The Energy Efficiency series

Towards an energy efficient mining sector

www.eskom.co.za/dsm

1. Sustainable use of electricity is a necessity

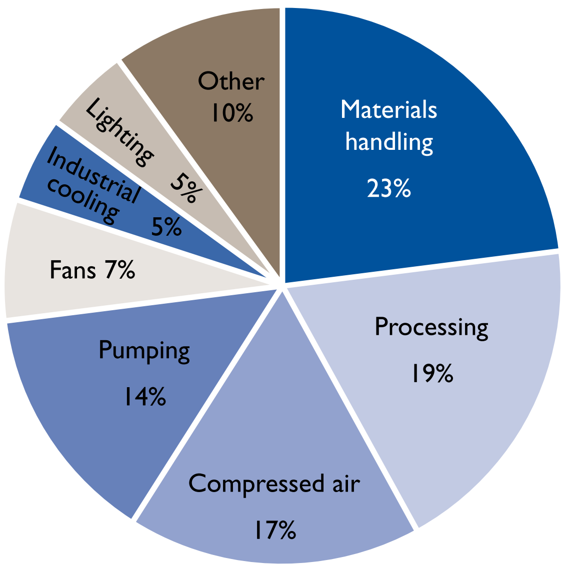
In common with most other countries in both the developed and the developing world, South Africa needs more generation capacity. The extent to which Eskom is able to supply the country's demand for electric power has a direct impact on economic growth.

All sectors of the economy can reap major benefits from implementing energy efficiency policies. By optimising processes and plant efficiency, companies reduce input costs, increase their return on investment and could gain from proposed future tax incentives which are currently being investigated by government. As an added benefit, reduced energy consumption means reduced environmental impact, an important part of the "triple bottom line".

2. The mining industry's role

As a leading producer of wealth for South Africa, the mining industry is a large consumer of electric power, taking about 15% of Eskom's annual output.

Within the mining industry the gold mining sector is the largest user, consuming 47% of the industry's electricity. Platinum mining is second, taking 33%, and all other mines together consume the remaining 20%. In mining, energy can be saved by applying efficiency solutions in the following areas, in order of importance:
materials handling, processing, compressed air, pumping, fans, industrial cooling and lighting.



3. Energy efficiency opportunities in the mining industry

Conscious of the need to facilitate energy conservation, Eskom has developed a strategic approach towards an optimised Demand Side Management (DSM) effort in the SA mining sector.

The main objective of this exercise is to identify electricity intensive industrial processes that can be targeted for DSM interventions, in order to achieve sustainable energy savings through energy initiatives.

Eskom, in association with suppliers belonging to the Mining and Industrial Energy Optimisation group (MIEO), as well as Energy Service Companies (ESCOs) and role players in the mining sector have spent much time and resources researching and investigating techniques to make the various processes more energy efficient.

Findings have resulted in the identification of technologies that have the largest potential for energy efficiency.
Let us look at improvements that can be done to reduce electricity in these areas.

3.1 Priority technologies showing largest potential for savings

3.1.1 Motors and motor systems

Electric motors are the heart of most mining and industrial process plants, converting electrical to mechanical power. The three major consumers of electricity in a large industrial setting are electric motors, driving pump systems, fan systems and compressed air systems.

Mines are increasingly focusing on ways to minimise their energy usage. One way in which they can achieve significant energy savings is by using high efficiency electric motors.

Motors account for some 60% of electricity consumption in industry. Over its life a motor can cost 100 times more to run than it did to buy. This provides significant scope for energy saving.

Of the total electricity consumed by the industrial sector, about 60% is used to drive motor systems, such as pumps, ventilation fans, compressed air systems, conveyor belts, etc., with pumps being the most dominant load.

Specification

- Standard efficiency electric motors tend to perform at their best around 75% of full load point.
- High efficiency electric motors possess a relatively flat efficiency vs. load curve, from around 70% and extending up to the rated load.
- Wherever appropriate, specify energy efficient electric motors. They run cooler, are compatible with variable speed drives (VSDs) and reduce energy costs.

Maintenance

- Electric motor maintenance, when neglected, can negatively impact on the efficiency of motors.
- Rewinding motors can have an even bigger negative impact on efficiency.
- Studies have shown that the first rewind of a new electric motor can result in as much as a 3% reduction in efficiency.
- Ensure that your rewind vendor has an SABS mark and rewinds your low voltage motors in accordance with SANS 10242-1.
- Avoid continued use of repeatedly rewound electric motors.
- Develop an electric motor management strategy, focused on life cycle costing, to guide staff from procurement to operation, maintenance and disposal.

To encourage users to switch from conventional motors to high efficiency motors, Eskom offers a rebate programme where it subsidises the cost of replacement. Details can be obtained on **www.eskom.co.za/dsm**

3.1.2 Compressed air systems

The mining industry has become dependent on compressed air to drive a wide variety of tools and applications, including the heavy drills that are an integral part of their operations. Although some have realised the benefits of using electrically powered tools, none have been able to dispense completely with their compressor rooms and compressed air pipes.

Unfortunately, compressed air systems are very vulnerable to damage and leaks, which result in wasted energy.

Specification

- A modular arrangement, when coupled with an energy management system, can allow for better control of compressed air to match the air requirements without driving each unit out of their best efficiency zone.

Operation

- Manage air leakages; a good system should not leak more than 5% of the compressor capacity. Bad systems lose over 40% to leaks.
- Minimise pressure drops; 1 bar pressure loss will result in about 6% increase in absorbed electricity.
- VSDs, when applied within the compressor optimum range, can yield energy savings (up to 25%, depending on operating profile).
- It might be possible to reduce the compressor pressure by one bar without compromising the working requirements.
- Discourage misuse of compressed air in the plant, such as for cooling purposes.

Maintenance

- A monitoring system will ensure that early warnings are identified on time and acted upon, thus avoiding costly downtime losses.
- Continuously identify, classify and fix leakages.

Replacement

- New equipment will be more efficient than old plant. Payback period based on energy savings may be fairly short.
- Correctly sized equipment (as opposed to oversized) can result in significant energy savings due to more efficient operation.
- Reduce the number of inline filters required by purchasing a unit that delivers the required air quality straight from the discharge flange. (Reduce overall pressure drop of the system).
- Look for value-added options, such as recovering heat generated during compression from the cooling medium used.

3.1.3 Pumps

Pumps are another essential part of virtually every mining operation. Without big, powerful pumps, most deep-level mining would be impossible. Water for drinking, washing and process applications must be pumped, often at high pressure, to many parts of a mine.

Specification

- Avoid over-sizing. Correct sizing of pumps is imperative for high efficiency. Pumps must be selected to operate closest to their best efficiency zone.
- A life cycle costing approach should be adopted when comparing and selecting pumps.
- For a multiple pump array, consider a modular arrangement with smaller and large pumps to allow for each pump to be run within its best efficiency zone.

Piping layout

- Avoid sharp bends (90° elbows, short radius bends). These cause turbulence in the fluid and require more power to overcome.
- Ensure that the correct pipe types (with minimal friction losses) and optimised pipe dimensions are correctly specified.
- Keep fluid velocity in the pipelines to a minimum by specifying the correct pipe dimensions.

Operation

- The first question to ask here is "Does the pump have to run?"
- Ensure that the most efficient pumps operate for most of the time.
- Make sure that pumps operated in parallel are balanced in terms of performance.
- Where possible, run multiple pumps into different columns to reduce friction loss.
- Eliminate inefficient throttling by running multiple smaller pumps in parallel, or introducing variable speed drives.
- Install variable speed drives to handle reduced demand.
- To ensure that pumps operate within their best efficiency zones, install instrumentation to monitor the key pump parameters, such as the suction and discharge pressures and flow rates.

Maintenance

Because of the nature of the liquids being pumped, pumps must be maintained frequently. This includes checking packing glands, bearings, belts, impellers and tolerances to ensure that each pump operates at optimum efficiency.

- Preventive or predictive maintenance are preferred above time-based maintenance to ensure that problems are detected early on and attended to.
- This will allow for early detection of surging, cavitation and gland service related problems.
- Maintenance should be based on drop off in pump efficiency and not time in service.
- Shafts, seals and bearings will last longer if pumps are operated within their best efficiency zone.

3.1.4 Fans

Fans are subject to more misuse, abuse and faulty applications than virtually any other type of equipment. The control of the energy consumed by fans is very important to the overall efficiency of the system.

Ventilation fans are one of the biggest energy users at underground operations and consume energy 24 hours a day. Fans are used for ventilation of underground mining operations, extracting flammable gases and providing fresh air for miners.

Specification

- Fan efficiency and failures have a significant impact on plant operation.
- Designers tend to compensate for uncertainties by oversizing fan systems.

Operation

- Design the system so that the inlet and outlet ducts to and from the fan are as straight as possible.
- Use devices such as turning vanes, airflow straighteners or splitters to accommodate the air profile.
- Optimise the duct sizing. Larger ducts create lower friction losses and lower operation costs.
- Adapt the airflow to accommodate demand changes using inlet vanes, outlet dampers or fan speed control.

Maintenance

- Check and adjust belt drives and fans regularly.
- Lubricate fan components.
- Clean fan components regularly.
- Correct excess noise and vibration to ensure smooth and efficient operation.
- Correct leaks.
- Replace loaded air filters.
- Implement maintenance programme.

3.1.5 Lighting

Lighting is one of the technologies perceived as negligible when it comes to energy savings especially in the industrial sector. Energy savings are not only achieved from merely retrofitting from one lighting system to another, but also from intuitive understanding of all lighting requirements and analysis of inefficiencies of the old lighting system. The power consumption by industrial lighting varies between 2 to 10% of the total power depending on the type of industry.

Every aspect of a mining operation, from residential facilities to administrative offices, from security to processing to extraction activities, must be lit with quality illumination, much of it for 24 hours of the day.

Lighting audits show that much light is wasted, and that large amounts of energy can be saved by applying scientific rules and common-sense measures.

Specifications

- Lighting is divided into two main categories, namely interior and exterior lighting. On both categories there are lux level specifications (SABS standards and OHS Act specifications on lighting), depending on the activities undertaken and the working environment.
- A luminaire for a hazardous location (such as explosive locations) needs to be correctly fitted with flame-proof material when doing a retrofit.

- Industrial lighting in production plants also include a lot of floodlighting which must also conform to legal and the Zone classification requirements.
- Commercial and Industrial sectors are required by law to install emergency lighting along the exits and escape routes.

Operation

- Switch off lights in unoccupied areas and where daylight provides adequate lighting levels. Switching can be done by automatic controls including photo cells, occupation sensors and time switches.
- Replace redundant lights in areas that are modified and reorganised but where the lighting system is not correspondingly updated.
- Electronic control gear (ECG) vs conventional control gear (CCG) – Electronic control gear consumes less power when compared to conventional control gear; by retrofitting CCGs with ECGs significant energy savings can be achieved on the ballast operation alone.

Maintenance

- The type of lamp reflector used determines the light beam characteristics and therefore affects light output. If not properly maintained, the reflector can affect the required lux levels.
- Lighting systems need to be regularly maintained especially in environments where there is dust, chemically aggressive gases or vapour.
- Light diffusers need to be properly cleaned to improve light output levels and hence efficacy.

This frequently overlooked sector provides handsome savings for comparatively little investment.

3.1.6 Heating using heat pumps and solar

Heat pumps

As with refrigeration equipment, a heat pump system employs an evaporator, a compressor, a condenser, refrigerant gas, and an expansion valve within a closed circuit. Latent heat is given off when the refrigerant gas is liquefied through the condenser and transferred to the surrounding water together with further "sensible" heat loss, effectively raising the temperature of the water to 65°C.

It may seem strange that an electro-mechanical device with moving parts (an electric motor driving a compressor) can be more efficient in heating water than a typical resistance element geyser. In fact, a heat pump can be up to three to four times more efficient than a hot water system powered by a normal resistance element, because for every kWh of electricity supplied to the heat pump, more than three kWh of thermal energy in the form of hot water is produced. A thermostat will keep the hot water at a constant temperature between 55°C and 65°C with 60°C being the most commonly used setting.

Specifications

- Systems can vary in size from 10 to 10 000 litres storage capacity for hot water.
- Heat pumps are usually mounted on the outside walls of buildings under the eaves or at ground level depending on the configuration of the system.

Operation

- The significant water heating efficiency combined with the cooling benefits favours the use of heat pumps in areas where there is a daily demand for hot water. In living quarters, for example, the cold side can be used to supplement cold water usually circulated through fan coil units in bedrooms and kitchens.
- Mines which depend on standby generators can use heat pumps during power outages to produce hot water as they are more efficient than direct heating of water with gas.
- The energy produced is usually three to four times the input. A unit consuming 30 kWh will produce outputs of approximately 100 kWh of water heating ability.

Maintenance

Although initial equipment and installation costs are higher than those of gas or electric geyser systems, these are offset by lower operating and maintenance costs. In South Africa, a typical payback period on a commercial system would be three to five years at the current electrical costs. As electricity costs increase this time frame will become shorter. Normal maintenance costs are also reduced.

Solar water heating

Solar water heating is a well established technology worldwide. It is one of the most cost-effective ways to include renewable technologies in a project. A typical residential solar water heating system reduces the need for conventional water heating by about two-thirds. It minimises the expense of electricity or fossil fuel to heat the water and reduces the associated environmental impacts.

Most solar water heating systems for buildings have two main parts: (1) a solar collector array and (2) storage tanks. The most common collectors used in solar hot water systems are the "flat-plate" and "evacuated tube" collector.

Solar water heaters use the sun to heat either water or a heat-transfer fluid in the collector. The heated water is then held in the storage tank ready for use, with a conventional electric element and/or heat pump providing additional heating as necessary.

Specifications

A solar water heater (SWH) is defined as an operating system that uses energy from the sun to produce hot water. It comprises one or more collectors, one or more storage tanks, an interconnecting pipe and functional components. It can be supported by supplementary energy sources such as an electrical element or heat pump.

The operating systems can be further classified in terms of the type of heating system:

- Direct heating system, where the potable water to be heated is circulated through the absorber.
- Indirect heating system, where a heat transfer fluid is circulated through the absorber and a heat exchanger is used to transfer the heat gained to the potable water in the tank.

The actual SWH installed is dependent on the geographical area, number of people/pieces of equipment using water, water consumption patterns and a number of other criteria. However, the basic requirements of a solar water heater are:

1) A solar system can be 100 litres up to 100,000 litres, or any combination thereof.
2) Storage tank must have a minimum operating pressure of 100 kPa.
3) The storage tank must be rated for interior or exterior installation.
4) Storage tank must be SABS compliant.
5) If installed with an electrical element/heat pump backup, the storage tank must be tested in accordance with the relevant SABS electrical safety standard.
6) The storage tank must be installed with a temperature, pressure release valve.
7) The collector may be of any type, as long as it has been tested in accordance with the SANS1307 standard, which tests for:
   - Hail resilience
   - Dry standing damage (system is left in the sun for 14 days dry)
   - Providing a daily energy savings figure per collector.
8) Depending on whether the systems are to be installed in a frost area or not will affect whether the storage vessel will be a direct or indirect (has heat exchanger internal to storage vessel) system.
9) All components used in the solar water heating system must be SABS compliant and the design must be signed off by an authorized person.

Maintenance

Solar water heaters have very few moving parts, thus they do not have very intensive maintenance requirements. Solar energy systems require periodic inspections and routine maintenance to keep them operating efficiently. Also, from time to time, components may need repair or replacement. Some of the inspections and maintenance tasks can be carried out by the consumer, but others may require a qualified technician.

3.1.7 Refrigeration

The purpose of a refrigeration or air conditioning system is to move heat from a cooler space to a warmer space. In very simple terms these systems move heat against its natural direction of flow. If you think of heat as flowing naturally downhill from warm to cold then you can picture a refrigeration system moving heat uphill.

The energy required to move the heat from colder to warmer depends on two things:

- The temperature difference from cold to warm (similar to the height of the hill)
- The amount of heat the system has to move (the cooling load).

An approach to energy savings

One attractive characteristic of many refrigeration systems is that the system will deliver the cooling effect required over a wide range of conditions. This keeps the user happy. Unfortunately, the energy consumed in the more extreme conditions may be more than double that under normal conditions.

Operation

Often, the extreme conditions that these systems experience are a result of inadequate operation practices. Therefore, a simple but effective strategy for minimising the energy cost involves attention to operations:

- Minimise the temperature lift.
- Reduce the cooling load.
- Regular monitoring.

Once the systems are operated efficiently and well matched to their cooling load, other technological measures that would improve efficiency could be considered:

- Avoid systems that enforce head pressure control.
- Avoid systems that do not unload well or use hot gas bypass.
- Consider a compressor upgrade to a more efficient unit.

Maintenance

To minimise the temperature lift:

- Clean heat exchange surfaces.
- Check and reset, if possible, evaporating and condensing temperatures.
- Avoid non-condensables in the refrigerant.

To reduce the cooling load:

- Insulate the cooled space and refrigeration lines.
- Reduce warm air infiltration to the cooled space (especially moist air).
- Minimise parasitic loads such as lighting in freezers.

To implement regular monitoring:

- Use the sight glass to spot problems - bubbles indicate problems.
- Check lubricants frequently - this will also prolong the compressor life.
- Log the operating parameters such as motor currents to spot abnormalities.

Selected savings opportunities

- Use conservative practices at point of use.
- Adjust control set points.
- Raise evaporator temperature (suction pressure).
- Lower condensing temperature (discharge pressure).
- Clean heat exchange surfaces.
- Provide cooler air to the condensers.
- Minimise head pressure control (HPC).
- Capacity control.
- Defrost management.

4. Eskom's energy advice

Advice on the many energy saving techniques and technologies that are available can be obtained from consultants or Eskom energy advisors. Interested persons can call the Eskom Contact Centre on **08600 ESKOM (08600 37566)** and log a query for an energy advisor in their area to contact them.

5. References

Eskom commissioned research 2008
Eskom Demand Side Management