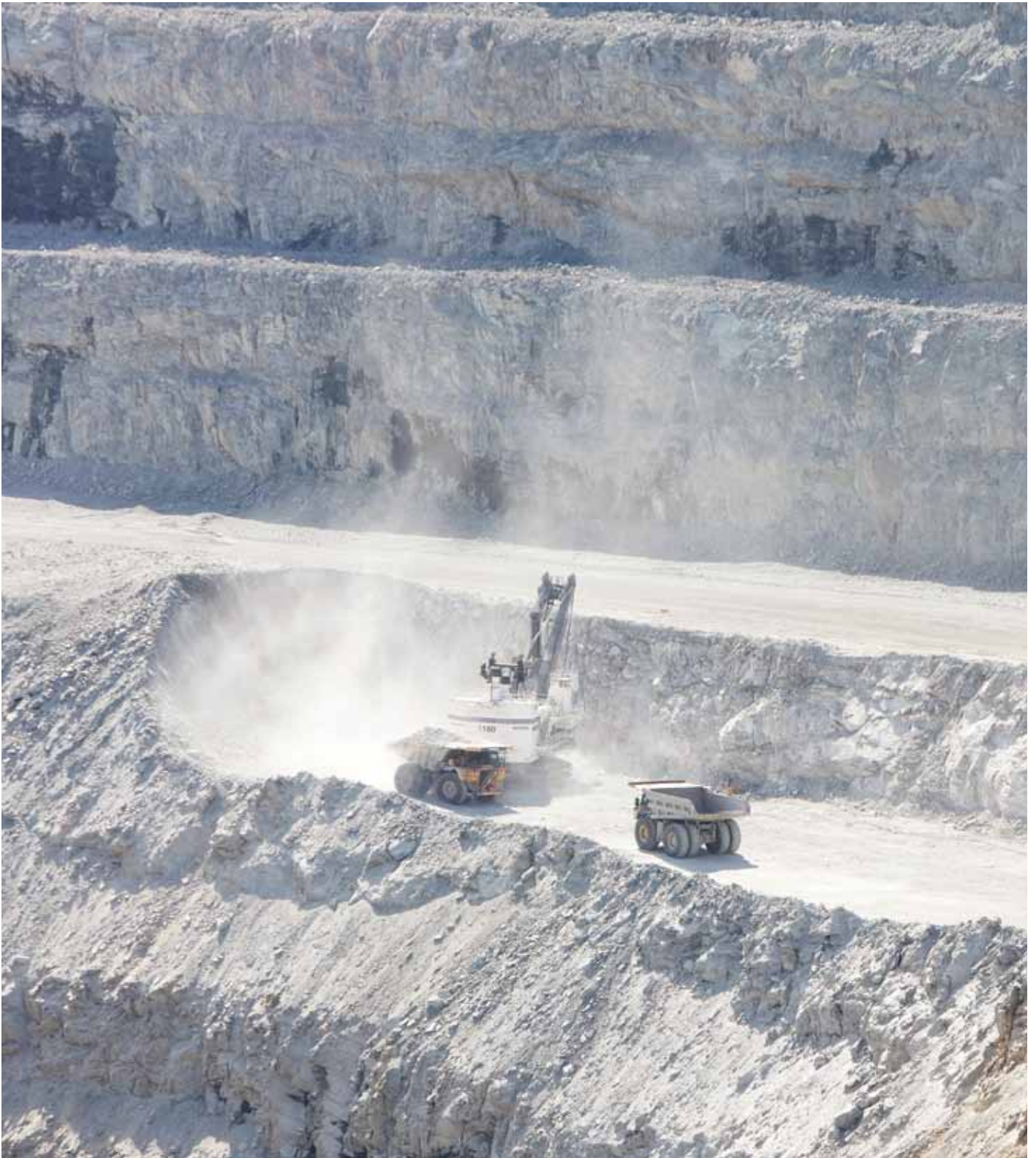




ABB drives in mining  
Medium voltage drives for reduced  
energy consumption and optimized  
process control





# Accelerating output and reducing production costs

Mining companies are facing major challenges for sustainable growth. As demand for commodities is exceeding supply, mining companies have to find new deposits in remote and inhospitable regions where production costs are escalating. In addition, they are taking measures to improve safety and reduce environmental impact.

To safeguard their future, mining companies need to:

- Improve performance
- Cut production costs
- Reduce environmental impact
- Improve safety
- Increase automation

## **Energy-intensive processes in harsh conditions and remote areas demand robust, safe and energy-efficient process equipment**

Energy costs represent 25 to 30 percent of a mining company's operating costs. Especially in remote areas energy costs are a major contributor to a company's operating costs. Much of the energy used is consumed by electric motors. Still today, many of these motors are constantly running at fixed speed regardless of actual output requirement, wasting a tremendous amount of energy. Energy use can be cut by up to 60 percent by controlling motors with electric variable speed drives (VSDs).

Equipment in most mining processes are exposed to extreme working conditions such as dust, precipitation, high temperature variations, high altitude and weak network conditions. Such conditions put a high demand on the process equipment. To ensure a high production output, the process equipment has to operate reliably under these conditions.

## **Meeting safety requirements**

Within the mining industry safety is of paramount importance. As mines can be hazardous working environments, the equipment in use has to provide a high level of personal safety. Precautions have to be taken to ensure that the equipment does not present a hazardous source for personnel.

## **Variable speed drives**

VSDs provide optimized process control and save energy. ABB has been supplying variable speed drives for over 40 years. Today, VSDs are used in a wide range of applications in the mining industry, such as:

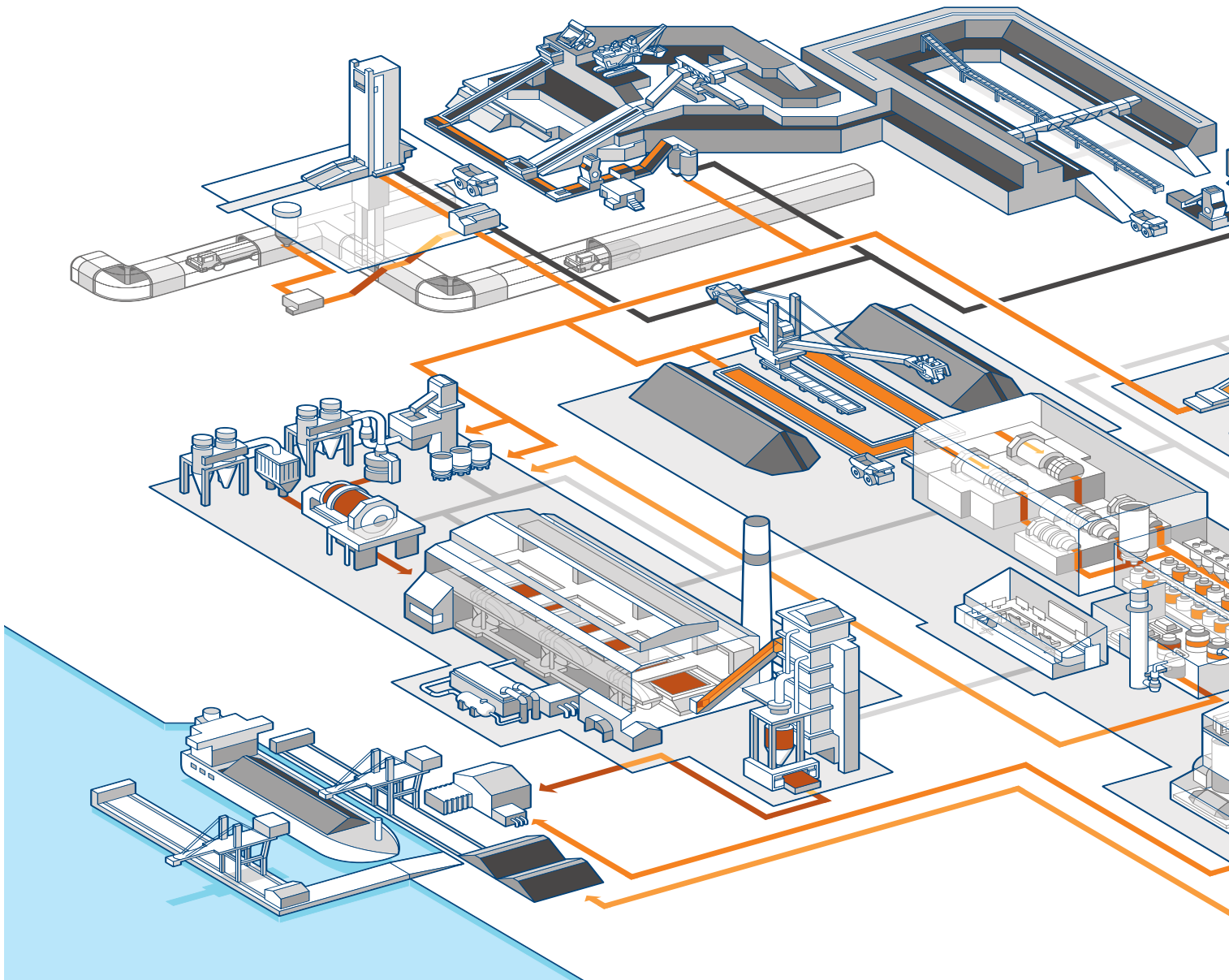
- Fans
- Pumps
- Conveyors
- Mine hoists
- Grinding mills
- High-pressure grinding rolls





# Variable speed drives for mining applications

Various processes and applications benefit from using variable speed drives.

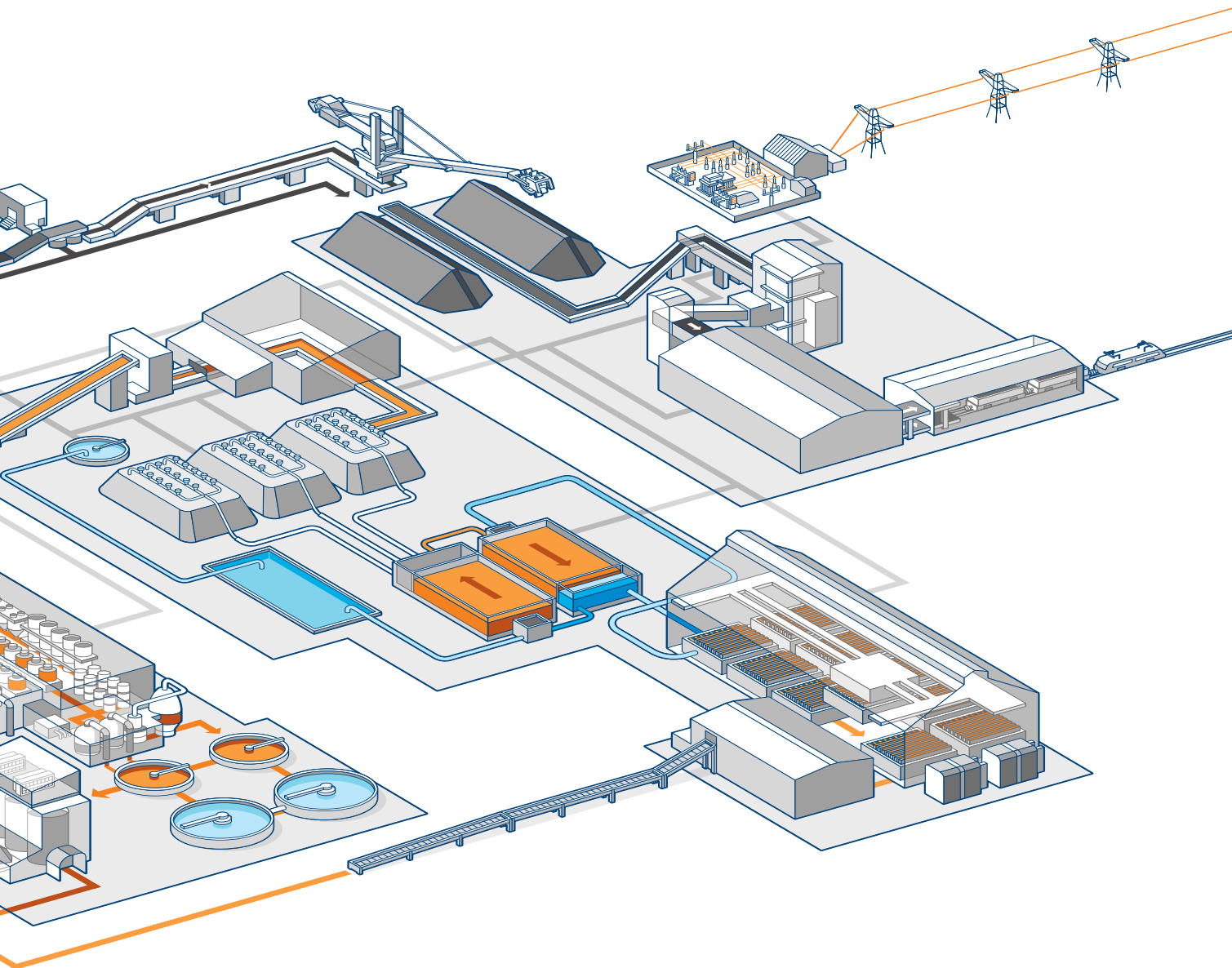


## Underground mining

- Ventilation
- Pumps
- Conveyors
- Mine hoists
- Shearers and armored face conveyors
- Crushers

## Open pit mining

- Pumps
- Conveyors
- Excavators
- Shovels
- Draglines
- Stacker-reclaimers
- Spreaders



#### Ore concentration

- Fans
- Pumps
- Mills
- High-pressure grinding rolls

#### Processing and refining

- Fans
- Pumps
- Conveyors

# Benefits of variable speed drives

Controlling processes with variable speed drives has a direct impact on a company's operating costs.

## Fixed versus variable speed control

The most common flow control method is by means of a fixed speed motor where the flow is adjusted by a mechanical device. This method can be compared to adjusting the speed of a car by braking while keeping the foot on the gas pedal. This technique does not only waste a tremendous amount of energy, it also wears out the equipment.

With electric variable speed drives, changing the flow is simply achieved by adjusting the speed and/or torque of the motor, which can be compared to reducing the speed by taking the foot off the gas pedal. The equipment is operated at the BEP (Best Efficiency Point) under all operating conditions. Electric variable speed drives are the most efficient control method – saving energy, decreasing CO<sub>2</sub> emissions and minimizing total operating costs.

Variable speed drives replace mechanical control devices such as valves, fan inlet vanes, hydraulic couplings and dampers which are often used in various mining processes.

## Benefits of variable speed drives

- Lower energy consumption and CO<sub>2</sub> emissions
- Minimized mechanical wear of equipment
- Higher process quality and efficiency
- Increased productivity and throughput
- Less investment in electrical network compensation devices, such as filters





### Energy savings and reduced emissions

The energy consumption of most motor-driven applications can be reduced with variable speed drives. Fans, for example, typically run at partial load. Huge energy savings can be achieved by controlling their speed with VSDs. The power required to run a fan is roughly proportional to the cube of the speed, ie a small reduction in speed can make a big reduction in the energy consumption. A fan running at half speed consumes less than 15 percent of the energy compared to one running at full speed. By employing VSDs on fans instead of dampers and vanes, the energy bill can be reduced by as much as 60 percent. Consequently, electric variable speed drives also help to reduce CO<sub>2</sub> emissions.

### Reduced maintenance costs and longer lifetime of equipment

VSDs also act as soft starters, reducing the stress on network, motors and process equipment. During the starting process, the VSD progressively increases the motor speed and smoothly accelerates the load to its required speed.

Soft starting eliminates high starting currents and voltage dips on the supply network which can cause process trips. By soft starting, maintenance costs will be reduced and the lifetime of the equipment extended.

### Reliable performance

#### Full starting torque

VSDs provide full starting torque even under weak network conditions. The torque can be precisely controlled throughout the entire speed range and harmful torque peaks are eliminated.

#### Power loss ride through

Due to the power loss ride through function, ABB drive systems are able to withstand disturbances on the power supply. The drive will continue to operate in an active but non-torque producing mode if the incoming supply voltage is cut off. The drive is active as long as the motor rotates and generates energy to the drive. It will resume normal operation immediately upon return of power supply.



# Applications

## Fans

### Energy savings and improved process control

The performance of centrifugal fans is controlled by a set of rules known as the affinity laws, which state that:

1. Flow is proportional to speed
2. Pressure is proportional to the square of the speed
3. Power is proportional to the cube of the speed

The diagram shows a typical fan characteristic which is a function of volume flow and pressure. Also shown is a typical system characteristic. The operating point of the application is at the intersection of these two curves. If the required volume of air is deviating from this point, the fan and/or system characteristic needs to be changed.

Traditionally, the most common way of changing the operating point is by using a damper which alters the system characteristic (operating point moves from position 1 to 2, see Fig. 1) increasing the system losses. However, increasing or decreasing the fan speed with a VSD will change the fan characteristic itself (point of operation moves from position 1 to 3, see Fig. 1) without adding additional losses. The energy consumption can be reduced significantly because lower pressure is needed for the same air flow.

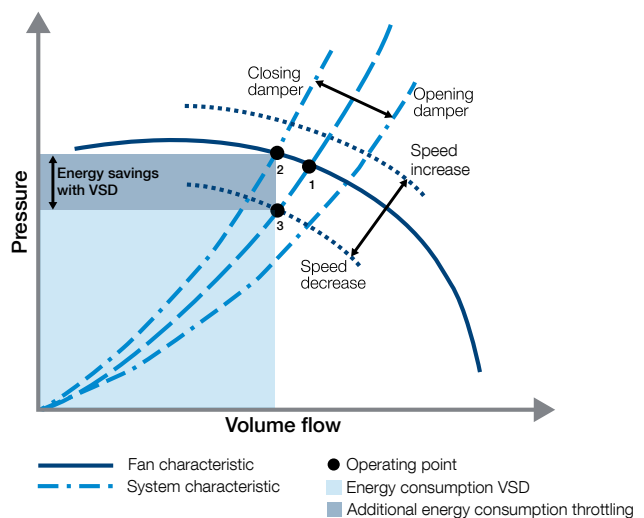


Fig. 1: Typical fan characteristic showing operating point

### Drives in action

ABB variable speed drive improves productivity and increases energy savings at iron ore mine

Pena Colorada, one of the largest iron ore mining operations in Mexico, replaced the damper fan control of its “pellet cooling fan”, rated at 1250 kW, with an ABB medium voltage drive.

The replacement resulted in the following benefits:

- Energy savings of 23 percent
- Increased productivity through increased system availability
- Reduction in service and maintenance costs
- Reduced motor noise and vibration





# Applications

## Pumps

Energy consumption is the most critical factor of a pump's total life-cycle costs. About 20 percent of a mine's total energy consumption is used by pumps.

### Flow and pressure control

The flow and pressure of pumps need to be controlled due to fluctuations in process demand and system parameters. The flow and pressure can be adjusted electrically with variable speed drives, or mechanically with fixed-speed solutions, such as throttling valves, hydraulic couplings or recirculation.

As the affinity laws also apply to centrifugal pumps, controlling the pump motor speed with a VSD brings substantial energy savings compared to on/off control, throttling or any other control method. The pumps will be operated at the BEP (Best Efficiency Point) under all operating conditions, saving energy, decreasing CO<sub>2</sub> emissions and minimizing total operating costs.

Soft starting, another benefit offered by VSDs, eliminates pressure peaks in pipelines.

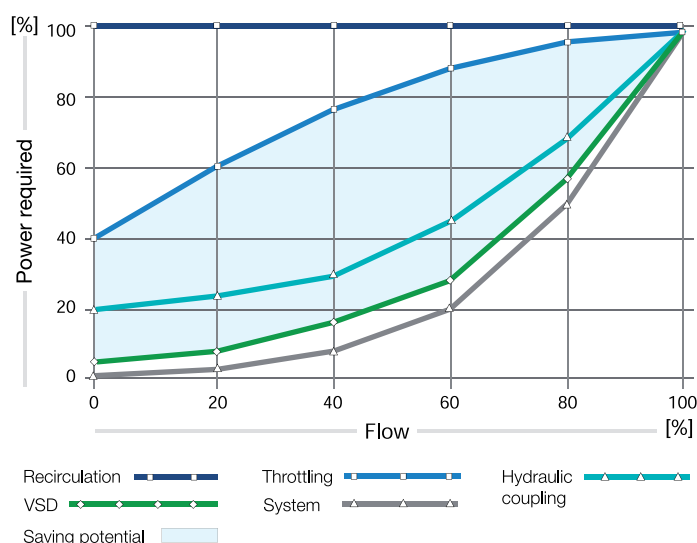


Fig. 2: Power consumption for various pump control methods

### Slurry pumps

Pumping slurry is one of the most demanding applications for a pump. Due to the high-density, abrasive and corrosive substances, parts wear out quickly and maintenance and energy costs are high.

The operating speed of a centrifugal slurry pump is one of the most important factors which determines the life of the pump. Operating them at full speed increases impeller wear and reduces the pump's lifetime. With a VSD the pump speed can be adjusted to match fluctuations in system parameters such as flow rate, static head and settling velocity. Should a pipe start to block, due to changes in concentration or particle size, the VSD can adjust the pump speed so that the flow is above the critical velocity preventing blockages and avoiding a shut down of the plant.

With VSDs slurry pumps are operated at the most efficient rate, reducing energy and maintenance costs considerably.



# Applications

## Mills

To sustain production, mills usually have to operate continuously 24/7. Reliable and precise control has a high impact on production throughput and operating costs. Controlling them with variable speed drives results in the following benefits:

### Optimized plant production

By controlling mills with VSDs, the system can easily react to changes in ore characteristics and throughput. There is no need to change mechanical components if ore characteristics change. Also, the speed of the mill can be tuned for optimal grinding and maximum throughput, resulting in a more efficient use of the grinding power. If up- and downstream processes require a lower grinding throughput, the mill can be operated at partial load without having to stop the process. VSDs can adjust the speed according to the fill level of the mill.

### Accurate and coordinated load sharing

With dual pinion mills, care must be taken that the load is shared equally between the two pinions. VSDs ensure an accurate and coordinated load sharing.

### Smooth ramp up

Torque pulsations and peak torques, generated by mill equipment during the starting phase, creates high stresses on network and mechanical equipment. VSDs provide a smooth ramp up of the mill. They deliver high starting torque for the current drawn from the power system and have a programmed upper limit to reduce peak torque during the start of the mill. The low starting currents and high starting torque enable a smooth start-up of the mill, even when fully loaded.

### Energy savings

Mills are one of the biggest energy consumers in a mine. Controlling them with VSDs results in significant energy savings.





### Drives in action

#### ABB variable speed drive increases output and performance of SAG mill

Agnico-Eagle's LaRonde mine in Canada produces about 260,000 ounces (7370 kg) of gold annually. In order to run the motor and the SAG mill at the required load output the existing drive was replaced with a medium voltage drive from ABB. The replacement enabled Agnico-Eagle to expand the milling facility, increasing its output, and to achieve the expected performance and stability.

The replacement resulted in the following benefits:

- Reliable operation
- Reduced maintenance costs
- Improved process control
- Longer lifetime of equipment



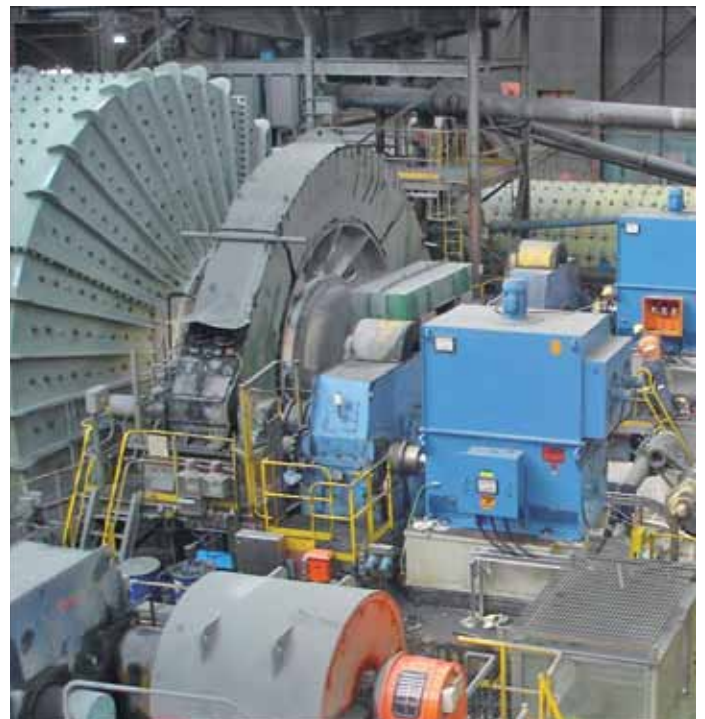
### Drives in action

#### ABB variable speed drives reduce energy consumption and operating costs at Australian mill

Grange Resources Limited operates two dual pinion autogenous mills at its Savage River mine in Tasmania. Variable speed drive systems have replaced four slipring motors and their variable resistance liquid starters, bringing significant energy savings and reduced operating costs.

The replacement resulted in the following benefits:

- Energy savings per month: A\$15,540 (US\$16,881)
- Reduction of maintenance requirements
- Optimized plant production
- Smooth start of the mills
- Improved power factor



# Applications

## Conveyors

Conveyors are used in various mining processes. The environment is demanding and there is always a risk of damaging the belt by overstretching, slipping or breaking. To reduce operational costs, it is important to extend the belt lifetime and availability.

### Extended lifetime and increased availability

VSDs provide accurate torque and speed control of conveyors. This reduces the stress on mechanical equipment such as gearboxes, pulley and belts, especially during start-up and stopping, but also during operation and maintenance.

With the use of VSDs it is possible to control the speed of the conveyors to match the production capacity and as such reduce wear and save energy. For maintenance inspection, belt changes, repairs or avoidance of ice build-up it is possible to run the conveyor belt at low speed.

### Accurate and fast load sharing

ABB medium voltage drives provide an accurate and fast load sharing between several drives. This is useful for conveyor applications, where two or more motors operate on the same conveyor belt, making sure all motors are loaded as needed. The converter control provides a window speed limitation to prevent belt slippage.

### Power factor compensation

With ABB medium voltage drives the power factor is greater than 0.95. There is no need for additional power factor compensation and there are less losses on the electrical network. Also, the electrical network is not exposed to high inrush currents when the conveyor is started.

### Regenerative braking of downhill conveyors saves energy

To minimize conveyor wear, downhill conveyors require continuous braking. This varies depending on the amount of raw material transported. VSDs provide the precise speed and torque control to meet the braking demand.

With regenerative VSDs, the braking energy can be fed back into the plant's electrical network, thereby not only saving, but also generating energy.





### Drives in action

#### ABB variable speed drive improves process control at mining plant

An ABB medium voltage drive was retrofitted to a conveyor belt at the Mine Los Colorados in Chile. With the existing gearbox, the nominal motor speed was not high enough in order to reach the nominal throughput of the conveyor belt. The ABB drive was installed to soft start the motor allowing a smooth ramp up. The existing gearbox did not need to be replaced and the speed could be increased by almost 25 percent.

The installation of the VSD resulted in the following benefits:

- Improved process control
- Elimination of motor problems
- Longer lifetime of conveyor equipment
- Minimized downtime
- Lower impact on electrical network



### Drives in action

#### ABB variable speed drives reduce downtime and increase conveying capacity of bauxite mine

Bauxite from Worsley Alumina's mine in Western Australia, is transported to a refinery 51 km away by a conveyor. This conveyor was originally driven by DC drives, which did not deliver the required levels of reliability, thus leading to high maintenance. The fundamental problem was that DC technology was underpowered for the requirements of the expansion designed to increase the refinery's capacity.

The replacement resulted in the following benefits:

- Increased conveying capacity
- Improved conveyor control
- Improved start/stop performance
- Reduced maintenance
- Increased availability



# Applications

## Mine hoists





The uninterrupted operation of a mine hoist is most important to safety and production. It provides access to the mine, allows the movement of miners and material and serves as evacuation route in case of emergencies.

#### Safe and reliable operation

Controlling mine hoists with electric variable speed drives provides safe and reliable operation.

#### Greater equipment control

VSDs enable soft starting and stopping of the equipment and a smooth and fast acceleration and deceleration. This allows for greater equipment control and avoids motors heating up.

#### Remote monitoring and diagnostics

Monitoring mine hoist equipment allows operators and maintenance personnel to schedule preventive maintenance tasks, thus increasing the safety and reliability of the operations. ABB's medium voltage variable speed drives can be equipped with an intelligent remote monitoring and diagnostics system which delivers important information on equipment status and possible maintenance tasks needed.

#### Half speed, full load redundancy

ABB's mine hoist variable speed drives can be designed with redundancy to allow for continued hoist operation at half-speed and under full-load if required by the process. This function ensures the safety of the hoist system, continued production and reduces maintenance time and cost.

#### Lower energy consumption

ABB offers VSDs with an active front end (AFE), also referred to as active rectifier unit (ARU), which allows regenerative braking. Braking energy is fed back into the plant electrical network, lowering the energy consumption.



# ABB medium voltage drives

The heart of a medium voltage drive system is the frequency converter. ABB offers a complete portfolio of frequency converters for medium voltage applications in the power range from 250 kW to more than 100 MW.

## **ACS 1000 (315 kW – 5 MW, up to 4.16 kV)**

The ACS 1000 is suitable for retrofit applications and new standard induction motors. Due to its unique output sine filter, bearing currents and voltage reflections at the motor are eliminated. The ACS 1000 is available with an integrated transformer or for connection to an external transformer.

## **ACS 2000 (250 kW – 2.6 MW, 4.0 – 6.9 kV)**

The ACS 2000 is suitable for retrofit applications and new standard induction motors. It can be used without an input isolation transformer, thereby allowing a direct connection to the line supply (direct-to-line), with an integrated transformer, or for connection to an external input isolation transformer. The ACS 2000 is also available for four-quadrant operation for energy regeneration and reactive power compensation.

## **ACS 5000 (2 – 32 MW, 6.0 – 6.9 kV)**

The ACS 5000 can be applied to standard industrial motors (induction, synchronous and permanent magnet). It is available with an integrated transformer or for connection to an external transformer.

## **ACS 6000 (3 – 27 MW, up to 3.3 kV)**

ABB's ACS 6000 is a modular high-performance drive designed for single or multi-motor applications for synchronous, permanent magnet and induction motors. It can be equipped with an Active Front End which enables four-quadrant operation for energy regeneration and reactive power compensation.

## **MEGADrive-LCI (2 – 100 MW)**

ABB's MEGADrive-LCI is an optimal solution for high voltage and high power applications. Standard designs are available for ratings up to 72 MW; engineered designs for more than 100 MW. The MEGADrive-LCI is available as a variable speed drive or soft starter.

## **Mining solutions**

ABB offers special variable speed drives for mining applications. They meet the most stringent mining standards. Special solutions for underground mining applications, such as underground mining conveyors and armored face conveyors have been developed. These low-height VSDs, designed for explosion-proof cabinets, are an ideal solution for the harsh environment and limitations in underground mines.





# Technology highlights

Reliability and safety are the main guiding principles of ABB's research and development activities for medium voltage drives.

## Arc fault protection

Electric arcs can cause catastrophic damage. For systems where large arc faults can occur, special attention is required. Therefore, ABB's high-power medium voltage drives are IAC classified. It assures very fast arc detection and elimination to protect people and equipment and eliminate unnecessary production stops.

## Emergency off / emergency stop

ABB medium voltage drives are equipped with emergency off and emergency stop functionality. SIL (safety integrity level) 3 certification can be provided.

## Remote monitoring and diagnostics

DriveMonitor™ allows secure real-time access to the drive. It supports monitoring and diagnostics of ABB drives independent of the implemented control method, thus enabling the connection of existing installations.

The optional DriveMonitor™ consists of a hardware module, as well as a software layer that automatically collects and analyzes selected drive signals and parameters. Long-term monitoring functions deliver important information on equipment status, tasks needed and possible performance improvements. Diagnostic procedures and trending can cover not only the converter itself but other parts of the drive system as well.

## Direct Torque Control (DTC)

ABB's drive control platform is based on the award-winning Direct Torque Control (DTC), resulting in the highest torque and speed performance, as well as lowest losses ever achieved in medium voltage drives. Control of the drive is immediate and smooth under all conditions.

## Low parts count

The fewer the parts the higher the reliability. ABB uses high power semiconductor switching devices and a topology that minimizes the parts count.



# Motors and transformers

A variable speed drive system includes a medium voltage frequency converter, motor and transformer.

ABB offers the complete variable speed drive system or can assist in selecting components that match the process requirements. ABB's equipment is known for its state-of-the-art technology, high efficiency, reliability and worldwide support.

## Converter motors

ABB's converter motors have earned an excellent reputation for performance and reliability. ABB's product range includes induction as well as synchronous motors.

Induction motors are the workhorses of industry due to their versatility, reliability and simplicity. In the power range up to 10 MW, a squirrel cage induction motor is usually the first choice. They are available up to 25 MW.

Synchronous motors are typically considered for higher power ratings (eg above 8 MW to more than 100 MW). In addition to their high power capabilities, synchronous motors offer the benefits of high efficiency and high performance through the utilization of different rotor designs. ABB also offers permanent magnet motors for low-speed and high-speed applications.

## Converter transformers

Converter transformers are especially designed for operation with VSDs. They adapt the converter to the supply network and provide a galvanic isolation between drive and supply network.

Converter transformers are available for practically all ratings. Secondary voltages are optimized to match the converter and motor voltage. Oil or dry types for indoor or outdoor mounting are available. Busbar connections can also be provided.





# Testing, service and support

ABB drives are backed by comprehensive service and support, from the customer's initial inquiry throughout the entire life cycle of the drive system.

## Testing

ABB is committed to ensuring the reliability of every drive it delivers. To verify that quality standards and customer requirements are fully met, every component of a drive is subjected to thorough testing in ABB's modern test facilities.

Routine tests and functional tests form an integral part of the scope of supply of ABB's medium voltage drives. They are performed in accordance with international standards and ABB quality assurance procedures.

Additionally, ABB can perform a combined test with the complete drive system – including transformer, converter and motor – to verify the performance and to ensure a smooth integration into the customer's facility.

## Installation and commissioning

Proper installation and commissioning of the equipment, done by qualified and certified commissioning engineers, reduces start-up time, increases safety and reliability and decreases life-cycle costs.

## Life-cycle management

ABB's drive life-cycle management model maximizes the value of the equipment and maintenance investment by maintaining high availability, eliminating unplanned repair costs and extending the lifetime of the drive.

Life-cycle management includes:

- Providing spare parts and expertise throughout the life cycle
- Providing efficient product support and maintenance for improved reliability
- Adding functionality to the initial product
- Providing a smooth transition to a new technology at the end of the life cycle

## Training

ABB provides extensive training for its medium voltage drives. A range of training programs is offered from basic tutorials to programs tailored to the customer's specific needs. In addition, experienced specialists can give practical training to personnel at site.

## Global network, local presence

After sales service is an integral part of providing the customer with a reliable and efficient drive system. The ABB Group of companies operates in more than 100 countries and has a worldwide network of service operations.



## Services for ABB's medium voltage drives

- Installation and commissioning
- Training
- Remote services
- Preventive maintenance
- Customized service agreements
- Local support
- 24 x 365 technical support
- Spare parts and logistics network
- Worldwide service network

# Contact us

For more information contact your  
local ABB representative or visit:

**[www.abb.com/drives](http://www.abb.com/drives)**