STRATEGIC ENERGY INNOVATIONS

ENERGIZE SCHOOLS
A PROGRAM OF SEI

Energize Schools

Distance Curriculum Preview

This distance learning curriculum preview was developed by Strategic Energy Innovations (SEI) and includes one activity from the Transportation Analyst 101, Solar Design 101, and Energy Consulting 101 curriculum.

The following additional resources are available for request through this google form, our Energize Schools distance learning website, or via an email to energizeschools@seiinc.org:

Access to the full SEI curriculum library

Waste Analysis | Water Conservation | Transportation Analyst | Solar Design | Energy Consulting

An editable version of this curriculum and/or answer keys

Remote curriculum implementation support from an SEI expert

Access Green Careers Conference webinars and recordings of career chats with sustainability professionals. To register and tune in live, go to our website here or request the presentation recordings here.

Join the Earth Day Campaign Competition to help students connect to their peers. Students will learn about climate change and sustainability, receive resources to create a campaign, and submit their work for prizes! Register here.

If you have interested colleagues, please direct them to our distance learning web page to request resources or have them reach out to energizeschools@seiinc.org.

Energy Consultant 101

Curriculum Preview

Request full curriculum here

If you have interested colleagues, please direct them to our distance learning web page to request resources or have them reach out to energizeschools@seiinc.org.

Reader: Introduction to Sustainability & Climate Change

Sustainability

The root of the word sustainability is the ability to sustain or continue. Practices that are sustainable can be continued indefinitely at their present level. When we talk about sustainability in an environmental context, we mean protecting the Earth's ecological balance by not depleting natural resources at a rate that is faster than the rate at which natural resources can regenerate.

- For example, if we managed a forest and 20 of those trees became mature for logging each year, the sustainable harvest rate would be 20 trees or less per year.

As consumers, we make choices that affect global sustainability. In order to be sustainable when we design new products, we must consider the impacts on the **triple bottom line**:

- People,
- The planet,
- and Profits (the economics of a decision)

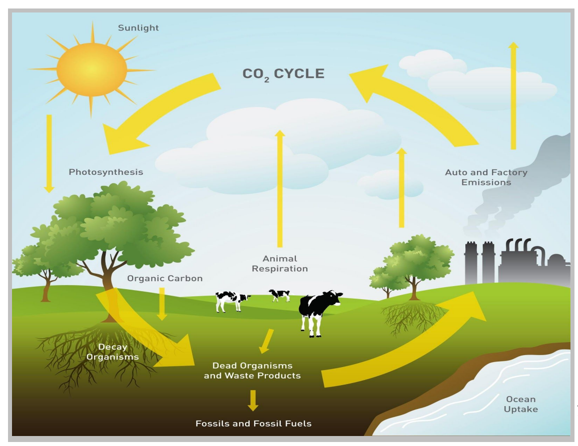
Our current economic system is linear: materials move quickly from extraction to manufacturing to consumption and then disposal. The Earth's systems, however, are cyclical. Waste becomes food for other organisms. For example, trees in the forest will shed leaves and branches that provide nutrients for both the tree and other organisms living on the forest floor. By moving materials quickly on this linear path from creation to disposal, we are wasting our natural resources, which is unsustainable.

Climate Change

The Carbon Cycle and Fossil Fuels

An example of how humans are changing the environment to which we have adapted is the effect we have had on global climate. Our reliance on unsustainable fuel sources has caused an imbalance in the carbon cycle and led to global climate change. This is known as anthropogenic (or human caused) climate change.

Fossil fuels, such as coal, oil, and natural gas, were formed when decaying plant and animal matter buried deep underground were subjected to unique conditions, including intense heat and pressure for millions of years. When we dig up these fuel sources and burn them for energy, carbon dioxide is released into the atmosphere. Because we are burning fossil fuels at a much faster rate than they can be formed, we are not only running out of these fuel sources but we have created an overabundance of carbon dioxide in the atmosphere.



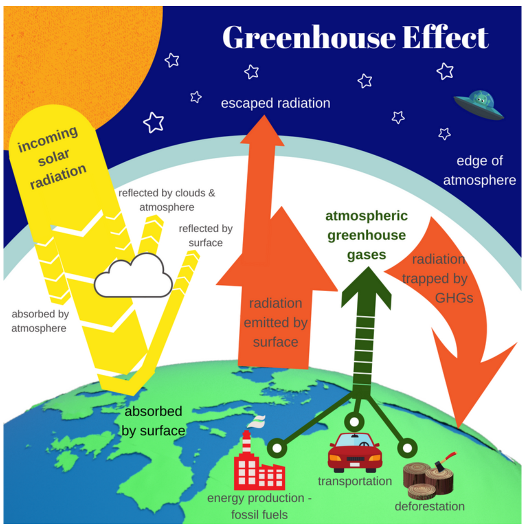
[1]

The Greenhouse Effect

Carbon dioxide, along with methane and nitrous oxide, are prevalent greenhouse gases (GHGs) on Earth. When solar radiation passes through the atmosphere and warms Earth's surface, the warm Earth re-emits infrared radiation. Some of this radiation is naturally trapped in the atmosphere by GHGs. Therefore, the more

[1] Carbon cycle image courtesy of Dave Murro

GHGs we have in the atmosphere, the more infrared heat is trapped, raising the overall surface temperature of the Earth, like a blanket. If there were no greenhouse gases in the atmosphere, the Earth's surface would be too cold to survive, so having some greenhouse effect is crucial to life. Unfortunately, by releasing GHGs (carbon dioxide from burning fossil fuels) into the atmosphere at an unprecedented rate, we are creating many environmental problems.

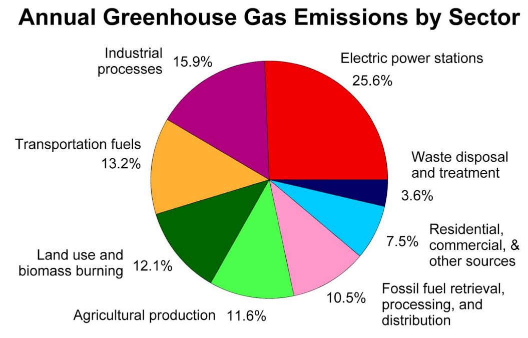


[2]

Carbon Dioxide in the Atmosphere

The human contribution to the greenhouse effect is largely due to the burning of fossil fuels, but agricultural practices, deforestation, waste, and many other societal systems also add to the total human-sourced carbon dioxide that is accumulating in our atmosphere. The Intergovernmental Panel on Climate Change (IPCC) has measured levels of carbon dioxide on Earth over hundreds of thousands of years and discovered that over the last 200 years CO_2 levels have increased from an average of 275 parts per million (ppm) to over 400ppm in 2013.

[2] Image created by SEI



[3]

Consequences of Climate Change

The large increase in atmospheric carbon dioxide and other greenhouse gases over the last 200 years has triggered an increase in average global temperatures that leads to many impacts. Scientists predict we will begin to see more: extreme events such as floods, droughts, storms, and fires; intense heat waves; shifting weather patterns that threaten food and water supplies; changing disease patterns such as malaria in expanded areas of the world; shrinking ice sheets; and rising sea levels, displacing coastal communities around the world.

Scientists at the IPCC have identified the highest safe level of carbon dioxide in the atmosphere to be 350ppm. If we do not reduce our carbon dioxide emissions, we risk reaching a tipping point in global temperature that could threaten the ability of current species on Earth, including humans, to adapt to rapidly changing conditions.

What is Energy?

Energy is the ability to do work—everything needs energy to function. We use energy for power, electricity, and heat in many aspects of our daily lives: to cook food, drive cars,

[3] Robert A. Rohde, Wikimedia Commons, "Greenhouse Gas by Sector"https://commons.wikimedia.org/wiki/File:Greenhouse_Gas_by_Sector.png

manufacture products, and construct buildings, just to name a few.

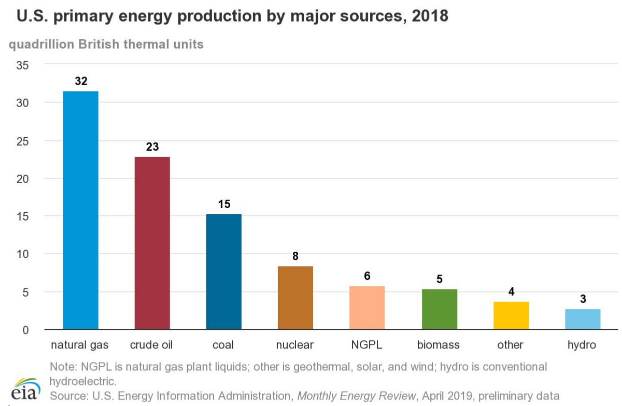
Energy comes from two different types of sources, non-renewable and renewable. A **renewable energy source** is one that can be replaced at the same pace or faster than it is used, while a **non-renewable energy source** can only be replaced over a *very* long period of time or cannot be replaced at all. Our reliance on non-renewable fuel sources has contributed to global climate change.

<u>**Non-Renewable Energy Sources**</u>

The most common non-renewable energy sources used worldwide are fossil fuels like oil, coal, and natural gas. **Fossil fuels** were created over millions of years as heat and pressure transformed the remains of decayed plants and animals buried underneath layers of sediment. Fossil fuels store carbon and emit carbon dioxide when burned. Burning fossil fuels also emits other pollutants like particulate matter, nitrogen dioxide, and sulfur dioxide.

<u>**Renewable Energy Sources**</u>

Renewable energy harnesses power from natural resources, like sunlight and wind, which are plentifully supplied by nature. The most common forms of renewable energy are solar, wind, hydropower, geothermal, and biomass. Renewable energy sources do not generally emit greenhouse gas emissions directly.



Energy Use in the US and California

The United States is largely dependent on oil, coal, and natural gas for its energy, which are significant contributors to global climate change. We use fossil fuels mostly for transportation fuel and electricity.

Electricity Resource Mix 2017			
Resource Type	**US**[4]	**CA**[5]	**GHG Emissions Level**
Coal	30%	4%	High
Large Hydro	7%	15%	Low
Natural Gas	32%	37%	Medium

[4] U.S. Energy Information Administration, "U.S. electricity generation by source, amount, and share of total in 2017". *Eia.gov*. EIA, October 29, 2018, https://www.eia.gov/tools/faqs/faq.php?id=427&t=3. (February 6, 2019).

[5] California Energy Commission, "2017 Total System Electric Generation in Gigawatt Hours". *CA.gov*, June 21, 2018, https://www.energy.ca.gov/almanac/electricity_data/total_system_power.html. (February 6, 2019)

Nuclear	20%	9%	Low
Petroleum	<1%	<1%	High
Other	<1%	9%	-
Renewables	17%	29%	Low

As shown in the Electricity Resource Mix table, the United States as a whole relies mostly on coal for electricity generation, since it is widely available in most parts of the US. California uses mostly natural gas for electricity. Some of this natural gas is extracted from within the state, but most is imported from nearby states like Colorado and Arizona. From this chart we can see that coal emits higher amounts of GHGs to produce electricity than renewable sources.

Historically, fossil fuels have cost much less to use than renewable energy, and are therefore used much more widely. However, concern over our reliance on fossil fuels is growing worldwide. Fossil fuels emit greenhouse gases, are becoming more expensive and complicated to extract, and involve numerous environmental, political, and social risks. New interest in renewable energy is blooming as the technology and cost of renewable energy improve.

In the United States, 79% of greenhouse gas emissions come from burning fossil fuels in the transportation, energy (28% of emissions[6]), and industrial sectors. The United States emits 15% of the world's greenhouse gases[7] but only makes up only 4.4% of the world's population.[8] Other countries with significant greenhouse gas emissions include China, Russia, Canada, and Japan.

[6] "Sources of Greenhouse Gas Emissions," U.S. EPA, https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions (accessed March 16, 2020)
[7] "Global Greenhouse Gas Emissions Data,"U.S. EPA, https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data#Country (accessed March 16, 2020)
[8] US Census, 2013: http://www.census.gov/main/www/popclock.html

Energy Conservation and Efficiency

Energy conservation and efficiency mean using less energy and using it wisely. **Energy conservation** is behavior that results in the use of less energy, such as turning the lights off. **Energy efficiency** is the use of technology that requires less energy to perform the same function. For example, compact fluorescent light bulbs (CFLs) use significantly less energy to produce the same amount of light as an incandescent light bulb.

Americans use six times more energy than the average world citizen.

Energy auditors, also known as energy raters or energy consultants, help prevent wasting resources by evaluating buildings to find areas of leakage and advise customers on how to fix and prevent leaks[9]. In this way, auditors reduce costs and the environmental footprint for residents.

We can take many steps in our own lives to reduce our use of energy and protect the climate, such as:

- Purchasing Energy Star® appliances. Energy Star is a government program that identifies energy efficient products.
- Using compact fluorescent lamps (CFL), use 75% less energy and last 9 times longer, or LEDs instead of incandescent bulbs.
- Set the thermostat at 78°F in the summer and at 68 °F in the winter to avoid overuse of your heater and air conditioner.
- Turn off and unplug equipment and appliances when not in use.

Why Perform a Personal Energy Assessment?

Performing a personal energy assessment is a useful way to assess the efficiency of your living

[9] U.S. Bureau of Labor Statistics. "Energy Auditors". https://www.bls.gov/green/energy_auditors/energy_auditors.htm. (Accessed March 17, 2020)

space and identify conservation opportunities. The information collected in an assessment can provide an understanding of how energy is used and wasted in your daily activities.

An energy assessment can include examining lighting, appliances, windows, and behaviors. The results of an audit can help consumers of energy make informed choices on how to best improve the efficiency of a home and also help identify opportunities for conservation by making users more aware of their habits.

Assignment: Introduction to Sustainability and Climate Change

Name: ____ Date: _______________

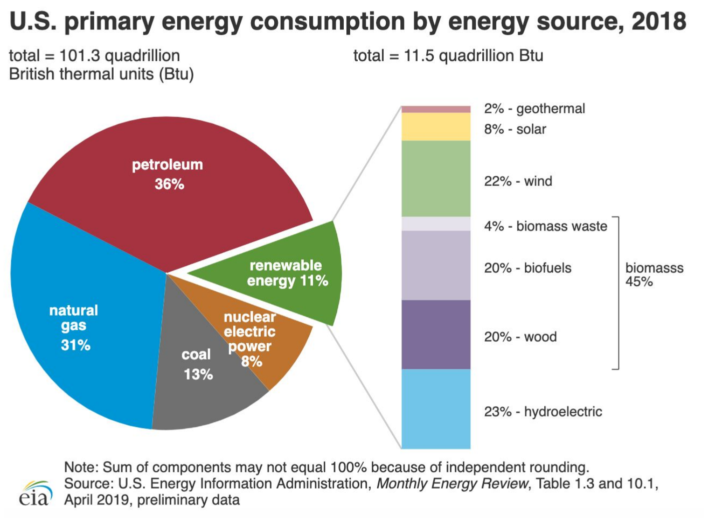
To complete this assignment read the Introduction to Sustainability and Climate Change and answer the following questions.

1. Define sustainability in your own words.

2. What is climate change? What causes it and what are the consequences (or impacts)?

3. What can we do to reduce the negative impacts of climate change and shift the balance of carbon in the cycle to return to below the safe limit of 350ppm?

4. Define renewable and non-renewable energy sources. Give an example of each.



5. Using the graph above, answer the following questions.
    a. Where does most energy in the US come from?

    b. Why do you think that most of the energy comes from non-renewable sources?

6. What are the key factors to consider when choosing an energy source?

7. Why is it important to save energy, aside from the fact that it helps our planet? (Think about how you could convince someone to save energy who might not be concerned about the environment)

8. List three ways you use energy in your daily life.

Reader: Appliance Energy Conservation

Electricity is used in our homes and schools to run our lights and appliances. In order to understand how much electricity we use in our buildings, we first need to understand energy and power.

Energy and power are different! **Electrical power** is the measure of the rate (how fast), electricity is transformed (into heat, into light, etc.), or the rate of energy demanded by an appliance at any discrete moment in time. The light bulb requires electrical power to light up, just as a paddle wheel requires the power of the moving water to spin.

- Similar to how height is measured in feet and weight in pounds, electrical power is measured in **watts**
- For example, a 100-watt light bulb requires 100 watts of power to produce light at one point in time.

Electrical energy is a measure of power consumed (by a light bulb, for example) or produced (by a power plant) over a given period of time (usually in hours). Energy is measured in "watt-hours (Wh)" or "kilowatt-hours (kWh)."

Energy (Wh or Watt hours) = Power (watts) x Time (hour)

The key difference between these two terms is time. For example, if a light bulb is on for 10 hours, it uses more energy than if the light bulb were on for 1 hour but the power the light bulb needs to be on is the same.

- Light bulbs are labeled with the power they need to give off light. A 60-watt incandescent light bulb needs 60 W of power to give off light at any given time. If the light bulb is on for 24 hours, it consumes 1.44 kWh of energy.
- Note: Because one watt is a very small amount of power, we often measure power in kilowatts (kW). To find kW, we use the unit conversion of 1,000 watts in a kilowatt.

Recall that a unit conversion is multiplying by a fraction equivalent to 1, to change the units of a number. In this case (1=1,000 watts/1 kilowatt)

$$1.44 \text{ kWh} = (60 \text{ W} \times 24 \text{ hours}) \times (1\text{kW}/1000\text{W})$$

The power demanded by a device while operational is referred to as **operating load**.

A **plug load** is any electrical device or appliance that receives power from a wall outlet, ranging from cell phone chargers to appliances like refrigerators. On the national scale, these products consume 114 to 146 billion kWh per year, or about 4% of all electricity used in the country. This is enough energy to fully power all of the homes in California and Washington State combined for one year.

Phantom loads — also known as "standby loads" or "energy vampire loads" — are small, constant loads in electronic devices that consume electricity, even when the device is turned "off." Examples of phantom loads are the clocks on conventional ovens and microwave ovens, cell phone adaptors, and televisions waiting for remote signals to turn on. These loads typically range from 1 to 10 Watts per appliance. In California, an average house constantly leaks between 50 and 100 Watts of energy, or between 5 – 23% of a home's total electricity consumption.

➤ There are a variety of ways to tell how much energy a device consumes.

- Most appliances and electronics have their power rating printed somewhere on the device. Examples of different plug loads and their rating can be found online on GE's Data Visualization Tool (http://visualization.geblogs.com/visualization/appliances/).
- We can also use a device called a Watt meter to get an accurate measurement of how much power a device draws when it is plugged in. This is called its power use.

➤ We can reduce plug load energy consumption four different ways.

- The first way is to conserve energy by changing behavior. Try unplugging devices not in use or turning off power strips.
- The second way is to invest in more efficient appliances. For example, by replacing an old TV with an ENERGY STAR labeled TV, we can save on the power use and reduce the phantom load. Sometimes lawmakers create standards to ensure that appliance manufacturers meet certain efficiency ratings.
- The third way is through controls, such as a Smart Strip, which turns off all appliances connected to a master appliance when the master is not in use.
- The fourth way is by reducing the number of appliances, such as the number of mini fridges or personal heaters in classrooms

ASSIGNMENT: APPLIANCE ENERGY CONSERVATION

Name ______________________________________ Date ____________________

In this activity you will calculate much energy, money, and CO2 it takes to power a coffee maker for a year. The coffee maker uses **1100 watt** when operating and and **3 watts** when plugged in and not in use.

1. What is the operating load of the coffee maker?

   ______W

2. What is the phantom load of the coffee maker?

   ______W

3. Calculate: Operating load hours ($\frac{hours}{yr}$). How many hours is the coffee maker brewing per year? (Hints: 365 $\frac{365\ days}{year}$ & 1 pot of coffee = 15 minutes or .25 hours of brew time)

   _______hrs per day x ________days per year = _______operating hours per year

4. Calculate: Phantom load hours. How many hours is the coffee maker plugged in and not brewing per year? (Hint: $\frac{8{,}760\ hours}{year}$)

   Phantom Load Hours = ______total hours per year – ______operating hours year

5. Calculate: Phantom load energy use per year ($\frac{kWh}{yr}$). How much energy is consumed in one year when the coffee maker is plugged in and not brewing every year? (Hint: $\frac{1kW}{1{,}000W}$).

   _____Phantom load W x _____Phantom load hours per year = _____Phantom load $\frac{Wh}{year}$

   _____Phantom load $\frac{Wh}{year}$ x $\frac{1kW}{1{,}000W}$ = __________phantom $\frac{kWh}{yr}$

6. Calculate: Operating load energy use per year (kWhyr). How much energy is consumed in one year when the coffee maker is brewing? (Hint: 1kW1,000W).

   _____Operating load W x _____Operating load hours per year = _____Operating load

_____Operating load $\frac{Wh}{year}$ x $\frac{1kW}{1,000W}$ = ___________Operating $\frac{kWh}{yr}$

7. Calculate: Total energy use per year ($\frac{kWh}{yr}$). How much total energy is consumed by the coffee maker in one year?

   ______phantom load $\frac{kWh}{yr}$ + _________operating load $\frac{kWh}{yr}$ =________total $\frac{kWh}{yr}$

8. List and explain two recommendations to decrease the amount of energy used by the coffee maker each year. Label your recommendations as conservation or efficiency measures.

9. Calculate the cost to operate the coffee maker for one year. Assume $0.18 per kWh

   _______ $\frac{kWh}{yr}$ x _________ $ per kWh = __________ $ per year

10. Calculate how many pounds of CO_2 are released by operating the coffee maker for one year. Assume 1.2 lbs. of CO_2 per kWh is released.

    _______ $\frac{kWh}{yr}$ x _________ lbs. of CO_2 per kWh = __________ lbs of CO_2 per year