

ENERGY EFFICIENCY & GREENHOUSE GAS REDUCTION

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FOREWORD

Protecting the environment is a priority for all members of our society. Governments have a key role in setting environmental standards and ensuring that individuals and organisations meet them. Increasingly, however, governments, industry and community organisations are working as partners to protect our environment for present and future generations.

Representatives of the minerals industry in Australia and Environment Australia, (the environment arm of the Federal Government), are working together to collect and present information on a variety of topics that illustrate and explain best practice environmental management in Australia's minerals industry. This publication is one of a series of booklets aimed at assisting all sectors of the minerals industry to protect the environment and to reduce the impacts of minerals production by following the principles of ecologically sustainable development. It should be of value to practitioners involved in exploration and planning through to supply chain and minerals processing.

These publications also provide information that allows the general community to gain a better appreciation of the environmental management practices applied by the minerals industry.

Our best practice booklets include examples of current best practice in environmental management in mining from some of the leaders in the Australian industry. They emphasise practical, cost-effective approaches to protecting the environment that exceed the requirements set by regulation. Case studies are provided to encourage better environmental performance in Australia and internationally. These case studies demonstrate how best practice can be applied in diverse environments across Australia, while allowing flexibility for specific sites.

The concept of best practice is simply the best way of working sustainably at a given site. The booklets integrate environmental issues and community concerns through all phases of mineral production, providing:

- Basic principles, guidance and advice;
- Case studies from leading Australian companies; and
- Useful references and checklists.

We encourage mine managers and environmental officers to take up the challenge to continually improve environmental performance and management of our global resources and to apply the principles outlined in these booklets.

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EXECUTIVE SUMMARY

A secure and reliable supply of energy is critical for all mining operators to meet their production requirements. For most, energy constitutes a major operating expense and its generation and distribution requires substantial capital investment. To minimise costs, it is important to recognise that energy is a controllable operating cost.

The use of energy also contributes to greenhouse gas emissions that are believed to contribute to global warming. How well greenhouse gas emissions are managed is a key indicator of the environmental profile of the industry. There is considerable public and stakeholder pressure on all businesses to demonstrate that they can operate in a sustainable manner, including the sustainable use of carbon based energy resources. Without public and stakeholder support companies can be restricted in gaining approval for new ventures and have access to funds limited.

Greenhouse is also becoming more prominent in International, Federal and State regulatory circles. Already some countries have introduced taxes on greenhouse emissions. In Australia, greenhouse policies are being supported by voluntary programs such as the [Greenhouse Challenge Program](#), as well as by economic instruments encouraging the use of renewable energy and energy forms with reduced greenhouse emissions.

It is highly likely that business will face a carbon-constrained future. Companies that do not account for this in their strategic planning processes may incur severe financial penalty.

So how do mining operators minimise their financial exposure and prepare for an uncertain future?

Applying energy efficiency measures to existing operations and introducing energy and greenhouse efficient plant and processes is one way of reducing cost, helping the environment and limiting risk. Such measures are consistent with operating a site at optimum efficiency and maximum output. This booklet contains case studies and guidance on some of these measures.

The introduction of new technology, process improvements and operational changes can significantly improve performance. However, without effective management processes in place, improvements will either not materialise or not be sustained. The booklet therefore includes guidance on developing the basic elements of an effective energy and greenhouse management system.

In doing so it has been recognised that many operations will have already adopted management systems for finance, quality, environment and health & safety. Therefore the intention here is to provide guidance on enhancing core business processes so that energy and greenhouse is adequately managed rather than introducing new stand alone systems.



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1 INTRODUCTION

This booklet is designed to promote best practice in energy efficiency and greenhouse gas management in the mining industry. It is targeted principally to small and medium sized mining operations, however, it contains information of value to all mining and associated operators.

The booklet is for use by those seeking to explore opportunities for reducing cost, energy use and greenhouse emissions. This will include senior or corporate management, operational management and energy engineers or those with a role that impacts on the use of energy.

Guidance presented in the booklet is broken into three key areas:

1. Developing the fundamental elements of an effective energy management system;
2. Opportunities in energy efficiency; and
3. Opportunities in greenhouse gas mitigation.

The suggested approach to the development or enhancement of systems for energy and greenhouse management has been left at a basic level. This will allow sites to consider their own particular circumstance and the relationship with their other business systems before more advanced management principles are introduced.

While there is an emphasis on developing a structure that ensures improvement activities will be effective and sustainable, the booklet also introduces opportunities that can be looked at for some quick wins in energy savings. These quick wins may be necessary to gain ongoing support of senior management in the development of management systems.

This booklet provides a generic framework and examples that can be used by mining sites. These will assist in improving energy and greenhouse performance however there is a point where site-specific issues will begin to dominate.

Every site has its differences in locality, size, environmental risk, management structure, culture and available resources. It is therefore critical that sites take on the guidance in a manner that is consistent with their normal business activity. Ongoing commitment from management is vital if improvements in energy and greenhouse performance are to be achieved and linking these issues to core business processes will help this occur.

There are many benefits for mining companies that manage energy and greenhouse in a systematic and strategic manner. These include:

Reduction in direct energy expense (e.g. power and fuels)

Simple energy efficiency measures can deliver savings on energy bills by as much as 15%. Improving management performance can help lock in these savings and deliver a further 5% to 10% savings.

Reduction in indirect energy expense (e.g. productivity and site infrastructure).

Looking strategically at energy and greenhouse management enables management to better accommodate the dynamic nature of energy and environmental markets when making major decisions on production and energy supply systems.

Lower risk (e.g. variation in prices and introduction of greenhouse related levies)

Improving greenhouse performance has the benefit of reducing the likelihood of having to make rapid (and often costly) investment decisions in order to meet external requirements. These requirements may be imposed at a corporate level or by governments either directly (e.g. in the form of carbon taxes) or indirectly (e.g. upstream renewable energy incentives).

Improved corporate profile (e.g. customers, consumers, employees, investors, public)

Historically the mining sector has had a high public profile on environmental issues. Demonstrating a proactive stance can help an organisation better achieve its goals and allow it to set its own agenda in terms of moving forward. Many major organisations have established policies and programs to ensure their operating sites are minimising energy expense and potential risks in a changing environmental climate.

Balanced Resource Application

Once the true value of using resources efficiently is identified, appropriate resources can be allocated to the development and implementation of improvement plans. A systematic approach will ensure accountabilities and skills are in place to deliver desired outcomes.

The guidance presented in this booklet will help sites move forwards capturing all the benefits identified above.

For sites seeking to develop more comprehensive management systems, the Best Practice Environmental Management (BPEM) booklet covering the Environmental Management Systems covers this area in more detail. The booklet can be accessed at <http://www.ea.gov.au/industry/sustainable/mining/>

Why is Energy and Greenhouse management important?

Energy use is a significant cost for the mining industry representing between 15 and 20% of operating cost. The use of energy, whether it is electrical power generated on site or off-site or other activities such as steam generation or explosions, results in emissions of greenhouse gases. It is estimated that the mining industry contributes 13.65 Mt of greenhouse gases from energy use and a further 16.7 Mt from fugitive emissions from coal seam methane (1995 [National Greenhouse Gas Inventory](#) cross-sectoral analysis data). In 1995 this accounted for approximately 7.3% of Australia's total greenhouse emissions.

2 ENERGY AND GREENHOUSE MANAGEMENT

Many in the mining industry will be familiar with business management systems that are designed to drive sustainable and continuous improvement. These business systems are typically applied in areas of finance, quality, environment and health & safety.

Without a systematic approach, such as that offered by a structured management system, a site can easily overlook opportunities for savings, use resources inefficiently and potentially incur financial penalties. Managing energy and greenhouse is no different to the management of other issues that affect the business.

The extent of application of management systems to energy and greenhouse will depend on organisational and site specific factors such as opportunity for improvement, corporate management culture, risk management and energy expense.

In many instances organisations will find that a combination of their existing business processes (e.g. environmental, capital planning, quality) are capable of progressing energy and greenhouse initiatives with minor enhancements. Others, at least initially, prefer to develop specific management processes and plans for energy and greenhouse.

Without a strategic approach to energy management, initiatives introduced to the organisation can quickly falter or not give sustainable results. Worse still, one off projects that sit outside the mainstream business can have negative impacts from a financial and motivational perspective.

To begin development of new systems or enhancement of existing ones, performance and requirements across the following management elements should be considered.



Figure 1 - The Elements of Effective Energy Management Systems

Guidance on each of these management elements is presented in the following section. The order in which you assess and develop each of the management elements will depend to some extent on the existing level of systems available. Unless already well developed, gaining senior commitment and understanding your use of energy are usually the most important initial steps.

2.1 LEADERSHIP

It is crucial that the leaders of an organisation guide the transfer of their corporate vision to operations. This is first achieved through articulation of a clear policy on corporate objectives regarding energy and greenhouse.

A policy, whether it is stand alone or combined with an environmental policy, is a set of fundamental principles and goals that help a company put its energy and greenhouse commitment into practice.

An effective policy framework is important in that it allows staff to act proactively on energy and greenhouse matters in the knowledge that they have the full support of management. If the policy is consistent with the actions of an organisation it can also be of value in demonstrating achievements to key stakeholders outside the organisation.

A sample energy policy for a mining company is presented in Figure 2.

While this example policy can be used as a guide, it is recommended that sites give consideration to their true values on energy and greenhouse. As a starting point senior management should ask itself the following questions:

- What level of energy reduction is the organisation seeking in both the short and long term?
- What are the factors that limit increased application of energy efficiency?
- What level of resources (people and financial) is the organisation prepared to commit?
- What value will you place on greenhouse emissions when selecting energy sources, processes or methods of operation?
- Would you be prepared to openly supply information on greenhouse and energy performance to the public, regulators and other third parties? and
- Will you publicly commit to improving greenhouse performance by joining voluntary industry programs?

It is imperative that actions of the organisation are consistent with the policy. Employees need to understand the policy. Options for communicating the policy internally include posting it around the site and incorporating the policy into staff induction. You may also wish to communicate the policy externally to suppliers, customers and other stakeholders.

Senior management will need to ensure there is an individual nominated to provide direction in energy and greenhouse management. This person must have the authority to implement changes that are consistent with the policy.

Figure 2 – Sample Energy Policy:

Mining Co. Energy Policy

Mining Co. is committed to sound environmental practices and enhancing its reputation as a responsible corporate citizen. The company is committed to sustainable creation of shareholder value, growth and cost reduction. Energy management is complementary to all these commitments and is one of the vehicles for achieving our objectives.

Mining Co. is responsible for a total annual energy use of around XX GJ, consumed across operations, offices and vehicle fleets. The greenhouse emissions are in the order of XX tonnes of CO₂.

Consistent with its' corporate objectives, Mining Co will reduce energy consumption and greenhouse emissions and specifically:

- commit to managing and reducing greenhouse emissions;
- consider the use of alternative energy sources where these have a greenhouse benefit;
- include energy management as a specific responsibility in the senior management ranks of Mining Co. and appoint energy management resources at an operations level;
- prepare an Energy Management Plan (EMP) guiding energy management initiatives throughout the company;
- Incorporate energy performance in the appraisal and reward mechanisms for groups (e.g. contractors) and individuals with significant energy management responsibilities;
- Maintain a mechanism to enable ongoing monitoring, evaluation and reporting of the company's energy consumption and greenhouse emissions; and
- Publicise and recognise achievements in energy reduction.

The Energy Policy represents the "Charter" for providing overall guidance in their implementation of the EMP and related energy management activities. It applies to all Mining Co. representatives and to contracted parties. Contractors must ensure their own policies, procedures and activities, while working with Mining Co. are consistent with this policy.

CEO

Energy Manager

1 October 2002

2.2 UNDERSTANDING

Without an understanding of the use of energy and what opportunities exist for reduction, it is impossible to cost effectively apply resources to areas where most benefit will be obtained. Information required to better understand energy use include:

- How much energy is used;
- Where and when it is used;
- The cost of energy; and
- The greenhouse emissions associated with energy use and other site emissions.

Where understanding is lacking or not adequate for making sound business decisions, an energy audit or energy review is often used to facilitate collection and evaluation of information. Energy audits typically provide the following information:

- Breakdown of energy use by fuel, energy users, activity and cost centre;
- Profile of energy load across specific plant items;
- Benchmarking (internally and externally) and development of performance indices;
- Consolidation and analysis of current or previous initiatives in energy and greenhouse management;
- Management, operational and maintenance procedures covering energy use; and
- An inventory of greenhouse gas emissions.

The results of the audit will assist an organisation evaluate the value of the energy efficiency and greenhouse mitigation options and to identify new opportunities.

An external specialist will usually be needed to complete a detailed energy audit. Before more detailed analysis takes place there are actions that can be done by the business to progress the understanding of energy use and available opportunity. These actions include:

- Compilation of historical billing data (consumption and cost) for all energy forms;
- Compilation of sub-metering data; and
- Identification of major energy using equipment and recording of its energy rating, running time and energy consumption patterns.

2.3 PLANNING

The first step in planning is establishing overall performance targets. Targets should be consistent with the objectives presented in the policy and refined through reference to energy reviews or audit studies. Targets need to be cascaded into meaningful deliverables at all levels of the organisation. For example:

- Overall site target - 10% reduction in energy use over 2 years;
- Cost centre target - 15% reduction in energy use per tonne crushed; and
- Operator target - reduce vehicle idling time by 10%.

Proceeding in this way allows you to match desired achievements with available resources. It also highlights the areas that will make the specific contribution that build to the overall target.

To meet targets it is ultimately necessary that some form of action be implemented (e.g. monitor, train, modify, build, repair, install, replace, and report). Many of these actions will be routine, and can be easily incorporated into day to day activity. More substantial actions will need a structured planning mechanism. This mechanism might be incorporated into an exiting planning process such as a Capital Improvement Plan, a Management Improvement Program or an Environmental Management Plan.

Alternatively an organisation may choose to develop a specific plan for energy and greenhouse management. Here guidance can be taken from the [Greenhouse Challenge Program](#) sponsored by the [Australian Greenhouse Office](#). The [Greenhouse Challenge Program](#) is a cooperative initiative between Government and Industry to voluntarily mitigate Australia's Greenhouse Gas emissions. This program provides a formal planning and reporting mechanism that can be used by companies as the basis of their energy and greenhouse management plan.

Whatever mechanism is used, the planning document or documents will guide all non-routine activities that relate to energy and greenhouse over a defined period (e.g. 12 months). As a minimum the plan would cover:

- A description of each project proposed;
- The project objectives;
- The specific series of activities needed to complete the project; and
- Responsibility and completion milestones.

When deciding on the format of your plan you should consider your existing mechanisms for project advancement and utilise these where possible. For planning mechanisms to be successful they must form part of the core business and not sit in isolation.

2.4 PEOPLE

For any business-related activity to be successfully managed there must be people with responsibility and accountability. Many mining operations have dedicated energy managers and groups; others include energy as one of many responsibilities for an individual.

In order to achieve results there must be someone responsible and accountable for energy management at the site with the authority to implement the energy policy and improvement plan. There are many ways to document and communicate responsibilities. If position descriptions are available, these can be modified to include energy management related duties. For key staff, effective energy management can also be part of their deliverables.

Whatever level of structure and responsibility applies to the business, there must be confidence that key activities are being covered and employees know what is expected of them. This premise applies to energy and greenhouse as it does to all other key business functions.

The most common cause of energy waste results from the actions of staff that do not have a full appreciation of the broader implications of their actions. By making employees more aware that the use of resources and generation of waste can have an impact on financial performance and on the environment, poor practices can be largely eliminated.

A basic level of awareness on energy management should be given to all staff through induction programs and simple promotion. This will suffice for many, however, others whose actions affect energy performance more substantially, will require specific training.



Staff have an important role to play in effective energy monitoring and management.
Photo courtesy of [Western Mining Corporation](#)

A basic training and awareness program should cover:

- What is energy and greenhouse?
- How is the company affected by energy and greenhouse (e.g. cost, emissions)?
- What is the company doing about energy and greenhouse (company policy)?
- What can you do to contribute to our energy and greenhouse objectives? and
- How will the company support you in these activities?

2.5 FINANCIAL MANAGEMENT

Most organisations have processes in place for evaluation and allocation of capital expenditure. Capital for projects designed to improve energy and greenhouse performance need not be considered differently from other projects, irrespective of whether pay back periods are set at six months or six years.

Capital is typically allocated in the following circumstances:

- Projects specifically designed to improve energy and greenhouse;
- Other operational improvement projects or plant expansion; and
- New or replacement equipment.

To capture the full value of proceeding down a path of energy efficiency and greenhouse mitigation, business cases for capital allocation should include life cycle costing and risk assessment.

Common accounting practices can be applied when evaluating the direct energy savings associated with a particular investment. From a greenhouse perspective some organisations have found that the allocation of a cost to emissions (e.g. \$10 / tonne of CO₂) assists to make the assessment more objective.

The financial evaluation and allocation process is an ideal entry point for energy efficiency and greenhouse mitigation. Clear guidance and procedures for capital allocation will prevent energy inefficient equipment and processes being introduced to the site.

2.6 SUPPLY MANAGEMENT

Part of the process of obtaining best practice energy management is to establish optimal conditions for the supply of energy. It is important to have robust mechanisms for selection of energy type, selection of suppliers and negotiation of contract conditions.

Energy costs can be minimised by having:

- **A purchasing process that captures the advantages of the deregulated energy market** - In most areas of Australia there is a competitive market for the major forms of energy. A process that enables suppliers to present their case is likely to result in the best outcome for the site from a cost, reliability and value adding service perspective;
- **Selection of the most appropriate energy source for a particular operation** - Different forms of energy might be evaluated for the specific activities (e.g. Diesel to LPG) or for the complete energy systems (e.g. Cogeneration). Options for introduction of renewable energy can also be considered as part of a greenhouse gas reduction program;

- **Control of demand charges and flexibility to take advantage of curtailment opportunities** - There may be opportunities for savings by managing demand so that the load profile remains as relatively flat as possible. This can be achieved by shedding non-essential load during periods of high demand or shifting loads to non-peak periods. Curtailment provides sites the opportunity to shed load in periods of high demand and receive a financial benefit from the energy (electricity) retailer;
- **Accurate billing data at the appropriate tariff or rate structure** - There are often several options available for the purchase of energy. It is important to have an understanding of plant energy use so that supply conditions can be most economically matched to plant needs. Other charges such as those associated with Power Factor need to be assessed; and
- **Contractual agreements to continuously improve quality and reliability of supply** - This aspect is important to the process as supply disturbances can result in substantial reductions in productivity and service quality. Having quality and reliability issues addressed in contract agreements minimises disruptions as a result of poor supply conditions. It is also important to assess infrastructure within the plant that can disrupt supply (e.g. excessive harmonics caused by variable speed drives).

2.7 OPERATIONS MANAGEMENT & MAINTENANCE

There are many day to day activities where operational control is already in place. The existence of operational control inspires confidence that specifications are being followed, risks are being minimised and that there is a plan for addressing any variations from normal operation.

Operational control is sometimes taken to mean the availability of a documented procedure or work instruction. While this can be an important part of demonstrating operational control, other factors in operational control include training, engineered / design controls and alarms / interlocks. Absence of operational control from an energy perspective may result in financial penalties.

Activities that need operational control from an energy management perspective will include those where operational procedures already apply and others where significant potential for variability in operation is identified by audits or reviews.

When deciding on the level of operational control that should be applied for a particular process, both the likelihood of the process deviating from standard operation and the consequences of deviation from standard operation should be considered. For example if settings on a control point have a plus or minus 10% impact on total energy consumption, what types of operational control should apply:

- Hope that someone will tell employees not to adjust the control; or
- Place a sign above the control point ("do not change"); or
- Ensure any staff working in that area had been formally trained; or
- Write a procedure covering adjustment of the control point; or
- Fit an interlock such that the control point can not be adjusted inadvertently.

It may be possible to identify 5% to 10% or more of energy savings in equipment simply by taking basic maintenance steps and having properly commissioned control systems. It is recommended that a comprehensive equipment database is developed. This should include sufficient documentation for all major equipment (or proposed for

installation) to highlight the energy use of that equipment and allow an efficiency to be calculated.

There may be a range of specific causes of energy waste that can only be overcome by new technology or improved controls. It is expected that maintenance crews would raise these issues during management meetings.

2.8 MONITORING & REPORTING

Monitoring tracks the use of energy, and identifies variances from target levels. The simple fact is that if you cannot measure energy use, you cannot control it. There is no possibility of continuous improvement without energy users having the tools to measure what they use and report performance compared to target.

When designing a monitoring system it is important that it matches your overall energy management objectives and resources allocated to energy management. The first step in development of a monitoring plan is to assess existing capabilities including any systems that have become redundant.

At a minimum you will need to have reliable and timely data on any external energy inputs to the site (e.g. electricity, natural gas, diesel, Liquefied Petroleum Gas (LPG)). Further sub-metering or logging may be necessary to understand specifically where energy is being used.

There are many options for monitoring energy use from a hardware, software and manual entry perspective. These can often involve a substantial capital investment or use of resources therefore temporary logging may prove a cost-effective way of refining monitoring plans. Often other monitored variables (e.g. production, temperature, pressure, operating time) can be used and extrapolated for energy consumption.

Monitoring should be applied to the key control points, generating data of value to operators and end users that need this information to control their area and report performance.

Once you can effectively monitor energy use, the next step is to use the information for effective reporting and feedback systems. Setting a hierarchy of reporting is often the best way to design reporting systems. Senior management commitment again is the overall driver.

Reporting ties in with accountabilities. In practice it seems that the best way to design effective reporting and feedback systems is to make sure accountabilities are correctly established and then get responsible parties for energy and greenhouse at each level to assist in the design of their own reports.



Hamersley Iron's computerised control room. *Photo courtesy of Hamersley Iron*

Examples of levels of reporting are:

- *Senior Management* - Overall energy, greenhouse emission and cost against target plus exception reports on a monthly basis. Used to develop corporate reports and tracking against policy;
- *Operations Management* - Cost centre/division performance and exception reports on a weekly basis. Used to develop reports for senior management and for driving improvement from operational teams; and
- *Operators* - Equipment and process performance reported daily or by shift. Reports consolidated for operations management.

2.9 PLANT AND EQUIPMENT

Financial mechanisms helping the evaluation and introduction of energy and greenhouse gas efficiency have been discussed already. However how does an organisation make itself aware of available technologies and ensure these are applied where cost effective?

Some businesses have processes to ensure that staff are up to date with industry developments. This can occur formally or informally. From an energy management perspective an individual should be assigned responsibility for understanding or at least having access to key developments. For most this will mean use of trade journals, conferences, internet, subscriptions, government publications (such as this one) and industry associations.

Where significant investments are proposed and expert knowledge on energy efficiency does not sit within an organisation, a design review by an external party can be of enormous value. The design review can introduce modifications and options that have been successfully adopted by others in the industry or similar.

Even if capital allocation processes capture the benefits of energy efficiency, there may be other purchases that come from a budget where a formal energy assessment is not required. In particular this applies to maintenance and replacement of equipment such as lighting, motors, fans and even for office equipment.

It is important therefore that the introduction of all energy consuming items and not just those associated with major capital projects are assessed for energy efficiency. Again this can be introduced through purchasing procedures supported by guidelines and efficiency criteria helping staff select the most appropriate equipment.

To achieve best practice in energy management, it will ultimately be necessary to employ technology that is energy efficient. Where efficiency is an integral part of design, procurement, plant upgrades and equipment selection this can be achieved over time, using resources and capital most cost effectively.

2.10 ACHIEVEMENT

Having established a policy, set targets and developed key performance indicators, mining operators will be better placed to assess how well their management system has performed.

Often performance analysis based on annual energy spend alone ignores variations associated with production, pricing and other external factors. It is possible to see an increase in energy expense even though performance may have dramatically

improved. Conversely an operator may achieve a lower energy expense in spite of poor energy management performance.

A management review is an opportunity to step outside energy management systems and evaluate their true effectiveness. It is likely that management reviews are already undertaken across a range of business activities including finance, environment, sales & marketing, quality and maintenance.

The extent to which the management review is formalised will depend largely on the nature of the business. These reviews should be completed at least annually and outcomes should be documented. The management review could be conducted as part of a routine management meeting or undertaken as a separate exercise.

Typically companies will use management audits to supplement the management review and to assess performance across specific areas of the operation. Many will be familiar with these processes in quality, environmental and health & safety fields.

The agenda for the annual Management Review should include :

- Strategic issues and energy policy amendments;
- New business methods, activities, technologies, economic circumstances that may impact on energy and greenhouse initiatives;
- Assessment of initiatives completed over the previous review period;
- Evaluation of Key Performance Indicators (KPI's) and refinement of targets; and
- Approval of projects and initiatives for the next review period.

3 ENERGY EFFICIENCY

Making existing plant and processes more efficient can be a cost-effective method of reducing energy consumption. Increased energy efficiency can often be achieved without major capital expenditure and deliver savings within a payback period consistent with other process improvement projects. Reducing energy use will have a direct and proportional effect on energy cost and greenhouse gas emissions.

When considering implementation of energy efficiency and greenhouse projects at your site it is important that you are guided by an understanding of energy use. For example, it may not be prudent to apply major resources to improvements in lighting systems if these represent only 1% of total energy use. Nevertheless cost effective projects will exist that provide excellent payback and these can act as examples for more advanced projects. It is important to first recognise that a certain unit or activity consumes most of your energy. It is then necessary to understand the potential this system may have for further improvements in efficiency. This understanding might come through load profiling, trend analysis or benchmarking.

Whilst energy efficiency and greenhouse projects should be implemented if they meet business payback criteria, it is also important to consider the total "life cycle" costs when decisions about capital expenditure are made. Buying an air compressor without considering the efficiency of its application may require less up-front capital, but over the total compressor life cycle, 85% of the costs associated with supplying compressed air will result from electricity use. Considered in this context, a marginally higher initial capital cost for energy efficiency may be justified.

Whether mining is carried out by contract or in-house, there are numerous ways that the mine operator can exercise an influence to reduce the impact of energy, fuel use and greenhouse emissions. Throughout the following discussion there are many options for energy efficiency. These can apply to all mining operations unless specifically directed at a unique mining method.

- Areas to consider when seeking improvement in energy efficiency include:
- Exploration and Drilling
 - Ore Extraction
 - Ventilation and Dust Extraction
 - Water Management
 - Process Pumping
 - Crushing and Milling
 - Transport
 - Separation Processes
 - Mixing
 - Agitation
 - Flotation
 - Electrowinning
 - Site Services
 - Compressed Air
 - Lighting
 - Power Generation

3.1 EXPLORATION AND DRILLING

Energy use associated with exploration and drilling is primarily from transport (diesel, LPG) and diesel used in generating compressed air for drilling. Overall exploration and drilling are not large energy consuming activities. Nevertheless, steps should be taken to make these operations as energy efficient as possible.

Consideration of energy efficiency should start with the exploration and drilling plan to ensure that fuel is not wasted on unnecessary travel or double handling. Areas to consider include:

- Consider using vehicles that operate on less greenhouse intensive fuels such as LPG, Compressed Natural Gas (CNG) or Liquefied Natural Gas (LNG) instead of diesel;
- Organise transport of equipment and supplies; and
- Minimise fuel use for camp operations, cooking and storage.

3.2 ORE EXTRACTION

Ore extraction is governed by the geology of the particular deposit. This can range from soft alluvial surface deposits mined by scraper or open cut, to hard rock mining at great depth. Between these two extremes, there is a multitude of methods and subsequent opportunities for energy efficiency. It is important that any decision to alter processes based on energy efficiency also takes account of issues such as the geology of the ore body, safety and health issues and broader environmental impacts.

Ore extraction can broadly be divided into open cut mining and underground mining. Each has unique energy consumption profiles and energy and greenhouse gas reduction opportunities.

3.2.1 Open Cut

The largest energy users in open cut mining will be drill and blast equipment, excavators, loaders and ore haulage.

- Conveyor vs. electric or diesel truck haulage. There is a trade off when deciding on the haulage method. Over longer distances (where electricity is available), electric trucks, electric assist for trucks, electric rail operations or overland conveyor may prove more energy efficient.
- In pit crushing can be used to reduce size and increase haulage efficiency. Size reduction will enable a greater mass of ore to be transported per load, which will reduce the total number of trips and reduce diesel consumption per tonne of ore hauled.
- There is also potential to reduce the energy required in the milling process by reducing the size of ore to be processed through modifying blasting regimes. From a greenhouse perspective this is a trade off between the emissions from electricity in the grinding circuit and the emissions associated with drill, blast and haulage.
- Priority should be given to minimising energy use in vehicles. Care should be exercised when comparing fuel and technology types. For example when comparing vehicles using diesel engines to direct electricity it should be noted that the electricity used has inherent inefficiencies associated with the generation process and this should be considered.

- Global Positioning System (GPS) based Supervisory Control and Data Acquisition (SCADA) systems can be used to optimise and schedule vehicle operations to reduce waiting times.
- Engine management, fuel efficiency and engine idle time all influence energy use and need to be managed.
- "Fast fill" methods for diesel refuelling and water cart filling have been used successfully to reduce engine idle time.
- On electric vehicles there is an added potential for regenerative braking with the electricity generated being supplied back to grid.

3.2.2 Underground

Operations such as drilling (Jumbo), bogging and transport can be powered by electricity, diesel or compressed air in a number of combinations. These exhibit varying energy efficiencies and subsequent outcomes:

- There is significant inefficiency embedded in the use of compressed air. Up to 70% of the raw energy input is lost during the generation of electricity and a further 85% is lost during the compression step. There are further losses in a widely dispersed underground distribution system;
- Direct electrical connection should be considered although the efficiency of electricity generation (and losses) still needs to be considered. When planning the mine layout, provision should be made for extension of the underground electricity distribution system;
- When considering the use of diesel operated equipment the associated energy penalty resulting from increased ventilation requirements should be kept in mind;
- The design of the mine method can lead to improved efficiency in cases such as "Block Caving" the ore "gravitates" to a stationary localised outlet where it can be handled by electric vehicles;
- Mined areas have to be backfilled. Cemented Aggregate Fill or Paste Fill operations can reduce energy associated with materials handling and pumping associated with tailings disposal. In addition, because tailing operations are avoided, energy associated with dam construction and extension activities may be avoided; and
- Shaft winder operations vs. Decline and truck haul: The key factor that determines whether a winder or a decline is used is the capital cost trade off between constructing a winder and perhaps leasing of mobile plant. Beyond a depth of perhaps 600 metres the winder option should be considered. There is also a trade off between diesel usage in trucks and electricity usage in the winder.

3.3 VENTILATION AND DUST EXTRACTION

Fan loads may account for up to 40% of energy used at an underground mine. The ventilation load is made up of surface and underground fans. Surface fans are either centrifugal or axial, while underground fans are predominantly axial.

Key Steps

A review of fan operations and systems should provide the operator with information on number of fans, duties, loads and layout. The objective here is to replace larger fans with combinations of smaller fans down to 22kW. This will provide the necessary flexibility to enable the ventilation rate to be matched to the demand.

Monitoring is a critical element in optimising and reducing energy cost. When linked with control systems (e.g. centralised SCADA or management systems) it allows immediate optimisation opportunities and helps avoid waste.

With appropriate control systems, fans need only be re-started (after shut down typically during underground blasting) when and if actually required in that particular drive or workings.

Controls also allow operators to take advantage of changing air densities. More dense cool air is easier to pump down the mine often by as much as 15%. In cooler months, there is an opportunity to reduce energy while maintaining desired ventilation levels. In warmer months it may sometimes be feasible to cool the intake air (by direct or indirect evaporative cooling) to reduce fan loads.

Other Recommendations

- Application of controls (including timers) to secondary ventilation fans (in individual drives) to minimise operation (when fans are not required);
- Centrifugal fans are generally more efficient and can be fitted with accessories to reduce inlets / outlet losses such as specially designed "evase" technology;
- Review diameter of ventilation drives, raise-bores and other restrictions to reduce pressure drop losses; and
- If there has been a significant change in the level of activity at a particular mine it is often possible to de-rate fans which will reduce energy consumption.

For variable duties the most energy efficient method to control flow is by use of a variable speed drive, followed by inlet (suction) guide vane control and variable blade pitch control. Control using discharge damper is generally inefficient and should be avoided wherever possible.

3.4 WATER MANAGEMENT

Whether open cut or underground, miners are likely to face problems with water entering the mine. Water may be derived from operations, groundwater or surface rainwater run-off. In any case, water must be removed from the mine and generally the deeper the mine the more energy that is required to keep the mine dry.

Key Steps

The first efficiency practice that should be considered is to prevent unnecessary ingress of water to the mine. As part of the mine de-watering system, rainwater and run-off should be diverted away from the mine. In remote areas where fresh water is a scarce resource or very costly to deliver, water diversion and "harvesting" can not only reduce energy costs but also save significant costs for additional water resources.

It is also generally more efficient to capture mine water at a range of levels within the pit or underground workings so that it can be pumped away before reaching the lower levels. This system of intermediate pumps may also offer benefits in reduced maintenance and capture of higher quality water.

Other Recommendations

There are a number of choices for pumps and pumping schemes. Centrifugal pumps generally offer limited head and lower efficiency than positive displacement pumps.

- Positive displacement pumps run at higher efficiency and are capable of stop-start operation. It is also possible in some cases to provide a single lift by use of positive displacement pumps.

Depending on the power supply arrangement at the site, it may prove advantageous to have extra pumping capacity that can be utilised to pump additional volumes during off-peak periods.

- This will not necessarily save energy but can save cost (through favourable tariff arrangements) and may offer other indirect savings in capital costs for electrical power generation or infrastructure.

Collection of mine water will often also involve pumping from intermediate sumps throughout the workings. It is common to use submersible pumps for this duty and not uncommon for these pumps to be poorly controlled, sucking air or running dry.

- Sump pumps should be controlled by level switch wherever possible to avoid energy waste.

3.4.1 Process Pumping

Process pumping may also be a significant energy using activity but this depends on the level of processing carried out at the mine site. Generally there may be a large number of pumps of varying types, sizes and efficiencies, load factors, run times and control mechanisms located at either the mine itself, or in the down stream ore processing plant.

Key Steps:

It is generally recommended that a comprehensive pump "audit" should be carried out at each mine, or processing site. This should check that pumps are standardised and correctly matched to the specified duty and load. Oversized pumps (delivering lower than rated flows) are inefficient both from a capital cost as well as an energy perspective.

Sites are increasingly utilising variable speed drives on large pumps to match energy use to process requirements:

- Variable speed drives (VSDs) are now a well-proven technology and considered as best practice in pumping systems that have variable flow requirements;
- The cost of VSD units has fallen over the years and VSD installations for pumps should be applied wherever cost justified;
- It is common for sites to have poorly controlled pumping systems. Simple controls such as level control using float switches can avoid energy waste associated with such systems as sumps or header tanks;
- Major pumping systems should be monitored using mill SCADA, or energy monitoring systems. This may be particularly applicable to slurry and tails pumps where density monitoring could be used to ensure that excess water is not being pumped with consequent energy waste; and
- Consider using the mine de-watering pumps as part of a demand control or load shedding regime. This may require consideration of some additional sump storage capacity.

Other Recommendations:

- Mechanical seals are more efficient than packed gland arrangements;
- Improved materials and clearances can be used to improve pump efficiency;
- Reduced eye impeller (improved pump clearances) on mill pumps and cyclone circuits improve efficiency; and
- Keep abreast of developments in pumping and control technology.

3.4.2 Tails Handling

Tailings dams should be located as close to the facility as other constraints allow, to reduce pumping costs. Where possible "free" transport should be utilised through using direct gravity flow or siphons and an analysis of pumping versus siphon costs should be carried out for the tailings dam transfer operation.

In circumstances where there is surplus water, return water from tailings facilities may not be required. In this case opportunities to enhanced evaporation rates should be investigated in preference to further pumping. Operating solar drying basins (with low water levels in the dam) and using sprinkler systems to increase evaporation rates (due to the increased effective surface area for mass transfer) should be considered.

Tails thickeners can be used to increase the density of tailings. This will reduce the volumes of water that has to be pumped to (and in some cases from) tailings dams. The increased recovery of water can reduce bore pump operation.



Solar drying basins should be considered where possible to reduce pumping costs.
Photo courtesy of [Australian Greenhouse Office](#)

3.5 TRANSPORT

There may be a number of areas related to mining plant and other transport operations where management can exercise an influence to reduce the impact of fuel costs and greenhouse emissions:

- Diesel Cost predicted to rise (GST, Fuel Rebate reviews);
- Review fuel efficiency of Mobile Plant;
- Engine Management / Idling Time;
- Use of alternative fuels including electric power and alternative fuels such as biodiesel;
- Reduce Double Handling; and
- Possible use of fuel additives / conditioners.

It is estimated that a reduction of idling time during meal breaks or shift change may save up to 5% of the diesel fuel usage. Such reductions have been achieved in mining fleets. Reductions in idle times can also be made by minimising refuelling time by optimising the location of the refuelling station as well as utilising latest "fast fill" technology.

3.5.1 Haul Truck Efficiency

New mobile plant should incorporate the latest technology in electronic management systems. Both loaders and trucks should be fitted with a remote data interface, which allows real time monitoring of performance, along with historical data collection. Sites can then provide a rapid response to addressing issues, which are outside normal operating parameters.

Other recommendations include:

- Road surfaces should be graded to maximise fuel economy. This may also increase tyre life and reduce downtime;
- Maintain optimum tyre pressure;
- Optimisation of incline /decline will reduce unnecessary transport distances; and
- Idling time should be minimised.

3.5.2 Haul Truck vs. Alternate Methods of Ore Transport

Open pit and underground mines use mobile plant and haul trucks fuelled by diesel. Beyond a certain depth (or over a longer distance) it may become more energy efficient to operate a winder and skip, electric cable, conveyor belt or electric rail system.

Skip optimisation: By ensuring that skips are filled to capacity (and completely empty on return) less energy will be consumed per tonne of ore hauled. Optimisation of bucket size and weight can also reduce energy consumption.

SCADA system can be used to co-ordinate vehicle movements, which will reduce idle times.

3.5.3 Light Vehicle Operations

Sites have replaced numbers of light vehicles with either scheduled bus services or troop carrier vehicles. This avoids multiple trips and reduces diesel use. This is particularly relevant to underground operations where emissions impact on ventilation costs, but is also applicable to journeys to and from the mine site where large numbers of staff and private vehicles trips may be avoided.

3.6 CRUSHING AND MILLING

Crushing and milling operations are highly energy intensive activities typically accounting for between 50-80% of all energy use at mine sites. It is critical that these operations are conducted as efficiently as possible. To manage energy effectively, timely information from specific meters should be available to ensure that energy is not being wasted and that action can be taken by line management to reduce waste.

Experience has shown that targeting savings plus continuous monitoring of KPI's such as energy use per tonne of ore milled can deliver realistic savings. This requires monitoring and feedback in order to gain and maintain these improvements.

3.6.1 Crushing Circuits

Based on the crusher throughput there are two main choices for primary crushing:

- For throughputs less than 500 tonnes/hour, a jaw crusher is generally more efficient; and
- For throughputs greater than 750 tonnes/hour, a gyratory crusher is generally more efficient.

Optimisation of Primary, Secondary and Tertiary crushing systems should be carried out at the design stage, although continuous monitoring may lead to further improvements at the plant level. Areas for review include:

- Crusher size settings and screen cloth optimisation;
- Reduction of circulating loads; and
- Early rejection and crushing of Scats to reduce mill burden.

3.6.2 Mill Optimisation and Grinding Efficiency

There are a number of areas, where rubber-lined mills may benefit from new technology. Mill trials need to be supported by detailed monitoring of both energy and other plant variables such as the mineral recovery percentage. Further options for increasing mill efficiency that might be considered include:

- Rubber discharge grates can allow longer continuous running hours;
- Rubber lining improvements can increase reliability;
- Optimising ball size or feed size (to Semi Autogenous mills): The mass of the material in the mill determines the efficiency of grinding. If there is inadequate mass there are sub optimal numbers of collisions and the mill will have to operate for longer periods of time to compensate for this, leading to inefficiency. Conversely, if the mass is too great the agglomeration also reduces the number of collisions leading to inefficiency;
- Noise monitoring can be used to determine the levels of collisions in the mill and this can be used to optimise feed rate and size distribution;
- Load cell monitoring can be used to ensure that the correct charge is in the mill;
- Size optimisation / Blending of sizes: If the size distribution in the mill is sub optimal the grinding efficiency may be reduced;
- Control feed size / monitor size with laser;
- Lining advances/ Lifters etc;
- Divert additional capacity to other mills e.g. Campaign or Contract Milling;
- Cyclone cut and separation improvements; and
- SCADA and optimisation of KPI's.

There is a strong research and development focus on energy efficiency in milling circuits and it is recommended that sites keep abreast with new developments.

3.7 SEPARATION PROCESSES

3.7.1 Mixers / Agitation / Flotation / Electrowinning.

Mixer and agitator manufacturers are claiming significant energy reductions (30 to 50%) by use of new blade and tank designs. An overall investigation of cell efficiencies should be carried out which may yield significant scope for further energy savings. Other recommended actions include a review of further options such as:

- Cell agitation and flotation efficiency: Cell geometry influences separation/flotation efficiencies and impact on agitation energy requirements;
- Impeller and drive technologies;
- Tooth belts to replace wedge belt drives: Wedge belts use friction to transfer work which is generally less efficient than tooth belts;
- Heat recovery to aid drainage and separation: Higher temperatures may reduce the viscosity of the fluids leading to reduced pumping energy requirements;
- Optimising chemical regimes in the flotation cells may reduce energy requirements; and
- Oxygen enrichment will reduce the volumes of air that have to be supplied for the separation process.

3.7.2 Concentrate Processing

- Dust collection can be a significant energy consuming activity on mine sites. The energy efficiency of dust collection systems should be considered;
- Concentrate drying is the major thermal energy using activity at mine sites where concentrate is processed. Where feasible sites should look to utilise waste heat to reduce the energy required for drying. Sources of waste heat include power station exhaust gases; and
- Solar drying of concentrate should also be considered. Capital costs associated with renewable technologies have reduced significantly over the last few years increasing the viability of such options. Note the cost of maintaining the solar panels in dusty conditions should be considered.

3.8 SITE SERVICES

Services that support the mining operation may account for 20 to 30% of total energy use depending on the type of operations and should be considered as a critical part of any best practice program on energy efficiency in mining.

3.8.1 Compressed Air

Many mine sites have multiple air compressors at site that add significantly to energy costs and greenhouse gas emissions. These units are usually not interconnected, and will run automatically to meet site demands. Compressed air may account for as much as 10% of the total energy use by a mining operation. Approximately 85% of the energy consumed by the compressor is wasted as heat and often as much as a further 30% of the energy within the compressed air generated is wasted as leaks.

Key Steps

When seeking to improve energy efficiency the first step is to understand the compressed air system, including control systems, rated capacities, line sizes and receiver capacities.

- Given that air leaks account for most energy losses, a survey of air leakage supported by a leak reduction program should be instigated.
- Ongoing management of compressors and keeping costs down requires regular monitoring. Parameters to be measured include energy consumption, which should be related to production, and airflow. This can be achieved by process control software or mine SCADA systems.
- The cost of monitoring systems at a small mine might be prohibitive. Nevertheless, the development of a KPI for air use, in terms of (l/sec/tonne) or energy used by compressors per tonne makes it possible to track, identify and rectify variances from target performance.
- Changes in KPI trends can highlight either energy waste (air leaks) or poor production efficiency (operational or maintenance problems requiring attention), or machines running idle unnecessarily.

Other Recommendations

- Design with flexibility and sizing to meet plant specific requirements;
- Air compressors should not be used for aeration or for skim air. (Low-pressure blowers or mechanical aerators are far more energy efficient);
- Air compressor systems should be inter-connected with piping of sufficient size to allow a distribution of air at appropriate pressure. This should allow a reduction in the number of necessary machines being run and avoid consequent energy waste;
- Screw compressors that run unloaded for long periods should be programmed to stop automatically after a limited idle time; and
- Where possible compressors should be installed in a ring main configuration. This allows for greater flexibility of operation.

3.8.2 Lighting

Lighting is a continuous cost that adds to the baseline load at many mine operations. Turning off lights when daylight is available (or lighting not required) can save up to 50% of lighting related energy costs. Some sites have skylights (that have been neglected) that may need to be cleaned or the area of skylights increased.

Other options for reducing lighting costs may include:

- Standardise lighting types;
- Reduce office lighting loads (up to 85% in commercial office case studies). This can be achieved by use of technologies such as dimmers, occupancy sensors and photocells combined with increased staff awareness to switching off lighting in unoccupied areas;
- Technology and Innovative Financing (such as third party ownership) can be used to make significant savings; and
- Automatic control (utilising Building Management Systems) can be used to control lighting circuits automatically.



Solar lighting saves energy related costs and as they don't require site wiring, installation costs

Photo courtesy [Australian Greenhouse Office](#)

3.8.3 Power Station Options

The operation of power stations on-site or under management control of a mining company is a specialised activity and will not be addressed in depth in this booklet. Some broad areas that should be considered are:

- *Choice of fuel:* There are significant greenhouse gas implications associated with the fuel source used to generate electricity. It should also be recognised that there are "hidden" emissions associated with fuel choice (eg: transport emissions associated with diesel and gas losses associated with piping). Greenhouse gas intensity should be one consideration used in deciding on fuel sources, however, it is important that fuel choice is made across the entire suite of sustainable development considerations;
- *Generation plant operating efficiency:* Apart from the basic choice of technology (eg: diesel vs. combined cycle gas), operating efficiencies may vary due to factors such as equipment age and condition, size and ambient conditions; and
- Choices have to be made with regard to the technology to be used as well as fuel types. Following are some options for power generation, all of which may be valid depending on the circumstance:
 - Diesel Plant;
 - Gas fired plant including gas turbines;
 - Combined cycle power plant;
 - Other heat recovery options;
 - Grid connected power lines; and
 - Renewable power such as wind, biomass, wave, hydro or solar (photo voltaic or thermal).

3.8.4 Other Options for Review

Electric motors use up to 80% of electricity in industrial plant and this figure is possibly exceeded at mining operations. Higher efficiency motors should be specified at the design and construction phase but are difficult to justify as a retrofit project.

If a motor burns out however, a higher efficiency motor should be selected as an alternative to rewinding. Rewinding can have a detrimental effect on energy efficiency. Each time a motor is rewound it can lose further efficiency.

Further, recent regulations related to motor efficiency prescribe minimum efficiency standards for motors between 0.73kW and 185 kW. As a result it is likely that any new motor (in this size range) will be significantly more efficient than the existing motor it will replace.

On 1 October 2001, new minimum efficiency standards (MEPS) for Packaged Air Conditioners (PACs) and large Electric Motors came into force. The new regulations in each State and Territory will call up revised Australian/New Zealand Standards applicable to packaged air conditioners and three-phase electric motors, which include minimum energy performance requirements.

The new regulations requiring higher minimum levels of energy efficiency apply to three-phase PACs sized to 65 kW and three-phase electric motors sized from 0.73 kW to 185 kW sold or supplied in Australia from 1 October 2001. Prior to the decision to regulate PACs and motors, extensive consultations with industry and other stakeholders were held over a period of three years. In 2000, a Regulatory Impact Statement for each was completed indicating that the benefits to consumers and the community from implementation of the MEPS regulations would significantly exceed costs of compliance.

Opportunities also exist to make savings in other areas, including lighting, air conditioning and equipment operation.

- Air conditioner and other office equipment efficiency. Improve controls and purchase energy efficient (star rating) equipment.
- Energy awareness programs linked to greenhouse and margin improvement programs. This needs to be supported by monitoring and improved communication of data.
- Investigate solar heating for large hot water users
- Review of lubricants to assess options for energy savings through reduction of friction.

4 GREENHOUSE GAS REDUCTION

For most mining operations, energy use represents almost all greenhouse gas emissions associated with the operation. In 1999, total fugitive greenhouse gas emissions comprised 6.7% of total Australian greenhouse gas emissions (excluding emissions as a result of land clearing). Methane emissions from coal seams accounted for the majority of these fugitive emissions, but these emissions are limited to a relatively small number of coal mines. Earlier sections of this handbook have dealt with energy use and efficiency. The outcome of improved energy efficiency is a reduction in greenhouse gas emissions. This section deals with other methods of reducing greenhouse gas emissions.

The reduction of greenhouse gas emissions will result from:

- Reduction in the use of the emission source;
- Shift to a source with a lower emission intensity;
- Direct capture or containment of emissions; and
- Capture of atmospheric emissions through sequestration.

4.1 SOURCES OF GREENHOUSE GAS EMISSIONS

In order to manage greenhouse gas emissions, an inventory should be developed to determine the full extent of greenhouse gas emissions resulting from your operations. This inventory should cover both energy and non-energy related emissions, and the scope (or boundary) of the inventory should be defined based on the needs of the business.

The most appropriate boundary for an inventory will be dependent on how it will be used. An inventory can include:

- Direct emissions of Carbon Dioxide (CO₂), Methane (CH₄) and Nitrous Oxide (N₂O) from the combustion of fuels on site;
- Direct emissions of CO₂ and other greenhouse gases from various process sources;
- Direct emissions of CO₂ and CH₄ from fugitive sources on site (e.g. coal seams);
- Indirect emissions from the generation and supply of purchased electricity used on site; and
- Indirect emissions from the production and supply of other fuels used on site.

The [Greenhouse Challenge](#) requires members to report full fuel cycle emissions but encourages the reporting of both full fuel cycle and point source emissions. The benefit of reporting both emission estimates is that companies will then gain a much clearer picture of their direct and indirect emissions profile. It will also ensure that all emissions are accounted for. This is useful in determining the exact magnitude of any potential carbon liability under a range of different policy scenarios should emissions be constrained (eg. emissions trading) at some stage in the future.

The extension of the concept of full fuel cycle is to cover other consumables that may have a high greenhouse gas intensity. Greenhouse gas intensity refers to the ratio of emissions per unit (or cost) of a product. Consumables such as cement, lime, gases (O₂, N₂, NH₄) etc. have a high greenhouse gas intensity per unit of cost. The development of a dual emissions accounting framework that clearly splits emissions into direct and indirect streams has several potential benefits to companies in terms of assessing appropriate greenhouse gas abatement actions. It is recommended, where possible, that companies develop a comprehensive greenhouse gas inventory (all gases, all sectors), which clearly distinguishes the direct and indirect emission streams. This will provide a company with an indication of its exposure to possible additional costs to obtain these consumables if a carbon levy is introduced.

4.1.1 Direct Non-Energy Sources

The use of the following products and processes will result in greenhouse gas emissions:

- Limestone, soda ash and dolomite used in neutralisation processes such as water and wastewater treatment;
- Explosives for materials blasting;
- Hydrofluorocarbons (e.g. HFC134a) from some air conditioners and refrigeration systems;
- Sulphur Hexafluoride SF₆ from some electrical transformers and switchgear;
- Land disturbance (emissions associated with loss of vegetation as well as soil disturbance). If the site also conducts farming activities, there may be emissions from irrigation and fertiliser application (which can stimulate the release of nitrous oxide) as well as emissions associated with livestock management; and
- Waste treatment and disposal.

The management of these products and processes, and the use of alternatives if available, will contribute to the reduction of emissions.

4.1.2 Evaluating Emissions

For most emission sources such as energy use, emissions are usually evaluated based on the consumption of the energy source multiplied by an emission factor. Different emission factors are available based on different boundary conditions. Most direct emissions can be evaluated from the chemical properties of the material or published methodologies from the [National Greenhouse Gas Inventory](#) workbooks.

For emissions such as those from coal seams and spontaneous combustion of waste coal the emissions may need to be evaluated from direct site measurement. The variations due to individual mine characteristics make the use of general emission factors impractical.

Workbooks including factors and methods for calculation of inventories are available from the [Australian Greenhouse Office](#). Additional information is available from Australian Coal Research Limited or the [CSIRO](#).

4.2 ALTERNATIVE PRODUCTS AND PROCESSES

The alternative use of a non-greenhouse gas emission related product, or a product with a lower greenhouse gas intensity (lower emissions per unit of product) will result in a reduction in emissions from your operations. Examples of this include:

4.2.1 Altering Processing Methods

There may be potential to reduce the overall impact of a site by making modifications to several processing steps leading to lower emissions.

4.2.2 Fuel switching

The choice of fuel used can have a significant impact on greenhouse emissions. The table below outlines the greenhouse gas emissions (kg CO₂ equivalent released per GJ energy, full fuel cycle, and higher heating value basis) for some common fuel types as specified by the Australian Greenhouse Office:

Fuel Type	Indicative Emissions (kg CO ₂ e/GJ HHV)
Natural Gas	64
LPG	69
Diesel	78
Coal*	96

*Calorific and emissions data for coal is highly variable.

Note that other factors such as effective (net) energy content and process efficiency will also influence total greenhouse gas emissions.

The substitution of natural gas in either a compressed or liquefied form for oil or coal will usually reduce the emissions. The remote nature of many mining operations often limits access to network fuel sources such as electricity and natural gas and where available there is often little flexibility in choice of energy source.

4.2.3 Reagents

Sodium hydroxide (caustic soda) can be used as a substitute for soda ash. The OH&S issues associated with handling, storage and use of sodium hydroxide as well as the broader environmental issues such as sodicity and salinity associated with the use of sodium hydroxide should be considered.

4.2.4 On-Site Electricity Supply

Many mining operations generate their own electrical power. As outlined in the energy efficiency section there are many ways to reduce the greenhouse intensity of the electricity generated by increasing the generation efficiency. In addition greenhouse intensity associated with the electricity can be reduced through the following options.

4.2.5 Renewable technologies

Currently many renewable electricity generation technologies are at (or approaching) the point of being a cost effective alternative to fossil fuel based power generation.

Depending on the site's location (and hence proximity to available resources), there are opportunities for sites to generate electricity from sources such as solar (photo voltaic and solar thermal), wind, wave or biomass.

Factors that govern the feasibility of renewable technologies include:

- Differential between capital cost;
- Differential between operational and maintenance costs (renewable fuels are generally free);
- Existing generation assets life expectancy (it is easier to justify replacing existing assets that are approaching replacement age with renewable technology than relatively new assets);
- Potential to generate renewable energy certificates;
- Avoiding extending the electricity network;
- Potential to access government funding (several schemes exist that fund renewable technology); and
- Potential for a carbon tax to be levied on fossil fuels.

Any new development or upgrade proposal should consider the use of renewable energy for long term savings in both cost and greenhouse gas emissions.

Immediate savings opportunities exist where diesel or natural gas can be substituted with renewable energy for applications such as remote area pumping, workshop and administration area equipment and signage/streetlights. The utilisation of solar power for water heating and large scale airconditioning plant are valid greenhouse gas reduction techniques.



Renewable power such as wind can provide long term savings in energy cost and greenhouse gas emissions. *Photo courtesy of [Australian Greenhouse Office](#)*

4.2.6 Emissions Capture and Abatement

In some situations it is possible to directly capture greenhouse gas emissions. For instance during the initial stages of coal mining a highly concentrated stream of methane can be emitted. Some sites capture this methane and use it as combustion fuel. When the methane concentration drops (often to less than 1%) it is possible to use this gas stream as combustion air. Both these actions reduce the amount of methane released to atmosphere as well as offsetting a fossil fuel source. [Case Study 5](#) illustrates the savings made by a site using waste methane in their power station.

From a greenhouse gas perspective methane is 21 times more potent than carbon dioxide. It is possible to reduce the greenhouse intensity of a process by ensuring that all possible methane emissions are converted to carbon dioxide by flaring. Ideally the conversion can be done in a boiler or engine, which will reduce a fossil fuel source, but if this is not an option, flaring all possible methane will help reduce greenhouse gas emissions.

It is also possible to create sinks for carbon dioxide by planting trees. Trees absorb atmospheric carbon dioxide and "lock it away" as biomass (both above ground in the trunk, branches and foliage as well as below ground in the root system). Note that tree planting is generally only suitable in locations which receive in excess of 400 mm of annual rainfall (Ref 1). It should be noted that tree-planting projects may have a myriad of other environmental benefits such as salinity abatement, erosion control, increasing habitat for indigenous species as well as the aesthetic value.

[Case Study 6](#) illustrates the greenhouse savings made by a site through implementing a tree planting scheme.

5 CONCLUSION

Mining is an extremely energy intensive process. Consequently, energy is often a significant component of total operating costs. Energy costs should be recognised as a variable cost and reducing energy consumption directly results in cost savings. Further it is expected that energy costs will increase in the future adding to the incentive to effectively manage energy.

Climate change is now a major environmental issue, both locally and internationally. Greenhouse gas emissions are linked to climate change. Owing to its high energy intensity, mining operations are also highly greenhouse gas intensive operations. Under increasing pressure to curb growing greenhouse gas emissions it is possible that economic inducements (either in the form of a tax/levy or through credits) will be applied by governments. Irrespective of future action, regulatory authorities are already considering greenhouse gas issues when granting licensing and works approvals. Specifically, in some instances greenhouse gas issues are required to be addressed as part of Environmental Impact Statements.

Greenhouse gas is also a major concern for the general public. There is increased public support for businesses that adopt a proactive stance to greenhouse gas mitigation. How greenhouse gas emissions are managed by businesses are regarded as reflective of the businesses overall response to broader environmental issues.

The guidance provided in this module is designed to help industry respond to the above challenges and is broken down into three areas:

- Energy and Greenhouse gas management: An integrated management approach will maximise savings opportunities identified. It will also provide the greatest chance that savings achieved will be sustained into the future. Where possible it is recommended that existing management structures and processes be used to minimise duplication. An effective management approach will ensure energy and greenhouse gas is considered when all business decisions are being made. It is particularly important that energy and greenhouse gas impacts are carefully assessed when new projects/plant are being in considered;
- Specific energy efficiency opportunities: Energy efficiency measures applicable to the different mining operations have been highlighted. Basic principles discussed include the necessity to focus on the biggest energy consuming plant (eg motors) and processes (eg milling) on site, investigating how they are controlled and what opportunities exist to make improvements; and
- Specific greenhouse gas mitigation opportunities: In addition to greenhouse mitigation associated with energy efficiency measures, the following opportunities have been discussed:
 - Using alternative fuels with lower greenhouse gas intensity such as natural gas and renewable energy sources;
 - Changing to lower intensity processes; and
 - Potential for carbon sequestration (carbon sinks)

Whilst many discrete energy and greenhouse gas reduction opportunities have been presented in this module, it should be reiterated that energy and greenhouse gas issues are best addressed through a coordinated and integrated management approach.

REFERENCES AND FURTHER READING

"What happened in Bonn? – The Nuts and Bolts of an Historic Agreement" – International Energy Agency.

[National Greenhouse Gas Inventory](#) (NGGI) – 1995 cross-sectorial analysis.

[Australian Greenhouse Office](#) (AGO) information.

Minerals Industry Greenhouse Workbook – [Australian Greenhouse Office](#), [Minerals Council of Australia](#) and [Australian Coal Association](#).

Websites and further reading on general mining and environmental issues, policies, programs and techniques

Best Practice Environmental Management in Mining – booklets, training kits, environmental management tools and resources –

<http://www.ea.gov.au/industry/sustainable/mining/>

Environment Australia – <http://www.ea.gov.au/>

Australian Greenhouse Office (AGO) – <http://www.greenhouse.gov.au/>

AGO Funding Programs – <http://www.greenhouse.gov.au/ago/funding/index.html>

Office of the Renewable Energy Regulator – <http://www.orer.gov.au/>

Minerals Council of Australia – www.minerals.org.au/

Australasian Institute of Mining and Metallurgy – www.ausimm.com.au/

Australian Mineral Foundation – www.amf.com.au/amf/

Australian Minerals and Energy Environment Foundation – www.ameef.com.au/

Australian Petroleum Production and Exploration Association – <http://www.appea.com.au/>

Australian Centre for Minesite Environmental Research – <http://www.acmer.com.au/>

CADDET (International Energy Efficiency Database) – <http://caddet-ee.org/>

Cooperative Research Centre for Mining Technology and Equipment – www.cmte.org.au/

Energy Efficiency Best Practice Website – <http://www.isr.gov.au/resources/netenergy/domestic/bpp/index.html>

Department of Industry, Tourism and Resources – <http://www.industry.gov.au/>

Sustainable Energy Development Agency – www.seda.nsw.gov.au

Sustainable Energy Industry Association – www.seia.com.au

Julius Kruttschnitt Mineral Research Centre – www.jkmrc.uq.edu.au

McIntosh Engineering Ltd (USA) – Rules of Thumb for the Mining Industry <http://www.mcintoshengineering.com/Hard%20Rock%20Handbook/rulesofthumb.htm#view>

Mining and Management Article –
<http://www.wspc.com.sg/profiles/anncat/anncat/jnlarticle/mrev9n2/S0950609800000184.pdf>

Motor Solutions Online – <http://www.industry.gov.au/motors/>

General information on Australia's policies, strategies and actions on ESD –
<http://www.ea.gov.au/esd/index.html>

Information on programs and initiatives by Australia's Federal Government for sustainability in industry – <http://www.ea.gov.au/industry/index.html>

Links to publications and Australian government web pages on ESD –
<http://www.ea.gov.au/esd/publications/index.html>

Information on environmental management techniques has been published by government departments and industry associations. Some useful references are:

- Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland, 1995. Department of Minerals and Energy. Brisbane, Queensland. ISBN 0724252606;
- Guidelines for Mining in Arid Environments, 1996. Department of Minerals and Energy, Perth, Western Australia. ISBN 0730978028;
- Mine Rehabilitation – a Handbook for the Coal Mining Industry, 1995. New South Wales Minerals Council, Sydney NSW. ISBN 0949337625; and
- Environmental Management in the Australian Minerals and Energy Industries, Principles and Practices. Mulligan DR (editor) 1996. University of New South Wales Press/Australian Minerals and Environment Foundation. Sydney NSW. ISBN 0868403830.

International resources for BPEM are accessible through the internet pages of the United Nations Environment Programme (UNEP) –
<http://www.mineralresourcesforum.org/tutorial.htm>

Major international initiatives to promote sustainability in mining are being pursued through:

- The Global Mining Initiative – <http://www.globalmining.com/index.asp> ; and
- The Mining, Minerals and Sustainable Development Project –
<http://www.iiied.org/mmsd/>

The Australian report prepared for the MMSD Project is available at –
<http://www.ameef.com.au/mmsd/pdfs/report/ozreport.pdf>

WEBSITES ON AUSTRALIAN ENVIRONMENTAL AWARD SCHEMES

AMEEF Environmental Excellence Awards –
http://www.ameef.com.au/awards/awd_abt.html

Banksia Awards - www.banksiafdn.com/awardabout.html

Northern Territory Government –
http://www.dme.nt.gov.au/dmemain/awards/2001/Awards_categories.htm#environment

New South Wales Government – <http://www.minerals.nsw.gov.au/minfacts/11.htm>

Tasmanian Government –
http://www.dpiwe.tas.gov.au/env/env_awards/awards2001.html

Western Australian Government – www.dme.wa.gov.au/goldengecko/about.html

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CASE STUDY 1: BETTER BUSINESS FOR BRADKEN MINING

Owned by Smorgon Steel Group, Bradken Mining is a leading supplier to the mining industry throughout Australia, South East Asia, Japan and the United States.

Bradken Mining has an energy management strategy that is aligned with its core management system. The system covers all areas of the business helping continuous improvement of production methods and processes. This helps them make the most efficient use of resources whilst minimising waste and emissions.

To develop their energy strategy, Bradken Mining reviewed their performance in each of the key elements needed for an effective management system. They supported the strategy with an energy review to identify savings in energy use and equipment.

Involving workshop groups that form a key part of their management process, they have been able to link energy projects into operational efficiency. This has provided the mechanism for rapid implementation of activities that have already provided significant savings and for achieving a savings target of more than \$250,000 per year.

Some of the key areas that are expected to deliver the targeted savings are:

- Utilisation of the most efficient plant and systems at different times and different operating scenarios;
- Calibration of metering to track and control operating efficiency;
- Investment planning for equipment; and
- Involvement of teams and setting improvement targets.

By setting a strategy that considered all factors that affect energy management, Bradken now have a framework and guidelines for continuous improvement in performance.

CASE STUDY 2: ST IVES GOLD - TAILS THICKENER

St. Ives Gold is located 80 kilometres south of Kalgoorlie, Western Australia. It is part of Goldfields Limited's gold operations. St. Ives Gold currently operates one underground gold mine (Junction), four active open pits (North Orchin, Argo, North Revenge, Kapai and Agamemnon), a 2 million tonne per annum Heap Leach operation and a 4.5 million tonne per annum capacity (Mtpa) gold processing plant.

In March 2000, the operation of a 4 Mtpa rake-less tailings thickener was commissioned with the aim of increasing the recovery of process water from the gold processing circuit.

The extraction of gold from ore delivered to the plant requires approximately 1 kilolitre of water for every tonne of ore entering the circuit. This water is conditioned with Cyanide for leaching of the gold and lime to raise the pH for maximum efficiency of extraction. Gold is extracted from this crushed ore and conditioned water mix (slurry), which is then sent to a tailings storage facility (TSF). Here the water either evaporates from the surface of the TSF, is lost as seepage from beneath the TSF or is recovered from a decant on the TSF or from seepage recovery bores.

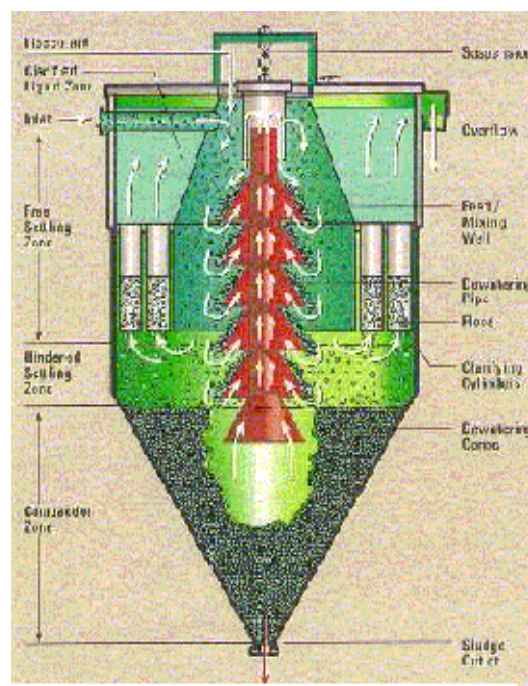


Figure 1: Diagram of St. Ives Thickener
Courtesy of St. Ives Gold

Figure 1: Diagram of St. Ives Thickener
Courtesy of St. Ives Gold

The rake-less thickener operating at St Ives is a lateral application of conventional thickening technology, which involves the settling of solids from slurry exiting the gold processing circuit. Following the settling of solids, water can be recovered and recycled through the plant rather than reporting to the TSF. Figure 1 provides a schematic diagram of the rake-less thickener used at St Ives. Briefly, this design uses a turbulent mixing system rather than moving parts to settle out solids. This has the benefit of reducing operating costs. As the recovered water from the thickener is

already pH and Cyanide conditioned, there is a benefit associated with reduced chemical usage. In addition, the recycling of water through plant provides the savings associated with decreased water pumping or water purchase requirement.



SIG Thickening Circuit
Photo Courtesy of St. Ives Gold

Energy and Greenhouse Benefits

As a result of the decreased pumping requirements from the Mt Morgan bore field, a substantial energy saving has been made. This saving in energy translates to a corresponding saving in the emission of greenhouse gases. In addition, the decreased requirement for lime through the processing circuit has resulted in a decrease in the production of CO₂ as a by-product of chemical reactions. In 2000 this reduced pumping and lime addition resulting in a saving of 1,261 tonnes of CO₂.

Broader Environmental Benefits

In addition to the direct operating benefits, the Thickener provides a number of environmental benefits to the gold processing circuit. These benefits include:

- Decreased water requirement as a result of process water reuse through the plant - Prior to the installation and operation of the thickener, tailings reported to the TSF at 48% solids. At present tailings exits the thickener at 52% solids with the potential to increase to 54% solids in the future. This has reduced annual water requirement from 3.2 million kL to 2.6 million kL (with a potential reduction to 2.4 million kL). This decreased requirement for water to the plant provides a number of flow-on environmental benefits;
- Reduction in Cyanide reporting to the Tailings Storage Facility - As a result of a decrease in the volume of tailings material reporting to the TSF, there is a corresponding drop in the amount of Cyanide reporting to the TSF. That is, the water reused though the plant maintains a proportion of its initial Cyanide level. Therefore, a recovery of approximately 20% of the water to thickener overflow will result in an estimated 20% lowering of the amount of cyanide reporting to the TSF;
- Reduced loss of water to seepage - With the decrease in water reporting to the TSF, there is a decrease in the volume of water lost as seepage;
- Reduced utilisation of the existing bore field - Prior to the installation of the Thickener, the bore field was 100% utilised over summer months. In 1999 prior to the Thickener installation, the Gold Plant used 1,408,614 kL from the bore field which was reduced to 746,883 kL in 2000. This decrease in water requirements decreased the impact of drawdown on the ground water table; and

- Reduced chemical requirements and reduced salt load to TSF - With a reduction in the volume of hyper-saline bore field water comes an associated decrease in the required volume of lime required to increase solution pH. Reusing process water that has already been pH conditioned reduces the lime requirement further. In addition the reused process water retains a proportion of initial Cyanide level, reducing the usage of Cyanide through the circuit. A reduction in the dependence on hyper-saline bore field water has also resulted in the salt load of tailings reporting to the TSF decreasing. Between 1999 and 2000, the average EC (electrical conductivity) level, a measure of water salinity, dropped from 84 mS/cm to 62 mS/cm.



SIG Thickening Circuit
Photo Courtesy of St. Ives Gold

Conclusion

The operation of the Tailings Thickener at St Ives Gold has yielded significant energy and greenhouse savings. As a result of this project a total of 1,261 tonnes of CO₂ emissions was avoided in 2000. In addition, significant operational benefits and broader environmental benefits resulted from this project.

The reuse of high quality process water has provided numerous associated environmental benefits including decreased pressure on the bore field, reduced the Cyanide and salt load reporting to the TSF and led to a decrease in the production of greenhouse gases. It is envisaged that water recovery will improve in the future further increasing the environmental benefits provided.

CASE STUDY 3: KAMBALDA NICKEL OPERATIONS – WASTE HEAT RECOVERY

Kambalda Nickel Operations is located 60 kilometres south of Kalgoorlie, Western Australia. It is part of Western Mining Limited's nickel group. The site consists of underground mines and a nickel concentrator.

Kambalda Nickel Operations utilised three diesel fired spray dryers for drying nickel concentrate from a moisture concentration of approximately 30% down to 0.5%. In 1996 approximately 250,000 tonnes of nickel concentrate was dried utilising around 8.5 million litres of diesel. This provided an efficiency of drying of around 1.3 GJ per tonne of concentrate dried.

In 1997 WMC commissioned four gas turbines, each with a capacity of 42 MW, at four different sites within the nickel business unit. The Kambalda site was one of the sites selected to allow the utilisation of the waste heat available from the turbine exhaust gases for drying of nickel concentrate.

Following the commissioning of the gas turbines and subsequent utilisation of the waste heat gas diesel usage dropped significantly. Natural gas was then used in place of diesel for the supplementary firing required beyond the heat available from the gas turbine exhaust. By 1998 the production throughput had increased to around 300,000 tonnes of concentrate. With the use of the available waste heat and the conversion to natural gas supplementary firing energy had been reduced to below 0.4 GJ per tonne of nickel concentrate dried. This represented a reduction in fuel use of approximately 270 TJ of diesel. The saving in diesel fuel represents a reduction in annual greenhouse gas emissions of approximately 20 kilotonnes of CO₂.

Additional greenhouse gas savings were achieved due to the lower greenhouse gas intensity of natural gas compared to diesel. At similar production levels the savings from the use of natural gas for supplementary heating was 1.5 kilotonnes.

A subsequent increase in concentrate production at Kambalda has required additional supplementary heating from natural gas, but the original savings have been maintained.

CASE STUDY 4: PAJINGO OPERATIONS – ENERGY EFFICIENCY ACTIONS

Pajingo Operations is located 72 kilometres by road south of the former major gold mining centre of Charters Towers which, in turn, is 136 kilometres by road southwest of Townsville in North Queensland. The project is owned and operated by Newmont Australia.

Through optimising processes and equipment operation, the Pajingo site has made significant reductions in energy use and greenhouse emissions. Many of these modifications did not require spending a significant amount of capital and payback periods were consistent with normal business criteria.

Some of the initiatives implemented at this site that delivered cost effective savings are briefly outlined below.

Optimise Usage of Current Crusher Circuit

The crushing circuit was originally designed to operate at 120 tonnes per hour. The circuit was being under-utilised, operating at only 90 tonnes an hour. This resulted in the circuit being operational for approximately 30% longer than actually required. As the power drawn at the lower throughput is only fractionally less than that drawn at full load, significant waste was occurring by operating in this mode.

The crushing circuit utilisation was increased to the point where throughput increased to 130 tonnes per hour. This resulted in savings of approximately 163 MWh of electricity or 166 tonnes of CO₂ emissions per annum.



The optimised crushing circuit. *Photo Courtesy of Newmont Australia*

Review of Mine Ventilation System

The site has three primary ventilation fans, one rated at 360kW and two rated at 220kW. A review of the ventilation system allowed the site to de-rate the primary fans and make substantial electricity savings:

- The 360 kW primary fan was de-rated by 80 kW delivering electricity savings of 688 MWh per annum or 701 tonnes of CO₂;
- One of the 220kW primary fan was de-rated by 80 kW delivering electricity savings of 688 MWh or 701 tonnes of CO₂; and
- The other 220 kW fan was de-rated by 70 kW delivered savings of 602 MWh or 614 tonnes of CO₂ per annum.

The extension of the primary ventilation system and rationalisation of the secondary fans provided significant savings in power consumption. The reduction in operation of secondary fans when not required saved 1,200 MWh of electricity per annum or 1,224 tonnes of CO₂.

Review of Compressed Air System at the Mine

Two compressed air units each rated at 75kW operated on separate reticulation systems to provide air for charge up and the refuge chambers. These units ran at low loads for extended periods of time, which is a very energy inefficient mode of operation.

The system was reconfigured to operate in a ring main system, which enables one unit to operate at higher loads (which is energy efficient) with the other unit coming on line to cater for periods of high air demand. This initiative delivered electricity savings of 172 MWh or 175 tonnes CO₂.



Pajingo Operations in North Queensland
Photo Courtesy of Newmont Australia

Double Handling of Water in the Mine

Water pumping operations at the mine were reviewed and wherever possible double handling of water was reduced/minimised. This reduced electricity consumption by approximately 240 MWh per year or 245 tonnes CO₂.

Float System on Pumps

Overfilling of tanks and the associated electricity waste associated with the unnecessary pumping was avoided by using a float system to control pumping. It has been estimated that this initiative will deliver electricity savings approximately 83 MWh per year or 85 tonnes CO₂ per year.

Reduction of Idle Time for Mobile Equipment

By reducing the waiting time and extended idle time on mobile equipment it was possible to reduce diesel consumption by 13 kL per year and an energy reduction of approximately 502 GJ per year. The associated emissions would be reduced by approximately 38 tonnes of CO₂.



Photo Courtesy of Newmont Australia

Pajingo Operations - optimised crushing circuit. Through optimising processes and equipment operations, the Pajingo Operations site has made significant reductions in energy use and greenhouse emissions. Many of these modifications did not require spending a significant amount of capital and payback periods were consistent with normal business criteria.

CASE STUDY 5: BHP BILLITON APPIN – UTILISATION OF COAL SEAM METHANE

Project Location: Appin Coal Mine, New South Wales, Australia

Generation Capacity: 55.6MW

Primary Fuel: Coal Seam Methane

Secondary Fuel: Natural Gas

Plant Type: Reciprocating Engine

Start of Operation: 1996

The Appin coal mine is an underground mine operated by the BHP Billiton Group. Methane gas is continuously extracted from the mine to maintain safe working conditions. The methane is treated by wet scrubbing and filtration and is then supplied as fuel for the generating plant. Natural gas supplied by pipeline is utilised as supplementary fuel if there is a shortfall in methane supply from the mine.

The generating plant comprises fifty-four gas engine generator sets. Gas engines were selected for this project due to their ability to use low pressure gas with low methane content. Generation voltage is 415 volts. Voltage is increased to 22,000 volts by unit transformers (one transformer per two generator sets). A high voltage substation is installed to further increase voltage to 66,000 volts. Interconnection with the utility network is at 66,000 volts.

Greenhouse and Energy Savings*

Approximately 250 million cubic metres per year of methane was being released to atmosphere from the Appin and Tower mines. This was seen as a wasted resource. BHP Billiton, in conjunction with Energy Developments Limited and Lend Lease Infrastructure, has developed a power generation plant that uses the waste methane to generate up to 94 megawatts of electricity – enough to power 60,000 homes.

Methane drainage at both mines must be carried out to allow mining to continue safely. Utilisation of the methane provides an important energy resource while reducing BHP Billiton Collieries Division's greenhouse gas emissions by approximately 50 per cent. This represents a reduction in greenhouse gas output by the equivalent of approximately three million tonnes of carbon dioxide per year.

* From the Cleaner Production case study on the EA website

<http://www.ea.gov.au/industry/eecp/case-studies/bhp.html>



Waste methane power generation unit at Appin
Photo courtesy of BHP Billiton Appin

CASE STUDY 6: NORTH PARKES - TREE PLANTING

Northparkes has embarked on a comprehensive tree-planting scheme to plant 10,000 seedlings per annum that assists with the return of the area to its original state and acts as a noise and visual barrier. In addition, these trees act as carbon sinks and offset the CO₂ output of the mine.

The planting of 10,000 trees per annum has been maintained as planned over the last 5 years however due to various reasons there have been significant mortality rates, which affected overall numbers. A further 10,000 trees per annum were donated to local land care groups in 1997 and 2000. Northparkes is utilising direct seeding (in addition to seedlings). The effective number of trees per hectare from this method has not yet been assessed. Five further forestry lots are due for planting but due to monitoring requirements; no trees were planted in 1999/00. Estimated total savings for 1999/00 were about 560 tonnes of CO₂.

Northparkes continues to farm around 4,800 ha using the "no till" method with no livestock grazing and full stubble retention. Continuous cropping includes wheat, canola, peas and lupins (legumes). This method reduces the effects of disease and insects by avoiding repetitive cycles. It is intended to further study the effect of this method on sequestration of carbon dioxide in the soil.



Initial tree planting underway.



Initial tree planting



Tree growth after a couple of years





Monitoring the progress of plants at Northparkes.
Photos courtesy of Northparkes