



## Carbon, Climate, and Energy Resources

### Module 4. Fossil Fuel Formation

#### Activity 3. Coal ranks and their heating value — Student Worksheet

Coal has been the largest energy source for electricity generation, and the burning of coal is one of the largest sources of carbon dioxide emissions — a greenhouse gas related to global warming. Coal is an organic sedimentary rock formed from the remains of plants. It is composed mostly of carbon, along with oxygen, hydrogen, and nitrogen. Coal burns readily, and contains more than 50% by weight (or 70% by volume) of carbonaceous, organic matter.

##### 1. Examining coal specimens

A. Compare and contrast the four coal samples provided, and list the characteristics of each in the table below. Then, identify each type of coal based on the information presented in the PowerPoint presentation.

	Color	Hard or crumbly?	Sooty?	Luster (shiny or dull?)	Plant material visible?	Identify type of coal
1.						
2.						
3.						
4.						

B. List the four types of coal in order by rank, from lowest to highest. Then line up the four coal samples in order by rank from lowest to highest to observe how they change.

C. Describe how the appearance of the coal changes as its rank increases.

D. Based on appearance alone, *without looking up the answer*, speculate on which type of coal you think contains the most carbon.

Explain your reasoning:



## 2. Comparing the carbon content and heating value of different ranks of coal

Different types of coal contain different percentages of carbon. Carbon, the major component of coal, is the principal source of heat when coal is burned. The highest percentage of carbon is found in the highest-rank coal. High-rank coal also has higher heating value or energy output, as shown in the table below. Heat is produced when carbon and hydrogen atoms combine with oxygen. Carbon combines with oxygen to produce carbon dioxide (CO<sub>2</sub>). Heating value (or energy output when a coal is burned) is typically expressed in British thermal units (BTU) per pound of coal burned. One BTU is the amount of energy needed to heat (or cool) one pound of water by one degree Fahrenheit. Water, minerals, and non-combustible elements reduce the heating values of coals.

Different ranks of coal can be compared by amount of coal necessary to produce a given amount of energy. This is typically expressed in pounds of coal burned to produce 1 million BTU (or 1,000,000 BTU) of heat energy.

A. Calculate the weight (number of pounds) of each rank of coal that would have to be burned to produce 1 million BTU (or 1,000,000 BTU) of heat, using the data in the table. Because a range of heating values (or energy output) is given for each coal rank, include a range in your answers. Put your answers in the column on the right, in the table below.

*As an example, here is how to set up the calculation for the first one.*

*1,000,000 BTU /5,500 BTU per pound = 181.8 pounds (lb) and 1,000,000 BTU /8,300 BTU per pound = 120.48 pounds (lb).*

Coal Rank	Carbon Content	Heating value or energy output (BTU per pound)	Weight of coal burned to produce 1 million BTU? (pounds)
Lignite	46 - 60%	5,500 to 8,300 BTU/lb (average= 6,900 BTU /lb)	120.48 to 181.8 lb
Sub-bituminous coal	46 - 60%	8,300 to 13,000 BTU /lb	
Bituminous coal	46 - 86%	11,000 to 15,000 BTU /lb	
Anthracite coal	86 - 98%	13,500 to 15,600 BTU /lb	

Compiled from <http://theenergylibrary.com/node/12170>



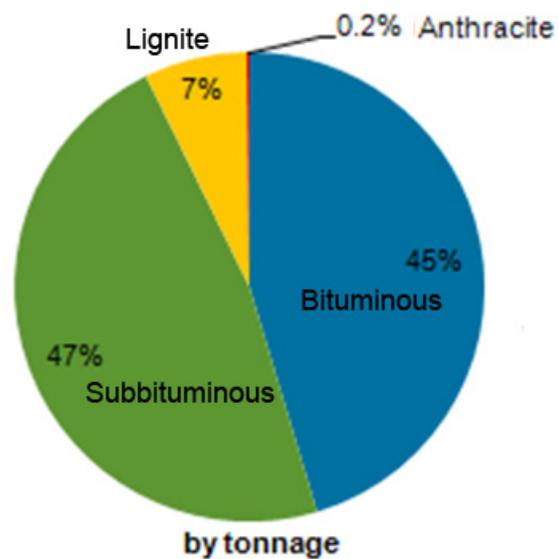
B. Which rank of coal has the greatest carbon content? \_\_\_\_\_

C. Which rank of coal has the greatest heating value? \_\_\_\_\_

D. Which type of coal is the most energy efficient to burn? \_\_\_\_\_

Although a certain rank of coal has the highest carbon content, and is the most energy efficient to burn, it is relatively rare in the United States, and comprises only 0.2% of total coal production, as shown in the diagram below.

This figure illustrates U.S. coal production by type of coal in 2010. Answer the question that follows on the basis of what you know about coal rank and heating value.



■ Bituminous   ■ Subbituminous   ■ Lignite   ■ Anthracite

Source: U.S. Energy Information Administration (August 2014)  
<http://www.eia.gov/todayinenergy/detail.cfm?id=2670>

E. Predict the relative amount of energy generated by each of the four types of coal. List the four coal types in order, starting with the type that produced the most energy and finishing with the type that produced the least energy.

Most energy —

Second most energy —

Third most energy —

Least energy —