Appalachia Coal Mining-to Marketing Training

September 24, 2015

NETL Pittsburgh, PA

Driving Innovation ♦ Delivering Results

U.S. Coal Mining Methods Deployed in the United States

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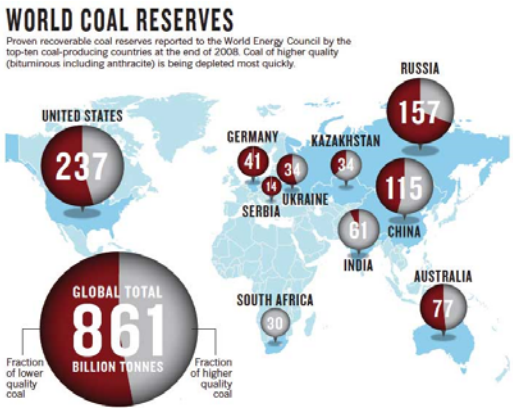
National Energy Technology Laboratory

Presentation Outline

- **Statistics**
- **Coal Characteristics**
- **Coal Mining Methods**
  - Underground Mining
  - Surface Mining
- **Coal Preparation**
- **Environmental**
  - Reclamation

Statistics – World Coal Reserves

- **U.S. has the highest coal recoverable reserve**
  - 237 billion tons
  - Enough for mining 200 - 300 years
  - Only the good seams are mined currently
- **China has the third largest reserve**
  - 115 billion short tons
  - 50 more years



Statistics – World Coal Production

- **China: No. 1 coal producer**
  - 2002: 1,380 million tons
  - 2004: 1,950 million tons
  - 2013: 3,561 million tons
- **U.S.: No. 2 coal producer**
  - 2002: 998 million tons
  - 2013: 904 million tons
- **India: No. 3 coal Producer**
  - 2002: 356 million tons
  - 2013: 613 million tons

Top 10 Coal Producing Countries

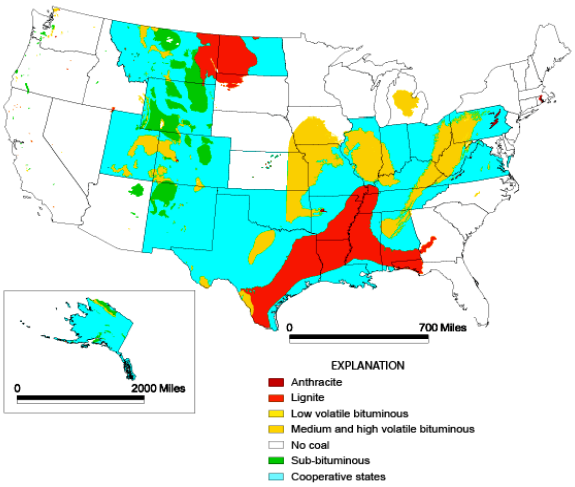
PR China	3561Mt	Russia	347Mt
USA	904Mt	South Africa	256Mt
India	613Mt	Germany	191Mt
Indonesia	489Mt	Poland	143Mt
Australia	459Mt	Kazakhstan	120Mt

World Coal Association

Statistics – U.S. Coal Fields

Average Heat Value

- Anthracite
  12,700 BTU/lb
- Bituminous
  13,100 BTU/lb
- Sub-bituminous
  9,500 BTU/lb
- Lignite
  6,700 BTU/lb



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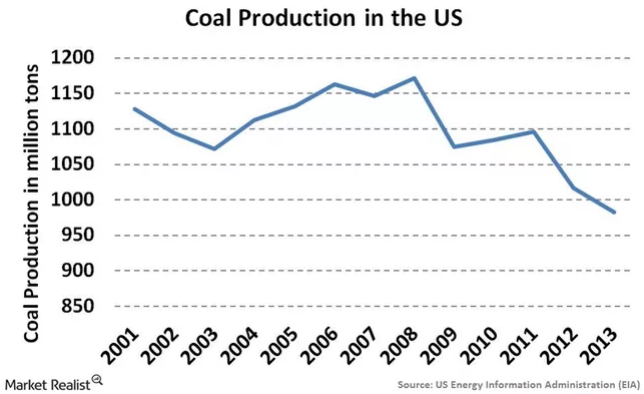
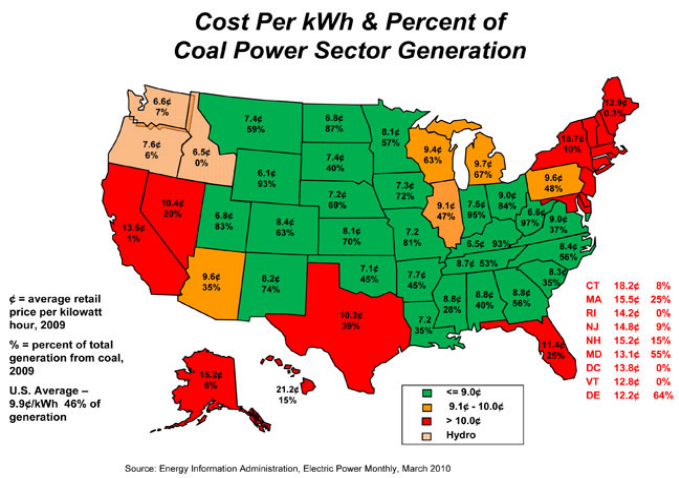
Coal Production in the U.S.



Coal Power Sector Generation



Source: Energy Information Administration, Electric Power Monthly, March 2010

Some General Facts

Coal Mining Methods
(2013 by Annual Production)

Surface Mining		67%
Underground Mining		33%
	Longwall mining	50%
	Continuous mining	45%
	Conventional mining	4.5%
	Others	0.5%

Source: energy information administration (EIA)

Coal Mining Industry

- **Main features of U.S. mines**
  - No or very few non-production personnel at mine level (e.g., about 300 employees at Cumberland Mine producing 6.5 million tons clean coal/year)
  - Mine life varies from several years to 30 years depending on the reserves and market forces
  - Mine size varies from several thousand tons to 111 million tpy
  - Common design tasks handled at corporate level
  - Contractors are heavily used for special or difficult tasks

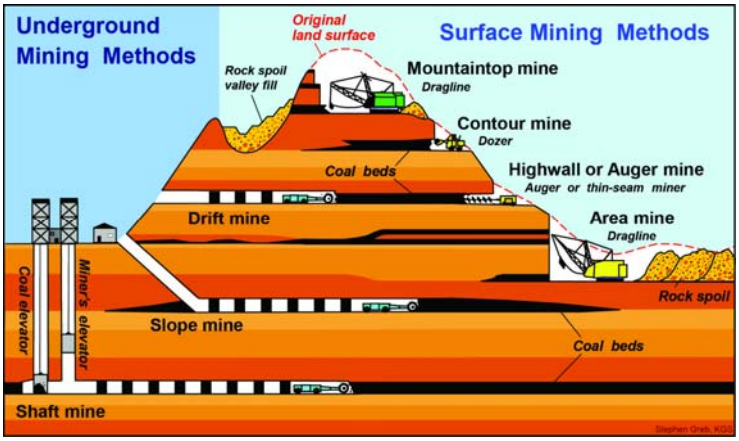
Coal Mining Industry

- **Main challenges of the U.S. Coal Industry**
  - Mine Safety is first priority
  - Ground control problems
    - Roof falls, cutter roof, floor heaving
    - Entry stability in deep mines (>500 m)
    - Surface subsidence, especially in the east, mid west
    - Longwall tail entry support
  - Environment limitations
    - Air and water pollution
    - Permitting issues
    - Environment groups
  - Depletion of good coal and good geologic conditions
  - Competition from gas industry
  - Longwall mine production limited by ventilation capability

Safety is Important Phase of Mining Methods

Raspadskaya Mine, Russia March 2010 – 66 killed

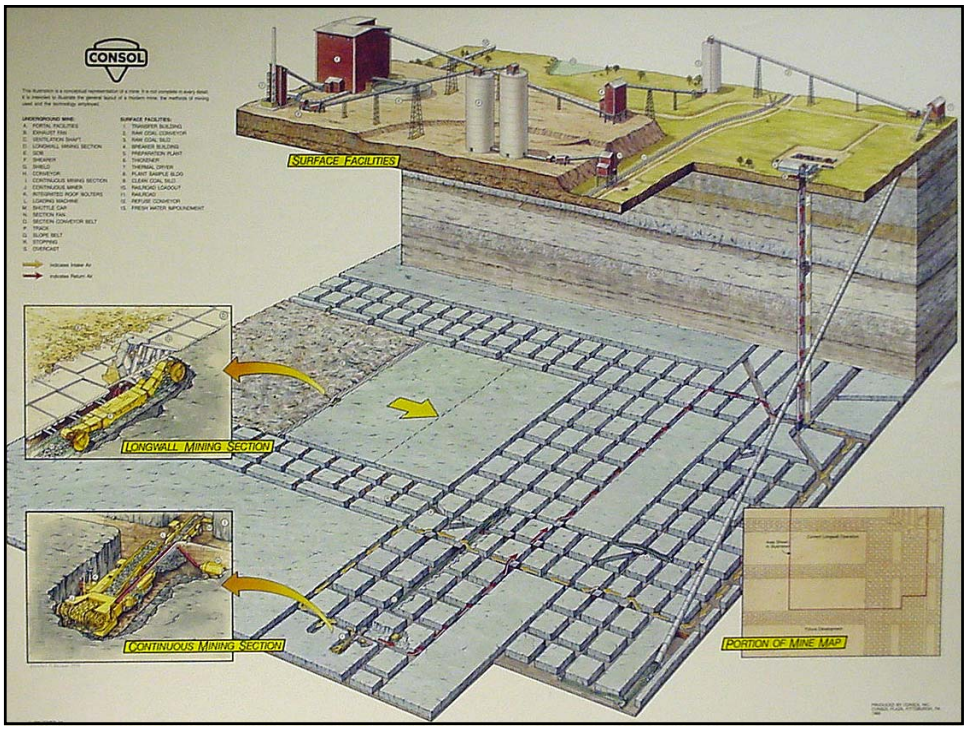
Coal Mining Methods



Uky.edu

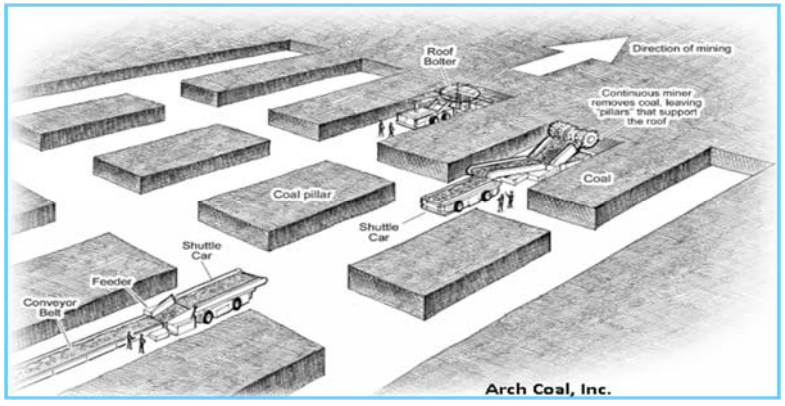
Underground Coal Mining Methods

- **Room and pillar method**
  - Very flexible, good for mining small and irregular reserves
  - Development mining only
    - Low recovery ratio, normally < 50 %
    - Not intend to cause surface subsidence
  - Development with pillar retrieving
    - Pillars are partially recovered
    - Higher recovery ratio
    - Normally cause immediate surface subsidence
  - Traditional (Drill, blast, load and haul operations) almost none now
  - Continuous miner (Miner = cut and load, hauling remains to be only non-continuous operation)



Early Coal Mining Methods

Underground Coal Mining Methods

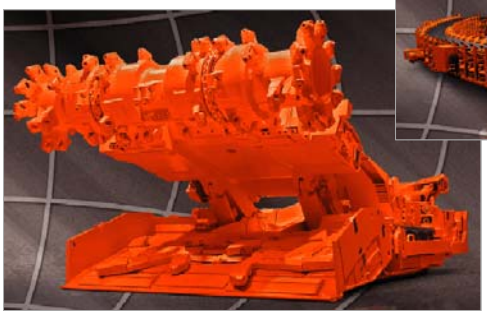


Traditional and Continuous Miner Room and Pillar Mining Methods

Continuous Mining Machine

Underground Coal Mining Methods

Shuttle Car



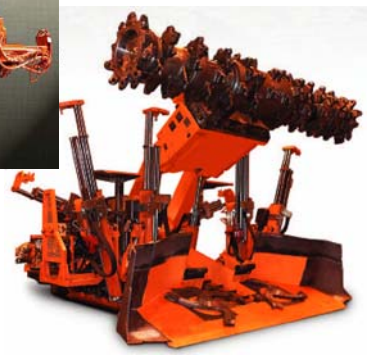
Continuous Miner

Joy Manufacturing

Underground Coal Mining Methods

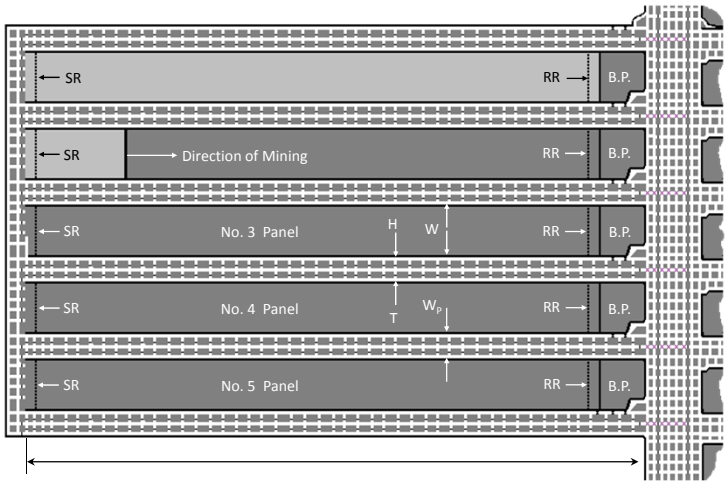
Dual Boom Roof Bolter
with TRS

Miner Bolter



Roof bolting operation could be the bottleneck for room and pillar mining operations

Longwall Method Panel Layout



Underground Coal Mining Methods

A Longwall Face in a Coal Mine

A Double Drum
Longwall Shearer

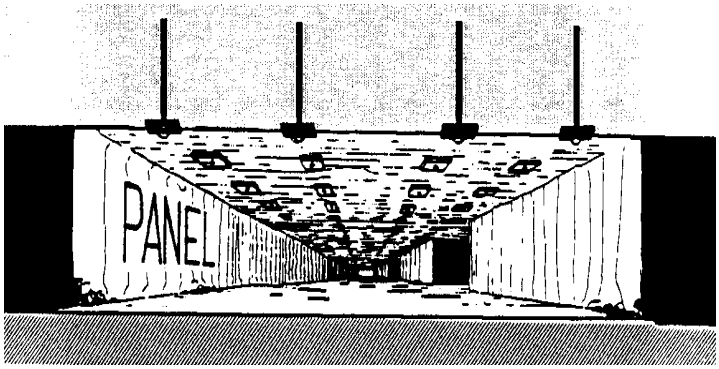
Underground Coal Mining Methods

Longwall Shield

Battery Hauler
Major equipment for
speedy longwall move

Longwall Panel Development

- **Primary support are roof bolts which are installed on cycle during development**



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Longwall Panel Development

- **Roof bolting key to the success of high productive longwall mining**
- **About 100 million pieces of roof bolts consumed per year in U.S.**
  - Mechanical bolts 40%
  - Resin bolts 40%
  - Specialty bolts. 20%
- **Bolt length**
  - Bolt length: 4 ft (1.2 m) ~ 16 ft (4.9 m)
  - Max. bolt length < Mining height.
  - If bolt length is longer than mining height, bolt notch or sectioned bolts (normally 4 ft 1) are used.
  - Majority are 1.5–2.5 m long.

Underground Coal Mining Methods

- **Longwall Mining Method**
  - All equipment becomes larger and more automated
    - 40 inches (1.07 m) cutting web
    - 1,000-ton shields
    - Wider shield (5.5 ft or 1.68 m)
    - 2-leg shields
    - 72 inches (1.83 m) belt conveyors, 6,000 tons/hour capacity
    - Batch shield moving system (8–10 shield per one operation)
    - Fewer workers in one crew (5–6 persons per shift)
      - 2 shearer operators
      - 1 shield operator
      - 1 headgate operator
      - 1 mechanic
      - 1 helper (optional)

Longwall Mines 2014

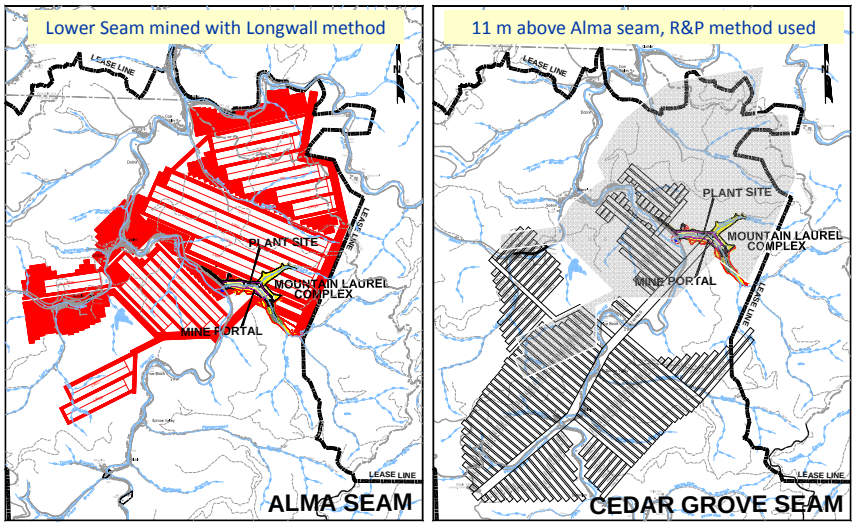
- No. of Longwall Mines – 42
- No. of Longwall Faces – 47
- Ave. U.S. Longwall mine produces 4.4 million tpy
- Ave. cutting height 91.4 inches
- Ave. Panel width – 1,228 ft.
- Ave. panel length – 12,117 ft.
- 17 walls operate in the Pittsburgh coal seam
- Max. overburden on average reaches 1,145 ft.
- Deepest longwall is 3,000 ft. overburden (West Ridge, Utah)
- Top 3 operators are Murray Energy, CONSOL Energy, and Foresight Energy
- State of WV has 13 faces, PA has 7, Illinois has 7 and Alabama has 5
- Highest horse power shear has 2,805 HP
- CONSOL Bailey and Enlow Fork produced 12.3 million tons of clean coal

Coalage.com

Longwall Mines

- **Daily advance rate**
  - Range: 15–35 m/day
  - Average: 23 m/day
- **Daily production: 18,000 tons (4 million tons/year)**
- **Main reasons**
  - Favorite conditions for longwall mining: inclination <5°, height most between 1.4 ~ 2.1 m
  - Relatively shallow overburden: average about 240 m
  - Low gassy mines
  - Normally single seam mining
  - Equipment automation
  - Mixing of room & pillar and longwall mining methods: Longwall in good areas and R & P in left-over areas.

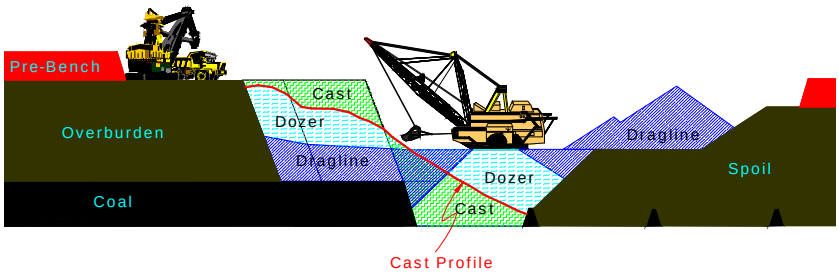
Mountaineer II Mine, WV – Mining Two Seams With Different Methods



Surface Mining

- **Coal surface mining methods**
  - 67% of the coal production
  - Mining methods
    - Open-pit
    - Area Mining
    - Contour mining
    - Mountain top removal mining
    - Highwall Mining

Surface Mining – Coal



Surface Mining Equipment

Typical Equipment Used for Overburden Removal

Surface Mining

Surface Mining

- **Some trends in surface mining**
  - Digital drives on shovels and draglines
  - Larger trucks
  - Global positioning systems
    - Driverless trucks
    - Collision avoid radar for large mobile equipment
  - High voltage equipment

Area Mining - Peabody Coal Company PRB Coal in Gillette, Wyoming

Mountain Top Mining

Mountaintop removal mining (MTR), also known as mountaintop mining (MTM), is a form of surface mining that involves the mining of the summit or summit ridge of a mountain. Coal seams are extracted from a mountain by removing the land, or overburden, above the seams.

Mining in Process

Mountain Top Mining

Restoration in Process

Highwall Mining

Coalcountrythemovie.com

Coal Preparation

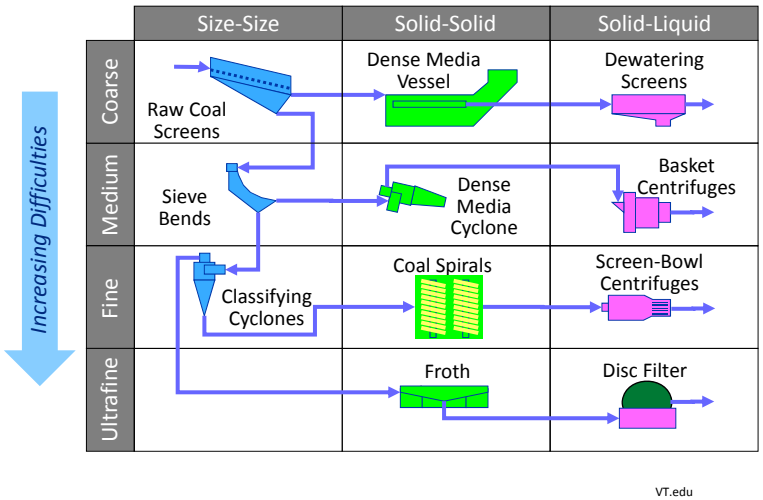
Modern coal processing plants incorporate a complex array of solid-solid and solid liquid separation processes.

- The processes remove unwanted impurities such as ash, sulfur, and moisture from run-of-mine (that is, unprocessed coal) feedstocks to improve coal utilization properties.
- Separation technologies used by the coal industry include screening, classification, dense medium separation, gravity concentration, froth flotation, centrifugation, filtration, and thickening.

Prep Plant Statistics

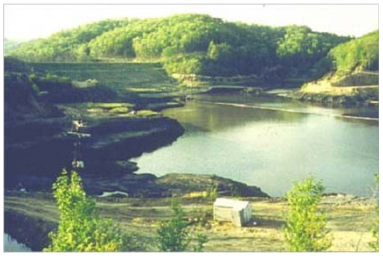
- **Operators**
  - ANR – 33 plants
  - Patriot Coal – 16 plants
  - Murray Energy – 15 plants
  - Blackhawk Mining – 14 plants
  - Arch and Alliance – 12 plants
- **No. of U.S. Coal Prep. Plants – 268**
  - 19% reported as idle
  - WV 80, KY 56, PA 44, VA 18, IL 16 and IN 14

Coal Preparation – Separation Processes Used for Coal



VT.edu

Coal Preparation – Images

Environment and Reclamation



Returning the land to as good or better condition than before mining

Mining Reclamation

Mining is Temporary Land Use

Mylan Park

Twisted Gun Golf Course

Mount Olive Prison

Logan WV. Airport

Driving Innovation ♦ Delivering Results

Appalachia Coal Markets

Perry Bissell

September 24, 2015

National Energy Technology Laboratory

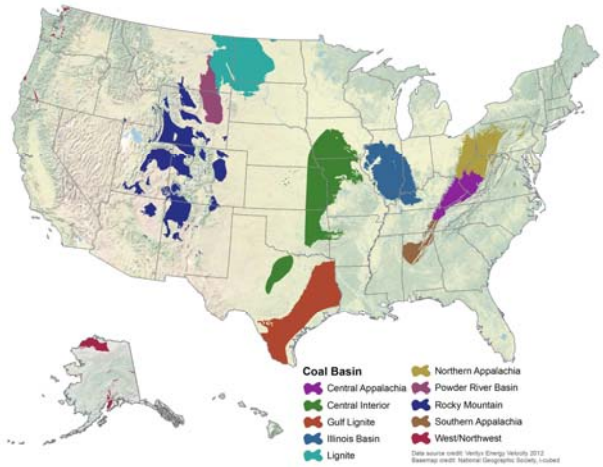
Presentation Outline

- **Overview of Appalachia Coal Markets and Infrastructure**
- **Reasons for Decline in Appalachia Coal Markets**

Quick C.V.

- PhD, Mineral Economics, Penn State
- Director, Market Development and Analysis, CONSOL Energy
- Senior Energy Market Analyst, John T. Boyd Company
- Senior Director, Coal, PIRA Energy Group

U.S. Coal Producing Regions

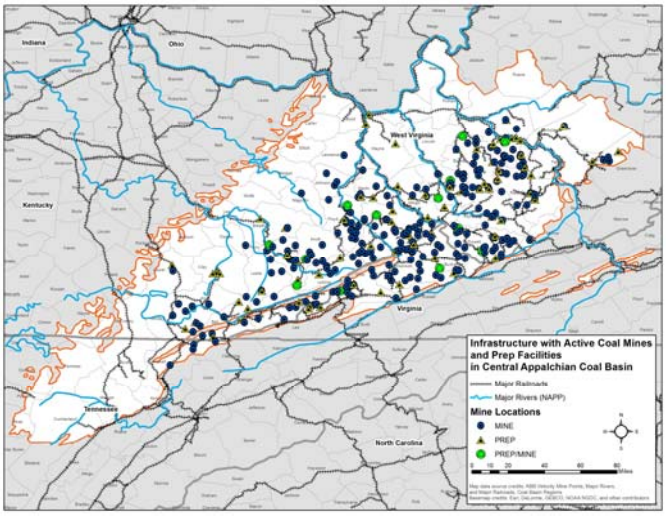


Appalachia Coal Quality v. Other Major Basins

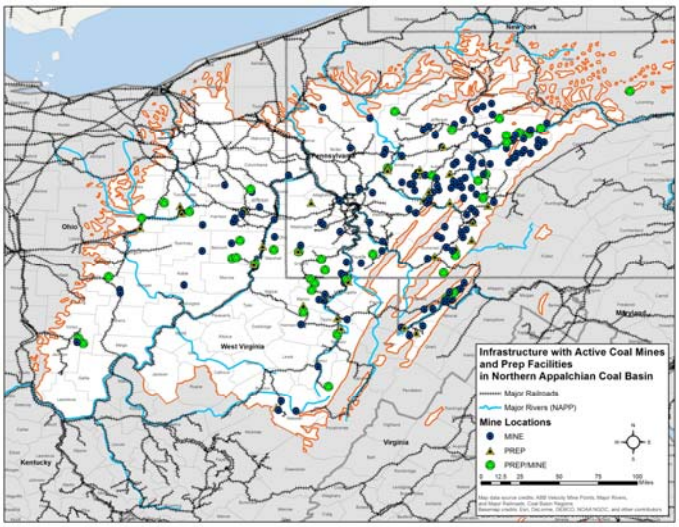
	Heat Content (Btu/lb)		SO2 Content (lbs/MMBtu)	
Basin	Low	High	Low	High
Central Appalachia	11,500	13,000	1.2	3.0
Northern Appalachia	11,500	13,000	2.5	7.0
Illinois Basin	10,000	12,500	4.0	6.5
Powder River Basin	8,300	8,800	0.7	1.0

Quality estimates are for illustrative purposes and represent "typical" low and high values. These are not intended to represent lowest and highest potential quality.

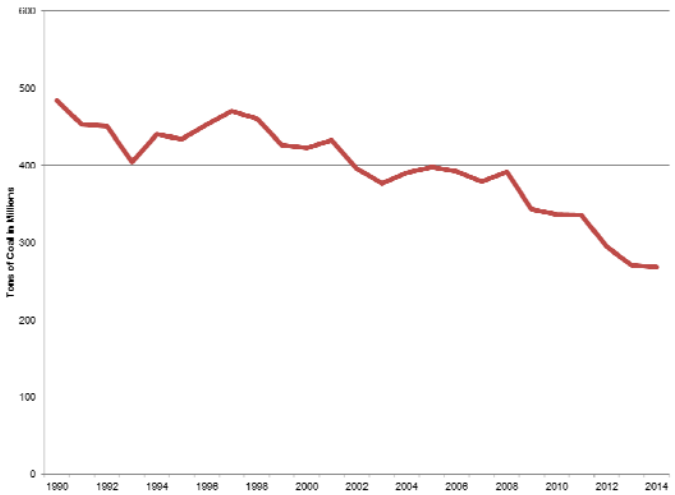
Central Appalachia Mines and Preparation Plants



Northern Appalachia Mines and Preparation Plants

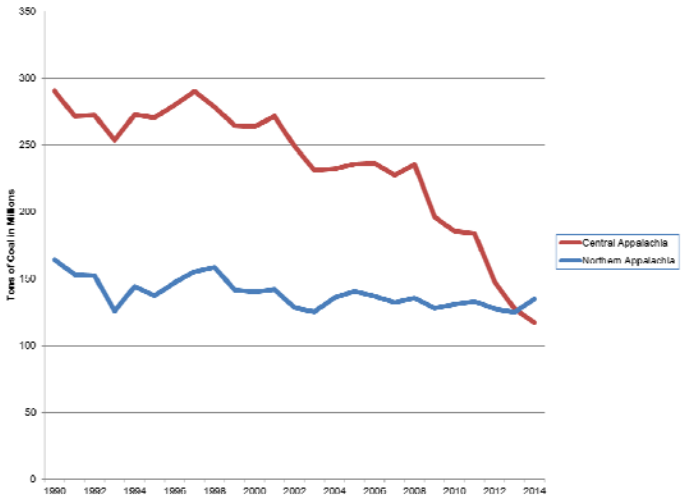


Appalachia Coal Production, 1990-2014



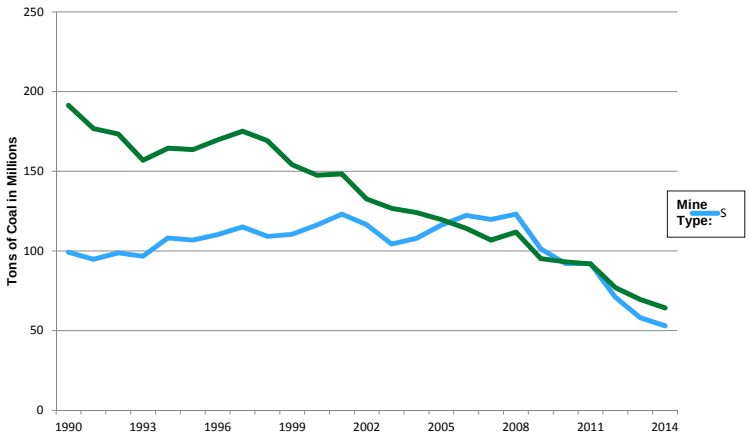
Source: Ventyx Energy Velocity

Central and Northern Appalachia Coal Production, 1990-2014



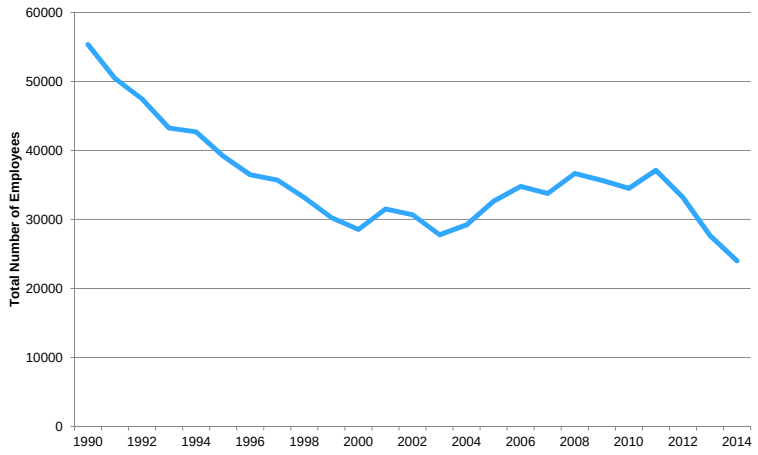
Source: Ventyx Energy Velocity

Central Appalachia Coal Production by Mine Type, 1990-2014



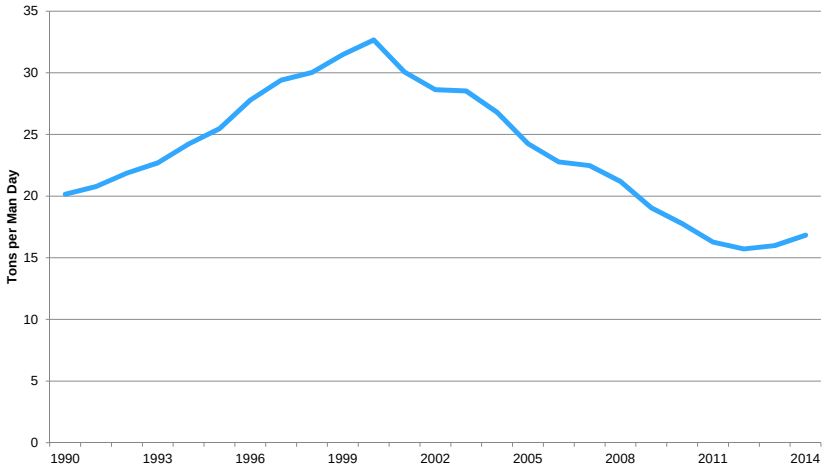
Source: Ventyx Energy Velocity

Central Appalachia Coal Employees, 1990-2014



Source: Ventyx Energy Velocity

Central Appalachia Coal Mine Labor Productivity, 1990-2014



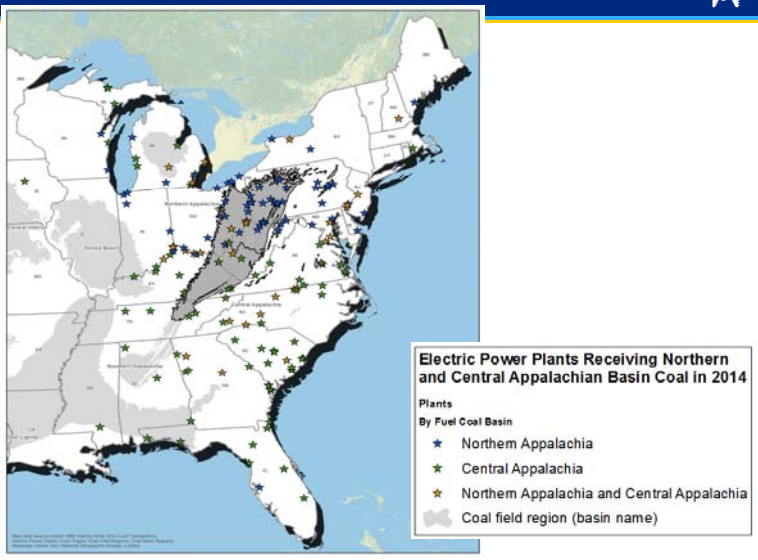
Source: Ventyx Energy Velocity

Summary Data for Central Appalachia, 1990 and 2010

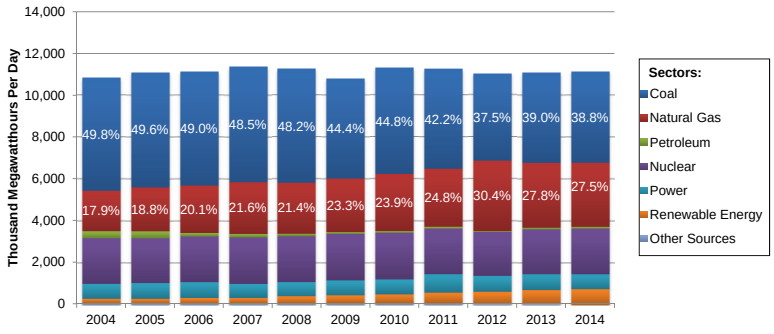
Metric	1990	2010	2014
Production (Million Tons)	291	185	117
Number of Mines	1,837	736	490
Employment (Average Number of Employees	55,359	34,503	24,005
Productivity (Tons per Man Day)	20.15	17.77	16.83

Sources: Ventyx Energy Velocity

Power Plants Receiving Appalachia Coal, 2014



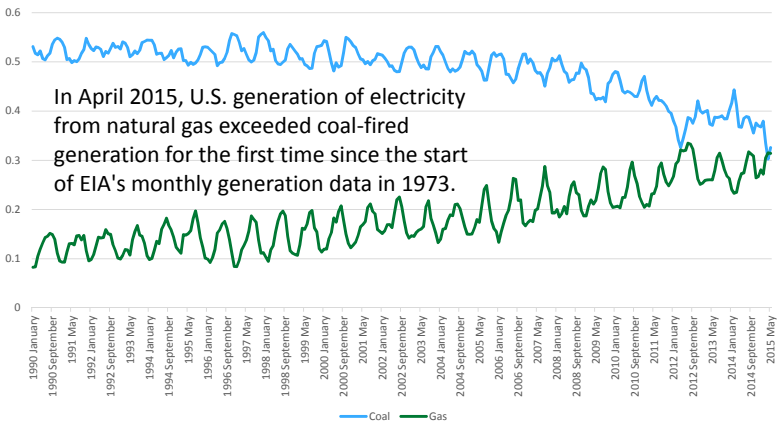
U.S. Electricity Generation by Fuel, All Sectors, 2004-2014



Note: Labels show percentage share of total generation provided by coal and natural gas.

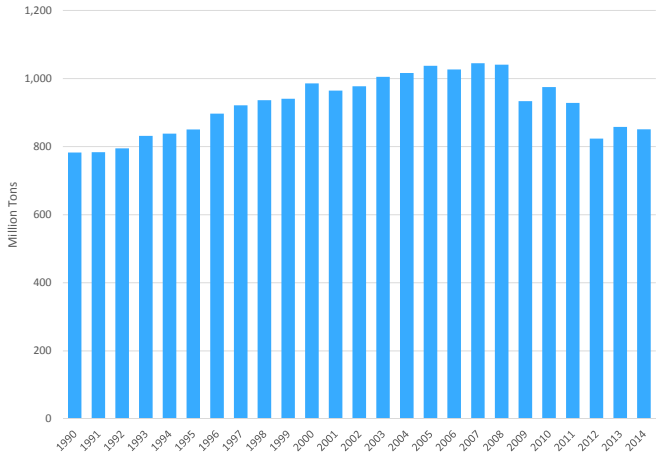
Source: EIA Short Term Energy Outlook, August 2015

Monthly Share of Total Power Generation by Fuel (Percentage of Total Generation)



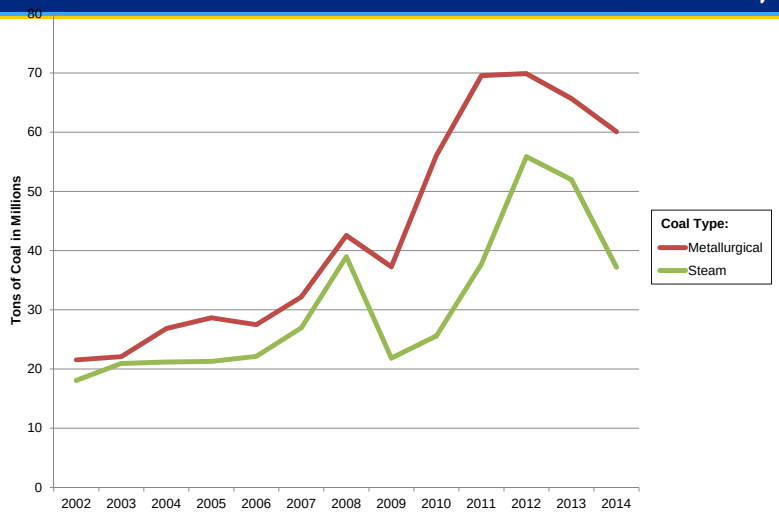
Source: Energy Information Administration, August 2015 Monthly Energy Review, Table 7.2a_Electricity_Net_Generation_Total_ All_Sectors.xls

U.S. Electric Power Sector Coal Consumption, 1990-2014



Source: Energy Information Administration

U.S. Coal Exports by Coal Type, 2002-2014



Source: EIA, Historical Coal Exports, Data from: Quarterly Coal Reports 2002 through Q1 2015 http://www.eia.gov/coal/data.cfm#imports

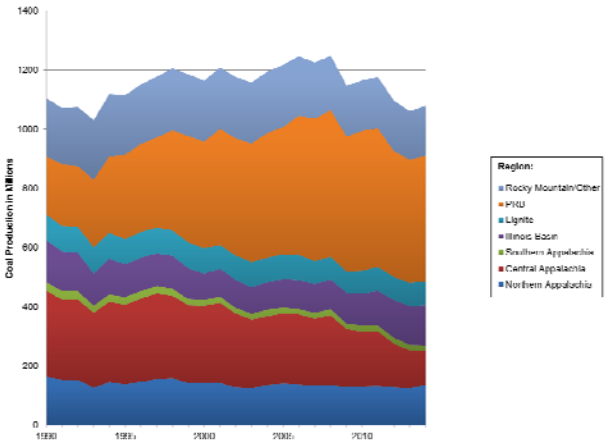
Central Appalachia Coal Prices, 2004-YTD

Source: EIA: NYMEX Central Appalachian Coal Futures Near-Month Contract Final Settlement Price History

Major Factors Behind Decline of Appalachia Coal

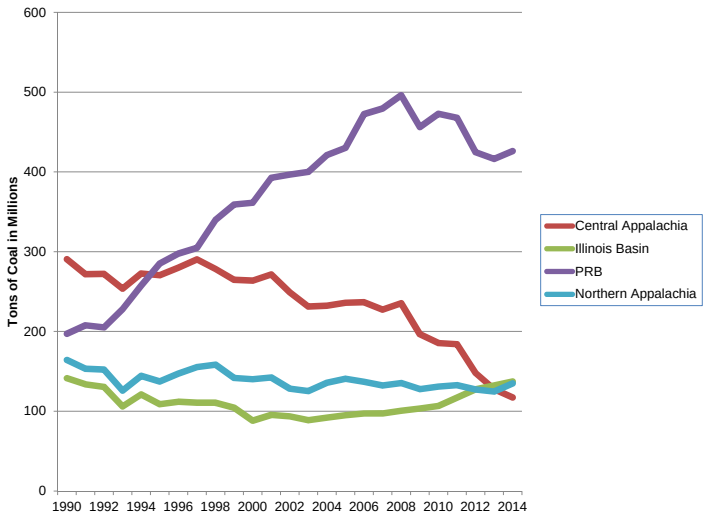
- **Regional Competition**
- **Natural Gas**
- **Tightening Environmental and Safety Regulations**
- **Declining Export Markets**

U.S. Coal Production by Region, 2009-2014

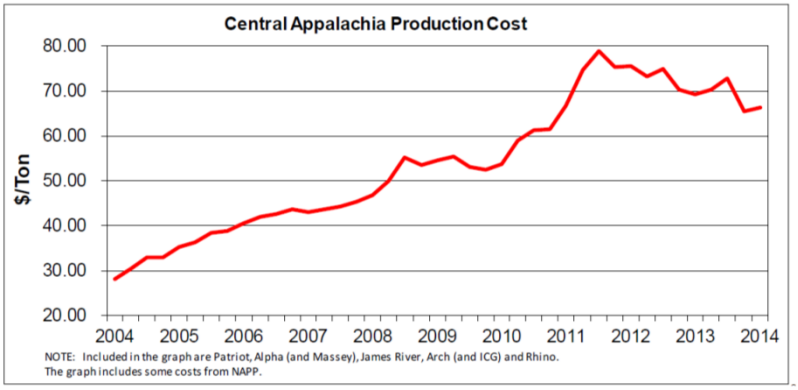


Sources: Ventyx Energy Velocity, EIA Annual Energy Outlook 2012

Major Coal Basins – Win, Lose or Draw?



Costs of Central Appalachia Production



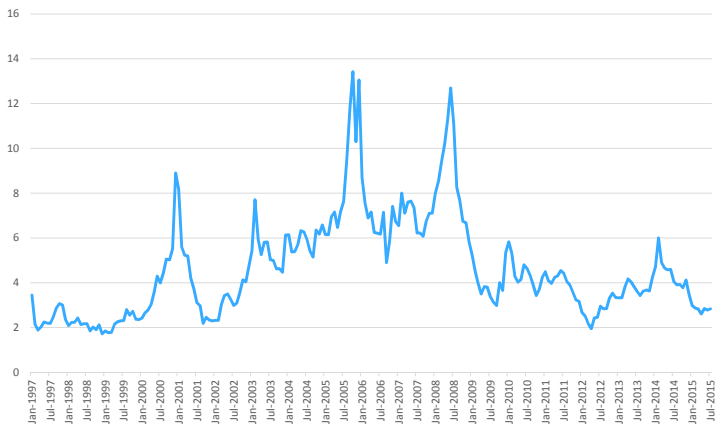
WV coal producer: "You cannot mine CSX [12,500 Btu/lb] coal and sell it for $45/st. You can't.", Platts Coal Trader, 8/24/15

Source: Patriot Coal "Changes Underway in the Central Appalachia Coal Industry, July 14, 2014

Central Appalachia Production Cost Drivers

- **Resource depletion**
- **Higher wages from prior labor shortages**
- **Mine safety and environmental regulations**

Henry Hub Natural Gas Spot Price (Dollars per Million Btu)



Source: Energy Information Administration

Illustrative Examples of "Breakeven" Delivered Costs of Coal Versus Gas

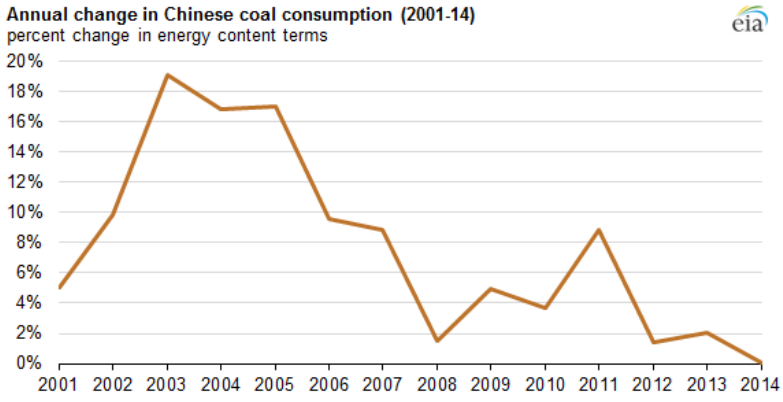
	Central Appalachia	Northern Appalachia	Illinois Basin	Powder River Basin	Natural Gas
Fob Mine ($/Ton)	$ 70.00	$ 60.00	$ 50.00	$ 15.00	na
Transportation ($/Ton)	$ 20.00	$ 20.00	$ 20.00	$ 35.00	na
Delivered Cost ($/Ton)	$ 90.00	$ 80.00	$ 70.00	$ 50.00	na
Delivered Cost ($/MMBtu)	$ 3.60	$ 3.08	$ 2.97	$ 2.84	$ 2.85
Assumed Heat Content	Btu/lb				
Central Appalachia	12,500				
Northern Appalachia	13,000				
Illinois Basin	11,800				
Powder River Basin	8,800				

Source: LTI Estimates

Central Appalachia Coal Exports

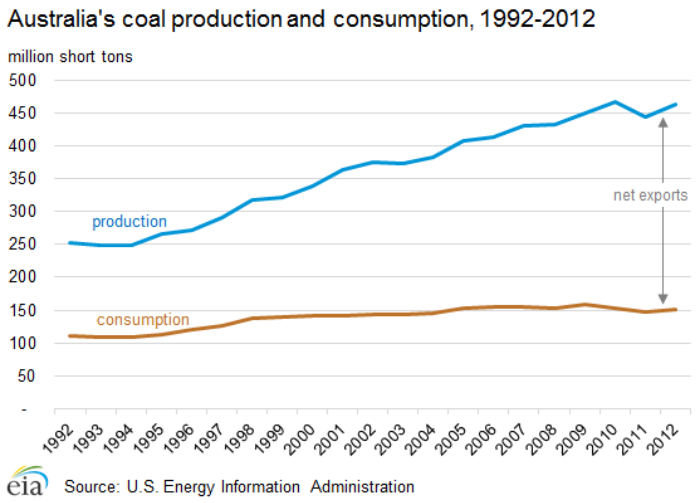
- **Global markets have weakened**
  - Lower-than-expected Chinese coal imports
- **Supply has increased**
  - Expanded production in Australia and Indonesia
- **As the "swing supplier" in international coal markets, Central Appalachia exports have fallen dramatically**

Growth in Chinese Coal Use is Slowing



Source: Energy Information Administration, Today in Energy, September 25, 2015

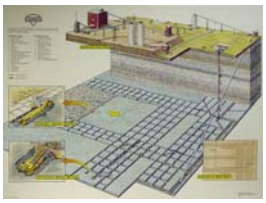
Australia Coal Production



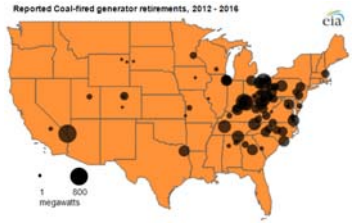
Tightening Environmental and Safety Regulations

- **Environmental regulations have tightened on both producers and consumers of coal**
  - Power plant emissions
  - MSHA safety regulations following 2010 UBB disaster
  - Valley fill permitting
  - Water treatment costs
- **Prospects for additional tightening discourage investments**

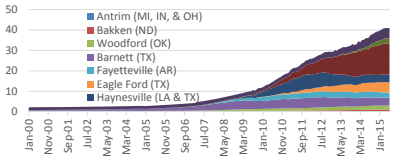
Five Visuals Explaining Decline in Central Appalachia



Thin seams, tough mining compared to thick PRB seams and longwalls in other regions



Plant retirements in core markets



The rise of shale gas

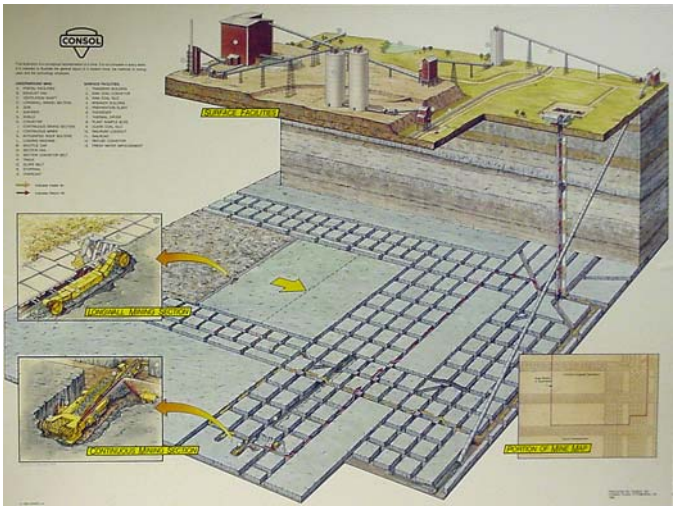
West Virginia Mine Entrance

Approximate Seam Height

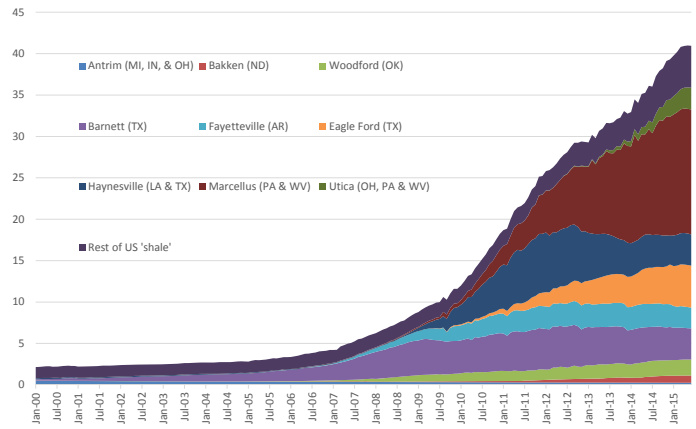
Source: TechCorr, http://www.techcorr.com/news/Articles/Article.cfm?ID=388

Peabody Coal Company
PRB Coal in Gillette, Wyoming

Longwall Mining Drives Northern Appalachia and Illinois Basin

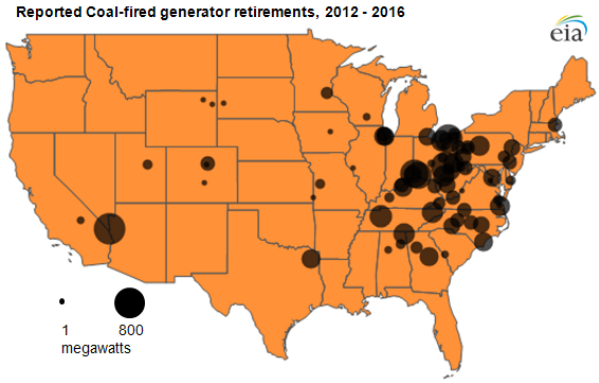


Monthly Dry Shale Gas Production (Billion cubic feet per day)



Source: EIA, Natural Gas Weekly Update, http://www.eia.gov/naturalgas/weekly/archive/2015/07_16/index.cfm#tabs-prices-1

Coal Plant Retirements are in Central Appalachia Core Markets



Source: Energy Information Administration

Summary

- **Central Appalachia production has been declining for a long time**
  - This is not a short-term phenomenon
- **The decline in Central Appalachia will continue**
  - Competition from other regions for limited markets will be intense
- **Natural gas is taking market share**
  - Short-term declines have been dramatic
- **Environmental regulations are taking away domestic markets**
  - Closing power plants
  - Forcing scrubbing that reduces demand for lower sulfur coal
- **Mining regulations are increasing production costs**
- **Export markets are declining**