

The Water-Electricity Connection



Summary: Students must supply water and electricity to their town. They'll need water to make electricity and they'll need electricity to clean and pump water. When drought comes, they'll have to make tough decisions.

Grade: Six

Subject Areas: Science, Social Studies

Activity Materials:

Materials per each small group

- One *City Mat*
- One *Water Conservation Hints* page

For the whole group

- One bag of turquoise glass beads (enough for each group to get about 20)
- One bag of blue glass beads (see above)
- One bag of brown glass beads (see above)
- One scoop that holds about 25 glass beads (a medicine cup works well)
- NEED poster shows water is used to make electricity
- Water-Electricity poster
- Map of electricity in NM poster
- Set of Flash Cards
- Labels for bead containers

NexGen Science Standards and Benchmarks

ESS3-A Natural Resources – Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes.

MS-PS3 Engaging in Argument from Evidence - Construct, use, and present oral arguments supported by evidence and scientific reasoning to support or refute an explanation about the designed world.

LS2.A: Interdependent Relationships in Ecosystems – In any ecosystem, populations with similar requirements for food, water or other resources may compete with each other for limited resources...growth of population increases are limited by access to resources.

Crosscutting Concepts – Influence of Science, Engineering, and Technology on Society and the Natural World...The use of technologies and any limitations on their use are driven by individual or societal needs, desires, and values.

Crosscutting Concepts – Science Addresses questions about the Natural and Material World...Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes.

Set Up: Set up a station at the front of the classroom with a container for each color of bead. Label the turquoise beads "San Juan / Colorado River Watershed." Label the brown beads "Electricity Generation: 1 water bead = 1 electricity bead". Label the blue beads "1 electricity bead = 2 water beads (1 from river, 1 from aquifer). Use placards to label each set.

WATER-ELECTRICITY ACTIVITY

TALKING POINTS:

- It takes electricity to pump and clean water for drinking.
- It takes water to make electricity.
- You use water and electricity indirectly whenever you use something that was manufactured.
- When we use water and electricity, we are modifying the planet and must monitor these changes to make sure they are not negative to, or adverse on, the environment.

WARM UP (15 minutes)

Explain that there are different types of water. Can the students identify them?

- o Drinking Water (treated)
- o Wastewater (treated)
- o Storm drain water (untreated)
- o Rain water (untreated)
- o Aquifer water (untreated)
- o River water (untreated)
- o others?
 - o Explain that some of this water is treated to make it safe for people and some of it is not. Can they identify which water is treated and which is not?
 - o This can be played as a game with the students:
 - make two categories: treated water and untreated water
 - Show students each type of water and ask them which category it goes into

Ask students where their water comes from:

Answer: River and Aquifer

- o Explain that to get water out of the ground requires pumping which takes a lot of electricity
- o Explain that to clean the river water to make it drinkable, takes a lot of electricity
- o Explain that PNM provides electricity to Albuquerque and Bernalillo County and that ABCWUA is the largest consumer of electricity in Albuquerque and Bernalillo County. When they (or their parents) pay their water bill, there are also paying for the electricity it takes to get them their water.

Ask students where their electricity comes from (from PNM):

Answer: Show pie chart

39% from coal

17% from natural gas

29% from nuclear power

15% from renewable energy (solar and wind)

- Explain that water is used at some point in the process of making electricity from these materials
- Show poster of coal to electricity flow chart (NEED poster)
 - The water used in this coal to electricity process comes from the San Juan River Watershed
- Explain that to make electricity with natural gas uses a process similar to coal
 - The water used in this process comes from the aquifer and other places (like wastewater). These gas power plants are located all over the state and get water from whatever source is close and convenient.
- Explain that to make electricity in a nuclear power plant, water is used for cooling in the process
 - The water used in this process comes from the wastewater from the city of Phoenix and the surrounding area in Arizona

Show students the Water-Electricity Connection poster, as well as the Burning fossil fuels to generate electricity poster. Reiterate how water is necessary to make electricity and how electricity is used to pump and clean water.

Explain that water is all around us on the planet, in rivers, lakes and underground. When we use water to make electricity we are altering the natural way the processes work. If we want to have a healthy planet for future generations, we must make sure we do not hurt the planet when we use water and when we make electricity.

ACTIVITY (20 minutes)

Divide students into groups of 2 – 4 students.

- Hand each group a *City Mat*. Explain that this is their city, and they are the city planners. They must provide water and electricity to the people in the town. Go over the three houses on the mat: Homes, Services, and Goods
 - Define Services as places that provide you with a “service” – stores, schools, hotels, hospitals, parks, restaurants and some government facilities.
 - Define Goods as places that provide you with a “good”, something that you can feel and touch, that you might buy at a store or restaurant in “services” – factories that make the stuff for the stores to sell,

manufacturers that make the computers and electronics we use, and the Water Authority which must clean the water before and after you use it.

- Note their city has landscaping. This includes lawns to play on and shade trees to sit under.
- Define Cooling as your air conditioning unit
- Define Appliances as including refrigerators, washer/dryers, stoves, water heaters
- Define Heating as heating system
- Define Electronics as computers, TVs and other small devices like tablets and phones.
- Define Sterilizing Medical Equipment as the cleaning of all the special medical tools in hospitals. Imagine how germs would spread if these weren't sterilized.
- Define Treating Wastewater as an activity that every city must deal with.
- Define Specialized Machinery as the special machines in factories that produce things we use. Often these must be cooled which is often accomplished with water (Define Cooling Machinery)
- Define Food Processing as being more than just growing food. For example, the processing of meat uses a lot of water in cleaning of the carcass and equipment. For beef it is estimated to be 1 gallon of water to process 1 pound of beef.
- Note their city also has a natural environment (bosque, river, foothills) nearby that must have water to survive.

In order to provide water and electricity they must do this:

- Get a scoop of turquoise water (Untreated Water). This is natural water that may come from such places as underground, rivers, rainwater, etc. The optimal number of beads for this activity to work perfectly is 32 beads, with no landscaping for goods and services. If some get more and some get less, that's okay because in reality, some towns have more water available and some have less.
- Show them the natural environment and explain that it represents the natural world, and if they want to keep it healthy, they'll need to always have some water there too. (They need at least 2 beads of water to keep their natural environment at least alive, although with 2 beads it may not be very healthy.) To start, have them allocate 5 of their Untreated Water to the natural environment.
- Count their remaining turquoise beads. This untreated water will be used to make electricity. Take their turquoise water over to the power plant. Trade in all of their water for electricity. The rate they must pay is one turquoise bead for one electricity bead.
- Take the electricity back to their town and begin allocating electricity for your town. Note that to provide some electricity services (such as lights) it takes 2 electricity beads, whereas some electricity services (such as heating) takes only 1 electricity bead.
- Decide how much drinking water they want to have. The rate they will pay is one electricity bead for 2 drinking water beads. When they trade, they must take one bead from the aquifer and one bead from the river for each electricity bead. Both sources require electricity. The drinking water the Water Authority provides is a mix of aquifer and river water, usually it is about 70% river water and 30% aquifer water, depending on drought conditions. For our example here we will assume a 50-50 split, even though this doesn't happen very often.
- Warn students not to use too much electricity to make drinking water, because if they run out of electricity, they cannot go back to the Untreated Water bin to use to make more electricity. They also cannot make more electricity with their drinking water. We use untreated water to make electricity, not drinking water. Drinking water is too precious to use to make electricity. However, they can take Untreated Water from their natural environment to make electricity, but this will hurt the natural environment. Less than 2 beads in the natural environment and the natural environment will wither away with time.
- Students spend some time planning and providing water and electricity for their community. Nobody will have enough water. Let them decide what they will cut.

- Once most groups have made their decisions and are in the process of finishing the activity, gather their attention. Hand out the *Water Electricity Conservation Hints*. Explain that if they can get their citizens to make the changes on the mat, they can use less by conserving more. Go over the changes that they need to make. Give them time to rearrange their beads.

DISCUSSION

What kind of services were they willing to cut before they realized they could conserve? Did they find themselves in a dilemma, trying to figure out how to meet their town's needs? How did your water and electricity use affect the natural environment?

Explain that this dilemma is something that the Water Authority and PNM must also grapple with.

Explain that the Water Authority must make sure you have enough drinking water, and PNM must make sure you have enough electricity, but neither organization wants to hurt the environment.

- If the Water Authority takes too much from the river it could hurt it.
- If the Water Authority takes too much water from the aquifer they could deplete it.
- When PNM makes electricity they take water away from the environment and they create carbon dioxide that contributes to climate change.

How did the conservation strategies help their towns?

How did using the conservation strategies affect the natural environment?

Further Discussion (if time)

Explain that it takes water to make everything we use. This is virtual water. Show virtual water flash cards. Ask students to guess how much water it takes to make these things. Ask them for examples of things they use – how is water used to make them? Message: Anything that is made using electricity also uses lots of water.

CONCLUSION (5 minutes)

How can we make sure we have a healthy planet for future generations?

Go over conservation strategies, especially things they can do as 6th graders:

- 5 minute shower
- Don't water your yard during hot part of the day
- Take shallow baths
- Use less electricity
- Refuse, reduce, reuse, recycle

Complete Challenge Problems if time or leave with teacher to do later

Questions? Contact
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Water Utility
Authority

Water-Energy Connection

Name: _____

Challenge Problems

1. In general water flows from faucets at a rate of 2 gallons every minute. If there are 500,000 people in Albuquerque, and everyone shortens their shower by 1 minute, how much water would be saved?

2. It takes $\frac{1}{2}$ gallon of water to make 1 kilowatt hour of electricity.

The average person uses 600 kilowatt hours of electricity per month. (That means the average person uses 300 gallons of water to generate their electricity each month.)

a. If everyone reduced their use of electricity by 1% each month (6KWH), how much water would be saved?

b. To reduce your electricity use by 1% each month (1% of 600 kilowatt hours = 6 KWH = 6000 watt hours) would be equal to reducing your electricity use by 200 watt hours per day. (6000 watt hours/30 days in a month = 200 watts per day)

A standard 100 watt incandescent light bulb uses 100 watts per hour. Keeping just one incandescent light off for 2 hours a day would reduce your electricity use by 1% each month. (100 watts x 2 hours per

day = 200 watt hours per day) But keeping your lights off and sitting in the dark at night isn't practical!
How many watts of electricity would be saved by using a 10 watt LED light bulb instead of a 100 watt incandescent light bulb?

Water-Energy Connection

Name: _____

Challenge Problems (Answer Sheet)

1. In general water flows from faucets at a rate of 2 gallons every minute. If there are 500,000 people in Albuquerque, and everyone shortens their shower by 1 minute, how much water would be saved?

500,000 people x 2 gallons per minute = 1,000,000 gallons saved

2. It takes $\frac{1}{2}$ gallon of water to make 1 Kilowatt hour of electricity.

The average person uses 600 kilowatt hours of electricity per month. (That means the average person uses 300 gallons of water to generate their electricity each month.)

- a. If everyone reduced their use of electricity by 1% each month (6KWH), how much water would be saved?
500,000 people x ((600 KWH x .01) x $\frac{1}{2}$ gallon per KWH) = 500,000 x 3 = 1,500,000 gallons of water would be saved.

This is not drinking water, but it is water in the natural world that could be helping the environment.

- c. To reduce your electricity use by 1% each month (1% of 600 kilowatt hours = 6 KWH = 6000 watt hours) would be equal to reducing your electricity use by 200 watt hours per day. (6000 watt hours/30 days in a month = 200 watts per day)

A standard 100 watt incandescent light bulb uses 100 watts per hour. Keeping just one incandescent light off for 2 hours a day would reduce your electricity use by 1% each month. (100 watts x 2 hours per day = 200 watt hours per day) But keeping your lights off and sitting in the dark at night isn't practical! How many watts of electricity would be saved by using a 10 watt LED light bulb instead of a 100 watt incandescent light bulb?

100 watts/10 watts = 10. A 10 watt LED light bulb uses 10 times less watts than a 100 watt incandescent light bulb. With an LED light bulb, you wouldn't have to sit in the dark for 2 hours every night to save 200 watt hours per day!

Notes about Electricity: (This needs to be reviewed/okayed by PNM still for accuracy)

Currently PNM gets 39% of its electricity from coal at the San Juan Generating Plant and the Four Corners Generating Plant. Both use water from the San Juan River Watershed. Because of climate change and the carbon dioxide created when burning coal, PNM is closing down its coal plants. By spring of 2022, the San Juan Generating Plant will be closed. Using only the Four Corners Generating Plant will drop coal use to about 10% of the electricity budget and use of the San Juan River Watershed for electricity will be proportionately reduced. The Four Corners Generating Plant is to close in 2031, at which time the San Juan River Watershed will not be used for generating electricity anymore.

To make electricity from natural gas also uses water in the process. There are about 6 different natural gas-generating plants used by PNM, and they use different processes and different water sources depending on their locations.

- Reeves Station, located in ABQ at Paseo del Norte and Jefferson -- this uses well water and is the oldest and dirtiest of all of them. It uses old technology (opened in 1959). (generated 154 MW as of 2017)
- Afton Plant, located in La Mesa NM, uses well water and a special combined cycle technology to capture and reuse the water, so it really doesn't end up using much water. Opened in 2007 (generated 230 MW as of 2017)
- Lordsburg Plant, located in Lordsburg, NM, uses well water, opened in 2002 (generated 80 MW as of 2017)
- Luna Plant, located in Deming NM, opened in 2006 and uses a special combined cycle technology like the Afton Plant. It has always used well water but is now starting to use grey water from Deming (generated 189 MW as of 2017)
- La Luz Plant, located near Belen NM uses well water and opened in 2015 (generated 40 MW as of 2017)
- Rio Bravo Plant, located in ABQ at I-25 and Rio Bravo, opened in 2000. Uses gas and old as its fuel. Uses well water. (generated 138 MW as of 2017)

The process to make electricity from gas is very similar to coal, except that the water is also used for evaporative cooling and in most cases is reused so there is very little leakage and need for additional water over time. Making electricity with natural gas uses much less water than making electricity from coal. Most of these plants recycle and reuse the water, losing a small portion to evaporation, meaning the total water use is not very much, especially compared to coal. The old Reeves Station uses more water than the other plants due to its older technology. All in all, coal is very water consumptive compared to gas.

The natural gas-generating plants also produce carbon dioxide and contribute to climate change. PNM is planning to close these natural gas plants by 2040, so by 2040 PNM will be emission free and will not be using water to create electricity from gas and coal.

Electricity from nuclear power comes from the Palo Verde Nuclear Power Plant outside of Phoenix, Arizona. Water is used in this process to keep the power plant cool. Since this power plant is in the desert and there is no water nearby, this nuclear power plant uses wastewater from Phoenix, Arizona. This is the nation's only nuclear plant not located on a body of water, so it uses more than 20 billion gallons of wastewater annually from surrounding municipalities to cool the plant.

With the phasing out of coal and gas generating plants by 2040, new sources for electricity will need to be found. We cannot get more electricity from the nuclear power plant. We will need to move to more renewable sources. These sources include solar, geothermal, and wind. Some renewable methane gas sources, such as biomass or landfill gas may be used (these do generate carbon dioxide, but methane gas creates carbon whether you get energy from it or not). The challenge will be the battery technology necessary to store the renewable electricity on a scale needed to provide electricity to our large city.

In addition to finding replacement electricity sources for the future, we also need to find more electricity, as we will be relying more and more on electricity as we get away from carbon producing activities. For example, as we move from gas car to electric cars, there will be an increased demand for more electricity. To further help with climate change, we will be moving away from burning natural gas in our homes (ovens, stoves, water heaters, dryers, heating systems) and using electricity for these purposes, and this will increase our electricity usage as well.

Electricity use in homes, ranked by most to least:

1. Space cooling (AC units and swamp coolers)
2. Water heater
3. Refrigerators
4. Other Appliances (stove/oven, washer/dryer, water heater, space heater, etc)
5. Lighting
6. Electronic Devices (Computers, tv's, phones, tablets, etc)

Other notes about electricity generation:

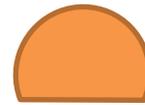
Step 1

Untreated Water

Take just one scoop!

Step 2

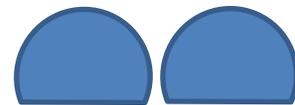
Electric Power Plant Trade



Trade in one San Juan water for one electricity.

Step 3

Albuquerque Water Supply

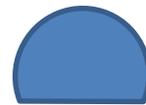


Trade in 1 electricity for 2 waters (one river, one aquifer)

River Water



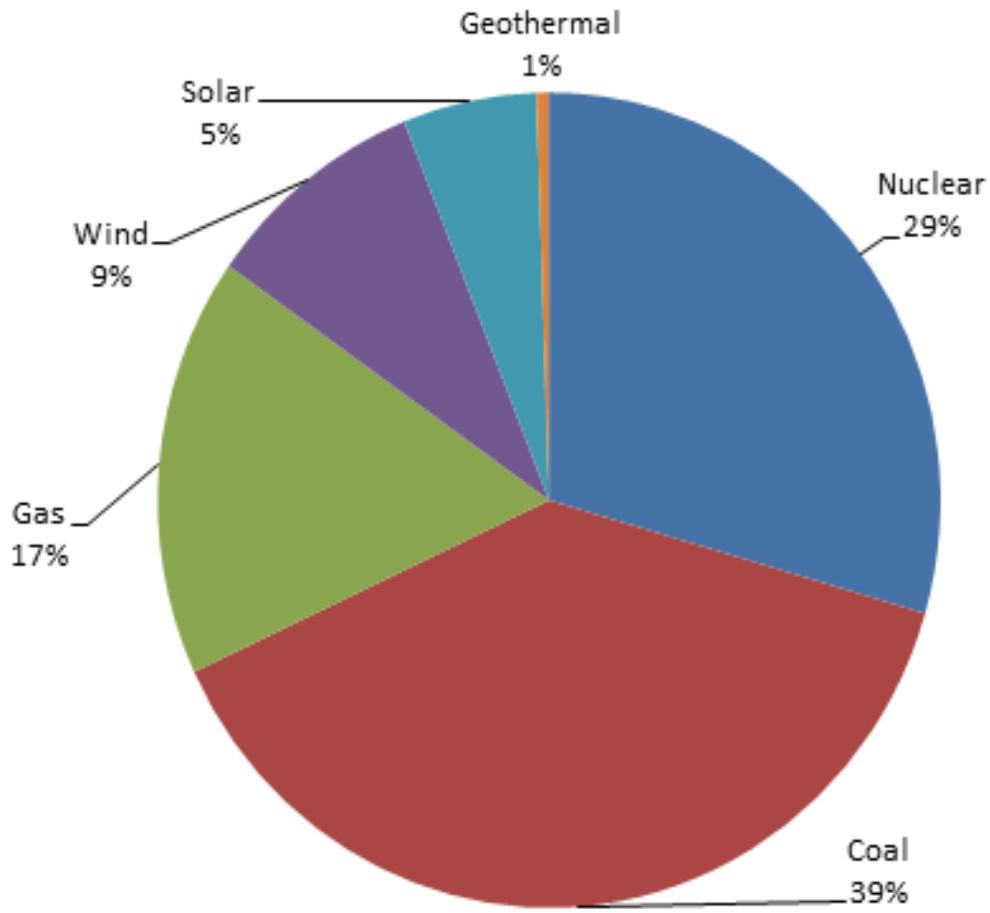
Aquifer Water



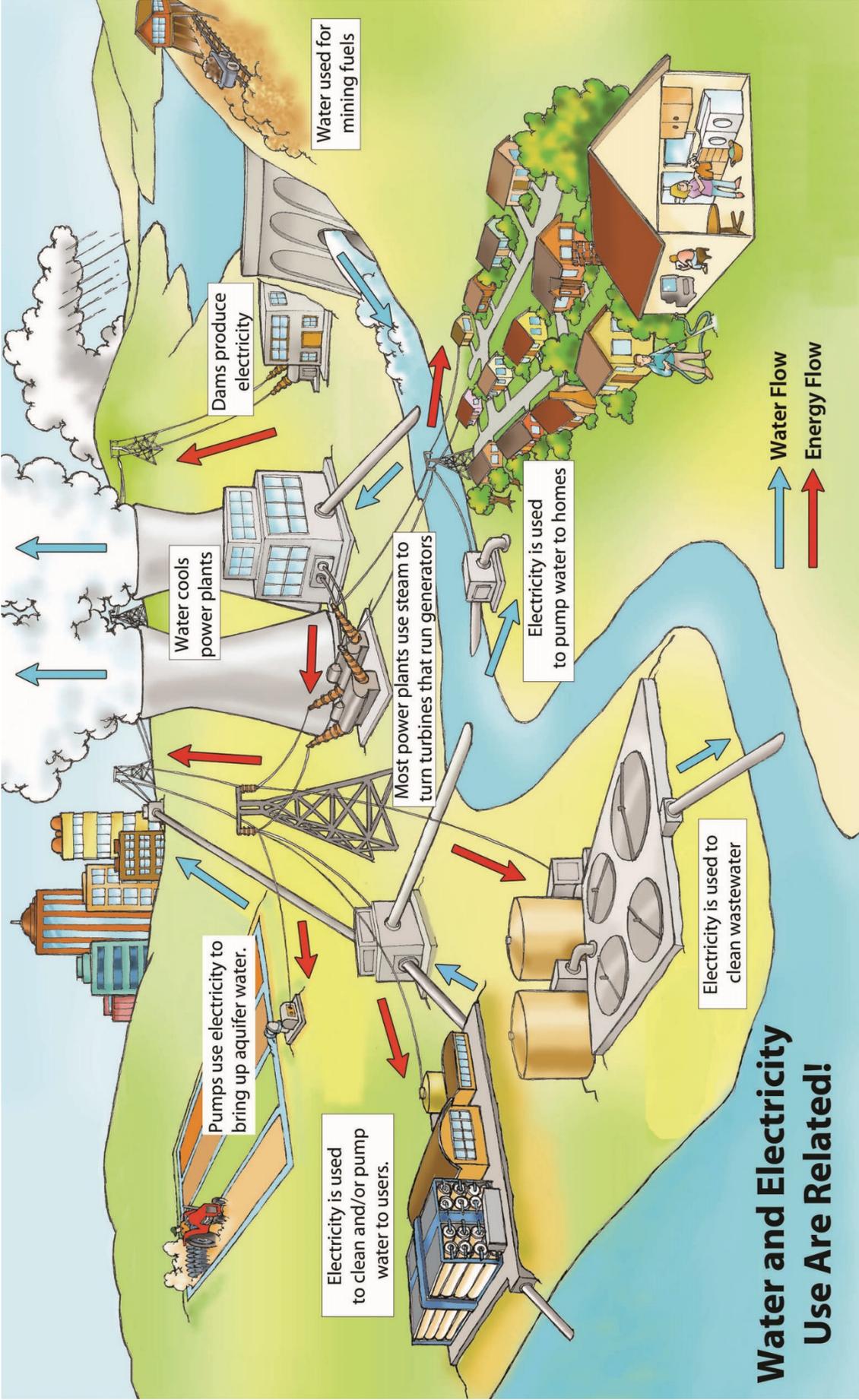
Sources of Electricity
for Albuquerque/Bernalillo County

2019

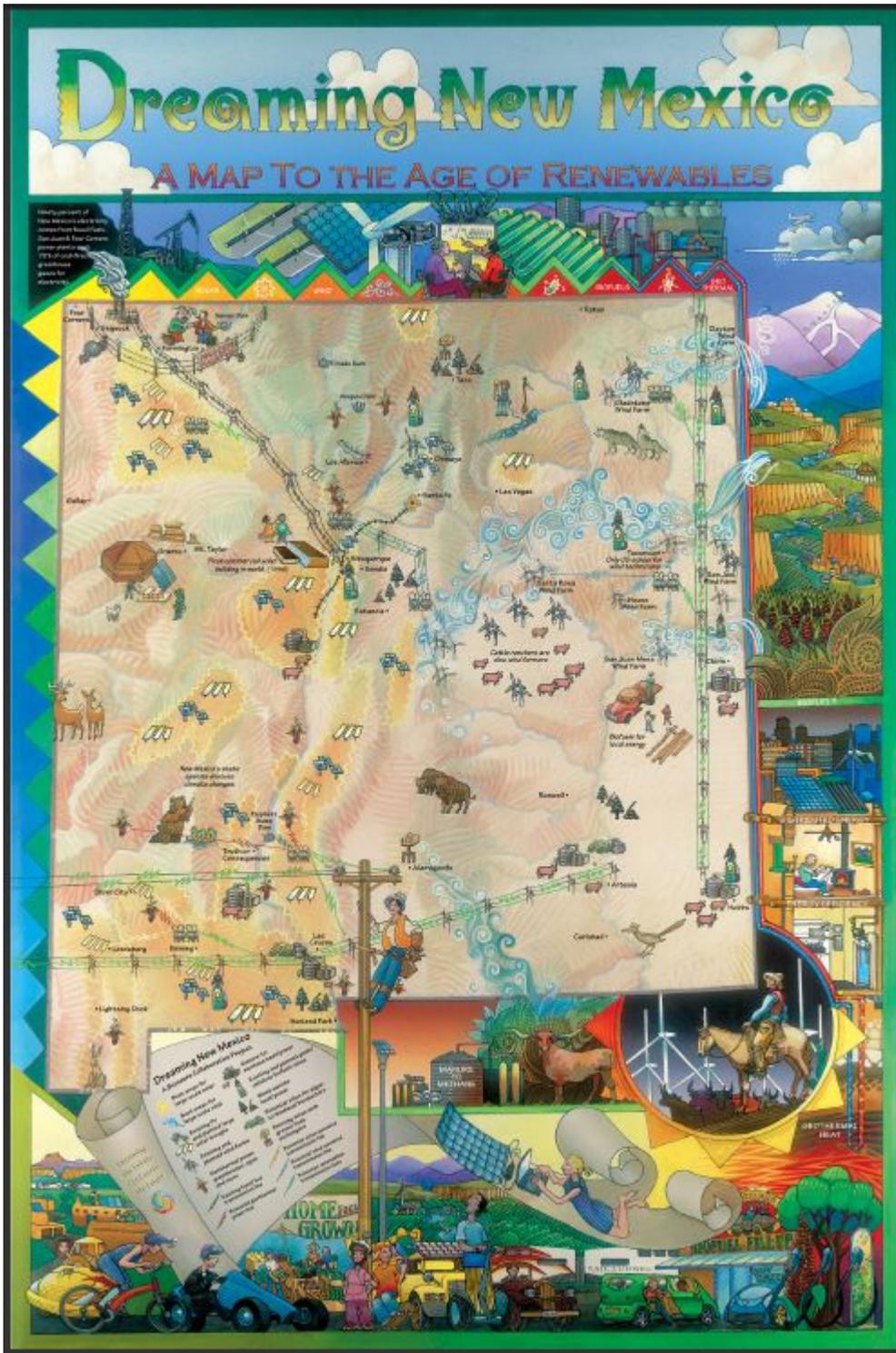




Source: PNM



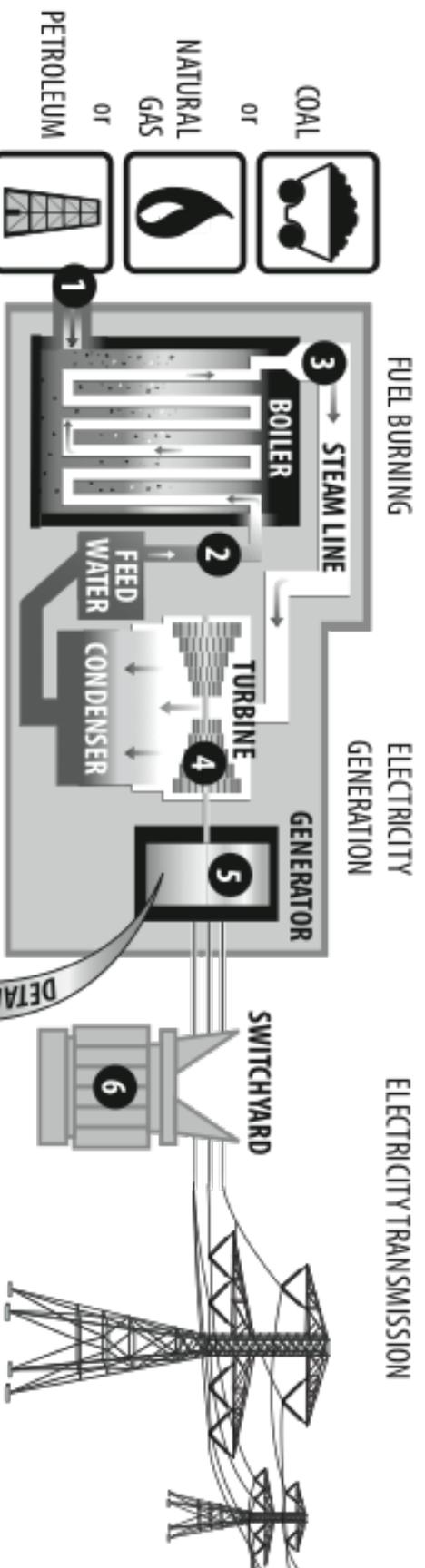
Water and Electricity Use Are Related!



You can get a copy of this map and the curriculum that goes with it from the Bioneers at <http://www.dreamingnewmexico.org/energy>



Burning Fossil Fuels to Generate Electricity



1. A fossil fuel is fed into a boiler, where it is burned to release thermal energy.
2. Water is piped into the boiler and heated, turning it into steam.
3. The steam travels at high pressure through a steam line.
4. The high pressure steam turns a turbine, which spins a shaft.
5. Inside the generator, the shaft spins coils of copper wire inside a ring of magnets. This creates an electric field, producing electricity.
6. Electricity is sent to a switchyard, where a transformer increases the voltage, allowing it to travel through the electric grid.

