New Mexico
Ag in the Classroom

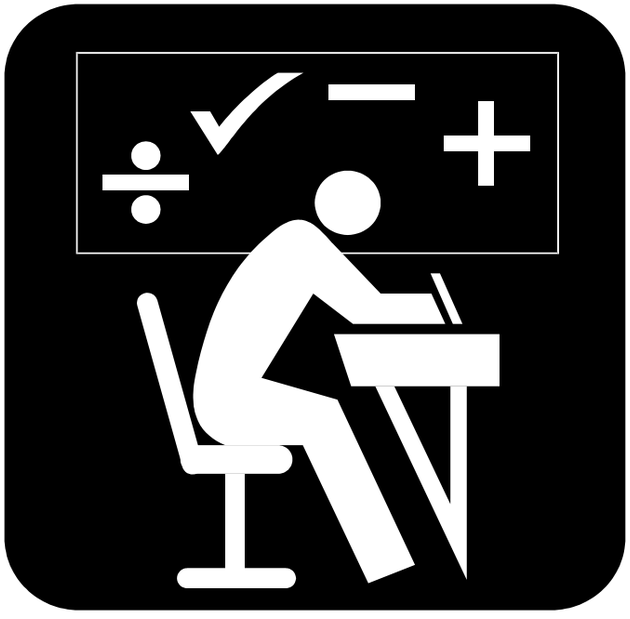
AG IN THE CLASSROOM—HELPING THE NEXT GENERATION UNDERSTAND THEIR CONNECTION TO AGRICULTURE

COLORADO FOUNDATION FOR AGRICULTURE ~ WWW.GROWINGYOURFUTURE.COM

The Math of Electricity

It is no secret that electricity plays an important role in our daily lives. Electricity powers the alarm clock that wakes you in the morning. It recharges your handheld video game. It is what keeps you warm in the winter and cool in the summer. Electricity is all around us.

So we agree that electricity is important. Do you know how much it costs for the electricity so you can watch your favorite TV show each week or keep the ice cream frozen? Do you know how electricity is created? How does it gets to the outlet on your wall? Math plays an important role to be able to answer these questions. In fact, nearly every part of producing electricity involves math.



Following is a list of how we use electricity in our homes. The average U.S. home spent 17.9% on cooling their homes. Lighting costs average 15.3% on lighting. For every $100.00 a family spent on energy, $17.90 was to keep cool. Write the dollar amount on the line to show how much a family typically spends for the different types of electricity usage, based on each $100 of electricity costs.

	$100.00
Cooling: 17.9%	$ 17.90
Lighting: 15.3%	_____
Water Heating: 9.3%	_____
Space Heating: 9.0%	_____
Refrigeration: 7.9%	_____
Televisions: 7.2%	_____
Clothes Dryers: 4.0%	_____
Computers: 3.8%	_____
Cooking: 2.3%	_____
Dishwashers: 2.0%	_____
Freezers: 1.7%	_____
Clothes Washers: 0.7%	_____
Miscellaneous Uses: 18.9%	_____

*2009 Data

What is electricity?

Electricity is a form of energy. Electrical energy is the movement of charged particles, negative (-) and positive (+). It can come from batteries or power plants. It can also be found in nature. Electric power companies, like electric cooperatives, produce the electricity and transport it to your home using transmission and distribution power lines. Voltage is a measure of the energy of electric charges in a circuit. It is the "force" of the electricity moving between two places.

Study the flow chart to the right and answer the following questions.

1. At what voltage does electricity move from the generation plant?

   _____

2. At the transmission system, the voltage has been increased from 115 to 500 kilovolts. What part of the system increases the voltage?

   _____

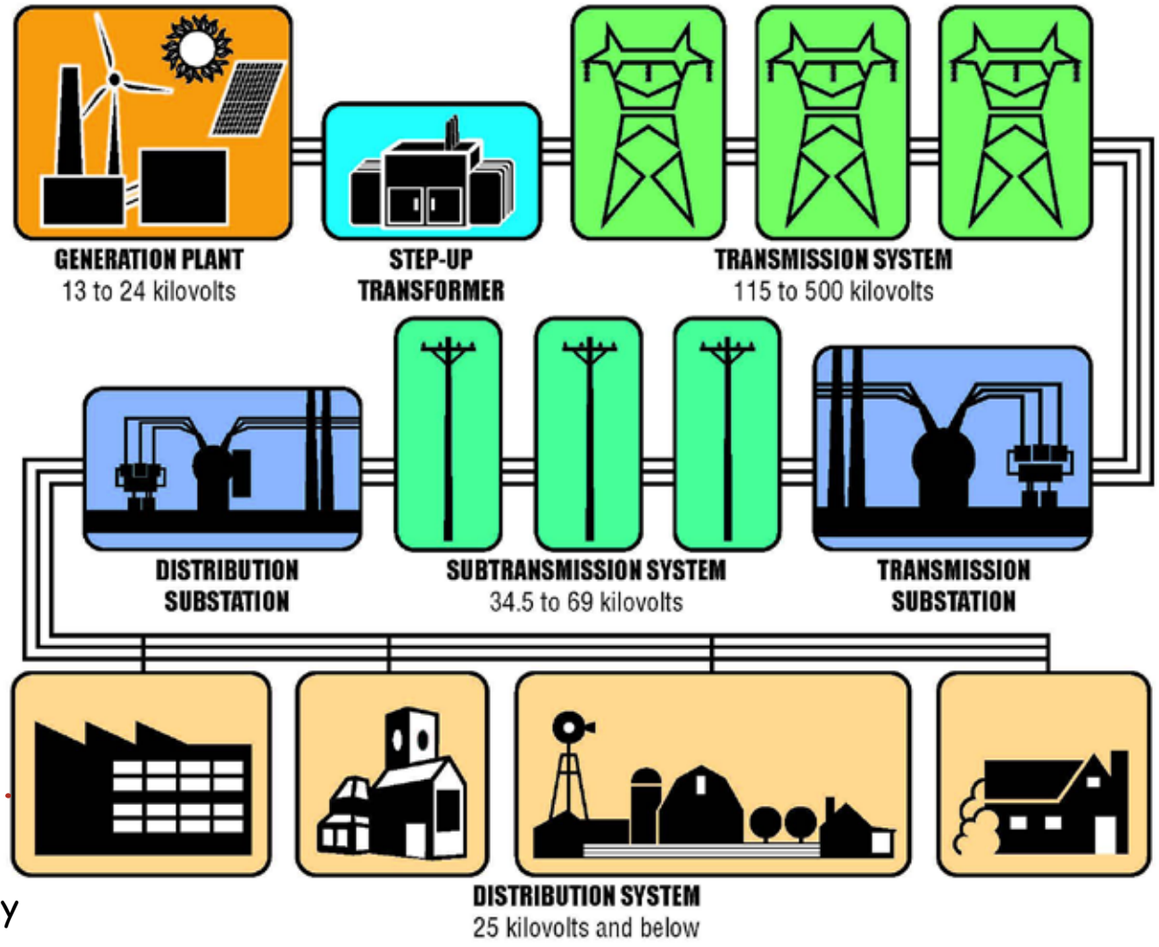
3. At the subtransmission system, the voltage has been lowered back down to:

   _____

4. From the distribution substation the electricity is sent to several places, name two.

   _____

   _____



Energy Sources

Electricity is known as a secondary energy source. It is generated by using energy from different types of fuel, such as coal or natural gas. Other ways to create electricity include nuclear power and renewable resources, such as water, wind and solar power.

U.S. electricity production (May 2011):

- ☐ 43.6% Coal
- ☐ 21.7% Natural Gas
- ☐ 19.4% Nuclear
- ☐ 9% Hydro
- ☐ 5.5% Renewables
- ☐ 0.9% Petroleum

Make a pie chart showing U.S. electricity production by source in the circle. Color each slice of the pie and identify your colors with a key by coloring the box in front of the percentage.

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TRI-STATE Generation and Transmission Association, Inc.
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Mega-what?

Electricity is measured in units of power called watts. One watt is a small amount of power. In fact, it won't even light an average light bulb.

A kilowatt (kW) is one thousand watts and a megawatt (MW) is one million watts. Both terms are commonly used in the power business when describing power production or consumption. One megawatt is enough electricity to serve the needs of about 700 average households in the United States.

Watts vs. watt-hours

Electricity is measured in either watts (the rate at any instant) or watt-hours or kilowatt-hours (the amount used in an hour). A watt can be compared to the speedometer in a car. If it says 35 miles an hour that means 35 miles an hour at that instant. If an appliance has a listed wattage of 100, that means the device is using 100 watts at that instant.

We use watts to measure how hungry a device is for power. We use watt-hours to measure how much electricity we actually used over a period of time.

watts X hours used = watt-hours

This picture shows a helicopter assisting in stringing a new power line. The linemen or women would use math to make sure they had enough line and the correct tension on the lines. The pilot uses math to make sure he/she has enough fuel for the length of time they plan to be in the air plus factoring in speed, wind and other weather concerns.

You can usually find the wattage of most appliances stamped on the bottom or back of the appliance, or on its nameplate. The wattage listed is the maximum power drawn by the appliance. Since many appliances have a range of settings (for example, the temperature control on an oven), the actual amount of power consumed depends on the setting used at any one time.

The cost of electricity depends on where you live, how much you use and, possibly, when you use it. Your electric company may charge a higher rate for electric use according to the time it is used or the amount used during a set period of time.

The average U.S. household used 908 kWh a month in 2009. The U.S. as a whole used nearly 4 trillion kWh in 2009. About 37% was used in homes.

This reader helps achieve the following common core state content standards for fourth grade:

Reading Ideas & Details
- Refer to details and examples in a text when explaining what the text says explicitly and when drawing inferences from the text.
- Determine the main idea of a text and explain how it is supported by key details; summarize the text.
- Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text.

Math ~ Operations and Algebraic Thinking
- Use the four operations with whole numbers to solve problems.
- Gain familiarity with factors and multiples.
- Generate and analyze patterns.

Math ~ Number and Operations in Base Ten
- Generalize place value understanding for multidigit whole numbers.
- Use place value understanding and properties of operations to perform multi-digit arithmetic

Riddle answers:
Gardener wanted to grow a power plant.
They both can use switch hitters.
Brain Power!

ELECTRICITY is unique

because it is used almost instantly after it is produced. When you turn on a light, you instantly have electricity to power the bulb. This electricity is not stored somewhere just waiting to be used. It is made just as people need it. This is amazing when you consider the number of people and businesses using electricity.

Measuring Electricity

One watt of power is equal to one ampere (a measure of electric current) moving at one volt (a measure of electrical force). In U.S. homes, electricity is provided at 120 volts. A 60-watt light bulb needs half an ampere of current to light up.

ACTIVITY ~ How does your school use electricity?
Ask your principal how much electricity your school uses each month? Each year? What does it cost?

The cost of electricity

When the grown-ups in your house receive the electric bill, they're charged by the kilowatt-hour (kWh). A kilowatt represents 1,000 watts. When you use 1,000 watts for one hour, that's a kilowatt-hour.

To calculate kilowatt-hours, take the wattage of a device, multiply it by the number of hours you use it and divide by 1,000. (Dividing by 1,000 changes it from watt-hours to kilowatt-hours.)

Here's the formula to figure the cost of running a device:

wattage X hours used ÷ 1,000 X price per kWh = cost of electricity

For example, let's say you leave a 100-watt bulb on for one month (730 hours per month) and you're paying 15¢/kWh. Your cost to run the bulb all month is 100 x 730 ÷ 1000 x 15¢ = $10.95.

How much does it cost?

Based on a rate of 15 cents per kilowatt-hour, solve the problems by calculating the cost to run the appliances. Use the formula above to help you solve the problem. You can calculate the annual cost to run an appliance by multiplying the cost to run per day by 365 (days in a year).

Here are some examples of wattages for various household appliances:

- Clock radio = 10 watts
- Coffee maker = 1200
- Clothes washer = 500
- Clothes dryer = 3000
- Dishwasher = 2400
- Hair dryer = 1875
- Microwave oven = 1100
- Laptop computer = 50
- Refrigerator = 725
- Flat screen television = 120

1 Estimate the yearly cost of running the clothes washer 2 hours per week. (There are 52 weeks in a year.)

2 Estimate the yearly cost of running the clothes dryer 3 hours per week.

Understanding your electric bill

Using the electricity bill on this page as an example, determine the following:

1. How much electricity was used for the billing period?

   _____

2. What rate was charged for the electricity?

   _____

3. How does the customer's use of electricity compare to the same month last year?

   _____

4. What is one reason this year's bill is less than the same month last year?

   _____

YOUR ELECTRIC COOPERATIVE
PO BOX 840
HOMETOWN, USA

Page 1 of 1

Customer Name	Service Address	Date Due	Amount Due
JANE DOE	1234 West Summerville Ln. Hometown, USA	Oct 24, 2011	$150.80

Account Activity

Date of Bill	Oct 9, 2011	Previous Balance	$141.20
		Total Payment	$141.20
Number of Days in		Balance Forward	$ 0.00
Billing Period	29	+ Current Bill	$150.80
		Current Balance	$150.80

Electric Service - Account Summary

Invoice Number	0383917583	Residential	900 kWh x .15	$135.00
Meter No	0000W2696677	Service & Facility		$ 10.00
Rate	Residential	Subtotal		$145.00
Days in Billing Period	29	Sales Tax	4%	$ 5.80
Current Reading	18374 10/08/2011	Total Amount		$150.80
Previous Reading	17474 09/11/2011			
Kilowatt-Hours Used	900			

Comparison Information

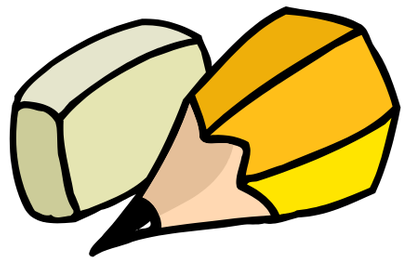
			Billing Period	kWh Usage/Month	Avg. Daily Temp
			This Year	900	55°
Electric	$150.80 per month	$5.20 per day	Last Year	978	48°

3 If the compressor in a refrigerator runs 10 hours per day, what would be the yearly cost to operate the refrigerator?

5 You spend 3 hours a day, 5 days a week doing homework on your laptop. What is your yearly electricity cost to do your homework over 36 weeks?

4 Your parents want to cut down your viewing of the flat screen television by one hour per day. How much will this save them on their electric bill in a year?

6 If the dishwasher takes one hour to clean the dishes, how much does it cost yearly to run one load per day?



Pyramid Generating Station, located in southwestern New Mexico, is a dual-fuel combustion turbine unit that uses natural gas and fuel oil to produce electricity.

Capacity Factor

One aspect that impacts the cost of producing electricity is the capacity factor. Whether electricity is created by using coal at a power plant or by the spinning blades of a wind turbine, each source can only be counted on to produce power a certain percentage of the time.

Capacity is a measure of the maximum potential output, or availability, of a power plant. If a power plant has a 1,000-megawatt capacity, it can potentially produce 1,000 megawatts at any given time.

However, there are a number of factors that come into play when determining how often and how much power can be produced, based on the source and the technology being used. For example, the sun does not shine all the time and the wind does not always blow. Also, all power plants are not always able to produce power because of scheduled maintenance.

This is where capacity factor comes in. Capacity factor is a measure of the percent of time a power source is able to operate at its full capacity. A power plant with an 80% capacity factor would operate at 100% power 80% of the time. Capacity factor is important because it reflects the performance of a generating station.

Average U.S. Capacity Factor by Energy Source

Nuclear: 90%
Coal: 73%
Natural Gas: 42%
Hydroelectric: 40%
Wind: 30%
Solar: 20%

1. Which electricity generation type has the highest average capacity factor?

_____

2. Give one reason why solar might have the lowest average capacity factor to generate electricity.

_____

_____

_____

3. Why would you expect wind to have a higher average capacity factor than solar?

_____

_____

_____

Using math in electric utility careers

"Math is important to my job at the power plant in nearly everything we do, all the way from beginning the construction of a new power plant to its completion and beyond to its ultimate purpose of producing electricity for your home. We use math to calculate how much fuel we will need to produce electricity for a day, week, month or year. If we are using coal, we also need to know how many train loads of coal we will need each day and how much steam we will need the coal to make in order to run the turbines. We also use math when creating a budget to determine how much it will cost to run the plant, which results in how much electricity costs."

Barry Ingold, senior manager of production assets at
Tri-State Generation and Transmission Association

"We use math every time we process an employee's paycheck. We calculate an employee's gross wages by multiplying their hourly rate of pay by the number of hours they worked during the pay period. Federal payroll tax laws require that we withhold applicable taxes from the employee's wages. Employees may also elect various deductions from their pay such as allocations to a retirement account. The resulting figure after all applicable taxes and deductions is called the "net" or "take home" pay. We use math every day and often rely on manual calculations to double check our payroll system. We also prepare a variety of weekly, monthly, quarterly and annual tax filings that require more complex calculations to report and remit taxes withheld from our employees' paychecks."

Tiffany Davis, associate accountant at Tri-State Generation and Transmission Association

Riddles ~

Why did the foolish gardener plant a light bulb?

How is energy conservation like a baseball team?

What is a renewable energy source that is used every day in school?

More riddles and activities can be found on the Internet at EIAEnergyKids.

Answers are on page 3.

Keeping electricity affordable and reliable

Of course there are other factors that play a role in electricity prices, including the cost of construction, transmission, maintenance, taxes, insurance and environmental regulations. Affordable electric power is important for families, businesses, communities and the economy. For some families, higher electricity bills could make for tough choices at home—even being forced to cut back on essentials like groceries. When businesses can't afford electricity, they have to cut back on new jobs and equipment. And for schools and hospitals, rising utility costs means less money available for investing in updated technology and additional teachers, doctors and nurses. It's important to know the value of electricity and how it affects every part of your life.

Safety First – Electricity can be deadly!

One of the most important things to know about electricity is that it can be dangerous. It doesn't take much power to hurt someone. Less than one-fifth of the electricity it takes to light a bulb can kill an adult.

Five rules for electrical safety:

- Always ask a grown-up for help when you need to use something that uses electricity.
- Don't yank or pull electric cords from a wall. Pulling cords can damage the outlet, appliance or plug.
- Never overload outlets with too many plugs.
- Keep electrical appliances, like blow dryers, away from water. Water and electricity don't mix. Most electrical accidents in the home happen when people use electricity near water.
- Look up for power lines. Never touch a power line, especially if it has fallen down.

New Mexico Electricity Facts

New Mexico has below average electricity prices. Coal produces more than 70 percent of New Mexico's electricity and natural gas provides over 20 percent.

New Mexico's natural gas production is almost 10 percent of the United States' total. The San Juan Basin, located on the New Mexico-Colorado border, is the nation's largest field of proven natural gas reserves.

New Mexico is a leading coalbed methane producer, along with Colorado and Wyoming, supplying about one-third of the state's natural gas production. The state also supplies about 3 percent of the United States' oil production. Most of New Mexico's coal deposits are in the San Juan Basin, which supply the state with its coal needs.

About 40 percent of the state's coal production is shipped to Arizona. New Mexico reportedly has substantial renewable energy potential through wind and solar power and has geothermal potential. Wind provides about 4 percent of the state's electricity, but solar and geothermal make negligible contributions to the state's electricity supply.

Electricity companies work 24 hours a day, seven days a week, so you and your family have electricity.

Choose the best answer

1. Electricity is
   - ❍ a form of energy
   - ❍ movement of charged particles
   - ❍ a secondary energy source
   - ❍ all of the above

2. What is the largest source of energy for electrical generation?
   - ❍ coal
   - ❍ hydropower
   - ❍ nuclear
   - ❍ solar

3. The unit of measurement of power is a
   - ❍ foot
   - ❍ hour
   - ❍ watt
   - ❍ none of the above

4. 1000 watts is a
   - ❍ kilowatt
   - ❍ megawatt
   - ❍ watt-hour
   - ❍ all of the above

5. Capacity is
   - ❍ the measurement of maximum potential output
   - ❍ a factor in the cost of electricity
   - ❍ reflected by the performance of a generation plant
   - ❍ all of the above

6. One thing you should always remember about electricity
   - ❍ it can be dangerous
   - ❍ water and electricity don't mix
   - ❍ never touch a power line
   - ❍ all of the above

7. A megawatt is
   - ❍ 1000 watts
   - ❍ 1 million watts
   - ❍ 1 billion watts
   - ❍ none of the above

8. What carries electricity from the generation plant to the substation?
   - ❍ step-up transformer
   - ❍ transmission line system
   - ❍ distribution substation
   - ❍ none of the above

9. Which is a renewable energy source?
   - ❍ solar
   - ❍ wind
   - ❍ hydropower
   - ❍ all of the above

10. Most of Colorado's electricity is produced by
    - ❍ coal
    - ❍ natural gas
    - ❍ hydro
    - ❍ none of the above