Geologist

Task

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Questions for the Geologist

- **What is the geologic story of how coal forms?**
- **What are the different types of coal?**

Information

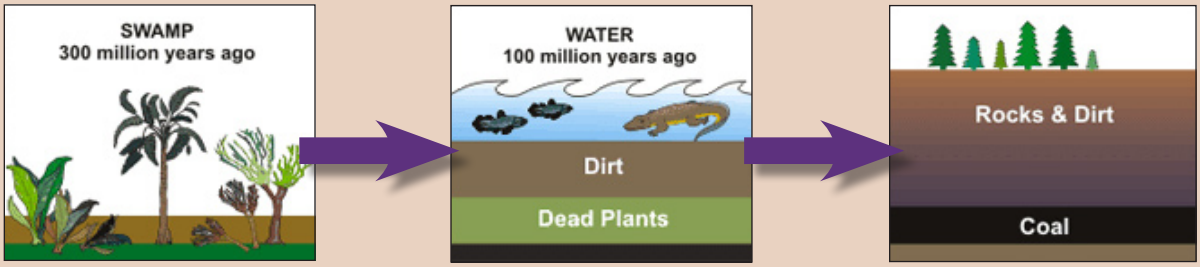
How Coal Forms

- Remains of plants settle to the bottom of the swamp or shallow sea.
- Peat forms from bacteria that partially decays the plants, leaving behind mostly carbon.
- Peat is crushed under the weight of hundreds or thousands of meters of rock above it, or it is squeezed in the folding layers of Earth's crust.
- After tens of millions of years of heat and pressure, the peat slowly turns to lignite. Then, with continued heat and pressure, the lignite turns to bituminous coal. The bituminous coal then turns to anthracite. Without the heat and pressure, one type of coal will not morph into another type.

Coal is a combustable sedimentary rock. It is consdered a nonrenewable resource because it takes millions of years to create. The energy in coal comes from the energy stored by plants that died and were covered by layers of sediment at the bottom of swamps. The heat and pressure from layers above helped compress the plant remains into what we call coal. The four types of coal are classified depending on the amount of carbon present and the amount of heat energy each type can produce when it burns.

More than one-third of the coal produced in the United States comes from the Appalachian coal region. West Virginia is the second-largest coal-producing state in the country.

PROCESS OF COAL FORMATION



Before the dinosaurs, many giant plants died in swamps.

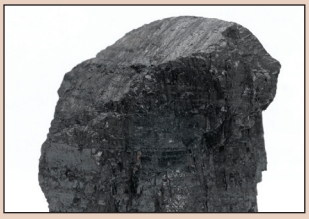
Over millions of years , the plants were buried under water and dirt.

Heat and pressure turned the dead plants into coal.

FOUR STAGES OF COAL

Peat: *Up to 65% carbon. Plant remains that have not yet turned to coal. Not used as a fuel in the United States. When dried, it is a highly effective absorbent for fuel and oil spills on land and water.*

Lignite: *65%–75% carbon. Uses: as the lowest rank of coal, it's used almost exclusively as fuel for electric-power generation.*



Bituminous: *85%–90% carbon. Uses: dense mineral, black or dark brown, used primarily as fuel in steam-electric power plants, for heat and power applications in manufacturing, and to make coke (for steel).*

Anthracite: *95%–99% carbon. Uses: harder, glossy, black coal is used primarily for residential and commercial-space heating.*

Events

360 mya: Plants and animals become established on land.

320–286 mya, Late Carboniferous Period: Much of the land mass of North America, Europe, and Northern Africa is located near the equator. The climate is warm and tropical.

320–280 mya:

- For about 40 million years, the sinking rate is about the same as the deposition rate.
- There are great forests of primitive plants on land—huge ferns, giant trees, vast swamps.
- Dead plants fall into boggy waters. Over centuries, they partially decompose into vast, thick mats of peat.
- On occasion, an area sinks below sea level. Swamps are submerged by shallow seas and are covered by sediment. Sedimentary rock layers form on top of peat layers.
- Successive cycles of uplift to create a swamp is followed by subsidence and sea submersion. The result is the sequence of horizontal bands of peat, sandstone, and shale.

300–270 mya:

- Under high temperature and pressure from layers of sediment, layers of peat morph into coal.
- Original plant layers compressed to as much as a 10- to 20-fold reduction in the thickness, forming horizontal coal seams (layers).

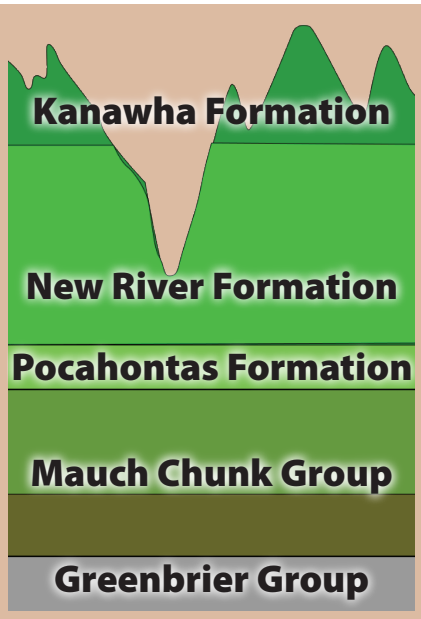
270–225 mya: West Virginia uplifted.

- Tectonic activity (folding and thrust faulting), which forms the Appalachian Mountains.
- Coal seams are folded and tilted by tectonic activity.

225–66 mya: There is repeated uplift and erosion.

65 mya: There is igneous activity in the eastern part of West Virginia.

45 mya: Dikes and sills made of basalt and rhyolite intrude into sedimentary rocks. These are some of the youngest rocks in eastern North America.



Rock Formations (from top to bottom)

Kanawha Formation (317 – 305 mya): *mostly sandstone with gray to dark-gray mudstone and shale and 26 mineable coal seams.*

New River Formation (319 – 317 mya): *sandstone with gray and dark-gray shale and several coal seams.*

Pocahontas Formation (320 – 319 mya): *sandstone, shale, and coal seams.*

Mauch Chunk Group (360-325 mya): *red, gray, and dark-gray shale; gray and red sandstone; and gray to dark-gray limestone. Some sandstone layers contain oil and natural gas.*

Greenbrier Group: *limestone with some gray to dark-gray and red shale. Oil and natural-gas deposits*

Vocabulary

carboniferous period the period of time (320–286 mya) when giant tropical forests in swamps covered much of the land. Enormous peat bogs were developing, which later turned to coal seams.

deposition the action of depositing something

subsidence sinking

tectonic activity large-scale processes resulting from the movement of Earth's crust

thrust fault an extended break in a body of rock, with relative movement putting older strata horizontally over younger strata

tropic equatorial regions between latitude 23°26' north and 23°26' south

uplift upward movement of Earth's surface

Geographer

Task

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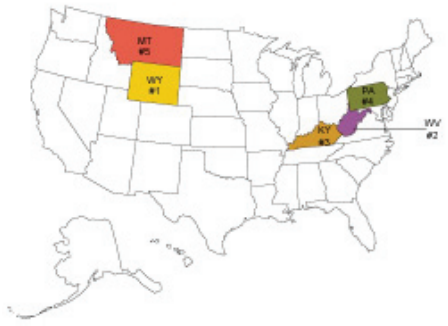
Questions for the Geographer

- **Which countries produce and consume the most coal?**
- **How does coal mining and coal use affect society?**

Information

- Major uses of coal are as
  - fuel (biggest used) to generate electricity, manufacture iron and steel, and manufacture cement;
  - raw material to make numerous other materials, such as plastics, fabrics, and carbon fiber;
  - raw material to convert into gas and liquid fuels.
- Coal is the least expensive fuel to use to generate electricity.
- 90% of the coal mined in the United States is used to generate electricity.
- 50% of electricity in the United States and 99% of electricity in West Virginia is generated in coal-fired power plants.
- The two largest industries in West Virginia are tourism and coal mining, both of which are very important to the economy of the state.
- About two-thirds of the coal mined in West Virginia is from underground mines, and about one-third is mined by mountaintop removal.
- Mountaintop-removal coal mining buries streams, tears down mountains and forests, destroys scenery, damages fish and wildlife habitats, pollutes water, and changes the topography of the area forever.
- Mountaintop-removal coal mining is less expensive and safer for the miners than underground coal mining.
- There is growing concern about the effect that the burning of any fossil fuels is having on global climate change.
- Residents of West Virginia argue bitterly over whether the jobs and income created from the mountaintop-removal mines are more important than other people's homes or the preservation of the area's natural beauty and heritage. The beauty and heritage draw millions of tourists to the state each year.

Top Coal-Producing States (2009)



Source: U.S. Energy Information Administration, Annual Coal Report 2009 *(Oct. 2010).*

Top 10 Coal-Producing Countries (unit: 1,000 short tons)

Country	2006	2007	2008	2009
China	2,572,076.0	2,743,724.6	2,849,983.4	3,209,677.3
U S	1,162,749.7	1,146,635.4	1,171,808.7	1,072,751.3
India	500,192.5	528,214.4	568,323.1	613,402.2
Australia	405,046.5	429,221.3	438,506.1	450,357.6
Russia	313,680.3	318,591.1	356,185.5	322,623.9
Indonesia	249,700.0	291,852.4	313,231.7	335,345.9
South Africa	269,817.2	273,005.1	259,596.5	256,862.0
Germany	220,553.8	225,528.3	214,351.1	167,622.5
Poland	171,134.9	159,773.4	157,881.9	146, 198.6
Kazakhstan	106,078.5	1.07,838.0	119,808.0	109,504.5
World	6,769,380.0	7,046,862.3	7,271,748.7	NA

Top 10 Coal-Consuming Countries (unit: 1,000 short tons)

Country	2006	2007	2008	2009
China	2,535,823.2	2,705,973.8	2,829,515.3	3,308,652.7
U S	1,112,291.8	1,127,998.1	1,120,548.4	1,000,423.6
India	539,485.5	583,948.3	637,521.8	608,873.3
Germany	270,533.7	281,338.5	269,892.1	222,930.9
Russia	240,254.3	230,401.8	269,684.9	222,631.3
Japan	198,108.5	207,580.7	203,979.4	185,621.3
South Africa	196,079.1	202,374.4	193,654.1	187,249.2
Australia	154,895.7	151,608.6	160,515.3	151,597.8
Poland	154,818.5	149,579.2	149,333.4	132,309.4
South Korea	89,636.65	98,225.9	112,843.6	117,191.0
World	6,724,693.1	7,019,212.7	7,238,207.6	NA

Coal as an Energy Source

Coal is burned in electric power plants in order to generate heat to vaporize water into steam, which, in turn, blasts through heavy-duty fans (turbines), which turn electric generators to create electricity.

Coal, oil, and natural gas are the three main types of fossil fuels burned in huge quantities in modern society.

Advantages of Coal as Fuel

- inexpensive, compared to other fossil fuels (or alternative-energy sources)
- more abundant source of energy than oil and natural gas
- electricity produced from coal is reliable
- can be safely stored and drawn upon in times of emergency
- not dependent on weather, unlike wind or solar power
- reduces dependence on fossil fuels in nations with unstable political regimes

Drawbacks of Coal as Fuel

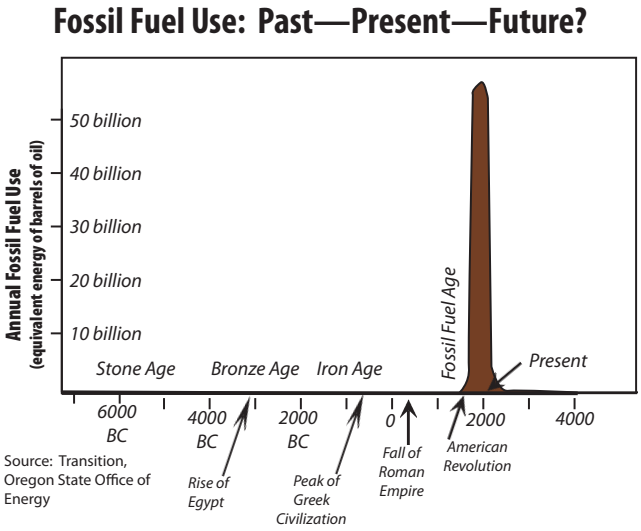
- air pollution when coal is burned; health problems, such as asthma and lung disease
- increased levels of carbon dioxide in atmosphere, leading to increase in average global temperature—climate change
- Mining coal with safety risks to humans and negative impacts on local environments
- Nonrenewable—takes millions of years to form

Events

1800s: Coal becomes the principal fuel used by steam-powered trains and steamboats. Coal is used to produce oil and gas for lighting.

1882: The first practical coal-fired electric generating station, developed by Thomas Edison, goes into operation in New York City to supply electricity for household lights.

1961: Coal becomes the major fuel used by electric utilities in the United States to generate electricity.



The graph of Fossil Fuel Use (above): "Fossil Fuel Age" just a blip in the course of human civilization. Throughout most of human history, no fossil fuels. Now humans burn equivalent of more than 50 billion barrels of oil a year with rate increasing. New fuels form very slowly: a certainty we will run out of fossil fuels, despite the global search for new fossil fuel deposits. The question is, "When?" At our present rate of fuel use: enough for at least 100 years but the price will continually increase as the fossil fuels become harder and harder to obtain. Source: Transition, Oregon State Office of Energy.

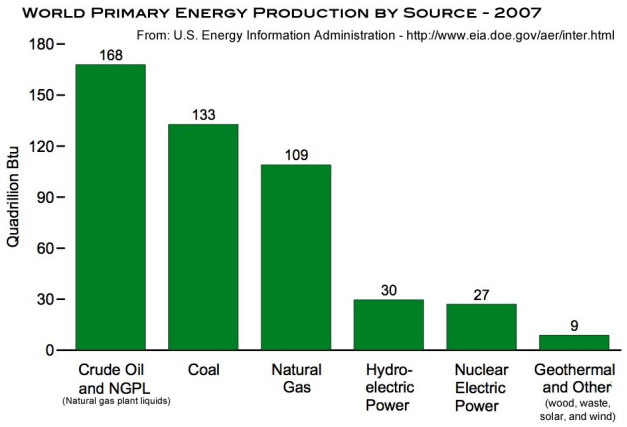


Chart illustrates a sense of how much coal dominates as a fuel source for energy production across the world. Right chart provides a perspective of how coal dominates as our most abundant fuel for creating electricity.

Vocabulary

combustible able to burn
fossil fuels fuels derived from the remains of ancient organisms. Coal, oil, and natural gas are the primary fossil fuels.
nonrenewable cannot be replaced within a useful period of time (usually 100 years or less)
pollution a contaminant in water or air
renewable can be replaced within a useful period of time

Coal Mining Engineer

Task

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Questions for the Coal Mining Engineer

- **How do we currently remove coal from the earth?**
- **What are some methods of making coal mining and coal use safer and healthier?**

Information

Duties of a Coal Mining Engineer:

- familiar with the geology, rock strata, water drainage, and the location of the coal seams
- plans how the mine will be developed and excavated
- plans for equipment needed for mining
- responsible for following safety and environmental policies and procedures
- in charge of restoring the area after coal has been removed

Types of Coal Mining

- **Underground (hard rock) coal mining:** deeper coal mines (hard-rock mining) are less safe and can result in cave-ins, explosions, or black lung disease from inhaling coal dust.
- **Strip mining or mountaintop removal (a type of strip mining):** a relatively safe and simple way to recover shallow coal deposits. Provides about half the coal for the United States. Is a five-step process. (See the pictures and drawings on the next page.)

Events

1748: The first commercial U.S. coal production begins near Richmond, Virginia.

1866: The practice of strip mining begins near Danville, Illinois. Horse-drawn plows and scrapers are used to remove the top layer of dirt or rocks so the coal could be dug and hauled away in wheelbarrows and carts.

1872: The C&O Railroad is completed, and coal can be shipped out of the area. This makes it possible for coal mining to flourish.

1907: On Dec. 6, 1907, 362 men and young boys are killed in an underground explosion at the Monongah Mine in West Virginia. This is the worst mining accident in the history of the United States.

1969: Federal Coal Mine Health and Safety Act of 1969 is passed by Congress. The Coal Act extended safety laws to surface mines and allowed miners with black lung disease to receive money for their care. More recent safety practices have made black lung disease, caused by inhaling fine coal dust, much less common than it used to be.

1970s: Mining companies begin using mountaintop-removal techniques.

1972: The Pittston Coal Company's dam bursts, unleashing over 132 million gallons of coal wastewater (cresting over 30 ft. high) and killing 125 people in what is called "The Buffalo Creek Flood."

2001: the United States Environmental Protection Agency (EPA) states that over 1,000 miles of Appalachian streams have been buried with overburden from mountaintop-removal mining.

2006: Coal production sets a record high with 1.16 billion short tons. Wyoming continues to dominate coal production in the United States.

2010: On April 5, 2010, 29 miners are killed in an underground explosion at the Upper Big Branch Mine in West Virginia. This is the worst mining accident in the United States since 1972.

A mountaintop-removal mining operation in West Virginia.

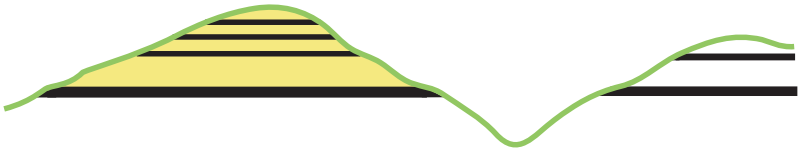
Vocabulary

strip mining surface mining in which soil and rock covering the coal are removed.

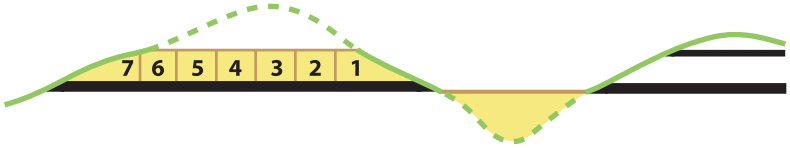
mountaintop-removal mining severe form of strip mining involving the removal of a mountain summit

Process of Mountaintop-Removal/Valley-Fill Coal Mining

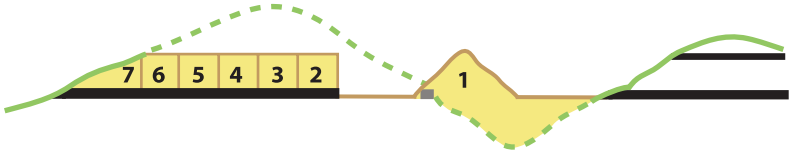
Step 1. *Layers of rock and dirt above the coal (called overburden) are removed.*



Step 2. *The upper seams of coal are removed, with spoils placed in an adjacent valley. Sometimes, over 300 meters of mountaintop has to be removed to get to the coal.*

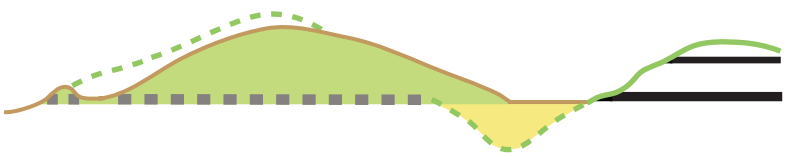


Step 3. *Draglines excavate lower layers of coal, with spoils placed in spoil piles.*



Step 4. *Regrading begins as coal excavation continues (see the black seam of coal at the bottom of the cliff).*

Step 5. *Once coal removal is complete, final regrading takes place, and the area is revegetated, usually with grass. The valley where a stream once flowed has been filled in with overburden. It is not possible for the mountains to be rebuilt, and it will probably be several decades or longer before a similar type of forest will regrow.*



Environmental Officer

Task

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Questions for the Environmental Officer

- **What are the environmental and human issues associated with extracting and using coal?**
- **What are the current efforts/solutions to these issues?**

Information

West Virginia has been debating both the costs and benefits of the mining industry for many years. Health, safety, and environmental issues are as impacted by mining practices as is employment and state revenue (which, in turn, funds most social services and schools).

In general, there is tension between society's need for coal to fuel our lifestyles and the adverse environmental effects, including polluting water systems, toxic sediment, and habitat destruction from removing mountaintops.

Environmental Problems Caused by Coal Mining

- Water that drains from a coal mine or through coal-mine spoils dissolves acidic chemicals, which creates acid runoff that will kill life in a stream.
- Water also dissolves toxic heavy metals found in coal and spoils and can contaminate streams and the human water supply.
- Abandoned underground mines collapse and create surface subsidence.
- The issue of where to place the spoils must be addressed.

Problems Caused by Mountaintop-Removal/ Valley-Fill Mining

- Forest habitats are destroyed.
- Mountaintops are removed. The overburden is dumped into valleys, which covers and destroys streams.
- Eroded sediment from the bare hills clouds the water and destroys or severely damages the stream habitat. Fish and other animals die.

After the mining is completed, federal law requires that the area be restored to its original surface condition. However,

- it is impossible to rebuild the mountain.
- it is impossible to restore forest habitats and streams to anything similar to what they were before the mining.

Events

1977: The Surface Mining Control and Reclamation Act of 1977 is passed by Congress. The purpose of the act is to reduce the environmental impact of surface mining. The act requires that surface mines no longer be used to be reclaimed, or restored, to their natural state.

1980: The National Acid Precipitation Assessment Program (NAPAP) study begins. Industries spend over $1 billion on air-pollution control equipment.

1986: The Clean Coal Technology Act passes.

2001: According to an EPA environmental-impact statement, more than 1,000 miles of Appalachian streams are permitted to be buried.

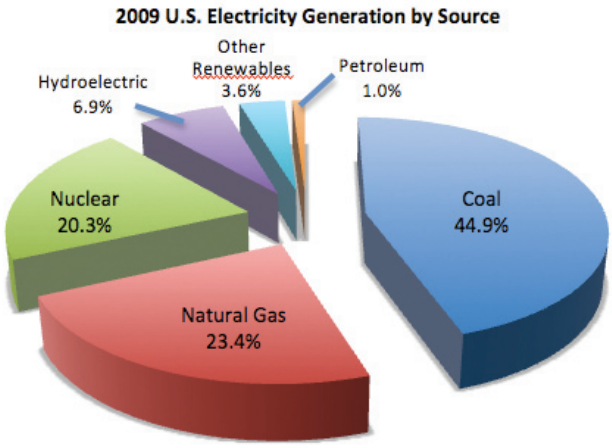
2003: The United States sponsors a $1-billion, 10-year demonstration project to create the world's first coal-based, zero-emissions electricity and hydrogen power plant.

2009: The U.S. government decides to fund research projects for CO_2 reduction instead of the 2003 plan for a zero-emission power plant.

Land destruction and air pollution from mining industry.

Hidden Costs of Using Coal (and other fossil fuels)

- additional health costs from respiratory disease (asthma, emphysema, infections)
- costs to clean up mine sites and streams
- costs for extra water treatment
- loss of recreational and scenic areas
- added expenses caused by climate change (more severe storm disasters, higher insurance, protection against sea-level rise, crop failures resulting in more expensive food, higher energy bills, etc.)
- renewable energy sources probably become much more cost competitive



What Consumers Can Do to Curb Impact on Coal Production and Use

- Seek electricity from green power, if possible. Most electric companies have this option.
- Since green power costs more, use less electricity to keep monthly bills down.
- Keep the home temperature between 65°F and 78°F. Close the blinds during hot days to keep the Sun out. Be conscious of not heating or cooling the outdoors!
- Replace lightbulbs with energy-efficient blubs. Turn off lights when leaving the room. Keep appliances and cell-phone chargers unplugged when not in use.
- Reuse things. Reduce new purchases. Recycle.
- Use a reusable water bottle instead of plastic, disposable bottles.

Problems with Using Coal as Fuel

- The release of greenhouse gasses (CO_2) when coal burns contributes to global climate change.
- Particulates (soot), toxic heavy metals, and chemicals that combine with moisture in the air to create acid rain are released into the air when coal burns.
- Soot and acid rain kill vegetation and damage buildings and vehicles.
- Trace amounts of heavy metals are released into the air and anywhere that soot falls.
- Soot, heavy metals, and acid rain cause health problems for people.
- A federal law passed in 1980 required power plants to clean the smoke from burning coal. This dramatically reduced the amount of soot, heavy metals, and chemicals released into the air, which create acid rain. However, it did *not* reduce the amount of carbon dioxide being released.

Problems Dealing with Carbon Dioxide

- With climate change, CO_2 emissions are becoming a more serious issue.
- Methods have been proposed to capture and store the carbon dioxide so it won't go into the air.
- Carbon capture and storage (CCS) is technically difficult, very expensive, and would require significantly more energy to run the equipment.
- CCS would make electricity generated by burning fossils fuels much more expensive.

Vocabulary

carbon dioxide an odorless, colorless gas produced when carbon combines with oxygen, as it does when fossil fuels burn

fossil fuels fuels that are composed of the remains of ancient plants and animals

greenhouse gases atmospheric gases that trap heat, causing a rise in temperature

hidden costs costs in addition to the price paid for the product

overburden the rock or soil layer(s) that is on top of the coal or ore that is being mined

slurry pit a pit where the mixture of water, coal dust, soil, toxic heavy metals, and other sediments that result from washing the coal are stored so they will not pollute streams and water supplies

spoils soil or rock that is removed in order to mine the coal or ore

valley fill rock or soil from the mountaintop that is removed and used to fill in a nearby valley