Curriculum Units by Fellows of the Yale-New Haven Teachers Institute
2010 Volume IV: Renewable Energy

Exploring Renewable Energy through Graphs and Statistics

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Overview

Students usually learn graphical representations by being taught to graph meaningless or boring, out of date data. I have designed a unit to give real life meaning and real word examples to teach New Haven Public School students how to create and interpret various tables and graphs. I have used data on renewable energy, national energy use and personal energy use. Students will also learn about fossil fuels and the importance of finding ways to decrease their own carbon footprints. Students will be asked to research and examine interesting and up to date data to gain the concepts and skills being asked in the Pre-Algebra curriculum. This unit will have the benefit of being interdisciplinary and will give students a chance to bridge the math and science gap, as renewable energy is part of the ninth grade science curriculum.

Students in Pre-Algebra study graphical models and have an introduction to correlation. The prior knowledge students need to come into this unit with is a broad understanding of tables and charts as well as an ability to interpret graphical representations. This unit will help give real life meaning to the skills and concepts associated with graphing by creating discussions based on scientific data and the math that backs it up. This unit should take 5-7 school days allowing a weekend to do some project research. Students should be able to read various pieces of literature that are rich in information about renewable energy concepts. They will then choose the appropriate way to display data from bar graphs, histograms, scatter plots and line graphs. The final assessment will be a project in which a student will be able to analyze his or her own energy use and waste. Students will demonstrate mastery of the new scientific information by backing up their analyses with facts researched in student resources. A short oral presentation can be given to the class and two graphical displays will be handed in as well as a plan to modify the students' habits into more sustainable living habits.

Where Do Fossil Fuels come from, How Much Are We Using and What for?

Over the course of time plants, animals, and other living organisms leave behind their remains. These dead remains get covered over by rocks, dirt and mud. Pressure, heat and time change the once living organisms into fossil fuels. The most commonly used fuels are oil, coal and natural gas. Although fossil fuels are constantly being made, they are nonrenewable on our timescale. It takes millions of years for the dead plants and animals to turn into usable fuel.

Because it is the cheapest fossil fuel, coal is the most used and most abundant fossil fuel used globally. Coal is made up of dead plant material. When coal is burned, the less oxygen and hydrogen remaining in the coal, the more energy released. The three kinds of coal that are commonly formed are lignite, containing about 40 percent carbon, bituminous, containing up to 85 percent carbon, and anthracite, containing 90-95 percent carbon (MacDougal Litell, Earth Science p.149).

Oil is made up of mostly animal and microorganism remains with some plant material. The oil settles into porous rock, like limestone or sandstone and is sealed into the ground by non-porous rock creating oil traps. Oil deposits are often found with natural gas and the pressure of the natural gas on top of the oil helps to bring the oil up to the surface of the earth when it is carefully drilled.

Natural gas is made up of the same materials as oil but it is lighter and can be found in a pocket above oil. Natural gas is piped out of the ground whether it is found with oil or by itself. Natural gas is preferred by many because it is cheaper, and burns cleaner than oil. The reason more people don't use natural gas is because it needs to be piped directly into homes.

The amount of oil the earth is estimated to have took about 500 million years to form, and about a quarter of it is already gone. The United States of America has over 250 billion tons of coal, equivalent to 800 billion barrels of oil, which is more than three times Saudi Arabia's proven oil reserve (Nersesian p.90). Burning these fossil fuels is a very dirty process and emits large amounts of carbon dioxide. Many people refer to the amount of carbon dioxide he or she creates through all energy consumption as a carbon footprint.

Students will be asked to look at energy use data from each state in the United States of America. The data students are asked to analyze will include total residential use, which includes non-renewable resources, and hydroelectric power, geothermal power, wind power and solar power.

What is a Carbon Footprint?

A carbon footprint is a calculation of the amount of carbon dioxide created by the daily activities in one's life. Things like heating a home, driving a car, and choosing non-local, out of season foods all leave a carbon footprint. There are several online carbon footprint calculators that can be used by anyone to figure out how much carbon dioxide one is causing to be emitted. A good one that takes into account urban, apartment style, living can be found at www.nature.org.

Students will be asked to calculate their own carbon footprints and analyze them. Time should be permitted in a computer lab, classroom or at home. Students should use the same online calculator as one another. The carbon footprint figure will accompany a histogram showing students' garbage generation.

Garbage, Garbage Everywhere

The United States is a throw away society. The average person creates about one ton of trash every year. Typical American residential trash is made of: 40 percent paper, 18 percent yard waste, 9 percent plastics, 8 percent metals, 7 percent glass, and 18 percent food and other waste (Holtzclaw, p121). There are three ways to deal with the waste: bury it, burn it or recycle it.

When trash is buried in a landfill it can last for a significantly longer time than if it were open to the elements. It is possible to find paper and other biodegradable waste decades old. If these things were left on a sidewalk or in a compost heap they would turn into soil or simply waste away. If trash is incinerated, the energy from the burning can be transformed into electricity. The downfall is that burning garbage is very expensive and the smoke pollutes the air. Things like plastic, metal and glass can be recycled. This is helpful because these materials are not biodegradable.

In a society where everyone wants the newest, biggest, and most expensive everything, it is no wonder there is so much garbage and so many of the resources are being used to make new things all the time. The average household in Europe or North America has so many devices and such a variety of food and clothing that to produce the same lifestyle in Roman times would have required six-thousand slaves, cooks, maids, minstrels, ice-house keepers, woodcutters, nubile women with fans, and many more. The amount of energy needed to make one soda can could power a television for three hours. The entire world throws away 250 billion cans a year (Pearce).

Making plastic bottles accounts for about 4 percent of the United States energy use. Enough energy is conserved by recycling a plastic bottle to light a 60-watt bulb for 6 hours. By using recycled materials to make new plastic products two-thirds less energy is used (earth911.com).

Glass is made up of sand, limestone, and soda ash and is completely recyclable. It can be recycled over and over again without a compromise to quality. Large amounts of fossil fuels are used to heat furnaces that melt glass in the production of glass containers. In 2002, the glass industry used roughly 8611,000,000 kWh of energy. Carbon dioxide emissions totaled 1.8 million tons from the fossil fuels burnt in the factories. A furnace requires 4 GJ of energy for each ton of glass melted. By using recycled glass, called cullet, about 40 percent less energy is used, than when glass is made from raw materials. Many glass containers are made of 70 percent recycled glass. If a glass bottle is not recycled, it can take about one million years to breakdown to its source material (earth911.com; wasteonline.org).

It is important for students to understand the amount of waste they are creating by not reusing or recycling packaging. By the end of the unit, students should feel responsible for recycling. The motivation for recycling is not only in the form of wanting to help but also is in the form of monetary gain. Students can easily be rewarded by recycling not only their own trash, but also by collecting recyclables from family members, schools and neighborhoods and redeeming them for the deposit. The most environmentally friendly thing one can do is to not use throw away packaging at all. Reusable packaging and water bottles can significantly reduce the amount of waste created by students on a daily basis.

Green for Free!

Students may claim that it's too expensive to make better choices, or they simply can't afford to do things any differently. Often times when people think of making greener choices they think of things like buying organic, local food, buying a hybrid car or designing a new house based on efficiency concepts. The truth is there are so many ways to do things cheaper, more efficiently and healthier that are also considered green.

There are several ways to make better choices for the planet that don't cost anything. In a city like New Haven, garbage pickup and recycling are a municipal service. Families can sort garbage and recyclables at home and recycle as much as possible. The city now offers a large recycling can that no longer requires residents to sort recyclables. New Haven accepts a surprisingly long list of paper, plastic and metal objects that can be put into recycling cans.

Choosing outdoor activities like bike riding, hiking and sports over things like watching TV or playing video games are things students can do easily on their own, or with friends, everyday. Often times indoor spaces need to be climate controlled, either heated or cooled, and this takes a lot of money and energy in many different forms. By staying outside, students not only reduce carbon emissions but also make healthier choices.

Something that may save money is to switch from bottled water to using a reusable water bottle and drinking either tap water or at-home filtered water. Drinking water instead of other beverages also has a decrease in carbon emissions as well as major health benefits. Students can chose to bring lunch to school that is not prepackaged; things like fruit and homemade sandwiches brought to school in reusable packaging create little to no waste.

Composting at home has several benefits; families will reduce the amount of trash they put out, which in turn creates less of a need for trucks. Less garbage in a garbage dump also creates less methane, which is usually burned and released as carbon dioxide. When one composts, he or she is creating soil that can be used to grow plants and further reduce carbon emissions.

There are many ways to reuse or recycle plastic bags. Many small bathroom garbage containers can take a small bag or one can take an old bag along to pick up after your dog instead of buying new bags made for the job. A good way to avoid using a plastic bag all together is to get cheap reusable bags made to help consumers reduce their carbon emissions; grocery stores are so supportive of this effort they are willing to give a five cent credit for each bag towards groceries if you use them.

Remembering to shut lights and any unused appliance off is always a good idea. Unplugging anything, such as microwaves, computers or televisions not in use is a great way to save electricity and money. Many appliances or electric equipment still allow an electrical current to flow through them when they are not being used, sometimes one can see this in a small digital clock or there may be no indication of an electrical current at all. Even a switched off appliance draws current, usually a small one but it is cumulative and adds up.

Walking, biking, or using public transportation instead of driving to a destination can save money and gasoline. Students can take the school's transportation, ride the city bus or walk to school instead of getting dropped off or driving their own car.

Students will be asked to reflect on their own carbon footprint. An individual graphical representation of the way students live now and a plan to lead a lower impact life will help students see they, alone, can make a difference. Students will follow up with a graphical representation of what they predict will be their lower carbon lifestyle habits.

Hydroelectric, Geothermal, Solar, and Wind Power

The way hydroelectric power works is by using the natural flow of water to spin a turbine attached to a generator which makes electricity. There are several ways in which water flows; down waterfalls, through a dam created by a reservoir, down a river, and in and out by tide.

Wind power uses large turbines, placed in strategically chosen locations, to catch air moving over the earth's surface. There can be either one or a few wind turbines to supply energy to the site at which the turbines are located, or hundreds of turbines that supply energy to a community.

Geothermal power is made by using the heat radiating from the earth. To get through the earth's layers to the heat, a large tunnel is drilled out about 2 miles deep. Either subterranean water is relied on or redirected water from a near by river is used to make steam from the geothermal heat. The steam then can be used directly to heat a building or can be used to spin a turbine connected to a generator to make electricity.

There are two types of solar energy: photovoltaic and thermal. Photovoltaic solar power is what we commonly use in calculators. It can also be placed on top of roofs or any place that can get sufficient sunlight. When photons from the sun hit photovoltaic cells, electrons, from the atoms of the photovoltaic cells, are set in motion creating electricity. This electricity can be used to power the house they are on and give back energy to the power grid. Thermal solar power uses the heat from the sun. Solar panels with copper pipes carrying either water or an anti-freeze solution are placed on a roof. The sun's radiation heats up the liquid inside the copper piping sending it into the house. The water running though the pipes can be sent to a hot water heater or into a pool. If anti-freeze is in the piping it can be used to heat the house in the winter.

Lesson Plans

It is a good idea to check students' prior knowledge with a work sheet based on skills needed to be successful in this unit.

Comparing, ordering, rounding and place value are important concepts when interpreting data. Place values of larger numbers can also be useful in interpreting data, especially if discussing national and world data.

A teacher should also check to see if students are able to read simple tables and graphs before they are expected to create their own data display. A good graph to interpret could be a bar graph with a simple scale, such as counting by 10's.

Lesson 1: Samples and Surveys

Objective: Students recognize biased samples and identify sampling methods.

Vocabulary: population, sample, biased sample, random sample, systematic sample, and stratified sample

Introduction: An environmental awareness magazine printed the results of a survey. Statements 1, 2, and 3 are different interpretations of the data collected. Which one do you think you are more likely to read in the magazine?

1. The average American recycles when it's convenient, but won't go out of his or her way to find a recycling receptacle.
2. The average reader of this magazine recycles when it's convenient, but won't go out of his or her way to find a recycling receptacle.
3. The average reader of the magazine who responded to this survey recycles when it's convenient, but won't go out of his or her way to find a recycling receptacle.

Discuss the realistic interpretation (1) and why a magazine would print it as opposed to printing the more true interpretation (3). The information seems like a bigger deal in interpretation 1 while interpretation 3 sounds very wordy.

Ask students who can actually answer the magazine's survey? Possible answers are: Americans, magazine readers, or anyone who wants to. The correct answer is: anyone who subscribes to the magazine or buys it at a news stand that month. Say "this group of people is the population."

Ask students if they think everyone who reads the magazine actually responds to the survey. Answer: no. Say "this group is called the sample". In statement 1, the population is all Americans and the sample is readers of the environmental awareness magazine who actually responded. This is a biased sample because it is not a good representation of the population.

Example 1: Identifying Biased Samples

Identify the population and sample. Give any reasons why the sample could be biased.

A scientist living in a coastal community chooses 2000 people out of the phone book to survey about whether or not they take precautionary measure to ensure they are not dumping any harmful chemicals, such as cleaners, down the drains or into sewers.

Population: People living in the costal community

Sample: 2000 people who take the survey

Possible biases: Not all people are in the phone book, people living on the coast may be more likely to think about what they are dumping in the drains as opposed to someone living inland that doesn't think much about where harmful chemicals can end up.

Ask students what they think might be the best way to take a survey with least amount of bias. Correct answer: randomly choosing people to survey. This is called a random sample. This method is the best because every member of the population has an equal chance of being chosen. Random sampling is not always the most convenient method so other methods are sometimes chosen.

Random: By chance

Systematic: According to a rule or formula

Stratified: At random from randomly chosen subgroups

Example 2: Identifying Sampling Methods

> A. In a city wide survey, 3 neighborhoods are chosen and 25 people are randomly chosen from each neighborhood to answer the question of whether or not they buy locally produced food and products.
> Answer: Stratified, the 3 neighborhoods are the random subgroups and people are chosen randomly from within those neighborhoods.
> B. An exit poll is taken of every third student leaving the auditorium. The question asked is do you get dropped off at school by a parent or drive a car yourself, or do you take the school bus, walk, or take the city bus?
> Answer: Systematic, the rule is to ask every third student.
> C. All the teachers in New Haven enter their names in a drawing for a chance to chaperone students to the Connecticut Science Center to view the Energy City exhibit. Ten teachers' names are drawn.

Answer: Random, names are chosen by chance.

Closure: Think of a question you would want to be answered about what or why students eat on an hourly, daily, or weekly basis. Choose your population: students in this classroom, all the freshmen, the entire student body. Decide a way to choose your sample from the three sampling methods. Your survey should be as unbiased as possible.

Have students write their answers on an index card and use as an exit sheet.

Homework: Find an article about a survey in the newspaper or a magazine, identify the population and sample. Decide if the survey taken was biased in anyway; if so, come up with suggestions about how to change the survey to make it unbiased.

Lesson 2: Measures of Central Tendency

Objective: Students find measures of central tendency.

Vocabulary: Mean, Median, Mode, and Outlier

Introduction: Ask students what these words mean: measures, central and tendency. Acceptable answers for 'measure' are: a way to tell someone how long or how big something is by using feet, inches, meters, pounds. An acceptable answer for 'central' is: in the middle. Acceptable answers for 'tendency' are: habits, common, and happens a lot. Tell students a measure of central tendency is a way to describe a lot of data with one number. This number represents the middle of the data.

Students have already done work with measures of central tendency, but did not use this vocabulary. Common mistakes are: students often want to use the word average and find the range; it is important to steer them to use the new vocabulary and tell them the range is not something we will be looking for today.

Find the Mean, Median and Mode.

Discuss the numbers. Ask students if they see anything or any state that stands out. Correct answer: New York. Explain that New York is a large state, and they have Niagara Falls for Hydro Electric Energy. Tell students this is called an outlier because it is so far away from the rest of the data. An outlier can throw off the mean of a data set.

North Eastern Energy Consumption Estimates-2007 (U.S. Department of Energy)

Trillions Btu	Total Residential	Hydroelectric	Geothermal, Solar and Wind
Connecticut	276.5	3.6	1.0
New York	1201.8	249.6	10.4
New Jersey	615.5	0.2	2.6
Massachusetts	443.1	7.9	0.8
Maine	106.6	36.9	1.2
New Hampshire	92.2	12.5	0.1
Vermont	47.5	6.4	0.2
Rhode Island	71.9	0.0	0.0

Discuss the findings:

Total Residential: mean: 356.9, median: 191.6, mode: no mode

Hydroelectric: mean: 39.6, median: 7.2, mode: no mode

Geothermal, Solar and Wind: mean: 2.0, median: 0.9, mode: no mode

Closure: Students should notice that some of the numbers are very different and in some cases the measurements can be misleading such as the case of the mean of 39.6 for hydroelectric power. Maine is the only state close to the mean; New York throws of the mean because it is an outlier. Students can also be asked to compare the total residential figures that include the non-renewable resources with the figures of the renewable resources.

Homework: Students will be sent home with similar data about another group of states such as the west coast or a group of southern states and a map of the Unites States with the states labeled so students can see the size of the state. Students will answer questions such as: Are there any outliers? How did this affect the data? Why was there an outlier? For example, New York gets hydroelectric power from Niagara Falls. Do you think this data table will begin to change as time goes on? What evidence have you seen in New Haven to back this up?

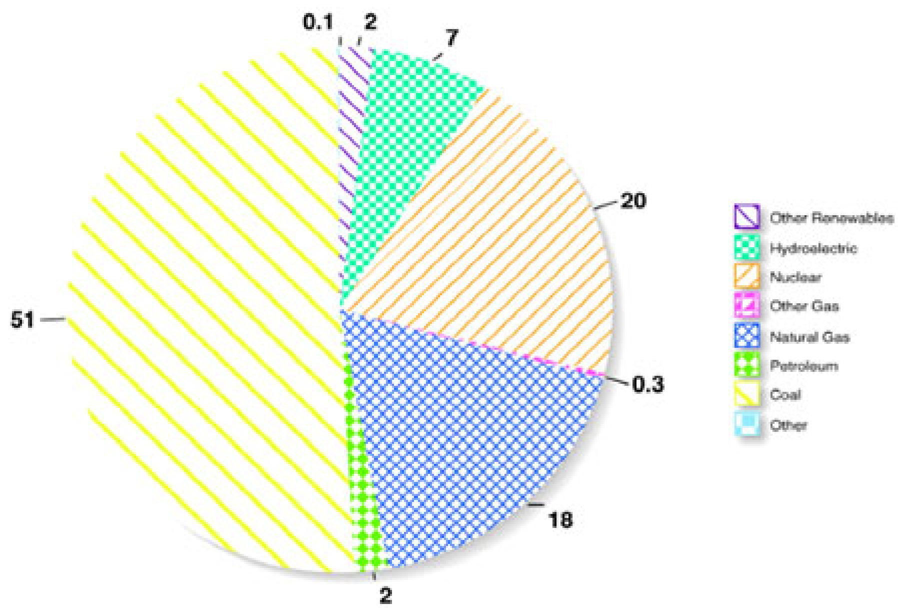
Lesson 3: Displaying Data (2 days)

Vocabulary: Bar Graph, frequency table, histogram, line graph

Introduction: Begin by talking about the previous day's lesson. We found a bunch of numbers! Did they look good written on your papers? Did the way they were written tell us anything about them? Do you think there is a way to show data that looks good but also tells us something about the information? Most students have been exposed to various types of graphs and will answer yes. This is a chance to find out what students already know.

Bar graphs are often used to show information that can be grouped. If the data are shown in a list, it is a good idea to start with a frequency table. A frequency table tells how many times a certain piece of data has happened.

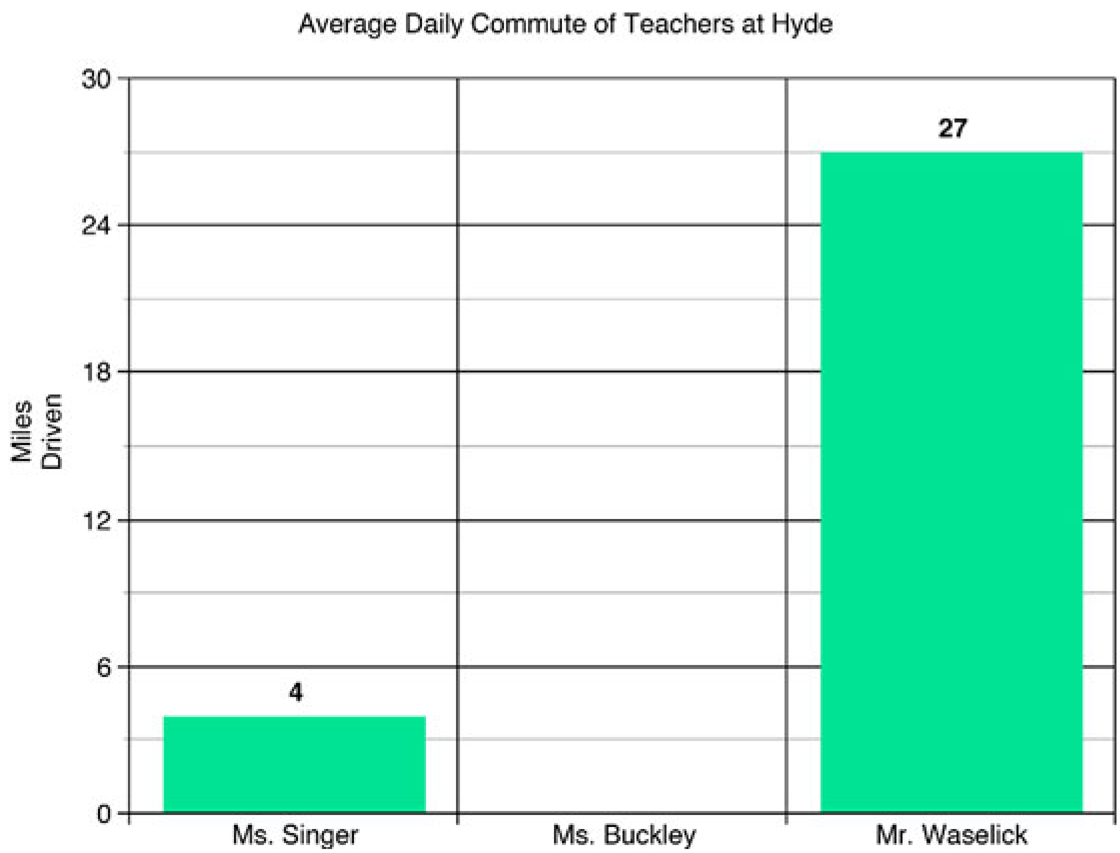
Total U.S. net electrical generation- year end 2002



U.S. Energy Information Administration, Electric Power Monthly, January 2004

Students will use total U.S. net electrical generation (2002) 304 billion kilowatt-hours (kWh) and Total energy supply 97.551 Quadrillion British thermal units (Btu) to convert percents given in pie charts into kWh and Btu to be graphed on a bar graph.

Example of a bar graph:



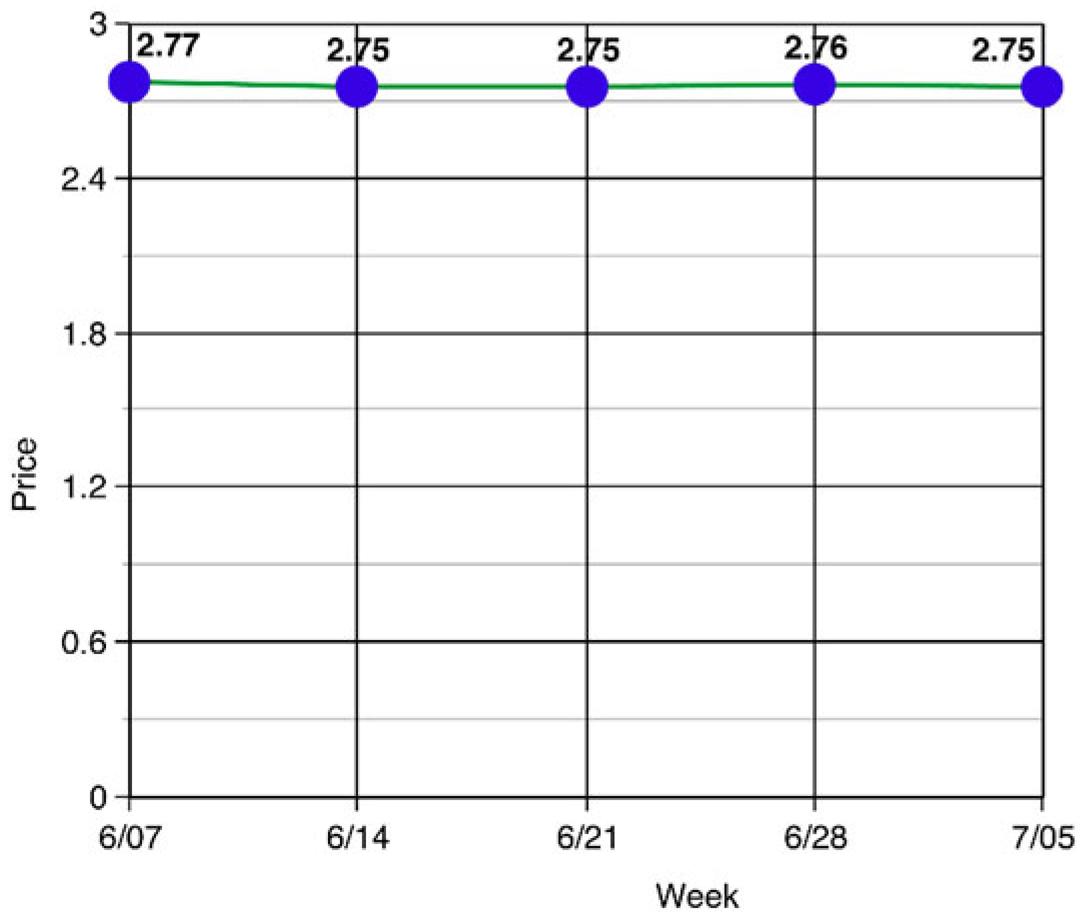
A histogram looks much like a bar graph except the bars are touching. The bars touch because a histogram shows intervals in which data are grouped.

This part of the lesson is a good chance for students to collect some of their own data. Have students create a list of their favorite junk foods and drinks. Then ask them to tally up the amount of wrappers, paper or plastic cups, cans (aluminum), glass and plastic bags they estimate themselves to use in a week. Allow students to subtract what they recycle regularly. Next make a frequency table on the board for all students to see. Decide on an appropriate interval. Create a class histogram and label it: Garbage we make that will be here long after we're gone. Hopefully, this graphic representation will promote class discussion; take time to talk about how much garbage this is in a year, and how much of a difference we could make as a class/school if we all recycled everything we could.

Students should be given time to calculate their own carbon footprint. Have students go to www.nature.org to generate individual, accurate carbon footprints.

A line graph shows trends and can be used to make estimates for information in between data points or predictions about future information. Create line graphs using total energy usage created by wind, solar, geothermal, and hydroelectric power over the past 10 years. Estimate the energy usage for future years: 5, 10 and 15 years away from now.

Example of a line graph:



US Energy Information Administration

Closure: Open a discussion about whether or not students think this is going to be enough or if they think we will be in trouble as a global community. Remind students to think about the growing population, more people will mean more energy demand.

Homework: Students will take personal garbage generation data home and create an individual histogram. This Histogram will be presented with the student's personal carbon footprint.

Lesson 4: Scatter Plots

Vocabulary: Scatter plot, correlation, line of best fit

Introduction: Give students a packet of data containing the populations of all countries and the total carbon emissions for each one. Depending on the level of the students, have them look up the country's data or give them the data to be graphed. The best counties to use in this example are Brazil, China, India, Mexico, Nigeria, and The Unites States. Graphs should have population on the X-axis and carbon emissions on the Y-axis. Have students graph coordinates.

Now that students have a graph with coordinates completed, begin to talk about a pattern they may see. Students should notice that the higher the population the higher the carbon emissions are for the country. Give the definition of correlation.

After students have had a chance to discuss patterns and correlation, give them a ruler and tell them to put the ruler in a place that they think is the average of all their graphed information. The ruler should be in a place that follows the correlation of the data and has a few points on top and below the ruler. Have students trace the line they think works the best. This line is called the line of best fit. Students should be given a few moments to compare their line with the lines of the students around them. Students will also notice a difference between their lines and the others. Let students know this is acceptable and this line is an estimate with many possible correct answers.

Assessment: Ask students to do the same process, using the same countries but this time they will be comparing water usage. Compare this scatter plot with the scatter plot about carbon emissions. Lead a discussion on the patterns and outliers they see.

Closure: Ask students what they do to be wasteful of energy and water. Ask if there are ways they can conserve at home.

Data can be found at www.cia.gov (accessed 7/6/10), www.nationmaster.com (accessed 7/6/10) and, www.worldwater.org (accessed 7/6/10).

Unit Assessment

Students can begin looking at and researching in provided books at any time during this unit. Students should be looking for any information relevant to themselves. They should be focusing on information about the impact they have on the environment. This information will be useful when it comes time to make a plan for them to live more sustainably.

Now that students have had a chance to talk about renewable resources and the ways they use energy as well as the garbage they create, ask them to represent their current usage graphically. Once all the students have a representation of their own usage, ask them to come up with a plan to use and waste less. This plan should be backed up with information researched out of provided books. Have students make predictions about the data and graphically represent his or her own usage after he or she implements the plans.

Vocabulary

Population- the entire group being studied

Sample- part of the population being studied

Biased sample- bad representation of the population

Random sample- Every member of the population has an equal chance of being chosen

Systematic sample- A sampling method in which the members of the sample are chosen by a rule or formula

Stratified sample- A sampling method in which the members of the sample are chosen at random from randomly chosen subgroups

Mean- The sum of the values, divided by the number of values

Median- if an odd number of values: the middle number, if an even number of values: the average of the two middle values

Mode- the value or values that occur most often

Outlier- an extreme value

Bar Graph- a good way to display data that can be grouped in categories

Frequency table- a way to organize data if the data are given in the form of a list

Histogram- a type of bar graph where the bars represent intervals in which the data are grouped

Line graph- often used to show trends or to make estimates for values between data points

Scatter plot- shows relationships between two sets of data

Correlation- describes the type of relationship between two data sets

Line of best fit- line that comes closest to all the points on a scatter plot

Btu- British thermal unit

kWh- kilowatt-hours

Electricity- a fundamental form of energy observable in positive and negative forms that occurs naturally (as in lightning) or is produced (as in a generator) and that is expressed in terms of the movement and interaction of electrons

Fossil Fuels- a fuel (as coal, oil, or natural gas) formed in the earth from plant or animal remains

Hydroelectric power- of or relating to production of electricity by waterpower

Solar power- radiation from the sun capable of producing heat, causing chemical reactions, or generating electricity

Geothermal power- of, relating to, or utilizing the heat of the earth's interior; produced or permeated by such heat

Wind Power- form of energy conversion in which turbines convert the kinetic energy of wind into mechanical or electrical energy that can be used for power

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ctcleanenergy.com (accessed June 1, 2010).

Teacher Resources

ctcleanenergy.com (accessed June 1, 2010). This is a great way to quickly learn about different types of energy production. This site has great visuals accompanied by short, to the point, explanations of the mechanics involved in harvesting the energy.

EIA.gov (accessed July 6, 2010). This site has a lot of statistical information. The data here is up to date and can easily be used to make various types of graphical representations.

Pearce, Fred, Confessions of an Eco-Sinner: Tracking Down the Sources of My Stuff. This book is a quick, interesting read. A lot of

facts easily support the opinions and conclusions the author comes to about a consumer society. Good place to go to for discussion topics.

Exline, J. et al. Earth Science. Any text book with up to date information on fossil fuels is helpful. It can be tough teaching science to math students, as a math teacher. By reading a few short sections in a science textbook, a math teacher can get a good idea of how in depth to go with the topics.

Student Resources

Exline, J. et al Earth Science. Good textbook to take excerpts from. Students will be able to grasp some information by reading sections on fossil fuels and renewable energy sources.

Holtzclaw et al. Science Explorer: Environmental Science. This text book has the same information as the previous one but is written on a lower reading lever. It is appropriate for a ninth grader reading on a fifth or sixth grade reading level.

Nature.org (accessed June 1, 2010). Easy to use carbon footprint calculator can be found at this web address.