What Can I Do as a Student to Make a Positive Impact on the Environment?

Submitted by: Tammy Guthrie, Environmental Science
Hellstern Middle School, Springdale, AR

Target Grade: 6th-8th Grade Science and Math

Time Required: 4-5 Days and 5 minutes every day of the semester (*for Elaboration*)

Standards:

Next Generation Science Standards (NGSS):

- MS-ESS3-3 Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
- MS-ESS3-4 Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.
- MS-ESS3-5 Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.

Common Core Mathematics Standards (CCSS):

- CCSS.MATH.CONTENT.6.RP.A.3.B Solve unit rate problems including those involving unit pricing and constant speed.
- CCSS.MATH.CONTENT.6.EE.B.7 Solve real-world and mathematical problems by writing and solving equations of the form $x + p = q$ and $px = q$ for cases in which p, q and x are all nonnegative rational numbers.

Lesson Objectives:

Students will be able to:

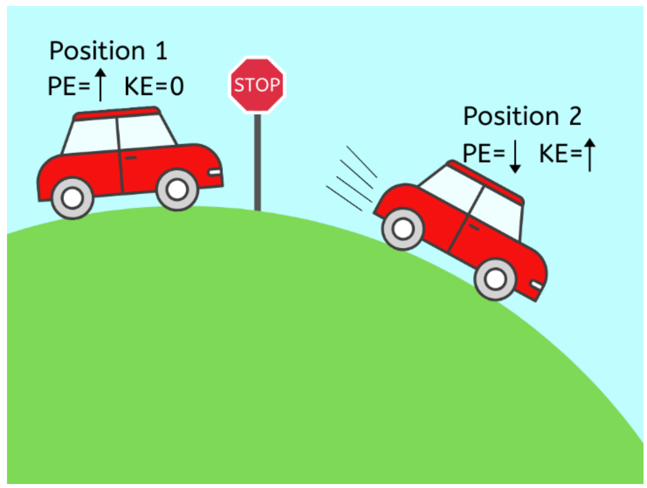
- Evaluate energy consumption to determine human impact and solutions.
- Collect and analyze data to provide supporting evidence for a claim.
- Investigate and cite research to participate in scientific argument.

Central Focus:

This lesson is *electric*! In this engaging unit, students will discover what they can do for the environment. Students will learn about human impact, efficiency, climate change, renewable and nonrenewable energy, sustainability, and much more! Throughout these exciting activities, students will evaluate real-world applications of gasoline versus hybrid cars, battery power versus solar power, energy consumption, greenhouse emissions, evolving technology, and long-term effects, in addition to evaluating their own town's energy consumption. In this cross-curricular unit, students will apply mathematical reasoning to graph, discover, average, predict, and evaluate data. Students will participate in data collection, investigation, research, argument, debate, application, modeling, and discussion. This unit will charge your students up to become informed environmental citizens!

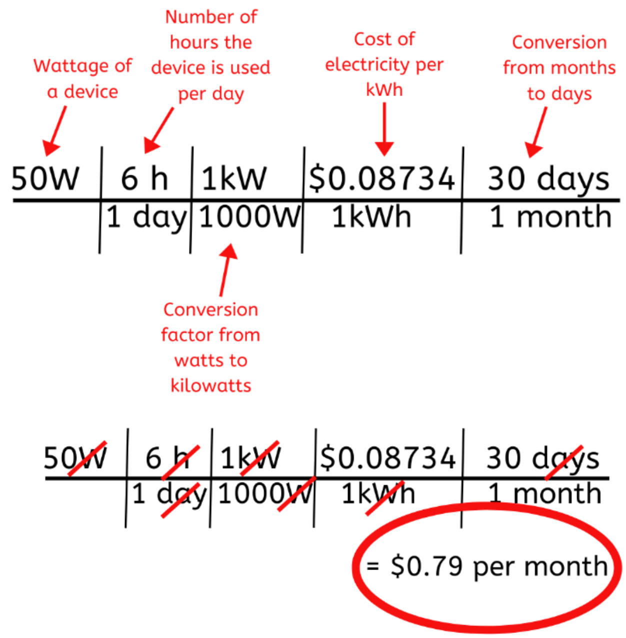
Key terms: electricity, discovery, sustain, efficient, tech, cause and effect, relevant, math, argue, predictions, evaluate, conservation, natural resources, monitor, solution

Background Information:



The Law of Conservation of Energy states that energy cannot be created or destroyed, but may be changed from one form to another. Kinetic energy is the energy due to motion. Kinetic energy will remain constant as long as the object is moving at a constant velocity. Kinetic energy is measured in Joules (J) and is calculated using the velocity and mass of the object. Alternatively, potential energy is determined by the object's state of "stored energy". An object's potential energy is not dependent on motion; therefore, velocity is not factored. However, potential energy is dependent on the mass, height from the earth's surface, and gravity. In the image to the right, the car stopped at the top of the hill (position 1) has no kinetic energy and its potential energy is higher than the moving car (position 2). The car in position 2 has decreasing potential energy as it is converted to kinetic energy as it rolls down the hill.

Chemical potential energy is energy that is stored in chemical bonds. A common example is energy stored in the chemical bonds of gasoline. When the gasoline is burned, the chemical potential energy in the gas is converted into thermal energy. Similarly, a battery also contains chemical potential energy. This potential energy can be converted into electrical energy to power a flashlight, battery operated car, or cell phone.



Energy can be measured in units. A watt is a measure of the instantaneous energy usage or power. A kilowatt-hour is a measure of energy, which is the amount of power used (watts) over a given amount of time. To calculate the cost of an electronic device, first multiply the wattage by the number of hours the device is used per day. To convert to kilowatt hours (kWh), divide by 1000 watts/1 kilowatts. To determine cost, multiply by the cost of electricity per kWh. Finally, to find the cost of the electricity for that device per month, multiply by the number of days. In the example to the right, the device uses 50 watts and 6 hours per day. This is then converted into kWh/day and multiplied by the cost of electricity per kWh. As this activity requires students to calculate the cost per month of a device, the product is multiplied by 30 days. The total cost of electricity for the device is $0.79 per month.

Power for electricity comes from different sources such as coal, wind, solar, water, and natural gas. A renewable resource has an endless supply, such as solar energy or hydropower. Renewable resources generally produce fewer greenhouse gas emissions and pollution than nonrenewable resources; however, renewable resources can often be affected by seasonal or daily changes which can cause an inconsistent energy production. Alternatively, nonrenewable resources are sources of energy that have a finite supply, such as fossil fuels and coal. These resources contribute pollution and greenhouse gases to the atmosphere.

Materials

- “Saving the World, One Kilowatt at a Time” Student Data Sheet*
- Kill-A-Watt Energy Usage Meters
- Variety of household electronics:
  - Laptop
  - Lamp 1 - LED bulb
  - Lamp 2 - non-LED Fan
  - Hair dryer
  - iPhone and charger
  - CD Player with Radio
  - Vacuum Cleaner
  - Game System
- Class set of calculators

- "Global Greenhouse Gas Emissions Data" Student Reading*
- Chart Paper
- Markers
- "Forcing Fuel Efficiency on Consumers Doesn't Work" Student Reading*
- Claim-Evidence-Reasoning (CER) Graphic Organizer*
- Student Devices
- "Should I Buy a Hybrid" Student Worksheet*
- "Introduction to Energy" Student Reading*
- Constant Velocity Battery Powered Cars (one per group)
- Solar Powered Cars (one per group)
- "Waste Heat" Lab Worksheet *(optional additional engage)**
  - Lamp
  - Thermometer
  - 25-watt incandescent bulb
  - 100-watt incandescent bulb
  - 2 Fluorescent bulbs that produce lumens comparable to the incandescent bulbs

*Attached

Instruction

ENGAGE:

Part 1: Math warm ups

- The teacher should instruct the students to work on the warm up as they enter the classroom. Students should work independently, in order for the teacher to formatively assess the math skills of each student prior to the lesson.
  1. Bella knows that it costs $.06 for every kWh she uses. How much would it cost if she uses 325 kWh of energy?
  2. How many kWh can Bella afford if she has $39?
  3. If Bella has set aside $100 for her monthly electric bill, and uses 140 kWh every 5 days, can she afford to pay her electric bill for the month?

Part 2: Kilowatt Data Collection & Comparison

- The teacher should bring in a variety of household electronic devices and display them for the students.
- Pass out "Saving the World, One Kilowatt at a Time" Student Data Sheet. The below questions are included in the instructions for the students.
  1. Examine the given electronic devices. Predict the order of the devices from least to greatest power usage. Write down your prediction on data sheet (if not previously completed prior to part 1).

2. Plug in the devices and use the Kilowatt Meters to collect power data for each electronic device (Watts). Record data in the table.
3. Estimate how much time (in hours) someone would use that electronic each day. Record.
4. Calculate the kWh used by the device in the give time using the following equation: E(kWh) = P (W) × t(hr) / 1000
5. The costs for electricity in Springdale (*can change to your city*) is currently $____ per kWh. Using ratios, calculate the cost to use the device/bulb for a month (30 days).
6. Make a graph on the back of your paper, showing cost as a function of time for two devices (time should be independent and on the x-axis, and cost should be dependent and on the y-axis).
7. What does this show? (*hint: discuss independent vs. dependent variables)
8. Was your prediction accurate? Explain, citing proof from your data collection.

Part 3: Discussion

- Facilitate a class discussion on electricity and energy usage. The below questions are suggested to help lead the discussion.
  1. What is a watt?
  2. What is a kilowatt-hour?
  3. Where does our power in our region come from?
  4. What are some reasons it is important to be energy efficient?
  5. How does the power consumption change if you alter your brightness on your iPhone?
  6. What does power-save mode mean on electronic devices?
  7. How does changing the fan speed affect the wattage?
  8. Does turning off your appliance mean that it is no longer using power? Why or Why not?

EXPLORE:

- Bring the class together for a discussion on the mathematical aspect of energy consumption. Below are suggested questions to propel the discussion.
  1. Let's think about some things mathematically. Let's assume that a few years ago, the gasoline version of a Honda Civic costs $21,000 and it get 35 MPG. The hybrid version of the same car costs $26,000 and gets 47 MPG. Let's assume that you drive 10,000 miles per year and that gasoline costs $2.50 per gallon (all year)
     i. First, without working any math, what are some thoughts that you have about this information?
  2. With a calculator, calculate how much gas costs per year for each of the cars if you drive each for 10,000 miles at $2.50 per gallon.
- Have the students calculate and graph the cost per year of the gasoline and hybrid versions of the Honda Civic.
  - Using the initial value of each car and the cost of gasoline for a year, calculate and graph the cost of each car per year for 10 years. Use years for the x-axis (independent) and total costs for the y-axis (dependent). Use these equations: t(1) = $21,000 + c1(year) where c1 is the

answer from question 3 for the gasoline car. Plug in year 0 - year 10 and record the answers for the total costs each year (t1). t(2) =$26,000 + c2(year) where c2 is the answer from question 3 for the hybrid car. Plug in year 0 - 10 and record the answers for the total of costs each year t(2).
    - Graph both lines using different colored pencils.
- As a class, discuss the results.
    1. Discuss what the graph looks like.
    2. Discuss what the lines represent.
    3. Is there a point on the graph where both lines intersect?
    4. What do you think that means?
    5. What is happening after that intersection point?
    6. What year does this happen?
    7. What does this mean?
- Assign reading "Global Greenhouse Gas Emissions Data" (https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data). Emphasize that we are just getting an overview of these ideas. We are becoming informed citizens. No information included is intended for mastery.
- Jigsaw the 4 paragraphs then have students use the Golden Line Strategy to summarize their paragraph. Have full copies for each student as a guide and each student can then add others' "Golden Line" to their paper.
- As a class, create a chart of highlights from the article that students shared out.
- Assign close independent read of "Forcing Fuel Efficiency on Consumers Doesn't Work" by Jerry Taylor.
    1. What claims does the author make?
    2. What evidence does the author use to support his claim?
    3. What are your opinions of these claims? Reason about your thinking.
- Using the article, have the students complete a Claim Evidence-Reasoning (CER) graphic organizer.
- Show Top Gear video "Petrol vs Electric - Mercedes SLS AMG Battle - Top Gear Series 20 - BBC
    1. https://www.youtube.com/watch?v=5gFGX43vubM (8:07)
    2. Make sure to discuss the difference between the electric car in this video and a hybrid car that we have been investigating and the different fuel sources that operate the car.
- Share 2 additional websites and copies of Comparison Data and Questions
    1. http://www.fueleconomy.gov/feg/Find.do?action=bt2 Greenhouse Emissions for Electric and Plug-In Hybrid Electric Vehicles
    2. http://www.epa.gov/otaq/consumer/420f08024.pdf Greenhouse Gas Emissions and Fuel Consumption for Gasoline-Fueled Passenger Cars and Light Trucks
- Allow silent time for students to explore websites. Bring the whole class back to answer questions about the websites.
- Pass out and have students complete the "Should I Buy a Hybrid" student worksheet.
- Bring the class together for a class discussion. Make sure to have students use evidence from their data when making a claim.

1. Why do different parts of the country have different data?
2. Compare and contrast CO_2 emissions from hybrids, passenger cars and trucks and plug-in electric.
3. What are the economic and ecological effects of each type of car?
   Students should make a claim stating which car they would purchase and support it with evidence. Examples: "I would buy a hybrid because it uses less gasoline. I know it is more expensive but it helps the environment." OR "I would buy a Dodge Charger because it is fast and looks cool! It doesn't cost as much as a hybrid and after 3 years I would sell it and buy a Corvette."

- Remember to make continual references to human impact.

EXPLAIN:

- Pass out "Introduction to Energy" from BP & NEED's (National Energy Education Development) Middle School Energy Experiments guide, pages 4 and 5.
- Have half of the students of read the section on Potential Energy and half read the section on Kinetic Energy. Use the attached 'Conga Line' strategy for student interaction.
- "Jigsaw" the 4 remaining parts (Conservation of Energy, Efficiency, Sources of Energy, & Electricity).

ELABORATE:

Long-term data collection and interpretation

- Demonstrate the operation of a battery powered constant velocity car and a solar powered car.
  - The idea is to predict and test which is a better deal, a solar powered car that operates for free on any sunny day, but is costly upfront, versus an inexpensive battery powered car that requires frequent battery replacement. Pose the question to the class prior to testing.
- The teacher should facilitate a discussion of predictions about which is more cost effective.

Battery Powered Car

Solar Powered Car

- Students should consider the research they just completed and the findings.
- Students should ask themselves if these ideas can transfer to these models or toy cars.
- The teacher will explain that this is a semester long data collection process. Students will use their journal to log the initial cost of each car and the daily data. Student teams will be assigned to run each car for 5 minutes each day (simulating the ride to school each morning). Students will record their observations such as "the solar powered car did not run today because it was cloudy" or "The battery powered car seems to be running low on juice."

- After sufficient data is collected, students present their findings and conclusions based on evidence, justifying the better buy or more cost efficient.

  Notes:

- Make sure data is collected at the same time each day when students run the battery powered car and solar powered car.
- Set cars side by side and run for 5 minutes.

EVALUATE:

- Assign the students to work in partners. Allow students to choose or assign a topic and argument. Students need to understand that they may take a side with which they do not necessarily agree.
- Students will research their topic and argument and prepare a 4 slide presentation that includes:
  1. Title, Student names, claim/argument statement
  2. Evidence to support the claim
  3. Proof or theory that opposing side is wrong
  4. Conclusion and questions from audience
- Each side (and whole class) will listen to others' arguments. Each team will then have 2 minutes to question or debunk opposite views.
- Topics could include:
  - Buying a hybrid versus gas car or electric
  - Use of renewable energy versus fossil fuels (affordability)
  - Sacrificing technology and appliance usage to conserve energy (Remember, part of science is inventing things that make our life easier BUT they might use more energy.)
  - Any other topics in which students show interest

Extensions

ENGAGE:

- Have students look at and discuss their energy bill with their parents OR have sample energy bills for students to discuss.
- Have students count the number of lightbulbs in their house.
- Have students identify one way they can conserve energy at home.

  Additional/Alternative ENGAGE Options:

- "Waste Heat" from BP & NEED's (National Energy Education Development) Middle School Energy Experiments guide. (Pg. 19)
- Students conduct a mini-lab to compare the amount of heat produced by a 25-watt Incandescent bulb, 100-watt Incandescent bulb, and 2 Fluorescent bulbs that produce lumens comparable to the Incandescent bulbs.
  - Is more heat produced when more light is produced?

- Which light bulbs are more energy efficient? How do you know?

ELABORATE:

Connections to Climate Change issues in the Marshall Islands:

- Article: "Awaiting A Wave" - Viewable Graphic Novel → Reported & Written by Dale Carpenter, Art by Nate Powell (weather.com) (URL: https://features.weather.com/us-climate-change/arkansas/)
- Video: "When Climate Change Wipes Your Country Off the Map" - CNN's John Sutter visits the Marshall Islands to see the impact of climate change on their families, communities, and country. (URL: https://www.cnn.com/videos/us/2015/06/24/orig-sutter-climate-change-marshall-islands-sinking-two-degrees.cnn/video/playlists/climate-change/)

Assessment

Formative Assessment:

- The teacher will continuously monitor and observe the students throughout the lesson.
- The teacher will assess student understanding throughout discussions.
- The teacher will assess the students through questioning (examples provided throughout the lesson). The teacher will use this information to inform further teaching, questioning, and additional help.
- Students will be assessed on completion and accuracy of "Saving the World, One Kilowatt at a Time" worksheet and concluding graph.
- Students will be assessed on completion and accuracy of "Should I Buy a Hybrid" worksheet and research.
- Students will be assessed through their notebooks detailing the long-term data collection and conclusion.

Summative Assessment:

- Students will be assessed on completion, accuracy, and thoroughness of CER graphic organizer.
- Students will be assessed on concluding debate, including presentation, evidence and justification, and argument using the CER rubric.

Claims, Evidence and Reasoning Rubric

Name: ____

Category	**N/A**	**Beginning**	**Approaching**	**Meeting**
Claim A conclusion that answers the original question.	Does not make a claim.	Makes an inaccurate claim.	Makes an accurate, but incomplete claim.	Makes an accurate and complete claim.
Evidence Scientific data that supports the claim. The data needs to be appropriate and sufficient to support the claim.	Does not provide evidence.	Evidence is inappropriate or it does not support the claim.	Provides appropriate, but insufficient evidence. May include some inappropriate evidence.	Provides appropriate and sufficient evidence to support claim.
Reasoning A justification that links the claim to the evidence. It shows why the data counts as evidence by using appropriate scientific principles.	Does not include reasoning.	Reasoning is not appropriate or does not link the claim to the evidence.	Provides reasoning that links claims to evidence. Repeats evidence and/or includes some scientific principles, but not sufficient.	Provides accurate and complete reasoning that links evidence to the claim. Includes appropriate and sufficient scientific principles.

Adapted from:
McNeill, K.L. & Krajcik, J. (2008). Assessing middle school students' content knowledge and reasoning through written explanations. In Assessing science learning: Perspectives from research and practice, eds. J. Coffey, R. Douglas, and C. Stearns, 101–116. Arlington, VA: NSTA Press

Adapted from: Hein & Price (1994); Bass, Contant, & Carin (2009)

The following article appeared in the *Lincoln (NE) Journal Star* on August 21, 2001.

Forcing fuel efficiency on consumers doesn't work

By Jerry Taylor

Although the late, great energy crisis seems to have come and gone, the political fight over yesterday's panic rages on. The big dust-up this fall will be over SUVs, light trucks and minivans. Should the government order Detroit to make them get more miles per gallon? Conservationists say "yes." Economics 101 says "no."

Let's start with a simple question: Why should the government mandate conservation? When fuel becomes scarce, fuel prices go up. When fuel prices go up, people buy less fuel. Economists have discovered over the long run, a 20 percent increase in gasoline costs, for instance, will result in a 20 percent decline in gasoline consumption. No federal tax, mandate or regulatory order is necessary.

Notice the phrase "over the long run." Energy markets are volatile because consumers do not change their buying habits much in the short run.

This has led some critics to conclude that people don't conserve enough when left to their own devices. They do, but consumers need to be convinced that the price increases are real and likely to linger before they'll invest in energy-efficient products or adopt lifestyle changes. But even in the short run, people respond. Last summer was a perfect example: For the first time in a non-recession year, gasoline sales declined in absolute terms in response to the $2 per gallon that sold throughout much of the nation.

Mandated increases in the fuel efficiency of light trucks, moreover, won't save consumers money. A recent report from the National Academy of Sciences, for instance, notes that the fuel efficiency of a large pickup could be increased from 18.1 miles per gallon to 26.7 miles per gallon at a cost to automakers of $1,466. But do the math: It would take the typical driver 14 years before he would save enough in gasoline costs to pay for the mandated up-front expenditure. A similar calculation for getting a large SUV up to 25.1 miles per gallon leads to a $1,348 expenditure and, similarly, more than a decade before buyers would break even.

"Fine with me," you say? But it's one thing to waste your own money on a poor investment; it's entirely another to force your neighbor to do so. You could take that $1,466, for instance, put it in a checking account yielding 5 percent interest, and make a heck of a lot more money than you could by investing it in automobile fuel efficiency.

Even if government promotion of conservation were a worthwhile idea, a fuel efficiency mandate would be wrong. That's because increasing the mileage a vehicle gets from a gallon of gasoline reduces the cost of driving. The result? People drive more.

Energy economists who've studied the relationship between automobile fuel efficiency standards and driving habits conclude that such mandates are offset by increases in vehicle miles traveled.

If we're determined to reduce gasoline consumption dramatically, The right way to go would be to increase the marginal costs of driving by increasing the tax on gasoline. Now, truth be told, I don't support this idea much either. A recent study by Harvard economist Kip Viscusi demonstrates that the massive fuel taxes already levied on drivers (about 40 cents per gallon) fully "internalize" the environmental damages caused by driving. But conservationists reject this approach for a different reason: Consumers hate gasoline taxes and no Congress or state legislature could possibly increase them.

Look, it's a free country. If you want to buy a fuel-efficient car, knock yourself out. But using the brute force of the government to punish consumers who don't share your taste in automobiles serves no economic or environmental purpose.[1]

[1] Forcing fuel efficiency on consumers doesn't work by Jerry Taylor, August 21, 2001, *Lincoln (NE) Journal Star*, p. 5B. Used with permission, © 2001, Jerry Taylor and Cato Institute.

Name(s)___________________________________ Science Block # ___

Title ____

Question:
Claim / Hypothesis:

Evidence:	Justification:

Project / Lab Title ____

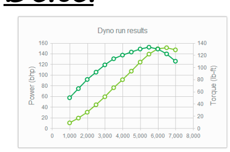
The Guiding Question:

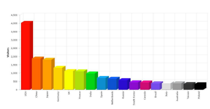
Claim / Hypothesis:

(Your Answer to the Guiding Question)

Evidence:

<u>Data</u>





<u>Analysis</u>

Show a *trend, difference*, or a *relationship.*

<u>Interpretation</u>

Explain what the analysis means →

This graph indicates _____
This chart shows _____
This graph suggests _____

Justification:

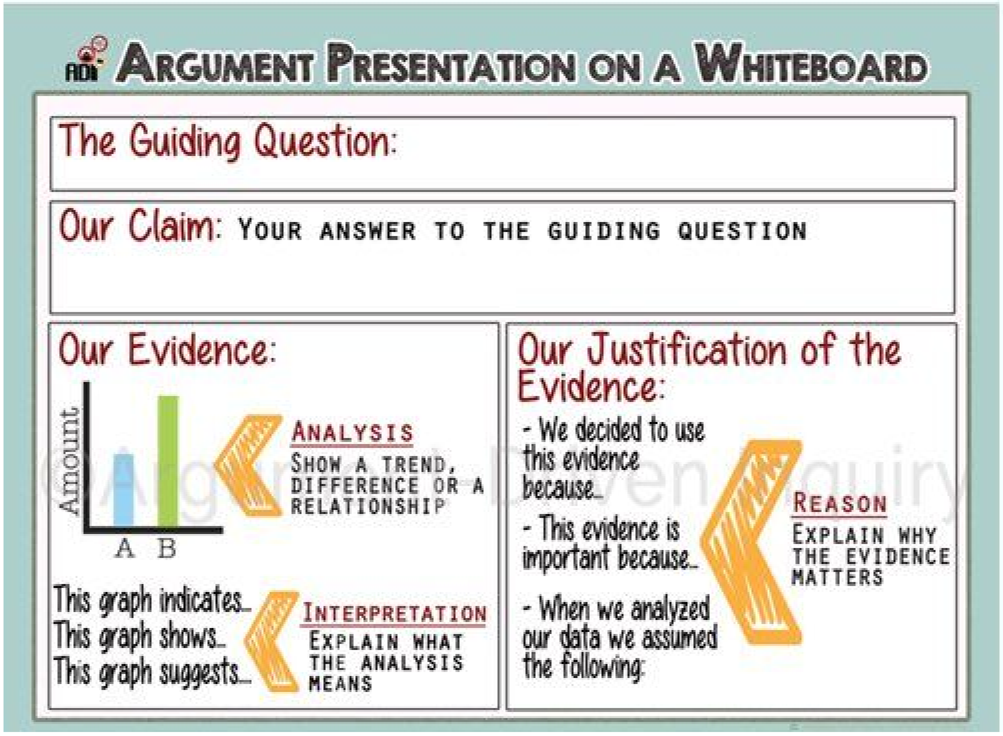
<u>Reason</u>

Explain why the evidence matters.

I decided to use this evidence because _____.

This evidence is important because _____.

When I analyzed the data, I assumed the following: _____, _____, and _____.


ADI
Argument Presentation on a Whiteboard
The Guiding Question:
Our Claim: Your answer to the guiding question
Our Evidence:
Amount
A B
Analysis
Show a trend, difference or a relationship
This graph indicates...
This graph shows...
This graph suggests...
Interpretation
Explain what the analysis means
Our Justification of the Evidence:
- We decided to use this evidence because...
- This evidence is important because...
- When we analyzed our data we assumed the following:
Reason
Explain why the evidence matters


ADI
A Scientific Argument
The Claim
State your answer to the guiding question.
Fits with...
Supports...
The Evidence
Provide analyzed data (measurements & observations) to support your claim that illustrates trends, comparisons, and/or relationships among variables.
Supported with...
Explains...
Justification of the Evidence
Defend your evidence using relevant scientific concepts.

Waste Heat

Grade Levels: 4-6

Background

Energy is never created or destroyed, it simply changes form. A light bulb uses electricity to create light that lights your home. Light bulbs use the electricity to first create heat and then light. Some light bulbs need a lot more heat in order to glow.

Questions

Does a high watt bulb produce more heat than a low watt bulb?

Does an incandescent bulb produce more heat than a fluorescent bulb?

Possible Hypothesis

A ________________________________ bulb produces _________________ heat than a ____________________________bulb.

Materials

- Lamp
- Thermometer
- 25-watt Incandescent bulb
- 100-watt Incandescent bulb
- 2 Fluorescent bulbs that produce lumens comparable to the incandescent bulbs

✔ Procedure

1. Put a 25-watt incandescent bulb in the lamp and turn it on.
2. Hold the thermometer six inches above the bulb for one minute and record the temperature. Turn off the lamp.
3. Let the bulb cool, remove it, put in the 100-watt light bulb, and turn it on. Repeat Step 2.
4. Repeat the procedure with the fluorescent bulbs.

Analysis and Conclusion

Is more heat produced when more light is produced?

Which light bulbs are more energy efficient—incandescent or fluorescent?

Introduction to Energy

What Is Energy?

Energy makes change; it does things for us. It moves cars along the road and boats over the water. It bakes a cake in the oven and keeps ice frozen in the freezer. It plays our favorite songs and lights our homes. Energy makes our bodies grow and allows our minds to think. Scientists define energy as the ability to do work.

Forms of Energy

Energy is found in different forms, such as light, heat, sound, and motion. There are many forms of energy, but they can all be put into two categories: potential and kinetic.

POTENTIAL ENERGY

Potential energy is stored energy and the energy of position, or gravitational potential energy. There are several forms of potential energy.

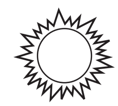
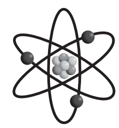
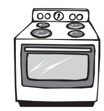
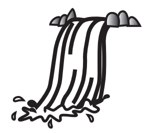
- **Chemical energy** is energy stored in the bonds of atoms and molecules. It is the energy that holds these particles together. Biomass, petroleum, natural gas, propane, and the foods we eat are examples of stored chemical energy.
- **Elastic energy** is energy stored in objects by the application of a force. Compressed springs and stretched rubber bands are examples of elastic energy.
- **Nuclear energy** is energy stored in the nucleus of an atom; it is the energy that holds the nucleus together. The energy can be released when the nuclei are combined or split apart. Nuclear power plants split the nuclei of uranium atoms in a process called fission. The sun combines the nuclei of hydrogen atoms in a process called fusion.
- **Gravitational potential energy** is the energy of position or place. A rock resting at the top of a hill contains gravitational potential energy because of its position. Hydropower, such as water in a reservoir behind a dam, is an example of gravitational potential energy.

KINETIC ENERGY

Kinetic energy is motion; it is the motion of waves, electrons, atoms, molecules, substances, and objects.

- **Electrical energy** is the movement of electrons. Everything is made of tiny particles called atoms. Atoms are made of even smaller particles called electrons, protons, and neutrons. Applying a force can make some of the electrons move. Electrons moving through a wire are called electricity. Lightning is another example of electrical energy.
- **Radiant energy** is electromagnetic energy that travels in vertical (transverse) waves. Radiant energy includes visible light, x-rays, gamma rays, and radio waves. Solar energy is an example of radiant energy.

Forms of Energy

POTENTIAL		KINETIC	
Chemical Energy		Electrical Energy	
Elastic Energy		Radiant Energy	
Nuclear Energy		Thermal Energy	
		Motion Energy	
Gravitational Potential Energy		Sound Energy	

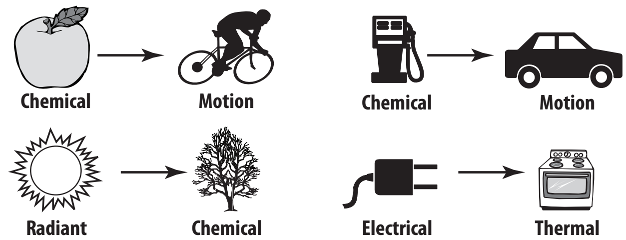
- **Thermal energy**, or heat, is the internal energy in substances; it is the vibration and movement of the atoms and molecules within a substance. The more thermal energy in a substance, the faster the atoms and molecules vibrate and move. Geothermal energy is an example of thermal energy.
- **Motion energy** is the movement of objects and substances from one place to another. Objects and substances move when an unbalanced force is applied according to Newton's Laws of Motion. Wind is an example of motion energy.
- **Sound energy** is the movement of energy through substances in longitudinal (compression/rarefaction) waves. Sound is produced when a force causes an object or substance to vibrate; the energy is transferred through the substance in a longitudinal wave.

Conservation of Energy

Your parents may tell you to conserve energy. “Turn off the lights,” they say. To scientists, energy conservation is not just about saving energy. The Law of Conservation of Energy says that energy is neither created nor destroyed. When we use energy, it doesn’t disappear. We change one form of energy into another.

A car engine burns gasoline, converting the chemical energy in gasoline into motion energy. Solar cells change radiant energy into electrical energy. Energy changes form, but the total amount of energy in the universe stays the same.

Energy Transformations



Efficiency

Energy efficiency is the amount of useful energy you get from a system. A perfect, energy efficient machine would change all the energy put in it into useful work—a technological impossibility today. Converting one form of energy into another form always involves a loss of usable energy.

Most energy transformations are not very efficient. The human body is a good example of this. Your body is like a machine, and the fuel for your machine is food. Food gives you the energy to move, breathe, and think.

Your body isn’t very efficient at converting food into useful work. Most of the energy in your body is transformed and released as thermal energy (heat). You can really feel that heat when you exercise! This is very much like most energy transfers. The loss of useable energy is often in the form of thermal energy (heat).

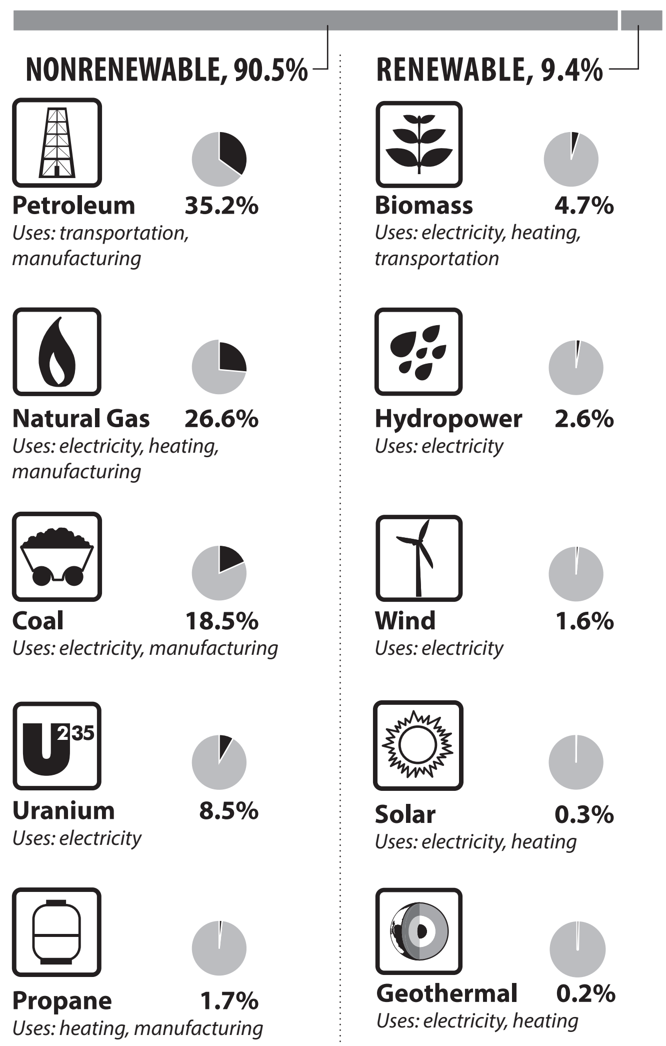
Sources of Energy

We use many different energy sources to do work for us. They are classified into two groups—renewable and nonrenewable.

In the United States, most of our energy comes from nonrenewable energy sources. Coal, natural gas, petroleum, propane, and uranium are nonrenewable energy sources. They are used to make electricity, heat our homes, move our cars, and manufacture all kinds of products. These energy sources are called nonrenewable because their supplies are limited. Petroleum, a fossil fuel, for example, was formed hundreds of millions of years ago from the remains of ancient sea plants and animals. We can’t make more crude oil deposits in a short time.

Renewable energy sources include biomass, geothermal energy, hydropower, solar energy, and wind energy. They are called renewable because they are replenished in a short time. Day after day, the sun shines, the wind blows, and the rivers flow. We use renewable energy sources mainly to make electricity.

U.S. Energy Consumption by Source, 2013



Data: Energy Information Administration
*Total does not equal 100% due to independent rounding.

Electricity

Electricity is different from the other energy sources because it is a secondary source of energy. We must use another energy source to produce electricity. In the U.S., coal is the number one energy source used for generating electricity.

Electricity is sometimes called an energy carrier because it is an efficient and safe way to move energy from one place to another, and it can be used for so many tasks. As we use more technology, the demand for electricity grows.

Name ________________________________ Science Block #___

Should I Buy a Hybrid?
Comparison Data and Questions

1) Compare and contrast the carbon dioxide emissions of a hybrid, passenger car, light duty truck, and plug-in electric car.
   a) Greenhouse Emissions for Electric and Plug-In Hybrid Electric Vehicles: https://www.fueleconomy.gov/feg/Find.do?action=bt2
   b) Greenhouse Gas Emissions and Fuel Consumption for Gasoline-Fueled Passenger Cars and Light Trucks: https://www.epa.gov/vehicles-and-engines

2) Compare data for our area (72762) and 3 other different zip codes.

Zip Code	City, State	Average New Vehicle	U.S. Average	Your Region
72762	Springdale, AR			
93561				
94089				
85701				

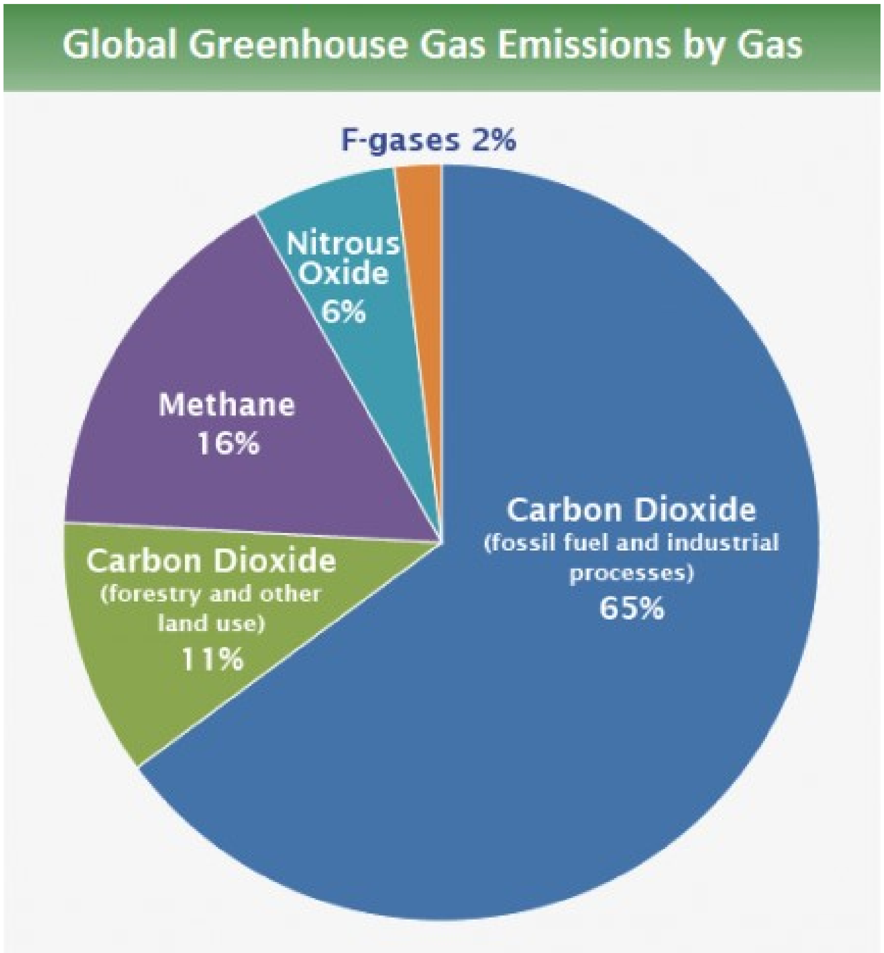
3) What differences do you think there are between these 4 cities that would cause their emission levels to be different?

Global Greenhouse Gas Emissions Data

On This Page:

Global Emissions by Gas

At the global scale, the key greenhouse gases emitted by human activities are:



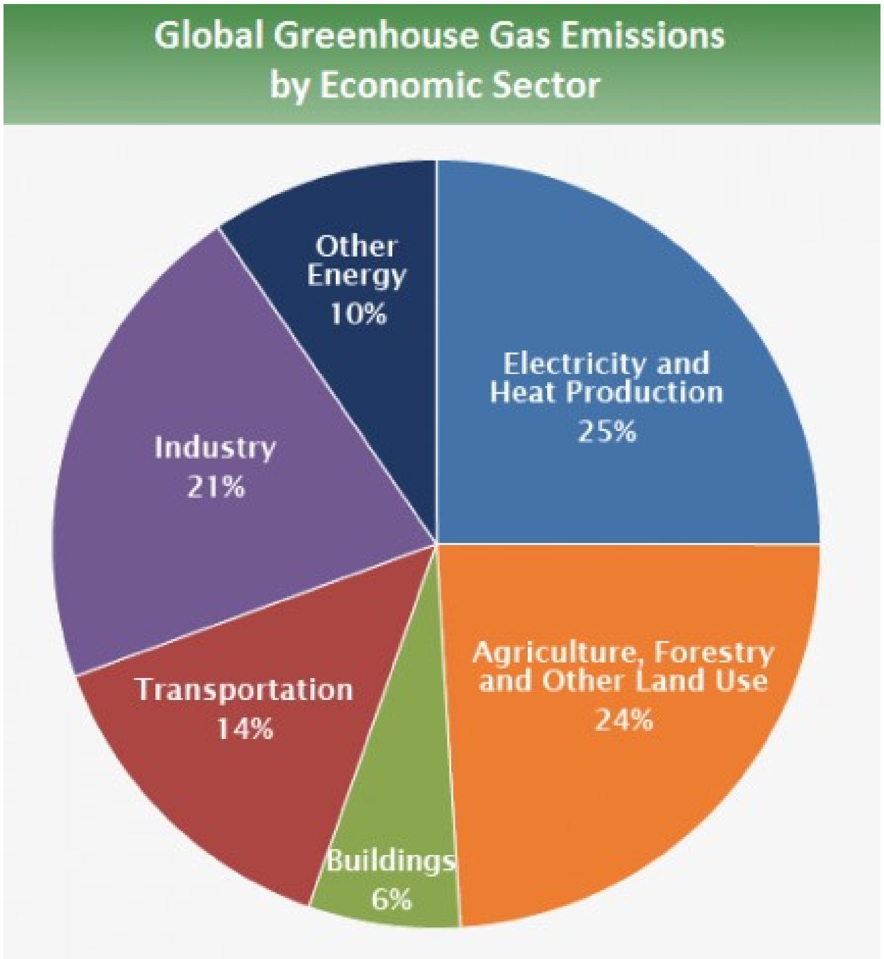
Source: IPCC (2014) EXIT based on global emissions from 2010. Details about the sources included in these estimates can be found in the *Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. EXIT

- **Carbon dioxide (CO_2)**: Fossil fuel use is the primary source of CO_2. CO_2 can also be emitted from direct human-induced impacts on forestry and other land use, such as through deforestation, land clearing for agriculture, and degradation of soils. Likewise, land can also remove CO_2 from the atmosphere through reforestation, improvement of soils, and other activities.
- **Methane (CH_4)**: Agricultural activities, waste management, energy use, and biomass burning all contribute to CH_4 emissions.
- **Nitrous oxide (N_2O)**: Agricultural activities, such as fertilizer use, are the primary source of N_2O emissions. Fossil fuel combustion also generates N_2O.
- **Fluorinated gases (F-gases)**: Industrial processes, refrigeration, and the use of a variety of consumer products contribute to emissions of F-gases, which include hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6).

Black carbon is a solid particle or aerosol, not a gas, but it also contributes to warming of the atmosphere. Learn more about black carbon and climate change on our Causes of Climate Change page.

Global Emissions by Economic Sector

Global greenhouse gas emissions can also be broken down by the economic activities that lead to their production.[1]



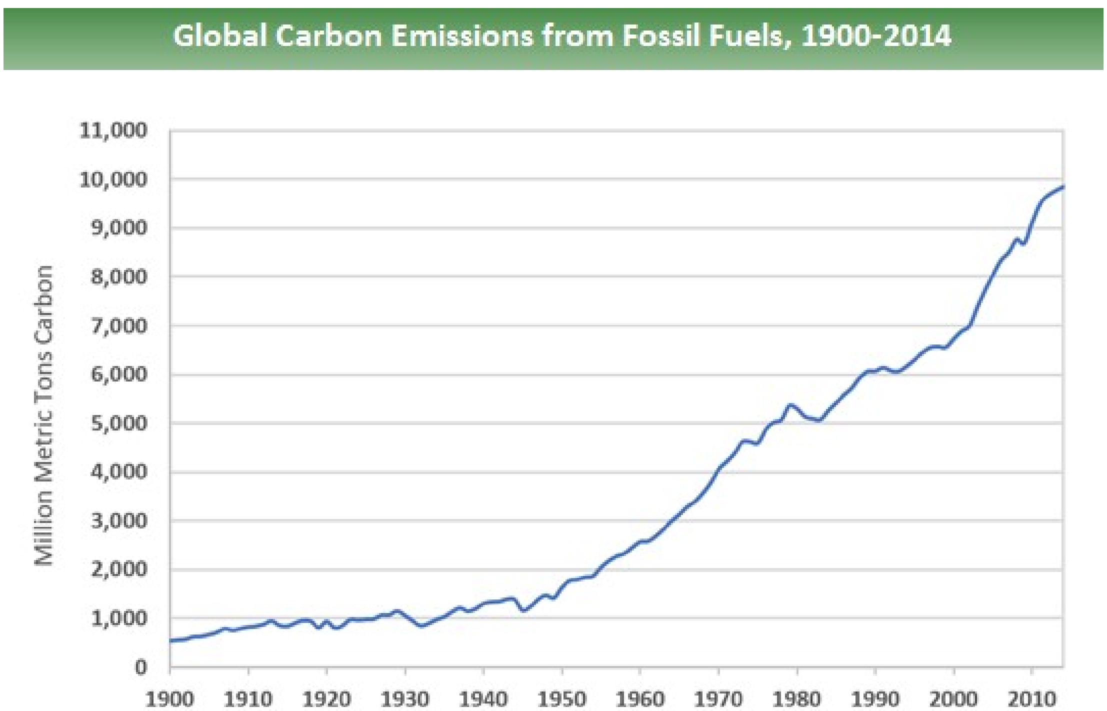
Source: IPCC (2014); EXIT based on global emissions from 2010. Details about the sources included in these estimates can be found in the *Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. EXIT

- **Electricity and Heat Production** (25% of 2010 global greenhouse gas emissions): The burning of coal, natural gas, and oil for electricity and heat is the largest single source of global greenhouse gas emissions.
- **Industry** (21% of 2010 global greenhouse gas emissions): Greenhouse gas emissions from industry primarily involve fossil fuels burned on site at facilities for energy. This sector also includes emissions from chemical, metallurgical, and mineral transformation processes not associated with energy consumption and emissions from waste management activities. (Note: Emissions from industrial electricity use are excluded and are instead covered in the Electricity and Heat Production sector.)

- **Agriculture, Forestry, and Other Land Use** (24% of 2010 global greenhouse gas emissions): Greenhouse gas emissions from this sector come mostly from agriculture (cultivation of crops and livestock) and deforestation. This estimate does not include the CO_2 that ecosystems remove from the atmosphere by sequestering carbon in biomass, dead organic matter, and soils, which offset approximately 20% of emissions from this sector.[2]
- **Transportation** (14% of 2010 global greenhouse gas emissions): Greenhouse gas emissions from this sector primarily involve fossil fuels burned for road, rail, air, and marine transportation. Almost all (95%) of the world's transportation energy comes from petroleum-based fuels, largely gasoline and diesel.
- **Buildings** (6% of 2010 global greenhouse gas emissions): Greenhouse gas emissions from this sector arise from onsite energy generation and burning fuels for heat in buildings or cooking in homes. (Note: Emissions from electricity use in buildings are excluded and are instead covered in the Electricity and Heat Production sector.)
- **Other Energy** (10% of 2010 global greenhouse gas emissions): This source of greenhouse gas emissions refers to all emissions from the Energy sector which are not directly associated with electricity or heat production, such as fuel extraction, refining, processing, and transportation.

Note on emissions sector categories.

Trends in Global Emissions

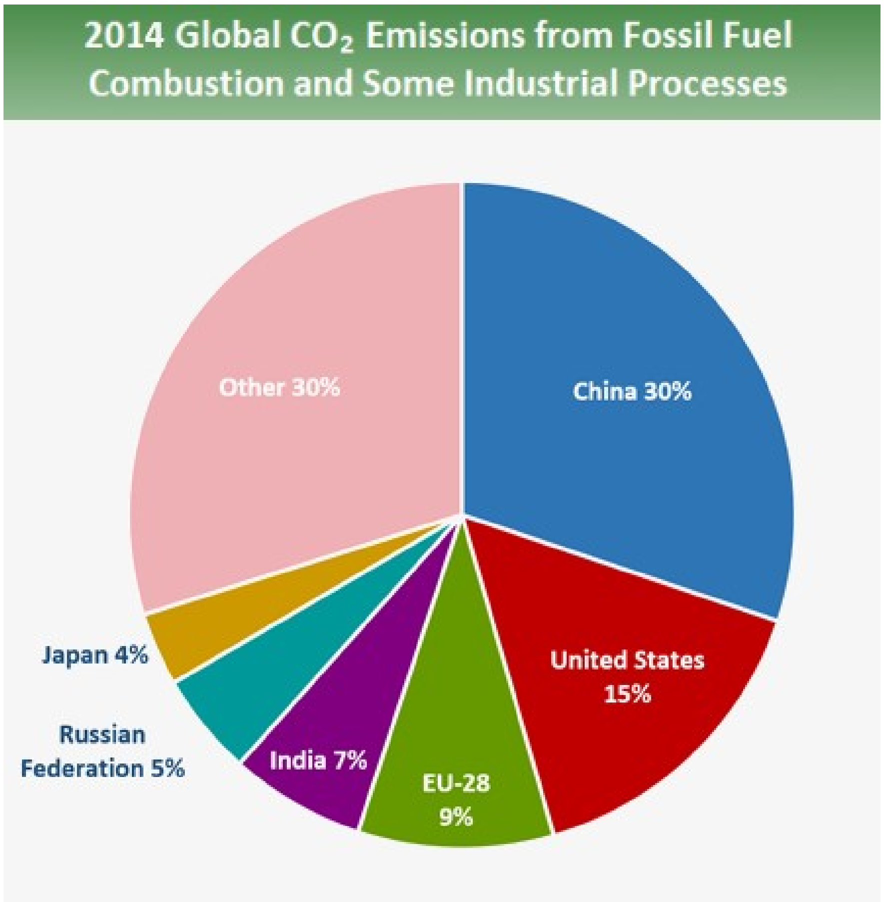


Source: Boden, T.A., Marland, G., and Andres, R.J. (2017). Global, Regional, and National Fossil-Fuel CO2Emissions. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tenn., U.S.A. doi 10.3334/CDIAC/00001_V2017.

Global carbon emissions from fossil fuels have significantly increased since 1900. Since 1970, CO_2 emissions have increased by about 90%, with emissions from fossil fuel combustion and industrial processes contributing about 78% of the total greenhouse gas emissions increase from 1970 to 2011. Agriculture, deforestation, and other land-use changes have been the second-largest contributors.[1]

Emissions of non-CO_2 greenhouse gases have also increased significantly since 1900. To learn more about past and projected global emissions of non-CO_2 gases, please see the EPA report, *Global Anthropogenic Non-CO_2 Greenhouse Gas Emissions: 1990-2020*.

Emissions by Country



Source: Boden, T.A., Marland, G., and Andres, R.J. (2017). National CO2 Emissions from Fossil-Fuel Burning, Cement Manufacture, and Gas Flaring: 1751-2014, Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, doi 10.3334/CDIAC/00001_V2017.

In 2014, the top carbon dioxide (CO_2) emitters were China, the United States, the European Union, India, the Russian Federation, and Japan. These data include CO_2 emissions from fossil fuel combustion, as well as cement manufacturing and gas flaring. Together, these sources represent a large proportion of total global CO_2 emissions.

Emissions and sinks related to changes in land use are not included in these estimates. However, changes in land use can be important: estimates indicate that net global greenhouse gas emissions from agriculture, forestry, and other land use were over 8 billion metric tons of CO_2 equivalent,[2] or about 24% of total global greenhouse gas emissions.[3] In areas such as the United States and Europe, changes in land use associated with human activities have the net effect of absorbing CO_2, partially offsetting the emissions from deforestation in other regions.

Related Links

EPA resources

- Greenhouse Gas Emissions
- Sources of Greenhouse Gas Emissions (in the United States)
- Non-CO_2 Greenhouse Gases: Emissions and Trends

Other resources

- Carbon Dioxide Information Analysis Center
- European Commission Emission Database for Global Atmospheric Research EXIT
- National Inventory Submissions EXIT
- World Development Indicators EXIT
- World Resources Institute's Climate Analysis Indicators Tool (CAIT) EXIT

References

1. IPCC (2014). *Climate Change 2014: Mitigation of Climate Change* . EXIT Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

2. FAO (2014). Agriculture, Forestry and Other Land Use Emissions by Sources and Removals by Sinks. (89 pp, 3.5 M, About PDF) EXIT Climate, Energy and Tenure Division, FAO.

3. IPCC (2014): Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. (80 pp, 4.2 M, About PDF) EXIT [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.

LAST UPDATED ON SEPTEMBER 13, 2019

Saving the World, One Kilowatt at a Time

1. Examine the given electronic devices. Predict the order of the devices from least to greatest power usage. Write down your prediction.

2. Plug in the devices and use the Kilowatt Meters to collect power data for each electronic device (Watts). Record data in the table. (Columns 1&2)

Electronic Device	Power (Watts)	Est. Time Used (hours per day)	kWh (per day)	Cost per Day	Cost for Month (30 days)

3. Estimate how much time (in hours) someone would use that electronic device each day. Record in the data table. (Column 3)

4. Calculate the kWh used by the device in the give time using the following equation:
$E(kWh) = P(W) \times t(hr) / 1000$ Record in the table. (Column 4)

5. The costs for electricity in Springdale is currently $ ________ per kWh. Record the cost for 1 day in the table. (Column 5) Using ratios, calculate the cost to use the device/bulb for a month (30 days). Record in the table. (Column 6)

6. Make a graph on the back of your paper, showing cost as a function of time for two devices (suggested: light bulbs). **(*hint: discuss independent vs. dependent variables)**
What does this show?

7. Was your prediction (#1) accurate? Explain, citing proof from your data collection.

What does the graph show?