UNDERGROUND COAL MINING: FACTORS, COST, AND TIME CONSIDERATIONS

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Antidote to Boring Presentations

Synergy strategic fit core competencies best practice bottom line Revisit **Expeditious** to tell you the truth (or "the truth is") 24/7out of the loop Benchmark value-added **Proactive** win-win think outside the box fast track result-driven empower (or empowerment) knowledge base at the end of the day touch base Mindset client focus(ed) Paradigm game plan leverage





Introduction

This presentation explores the recent history and current trend of underground coal mining methods and production, planning and timing, and capital and operating cost considerations.





Presentation Content

- Historic and Current Underground Coal Production
- Description of Underground Mining Methods
- Means of Accessing Underground Coal Reserves
- Development Activities for a Mining Operation
- Development Scheduling
- Capital and Operating Cost Considerations





United States Coal Producing States





2003 Coal (and lignite) Production Statistics (source: EIA and MSHA)

- 33% of all Coal Production in the U.S. is from Underground Mines
- 63% of all Coal Produced East of the Mississippi is from Underground Mines
 - In all states east of the Mississippi, except Indiana and Tennessee, the majority of coal production comes from underground mining activities
- 9% of all Coal Produced West of the Mississippi is from Underground Mines
 - Arkansas (13%), Colorado (76%), Kansas (100%), Montana (<1%), New Mexico (22%), Oklahoma (25%), and Utah (100%) produce from underground mines.





Historically.....

• Until the early 1970's, the majority of coal production in the U.S. was via underground mining methods.

Voor	UG Production	Percentage	Surface
rear	(mm)	Underground	Production (mm)
1930	448	96%	20
1940	418	91%	43
1950	393	76%	123
1960	285	69%	131
1970	339	56%	264
1980	336	41%	487
(Source: Dona	rtmont of Enorgy)	110000	ALL CONTRACTOR

Advancements in technology (primarily hydraulics and explosives) and expansion of mining activities in the west (particularly in the PRB), have shifted mining trends from underground to surface production over the past 40 years.





Looking at the past and present..

Number of Surface versus Underground Coal Mines

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Mine Type	No. of Mines	% of Total	Production (millions tons)	% of Total
Surface	3,176	54%	398	63%
Underground	2,692	46%	229	37%
Total	5,868	100%	627	100%
The second se	XELA	2004		
Mine Type	No. of Mines	% of Total	Production	% of Total
Surface	770	55%	738	67%
Underground	642	45%	367	33%
Total	1,412	100%	1,105	100%
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(Source: Department of Energy



By what means is underground coal being produced?

Year	Longwall Production	Total Underground Production	Longwall Production %
1983	79.6	298.3	26.7
1993	103.7	350.4	31.3
2003	183.5	352.8	52.0

(Source: EIA)

- Longwall production peaked in 1998 at nearly 200mm tons
- Longwall systems declined between 1996 and 2005 currently 50 systems operating
 - Likely reasons for decline
 - limited flexibility
 - large capital outlay/lack of customer commitment
 - regulatory issues





2004 Top 10 producing underground mines in the U.S. - all longwall operations

Mine

Enlow Fork (Consol) Bailey (Consol) Foidel Creek/Twentymile (Peabody) **McElroy** (Consol) San Juan South (BHP) Sufco/Canyon Fuel (Arch) West Elk (Mountain Coal) **Robinson Run (Consol) Century** (Murray) **Emerald** (Foundation) (source: NMA)





State

PA

PA

CO

WV

NM

UT

CO

WV

IL

PA



"Today's underground mines are high tech coal production factories -they ain't your grandpa's dog hole no more!"





Underground Mining Methods

Two primary methods employed

 Room and Pillar
 Longwall





Definition of Room and Pillar Mining

- A system of extracting coal by driving a series of openings referred to as entries
- Entries are connected to each other by driving cuts commonly referred to as cross-cuts
- Remaining coal "blocks", referred to as pillars, support the overlying strata
- Size of entries and cross-cuts vary from mine to mine
 - determined by size of equipment employed
 - thickness of overburden
 - coal seam thickness
 - ground control
 - surface protection requirements
- Entry and cross-cut widths generally range from 15 to 25 feet
- Pillar sizes will generally range from 30 to 100 feet and have a rectangular configuration
- Extraction Ratio is the ratio of coal removed compared to estimated inplace tonnage
 - normal extraction ratio is from 35 to 55%
 - retreat mining will result in extraction ratios of up to 70%





Primary Mining Equipment - Single Section

- Continuous Miner one unit
- Face Haulage two / three units
 - shuttle car
 - coal hauler
 - coal scoop(s)
- Roof Bolter (single or multiple head) one unit
- Coal Scoop
- Belt Conveyor
- Ancillary Equipment





Variations to "Conventional" Room and Pillar Operations

- Supersection/Double Section
 - two continuous miners operating at any given time in the same panel
 - increased infrastructure requirements
 - ventilation
 - roof support
 - labor
 - material handling systems
 - production is nearly doubled
 - infrastructure costs are less than that of a two section conventional room and pillar mine
- Synchronized Section
 - two continuous miners operating in the same panel but only one operating at a time
 - increased availability of approximately 1.5 to 1.75 of a single miner
 - increase in infrastructure off-set by higher production





Schematic of Room and Pillar Mine













Definition of Longwall Mining

- A high extraction method of mining along the face of a predefined block of coal, referred to as a panel, while allowing the immediate roof to collapse upon advancement
- Panel Configuration
 - Panels generally range in size from 500 to 1,000 feet in width and lengths exceeding two miles
 - In the US, longwall mines are operating in coal seams ranging from 5 to 15 feet in thickness
 - Gateroads are developed by driving two sets of room of pillar entries along the length of the proposed panel
 - entries can be from 2 to 5 headings
 - entries are defined as headgate and tailgate
 - entries are developed to contain necessary infrastructure and to provide a transportation corridor along the face
 - headgate for one panel becomes tailgate for subsequent panel
- Development of headgate and tailgate and connection of each to the other is completed prior to installation of the longwall extraction equipment





Primary Mining Equipment

- Cutting Machine
 - single drum shearer
 - double drum shearer
 - plow
- Hydraulic Shields (roof supports)
- Armored Face Conveyor (AFC)
- Stage Loader
- Main Haulage





Extraction Procedures

- Cutting machine moves parallel to the extraction face
- Coal is "cut" and falls into the AFC which transports the product from the face
- Following successive "passes" of the cutting machine, hydraulic roof supports more forward
 - roof is supported above extraction equipment (cutting machine and AFC)
 - roof collapses behind shields
- Upon completion of the panel, the equipment is moved to the next defined panel
- Continuous miners work in harmony with the longwall equipment to complete the development activities





Schematic of Longwall Mine













Key Physical Features in the Selection of an Underground Mining Method

- Coal seam thickness
- Overburden depth
- Overburden characteristics
- Reserve configuration
- Geologic features
- Surface features
- Obstacles
- Previous mining activities





Other Factors in the Selection of an Underground Mining Method

- Regulations
- Need for mobility and flexibility
- Capital Commitment





Types of Mine Openings

- Underground mines are at times defined by its type of opening
 - Drift
 - Slope
 - Shaft





Mine Opening Development Requirements



- may or may not require excavation
- face-up requirements
- near horizontal entry
- Slopes



- inclined opening
 - 10 to 18 degrees
- overburden tunneling required
 - drill and shoot
 - rock miner
 - tunnel borer





Mine Opening Development Requirements

(cont'd)



- sometimes referred to as vertical slopes
 - excavation and removal of overburden to predetermined diameters
 - drill and shoot
 - blind hole
 - raise boring
 - lined walls

Shafts

- various applications
 - man-way / escape-way
 - coal transportation
 - material and supply
 - air





Factors for Consideration in Selection of Mine Opening

- Capital
- Coal depth/accessibility
- Coal thickness/equipment selection
- Geology
- Surface/space considerations





The general public knows that when they need electricity, they "simply" flip a switch and it's there. The electric utility industry realizes the years of planning, construction, and maintenance of power generating facilities and infrastructure to get these results when that switch is flipped. The same levels of investigation and planning, engineering, and capital commitments along with various other activities must take place to bring a coal mine into production!

It's not just a "flip of the switch"!





Each activity/investigation undertaken in assessing a mineral property as a commercially viable mining venture serves as a decision point. The findings of any single investigation may result in a nogo decision!





The approach taken to evaluate a mineral property can vary based on the criteria and policy of any specific organization. The following presents a "canned" approach for consideration.





- Identification of a Resource Area
- Obtaining rights to explore
- Exploration
 - primary purpose is to define and/or confirm coal seam presence; coal and overburden characteristics; and presence, quality, and quantity of water to be encountered
 - various means and phases of exploration activities
 - completed under the supervision of a professional geologist
 - permits are required sometimes bonding





• Sample collection and analysis

- define properties of coal seam(s) and related overburden
 - full suite of chemical and physical analysis
 - mineral and trace element analysis of ash
- coal washability tests
- Development of Geologic Model
 - quantity
 - quality

Securing Surface and Mineral Options

- surface needed for development of infrastructure to support mining operation
- mineral rights adequate to support capital investment
- potentially a long term commitment initiated long before coal production





Environmental Investigations

- general
 - defining constraint areas/determining environmental limitations
 - determining the applicability of mitigation
 - identifying future permitting obligations/requirements
 - additional sampling and testing
- identification of environmentally sensitive areas
 - protected surface structures
 - federally designated wild and scenic river systems
 - state and national parks, recreation, and wilderness areas
 - streams and wetlands
 - public/private water supplies
 - other areas designated by local, state, and federal agencies





- Conceptual/Preliminary Mine, Surface Facilities, and Transportation Planning
 - Application of physical characteristics
 - Production requirements
 - Mine life projections
 - Identification of preferred mining method
 - equipment requirements
 - mine orientation
 - Type and location of openings
 - Mine design characteristics
 - number of main and panel entries
 - size and number of production panels
 - determination of most efficient and economical design
 - Ventilation requirements
 - Material handling requirements





- Conceptual/Preliminary Mine, Surface Facilities, and Transportation Planning (cont'd)
 - Surface facility requirements and layout
 - Preliminary economic analysis
 - Market assessment and sales potential
 - coal quality
 - mine location relative to potential markets
 - market demand
 - transportation infrastructure
 - government regulations
 - Transportation options
 - railways
 - waterways
 - roadways
 - overland conveyors



Investigating and planning will likely identify the need for additional investigating and planning. Such is logical and appropriate in a phased approach to determining the viability of a mineral resource as a commercial entity. It's merely a factor of time and money!





Permitting

Confusing

- Annoying
- Frustrating
 Ever-changing
- Unreasonable
 Costly
- Time Consuming Necessary!





Permitting

- Need to identify permits to be acquired
 - exploration
 - mining
 - water discharge (NPDES)
 - air
 - highway occupancy
 - coal waste dam and impoundment (MSHA)
 - other federal, state, and local
 - ACOE
 - US Fish and Wildlife
 - state EPA
 - state wildlife
 - cultural resources
 - zoning





Permitting (cont'd)

- Need to adequately schedule permit acquisition
 - research
 - data collection/background
 - engineering
 - planning
 - paperwork/forms
 - regulatory interface pre-ap meeting
 - submission
 - review and comments
 - revisions
 - resubmission
 - approvals maybe!





Equipment Needs/Lead Times

- Preliminary Equipment List Developed During Conceptual Planning Phase
- Development of Refined Equipment List
- Preliminary Vendor Selections
- Vendor Discussions
 - pricing
 - availability of equipment consistent with mine plan
 - establish order lead time requirements which may be impacted by
 - current market conditions demand
 - national and international economic conditions
 - logistics getting from the manufacturer to the buyer
 - manufacturer's labor availability
 - the availability of raw materials and supplies
- Final Vendor Selection and Contracting





Construction

- Identification of Construction Activities/Development of Master Construction Plan
 - surface
 - underground
- Develop Individual Component Designs, Plans, Specifications
 - internal
 - consultants
- Development of Schedules and Budgets
 - this is a very dynamic function in today's climate giving to shortages in labor and supplies and volatile material costs





Construction (cont'd)

Construction Assignments

- developer
- contractor
 - identification of qualified contractors
 - preparation of bid documents
 - invitation of bidders
 - bid review
 - bid award
 - contract negotiations

Construction Monitoring

- developer
- contractor
- Budget and Schedule Management
 - demands effective across-the-line communications





Time Line

- Exploration 6 months to 2 years
- Property Acquisition up to 10 years and beyond
- Environmental Investigations 3 to 12 months
- Conceptual Planning 6 months to 2 years
- Permit Preparation and Approval 18 months to 3 years
- Facility Construction 1 to 2 years
- Ramp-up to Full Production 6 months to 2 years





Time Line

It is conceivable that from the identification of a coal resource to development of the same, 10 years could pass. It is also conceivable that a know coal reserve could be brought into full production within 2 to 3 years from a decision to develop the site.





Capital and Operating Cost Considerations

Projected profitability of a mining venture must insure the investors that the desired return on the investment at the projected risk is agreeable to justify the required capital!





Capital and Operating Cost Considerations

Every mining operation, regardless of location, size, mining type, or conditions, will reflect different economics due to both controllable and non-controllable elements.





Capital and Operating Cost Considerations

Case Scenario 1 -Case Scenario 2 -Underground LongwallUnderground Room andOperationPillar Operation

Annual Production	6.5 mmtpy	4.0 mmtpy
Coal Preparation	None	None
Mine Entry	Slope from Strip Pit	Slope / Shaft
Mine Life	20 Years	20 Years
Total Planned Production	130 mm tons	80 mm tons





Economics/Cost Considerations (cont'd)

	Case Scenario 1 –	Case Scenario 2 –
and the second	Underground Longwall Operation	Underground Room and Pillar Operation
Initial Capital	\$140 mm.	\$77 mm
Replacement Capital	\$370 mm	\$140 mm
Total Capital/ Total Ton	\$3.92	\$2.71
Average Operating (Cash) Cost/Ton	\$8.00	\$12.75





Summary Comments

- Underground coal mining has a long, long tradition in the United States.
- The majority of coal producing states in the U.S. produce from underground mining methods.
- Technology over the past 25 years has made underground mining highly productive.
- Underground mining has evolved into two primary mining methods, room and pillar and longwall.
- Various site features may dictate the type of underground mining operation planned. Regulations and capitalization can also impact the decision.





Summary Comments (cont'd)

- Over 45 percent of US production comes from underground coal mines. This percentage is heavily skewed by the surface mining production originating in Wyoming.
- Current underground coal production from room and pillar mines and longwall mines is early equal.
- Longwall mines represent the 10 largest producing underground mines in the U.S.
- Longwall mining operations are more capital intensive that room and pillar operations; generally realize lower operating costs, and have a higher rate of production.
- Planning and start-up of an underground mining operation will likely take a long lead time.





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