

First Batch of Domestic TOP TENS List

Australia BAT List

BAT1:Pumping System Optimisation – Throttling

Its estimated current energy savings across the sectors are 60 petajoules per annum (PJpa) with prospective savings of 187 PJpa in 2017.

Pumping systems are used in various industrial systems, for example removal of groundwater from mines through dewatering, pumping of condensate or dosing, hot water circulation systems or for circulating liquids like fuel, water, wastewater, chemicals, oil, petroleum, sludge, slurry or reactants. Throttle controls typically restrict flow within the system to achieve a variable flow suitable from fixed pump speed. However this can result in an inefficient system as energy losses are incurred in the throttling valve and through loss of pump efficiency when it runs away from its most efficient operating point. With a variable speed drive, efficiency can be improved because

the speed of the pump and the pumping rate can more closely match the flow rate of the system as it varies over time, reducing or eliminating throttling losses and keeping the pump operating near its best efficiency point.

Pumping system optimisation – Throttling is a technology applicable to the following sectors:

- Electricity Generation – pumping of cooling water, condensate extraction pumps, and boiler feed pumps.
- Mining – pumping for mine dewatering, slurries and wastewater, flocculant dosing or provision of fire-fighting systems.
- Manufacturing – Boiler feed systems, hot water circulating systems, mixer pumping, condensate and dosing systems, as well as transfer systems, amongst others.

- Oil and Gas – pump systems for oil tankers and offshore platforms, dewatering systems, pumping of cooling water.

Example 1: Replace throttled pumps and gen-sets to improve efficiency

- A review of a company's dewatering bores on site revealed that many of the standard bore pumps are throttled as a means of reducing the water flow to a level the bore can sustain. Detailed analysis of the dewatering pump performance showed that highly throttled pumps consume significantly more diesel per megalitre of water pumped than pumps with little or no throttling.

- The assessment proposed to improve the energy efficiency of this dewatering function by creating a rateable store of spare pumps of varying sizes and replace heavily throttled pumps in the field with better matched pumps and generators.

- Pumps at the first mine have been progressively swapped to more appropriate sized equipment where possible and the same approach is now also planned for implementation at a second mine.

- Technology that allows pumps to run at variable speeds is being evaluated at present as a further improvement to the rateable store approach.

Example 2: Another company's scheme has very large electrical pumps which use considerable energy. The scheme consists of three major pumping stations: (2 x 80MW), (2 x 40MW) and (2 x 5MW) Squirrel Cage induction motor. When motors are operated at a constant speed with the flow and pressure of the pump controlled by a valve, optimal energy use is not achieved. Losses can be minimised and large savings realised with inverter 'speed control instead of control by valves. At the

pumping station, the variable speed drive can be installed at a cost of \$1,188,000. The energy saving will be around 6,219,427 kWh, giving a return of about 15% internal rate of return (IRR) provided it is a drought year when a lot of pumping occurs.

BAT2: Cogeneration Plant

They are used in the Manufacturing sector and commercial buildings. Currently sector-wide energy savings are estimated to be 9 PJpa and 70 PJpa to 2017. This technology scored very well in investment per energy unit saved.

When fuel is combusted in an engine or turbine, energy not converted into useful mechanical energy is turned into heat. Typically in a turbine or engine, only 40%-50% of the energy in fuel is converted into mechanical energy. Cogeneration makes use of the waste heat from the turbine or engine and uses it for heating or cooling purposes. Overall efficiency for cogeneration plants can be greater than 80%.

Cogeneration is the combined production of electricity and heat. It is used in a variety of manufacturing processes and buildings where a fuel is available and both electricity and heating and/or cooling is required. Examples include production of electricity, heating and cooling for buildings or manufacturing known as tri-generation, production of electricity and steam that can be used in a manufacturing plant or passed through a steam turbine to generate further electricity and direct use of the hot exhaust gases from the

electricity generation in a process.

Electricity is generated from a fuel, usually natural gas, in a turbine or large engine. If a turbine is used, the exhaust gases can be used directly to heat ovens or dryers or the heat captured in a Heat Recovery Steam Generator (HRSG) to create steam. This steam can be fed into the site steam system or used in a steam turbine to generate further electricity. In the latter case, low pressure steam is often taken off part way along the steam turbine at different pressures to supply site demand. If an engine is used, energy can be captured from the exhaust gases to heat water or raise low pressure steam, while water from the closed loop cooling system can be used for heating duties around the site or building. These uses of waste heat displace other fuel sources that would otherwise be required to supply the heating and cooling demands.

If cooling not heating is required, the heat captured from the turbine or engine can be converted into cooling through the use of absorption chillers.

Cogeneration is used in the following industries:

- Manufacturing subsectors including paper, food manufacturing, small-scale electricity generation, chemical manufacturing
- Oil and gas production and processing facilities
- Commercial buildings to produce energy and heat or cool building

Example 1: As part of a recent upgrade, a food manufacturing site has installed a natural gas-fired cogeneration plant to provide both electricity and process steam to the facility. Energy efficiency is

achieved through the utilisation of waste heat from the exhaust of the electricity generator to produce steam in a boiler. By using natural gas to produce electricity, rather than purchasing electricity from the grid and by using waste heat to produce steam, it is estimated that the cogeneration system will reduce greenhouse gas emissions by 39,714 tonnes of carbon dioxide equivalent per year.

Example 2: Another Cogeneration project includes a 7.9 MW gas turbine and heat recovery steam generator. This will eliminate the use of coal on the site and significantly reduce Scope 1 and 2 greenhouse gas emissions. This project will also reduce energy use on the site by about 43,000 GJ.

Example 3: Another company installed a gas fired cogeneration plant on a Conti 1 Dryer within an MDF production line to capture steam generated by the dryer unit. The exhaust gas from the cogeneration plant is ducted to the mixing chamber of the Conti 1 Dryer where it is blended with flue gas from the hot gas generator and ambient air. The resulting mix of flue gases and air is used to dry fibre by direct contact with the fibre while it is transported in the air stream of the dryer.

BAT3: Heat Recovery and conversion to Electricity

This sector coverage for this technology includes Mining, Manufacturing, Oil & Gas. Heat Recovery to Electricity has excellent sector-wide energy savings of 81 and 400 PJ per annum for current and estimated

savings respectively.

Heat recovery to electricity can be applied in almost any industrial setting where fuel is combusted as part of the industrial process or a chemical reaction takes place that produces heat (exothermic). This technology can be implemented wherever there is a waste heat stream (either liquid or gas) of adequate temperature and flow. The electricity generated can be returned as a source of power for running the process or used in a separate application.

To generate the electricity, the hot gas or liquid from the process is passed through a waste heat boiler to produce high pressure steam. This steam is then passed through a steam turbine to generate electricity. For lower temperature heat sources where steam of sufficient pressure cannot be created, low temperature electricity generation cycles can be used such as Organic Rankine Cycle (ORC).

Sectors that utilise heat recovery to electricity include:

- Mining, oil and gas – generators and cooling applications.
- Manufacturing – chemical reactions, cooling applications, boilers, ovens and kilns.

Example : A company proposed to adopt new sintering technology, heat treatment of the lead concentrate prior to smelting, which would allow for a potential increase in energy recovery. A waste heat boiler and co-generation facility to produce electricity could also potentially be part of this project. The project has completed the concept phase +/- 30%. The project has since secured funding to proceed to the next feasibility phase. The

project capital, operating costs and the amount of electricity generation is being determined to a +/- 12% accuracy level as part of the next phase (bankable feasibility study).

BAT4: Drying Optimisation

Drying optimization is used in the Mining and Manufacturing industries. Sector energy savings are estimated at 58 PJpa (current), and 283 PJpa for prospective energy savings.

Drying processes are a part of industrial applications, primarily in the manufacturing industry but also in mining and wastewater services. Optimisation of drying processes involves identifying efficiencies in the removal of water or other liquid from raw or processed materials or goods.

Efficiency improvements often involve the use of a mechanical process to remove additional liquid prior to drying with heat. Mechanical processes, such as filter presses, are a much more energy efficient way to remove moisture but are not always able to achieve final moisture content specifications. Natural drying using ambient air can also be used to reduce the amount of liquid to be removed.

Sectors and applications of drying optimisation are:

- Mining – drying raw mined materials before processing.
- Manufacturing – food products such as dried fruit, tablet coating (pharmaceuticals), paper manufacturing.
- Services – drying of sludge in wastewater treatment.

Example: Separating minerals via electrostatic separation requires the minerals to be completely dry. Drying of the minerals prior to electrostatic separation is accomplished using gas-fired fluidised bed dryers. The wetter the minerals entering the dryer, the more energy is required for the drying operation. To minimise energy required for drying, methods were introduced to processing plants to minimise the water content of the minerals entering the dryers.

BAT5: Flotation Circuit Optimisation

This technology is used in the Mining sector. Its current and 2017 energy savings are estimated at 6 and 33 PJpa. Relative to other technologies Flotation Circuit Optimisation has a good level of energy efficiency and payback period. The mining sector uses flotation circuit optimisation in the mining of sulfide ores, carbonates, oxides, as well as phosphates and coal. It is also used in wastewater treatment services.

Flotation is a highly complex chemical process used to separate and concentrate a particular substance from the solid or liquid in which it resides. This includes metals from raw mined materials, but also removal of solids and other pollutants within wastewater. In mining processes, optimisation of flotation circuits to achieve optimum recovery rates and / or grade of materials from the process can involve tracking and changing level and aeration set points to change the concentrate flow rates, or manipulating the residence time and circulating flows in the circuit. Where flotation circuits have more complex instrumentation, optimisation can involve mass

pull, reagent concentrations, air flow rates as well as level and airflow setpoints.

Optimisation of flotation circuits is a technology that can involve reconsideration of the size and/or speed of selected motors for different processes. It is quite common for a process to be designed with higher speed motors than required, which results in an increase of energy consumption. A reduction in motor speed of coal pulverisers for example, has demonstrated reduction of 30% energy usage, as well as significantly increased life of grinding rings.

Example 1: In the gold production process, Run of Mine (ROM) ore is reclaimed from stockpiles and fed through a single-stage toggle jaw crusher where the crushed ore provides feed to a semi-autogenous grinding (SAG) Mill. Overflow from the SAG mill gravitates to a flotation circuit where gold containing sulphide minerals are concentrated. Naturally occurring bacteria is then used to separate the gold from the sulphide matrix in a process using the patented technology. The circuit contains six reactors, three primary (Tanks 2-4) and three secondary (Tanks 5 -7), all fitted with agitators driven by electric motors. In the original configuration, the first four reactors were fitted with agitators driven by 220kW motors connected to the agitator shaft with a fixed speed gearbox. Tank 6 has 185kW motor and Tank 7 has 110kW. It was discovered that the rotational speed of the agitators could be reduced by 20% by changing the gearboxes. Savings in energy were estimated at 11,180 GJ/year.

Due to the relative simplicity and high savings that this project generates, it was decided to implement this energy

efficiency opportunity. Following metallurgical test-work to ensure minimal risk to the oxidation process, Tank 5 gearbox motor was changed from a 220kW 4 pole motor to a 150kW 6 pole motor, thereby reducing the speed by 33%. In accordance with the processing department's shut-down schedule, it is planned to replace the 185kW 4 pole motor on Tank 6 with a 150kW 6 pole motor. Additional metallurgical testing is planned to review the impact of reduced agitation speed on the primary reactors.

Example 2: Another company decided that the current spirals-based circuit for reprocessing of flotation tailings at one of their mine's coal processing plants was sub-optimal. Replacing the spirals with a state-of-the-art fluidised bed separator (reflux classifier) to scavenge fines tailings will provide a more effective solution, and improve overall plant yield.

Example 3: Another company decided to improve the flotation yield of their mine's coal preparation plant through installation of Microcel launders and air compressors. This will increase plant yield, and reduce overburden removal, coal mining quantity and save (GJ) 156,220 of fuel use per tonne of final coal produced.

BAT6: Grinding Optimisation

This technology is used in the Mining sector. Estimated energy savings are 18 and 66 PJpa to 2017. This technology scored well in its payback period and energy efficiency, relative to other technologies.

Grinding is used to reduce the size of mineral materials for use, transport or further processing. This size

reduction process is an integral part of each of the sub-processes from production of ore from the mine to the final finished particle size and includes: blasting, crushing, screening, grinding and separation. In many cases grinding is used to liberate valuable minerals from waste materials. The opportunity is to optimise this production chain to minimise the overall energy consumption but with consideration of product losses that can increase if waste is rejected earlier in the process.

Crushing and grinding uses more than 50% of the energy used in mining.

The blasting design affects the energy required in crushing. The size achieved in crushing impacts the amount of material that does not pass through screening and must be re-crushed. The size of material passing through the screen impacts on the energy use of milling. The amount of material that can be rejected as waste between stages impacts on the energy use of the system and the amount of product lost in the waste stream.

Example 1: SAG throughput improvement for milling at a Nickel Mine. A company analysed the energy efficiency of SAG milling at their nickel mine. Analysis indicated that one module had consistently outperformed another. Investigations identified design improvements to the pulp lifter and discharge grate, which were subsequently implemented on the other module. The design improvements resulted in an increased throughput and a reduction in energy consumption per tonne, corresponding to an annual energy saving of 59.6 TJ.

Example 2: Ore drying and grinding through use of alternate technologies. A mining company assessed that additional drying aided the energy efficiency of their

grinding circuit. The ore reclaimed from a solar drying area is further dried in three 34m long rotary kilns to a nominal moisture content of 6% before the grinding process. Two of the dryers are fuelled by coal and the other is fuelled by coal seam methane. Dried ore is then fed through two electrically driven ball mills. It is proposed that other technologies could replicate ore grinding and/or drying at a lower fuel cost.

BAT7:Boiler Economiser

Boiler Economiser technology is available to the Manufacturing and Oil & Gas sectors. This technology has 14 and 45 PJpa for estimated current and future energy savings,with placement on the Top Ten list largely due to its level of energy efficiency and investment per unit energy.

Boilers are used in a wide range of manufacturing industries,as well as oil and gas,to provide heat to an industrial process via the transfer of water or steam. Instead of discharging flue gases from the boiler directly,efficiency can be improved by first passing them through a heat exchanger,called an economiser. The flue gases passing through the economiser are usually used to heat boiler feedwater prior to being pumped to the boiler,thus saving fuel to raise steam and improving the thermal efficiency of the boiler. Economisers can also be used to heat other process streams such as liquid feeds into chemical reactors.

Example:Boiler Economiser Replacement - A boiler economizer is a hot gas to liquid heat exchanger that pre-heats boiler feedwater using the heat in the flue gas

exiting the boiler. The benefits of such a system are to improve the overall heat recovery of the combustion process and hence reduce fuel consumption.The economiser on the Number1 boiler of a sugar mill had been in poor condition and had led to a number of tube leaks. The reliability of the unit deteriorated such that it was by-passed in the previous crushing season.

The direct result of this was a reduction in steaming capacity of the boiler (- 28%) and an increase in the rate of bagasse consumed in the boiler (ie. boiler efficiency). Replacement of the economiser is expected to cost \$1.2 million but result in estimated benefits of higher boiler efficiency higher export of electricity from the site and improved boiler reliability. The overall payback of the project is expected to be 1.43 years.

BAT8:Chiller Controls

Chiller Controls can be applied in the Services and Manufacturing sectors. This technology has relatively good economic characteristics including payback period and investment per unit energy.It has energy savings estimated between 26 to 79 PJpa to 2017.

Chiller controls refer to controls on individual chiller units,chiller plant controls or building management system panels. Control of chillers can include chiller motor speed control (VSDs) or pressure control. Pressure control in chillers is achieved through changing the duty of the condenser side through speed control of the fans or switching fans on and off as required by demand and ambient conditions. In both cases,the

duty of the chiller is matched more closely to the cooling demand resulting in more efficient operation.

Changes in ambient conditions can affect both chiller demand and performance. As ambient temperatures and humidity increase, demand for cooling from occupied spaces, cool rooms, freezers and process cooling will also increase. In addition, the efficiency of the chiller will reduce under these conditions, caused by the reduction in the ability of the chiller to reject heat to the atmosphere.

The variability of loads and conditions must be taken into account when engineering and analysing chillers systems. Significant energy savings can be achieved by designing a flexible system that can respond to loads and conditions, through the use of multiple or variable speed fans on condensers for example. Systems without flexibility are likely to operate in a maximum output configuration that may only be required a few times a year, resulting in a less efficient process for the majority of the time.

Example 1: Extending usage of Variable Speed Drives. Implementation of this opportunity for one company saw extensive introduction of VSDs in key applications, however there is continuing opportunity for benefit in this area due to existing systems, new installations or changed circumstances. For example at one hospital a change in the sizes of chillers removes the previous optimisation by programmed selection of chiller call up, and necessitates use of some larger chillers away from their optimum efficiency, so retrofitting a VSD (which was previously determined to be unnecessary) is now desirable.

Example 2: Another company decided to install a regulation on ammonia compressors and condenser fans

to enable them to work according to the outside air and humidity conditions. This project will save on electricity consumption by reducing the load on the compressors and the condensers.

BAT9: Road design

Road design is used in mining and construction. Estimated energy savings are 7 to 37 PJpa. Road design is relevant at sites where vehicles operate 24 hours, seven days per week. Fuel savings are achieved from road design that reduces rolling resistance through the use of improved surfaces, for example, paving a gravel road. Improved designs can allow vehicles to travel at their optimum speed with minimal stops and takes into consideration factors such as intersections expected load weights and uphill/downhill transport activities.

The energy savings achieved through improved road design are significant due to the type of vehicles used as well as the long operating hours in the mining and construction sectors. The most significant savings are made in mining haul trucks. These trucks carry up to 200 tonne of payload from the face of the mine to an onsite processing facility.

Example 1: Road design - removal of one stop per cycle per truck. The assessment identified an opportunity to review the haul road design to enable trucks to achieve and maintain an optimal trip speed. It was noted a considerable fuel saving would result if the road design could allow the removal of stop signs, where this does not compromise safety. The truck manufacturers were asked to do modelling for a fully loaded truck to accelerate from stationary for 100 metres and to advise the final speed at

this distance. They were also asked to model the same truck operating at this same final speed, but using this same speed for a distance of 1,000 metres, so that the steady state fuel consumption can be calculated. In this way the fuel saving as a result of the truck not having to stop is the difference between the two scenarios. Evaluation of this opportunity revealed that for each stop removed from the load cycle, estimated saving of 361 kL per annum for Caterpillar 777 haul trucks could be achieved and 407 kL per annum for the Terex 3700 AC haul trucks. Savings are based on the removal of one stop-sign intersection. However, with careful consideration of traffic safety, FMG will continue to look for opportunities to remove additional stop signs.

Example 2: Another company found a potential energy efficiency opportunity through optimising a haul road. The existing profile of the haul road comprises a combination of downhill and level sections. Real time monitoring of various truck variables on the truck fleet showed that the trucks consumed fuel on the level sections. Modelling of a modified haul road profile showed that fuel consumption could potentially be reduced on both downhill and uphill journeys for the truck fleet resulting in improved fuel consumption. The potential saving was estimated to be a saving of 750 kL of diesel per year for the truck fleet. This project is one of a number of projects to be considered by the site energy team in 2012 for practicality and implementation potential.

27, increasing to 120 PJpa to 2017. This is a significant technology for the Construction, Services, Mining and Transport sectors.

Weight reduction of vehicles is a relatively simple approach to realising energy efficiencies for the transport, mining, construction and services sectors. Weight can be reduced through the use of new designs for mobile equipment and through the use of lightweight materials. Savings can also be achieved by reducing the amount of material that is transported unnecessarily, for example, reducing the amount of product that gets stuck to the tray of a dump truck.

Example 1: An opportunity was identified to fit lighter truck bodies to the haul truck fleet. This would reduce the weight of the vehicle and therefore allow the truck to carry more ore/waste thereby increasing the potential payload of the truck fleet. The project would require a large capital investment in the truck fleet with a payback period greater than four years.

Example 2: Light weight truck trays - A project is in progress to increase the payload capacity of one company's haul trucks. This has been accomplished through the use of light weight truck trays. As these trays are lighter than the previous trays, more ore can be hauled for the same fuel consumption - thus increasing fuel efficiency. The mine production reporting system and fuel management system have been used to confirm that the increase in fuel efficiency has been realised as predicted. ■

BAT10: Weight Reduction - Vehicles

This technology has estimated current energy savings of