Electricity in Mining
Using Electrons to Move the Earth

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Mike Butts, PE
Vice President – Engineering, Lands, Underground Operations
Electricity in Mining

It’s been said that:

“If can’t be grown, it must be mined”

and:

“Mining is the art and science of extracting minerals from the earth.”
To maintain our standard of living, each person in the United States uses over 20 tons of minerals each year:

- 12,428 lb. of stone
- 9,632 lb. of sand and gravel
- 940 lb. of cement
- 276 lb. of clays
- 400 lb. of salt
- 302 lb. phosphate rock
- 639 lb. of industrial minerals
- 425 lb. of iron ore
- 77 lb. of bauxite (aluminum)

- 17 lb. of copper
- 11 lb. of lead
- 10 lb. of zinc
- 6 lb. of manganese
- 29 lb. of other metals

Plus fuel minerals:

- 7,667 lb. petroleum
- 7,589 lb. coal
- 1/3 lb. uranium
## The Simple Math of “BTU Energy Cost Ratio”

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>BTU/lb/gal</th>
<th>Cost/gal</th>
<th>Cost/MMbtu</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diesel Fuel</td>
<td>142,000</td>
<td>$3.50</td>
<td>$24.65</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>1000</td>
<td>$2.50</td>
<td>$2.50</td>
</tr>
<tr>
<td>Coal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Powder River Basin</td>
<td>8800</td>
<td>$35</td>
<td>$1.99</td>
</tr>
<tr>
<td>Central Appalachia</td>
<td>12000</td>
<td>$70</td>
<td>$2.92</td>
</tr>
<tr>
<td>Northern Appalachia</td>
<td>13000</td>
<td>$65</td>
<td>$2.50</td>
</tr>
<tr>
<td>Illinois Basin</td>
<td>11500</td>
<td>$55</td>
<td>$2.39</td>
</tr>
</tbody>
</table>

**Simple Average of Coal and NG**

\[ \text{SIMPLE AVERAGE} = \frac{1.99 + 2.50 + 2.92 + 2.50 + 2.39}{5} = 2.46 \]

**CURRENT “BTU ENERGY COST RATIO” IS 10:1**

When DF per gallon costs the same as NG per mcf, the “Energy Cost Ratio” is 7:1
Electricity in Mining

• By nature, mining operations are heavy users of energy...
  – The source of the energy to power the equipment and systems at a mining operation is driven by economics, availability, flexibility, and infrastructure

• Mining Methods for all minerals can first be classified into either Underground or Surface mining methods… with many variations of each.
  – Typically, underground mining methods involve more electrical equipment than surface mining methods.
Typical Coal Mining Methods

Also applicable to other deposits such as trona, salt, gypsum, potash, etc.
Typical “Hard Rock” or Mineral Ore Mining Methods

Copper, gold, iron ore, Aggregates, etc.
Typical Underground Longwall Mine

Portal Facilities
Exhaust Fan

Longwall Mining Section
Shield
Pan Conveyor

Section Conveyor Belt
Continuous Mining Section
Continuous Miner

Shuttle Car
Section Fan

Preparation Plant
Slope Belt

Portion of Mine Map
Continuous Miner
995v or 2300v systems
Electric Shuttle Car
600v or 995v systems
Roof Bolters

Roof bolters typically run on 550v systems
Longwall Operations
Typical Longwall Shearer
Longwall systems typically use 4160v to 12,000v systems with loads of 5-10mw
Using Electricity in Surface Mining

• Surface Mining has historically been more dependent on mobile diesel powered equipment...

• But there are several applications for electrical equipment powered from the Grid:
  – Conveyors
  – Draglines
  – Shovels
  – Haul Trucks
Conveyors are not only used in Underground mining...

Overland Conveyor Belts are used throughout the World to transport mined materials
In this Arizona Copper Mine conveyors are used for a significant amount of the “vertical lift” of the ore from the open pit mine.
In-Mine Conveyor Belts Replace Diesel Powered Haulage

Installation of permanent in-mine conveyors require long-term mine planning and significant investment in infrastructure.
In-mine Conveyors in Open Pit Mining
Here dozers feed in-pit crushers that dump onto conveyors
Drummond developed this system for mine in Colombia. Crushers dump onto in-pit moveable conveyors.
In-pit conveyors headed out of the mine
In-pit conveyors transfer to overland belts
Overland belts going to the external overburden disposal areas
Overburden is disposed in excess spoil piles by mobile conveyor spreader
Drummond Operates 3 draglines in Colombia, SA.

The draglines at our Colombian mine are powered by an on-site Natural Gas generating plant.
Dedicated Natural Gas Power Plant at Mine in Colombia
Total plant capacity 160mw

Power Plant has 3 LM6000 and 1 LM2500 NG turbine generators with Diesel Fuel peaking capacity and back-up
Mine Site 110kv transmission system in Colombia

Supplies power to conveyor systems, 3 draglines, 12 electric shovels, and all mine facilities
Draglines are a significant use of electricity in surface mining. This 78 yd³ dragline will cycle from +14mw to -6mw and will use approximately 2.3 million kwh per month.
This Dragline is currently being rebuilt to return to service in Alabama
The Shannon Mine was acquired in January 2011.

From 2011 to 2014 production is projected to increase +50%.

Current primary earthmoving equipment consists of 10 diesel powered backhoes.

By 2014 primary earthmoving equipment will consist of 1 electric rope shovel, 3 electric hydraulic shovels, and 1 electric dragline.
Electric Rope Shovel

34 yd³ shovel loading 150 ton trucks
Currently operating at Shannon mine near Bessemer, Alabama
Electric Hydraulic Shovel
55 yd³ shovel loading 240 ton trucks
Electrical load 2.3mw and approximately 1.3 million kwh per month

3 of these shovels are planned for Shannon Mine
Electric Rope Shovel
75 yd³ shovel loading 240 ton trucks in Colombia
Diesel Electric Haul Trucks
Available in sizes from 150 ton to 400 ton capacity

The largest diesel electric mining truck currently in production, the Liebherr T 282 B
Anatomy of a Diesel Electric Haul Truck
Originally DC but moving to mostly AC drives
240 ton Diesel Electric Haul Truck
But it still uses Diesel Fuel
Trolley assist can replace Diesel Fuel with Grid Electric Power

Trolleys can supply power to trucks when climbing long steep grades to replace more than 50% of diesel fuel.

As the DF vs Grid power costs widen, systems like this become more attractive to large mine operators in spite of infrastructure costs.
3 Take-Aways

• The Use of Electricity in Mining is motivated by equipment size and the replacement of high cost Diesel Fuel and the resulting cost savings.

• Confidence that the cost of Electricity will remain low compared to Diesel Fuel is needed to justify the investment in mine site electrical infrastructure.

• Installation of Electrical Equipment at mines requires incorporation into long term mining plans due to reduced operational flexibilities.
As you see... We’ve come a long way in how we recover the resources that make our way of life possible.

Thanks for listening...

?Questions?