EARTH

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THE HUMAN ELEMENT

> *"What we've dug up from the earth and burned has changed the other elements. Burning too much coal, oil, and natural gas has dumped toxic gases into the atmosphere and altered the climate."*
>
> **—James Balog, *The Human Element***

EARTH LESSON OBJECTIVES

Since the industrial revolution, technology that harnesses the earth's natural resources to create energy has continued to evolve. As we see in ***The Human Element***, coal remains a key source of energy and a cornerstone of the economy in many rural American communities. While the extraction and burning of coal is not the sole energy source contributing to climate change – since oil and natural gas also play pivotal roles – coal will be the central focus of this lesson.

At the end of the lesson, students will be able to:

- Explain how the human use of coal has altered the earth and how those changes are affecting humans.
- Use visual evidence and scientific data to articulate how different fuels are currently used in our economy.
- Explore the ways in which renewable energies are emerging to change our reliance on and consumption of fossil fuels.

MATERIALS

- You can find the Earth Chapter here: **https://vimeo.com/329007369**. The password is: **THEedu**.
- Projection equipment to screen the "Earth" chapter of ***The Human Element***
- Printed copies of **Handout One—Earth Note Catcher**
- Printed copies of **Handout Two—Artist Statement**
- Student access to the internet or copies of **Research Appendix One and Two**

DURATION

Two 50-minute class periods

OPENING EXERCISE: CLIMATE CHANGEMAKER

Read aloud, project, or print and distribute this introduction to Barbara Freese, author of Coal: A Human History*:*

Barbara Freese reveals the complexity of the social and economic challenges we face as we confront how burning fossil fuels causes climate change. As the power source of the original steam engines, electricity, and other fossil fuel mining technologies, coal is firmly embedded in the development of our modern world, and cannot easily be replaced. Freese's scholarship shows that, while it is clear we need to drastically reduce our burning of fossil fuels in order to slow or reverse the effects of climate change, the economic and human costs of how we do it must be considered.

Use a continuum activity to get students thinking about the interaction between people and the acquisition and burning of fossil fuels.

Designate one side of the room as an "Agree" side and the other side as a "Disagree" side. Ask students to stand and place themselves along the continuum according to their answers to the below statements. Once students have spread out along the continuum, ask for a few comments from different sides. This activity is not meant to elicit argument but, rather, reveal different perspectives.

1. Preventing climate change is more important than the economies of towns that rely on fossil fuels.
2. People employed in fossil fuels industries do not care about the environment.
3. Our modern world can exist without a reliance on fossil fuels.
4. It is important to consider the human costs of shifting away from fossil fuels, such as lost jobs and changing economies.
5. Our society needs energy from fossil fuels, and transitioning to renewable energy sources won't work.

Watch the Film Chapter "Earth" (run time, 14:25)

Distribute **Handout One—Earth Note Catcher** and ask students to take notes as they watch "Earth." After the chapter ends, offer students a brief opportunity to share what they noticed or learned.

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EXPLORE THE EFFECTS OF HUMANS' USE OF COAL

The following quote and quick facts can be shared aloud, printed, or projected as background information.

> *"There have actually been at least two industrial revolutions. The first one was fueled by steam, which was fueled by coal. The second one was driven by electricity, and electricity and coal went hand-in-hand. Within a couple of years after inventing the light bulb, Thomas Edison was building a coal-fired power plant, and when electricity grew in this nation it allowed us to use all kinds of newer, more modern technologies. It really changed our lives, and that very much depended—not entirely, but almost entirely—on coal."*
>
> **—Barbara Freese, in an interview for *The Human Element***

There are three major pollutants affecting our earth and contributing to our warming climate: the burning and use of **coal**, **oil** and **natural gas**. Oil and gas, like coal, are the organic remains of ancient animals and plants rotting and decomposing deep inside the earth. The United States gets 80 percent of its total energy from fossil fuels (coal, oil, and natural gas), 9 percent from nuclear energy, and 11 percent from renewable sources. We depend on those fuels to heat our homes, run our vehicles, power industry and manufacturing, and provide our nation with electricity.[1]

Coal Quick Facts:

- Coal is the dirtiest fuel source in the world. For every gram of carbon burnt, coal produces nearly four grams of CO_2.
- Coal plants are responsible for 42 percent of U.S. mercury emissions and much of today's atmospheric warming.
- In the United States today, burning coal satisfies roughly 30 percent of total electricity demand (down from almost half the supply at its peak in the mid-20th century).
- Burning natural gas emits about half the CO_2 of coal, but drilling, fracking, and burning natural gas releases methane—a greenhouse gas roughly 34 times stronger than CO_2 in terms of trapping heat to the earth, which is a leading cause of climate change.[2]
- Coal is among the least expensive fossil fuels to convert from its geological state to fuel that can be used for energy.[3]
- Approximately 100,000 Americans are directly employed in coal mining and/or the function of coal power plants, with an estimated 10 times that number indirectly employed by coal, either as contractors who transport or store coal, or as people who support the economies of towns created around coal mines or power plants.[4]

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Instruct students to gather further information about coal, including where it comes from, how it is used, its impact on climate change, and its relationship to the U.S. economy. Students may read Research Appendix One, Research Appendix Two, and/or conduct research online.

When students complete their research, ask them to write three "headlines" about what they learned, beginning with the following phrases:

- "Coal mining is..."
- "Coal's use is..."
- "The coal economy is..."

Have students share their headlines aloud in a choral reading format. Then discuss as a class what you heard from one another, the questions that remain, and any conclusions you have reached about the relationship of coal to society, energy and climate change.

EFFECTS: VISUAL EVIDENCE

Ask students to find an image that best represents what they have learned about the central role of coal as an energy source in today's economy. Images may come from the film chapter, the TheHumanElementMovie.com/earth/ website, or other images they find during their research.

Instruct students to prepare to present the following information about each image:

1. What do you see in this image?
2. What does this image tell you about the relationship between humans and coal?
3. What does the image tell you about coal consumption's effect on the earth?
4. Where does the image come from? Do you trust what you see in the image? Why or why not?
5. What do you hope the person looking at the image learns about coal or renewable energy?
6. What ideas or actions does this photo suggest to you as you think about how to influence modern society's use of fossil fuels?

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THE HUMAN ELEMENT OF CHANGE

"Humans, like almost every life form, ultimately depend on solar energy. Initially we depended on energy from the sun in the sense that it warmed us. And the plants that were collecting solar energy fed us, as did the animals that ate those plants. So you can look at nature as this vast system of collecting solar energy, and storing it, and then distributing it. And the success of our species depends in part on how well we are able to collect that energy and put it to our own uses."

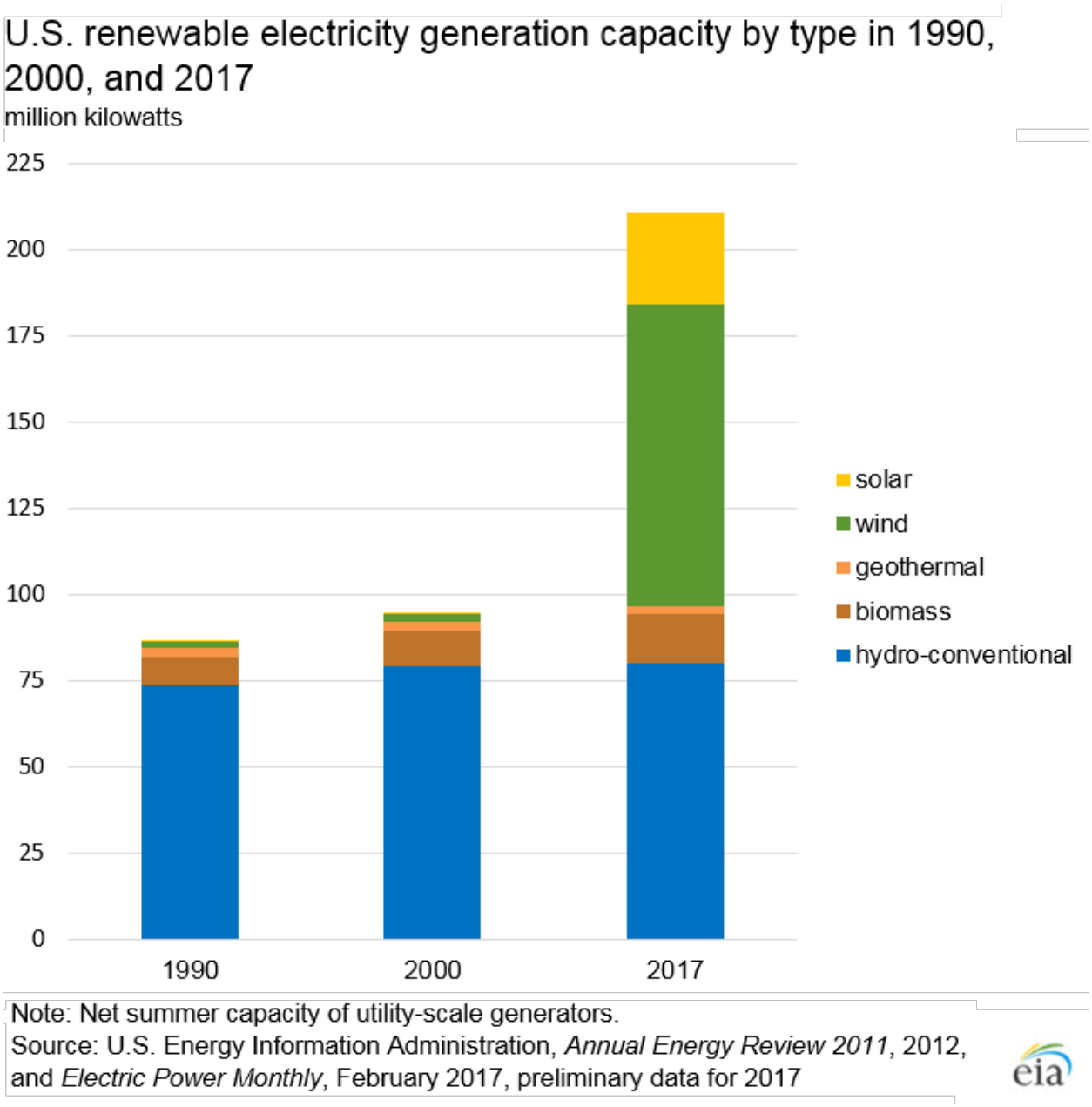
—Barbara Freese, in an interview for *The Human Element*

"People have always evolved from one technology to another. The technology of my grandfather's time became the junk pile of today. Ingenuity moves us all forward, and that gives me hope."

—James Balog, *The Human Element*

Project or distribute the following information and graph to your students to discuss how humans are transitioning from fossil fuels:

The U.S. Energy Information Agency (EIA) forecasts that renewables will be the fastest growing source of electricity generation as a result of increased generating capacity.[5] Since 2000, the growth of renewables has steadily increased, as have consumer conservation efforts.



Note: Net summer capacity of utility-scale generators.
Source: U.S. Energy Information Administration, *Annual Energy Review 2011*, 2012, and *Electric Power Monthly*, February 2017, preliminary data for 2017

eia

https://www.eia.gov/energyexplained/index.php?page=electricity_in_the_united_states#tab2

The above chart represents the growth of different types of renewables since 1990. It is also worth noting that, in Iowa and Texas specifically, wind energy currently accounts for 36 percent and 15.7 percent, respectively, of the total electricity generated in each state.

This lesson culminates with a project to help students synthesize their learning of our society's reliance on coal as well as the opportunity to transition to renewable energy sources. These projects can be completed during class or assigned as homework. If you are planning to complete all four of ***The Human Element*** lessons, this portion of the lesson can contribute to the final Culminating Lesson.

Suggested project ideas:

1. Interview someone who is involved in energy in your community about your city or town's energy consumption. Consider the state public utilities commission or a communications person from an energy company.

2. Choose a major energy company for either coal, natural gas or petroleum, and research their public statements about how they are trying to protect the environment. Check newspapers, magazines or other reliable sources that corroborate or challenge what the companies say they are doing.

3. Create an artistic expression representing how people's lives will change as we decrease our dependence on fossil fuels. This can be about how communities whose economies revolve around it will change, or how habits of energy users will have to change. See **Handout Two—Artist Statement** for a written artist statement to accompany the project, as well as a peer review exercise.

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HANDOUT ONE

EARTH NOTE CATCHER

As you watch, write down ideas, words, or phrases that stand out to you:

What is the film teaching you about the human causes and costs of coal?

What further questions do you have?

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HANDOUT TWO

ARTIST STATEMENT

Artist Statement:

Write a paragraph about your artwork. What does it say about how human use of coal has altered the earth, and how those changes are affecting humans?

Peer Review Questions:

What message do you gain from the artwork and the artist's statement above?

What questions arose for you, and what would you like to know more about?

What did you like about this work?

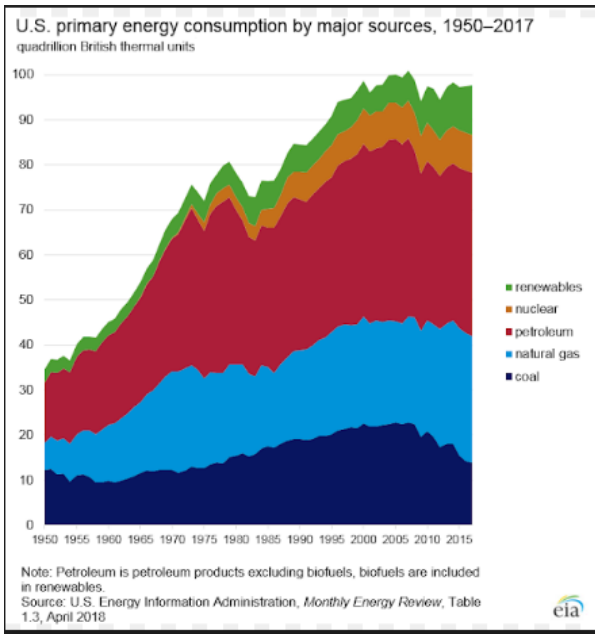
What opportunities for growth do you see?

RESEARCH APPENDIX ONE

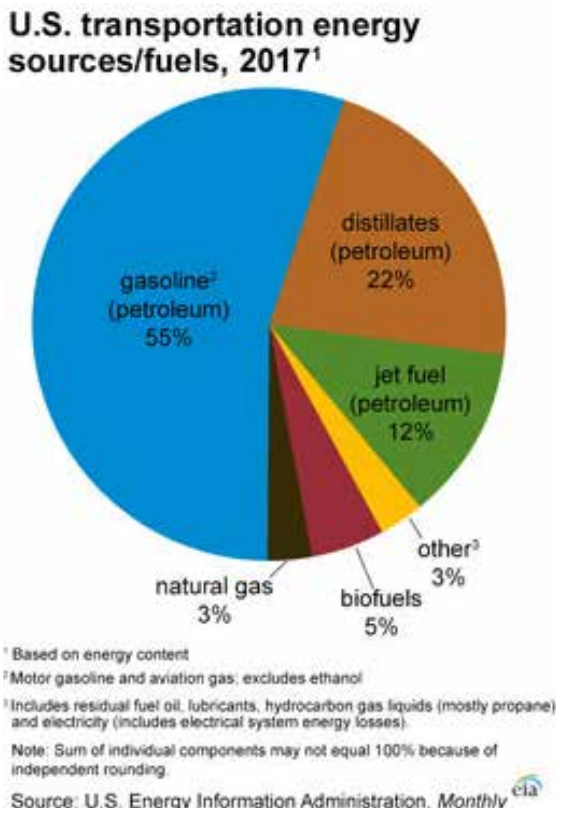
COAL

Adapted from: https://www.eia.gov/energyexplained/index.php?page=coal_home

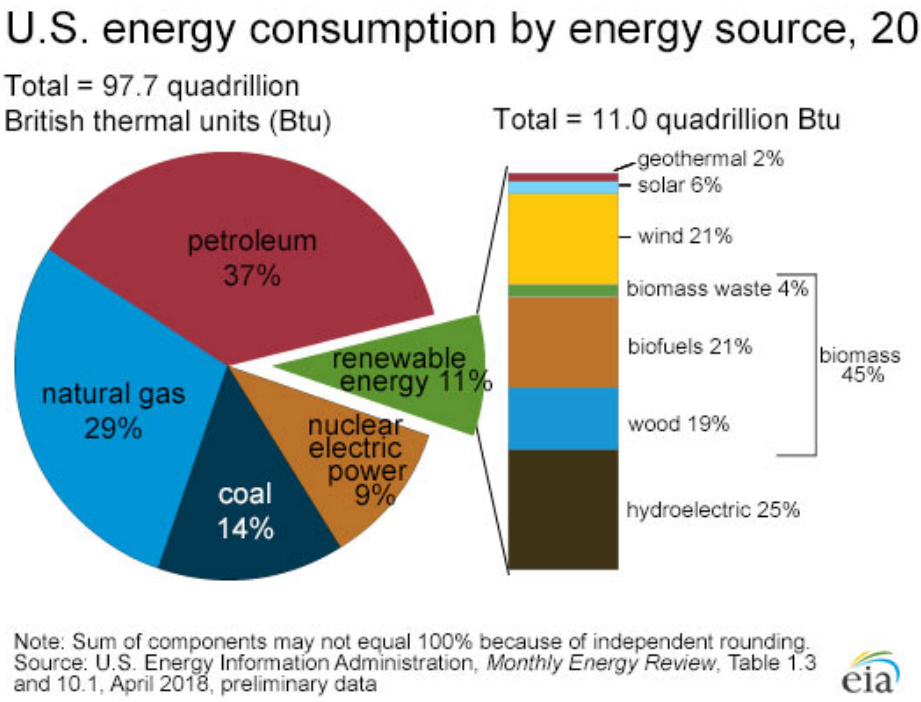
The below three graphics from the U.S. Energy Information Administration (EIA) offer a big picture of coal's role in U.S. energy consumption:



https://www.eia.gov/energyexplained/?page=us_energy_home



https://www.eia.gov/energyexplained/?page=us_energy_home



https://www.eia.gov/energyexplained/?page=us_energy_transportation

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COAL

Adapted from: **https://www.eia.gov/energyexplained/index.php?page=coal_home**

Coal is a combustible black or brownish-black sedimentary rock with a high amount of carbon and hydrocarbons. Coal is classified as a nonrenewable energy source because it takes millions of years to form. Coal contains the energy stored by plants that lived hundreds of millions of years ago in swampy forests.

Mining coal

Coal miners use large machines to remove coal from the earth. Many U.S. coal deposits, called coal beds or seams, are near the earth's surface, while others are deep underground. Modern mining methods allow coal miners to easily reach most of the nation's coal reserves and produce about three times more coal in one hour than in 1978.

Coal miners use two primary methods to remove coal

Surface mining is often used when coal is less than 200 feet underground. In surface mining, large machines remove the topsoil and layers of rock known as overburden to expose coal seams. Mountaintop removal is a form of surface mining where the tops of mountains are dynamited and removed to access coal seams. Once the coal is removed, the disturbed area may be covered with topsoil for planting grass and trees. About two-thirds of U.S. coal production is from surface mines because surface mining is less expensive than underground mining.

Underground mining, sometimes called deep mining, is necessary when the coal is several hundred feet below the surface. Some underground mines are thousands of feet deep with tunnels that may extend out from the vertical mine shafts for miles. Miners ride elevators down deep mine shafts and travel on small trains in long tunnels to get to the coal. The miners use large machines to dig out the coal.

Effects of coal mining

Surface mines (sometimes called strip mines) were the source of about 65% of the coal mined in the United States in 2017. These mining operations remove the soil and rock above coal deposits, or seams.

Mountaintop removal and valley fill mining has affected large areas of the Appalachian Mountains in West Virginia and Kentucky. In this form of coal extraction, the tops of mountains are removed using explosives. This technique changes the landscape, and streams are sometimes covered with rock and dirt. The water draining from these filled valleys may contain pollutants that can harm aquatic wildlife downstream. Although mountaintop mining has existed since the 1970s, its use became more widespread and controversial beginning in the 1990s.

U.S. laws require that dust and water runoff from areas affected by coal mining operations must be controlled, and the area must be reclaimed close to its original condition.

Underground mines generally affect the landscape less than surface mines. However, the ground above mine tunnels can collapse, and acidic water can drain from abandoned underground mines.

Methane gas that occurs in coal deposits can explode if it concentrates in underground mines. This coalbed methane must be vented out of mines to make mines safer places to work. In 2016, methane emissions from coal mining and abandoned coal mines accounted for about 9% of total U.S. methane emissions and nearly 1% of total U.S. greenhouse gas emissions (based on global warming potential). Some mines capture and use or sell the coalbed methane extracted from mines.

Where the United States gets its coal

In 2017, about 775 million tons of coal were produced in 24 U.S. states. Surface mines were the source of 65% of total U.S. coal production and accounted for 64% of the total number of mines. About 0.7 million tons, or about 0.1% of total coal production, was refuse recovery coal.

Five states accounted for approximately 71% of total U.S. coal production in 2017:

- Wyoming—41%
- West Virginia—12%
- Pennsylvania—6%
- Illinois—6%
- Kentucky—5%

Coal is mainly found in three regions: the Appalachian coal region, the Interior coal region, and the Western coal region (includes the Powder River Basin).

Coal consumption

In 2017, about 717 million tons of coal were consumed in the United States, equal to about 14% of total U.S. energy consumption. The electric power sector accounts for most of U.S. coal consumption. U.S. coal consumption peaked in 2007 and has declined in most years since then, mainly because of the use of other energy sources for electricity generation.

Industry

Many industries use coal and coal byproducts. The concrete and paper industries burn large amounts of coal to produce heat. The steel industry uses coal indirectly to make steel. Coal coke is made by baking coal in furnaces. The steel industry uses coal coke to smelt iron ore into iron to make steel. The high temperatures created by burning coal coke give steel the strength and flexibility needed for bridges, buildings, and automobiles.

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Emissions from burning coal

Several principal emissions result from coal combustion:

- Sulfur dioxide (SO_2), which contributes to acid rain and respiratory illnesses.
- Nitrogen oxides (NOx), which contribute to smog and respiratory illnesses.
- Particulates, which contribute to smog, haze, and respiratory illnesses and lung disease.
- Carbon dioxide (CO_2), which is the primary greenhouse gas produced from burning fossil fuels (coal, oil, and natural gas).
- Mercury and other heavy metals, which have been linked to both neurological and developmental damage in humans and other animals.
- Fly ash and bottom ash, which are residues created when power plants burn coal.

In the past, fly ash was released into the air through the smokestack, but laws now require that most emissions of fly ash be captured by pollution control devices. In the United States, fly ash and bottom ash are generally stored near power plants or placed in landfills. Pollution leaching from ash storage and landfills into groundwater and several large impoundments of ash that ruptured are environmental concerns.

Reducing the environmental effects of coal use

The Clean Air Act and The Clean Water Act require industries to reduce pollutants released into the air and water.

The coal industry has found several ways to reduce sulfur and other impurities from coal. The industry has also found more effective ways of cleaning coal after it is mined, and some coal consumers use low sulfur coal.

Power plants use flue gas desulfurization equipment, also known as scrubbers, to clean sulfur from the smoke before it leaves their smokestacks. In addition, the coal industry and the U.S. government have cooperated to develop technologies that can remove impurities from coal or that can make coal more energy efficient, which reduces the amount of coal that is burned per unit of useful energy produced.

Equipment intended mainly to reduce SO_2, NOx, and particulate matter can also be used to reduce mercury emissions from some types of coal. Scientists are also working on new ways to reduce mercury emissions from coal-burning power plants.

Research is underway to address emissions of carbon dioxide from coal combustion. One method is carbon capture, which separates CO_2 from emissions sources and recovers it in a concentrated stream. The CO_2 can then be injected underground for permanent storage, or sequestration. [So far no projects of this sort have proven to be economically viable at a meaningfully large scale.]

Reuse and recycling can also reduce the environmental effects of coal production and use. Land that was previously used for coal mining can be reclaimed and used for airports, landfills, and golf courses. Waste products captured by scrubbers can be used to produce products such as cement and synthetic gypsum for wallboard.

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ENDNOTES

1 http://needtoknow.nas.edu/energy/energy-sources/fossil-fuels/

2 https://thehumanelementmovie.com/earth/

3 http://needtoknow.nas.edu/energy/energy-sources/fossil-fuels/coal/

4 https://phys.org/news/2018-11-uncertain-future-coal.html

5 https://www.eia.gov/todayinenergy/detail.php?id=38053