David B. Durocher, Eaton, USA, explains how to leverage technology upgrades to control energy consumption.

For the coal mining industry, new power management and energy efficiency technologies can, of course, save money; they can also improve process efficiencies. Amid, the plethora of options available, how do mine owners and operators determine what new technology adoptions or upgrades are truly right for their own unique business conditions?

**Case study: Canada**

A coal preparation plant in British Columbia, Canada, carried out an installation of a 6000 hp medium-voltage adjustable frequency drive (AFD) to improve control of the plant’s main coal dryer exhaust fan. By carrying out this single product upgrade, the plant not only reduced its operating costs by saving energy, it also gained greater control over its overall production quality. By replacing the inlet vane controllers with AFDs, the coal company reduced monthly kilowatt-hour (kWh) consumption by 197,000 kWh and also improved power factor, which would be near unity with a AFD. There were also non-electrical savings identified, including:

1. Reduced dryer fuel consumption as a result of lower air flows during both operation and idling periods.
2. More precise and consistent product moisture control, allowing the site to achieve higher product quality.
3. Operational replicability across three shifts, such that all operators run the dryer system in the same way, setting the speed of the fan at the required cyclone pressure drop to regulate air flow through the dryer.

4. Reduced maintenance costs due to the controlled soft start via ramping up frequency during start-up and eliminating the reliance on mechanical components (i.e. the inlet dampers) that required frequent maintenance and adjustment.

5. Annual energy savings of 2.37 kWh for electricity and 11 730 GJ for gas in British Columbia with reduced greenhouse gas (GHG) emissions (CO₂, methane and NOₓ) by 349 short tpy.

By approaching upgrades and product selection more strategically, the process leveraged by the site exemplifies a worthwhile and repeatable way to leverage innovations that ultimately transform efficiency losses into substantial gains across the board. Ultimately, the AFD upgrade project saved the company extensive costs by reducing energy, improving processes and delivering a higher-quality final end product.

The following focuses on some best practices that led to both project and product selection for this site.

**Tools: resources to guide appropriate adoption of energy efficiency solutions**

At its core, the project was successful because it did not unthinkingly jump onto the bandwagon of the next best energy efficiency innovation; there can be a lot of hype around new ‘energy saving’ products as they first hit the market.

Instead, the project began with an energy efficiency feasibility study (EEFS) intended to explore a range of new technologies that would be capable of offering the greatest gains in the mine and coal preparation plant specifically. The local utility was closely involved in this project from start to finish and product selection did not occur until energy benchmarking first ruled out both the most common problem areas and the simplest solutions.

By learning to leverage three tools – EEFS, energy use and plant process model, and utility supported energy credits – more effectively, coal mine operators can be more assured of choosing new technologies that deliver a maximum return on investment in a predictable amount of time.

**The EEFS**

A site EEFS is the optimal way to identify appropriate solutions tailored to unique and specific mine operation processes and conditions. This approach generally assembles a team of experts to collectively analyse the site’s actual needs and potential for improved energy efficiency. The team includes engineers, certified energy managers (CEMs), coal processing engineers, other optional representatives from the local utility, the coal operation’s administration and staff and other professionals.

Once assembled, the EEFS team then carries out a period of observation during live production operations. At the coal preparation plant, the observation took place over roughly four days. The objective of the observation period is to capture a range of different energy measurements from multiple points in the facility’s processes and systems. Interviews with site operators are also included to facilitate an in-depth understanding of plant operations from human, machine and human-machine-interaction points of view. Together, these data points provide a clear understanding of what is happening throughout the facility’s power management and distribution infrastructure.

Although it is important to establish a focus on the major energy consumers for a site, it is equally important to focus on specific areas of opportunity for energy improvement for the system components. For example, after reviewing the system operation and energy consumers at the facility, the team quickly narrowed the EEFS scope to address only the main dryer exhaust fan and the combustion air fan. These two pieces of critical equipment were observed to account for 81% of all estimated kilovolt amperes (kVA) used on site.

**Energy use and plant process model**

Equally as important as the EEFS is the task of considering commonly overlooked causes of energy inefficiency based on a clear understanding of existing processes and personnel. It is important to complete this step to be sure that resources and new investments are applied where they will truly have the greatest possible impact in maximising both efficiency and process reliability.

A thorough review of all standard best practices for identifying common problem areas within the plant’s existing systems and technologies is necessary. Some areas that the process model considered included:

- The dryer systems already had AFDs applied on eight feed screws.

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**Figure 1.** Example list of electrical ‘energy users’ within a coal drying plant. In this example case, the scope of the EEFS study was narrowed to the main dryer exhaust fan (6000 hp) and the combustion air fan (150 hp).
The scrubber pumps, transfer conveyors and dryer dust screw conveyors were considered properly sized, with constant speed operation; therefore AFD control or other measures would not be effective.

Upgrades to the dust screw and multiple small equipment items would deliver insignificant power savings considering the overall site energy footprint.

Equipment marked as known energy consumers (such as select items detailed in Figure 1) were already functioning at an optimal level of efficiency.

Maintenance records should be reviewed before any energy use and plant process discovery, troubleshooting and modelling. For example, logs, service records and multiple-user focus group inputs gathered over time help to confirm user experiences with operation and maintenance of existing equipment. This information can be informative and be used to identify how the degree of complexity in current processes impacts system and product efficiencies.

Energy credits
A final key factor in this site’s energy efficiency success lies in the close assistance received from the utility servicing the site. The site serving electric utility offered financial incentives that supported the cost of both the site energy audit and the installation of the new 6000 hp dryer exhaust fan AFD.

Many global utilities today have a keen interest in partnering with their large energy consumer clients to identify energy savings projects in order to avoid the significant cost of new generation assets. Often, saving electrical energy and passing a component of the avoided cost on to ratepayers can be the most prudent choice.

Today, many utilities offer some very forward-looking and creatively structured energy credit programmes. These programmes go beyond basic rebates and incentives. In the coal plant’s case, the utility offered a Power Smart Industrial Alliance Energy Grant Program that was especially well suited to support the site EEFS, establishing a front-end collaborative relationship between the coal mine operation and the utility.

Free energy calculators are available to help assess AFDs versus other variable flow technologies. Users can leverage these tools to calculate payback, weigh various options for technology investment and then document intended savings when applying for energy efficiency programmes or credits.

Return on investment: leading energy efficiency innovations
Three of the most effective, agile and innovative energy efficiency improvements available on the market today include AFDs, LED lighting upgrades and energy management and monitoring systems. The decision criteria identified below offers guidance on when and how to optimally leverage these innovations in a mining facility.

Best-in-class adjustable frequency drives
Low-voltage and medium-voltage AFDs can be especially effective in delivering energy efficiency improvements through speed control of variable flow centrifugal loads. Replacing valves and dampers with drives offers significant energy savings along with better control during idle plant conditions. A facility can identify idle conditions at any period where equipment must be kept running despite the fact that materials or product are not active in the process flow. Idle conditions are common when operating issues occur in some areas of the plant but often other equipment must be kept running, even when not in immediate use.

The thermal coal dryer exhaust fan was just such a process load at the coal preparation plant. In fact, its idle running conditions were a big contributor to high energy consumption. Thus, during idle periods, it was advantageous to reduce the airflow through the dryer by reducing the revolutions per minute (RPM) of the motor via the AFD speed controller. Controlling the RPM of the fan motor has the same variable airflow effect of opening and closing the inlet dampers to the fan, but with higher energy efficiency. The end result was a significant reduction in power consumption of the exhaust fan motor. And, while the new AFD positively controlled the fan’s exhaust airflow rate, it also impacted other process parameters throughout the system, such as temperatures and coal moisture content.
With respect to the EEFS, this example actively demonstrates how an area of largest energy consumption could also be one of the areas of greatest energy efficiency improvement.

Some additional user selection criteria for the AFD equipment selection at the plant included:

- Near unity input system power factor.
- Very low harmonic distortion to assure there was no potential interaction between the new AFD and other electrical equipment installed at the site.
- A robust design impervious to coal dust, moisture and other airborne contaminants.
- Finally, the serviceability of the new drive was very important.

**LED lighting, light quality and safety**

LED luminaires provide compelling benefits, such as long-term cost savings and safety advantages through longer life and durability. Common considerations for LED adoption include luminaire placement; the intensity, dispersion, and quality of light; thermal management; material selection; and redundant safety and operating systems. Users need to ensure the right factory experts are brought on site to survey existing lighting systems and recommend the most suitable LED replacement fixtures based on the application. For instance, vibration and extreme operating temperatures typically found for mine site mobile equipment are excellent opportunities for LED lighting upgrades.

To ensure long life, LED fixtures must be constructed with robust and durable heat sinks that allow maximum heat transfer from the LEDs to the ambient environment. For example, finned heat sinks serve as an excellent source for dissipating heat and lowering the LED junction temperature in the light fixture. Effective thermal management ensures longer life, lower lumen depreciation and minimal colour shift over the life of the LED fixture. It also ensures lower surface temperature and temperature codes for safe and reliable operation in applications where flammable gases, dust and fibres are present.

LED fixtures incorporate a self-contained power supply known as a driver, which matches lighting outputs to the electrical characteristics of the specific LED. Therefore, redundancy in drivers can also ensure reliable operation over a proven extended product life versus high intensity discharge (HID) fixtures and other available technologies. Multiple drivers connected to multiple LED circuits ensure that the light fixture will have a string of LEDs illuminated in the rare event when one of the drivers fails.

Due to the directional nature of LEDs, custom optics can be easily incorporated into the construction of the LED light fixture. Optics enable more uniform light distribution, improved coverage and minimal light loss in the work area. This allows the facility to maximise application spacing and minimise the number of light fixtures required to safely illuminate the work area. Some examples of common optics used in industrial locations are:

- **Type I:** Long and narrow beam distribution for applications such as aisles, catwalks, ramps, tunnels, long passageways, conveyer belts, loading docks, etc.
- **Type III:** Semicircular kidney-shaped beam pattern for narrow crosswalks or passages with wall fixtures, tunnels with wall mount and wall stanchion mount with 180° forward throw.
- **Type V:** Circular beam pattern for pendant, ceiling or stanchion mount overhead building, processing mills, industrial plants, large buildings and warehouses, etc.

Investing in work place safety through the use of new lighting installations can provide a compelling return on investment in energy savings, while enhancing safety for mine site personnel. Case studies have proven that operator safety, more than energy efficiency, is the primary benefit derived from LED upgrades.

Mobile mining equipment is often operated with a number of traditional fixtures that have burned out, compromising the safety of personnel operating machinery at night. Human error, including trips and falls, is identified as the primary cause of approximately 85% of industrial incidents. To address these concerns and improve safety, new lighting installation technologies facilitate safer and more efficient placement of light fixtures. The extended life of LED luminaires reduces the incidence of personnel navigating lifts to replace burned out lamps. When multiplied by the large number of fixtures in facilities, there is a significant safety and also energy efficiency savings opportunity.

**Energy management and monitoring systems**

In today’s culture, it is clear that continuing production without making fundamental changes to the operation is simply not an option.
Many plant owners, operators and managers face tough decisions navigating and negotiating improvement plans that carefully optimise available capital investments. Physical plant operations are often compromised by legacy technologies that make it difficult to run reliable processes. Scarce capital funding that could be used for upgrades must often yield to required spending to address environmental regulations and emissions standards.

Both business leaders and facility operators need to be committed to continuous improvement, finding new ways to optimise the manufacturing process or run the risk of permanent closure.

**Case study: USA**

A mineral processing plant located in the US serves as a good case study in the adoption and application of an energy management system that helped transform site operators into ‘site energy owners’, ensuring each department was responsible to and accountable for achieving improved energy optimisation. In this example, an individual plant leveraged a unique energy management programme at the multi-site enterprise level to financially support the cost to install a state-of-the-art energy monitoring system.

Previous energy management procedures in the plant included manual meter reading and recording of energy at each substation, which took place on the last operating day of the month. Kilowatt-hour readings were transferred to a spreadsheet and distributed to accounting, where the information was used by operations to determine the electrical energy efficiency in kWh per tonne produced by each operational department. In this way, ‘energy owners’ of each individual process, such as the raw mill, the kiln and the finish mill, could be aware of the energy usage based on the previous month’s production.

Although the recorded energy metrics offered some visibility to the total electrical energy consumed, the legacy system offered only a ‘rear-view-mirror’ view of energy consumption. Due to the lack of awareness of real-time energy usage or performance, there was no clear process to evaluate and respond to changes in monthly energy usage. Actionable, operational changes, such as responding to peak power usage events that would trigger utility demand charges, were not possible. There was no clear method to track electrical system efficiency; no real-time method available to identify and then manage the electrical loads with the largest demand; and no immediate means to alert an operator of a potential for energy savings.

In evaluating alternatives, the staff recognised that, at this facility, nearly every piece of equipment needed to be running to produce the final product. The existing systems were sized with little extra capacity, leaving little room for peak-demand and on-peak energy management. At the same time, the plant enterprise – which owns and operates seven other facilities in the US – held the view that ‘if you cannot measure it, you cannot manage it.’ As such, accurate real-time metering was identified as a required first step before any other energy saving process changes would be adopted.

As a result, the plant installed a facility-wide monitoring and energy management system. In-plant resources were effectively used to specify, procure, install and integrate new energy meters during scheduled market-related outages, delivering the new system at an optimal cost. The work scope included replacing/upgrading the protection relaying at the incoming 4160 V plant service and integrating these new protective devices with point-of-service energy/power-quality metering. Submetering was also installed at the downstream substations. The energy monitoring devices were integrated into the plant distributed control system (DCS) via local programmable logic controllers (PLCs) so that real-time energy usage throughout the plant would be visible to the operators. Increased operator awareness, electrical diagnostic capability and potential for integration of energy management with existing process controls made the new power monitoring system a significant asset to the plant.

As a result, the plant operators are now making informed decisions based on optimised energy usage. Today, the plant is running more efficiently, as energy usage is measured and visible at all levels across the plant’s organisation.

And because it was created by in-plant resources, the new energy management system was embraced by operations and well-understood right from the start. In addition to a two-and-a-half-year payback from the energy management system and a double-digit reduction in consumed kilowatt-hour per tonne produced, there were also environmental benefits. Since the plant used fossil fuels to produce much of its electrical energy, the reduction in energy consumption also significantly reduced GHG emissions.

**Leveraging a network of experts who can deliver success**

Of course, the most successful technology-based initiatives are often the result of human capital. With diminishing onsite resources, leveraging suppliers that offer a network of high-quality service professionals is critical. By selecting the right service providers offering guidance in selection of appropriate energy efficiency technologies, coal mine plant owners and operators can meet their most pressing production goals, while lowering costs and improving product quality.

Qualified energy services companies bring needed expertise in site investigation, measurement, identification and recommendation of energy initiatives. The right design experts understand the challenges of the coal industry and can help navigate organisations through the complexity of finding optimal energy efficiency solutions that will enhance site productivity and system reliability.