

The ROI of Power Factor Correction

A comparative analysis of power factor correction with upgrading or installing new equipment.

Present issues surrounding escalating production costs, energy efficiency and a growing trend of electricity supply companies introducing kVA- based maximum demand charges are driving mining companies to re-think how they optimise their electricity supply and distribution infrastructure.

Often located at the end of the grid and characterised by heavy start up loads, mine sites are particularly susceptible to power quality issues. These issues can result in negative technical and financial impacts by interrupting production and driving up operational costs. It can also restrict plans for mine expansion.

Mines, considered very large energy users, are also being targeted by electricity supply companies to address their power quality (in particular power factor) issues to meet electricity supply standards and their electricity supply connection agreement conditions.

Power quality equipment and solutions are increasingly being considered to alleviate technical problems associated with poor power quality, reduce kVA demand charges and avoid capital outlay when looking to increase capacity.

What is power factor?

Power factor is a measure of how efficiently electrical power is being consumed on site. The way a business manages their power and electrical infrastructure is therefore incredibly important, as poor power factor can have a number of financial or operational implications.

While a power factor of 1 (or unity) is ideal, in most cases it is not economically viable as compensation is not a linear function. Though largely dependent on connection agreements, it is widely accepted that a power factor of 0.95

or higher is considered to be an efficient use of power, while power factor lower than 0.9 risks breaching agreements and can lead to higher than necessary kVA demands and subsequent higher electricity bill charges.

In the mining sector, power factor is affected particularly by the electric motors in longwalls, conveyors, ventilation fans, coal preparation plants etc., all of which use large amounts of energy and require large amounts of reactive power to support the network.

If a mine's electrical system is not optimised for these types of loads, power factor is likely to be negatively affected. Poor power factor affects a mine's operating efficiency and operating costs in several ways. Electrical losses and voltage instability in the system may be amplified, resulting in transformers or switchboards overheating, motor start issues and loss of torque at the cutting face. The consequence can be costly damage or a reduced life expectancy to electrical distribution and production equipment as well as possible loss of production through downtime.

A system with poor power factor draws more apparent power from the network and as a result the supply network needs to provide infrastructure and generation that will support this. To reduce the demands placed on the grid, end users are subjected to a demand charge (based on kVA) as an incentive to improve their power factor to reduce the apparent power the site draws from the network.

The application of power factor correction (PFC) systems compensate for some of the problems associated with the dynamic loads that are characteristic of mining networks. A PFC system will monitor and regulate a site's power factor by energising optimally sized and designed capacitor steps that will locally supply the required reactive power to the connected loads, thus reducing the power drawn from the supply source.

Benefits of installing Power factor correction systems

There are a number of positive benefits associated with installing PFC equipment and solutions, as outlined below.

- **Tariff savings (avoiding penalties)**

Reduces costs where tariffs are related to KVA maximum demand, with poor power factor, you will pay more for your electricity supply as you are subject to KVA maximum demand charges. These charges can often be a large percentage of an electricity bill, with some as high as 25% of a total electricity bill.

- **Capital avoidance**

Reduce the loading of supply transformers, switchboards and cables and as a result release capacity in your electrical infrastructure and plant without expanding supply infrastructure, thereby avoiding or deferring capital outlay on upgrading or purchasing new equipment to increase your electrical capacity.

- **Mitigation of network and technical problems**

Provide voltage stability and as a result reduce or eliminate issues associated with voltage fluctuation that may cause difficulty with large motor start, low torque issues for cutting machines due to lower than desired voltage levels and starting fully loaded conveyer systems. In addition, a PFC system can be designed to filter harmful harmonic distortions which can cause premature failure of electrical equipment, nuisance tripping, breaching of connection agreements or impact the validity of Ex certifications of flameproof motors.

Scenario

The following scenario is appropriate to mining operations that are considered very large energy users by their electricity supply network company.

An underground thermal coal mine in Queensland currently has a power factor of 0.8. The mine is a 66kV metered customer with billing partially calculated on kVA maximum demand and capacity charges with an Authorised Demand structure. The existing infrastructure features a 66kV /11kV transformer with 11kV switchyard, currently distributing to the underground mine as well as surface operations. One 11kV circuit supports an 11KV/415V transformer with several ventilation fans. Another 11kV circuit supplies the underground, including continuous miners.

At present the mine is experiencing motor start issues with their ventilation fans and loaded conveyers.

The mine is planning on expanding their current operations to accommodate an additional continuous miner and increased production. To achieve this they have determined they will need to:

- Install new, larger capacity cable for several kilometres underground to allow for an increased electrical demand
- Upgrade the 66/11kV transformer
- Upgrade the existing 11kV/415V transformer (although this won't fix the motor start issues)

The mine investigated two options to achieve increased energy supply and mitigate the operational problems.

Option A: Capital expenditure - installing new/ upgrading existing equipment

To cater for additional electrical capacity, the following installations/upgrades are required:

- Increase transformer capacity at the 66/11kV transformer by installing cooling fans
- Replace the existing 11kV/415V transformer with one of larger capacity to support an additional vent fan
- Upgrade cable size underground to support the electrical load from an extra continuous miner

An initial estimate of these total upgrades would require over \$600,000 in capital expenditure.

There are no electricity bill savings from this project/option.

It is noted that Option A does not mitigate the existing operational problems with starting certain motors and concerns about less than desirable torque for the cutters at the face.

Option B: Installing power factor correction

The installation of the following two PFC systems will yield the same increase (more in fact) in energy supply capacity as the installations/upgrades outlined in Option A, as well as mitigating the motor start issues currently being experienced.

- Install a low voltage PFC system on the 415V side of the transformer ventilation substation
- Install a medium voltage (11KV) PFC system in the underground drift

An initial estimate of these systems would require \$650,000 in capital expenditure.

This project will mitigate the mine's motor start issues, as well as delivering a reduction in electricity Network Demand and Capacity charges of \$180,000 per year based on the client's existing tariff structure.

Business case comparison

The decision as to which project to proceed with is obvious by comparison:

Option A has a Capital cost of \$600,000, but no reduction in Electricity Network charges.

Option B has a Capital cost of \$650,000 and a reduction in Electricity Network Charges of \$180,000 per year.

However, Option B is also delivering the capacity increase provided by Option A. A comparison of the two projects shows that the incremental capital for Option B is \$50,000 more than for Option A. This means Option B's incremental investment has a Return on Investment of 360% or 0.33 year simple payback as this option is also delivering a reduction in electricity charges of \$180,000 per year.

Captech can provide assistance and advice on any aspect of power quality requirements, including power factor correction, kVA demand minimisation, voltage disturbance, harmonic filtering and voltage control analysis and solutions.