables for assigning efficiency measures.

Electricity monitoring

In general there is an inability by mines to monitor the electricity consumed by individual machines. It was common that measurement Systems did not undertake the task and the information currently being displayed was not in a user friendly form.

Electricity measurement Systems in place varied from the more recent sites fitted with transducers to the older sites where standard type kWh meters were fitted in portable substations. Some Sites had no metering facilities on some circuits. Where older type kWh meters were fitted, often the meters did not function or were not considered accurate. Where transducers had been installed they were not always appropriate for the measurement task, or had been installed incorrectly (with vt and/or Ct polarity/continuity problems), or the data gathering software had not been purchased.

Some mines said they were proposing to install on-board electricity metering on major items of plant, for example electric shovels.

Diesel consumption monitoring

Monitoring of diesel fuel consumption by all mines studied is not adequate to enable the consumption by individual machines to be detailed. This limits any cost comparison analysis between vehicles or any diagnostic alarms to be sounded if diesel consumption becomes excessive.

At one mine site, it was asserted that on-board data logging of diesel fuel usage was in place, at least for the major haulage trucks. However, it was found that this was not the case. Many modern diesel powered trucks incorporate sophisticated computer control and whilst in principle, fuel consumption data should be available for logging and use in energy management, this information is not captured.

Draglines

Electro/mechanical differences

For draglines of the same design and size, working in similar conditions 'and at similar production rates there were in some cases significant variations in energy consumption between the machines. This is only explainable by some electromechanical differences inside the machines which need to be further investigated. The ACARP study on draglines (ACARP, 1994) confirms this situation.

To lower energy costs work to design limits

For all draglines, the higher the production rate the lower the energy consumed, ie kWh/BCM. To lower the unit energy cost, work the machines to their upper design performance limits and produce higher outputs. In general, even when worked to these upper limits, for example working at maximum dig, hoist and swinging speed, there is still substantial reserve capacity.

Shovels

Electro/mechanical differences

For shovels of the same design and size, working in similar conditions and at similar production rates, significant variation in energy consumption between the machines has been found. This is only explainable by some electromechanical differences inside the machines which need to be further investigated. The differences in energy consumption level could not be attributable to the operator. Reference to the ACARP study on draglines draws a comparison for a similar expectation with electric face shovels.

To lower energy costs work to design limits

For all shovels, the higher the production rate the lower the energy consumed, ie kWh/BCM. To lower the unit energy cost, work the machines to their upper design performance limits and produce higher outputs. In general, even when worked to these upper limits, for example working at maximum crowd, there is still substantial reserve Capacity.

Drilling

Electric more energy efficient than diesel

Electric drills were more energy efficient than diesel drills. This conclusion was drawn from an analysis and comparison of fuel costs. Whilst, as stated previously, direct diesel consumption data was not available for drills, when manufacturers' fuel consumption data was used (for drills), and compared with manufacturers' fuel consumption data for diesel engines making allowances for the overall efficiency of the drive train, the outcome was similar. Thus there is a high degree of confidence in the statement. However, cost efficiency depends on the relative prices of diesel and electricity.

In some instances, diesel drills are floated from area to area to provide rapid re-positioning and reduction of wear on drill crawler tracks on a similar basis to movement of some electric drills. Electric drills require more rigorous planning since there is a need to also reposition the cables and connection boxes.

Equipment overdesign

It was found that there was an overdesign in some coal preparation plants. This could be used to advantage with the plant driven beyond its 'rated' design capacity and a consequent lower energy cost or the plant idles at low loads and low energy efficiency. Before committing further capital to increase capacity there is a need to check how much capacity is still available within the existing plant.

Alternatively, in principle some modules of a modular designed plant could be shut down to maximise the throughput in the remaining modules and reduce the energy costs.

Transport alternatives

Currently monitoring of diesel fuel consumption by truck fleets is not adequate to enable the detailed cost comparisons that are required in any evaluation of comparative trucks and/or transport modes. The McCoy truck study in the USA did undertake detailed evaluation of comparative truck performance and fuel consumption. In order to evaluate comparative truck performance or the use of an overland conveyor or a trolley wire assist system for diesel electric trucks there is a need for detailed information on fuel consumption. Many modem diesel powered trucks incorporate sophisticated computer control and whilst in principle, fuel consumption data should be available for logging and use in energy management, this information is not captured.

Mine management should review the method of collecting and assessing fuel consumption for existing truck fleets. In many instances this would require additional data logging software to be used to capture this information.

OPPORTUNITIES AND RECENT TRENDS

Across the mine sites assessed during the course of this study, the following opportunities have significance.

In many ways, these opportunities may be considered to be generic for open cut mines. Naturally, the particular circumstances will need assessing on an individual case basis.

Optimisation of dragline and face shovel performance

From the energy research undertaken over a range of different mining equipment, it has become apparent that there is scope for optimisation of dragline and face shovel performance from a strictly electrical engineering perspective.

This observation matched recent findings of a comparative ACARP study of some 15 draglines in which it was discovered that many of the draglines operated well below their rated capacity due to a variety of factors including de-rating of individual motors.

In the design of this type of machinery, engineers include various safety margins depending on their own experience and the design philosophy of the manufacturer. Particularly with dc machines where dc drive motors are supplied from an ac/dc generator or a thyristor inverter, it is possible to vary the dc output voltage which will change the performance characteristics of the dc drive motor.

It would appear that draglines which have been operating at well below their rated capacity, have been 'de-tuned' in this way by reducing the supply voltage to the dc drive motors.

Conversely, in principle it would be possible to increase the power available and operational speed of the machine by increasing the supply voltage to the dc drive motors, thus gaining additional output from the machinery. Increasing the power would need to be done with a full understanding of the performance limits of both generator and motor.

The same comments about improving efficiency are applicable to face shovels.

Drills

Some mines with an all diesel drill fleet move the drills from place to place by low loader to increase speed of re-positioning and to reduce wear and tear on tracks. Since this is a common practice for many operators of electric drills, consideration should be given to the planning needs for electric drilling once the overburden is harder and requires blasting.

In the past there was an aversion to large electric drills because of the industrial issue of two operators being required. The smaller and more flexible diesel powered drills were more likely not to require a second operator and many mines selected them for almost this reason alone. With mines now entering into Enterprise Agreements this overmanning of drills is no longer an issue.

A fresh look should now be taken by mines as to the real costs of this move to diesel drills, especially with the need to increase productivity and overall mine output.

Larger trucks lead to larger shovels and loaders

Recent studies have demonstrated the fuel efficiency of large rear dump trucks over that of smaller rear dump trucks (eg the McCoy truck study). This points to a continuing trend for major operations when purchasing new trucks to select the largest available trucks since they give all-round economies of scale including fuel efficiency.

This in turn leads to the continuing trend for companies to purchase larger loading machines to match the trend to larger trucks. In particular, larger electric face shovels and diesel/electric front end loaders are being purchased with the predominance of main overburden machines being electric face shovels.

Hydraulic excavators

Some mines are giving consideration to purchasing one or more large hydraulic excavators in backhoe configuration. The purpose is to use the excavator(s) for coal removal with an expected reduction in the contamination of the ROM coal over the current system using dozers to rip and front end loaders to load into rear dump trucks. These machines, in common with other excavators in the Hunter Valley, are likely to be diesel powered. An opportunity exists for consideration to be given about how such a machine could be electrically powered without losing its required flexibility.

In recent years there has been a trend throughout the Hunter Valley for smaller operations (in annual production/relatively small reserves) to contract out their mining operations.

Contractors have increasingly used diesel powered hydraulic excavators for a variety of reasons:

- availability;
- easily transported;

- highly versatile machine; and
- short duration of the contract.

Disadvantages for this type of equipment include:

- high operating costs; and
- relatively low productivity (when compared to electric equipment).

An opportunity exists for a study to be undertaken to demonstrate that with suitable substations and good mine planning an electrically powered excavator can operate at lower operating costs without sacrificing flexibility and manoeuvrability. Whilst hydraulic excavators are being used increasingly, performance does not match that of electric shovels.

In addition, an opportunity exists for the electricity supply industry to assist with the provision of appropriate electrical infra-structure to insure that these possible electrical loads are not lost permanently to another fuel type.

Diesel or electricity

In assessing the use of diesel or electricity as a fuel, a comparison may be made on relative energy costs, energy content and likely efficiency of the plant.

Present diesel costs are 23 - 28.4 cents/litre for an energy content of 38.4 MJ/l equivalent to 6.0 - 7.4 $/GJ. With an overall fuel conversion efficiency (to useful work) of about 20 - 25 per cent, the effective fuel cost is 24 - 37 $/GJ. the present average electricity price is 6.84 - 8.28 cents/kWh equivalent to 19.00 -23.00 $/GJ.

For electrical equipment with a conversion efficiency of 90 per cent, the final energy' cost is 21.1 - 25.6 $/GJ.

Thus if options exist to use electrically powered equipment in preference to diesel powered equipment, savings of 14 - 75 per cent in running costs would be achieved.

New fuels for trucks - LPG/CNG

In the Pilbara iron ore mining industry of Western Australia, there is considerable interest in the use of alternative fuels for the large rear dump trucks.

The laying of a natural gas pipeline into the Mt Newman mine is under consideration and as a result the possibility of using compressed natural gas.

As well the engine manufacturer Detroit Diesel is working on the introduction of LPG for large engines.

Both these initiatives provide alternatives in the search for lower overall operating costs for large rear dump trucks.

Bath house

In the mines studied, electricity was used for space heating, and it is not known if other mines use gas for space heating. In some instances, conversion has been made to gas at the expense of electricity, apparently because of operational difficulties with the existing system (which may relate to an original design problem).

Generally, control of bath house heating systems is simple, often with significant waste occurring. The explanation for this occurrence is that certain temperature conditions are required to be met in bath houses by law. In principle, significant savings in operating costs would result if high efficiency heat pump technology is used for the provision of both space heating and hot water.

In particular, the application of a ground source heat pump with a coefficient of performance of better than 5.0 appears to be most attractive as a combined system for the site to provide hot water, bath house heating and office space heating.

In addition, the installation of engineered flow control devices in all taps and showers through the bath house would be expected to save up to 30 per cent in hot water.

The estimated return on the investment for these projects would need to be assessed on an individual site basis. However, a return on the investment of less than three years or better appears readily achievable.

Alternative coal transport methods

Where the majority of coal is transported by diesel powered trucks over substantially fixed haulage distance, there is a need to assess the relative economics of continuing to transport coal by rear dump truck in comparison with other options.

Option 1- overland conveyor

Consider the use of a satellite dump station and conveyor to transport raw coal to the existing dump station and coal handling facilities.

Option 2 - trolley wire assist for coal haulage trucks

Consider the use of trolley assist when selecting new diesel/electric coal haulers since a substantially fixed haulage distance lends itself to the use of the concept.

The concept of trolley-assist involves supplying the truck electric traction motors with electricity directly from overhead conductors arranged along the principal haulage routes through pantograph collectors, thereby by-passing the truck-mounted diesel engine driven alternator.

While the introduction of a trolley-assist system can provide diesel fuel savings to be compared against the cost of electricity there are other advantages that need to be taken into account.

The additional advantages are drawn from the experience at the Palabora open pit copper mine in South Africa, which introduced the system on a large scale in 1981 on 75 of its 154 tonne rear dump trucks.

The additional advantages are given as:

- reduced cycle times due to increased speed;
- increased life of truck diesel engine;
- increased life of wheel motor armatures; and
- postponement of the need for large wheel motors.

The system enables trucks by way of a pantograph to connect onto and disconnect from an overhead trolley wire system to greatly improve haulage speeds out of the pit while also reducing the overall operating costs.

While the trolley wire installation is fixed on main haulage roads the trucks have flexibility to operate within the pit and at the dump stations and stockpiles using their standard diesel/electric wheel motor configuration.

The South African installation has until now been the only significant trolley wire assist system in operation and conventional wisdom was that the 'low' cost of electricity and 'high' diesel costs in South Africa was the reason for its continued operation.

However, it is now apparent that the system is capable of bringing significant advantages in overall efficiency and operating costs to operations elsewhere.

The Barrick Goldstrike Mine in Elko Nevada, USA, is in the process of final decision-making to install a trolley wire assist at its operation which currently operates with 52 Dresser 190 tonne diesel/electric drive trucks.

The installation will enable the mine to increase haul speeds on main haulage where trolley wire is installed without the need to either re-engine the trucks or replace them with larger trucks to meet its required production levels.

The installation will be the first outside South Africa and its successful introduction will provide an impetus for consideration by other producers of the benefits of using trolley wire assist.

Opportunities for its installation include:

- introduction into existing mines where they currently operate diesel/electric trucks and want higher haulage speeds;
- at mines where increasing depth means slower haul cycles; and
- where mines are considering larger trucks and they wish to get carrying capacity at lower capital cost since trucks with trolley assist don't need as large engines.

More detailed information will be required to be able to determine the cost effectiveness of trolley wire assist system and the Barrick Goldstrike installation will provide a valuable model.

In addition, there may be a role for Shortland Electricity to assist with provision of infra-structure to support these types of projects.

Co-disposal of fine and coarse rejects

Co-disposal of fines is an option to utilise the advantages of low electricity costs for pumping purposes. However, some mines have considered this scheme and decided to discontinue further consideration due to anticipated difficulties in moving and re-positioning the co-disposal pipeline.

Review of this type of decision where it has been taken seems appropriate to maximise the benefits of non-truck transport of coarse rejects.

At present, co-disposal is in place at the following locations:

- Jeebropilly (Queensland);
- Gordonstone (Queensland);
- North Gonyella (Queensland); and
- Cummnock Coal (New South Wales).

Plans are in place for the introduction of co-disposal at Stratford open cut. Construction at the Stratford coal preparation plant has commenced.

Conveyor belt operation

In some instances overland conveyors often are run with no load on the conveyor belt. These conveyors have large drives.

Significant energy savings can be achieved by ensuring the belt is not left running unloaded.

MOTOR SIZING AND DRIVE SYSTEMS

With any plant which utilises large numbers of electric motors, consideration should be given to motor sizing and the use of high efficiency motors.

It is not suggested that replacing motors with energy efficient motors is an economic proposition. However, when a motor fails, replacement at that time with an energy efficient motor should be considered. Often the additional marginal cost will be paid for in less than 12 months.

Typically, high efficiency motors will give efficiency advantages of three to five per cent over standard motors. Also, improved drive coupling systems using high efficiency flat or notched belts will give additional energy savings of three to five per cent

Power factor correction

At some sites, additional power factor correction could be considered. However, each location would need to be considered on an individual case basis taking into account the capital costs, electricity tariff, and the possibility of demand reduction through energy management

While power factor correction in some instances can provide a better utilisation of existing assets, if the electrical load is approaching the total installed capacity of transformers, the cyclical nature of electrical loads of shovels and draglines require substantial transformer capacity to cater for the sizeable power swings. Under these circumstances, power factor correction is unlikely to be attractive. Also, for maximum effect power factor correction should occur at the source. For mines with high voltage motors, this would be difficult to achieve economically.

Nevertheless, power factor correction may he worthwhile depending on the particular circumstances.

Purchase of sub-transmission assets

For some locations, the purchase of the sub-transmission assets may be a viable proposition to reduce electricity costs.

CONCLUSIONS

General

Most if not all Australian mine managers would be unaware of the energy consumption details for his operation and do not know where he fits in the ranking of energy efficiency. As a result of this study, energy benchmarks have been established which in the future could allow management of open cut mines in the Hunter Valley to know these answers and be leaders in energy efficient coal mining.

In addition, the major important finding arising from this study is:

Given the current pricing differential between electricity and diesel, greater use of electricity in all facets of mining operations leads to lower overall energy costs.

This observation has been drawn from the performances of the individual mine sites making allowances for the possible improvements in energy use at each location.

Potential cost reduction at a mine

The results from the study indicate that all mines could benefit significantly from introducing energy management and an energy policy to cover existing and new facilities.

The potential cost reduction at each mine is estimated at a minimum of ten per cent with probably closer to 20 per cent being achievable. See the established benchmarks in comparison with current performance.

Some mine sites waste large amounts of energy. If the performance of these sites could be changed to match the performance of other sites, energy cost reductions of 25 per cent and higher should he possible.

Future for the Electricity Supply Industry (ESI) in assisting the coal industry

Arising from the findings of this study, Shortland Electricity is in the process of establishing a business to provide the range of services listed below:

1. Auditing and project identification in a similar way to audits already completed. Projects identified, and mines provided with comparative performance data.
2. Assistance with detailed project analysis, feasibility studies (eg more complex projects such as trolley wire assist).
3. Assistance with project implementation.
4. Assistance with energy monitoring techniques, data gathering equipment, (specification and installation) software, use of information and report design as part of an energy management package.
5. Assistance with on-going monitoring of energy usage and appropriate management reports.
6. Assistance with energy management planning and incorporation of energy management practices into the day to day management of the mines.
7. Reassessment (re-evaluation of energy saved from project implementation and/or energy conservation measures) at a later stage following project implementation.
8. Reappraisal of comparative performance, either as one off or occasional exercise, or on an on-going basis.

ACKNOWLEDGEMENTS

The authors acknowledge the assistance from Shortland Electricity and Pacific Power and their permission to present this paper.

REFERENCES

Department of Primary Industries and Energy, 1994. An International Comparison of Performance Indicators for the Australian Coal Industry.

Smith, J. 1993. The McCoy/Cove Mine Haul Truck Study. General Superintendent Echo Bay Mines, September.

The Australian Coal Association Research Program's Study (ACARP) Improved Monitoring of Dragline Operation, June 1994.

ABBREVIATIONS

BCM	bank cubic metre
GJ	Gigajoules
kW	kilowatts
kWh	kilowatt hour
MW	Megawatts
$M	million dollars
M	million
Mt	million tonnes
MJ	Megajoules
ROM	run of mine (coal)
t	tonnes
vt	voltage transformer
ct	current transformer

UPDATE: 2001

The Electricity Supply Industry did attempt to set up a business providing the range of services listed in the previous section.

After a number of years, they withdrew from this activity for their own reasons. It was not because of a lack of mining projects because there were many projects available. The most likely explanation is that the business required the ESI to operate in areas outside their normal practice.

For further information, please contact Denis Cooke on 02 9871 6641 or visit our web site at www.decoa.com.au