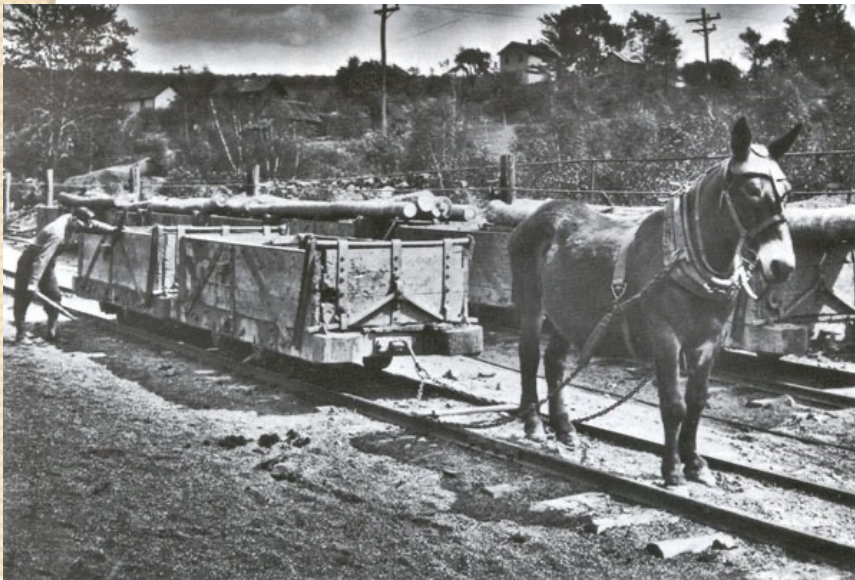


Introduction to Coal

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Prepared for EGY 105

at Wilkes University



What is coal?

- A form of rock rich in organic carbon
- Able to be burned as a source of energy
- Contains
 - Organic carbon (rings and straight chains)
 - Inorganic elements (Fe, Al, clay, CaCO_3 , trace metals)
 - Form ash
 - Water
- Elemental analysis
 - Bituminous: $\text{C}_{137}\text{H}_{97}\text{O}_9\text{NS}$
 - Anthracite: $\text{C}_{240}\text{H}_{90}\text{O}_4\text{NS}$

Different forms of coal



Anthracite



Bituminous



Sub-bituminous



Lignite



Peat

Comparing forms of coal

	Carbon content	Heat value (MBTUs / lb)	Use	Comments
Peat	<60%	8	Home heating	Not quite coal
Lignite	60-70%	4.0 - 8.3	Electrical gen.	Least mature form of coal, geologically. May contain 70% water
Sub-bituminous	71-77%	8.5 - 13	Electrical gen.	Found mainly in western U.S.
Bituminous	77-87%	11.0 – 15.0	Electrical gen., make coke for steel	Most abundant coal in US
Anthracite	>87%	13.0 - 15.0	Home heating	Found mainly in NEPA

Sources: <http://www.ket.org/trips/coal/agsmm/agsmmtypes.html>

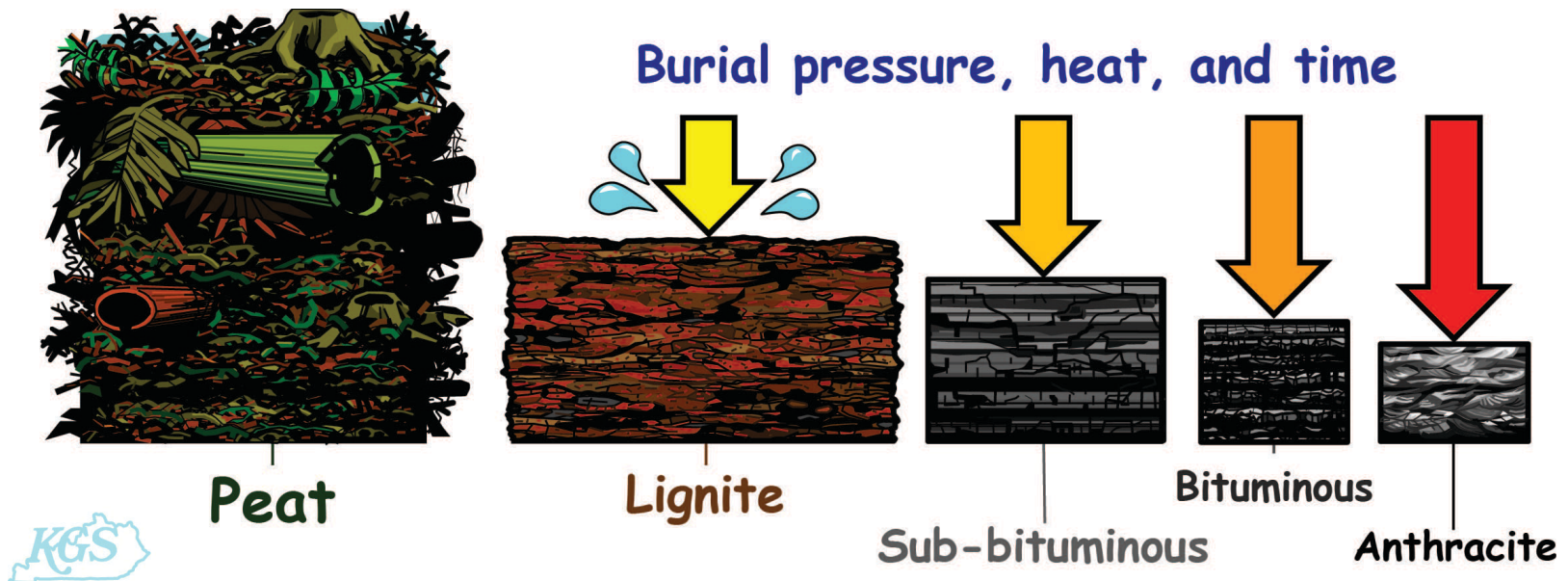
<http://www.purdue.edu/discoverypark/energy/assets/pdfs/cctr/outreach/Basics8-CoalCharacteristics-Oct08.pdf>

Some carbon compounds are “volatile”

- Driven off when coal heated $>950^{\circ}\text{C}$ (1742°F)
- Some components condense to form oils and tars when cooled.
- More in lignite & sub-bituminous, less in anthracite.
- Coals divided into 22 classes based on volatiles

How is coal created?

- From special form of fossilization of plants that lived hundreds of millions of years ago.
- Carbon in bodies not decomposed



Coal-forming plants



Geology of coal

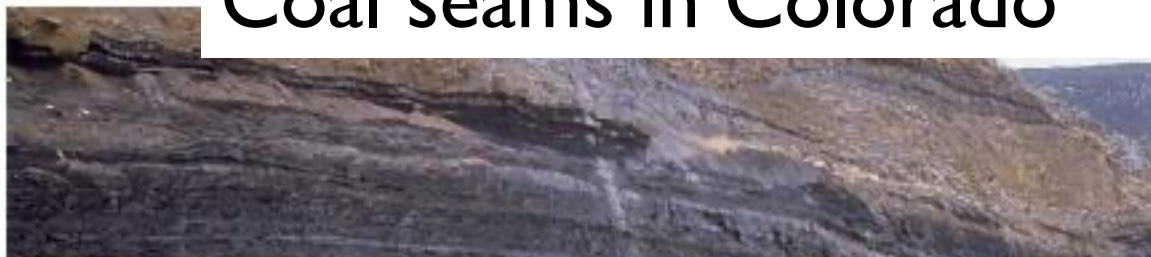
- Coal normally produced in horizontal bands called seams.
 - Thickness can range from a few feet to hundreds of feet.
- Overtopped by non-coal rock called overburden
- Geological forces can cause seams to tilt over time
- Sometimes coal becomes exposed due to surface erosion.

Coal seams in Alaska



<http://dnr.>

Coal seams in Colorado

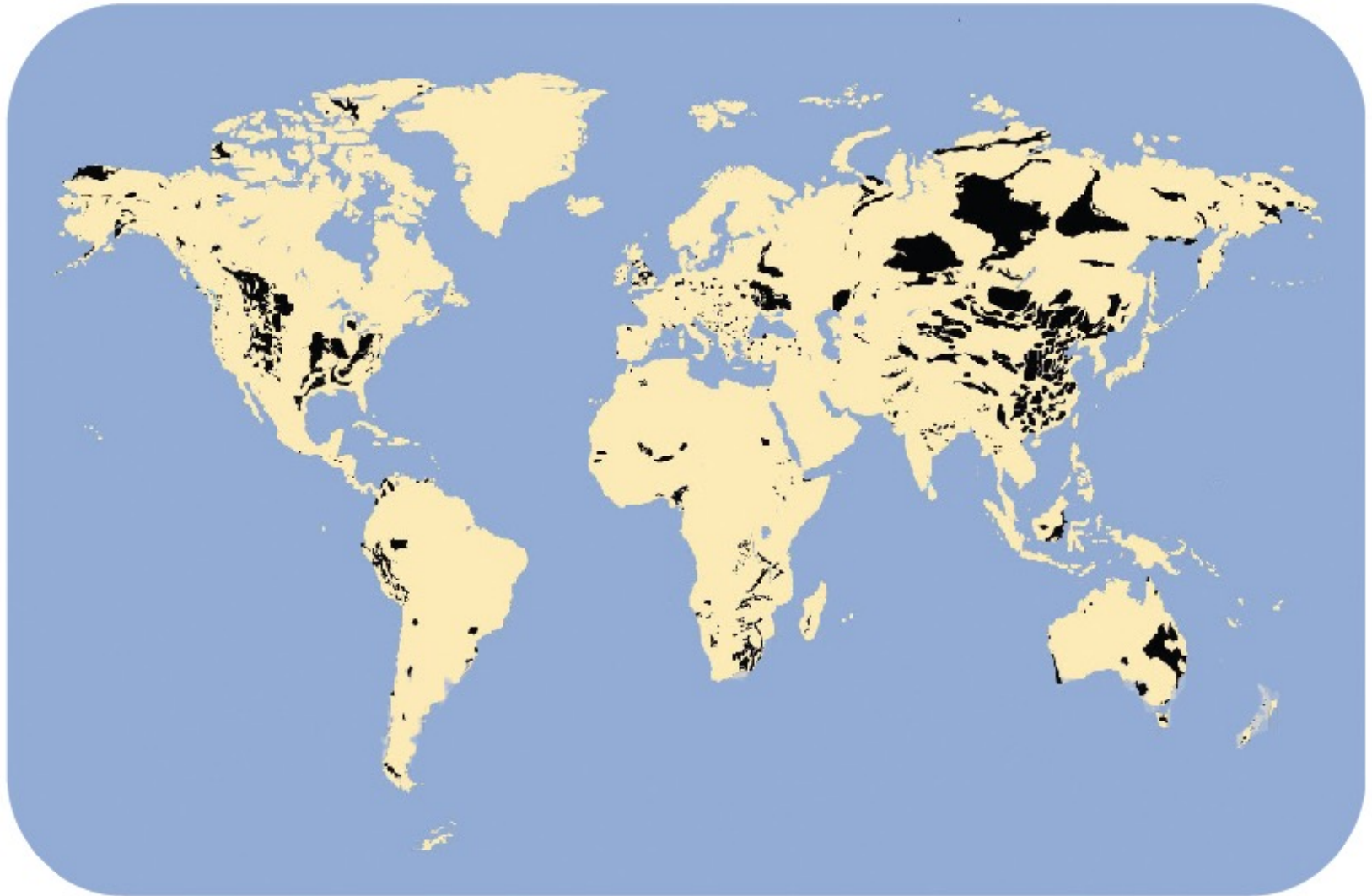


Coal seams in Pennsylvania



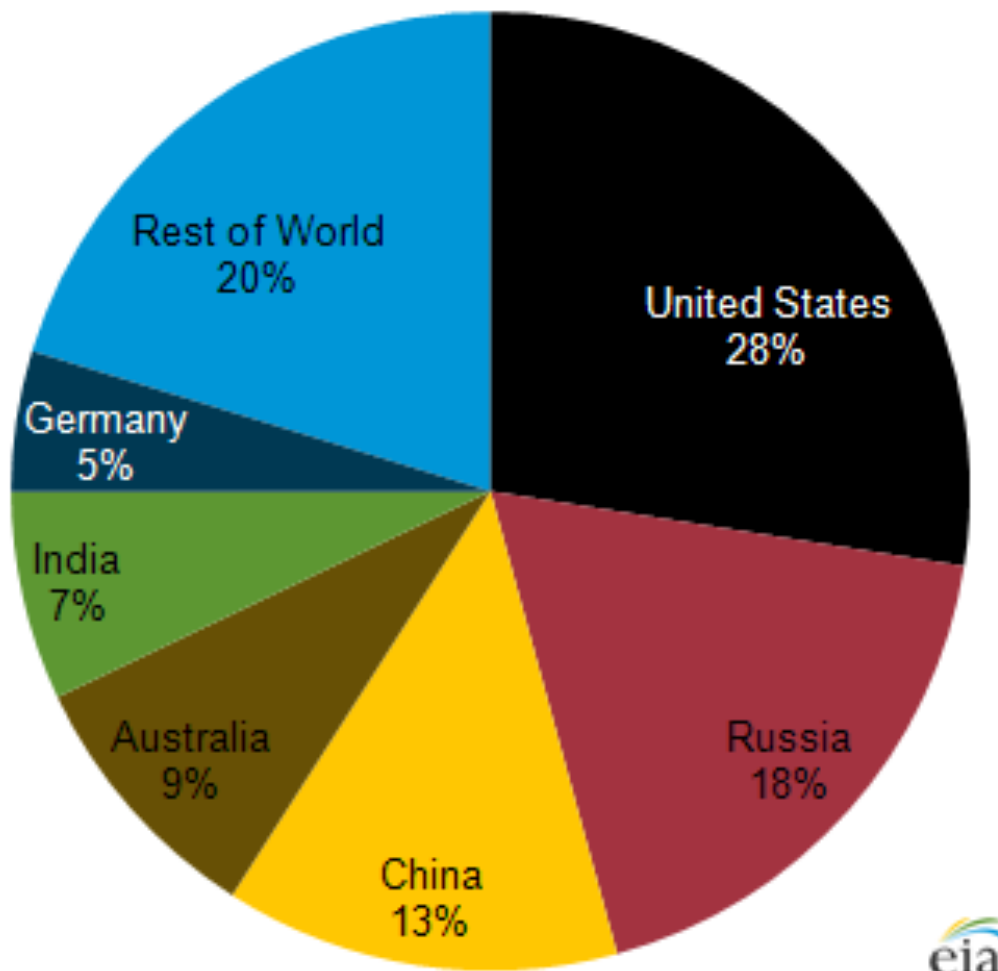
<http://www.bucknell.edu/x17745.xml>

Coal deposits worldwide

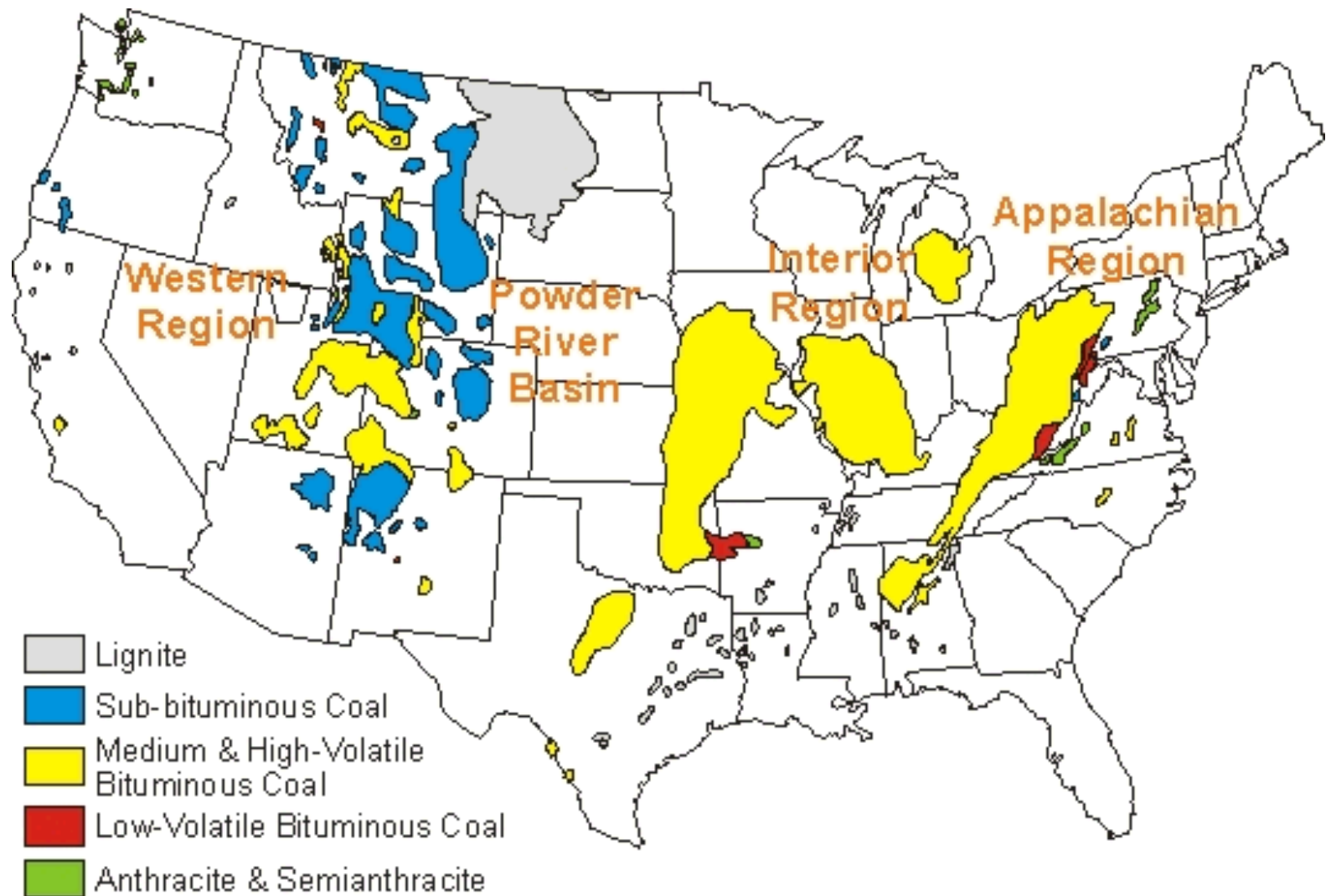


Recoverable coal reserves worldwide

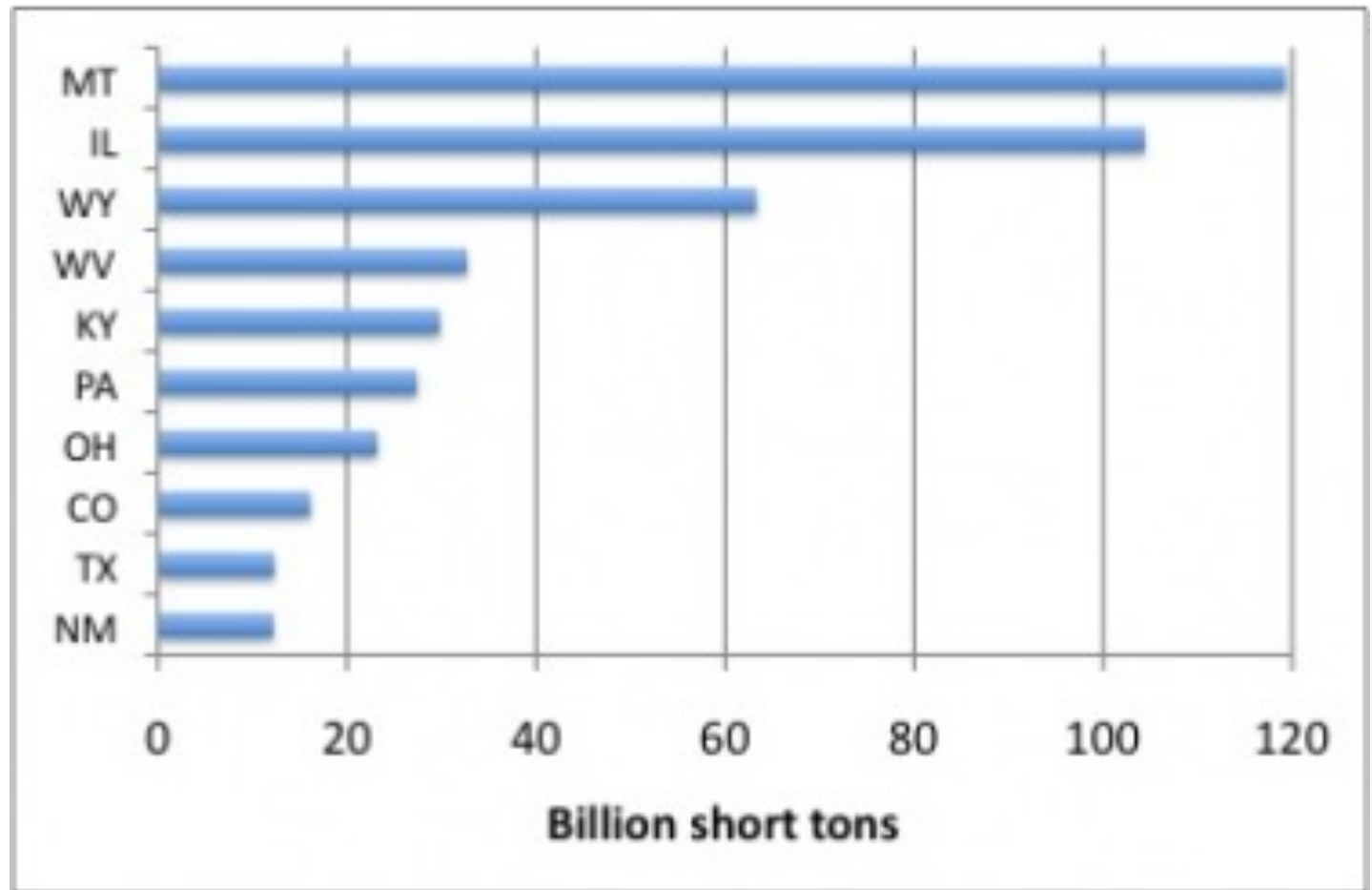
Global share of recoverable coal reserves



Coal deposits in United States



US coal reserves by state



History of coal production and use

- Coal mined in ancient cultures >2600 years ago. Burned for heat.
- Used in metal-working by 300 B.C.
- Mined extensively in northern Europe by 100 A.D. Used in smelting iron and heating buildings.

Coal use in middle ages

- Not much use of coal between 400-1200 A.D.
- Resurgence in early 13th Century, especially in northern Europe and British Isles.
 - Used by metal workers and for heat
- Use increased through 18th Century
 - Replaced wood which was being depleted.

Coal fueled the industrial revolution

- Powered steam generators, locomotives, and eventually electric generators.
- Made industrialization possible.
- First in British Isles (18th Century), then continental Europe and US by 19th Century.



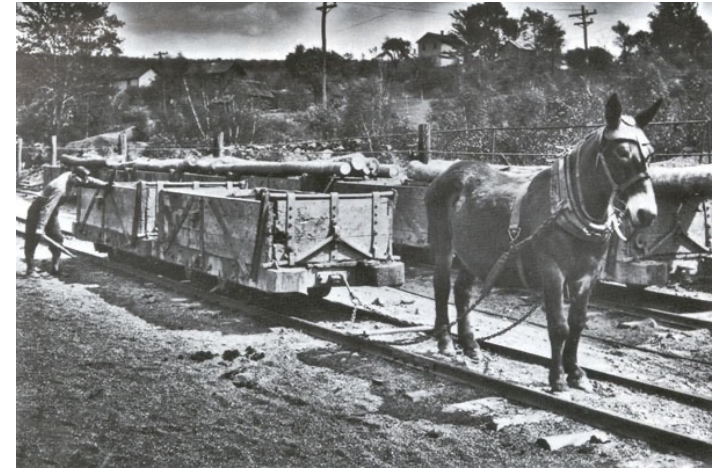
<http://blogs.cas.suffolk.edu/adlane/>



<http://www.bbc.co.uk/history/0/20979973>

Coal important in US

- Anthracite from NEPA thought to be worthless in 18th Century.
- Technique for burning discovered in 1808.
- Became mined extensively by 1850, replacing wood.
 - Used for heating, transportation, industrial
 - Scranton, Wilkes-Barre, Hazleton, Pottsville, and surrounding towns grew greatly
 - Railroads preferred way of getting coal to market.



<https://sites.google.com/a/ignatius.edu/mpecot/apush>

Other areas produced coal by late 19th and early 20th century

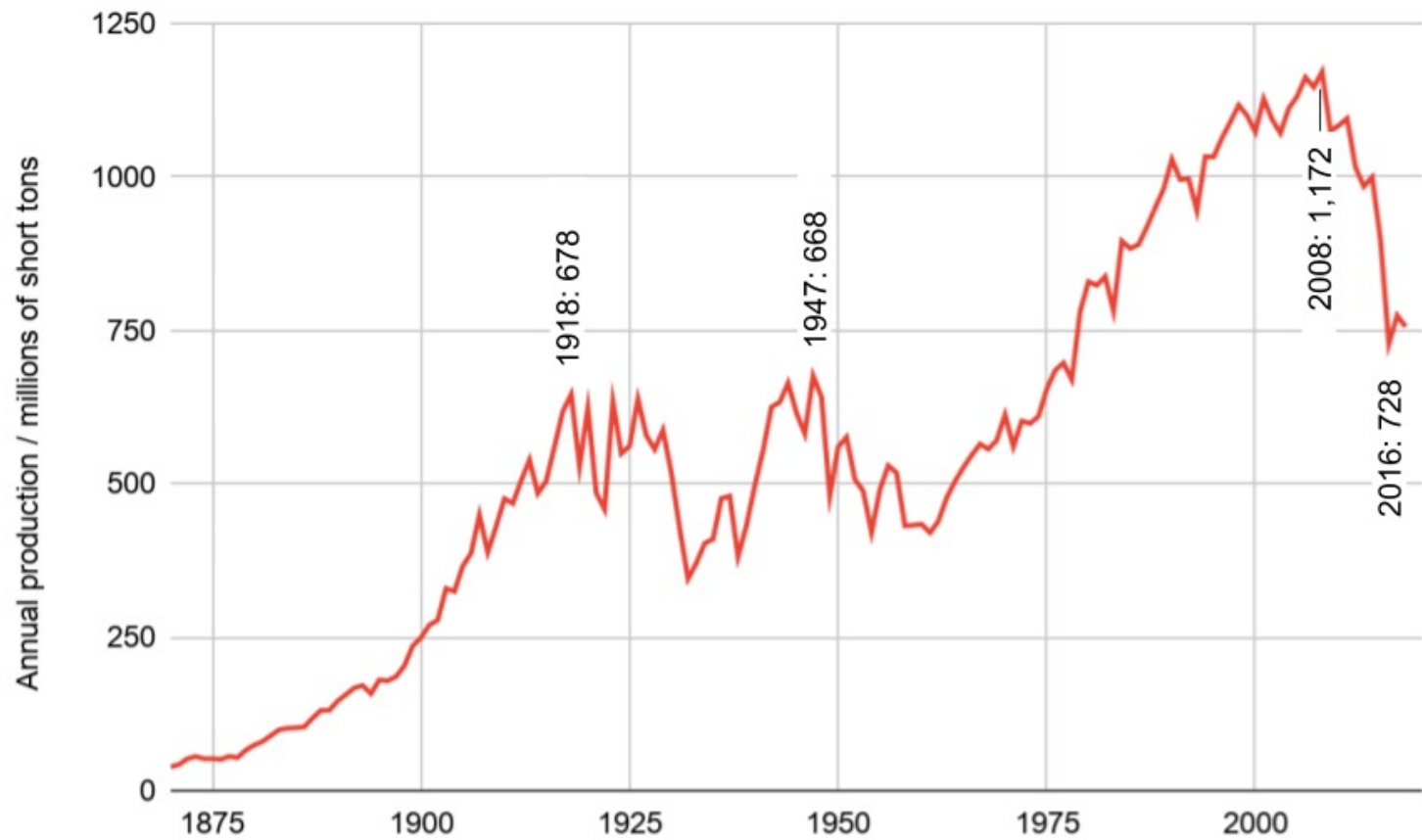
- Western PA and WV produced bituminous coal, mainly for steel production
- Colorado also significant by 1880s.
- Illinois produced bituminous by 1920.



Coal in 20th Century

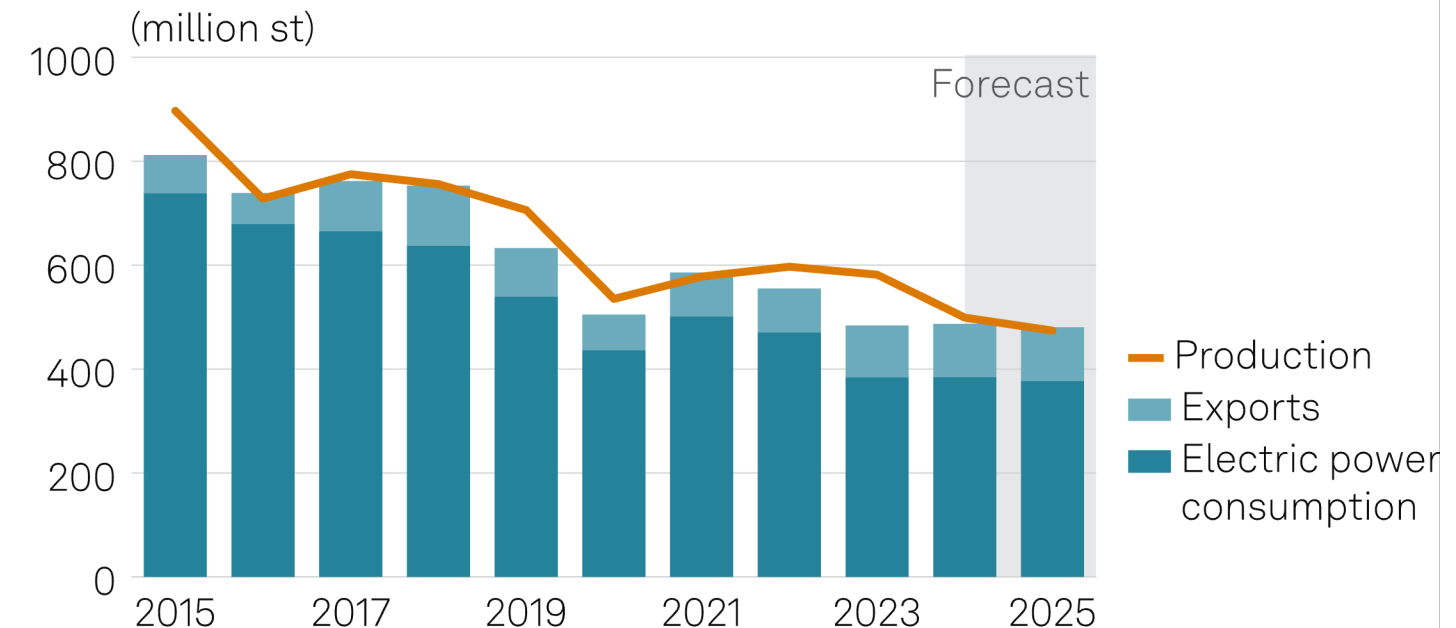
- Production of anthracite declined following World War II
 - Mines became depleted, flooded
 - Other fuels replaced coal for transportation and home heating
- Production still strong in West Virginia, Wyoming
 - Used primarily for electrical generation
- In past 10-15 years natural gas replacing coal for electrical generation.

US coal production 1875-2016



US coal production 2015-2025

US coal supply and demand



Source: EIA Short Term Energy Outlook

Mining methods I

- Before 1930s, most mining underground.
- Miners would often follow seam, extract with hand tools, load small railcars by hand.
- Room and pillar mining common.
- Raw coal transported to surface, processed and crushed in breaker
- Waste coal (culm, gob) dumped into huge piles



<http://www.coalcampmemories.com/miningmethods.html>



<http://ehistory.osu.edu/osu/mmh/LaborConflict/OnStrike/default.cfm>

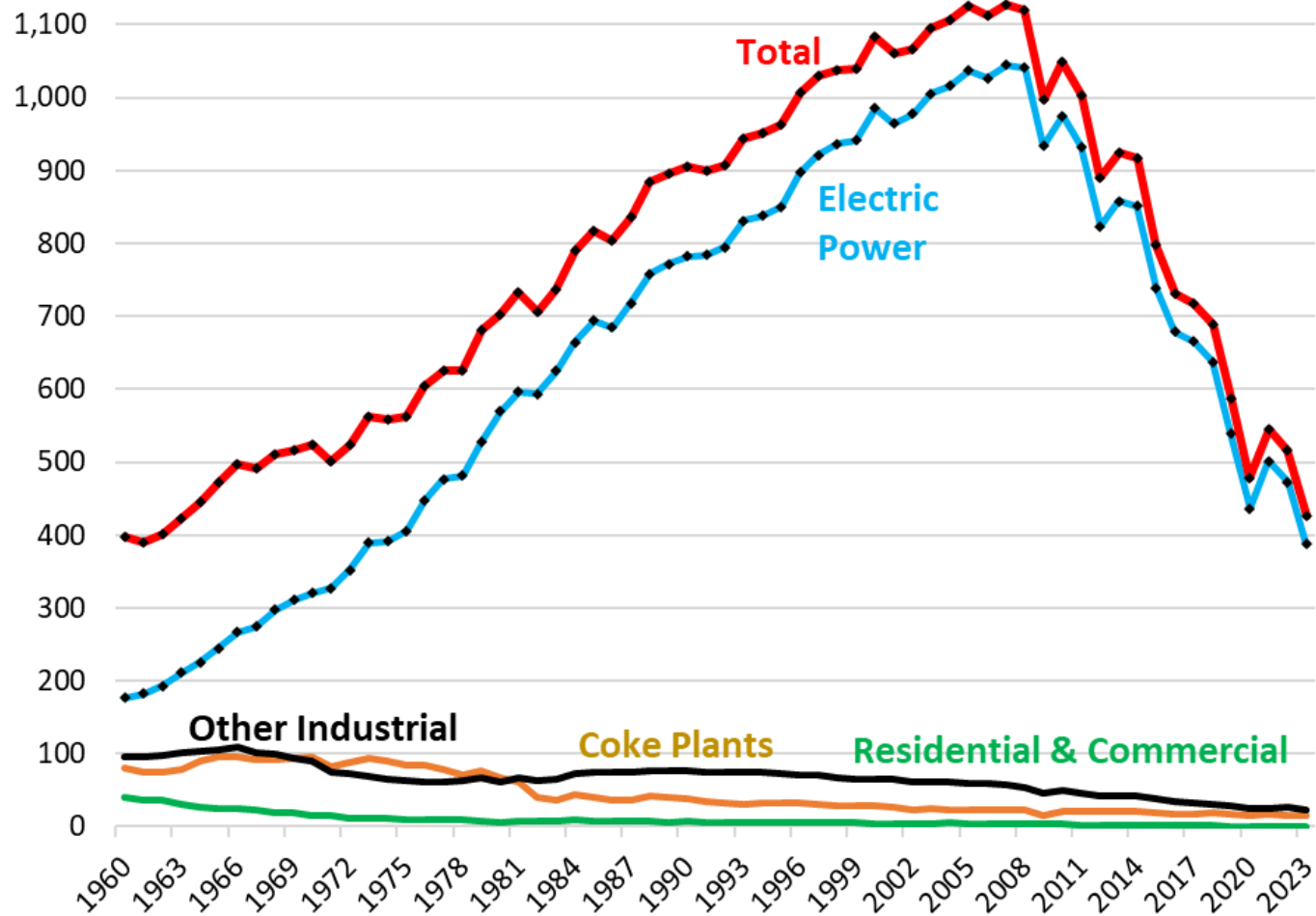
Mining methods II

- Emergence of new technologies (large steam shovels, draglines) permit surface mining
- Remove overburden to expose coal
 - Often result in large pits
 - Mountaintop mining in WV and KY



Coal consumption 1960-2023

US Coal Consumption by Major End User, Million Short Tons



Source: EIA

WOLFSTREET.com

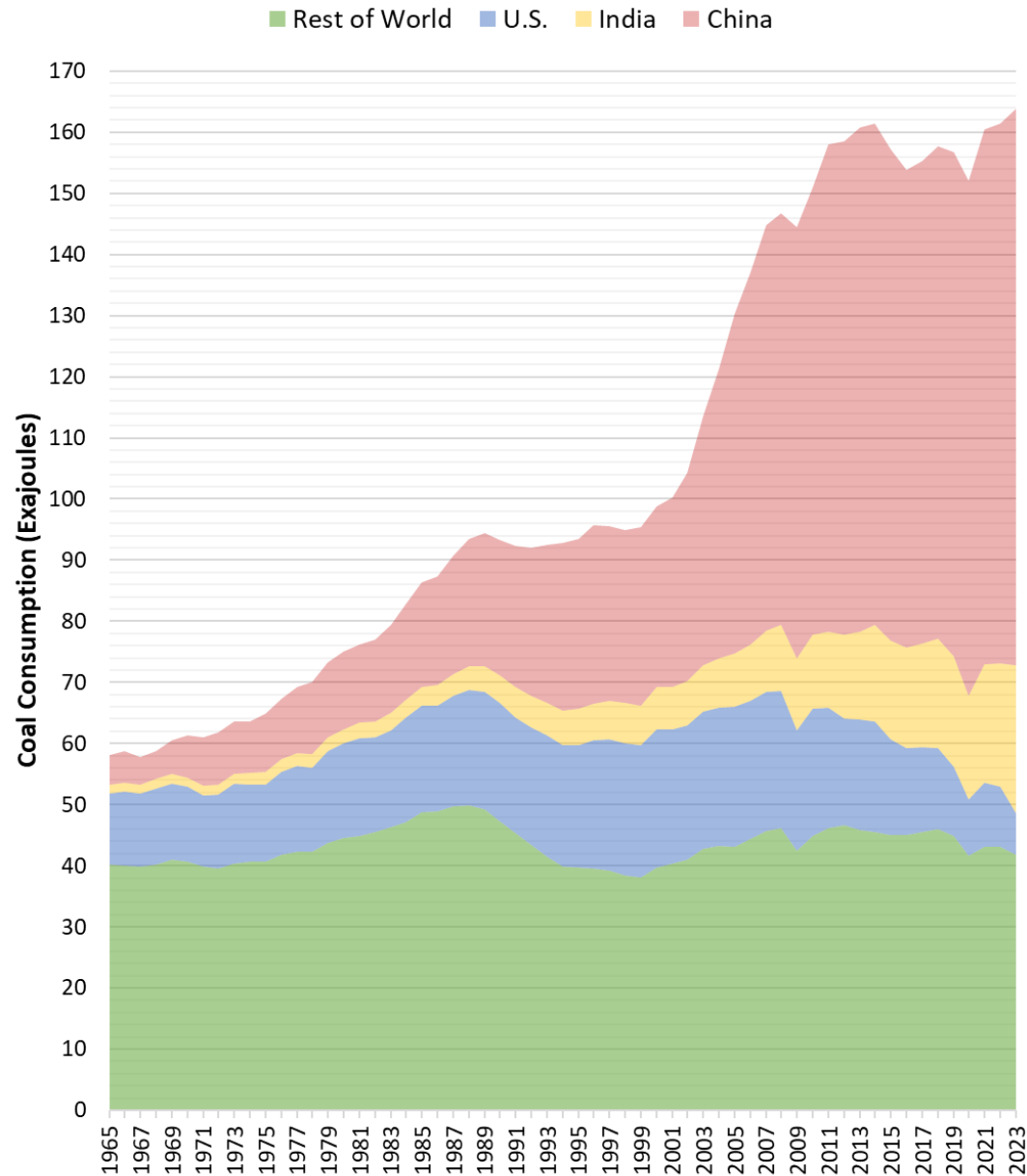
Electricity Production by Coal

- Over 10 TWh
- 8 to 10 TWh
- 6 to 8 TWh
- 2 to 6 TWh
- 1 to 2 TWh

http://en.wikipedia.org/wiki/Coal_power_in_the_United_States

Worldwide Coal Consumption

Exajoules Consumed from 1965 through 2023



Sources: Energy Institute (1965-2022), International Energy Agency (2023 Forecast), Author's Calculations (2023 estimate)

© Political Calculatons 2024

Cost of coal worldwide 1987-2023

Coal prices

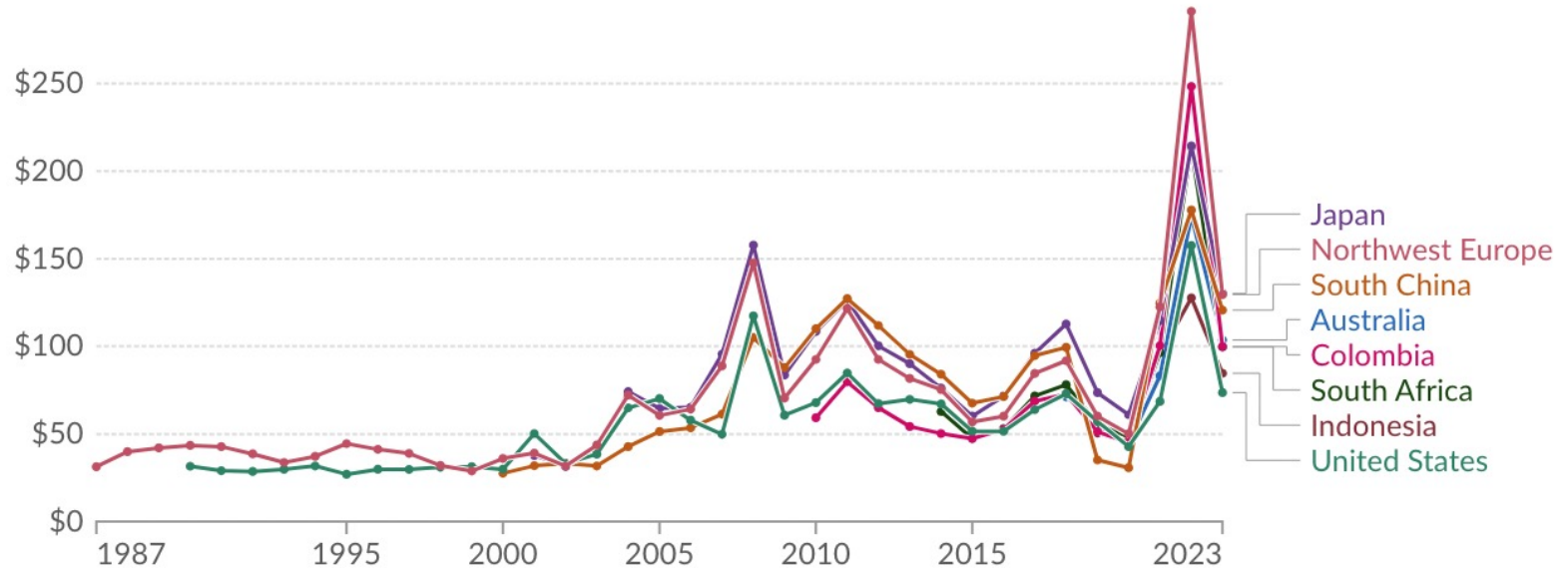
Coal prices of various production locations are measured in US dollars per tonne. This data is not adjusted for inflation.

Our World
in Data

Table Chart

Edit countries and regions

Settings



1987



2023

Data source: Energy Institute based on S&P Global Platts - Statistical Review of World Energy (2024) - [Learn more about this data](#)

[OurWorldinData.org/fossil-fuels](https://ourworldindata.org/fossil-fuels) | CC BY



<https://ourworldindata.org/grapher/coal-prices?time=earliest..2023>

Benefits of coal

- High energy density
- Abundant fuel
- Relatively inexpensive
- Employs many thousands of workers
- Often found where energy needed
- Reliable
- Easy to transport



Drawbacks

- Terrestrial impacts
 - Habitat destruction
- Aquatic impacts
 - Abandoned mine drainage
 - Mercury in water
- Atmospheric impacts
 - Particulates
 - Sulfur
 - Greenhouse gases



http://republicanherald.com/polopoly_fs/



http://klemow.wilkes.edu/images/AMD_stream.gif

Coal policy

- Coal extraction regulated by environmental laws:
 - Waters protection
 - Reclamation
- Coal burning regulated by restrictions on methane emissions.

Coal politics

- Coal share of energy consumption dropping in U.S.
 - Largely due to electric generators switching from coal to natural gas.
- In 2016, President Trump declared an end to “The War on Coal”
 - Eased regulations on water pollution and air pollution.
- Did not result in a resurgence of coal production.

Trump vs Harris on Coal



Do their policies differ?
Is it an issue?