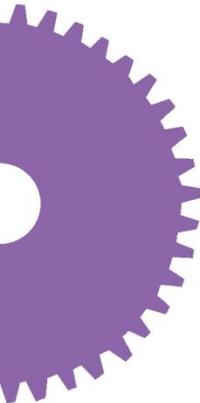


# SUSTAINABLE MANUFACTURING CURRICULUM

GREENING THE FUTURE BY EDUCATING TOMORROW'S WORKFORCE



## MODULE 3 ENERGY AND CARBON



## FACILITATORS GUIDE



## TABLE OF CONTENTS

Learning Objectives.....	3
Approved Resource Materials.....	4
Glossary Terms.....	5
Module-At-A-Glance.....	7
<b>Step-By-Step Instructions</b>	
Introduction.....	11
Carbon Intensity of Energy Sources.....	14
Why Carbon Matters to Manufacturers.....	18
How Manufacturers Pay For Energy.....	23
Energy Efficiency.....	29
<b>Appendix A: Video Resource List</b> .....	36
<b>Appendix B: Module Quizzes</b> .....	37
<b>Appendix B: Facilitator Materials</b>	
KLW Chart.....	43
Environmental Terms Crossword.....	44
What Is Energy Explained.....	46
The Use of Energy In The United States Explained.....	48
Your Family's Carbon Footprint.....	50
A Simple Energy Audit.....	57
<b>Concluding Activity</b> .....	60

## LEARNING OBJECTIVES

By the end of this session, students will be able to:

- Define energy.
- Rank the carbon intensity of various energy sources.
- Describe the role of carbon dioxide and other air emissions in the greenhouse effect.
- Calculate a discrete carbon footprint and propose ways to reduce it.
- Read and disseminate information from an industrial energy bill.
- Recognize energy intensive manufacturing processes and equipment.

## APPROVED RESOURCE MATERIALS

Throughout the workshop, you will see references to approved materials not included in Appendix C which include:

*Carbon Dioxide Emissions from the Generation of Electric Power in the United States:*  
[http://www.eia.gov/cneaf/electricity/page/co2\\_report/co2emiss.pdf](http://www.eia.gov/cneaf/electricity/page/co2_report/co2emiss.pdf)

*Life Cycle Balance and Greenhouse Gas Emissions of Nuclear Energy:*  
[http://www.isa.org.usyd.edu.au/publications/documents/ISA\\_Nuclear\\_Report.pdf](http://www.isa.org.usyd.edu.au/publications/documents/ISA_Nuclear_Report.pdf)

*Climate Literacy: The Essential Principals of Climate Sciences:*  
<http://downloads.climate-science.gov/Literacy/Climate%20Literacy%20Booklet%20Low-Res.pdf>

Energy Policy Act of 2005: <http://www1.eere.energy.gov/femp/regulations/epact2005.html>

*Energy Strategy for the Road Ahead: Scenario Thinking for Business Executives and Corporate Boards:* [http://www.energystar.gov/ia/business/GBN\\_Energy\\_Strategy.pdf](http://www.energystar.gov/ia/business/GBN_Energy_Strategy.pdf)

*Energy Efficiency Improvement and Cost Saving Opportunities for the Vehicle Assembly Industry: An ENERGY STAR® Guide for Energy and Plant Managers:*  
<http://www.energystar.gov/ia/business/industry/LBNL-50939.pdf>

*Energy Efficiency Improvement and Cost Saving Opportunities for the Vehicle Assembly Industry:*  
<http://www.energystar.gov/ia/business/industry/LBNL-50939.pdf>.

## Glossary Terms

*Alternative energy*—energy derived from nontraditional sources (e.g., compressed natural gas, solar, hydroelectric, wind).

*Autonomous maintenance*—ongoing maintenance activities performed by equipment operators on their own equipment.

*Carbon dioxide*—naturally occurring gas, and also a byproduct of burning fossil fuels and biomass, as well as land-use changes and other industrial processes. It is the principal anthropogenic greenhouse gas that affects the Earth's radiative balance.

*Carbon footprint*—the total amount of greenhouse gases that are emitted into the atmosphere each year by a person, family, building, organization, or company.

*Carbon intensity*—the amount of carbon by weight emitted per unit of energy consumed. A common measure of carbon intensity is weight of carbon per British thermal unit (Btu) of energy.

*Climate*—the average weather in an area.

*Consumption charges*—charge applied for the amount of an energy source used during a billing period.

*Demand charges*—charge applied in an electricity bill that is based on the peak use each month averaged over a short time period.

*Electricity*—a form of energy generated by creating an electrical charge.

*Energy*—the capacity to perform work.

*Energy audit*—accounting analysis of energy flows in a building, process, or system to establish a baseline for the amount of energy input into the system and to identify potential reductions.

*Energy efficiency* —reducing the amount of energy required to heat and cool homes, and to power appliances and electronics.

*Fuel adjustment charges*—charges that account for fluctuations in the cost of fuel, or purchased power, used to supply electricity.

*Fuel costs*—amount charged for the fuel you receive and a delivery charge for the transportation and delivery of the fuel. Fuel charges can vary based on seasonal demand or by the volume purchased.

## Glossary Terms

*Greenhouse effect*—trapping and build-up of heat in the atmosphere (troposphere) near the Earth's surface.

*Greenhouse gas*—any gas that absorbs infrared radiation in the atmosphere. Greenhouse gases include, but are not limited to, water vapor, carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O), chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), ozone (O<sub>3</sub>), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF<sub>6</sub>).

*Infrared radiation*—radiation emitted by the Earth's surface, the atmosphere and the clouds.

*Non-renewable energy*—energy from a natural resource that cannot be re-made, re-grown or regenerated on a scale comparative to its consumption.

*Peak demand*—measure of metered usage at the highest rate over a short (15, 30, or 60 minute) interval for the billing period.

*Power factor adjustments*—charges that account for a manufacturing facility's ability to effectively convert the electrical input current and voltage into "useful" electric power.

*Radiation*—transmission of energy through space or any medium.

*Renewable energy*—energy obtained from sources that are essentially inexhaustible. Renewable sources of energy include wood, waste, geothermal, wind, photovoltaic, and solar thermal energy.

*Solar radiation*—radiation emitted by the sun.

*Total productive maintenance*—to focus on optimizing the effectiveness of manufacturing equipment through team-based maintenance that involves employees at every level and function.

*Transmission charges*—charge added to a customer's energy bill to cover the cost of delivering energy over the distance between the supply or generation facility to the local utility's distribution system.

*Visual controls*—graphic prompts or cues that reinforce standardized procedures or display the status of an activity that every employee can see and take appropriate action.

*Weather*—atmospheric condition at any given time or place.

**MODULE-AT-A-GLANCE**

<b>Duration &amp; Elapsed Time</b>	<b>Module 3 Topics</b>	<b>Assets</b>
10 minutes <i>10 minutes</i>	Introduction	Facilitator Notes PowerPoint Slides Flipchart Handouts Activity 1
20 minutes <i>30 minutes</i>	Carbon Intensity of Energy Sources	Facilitator Notes PowerPoint Slides Images Activity 2
25 minutes <i>55 minutes</i>	Why Carbon Emissions Matter to Manufacturers.	Facilitator Notes PowerPoint Slides Images Videos Handouts Activity 3
15 minutes <i>1 hour 10 minutes</i>	How Manufacturers Pay for Energy	Facilitator Notes PowerPoint Slides Images Handouts
15 minutes <i>1 hour 25 minutes</i>	Energy Efficiency	Facilitator Notes PowerPoint Slides Images Handouts Websites Activities 4 and 5

**MODULE-AT-A-GLANCE (continued)**

Duration	Module 3 Activities	Materials
10 minutes	Activity 1: Know, Want to Know, Learned (K-W-L) Chart	Handout
5 minutes	Activity 2: Ranking Carbon Intensity of Energy Sources	Graphics
20 minutes	Activity 3: Calculating Carbon Footprint	Website Handout
15 minutes	Activity 4: Kia Virtual Tour	Website
25 minutes	Activity 5: A Simple Energy Audit	Handout
<b>TOTAL TIME: 2 HOURS, 40 MINUTES</b>		

# Step-by-Step Instructions

## Facilitator Icon Key



### Instructions to the Facilitator

This icon means there are specific instructions for the facilitator. This content should not be read aloud.



### Background for the Facilitator

This icon indicates that there is background information the facilitator should be aware of when covering this topic. This information is for the facilitator only.



### Facilitator Says

This icon means the facilitator should read the content nearly verbatim, interjecting his/her thoughts when appropriate.



### Key Point

This icon indicates an important point that the facilitator should communicate to the audience in his/her own words.



### Questions

This icon means the facilitator should allow time for the audience to ask questions or the facilitator should ask the audience questions.



### Activity

This icon indicates an activity that the facilitator should explain. The activity can be either a group or individual activity.



### Assessment

This icon indicates the facilitator will conduct an assessment.



### Multimedia

This icon indicates the facilitator will have students watch a video.



### Computer

This icon indicates the facilitator will have students visit an online resource.



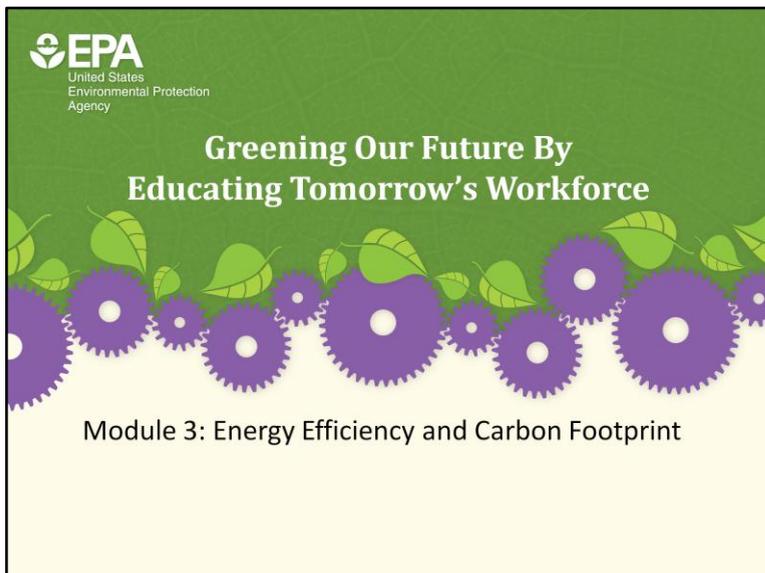
### Handouts or Resource Materials

This icon indicates the facilitator will give students a handout or other resource material.



### Transition

This icon indicates the facilitator will provide a transition from one topic to another.



## Topic

---

Introduction  
10 minutes

## Learning Objective

---

Define energy.

## Notes for the Facilitator

---



As a class or in small groups, ask students to brainstorm what they already know about energy efficiency or carbon footprints and what they would like to know.



Pass out the *Know, Want to Know, Learned* (K-W-L) chart.



Have students begin a K-W-L chart. The K-W-L strategy allows students to take inventory of what they already know and what they want to know. This chart is to be completed by the end of the module.

Possible homework assignments: Add "How we can learn more" (H) to the K-W-L chart and ask students to select a related topic to research and present to the class.

## Module 3: Energy Efficiency and Carbon Footprint

### What You Will Learn From This Module:

- Carbon intensity of various energy sources
- The role of carbon dioxide and other air emissions in the greenhouse effect.
- How to calculate a discrete carbon footprint and propose ways to reduce it.
- How to read and disseminate information from an industrial energy bill.
- Energy intensive manufacturing processes and equipment.



### Topic

---

Introduction  
10 minutes

### Learning Objective

---

Define energy.

### Notes for the Facilitator

---



Share the learning objectives with the students.



Another big part of our training philosophy is that you are responsible for your own learning. Now that you've seen the objectives, I'm going to ask you to please think about your expectations. Is there anything that's missing; anything you thought we would be going over or you wanted to go over that is not covered in the objectives?



Record all answers on a flipchart.



Thank you for your input on this topic. Some of these topics are the out of the scope of this course, but I'll see if I can find some resources for you or if we can fit it in if we have time.

## Why Care About Energy?

- Economic imperative
- Energy security
- Environmental impacts



### Topic

---

Introduction  
10 minutes

### Learning Objective

---

Define energy.

### Notes for the Facilitator

---



Introduce topic by asking the following questions:

- What is energy? Energy is the capacity for doing work.
- What are primary energy sources in the United States? Petroleum (oil), natural gas, coal, nuclear, and renewable energy.
- Where do we use energy? Everywhere! Ask students for examples.
- How are energy costs currently trending? Is there potential for manufacturers to significantly reduce costs by saving energy?



Show this video to help make the case for why manufacturers care about energy use.

*Reinventing Fire*: [http://www.youtube.com/watch?v=IT-g\\_695Go](http://www.youtube.com/watch?v=IT-g_695Go)



Primary energy sources are commonly measured in different units: barrels (= 42 gallons) of oil, cubic feet of natural gas, tons of coal. To compare across fuels, we need to use a common unit of measure. The United States uses Btu, or British thermal units, which measure fuel use by the energy content of each fuel source.



Print copies or project on screen the two short articles from the U.S. Energy Information Administration for students to read about energy. The handouts are located in Appendix C.

- *What Is Energy Explained*
- *The Use of Energy in the United States Explained*

## Carbon Intensity of Energy Sources



*All energy sources are not created equally...*



### Topic

Carbon Intensity of Energy Sources  
20 minutes  
(Elapsed Time: 30 minutes)

### Learning Objective

Rank the carbon intensity of various energy sources.

### Notes for the Facilitator



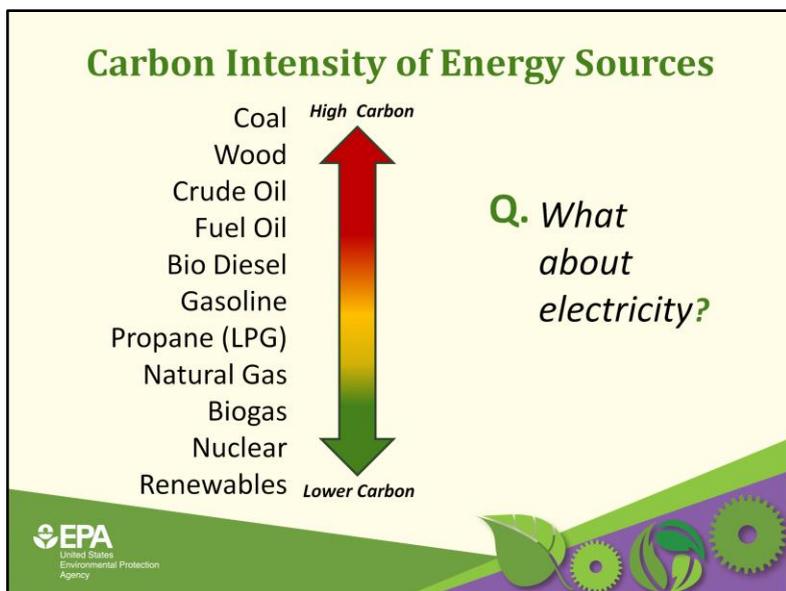
When we consume common sources of energy (coal, natural gas, petroleum, nuclear, renewables), which types create the highest amounts of carbon dioxide emissions?



Let's try to rank types of energy from most carbon and least carbon. Remember that we consume petroleum in refined forms (i.e., diesel and gasoline). Try to think of two additional less common sources of energy and add them to your rankings.



Students will pair with a classmate and predict which energy sources have the highest carbon intensity. Have students write down their reasoning so they can share them once the data is presented in the next slide. After all students make their predictions, show the graphic on the next slide and compare it to the students' predictions.



### Topic

Carbon Intensity of Energy Sources  
20 minutes  
(Elapsed Time: 30 minutes)

### Learning Objective

Rank the carbon intensity of various energy sources.

### Notes for the Facilitator



Ask students to share how their estimates differed from data presented. They will present their conclusions and reasoning to the class in a short statement.



Why isn't electricity included on this slide?



Explain that electricity is generated using many sources of energy. Remind the students that energy is the capacity to do work. The work being done when generating electricity is turning a turbine.

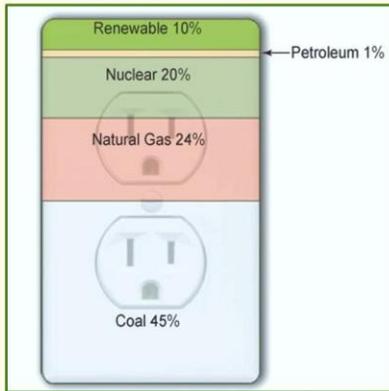


Let's look at the different energy sources from which electricity is generated.



Source: [www.epa.gov/climatechange/emissions/downloads09/GHG-MRR-Full%20Version.pdf](http://www.epa.gov/climatechange/emissions/downloads09/GHG-MRR-Full%20Version.pdf) (Table C-1 to Subpart C of Part 98, page 151 of 262)

## Sources of Electricity Generation in the U.S.



### Topic

Carbon Intensity of Energy Sources  
20 minutes  
(Elapsed Time: 30 minutes)

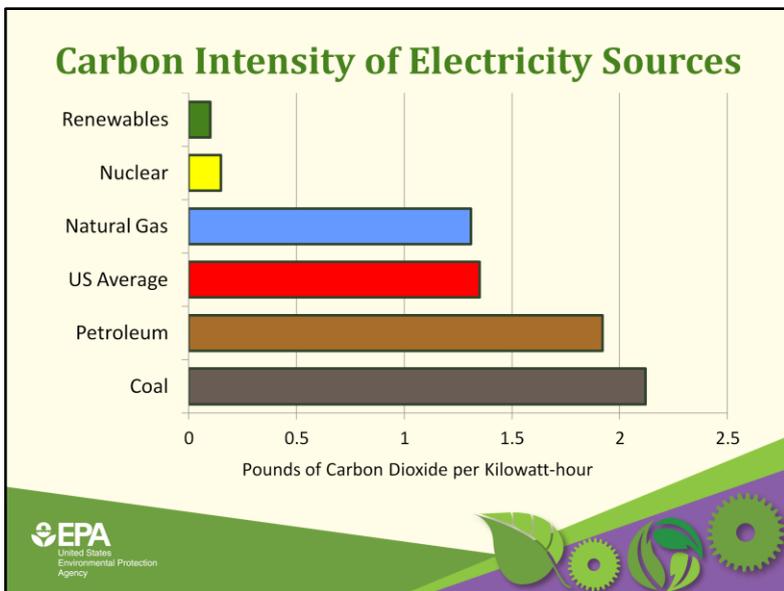
### Learning Objective

Rank the carbon intensity of various energy sources.

### Notes for the Facilitator



Discuss the graphic presented in this slide with the class. Point out that the source of energy most used in generating electricity is also the highest in carbon intensity. The next slide shows the carbon intensity of all the types of energy used to generate electricity.



## Topic

Carbon Intensity of Energy Sources  
20 minutes  
(Elapsed Time: 30 minutes)

## Learning Objective

Rank the carbon intensity of various energy sources.

## Notes for the Facilitator



Discuss the graphic presented in this slide with the class.



Source of data: Department of Energy EIA, and U.S. EPA. Carbon Dioxide Emissions from the Generation of Electric Power in the United States. 2000.

[http://www.eia.gov/cneaf/electricity/page/co2\\_report/co2emiss.pdf](http://www.eia.gov/cneaf/electricity/page/co2_report/co2emiss.pdf)

and

Bilek, Marcela, et al. Life Cycle Balance and Greenhouse Gas Emissions of Nuclear Energy. 2008. [http://www.isa.org.usyd.edu.au/publications/documents/ISA\\_Nuclear\\_Report.pdf](http://www.isa.org.usyd.edu.au/publications/documents/ISA_Nuclear_Report.pdf)



So, why does carbon intensity matter? Let's move on to look at carbon's role in the greenhouse effect.

## Why Does Carbon Matter?



### Topic

Why Carbon Emissions Matter to Manufacturers

25 minutes

(Elapsed Time: 55 minutes)

### Learning Objective

Describe the role of carbon dioxide and other air emissions in the greenhouse effect.

### Notes for the Facilitator

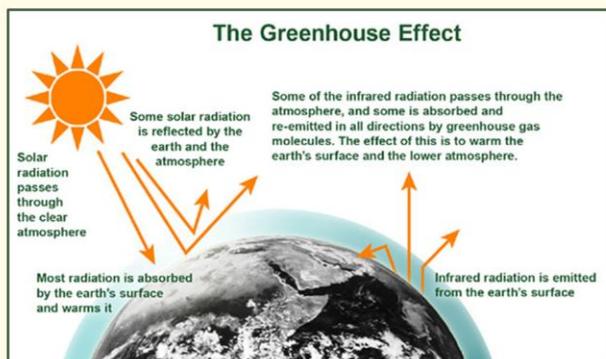


Watch Robert Krulwich's five-part cartoon series, *Global Warming: It's All About Carbon* <http://www.npr.org/news/specials/climate/video>.



If time is not available to watch the entire series, episodes 1, 4, and 5 are most relevant.

## Greenhouse Effect



### Topic

Why Carbon Emissions Matter to Manufacturers  
25 minutes  
(Elapsed Time: 55 minutes)

### Learning Objective

Describe the role of carbon dioxide and other air emissions in the greenhouse effect.

### Notes for the Facilitator



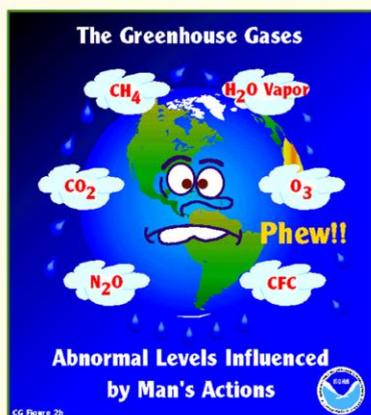
Read slide aloud.



Climate Literacy: The Essential Principles of Climate Sciences available at <http://downloads.climate-science.gov/Literacy/Climate%20Literacy%20Booklet%20Low-Res.pdf> notes the following points about earth's climate system and the greenhouse effect.

- The sun is the primary source of energy for earth's climate system.
- Earth's climate is influenced by interactions involving the sun, ocean, atmosphere, clouds, ice, land, and life. Climate varies by region as a result of local differences in these interactions.
- The greenhouse effect is a natural phenomenon whereby heat-trapping gases in the atmosphere, primarily water vapor, keep the Earth's surface warm.
- Human activities, primarily burning fossil fuels and changing land cover patterns, are increasing the concentrations of some of these gases, amplifying the natural greenhouse effect.

## Role of Greenhouse Gasses



EPA  
United States  
Environmental Protection  
Agency

### Topic

Why Carbon Emissions Matter to  
Manufacturers  
25 minutes  
(Elapsed Time: 55 minutes)

### Learning Objective

Describe the role of carbon  
dioxide and other air emissions in  
the greenhouse effect.

### Notes for the Facilitator



Watch a brief animation on the greenhouse effect:

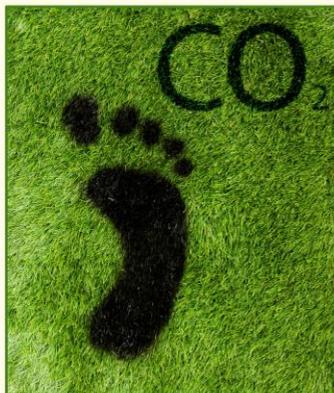
<http://www.epa.gov/climatechange/kids/basics/index.html>

Link for animation is located in the textbox that is located on right-hand side of the webpage.



The amount of solar energy absorbed or radiated by Earth is modulated by the atmosphere and depends on its composition. Greenhouse gases—such as water vapor, carbon dioxide, and methane—occur naturally in small amounts and absorb and release heat energy more efficiently than abundant atmospheric gases like nitrogen and oxygen. Small increases in carbon dioxide concentration have a large effect on the climate system. Increased levels of heat-trapping gasses will warm the planet.

## What's Your Carbon Footprint?



### Topic

Why Carbon Emissions Matter to Manufacturers.  
25 minutes  
(Elapsed Time: 55 minutes)

### Learning Objective

How to calculate a discrete carbon footprint and propose ways to reduce it.

### Notes for the Facilitator



At least three days before this class, distribute worksheet so students can collect data. They will need recent electric, gas, and/or oil bills so they can use real numbers for to calculate their household's energy consumption.



In class, introduce the idea of a carbon footprint—the amount of carbon dioxide each person release into the atmosphere as a result of their daily activities.



Have students enter the data they collected into EPA's household emissions calculator available at: [http://www.epa.gov/climatechange/emissions/ind\\_calculator.html](http://www.epa.gov/climatechange/emissions/ind_calculator.html).



Distribute *Your Family's Carbon Footprint* worksheet as a supplement to EPA's emissions calculator.

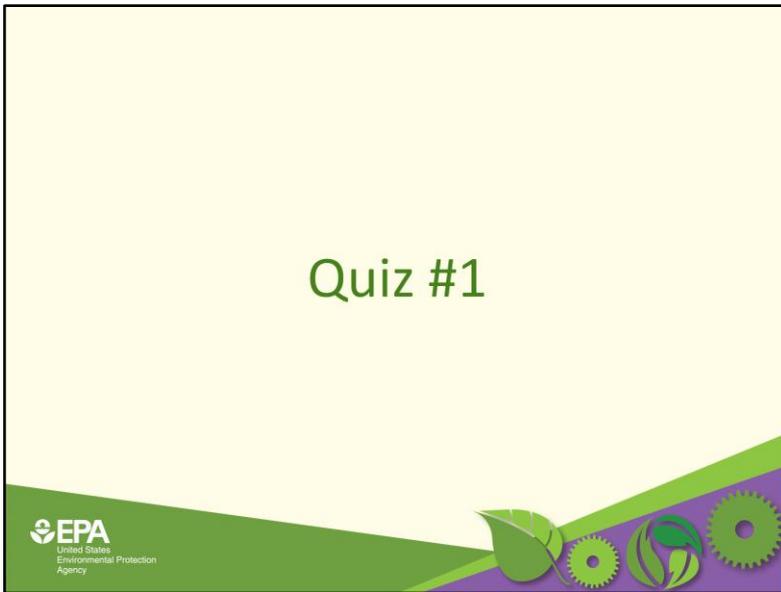


Possible homework assignment is a two to three page paper covering topics including:

1. In what ways do you and your family release greenhouse gases into the atmosphere?
2. How might these activities contribute to the greenhouse effect and to global warming?
3. What can you and your family do to reduce your greenhouse gas emissions? Students should include at least three methods they could use to reduce your carbon footprint in the next month and calculate your potential emission reductions.



If needed, energy conversion calculators are available at: [http://www.eia.gov/kids/energy.cfm?page=about\\_energy\\_conversion\\_calculator-basics](http://www.eia.gov/kids/energy.cfm?page=about_energy_conversion_calculator-basics).



**Topic**  
\_\_\_\_\_

**Learning Objective**  
\_\_\_\_\_

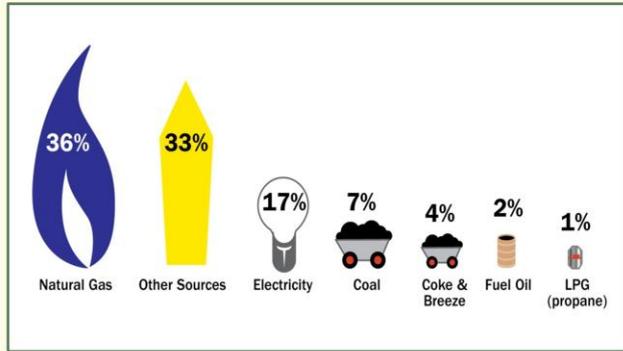
## Notes for the Facilitator

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This quiz can serve as the end or the beginning a classroom session. The material covered in the rest of module 3 builds upon the material covered in this quiz. See Appendix B for sample quiz and answer key.

## Sources of Energy Used in Manufacturing



Source: U.S. Energy Information Administration, Annual Energy Review 2005



### Topic

How Manufacturers Pay for Energy  
15 minutes  
(Elapsed Time: 1 hour, 10 minutes)

### Learning Objective

Read and disseminate information from an industrial energy bill.

### Notes for the Facilitator



This slide shows the percentages of the types of energy used in the U.S. manufacturing sector.

## How Manufacturers Pay for Energy



- Fuel Costs
- Consumption Charges
- Demand Charges
- Transmission Charges
- Power Factor Adjustments
- Fuel Adjustment Charges



### Topic

How Manufacturers Pay for Energy  
15 minutes  
(Elapsed Time: 1 hour, 10 minutes)

### Learning Objective

Read and disseminate information from an industrial energy bill.

## Notes for the Facilitator



Ask students to brainstorm definitions for the terms listed on the slide.



**Fuel costs**—for energy sources other than electricity (such as natural gas, fuel oil, coal and liquid propane) the amount of fuel you receive and a delivery charge for the transportation and delivery of the fuel. Fuel charges can vary based on seasonal demand or by the volume purchased.

**Consumption charges**—electricity is charged based, in part, on the amount of electricity used (in kilowatt-hours, [kWh]) in a billing period. The per kWh rate for electricity can vary based the time of day (peak or off-peak hours).

**Demand charges**—most manufacturers pay a demand charge (per kilowatt) that is based on the peak electricity use each month averaged over a short time period (e.g., 15 minutes). A manufacturing facility could pay a much higher cost based on demand rather than consumption, although the two costs can be incorporated into a single line item in the utility bill.

**Transmission charges**—added to a customer's energy bill to cover the cost of transmitting energy over the distance between the supply or generation facility to the local utility's distribution system.

**Power factor adjustments**—account for a manufacturing facility's ability to effectively convert the electrical input current and voltage into "useful" electric power. As buildings and electrical systems become antiquated, they lose their ability to effectively convert received electricity current into useful energy.

**Fuel adjustment charges**—account for fluctuations in the cost of fuel, or purchased power, used to supply electricity.



## Peak Electric Demand

- **Q:** Why do electricity providers need to charge demand-based fees?
- **A:** Demand-based fees cover the cost for the utility to maintain the infrastructure capacity to meet all its customers' needs at all times.



## Topic

How Manufacturers Pay for Energy  
15 minutes  
(Elapsed Time: 1 hour, 10 minutes)

## Learning Objective

Read and disseminate information from an industrial energy bill.

## Notes for the Facilitator



While usage-based rates cover the cost of generating the electricity, utilities need to cover the significant costs of either maintaining adequate capacity or purchasing it from other electricity providers. The issues with estimating the appropriate capacity for a service area are caused by the peak demands of large energy consumers that fluctuate sporadically over different times. Utilities must maintain capacity for the combined peak demand or risk not being able to meet the needs of its customers.

## Using Energy Bills as a Data Source

Energy bills can...

- Serve as up-to-date accounting of monthly energy consumption and associated costs.
- Provide records for each type of energy used (e.g., gas, electric, and oil)
- Can be converted into a single common unit to express the heating values of the various fuel sources (MMBtu).
- Detect trends and irregularities in energy usage and costs.



## Topic

How Manufacturers Pay for Energy  
15 minutes  
(Elapsed Time: 1 hour, 10 minutes)

## Learning Objective

Read and disseminate information from an industrial energy bill.

## Notes for the Facilitator



Understanding how to read energy bills is an important first step in any energy efficiency improvement projects. You can't manage what you don't measure.

## Reading Natural Gas Bills

Natural Gas Charges typically have two metered components:

- Supply charges—the cost to purchase natural gas from wholesalers.
- Distribution charge—the cost to deliver natural gas to the customer.

Energy Units

- Ccf—one hundred cubic feet
- Mcf—one thousand cubic feet



### Topic

How Manufacturers Pay for Energy  
15 minutes  
(Elapsed Time: 1 hour, 10 minutes)

### Learning Objective

Read and disseminate information from an industrial energy bill.

### Notes for the Facilitator



Natural gas bills are generally simpler to read and comprehend than industrial electricity bills. Natural gas is measured in volumetric units of cubic feet and customers are charged for the volume of fuel delivered and an additional cost of delivering the gas.



As you can see, energy bills are a significant factor in a company's budget so reducing energy use benefits both the environment and the company's bottom line.

## Legislating Energy Efficiency

U.S. Congress passed major legislation that addressed energy efficiency and energy management.

- Energy Policy Act of 1992
- Energy Policy Act of 2005



### Topic

Energy Efficiency

15 minutes

(Elapsed Time: 1 hour, 25 minutes)

### Learning Objective

Recognize energy intensive manufacturing processes and equipment.

### Notes for the Facilitator



The Energy Policy Act of 2005 (EPAAct 2005) addresses energy production in the United States, including: (1) energy efficiency, (2) renewable energy, (3) oil and gas, (4) coal, (5) Tribal energy, (6) nuclear matters and security, (7) vehicles and motor fuels, including ethanol, (8) hydrogen, (9) electricity, (10) energy tax incentives, (11) hydropower and geothermal energy, and (12) climate change technology. For example, EPAAct 2005 provides loan guarantees for entities that develop or use innovative technologies that avoid the byproduction of greenhouse gases. Another provision of the Act increases the amount of biofuel that must be mixed with gasoline sold in the United States.

The Energy Policy Act of 1992 (EPAAct 1992) aims to reduce U.S. dependence on imported petroleum and improve air quality by addressing all aspects of energy supply and demand, including alternative fuels, renewable energy, and energy efficiency. EPAAct 1992 encourages the use of alternative fuels through both regulatory and voluntary activities. It requires federal, state, and alternative fuel provider fleets to acquire alternative fuel vehicles.

EPAAct 1992 also defined "alternative fuels" as methanol, ethanol, and other alcohols; blends of 85 percent or more of alcohol with gasoline (E85); natural gas and liquid fuels domestically produced from natural gas; propane; hydrogen; electricity; biodiesel (B100); coal-derived liquid fuels; fuels, other than alcohol, derived from biological materials; and P-Series fuels, which were added to the definition in 1999. Under EPAAct 1992, the U.S. Department of Energy has the authority to add more alternative fuels to the list of authorized alternative fuels if certain criteria are met.



EPAAct 2005 can be viewed online here:

<http://www1.eere.energy.gov/femp/regulations/epact2005.html>.

## Why Energy Efficiency?

“Of one thing we can be sure; energy will be more challenging and more important in the future. Will you, and your business, be ready?”

— Peter Schwartz, Chairman, Global Business Network

“My interest is in the future because I going to spend the rest of my life there.”

— Charles Kettering, Founder of A.C. Delco and Former VP of Research General Motors



## Topic

Energy Efficiency

15 minutes

(Elapsed Time: 1 hour, 25 minutes)

## Learning Objective

Recognize energy intensive manufacturing processes and equipment.

## Notes for the Facilitator



The Energy Information Administration states that significant opportunities exist to increase energy efficiency in the current manufacturing sector, and its investigations show that no segment of the U.S. economy has as much to gain from energy reduction as the manufacturers. In fact, a September 2005 poll taken by the National Association of Manufacturers revealed that 93 percent of directors from small and medium-sized manufacturing companies believe that higher energy prices are having a negative impact on their profitability.



Current business trends show that energy efficiency is becoming a market differentiator for manufacturers. Customers are including suppliers' energy performance when making purchasing decisions.



Other reasons for energy efficiency include:

- Reduce greenhouse gas emissions and carbon footprint.
- Industrial sector consumes about one-third of all the energy used in the United States.
- Industrial manufacturers consume nearly 40 percent of all electricity generated in the United States.
- Natural gas prices are up 136 percent in 5 years.
- Crude oil price are up 5 times greater than 1998 price (22 percent increase per year, every year, for 8 years).
- Electricity demand in the United States will grow by at least 40 percent by 2032.



Energy Strategy for the Road Ahead: Scenario Thinking for Business Executives and Corporate Boards. The Global Business Network:

[http://www.energystar.gov/ia/business/GBN\\_Energy\\_Strategy.pdf](http://www.energystar.gov/ia/business/GBN_Energy_Strategy.pdf)

## Energy Intensive Manufacturing Processes

- Air make-up units
- Heating, cooling, and ventilation unit
- Boilers
- Lighting
- Compressed air systems
- Melting, smelting, and metal heating
- Conveyors
- Milling rotors
- Curing and drying ovens
- Transportation
- Electric motors
- Any process with large amounts of waste heat as byproduct.



## Topic

Energy Efficiency  
15 minutes  
(Elapsed Time: 1 hour, 25 minutes)

## Learning Objective

Recognize energy intensive manufacturing processes and equipment.

## Notes for the Facilitator



Distribute sections 3 and 4 of Energy Efficiency Improvement and Cost Saving Opportunities for the Vehicle Assembly Industry: An ENERGY STAR® Guide for Energy and Plant Managers. <http://www.energystar.gov/ia/business/industry/LBNL-50939.pdf>. Have students read in class.



Then, as a class or in small groups, visit the following website: <http://www.history.com/interactives/start-to-finish/#/kia>.



Using the “tour” as a guide, have the groups brainstorm and identify where opportunities for energy efficiency and conservation exist. Ask the groups to list their opportunities to share with the class at the end of the time provided.

## Holistic Energy Efficiency Opportunities

- Total productive maintenance
- Autonomous maintenance
- Right-sized equipment
- Reduce movement /motion
- Install visual controls



## Topic

Energy Efficiency  
15 minutes  
(Elapsed Time: 1 hour, 25 minutes)

## Learning Objective

Recognize energy intensive manufacturing processes and equipment.

## Notes for the Facilitator



Some of the most impactful energy efficiency opportunities are ones that take place facility wide and are not limited to one process or piece of equipment. These types of behavioral changes do more than just reduce energy use; they can change the manner in which a manufacturer operates on a daily basis.



*Total productive maintenance*—focuses on optimizing the effectiveness of manufacturing equipment, builds upon established equipment-management approaches, and focuses on team-based maintenance that involves employees at every level and function.

*Autonomous maintenance*—ongoing maintenance activities operators undertake on their own equipment. Typical activities include daily inspections, lubrication, simple repairs, and precision checks. Autonomous maintenance provides an opportunity to integrate process-level energy-reduction strategies into ongoing equipment maintenance.

*Right-sized equipment*—oversized equipment is a common wasteful use of energy in manufacturing. Capital equipment tends equipment often runs well below capacity, significantly reducing energy efficiency per unit of production. It tends to be over-sized “just in case” a facility needs to accommodate increased demand. Can drag down profit margin if demand is not realized.

*Reduce movement*—the distance that a product and process inputs move can significantly increase or decrease the amount of energy required to support a production process.

*Visual controls*—graphic prompts or cues that reinforce standardized procedures or display the status of an activity that every employee can see and take appropriate action. Can be as simple as color-coding pipes or installing a sign over on/off switches or power outlets to remind operators to turn off or unplug equipment that is not in use.

## Distribution of Electricity Use in Vehicle Assembly Plants

End Use	Share of Electricity Use (%)	Estimated Typical Electricity Consumption (199) (KWh/car)	Average Electricity Applied in Analysis (kWh/car)
HVAC	11 – 20	95 – 170	160
Paint Systems (e.g., fans)	27 – 50	230 – 320	260
Lighting	15 – 16	130 – 140	130
Compressed Air	9 – 14	80 – 120	120
Materials Handling/Tools	7 – 8	60 – 70	60
Metal Forming	2 – 9	20 – 80	30
Welding	9 – 11	80 – 95	80
Miscellaneous	4 – 5	35 – 45	20
Total	100%	730-1040	860

### Topic

Energy Efficiency  
15 minutes  
(Elapsed Time: 1 hour, 25 minutes)

### Learning Objective

Recognize energy intensive manufacturing processes and equipment.

### Notes for the Facilitator



Discuss the table presented in this slide. The table shows a range of typical energy use per process line based observations made in a number of vehicle assembly plants in the United States and Europe.



Source: Galitsky, Christina and Ernst Worrell. Energy Efficiency Improvement and Cost Saving Opportunities for the Vehicle Assembly Industry. Ernest Orlando Lawrence Berkley National Laboratory. March 2008.



The full report can be viewed here: <http://www.energystar.gov/ia/business/industry/LBNL-50939.pdf>.

## Energy Audits

Manufacturers perform energy audits to establish a baseline for energy use, estimate potential savings, and benchmark energy reductions.

- Use accounting to gain a picture of a manufacturer's energy consumption.
- Compare energy used versus what is actually needed to produce products.
- Focus on specific energy-intensive processes or a comprehensive facility-wide assessment.
- Typically the first step taken in projects to increase energy efficiency.



## Topic

Energy Efficiency

15 minutes

(Elapsed Time: 1 hour, 25 minutes)

## Learning Objective

Recognize energy intensive manufacturing processes and equipment.

## Notes for the Facilitator



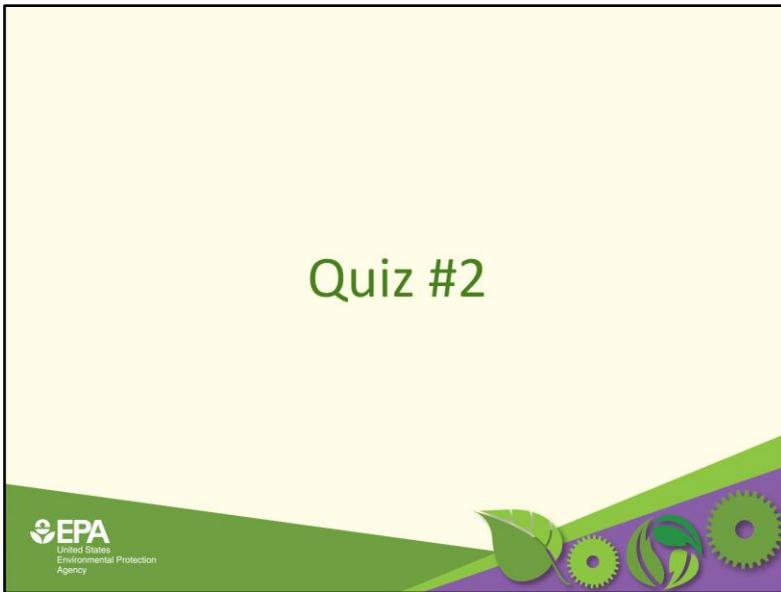
An energy audit is a comprehensive assessment of the energy use of a building. Energy audits help to identify and prioritize specific areas for efficiency improvement. In the residential and commercial sectors, energy audits target the building as a whole, and are therefore an avenue for maximizing energy savings in existing buildings. In the industrial sector, audits are often comprehensive, but may focus on specific energy-intensive processes.



Have students complete a simple energy audit in the classroom using *A Simple Energy Audit*.



A handout for this activity is included in Appendix C.



**Topic**  
\_\_\_\_\_

**Learning Objective**  
\_\_\_\_\_

**Notes for the Facilitator**

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This quiz can serve as the end or the beginning a classroom session. See Appendix B for sample quiz and answer key.

## APPENDIX A: Video Resource List

*Reinventing Fire:*

[http://www.youtube.com/watch?v=IT-g\\_695Go](http://www.youtube.com/watch?v=IT-g_695Go)

*Global Warming: It's All About Carbon:*

<http://www.npr.org/news/specials/climate/video>

*Greenhouse Effect Animation*

<http://www.epa.gov/climatechange/kids/basics/index.html>

## **APPENDIX B: Module Quizzes**

**Energy and Carbon  
Quiz #1**

**1. Name three primary energy sources in the United States.**

- A) \_\_\_\_\_
- B) \_\_\_\_\_
- C) \_\_\_\_\_

**2. Explain the difference between energy and electricity.**

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

**3. Which energy source has the highest carbon intensity? Place the number 1-4 in the correct order with 1 as highest carbon intensity.**

- |              |                 |
|--------------|-----------------|
| ___ Wood     | ___ Natural Gas |
| ___ Fuel Oil | ___ Coal        |

**4. Statement: True or False**

\_\_\_ The source of energy most used in generating electricity is the lowest in carbon intensity.

**5. Why is an increase in the concentration of greenhouse gases a concern?**

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

**6. Explain carbon footprint.**

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_



**Energy and Carbon  
Quiz #1  
(Answer Key)**

1. Name three primary energy sources in the United States.

A) Coal

B) Natural Gas

C) Nuclear

Or Petroleum or Renewables

2. Explain the difference between energy and electricity.

*Electricity is generated using many sources of energy. Energy is the capacity to do work. Electricity is a means of distributing energy from a power plant to the end user.*

3. Which energy source has the highest carbon intensity? Place the number 1-4 in the correct order with 1 as highest carbon intensity.

2 Wood

4 Natural Gas

3 Fuel Oil

1 Coal

4. Statement: True or False

**FALSE** The source of energy most used in generating electricity is the lowest in carbon intensity.

5. Why is an increase in the concentration of greenhouse gases a concern?

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6. Explain carbon footprint.

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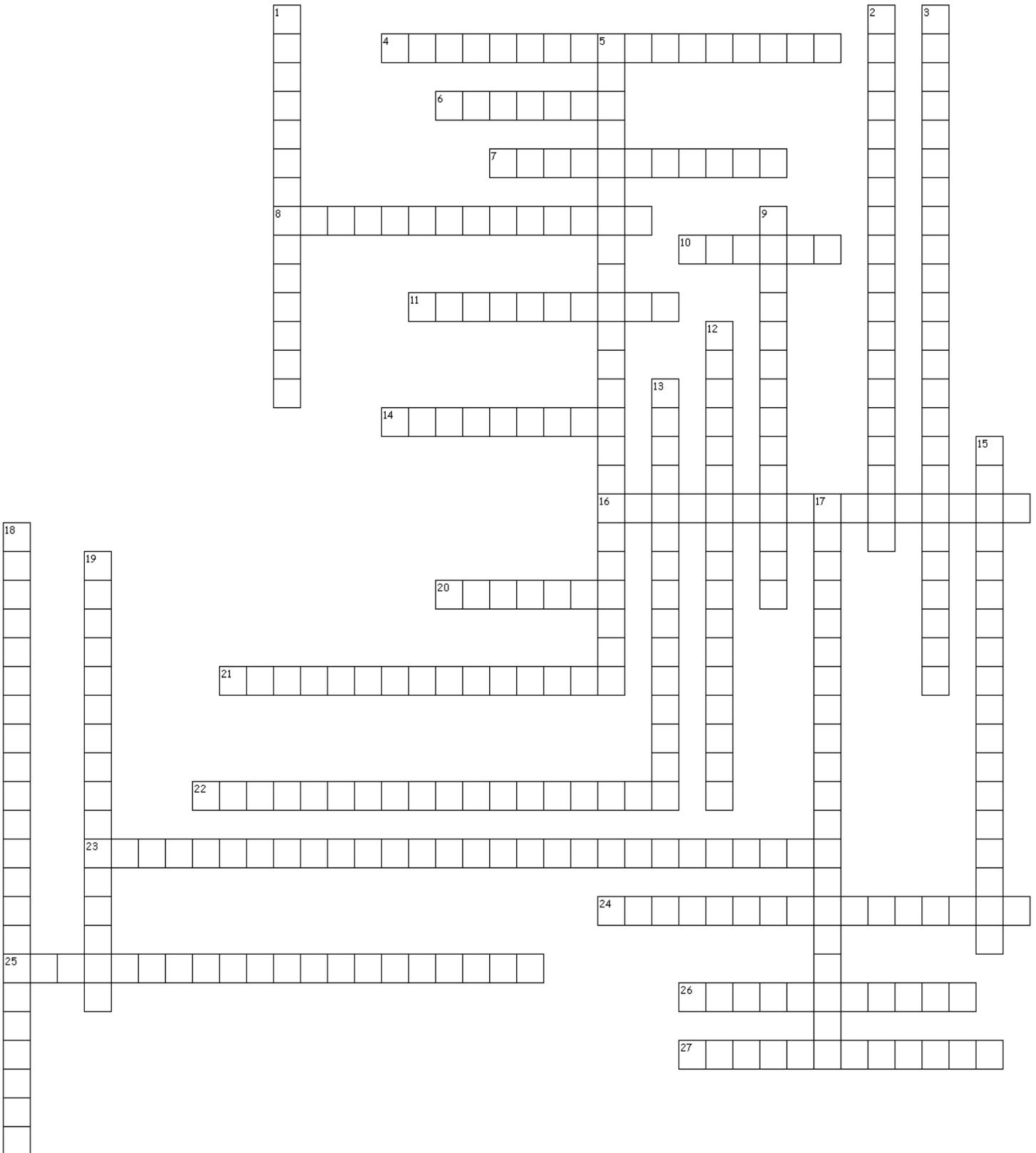
## **APPENDIX C: Facilitator Materials**

## KWL Chart

<b>What do I know?</b>	<b>What do I want to find out?</b>	<b>What did I learn?</b>

# Environmental Terms Crossword

## Energy and Carbon



**Across**

4. Reducing the amount of energy required [Two words]
6. The "average weather" in an area.
7. Measure of metered usage at the highest rate over a short (15, 30, or 60 minute) interval for the billing period. [Two words]
8. A naturally occurring gas, and also a by-product of burning fossil fuels and biomass. [Two words]
10. The capacity to perform work.
11. Amount charged for the fuel you receive and a delivery charge for the transportation and delivery of the fuel. [Two words]
14. Transmission of energy through space or any medium.
16. The amount of carbon by weight emitted per unit of energy consumed. [Two words]
20. Atmospheric condition at any given time or place.
21. Graphic prompts or cues that reinforce standardized procedures or display the status of an activity that every employee can see and take appropriate action. [Two words]
22. Radiation emitted by the Earth's surface, the atmosphere and the clouds. [Two words]
23. To focus on optimizing the effectiveness of manufacturing equipment through team-based maintenance that involves employees at every level and function. [Three words]
24. Energy obtained from sources that are essentially inexhaustible. [Two words]
25. Charge added to a customer's energy bill to cover the cost of delivering energy over the distance between the supply or generation facility to the local utility's distribution system. [Two words]
26. A form of energy.
27. Accounting analysis of energy flows. [Two words]

**Down**

1. Charge applied in an electricity bill that is based on the peak use each month averaged over a short time period. [Two words]
2. Charge applied for the amount of an energy source used during a billing period. [Two words]
3. Charges that account for a manufacturing facility's ability to effectively convert the electrical input current and voltage into "useful" electric power. [Three words]
5. Charges that account for fluctuations in the cost of fuel, or purchased power, used to supply electricity. [Three words]
9. Any gas that absorbs infrared radiation in the atmosphere. [Two words]
12. Trapping and build-up of heat in the atmosphere near the Earth's surface. [Two words]
13. Radiation emitted by the sun. [Two words]
15. Energy derived from nontraditional sources. [Two words]
17. Energy from a natural resource that cannot be re-made, re-grown or regenerated on a scale comparative to its consumption. [Two words]
18. Ongoing maintenance activities performed by equipment operators on their own equipment. [Two words]
19. The total amount of greenhouse gases that are emitted into the atmosphere each year by a person, family, building, organization, or company. [Two words]

# What Is Energy? *Explained*



## Basics

### Energy Is the Ability To Do Work

Energy comes in different forms:

- Heat (thermal)
- Light (radiant)
- Motion (kinetic)
- Electrical
- Chemical
- Nuclear energy
- Gravitational

Energy is in everything. We use energy for everything we do, from making a jump shot to baking cookies to sending astronauts into space.

There are two types of energy:

- Stored (potential) energy
- Working (kinetic) energy

For example, the food you eat contains chemical energy, and your body stores this energy until you use it when you work or play.

### Energy Sources Can be Categorized As Renewable or Nonrenewable

When we use electricity in our home, the electrical power was probably generated by burning coal, by a nuclear reaction, or by a hydroelectric plant at a dam. Therefore, coal, nuclear and hydro are called energy sources. When we fill up a gas tank, the source might be petroleum or ethanol made by growing and processing corn.

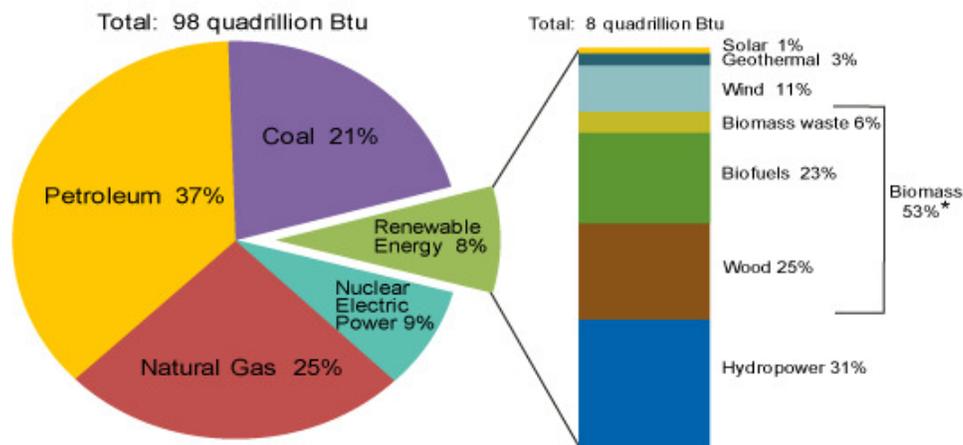
Energy sources are divided into two groups — renewable (an energy source that can be easily replenished) and nonrenewable (an energy source that we are using up and cannot recreate). Renewable and nonrenewable energy sources can be used to produce secondary energy sources including electricity and hydrogen.

### Renewable Energy

Renewable energy sources include:

- Solar energy from the sun, which can be turned into electricity and heat
- Wind
- Geothermal energy from heat inside the Earth
- Biomass from plants, which includes firewood from trees, ethanol from corn, and biodiesel from vegetable oil
- Hydropower from hydroturbines at a dam

## U.S. Energy Consumption by Energy Source, 2010



\*Note: Sum of biomass components does not equal 53% due to independent rounding.  
Source: U.S. Energy Information Administration, Monthly Energy Review, Table 10.1 (June 2011), preliminary 2010 data.

### Nonrenewable Energy

We get most of our energy from nonrenewable energy sources, which include the fossil fuels — oil, natural gas, and coal. They're called fossil fuels because they were formed over millions and millions of years by the action of heat from the Earth's core and pressure from rock and soil on the remains (or "fossils") of dead plants and creatures like microscopic diatoms. Another nonrenewable energy source is the element uranium, whose atoms we split (through a process called nuclear fission) to create heat and ultimately electricity.

We use renewable and nonrenewable energy sources to generate the electricity we need for our homes, businesses, schools, and factories. Electricity "energizes" our computers, lights, refrigerators, washing machines, and air conditioners, to name only a few uses.

Most of the gasoline used in our cars and motorcycles and the diesel fuel used in our trucks are made from petroleum oil, a nonrenewable resource. Natural gas, used to heat homes, dry clothes, and cook food, is nonrenewable. The propane that fuels our outdoor grills is made from oil and natural gas, both nonrenewable.

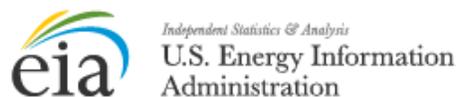
The chart above shows what energy sources the United States used in 2010. Nonrenewable energy sources accounted for 92% of all energy used in the Nation. Biomass, the largest renewable source, accounted for over half of all renewable energy and 4% of total energy consumption.

### Learn More

- [EIA Home Page](http://www.eia.gov/) — <http://www.eia.gov/>
- [DOE Home Page](http://www.energy.gov/) — <http://www.energy.gov/>
- [What Is Energy?](http://simple.wikipedia.org/wiki/Energy) — <http://simple.wikipedia.org/wiki/Energy>

Last Reviewed: July 15, 2011

[http://www.eia.gov/energyexplained/index.cfm?page=about\\_home](http://www.eia.gov/energyexplained/index.cfm?page=about_home)



# Use of Energy in the United States *Explained*



## Basics

### How We Use Energy

The United States is a highly developed and industrialized society. We use a lot of energy in our homes, in businesses, in industry, and for personal travel and transporting goods. There are four major sectors that consume energy at the point of end use.

- The [industrial sector](#) includes facilities and equipment used for manufacturing, agriculture, mining, and construction.
- The [transportation sector](#) comprises vehicles that transport people or goods, such as: cars, trucks, buses, motorcycles, trains, subways, aircraft, boats, barges, and even hot air balloons.
- The [residential sector](#) consists of homes and apartments.
- The [commercial sector](#) includes buildings such as offices, malls, stores, schools, hospitals, hotels, warehouses, restaurants, places of worship, and more.

Each end-use sector consumes electricity produced by the [electric power sector](#).

### U.S. Total Energy Consumption by End-Use Sector, 1949-2010

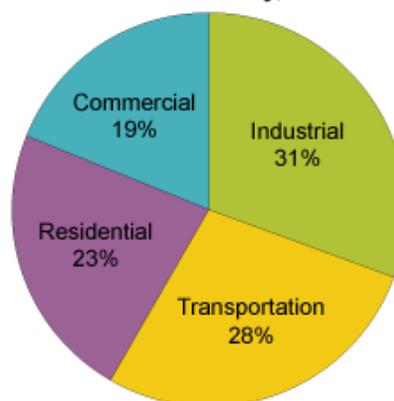
From 1949 to 2010, primary energy consumption in the United States tripled. In all but 16 of those years, primary energy consumption increased over the previous year.

The year 2009 provided a sharp contrast to this historical trend, in part due to the economic recession. Real gross domestic product (GDP) fell 2% compared to 2008, and energy consumption declined as well: by nearly 5%. Decreases occurred in all four major end-use sectors: residential — 2%, commercial — 1%, industrial — 9%, and transportation — 4%.

Consumption decreased the most in the industrial sector, which was particularly hard hit by the recession. Real value added for the manufacturing sector fell by 6%. Total energy consumption in the transportation sector fell by about 4% in 2009. Decreases in total transportation sector consumption in 2008 and 2009 were the first since 1990 and 1991 that consumption fell in consecutive years.

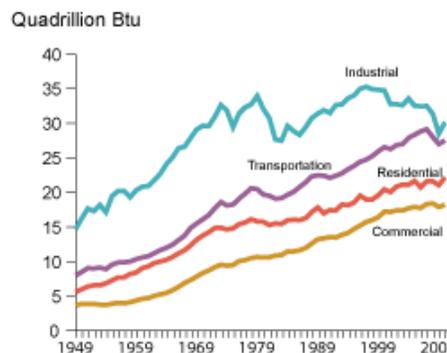
The general historical trend for annual increases in energy consumption resumed in 2010 as the U.S. economy improved. Total energy consumption increased by about 4% over 2009. Increases occurred in all sectors: residential — 5%, commercial — 2%, industrial — 6%, transportation — 2%.

**Share of Energy Consumed by Major Sectors of the Economy, 2010**



Source: U.S. Energy Information Administration, *Annual Energy Review 2009*, and *Monthly Energy Review* (June 2011), preliminary 2010 data.

**Energy Consumption by Sector, 1949-2010**



Source: U.S. Energy Information Administration, *Annual Energy Review 2009*, Table 2.1a, and *Monthly Energy Review* (June 2011), preliminary 2010 data.

### Learn More

- [Energy Perspectives](http://www.eia.gov/emeu/aer/ep/ep_frame.html) — [http://www.eia.gov/emeu/aer/ep/ep\\_frame.html](http://www.eia.gov/emeu/aer/ep/ep_frame.html)

- [Major sources and users of energy in the United States](http://www.eia.gov/energy_in_brief/major_energy_sources_and_users.cfm) — [http://www.eia.gov/energy\\_in\\_brief/major\\_energy\\_sources\\_and\\_users.cfm](http://www.eia.gov/energy_in_brief/major_energy_sources_and_users.cfm)
- [Monthly Energy Review](http://www.eia.gov/totalenergy/data/monthly/) — <http://www.eia.gov/totalenergy/data/monthly/>

Last Updated: July 20, 2011

[http://www.eia.gov/energyexplained/index.cfm?page=us\\_energy\\_use](http://www.eia.gov/energyexplained/index.cfm?page=us_energy_use)



# Your Family's Carbon Footprint

## Key Concepts:

- Carbon footprint
- Carbon dioxide
- Greenhouse gas
- Greenhouse effect
- Methane
- Nitrous oxide

## WHAT YOU WILL LEARN

1. You will calculate the amount of carbon dioxide you and your family release into the atmosphere each year—your carbon footprint.
2. You will identify ways for you and your family to reduce your carbon footprint.
3. You will calculate the mean, median, mode, and range for your class's carbon dioxide emissions data: your class carbon footprint.

## *Engage Your Thinking*

How much greenhouse gas (carbon dioxide and methane) does your family release into the atmosphere each year? How do you and your family contribute to the greenhouse effect and to global warming? To answer these questions, you will use the Environmental Protection Agency's (EPA) *Personal Emissions Calculator* to estimate your family's greenhouse gas emissions and to think about how you and your family could reduce your greenhouse gas emissions. Before starting this activity, however, answer the following questions based on what you currently know and think.

1. In what ways do you and your family release greenhouse gases into the atmosphere?
2. How might these activities contribute to the greenhouse effect and to global warming?
3. What can you and your family do to reduce your greenhouse gas emissions?

## *Explore and Explain*

Scientists believe that **global warming** is caused by an increase in the atmospheric concentration of the naturally occurring **greenhouse gases**. The major greenhouse gases are **water vapor**, **carbon dioxide**, **methane**, and **nitrous oxides**. The main greenhouse gases that enter the atmosphere because of human activities are:

- Carbon Dioxide (CO<sub>2</sub>): Carbon dioxide enters the atmosphere through the burning of fossil fuels (oil, natural gas, and coal), solid waste, trees, and wood products.



- Methane (CH<sub>4</sub>): Methane is emitted during the production and transport of coal, natural gas, and oil. Methane emissions also result from livestock and other agricultural practices and from the decay of organic waste in municipal solid waste landfills.
- Nitrous Oxides (NO<sub>x</sub>): Nitrous oxides are emitted during agricultural and industrial activities, as well as during the combustion of fossil fuels and solid waste.

Many of your daily activities result in carbon dioxide and methane emissions; these activities add greenhouse gases to the atmosphere and this contributes to global warming and climate change. The greenhouse gas emissions you produce reflect your **carbon footprint**: the amount of greenhouse gases you contribute to the atmosphere measured in units of carbon dioxide. By calculating your carbon footprint you better estimate your contribution to global warming. When you understand the impact of your actions on the environment, you can make more informed decisions about specific ways to reduce your carbon footprint and to minimize your personal impact on the Earth's temperature and climate.

The Environmental Protection Agency (EPA) has developed the *Personal Emissions Calculator* that allows individuals and households (families) to calculate the amount of greenhouse gas they emit each year and to estimate their individual carbon footprints. The estimate is based on energy use and waste disposal. In the following activity, you will use the EPA online calculator to estimate how much greenhouse gas you and your family release into the atmosphere each year. To use the online calculator go to:

[http://epa.gov/climatechange/emissions/ind\\_calculator.html](http://epa.gov/climatechange/emissions/ind_calculator.html)

Follow the instructions for using the calculator; you will need about 10-15 minutes to enter the data. For more accurate results, ask your parents to assist you in answering the following questions before going to the online calculator:

- How do you heat your home? \_\_\_\_\_
- How much does your family spend per month on electricity? \_\_\_\_\_
- How much does your family spend per month on natural gas? \_\_\_\_\_
- How much does your family spend per month on heating oil? \_\_\_\_\_
- On average how many miles does your family drive per week? \_\_\_\_\_
- What is the average gas mileage for your family car(s)? \_\_\_\_\_
- Does your family recycle newspaper? \_\_\_\_\_
- Does your family recycle glass? \_\_\_\_\_
- Does your family recycle plastic? \_\_\_\_\_
- Does your family recycle aluminum/steel cans? \_\_\_\_\_

As you enter your information, the calculator automatically estimates the pounds of greenhouse gas your family emits in carbon dioxide equivalents: your family's carbon footprint. Record the pounds of carbon dioxide equivalent in the table below.

*Table 1. Pounds of carbon dioxide equivalent emitted per year*

Activity	Total from Activity
Transportation	
Home Energy	
Waste	
Total	

*Note: Waste produces methane; the calculator converts this to the equivalent of pounds of carbon dioxide.*

- How do your family's greenhouse gas emissions compare to the U.S. average? (Note: The U.S. average is for a family of 2; for a family of 4, double the U.S. average.)

To explore actions your family could take to lower your greenhouse gas emissions while reducing energy and waste disposal costs, use the *What You Can Do to Reduce Emissions* section of the calculator. For each of the actions listed below, the calculator displays the amount of emissions your family could avoid. Calculate the items below, and record your results in the table.

- If your family bought a new car that gets 5 miles more per gallon of gas, how many pounds of carbon dioxide would your family avoid releasing into the atmosphere per year?
- If your family drove 10 fewer miles per week how many pounds of carbon dioxide would your family avoid releasing into the atmosphere?
- If your family turned down the heating thermostat in the winter by 2 degrees and turned up the air conditioning thermostat in the summer by 2 degrees, how many pounds of carbon dioxide would your family avoid releasing into the atmosphere per year?

- d) If your family replaced two incandescent light bulbs with two ENERGY STAR compact fluorescent light bulbs (CFLs), how many pounds of carbon dioxide would your family avoid releasing into the atmosphere per year?
- e) If your family does not recycle, how many pounds of carbon dioxide would they avoid releasing into the atmosphere per year if they did recycle?

*Table 2. Potential reduction in greenhouse gas emissions per year*

Activity	Amount of Greenhouse Gas Reduction
a) More energy efficient car	
b) Drive less	
c) Turn down thermostat in the winter and up in the summer	
d) Use compact florescent light bulbs	
e) Recycle	
Total Reduction of Greenhouse Gas	

5. In which ways would these changes reduce your family's carbon footprint?

### *Extend Your Thinking*

How many pounds of greenhouse gas do the families in your class emit in a year? Using the class data:

6. Determine the total pounds of greenhouse gas emitted by the families in your class.

- Calculate the mean, mode, median, and range of greenhouse gas emitted by the families in your class from transportation, home energy, and waste disposal (Table 3).

*Table 3. Yearly class total pounds / carbon dioxide equivalent emissions*

	Mean	Median	Mode	Range
Transportation				
Home Energy				
Waste Disposal				

- Create a graph that displays the relationship between the amount of greenhouse gas emitted in a year from transportation, home energy use, and waste disposal for the families in your class.
- How do your family's greenhouse gas emissions compare to those of your classmates' families?

There are about 100 million families (or households) in the U.S. If each family did the following, how much greenhouse gas would be eliminated from the atmosphere?

- If each household replaced two incandescent light bulbs with two ENERGY STAR compact florescent light bulbs (CFLs), how many pounds of carbon dioxide would be eliminated from the atmosphere per year?
- If each family drove 10 fewer miles per week, how many pounds of carbon dioxide would be eliminated from the atmosphere per year?

11. If each family turned down the heating thermostat in the winter by 2 degrees and turned up the air conditioning thermostat in the summer by 2 degrees, how many pounds of carbon dioxide would be eliminated from the atmosphere per year?

### *Apply What You Have Learned*

Create a brochure that could be used to inform families about actions they could take to reduce greenhouse gas emissions, and why such actions are important. The brochure needs to explain the ways in which each action would reduce greenhouse gas emissions and make a positive impact on the atmosphere and the environment.

### *Reflect on What You Have Learned*

12. In which ways do you and your family release greenhouse gases into the atmosphere?
13. How might these activities contribute to the greenhouse effect and to global warming?
14. What can you and your family do to reduce your greenhouse gas emissions?
15. Please explain changes in your ideas and thinking about greenhouse gases and your family's carbon footprint.



## STUDENT ACTIVITY #3

# A Simple Energy Audit

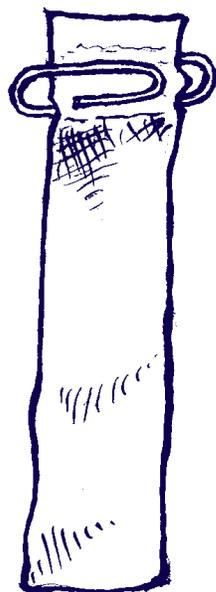
**Purpose:** This audit will encourage you to examine your classroom and identify ways in which you can help conserve energy.

**Time required:** 20–45 minutes

**Equipment:**

- This worksheet
- a pencil
- a paper clip
- a small piece of lightweight paper (such as tissue paper), approximately 1" across and 3" long, that hangs on a paper clip (see drawing)

**Introduction:** We spend much of our day in school. But few of us notice details about buildings, such as windows and thermostats. We also pay little attention to the small actions that each of us does—such as turning lights on and off—that affect energy use. These actions are important not only because they contribute to our comfort, but also because the use of energy to heat, cool, and provide lighting in school buildings increases the cost of operating our schools.



An energy-efficient school is more comfortable than one that is not energy-efficient, and it needs less oil, natural gas, coal, or electricity for heating or cooling. A building that is badly designed or poorly maintained is expensive to operate because it is trying to heat or air-condition the outdoors as well as the indoors.

The following activity will teach you to conduct a simple energy audit. By conducting this exercise, you will point out areas that could be improved and save energy, which means saving money and making you more comfortable. You will learn about things that you and your classmates can do to save energy.

You will conduct an audit inside your classroom.

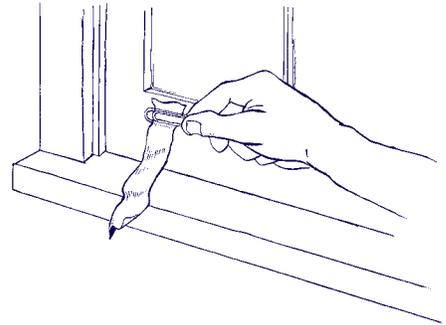
### Audit: Inside Your Classroom

1. Where is the thermostat located?
  - A. It should be located on inside walls, away from a bright light source (such as sunlight) or a heating or air conditioning vent. Is it?  yes  no
2. What setting is the thermostat reading?
  - A. It should be set at 68 degrees Fahrenheit in winter or 78 degrees Fahrenheit in summer. Is it?  yes  no
3. Do you have windows in your classroom? Answer these questions, if you have windows.
  - A. Does your classroom have window coverings that allow you to block out intense sunlight during hot days?  yes  no





B. Take the small piece of paper and paper clip you made. This is a “draft detector.” Walk up to the window, and hold the piece of paper at four different spots along the edge of the window, where the window meets the wall. Hold it still for about 30 seconds in each spot. Be sure to get really close to the window, if you can do it safely, and make sure that the heating vents aren’t blowing the paper.



C. Does the paper move? Can you feel warm or cold air coming in through the window? If you can feel air move, the windows are not energy-efficient. Are your windows energy-efficient?

\_\_\_\_\_ yes \_\_\_\_\_ no

4. Now take your draft detector to your classroom door. (If you have a door to a hallway and a door to the outside, do this activity with both doors.)

A. Place the detector along the sides of the inside of the door, where it meets the walls, and along the floor. Do you detect any air moving through the cracks between the door and the wall or the floor? If you can feel any air moving, your door is not energy-efficient. Is your door energy-efficient? \_\_\_\_\_ yes \_\_\_\_\_ no

B. Place the detector along the sides of the outside of the door, where it meets the walls, and along the floor. Do you detect any air moving through the cracks between the door and the wall or the floor? If you can feel any air moving, your door is not energy-efficient. Is your door energy-efficient? \_\_\_\_\_ yes \_\_\_\_\_ no

5. Does your classroom have a floor covering, such as carpeting? \_\_\_\_\_ yes \_\_\_\_\_ no

6. How high is your ceiling? (Use caution when trying to determine this.) Is it 8 feet or less? \_\_\_\_\_ yes \_\_\_\_\_ no

7. If you can safely open the air conditioning or heating unit in the classroom, do so, and look at the filters. Are they clean (little dust or dirt, not clogged)? \_\_\_\_\_ yes \_\_\_\_\_ no

8. Are the light bulbs used in your classroom energy-saving bulbs? (You might need to ask your facilities manager this question.) \_\_\_\_\_ yes \_\_\_\_\_ no

9. Are all the desks and chairs away from heating or cooling vents? \_\_\_\_\_ yes \_\_\_\_\_ no

10. Now we will look at some of your personal activities in your classroom that affect energy use.

A. Do you wear clothing that is appropriate for the season, such as sweaters in the winter and lightweight clothes in the summer? \_\_\_\_\_ yes \_\_\_\_\_ no

B. Do you turn off the lights if you are the last one out of the room? \_\_\_\_\_ yes \_\_\_\_\_ no

C. Do you avoid putting your textbooks, notebooks, etc. on top of heating or cooling vents? \_\_\_\_\_ yes \_\_\_\_\_ no

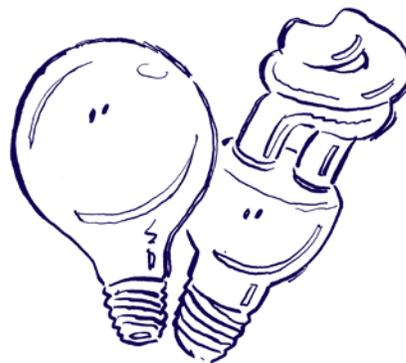
*continued*

### **STUDENT ACTIVITY #3: A SIMPLE ENERGY AUDIT**

If you answered “yes” to most of these questions, your classroom is doing well. But if you said “no” to three or more, you need to work with your teacher, facilities manager, or other adult to improve these areas.

Here’s why your answers matter:

1. If your thermostat is located too close to a strong light or heat source, it will not properly measure the room temperature, which means that energy will be wasted because the heater or air conditioner runs more than it needs to. It also could mean that you are uncomfortable in your classroom, because if the thermostat is near a source of heat or air-conditioning, it will turn off well before the entire room is heated or cooled.
2. If your thermostat is set too high in winter or too low in summer, you are wasting energy. Ask the person responsible for energy management in your school to check your thermostats and make sure that they are working properly.
3. If your windows do not have the ability to block out intense sun, your air-conditioning costs are too high, or your comfort level is lowered (because the room cannot cool down). If you see or feel air moving through the edge of the window, this means you are losing energy from your classroom, and the windows need to be caulked, sealed, or covered by a storm window system.
4. Your draft detector has helped you to determine whether your door is energy-efficient.
5. Carpeting helps keep rooms more comfortable and conserves heat.
6. Ceilings higher than 8 feet waste energy, because warm air moves to the top of the room instead of remaining near the floor where we are.
7. Clean filters conserve energy by allowing the unit to run efficiently. Dirty filters waste energy.
8. Energy-saving bulbs are more expensive to buy but save lots of money on electricity in the long term.
9. If furniture blocks heating or cooling vents, the furnace or air conditioner will insufficiently heat or cool the room.
10. When you wear clothes that are appropriate for the weather, you require less energy to keep warm or cool. Keeping lights on when you do not need them wastes energy. Again, if objects block heating or cooling vents, the furnace or air conditioner will insufficiently heat or cool the room.



## Concluding Activity

*"When you try to pick out anything by itself, you find it hitched to everything else in the universe."*

- John Muir

## It's All Connected!



## Topic

Concluding Activity  
15 – 30 minutes (depending on number of students in class)

## Learning Objective

Understand connections between environmental issues.

## Notes for the Facilitator



Materials Needed: Ball of yarn (untangled) and *Environmental Term Cards* (cut into individual cards)

Instructions:

1. Ask students to stand in a circle and give each person an *Environmental Term Card*. If the class is large, students can work in pairs.
2. Start the activity by reading your card. Hold on to one end of the yarn and gently toss the ball to someone on the other side of the circle.
3. The person now holding the ball of yarn will read their card, then state how the two terms on the cards are connected. For example, if the first card is 'recycle' and the second card is 'energy,' the statement could be "Processing a material that has been recycled takes less energy than using virgin materials. "  
Note: Other students may help brainstorm a connection if necessary. If no one is able to make a connection between the terms, return the ball of yarn to the previous person and toss to a different student.
4. Once the student makes a connection between the two terms, they will hold onto a piece of the yarn and toss to someone else across the circle.
5. Continue the exercise until everyone has caught the ball of yarn, called out the interconnections and is now holding a piece of the yarn.
6. Everyone pulls the yarn so the "web" is taut.
7. Pull on your piece of the yarn and ask if anyone felt the tug. Have other students pull on the yarn at varying strengths and see if others feel it.
8. Conclude with a discussion about What might that pull represent or signify about the connections between environmental issues? What might the softer pull represent or signify? How can understanding the interconnectedness of environmental issues help us green the manufacturing sector?

*Adapted from: Facing the Future, Making Global Connections, [www.facingthefuture.org](http://www.facingthefuture.org).*