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Mining Electrification: Potential and Benefits

The mining industry is a significant consumer of electricity. The industry ranks third among U.S. industrial sectors in electricity demand, topped only by the chemical and forest product industries, according to the U.S. Dept. of Energy.[1]

Electricity is used to power much of the machinery operating in mines around the world. For example, longwall and continuous mining operations in underground mines rely on electricity supplied from above ground or from underground electrical substations. In surface mines, some of the largest draglines and drills are also electrically powered. Many mining operations, however, still rely on diesel powered heavy equipment, and could benefit from replacing the diesel equipment with electric drive equivalents. Electric drives are consistently more cost-effective, reliable, operationally efficient, and environmentally superior. They also enhance worker health and safety.

Benefits of Electric Mining Equipment

- Cost-Effective
  - Electricity is less expensive than diesel per unit of energy delivered
  - Electric motors are inherently simpler when compared to complex engines with thousands of moving parts, and require fewer parts and less maintenance
  - Savings from reduced fuel, maintenance, and personnel expenses result in short payback time
- Enhanced Worker Safety and Comfort
  - Zero-emissions at the source ensure a safer, healthier workplace
  - Reduced noise is especially beneficial in confined settings
  - Reduced vibrations and heat generation enhance comfort for workers who ride or operate machinery
  - Electric equipment requires no fuel and little lubrication, reducing hazards associated with leaks
- Regulatory Compliance
  - Electric mining equipment helps ensure that operations meet varied state and federal requirements for emissions, worker safety, and health

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[1]Energy Use, Loss and Opportunities Analysis: U.S. Manufacturing and Mining. Energetics, Inc. and E3M, Inc., for U.S. Dept. of Energy, EERE, Industrial Technologies Program, 2004

Continental Overland Conveyor System

Electric Mining Equipment Options

The following section highlights opportunities for electrification of equipment in surface and underground mines.

Conveyance Systems

In many mining applications—both surface and underground—electrically powered conveyers can replace internal combustion vehicles that transport materials and perform a series of loading and unloading handoffs.

Factors that determine feasibility, cost, and payback of such systems include: distance or horizontal length of the conveyance system, vertical lift, maximum size of the lump material, composition,

In the Southeastern United States, electrically powered conveyance systems recently installed to replace diesel haulage trucks had a payback period of two years or shorter. In these mining applications, distances ranged from 900 yards to five miles. Harsh operating conditions demanded constant maintenance for the diesel haulage trucks. For example, the oversize and costly tires had to be replaced frequently. A significant portion of the savings associated with the conveyer installation came from eliminating truck maintenance and driver costs.

weight and moisture content of the material, internal or external operation, climate, elevation gain, and terrain. Most conveyance systems are custom-designed for each operation's need and circumstances, and can range from low-voltage 100-HP systems to medium-voltage 2000-HP systems. Electricity usage is calculated based on the demand horsepower for the application.

These vehicles are made with both electric and diesel drivetrains by a number of manufacturers, and can be operated by a driver, or by remote control, depending on application and design.

Shuttle Cars, Ram Cars, Haulage Systems

Whether the application is surface or underground mining, haulage vehicles that transport the mined material from its origin to a handoff point represent a significant component of the mining transport chain. These vehicles are made with both electric and diesel drivetrains by a number of manufacturers, and can be operated by a driver, or by remote control, depending on application and design. In many cases, heavy-duty diesel trucks, operating in harsh conditions that challenge the equipment's operation and result in significant maintenance costs, could be replaced with electric shuttle or haul cars that can do the same job more efficiently, less expensively and in a more environmentally beneficial manner.

Some manufacturers offer AC-powered electric drive systems, which significantly increase a vehicle's traction, improving its ability to climb gradients and drive through rough terrain. AC drive motors typically require less maintenance because they have no brushes to inspect and replace. Many also incorporate regenerative braking—just like the new on-road electric and hybrid vehicles. In mining applications, regenerative braking reduces maintenance, allows mechanical brakes to run cooler, and stabilizes vehicle speed when descending gradients.

One manufacturer's detached continuous haulage system is a combination vehicle and conveyor system that is equipped with 480/950-volt AC.

Draglines and Electric Shovels

Used in surface mining operations, draglines are huge machines with a scoop suspended from a crane and maneuvered by a series of ropes and chains. Among the largest mobile machines on earth, draglines remove dirt or "overburden" to expose coal or minerals below. They weigh as much as 14,000 tons and move—very slowly—by "walking" on footpads or rollers that are as long as a city bus. These machines can lift several hundred tons in a single scoop; their buckets can be as large as a four-car garage.

Joy Shuttle Car

Bucyrus 8750 Model Dragline with AC Drives

Unlike other diesel-fueled heavy construction and earth-moving equipment, most mining draglines are all-electric, powered by a trailing cable connected to a medium voltage DC source (6.6 to 22 kV) or land barge that serves as a step-down power source from the high voltage provided by the electric utility. In some cases, they receive their power from a nearby generator not connected to the grid. Power consumption is significant. For example, a walking dragline with a 220-cu-yd bucket, a 400-ft boom, machine mass of 14,000 tons, and connected AC load of 36,000 kW is in service in the United States.[2]

[2]SME Mining Engineering Handbook, Volume 2

P&H 4100XPC Electric Shovel

A. L. Lee Corporation 9RR-B Battery Powered Rail Runner

Use of electric equipment in open air operations is more cost-effective over the full lifecycle.

Electric mining shovels are smaller than walking draglines. Bucket capacities range from 10 cu yd to 100 cu yd. Power consumption of an electric loading shovel with 25-cu-yd dipper is approximately 900 kWh/hr in good conditions.[3]

The newest draglines and shovels utilize highly efficient brushless AC motors, which reduce energy consumption, operate at higher speeds, and require less maintenance and downtime. Use of electric equipment in open air operations is more cost-effective over the full lifecycle. It enhances worker comfort and safety, and reduces criteria and CO_2 emissions enabling improved compliance with worker safety and air quality regulations, respectively.

Rail Locomotives

Battery powered or trolley-style electric rail locomotives offer another electric alternative to diesel locomotives. At least one manufacturer offers rail locomotives designed with one or two electric motors, with the system powered by 300-volt or 600-volt DC trolley or 120-volt battery, or in combination.

Personnel Vehicles

Personnel vehicles, which transport miners and equipment from the surface of the mine to the underground working locations, come in battery-electric and internal combustion options, as well. These vehicles typically carry 4 to 12 passengers plus equipment, and achieve speeds of 6-12 mph. Battery options include 220-volt or 440-volt charging.

Forklifts and Custom Material Handling Equipment

Battery-powered forklifts are commonly chosen over internal combustion forklifts in interior warehouse and industrial settings. Operations managers have learned that the economic, environmental, ergonomic and safety benefits make electric the obvious choice over IC trucks for many applications. In recent years, electric outdoor forklifts, with pneumatic tires, sealed battery compartments

[3]Ibid.

A recent EPRI outdoor lift truck demonstration testing 6,000-lb capacity trucks operating in harsh New York winter and Alabama summer weather conditions, in demanding 24/7 operations showed that outdoor electric trucks perform work duties equally as well, or in some cases, better than internal combustion trucks. It also demonstrated that electric outdoor lift trucks operate as efficiently as their combustion counterparts, and greatly reduce fuel costs and emissions.

Doosan Electric Outdoor Forklift, 8,000 lb. Capacity

and higher payload capacities of 11,000-20,000 lbs., have been introduced to the market, and represent another potential fuel-switching opportunity for mining operations. Many of these trucks have higher and more efficient AC power systems.

Some mining equipment manufacturers produce custom material-handling equipment that resembles a forklift attachment to a shuttle or ram car.

Additional Resources

- Energy Information Agency
  www.eia.doe.gov
- National Mining Association (NMA)
  www.nma.org
- Minexpo International
  www.minexpo.com
- American Coal Foundation
  http://www.teachcoal.org
- Copper Development Institute
  www.copper.org
- Gold Institute
  www.goldinstitute.org
- Mineral Information Institute
  www.mii.org
- Silver Institute
  www.silverinstitute.org
- Society for Mining Metallurgy & Exploration (SME)
  www.smenet.org

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