Student Reading: Electricity for You and Me

Our electricity comes from a variety of sources. The table below shows some of the largest power generating facilities in Arizona. We have other power sources as well. There are many smaller power plants scattered across the state. Also, we exchange electric power with other states, both importing and exporting it.

Note that in the chart below, it is possible that some energy sources at a given power plant may change. For example, some coal power plants can switch from using coal to natural gas as the energy source.

Ten Largest Power Generating Facilities in Arizona

Name of Facility	Energy Source	Operator	Location	Generating Capacity in megawatts (MW)
Palo Verde	Nuclear	APS	50 miles west of Phoenix, near Wintersburg	3,937
Navajo	Coal	SRP	Page	2,250
Gila River Power Station	Natural Gas	Gila River Power Station LP	Gila Bend	2,060
Springerville	Coal	TEP	Springerville	1,618
Glen Canyon Dam	Hydroelectric	U.S. Bureau of Reclamation	Colorado River, near Page	1,312
Santan	Natural Gas	SRP	Phoenix	1,227
Mesquite Generating Station	Natural Gas	Mesquite Power, LLC	50 miles west of Phoenix, near Arlington	1,073
Harquahala Generating Station	Natural Gas	New Harquahala Generating Co, LLC	Tonopah	1,054
Hoover Dam	Hydroelectric	U.S. Bureau of Reclamation	Colorado River, 25 miles southeast of Las Vegas, NV	1,040
Cholla	Coal	APS	80 miles east of Flagstaff	1,027

Student Reading: Fact Sheet
Coal in Arizona

What Is Coal?

Coal is a fossil fuel. It formed from the remains of plants that grew in swamps 354 to 290 million years ago. The plants died and sank beneath the waters of the swamp. Before they fully decayed, sediments buried them. Over geologic time (that is, millions and millions of year), heat and pressure changed the sediments. The result was coal, a form of stored chemical energy and a nonrenewable natural resource. Producing electricity from coal is inexpensive given the current power infrastructure and abundance of coal in the United States.

Use of Coal in Arizona

The Earth has more coal than any other fossil fuel. About 1/4 of all world coal reserves are in the United States. Thus, coal is abundant as well as reliable and cheap. Arizona has coal deposits in the northeastern part of the state, on Native American lands. Two large mines are located near the town of Kayenta – the Black Mesa Mine and the Kayenta Mine. Less than half of the coal used in Arizona comes from these mines. Much of the rest comes from New Mexico.

The coal mines in Arizona are surface mines. Giant earth-moving equipment is used to move the soil and rock. Coal-bearing rock is collected, crushed, and separated into coal and rock. Next, the coal is crushed to a powder. Then it is transported to a power plant. Here it is burned to create heat energy, which is used to make steam with kinetic energy. The steam turns a turbine generator to make electric energy.

In Arizona coal has historically been the major energy source of electricity. As of 2010, due to the downward spike in natural gas prices, burning coal produced only 24 percent of our electricity while natural gas accounted for 49 percent. Arizona has many major natural gas and coal-burning power plants and also receives power from natural gas and coal-burning plants in other states.

Student Reading: Fact Sheet
Coal in Arizona *(Continued)*

Coal and the Environment

Mining and burning coal impacts the environment in several ways. Coal mining can damage habitat and cause erosion. In some cases, coal mining also results in toxic runoff to rivers or ground water.

Burning coal can cause air pollution, too. Tiny pieces of soot, called particulate pollution, can be released into the atmosphere. If people inhale a large amount of these tiny particles, health problems sometimes result. For this and other reasons, coal-fired power plants tend to be located far from cities.

Other pollution from burning coal includes the chemicals that cause smog and acid rain. Smog can damage crops, forests, and even buildings. Acid rain can make soil and water more acidic. Plants and animals may be harmed if the conditions become too acidic. However, many coal-burning power plants have special equipment to reduce these pollution problems.

Finally, burning coal releases carbon dioxide and other greenhouse gases. These gases are a major cause of global warming. Generating electricity accounts for one-third of the greenhouses gases released each year in the United States. In fact, the greenhouse gas emissions from power plants are the largest single source of greenhouse gas emissions in the United States…more than cars! Most of this is from generating electricity with coal and other fossil fuels such as natural gas.

Student Reading: Fact Sheet
Hydroelectric Power in Arizona

What Is Hydroelectric Power?

Electricity generated from flowing water is called hydroelectric power or hydropower. Usually a dam is built to store the water. The stored water has potential (or gravitational) energy. When water is released, it flows down the penstocks towards the turbines. The potential energy becomes kinetic (or motion) energy. The moving water turns turbine generators that make electric energy.

The amount of electricity generated depends on the amount of water and the distance it falls. Small hydropower plants can be built on streams or canals. Generating large amounts of hydropower requires damming a sizeable river.

Water is always moving through the water cycle. Therefore, flowing water is a renewable natural resource. In the United States, hydroelectric power is by far the largest renewable energy source in use.

Electricity from hydropower is relatively inexpensive. The cost is low for several reasons. Arizona's largest dams have been in place many years. Also, some of the costs typical of fossil fuels are avoided. There is no need to mine, transport, or buy fuel. There is also no need for the expensive pollution control equipment required on fossil fuel power plants.

Use of Hydropower in Arizona

About 10 percent of Arizona's electricity is made by hydropower. This amount is likely to slowly decrease over time. Arizona does not have many large rivers, and the best sites for dams have already been utilized. Some potential remains to develop small hydropower sites, such as along canals.

Arizona has a number of hydropower plants. The largest, at Hoover Dam, can generate over 1,000 megawatts. The smallest hydropower plants are along canals in the Phoenix area. These include the Crosscut Canal plant (3 MW) and Arizona Falls (.75 MW). Other hydropower plants in Arizona include the Theodore Roosevelt, Horse Mesa, Mormon Flat, and Stewart Mountain Dams along the Salt River near Phoenix. The combined generating capacity of these facilities is about 244 MW.

Student Reading: Fact Sheet
Hydroelectric Power in Arizona *(Continued)*

Hydropower and the Environment

Hydropower is clean energy. Because no fuel is burned, no pollution is made. Hydropower can still result in other environmental problems.

The reservoir behind a dam floods upstream riparian (streamside) habitats. Many plants and animals depend on these habitats. There are effects below a dam, too. Stream flow and flood cycles change. This harms the downstream riparian habitats. Also, water held behind a dam changes in temperature, chemistry, and the amount of sediment it carries. Releasing this water affects the ecology of the river itself. In some cases, the changes are great enough that native fish can no longer live in the river. For example, the Colorado River used to have a wide temperature range and ran relatively muddy (full of sediment) for much of the year. Today, Colorado River water released from the Hoover Dam is always a consistent 46 degrees Fahrenheit and is free of sediment.

Hydropower plants along canals are important examples of low-impact hydropower. They do not have any negative effects on natural systems. They also do not affect river flows, water quality, riparian habitats, aquatic habitats, and fish or other wildlife.

Student Reading: Fact Sheet
Photovoltaic Solar Power in Arizona

What Is Photovoltaic Power?

Photovoltaic or PV energy is created when light energy from the sun is transformed directly into electric energy. PV technology is based on the photovoltaic effect. This is a natural phenomenon in which light energy "excites" the electrons in certain kinds of materials. The electrons "flow" or create an electric current.

Silicon is one of the materials in which the photovoltaic effect can take place. Almost all photovoltaic cells are made of silicon. PV cells are the basic building block of all PV solar electric systems. Photovoltaic power can be used on a very small scale, such as in calculators, or on a very large scale, such as in commercial power plants.

PV equipment is expensive. The cost of PV power is almost all up front, to install the equipment. After that, operating costs are very low.

Use of Photovoltaic Power in Arizona

Arizona is an ideal place to use solar energy. The Southwest receives more sunlight than anyplace else in the continental U.S. Yet solar power provides less than one percent of Arizona's electricity. This is largely because of its cost, which remains high in spite of technological advances.

The major electric companies in Arizona all own large PV power plants. One large system in Arizona is a 2.4 megawatt (2400 kilowatt) array near Springerville. In the Phoenix area, there are a variety of large, utility-scale PV arrays. These large arrays are also appearing all over Tucson, including a large one at Davis-Monthan Air Force Base that can be seen from Golf Links Rd. Though it still represents a small part of Arizona's total energy portfolio, solar power is growing across the state.

Student Reading: Fact Sheet
Photovoltaic Solar Power in Arizona *(Continued)*

The largest of these systems are power plants that produce electricity for distribution to many users. As the size of a PV system decreases, it can be installed on the roof of a business or home. Countless rooftop PV systems can be found across the state. Some are in remote areas but many are in cities.

PV cells and many arrays have no moving parts, so they run well for a long time with little maintenance. Some arrays have moving parts which enable the whole array to track the sun during the day, enabling the system to receive an optimal amount of sunlight. No fuel is required for PV power because sunlight is the only input needed.

Photovoltaic Power and the Environment

PV is a clean energy source. A small amount of pollution is created when PV cells are manufactured. During use, there are no environmental impacts. PV does not cause problems related to air pollution, greenhouse gases, toxic or radioactive waste, or habitat loss.

There is some concern that large PV power plants require large areas of land – much more than for a coal or nuclear power plant. However, mining and processing the fuel for coal or nuclear plants also requires land. When this is taken into account, the total area of impacted land is similar.

Student Reading: Fact Sheet
Bioenergy in Arizona

What Is Bioenergy?

Green plants use light energy from the sun to change carbon dioxide and water into sugars or carbohydrates. This process is photosynthesis. The carbohydrates that result are a form of chemical energy. Plants store this chemical energy in their cells. They can use it for biological processes and to grow. Animals that eat plants are using this same stored energy for their own biological processes and growth. If plant matter is burned, the stored chemical energy changes to heat energy.

Bioenergy is energy that we get by burning biomass or organic matter. Organic fuels or biofuels are solids, liquids, or gases that came from a living thing. Examples of biofuels include wood, other plant matter, animal dung, ethanol, and biogas.

Organic wastes in a landfill break down or decay very slowly, over a period of years or decades. As they decay, methane and other gases are released. This landfill gas or biogas can be used as fuel in a power plant.

All biofuels are renewable energy sources. The cost of bioenergy varies with the fuel type. Electricity costs made with landfill gas or biogas is typically inexpensive. The gas is free, as it is a waste product, but there are costs for equipment to collect and process the gas. Sometimes, operators will build a power plant at the landfill site itself to harness the biogas and to reduce the cost of piping it elsewhere.

Use of Bioenergy in Arizona

The stored chemical energy in biofuels can be burned to make heat energy. The heat energy can be used directly, for example by burning wood in a fireplace to keep warm. Or the chemical energy can be used to make electricity. The heat can be used to heat water and make steam. The steam will turn a turbine. A turbine generator can change the spinning kinetic (motion) energy of the turbine into electric energy.

Less than one percent of Arizona electricity is made with biofuels. Only a few power plants in Arizona use biofuels. This includes two landfill gas or biogas plants. One of these is a four-megawatt (4000 kilowatt) plant near Scottsdale, at the Tri-cities Landfill on the Salt River Pima-Maricopa Indian Community. The other is a six megawatt (6000 kilowatt) plant near Los Reales Landfill in Tucson.

Student Reading: Fact Sheet
Bioenergy in Arizona *(Continued)*

Bioenergy and the Environment

Different kinds of biofuels have different effects on the environment. Landfill gas or biogas offer primarily environmental benefits. Biogas that is not collected and burned will escape into the atmosphere to become an air pollutant and a potent greenhouse gas. These impacts are avoided when biogas is collected and used as a fuel. As an added benefit, using this waste product as a fuel helps conserve other energy resources.

Student Reading: Fact Sheet
Wind Power in Arizona

What Is Wind?

Wind is caused partly by the uneven heating of Earth's surface by the sun. Warm air rises and cool air sinks. This causes pressure differences in which air masses move around to balance the pressure differences, creating wind. The rotation of Earth on its axis also affects wind. Wind is created through ongoing natural processes. Thus, it is a renewable natural resource.

Wind farms are easy to build compared with new coal or hydropower plants. The cost of wind energy varies but is similar to and competitive with other mainstream energy sources such as coal, natural gas, and hydropower. Obviously, wind is most efficient, and therefore cost-effective, in places where it is consistently windy.

Use of Wind Power in Arizona

Windmills capture the kinetic (motion) energy of wind. The motion of air becomes motion in a machine – mechanical spinning energy. Modern wind turbines use this energy to make electric energy. The spinning windmill turns a turbine, which runs a generator that produces electricity.

Producing wind power for large numbers of homes and businesses requires many large wind turbines. The turbines used to produce power on a commercial scale are huge! The towers may be 100 to 250 feet tall. Each tower has a set of three blades, and each blade may be 50 to 100 feet long. Tens or hundreds of wind turbines may be built in a group called a wind farm.

Wind power can be used on a small scale in many areas, with one small windmill making power for one house. Producing wind power on a large scale requires an area that is very windy all year. Most of Arizona has limited potential for commercial wind generation.

Arizona has one major wind farm, located in Navajo County. The Dry Lake Wind Power Project opened in 2009 and consists of 30 turbines that generate a total of 63 MW. In addition, Arizona power companies purchase wind power from outside the state.

Student Reading: Fact Sheet
Wind Power in Arizona *(Continued)*

Wind Power and the Environment

Wind is a fairly low-impact energy source. Making power from the wind does not create solid waste, toxic waste, water pollution, air pollution, or greenhouse gases. However, large wind turbines can be quite noisy, so they must be located away from places that people live.

Roads must be built for installing and servicing the many turbines at a wind farm. These roads damage the natural habitat. Also, birds can die if they fly into the spinning blades of a wind turbine. Newer turbine styles greatly reduce this problem. Placing large wind farms away from major migration routes also helps keep bird deaths low.

Student Reading: Fact Sheet
Natural Gas in Arizona

What Is Natural Gas?

Natural gas is a fossil fuel. It is usually found with coal or oil. Like these other fossil fuels, natural gas formed from the remains of plants and animals that lived long ago. The organisms died and were buried by layers of sediment before they fully decayed. Over millions of years, pressure and heat deep in the Earth caused chemical changes. The fossil fuels thus formed are considered nonrenewable natural resources.

Natural gas can be a mix of several gases but is primarily methane. Special wells are used to remove natural gas from deep underground. Then it is refined to almost pure methane, a colorless, odorless, and highly flammable gas. New technology has enabled natural gas companies to access previously inaccessible reserves of natural gas trapped in shale rock. This is called shale gas. The techniques, called hydraulic fracturing and directional drilling, have been nicknamed "fracking."

Studies have shown that fracking can contaminate groundwater. Its effects on seismic activity are still unknown, though some research in states like Ohio and Pennsylvania shows fracking has an effect on seismic activity. Fracking has also come under scrutiny because of methane leaks at the drilling sites, in which methane leaks directly into the atmosphere. Methane is 40 to 80 times more powerful as a greenhouse gas than carbon dioxide, so methane leaks from fracking are a serious concern.

Use of Natural Gas in Arizona

Arizona has only very limited natural gas deposits. Almost all of the natural gas used here comes from other states. Arizona has many natural gas power plants. Fifty percent of our electricity is generated from natural gas and this percentage is likely to continue to rise in the future due to advances in technology. The use of natural gas to make electricity is rapidly increasing across the country.

Student Reading: Fact Sheet
Natural Gas in Arizona *(Continued)*

Generating electricity from natural gas is a lot like generating electricity from coal and other sources involving heat. The gas is burned. This changes its chemical energy to heat energy. The heat is used to make steam. The steam turns a turbine. Turbine generators turn the kinetic (motion) energy into electric energy.

Electricity made from natural gas is currently very inexpensive due to the recent abundance of natural gas. Experts predict this abundance will taper off and the cost of electricity from natural gas will rise.

Natural Gas and the Environment

Natural gas burns cleaner than coal or oil. Thus, natural gas power plants are often located near or in towns and cities.

Burning natural gas produces very little particulate matter or soot. It also produces few of the air pollutants that are a problem with other fossil fuels. Use of natural gas also releases less carbon dioxide, a greenhouse gas, than other fossil fuels.

Removing natural gas from underground does create problems, however, as previously discussed. Plant and animal habitat is destroyed around the natural gas wells. Also, the wells and extraction process can pollute the soil, surface water, and ground water. Some of the pollutants are poisonous. This creates further problems for plants and animals in the area.

Student Reading: Fact Sheet
Nuclear Energy in Arizona

What Is Nuclear Energy?

Nuclear energy is the energy stored in the nucleus of atoms. It is the energy that holds the different subatomic particles in the nucleus of an atom together.

The atomic nucleus can be split, so that its subatomic particles separate. The splitting of an atomic nucleus is called fission. Through fission, nuclear energy is released as heat energy.

The cost of nuclear power varies widely, though in Arizona the cost is lower than in other parts of the United States. These figures do not include the long-term cost of storing the radioactive waste.

Use of Nuclear Energy in Arizona

Arizona has one nuclear power plant, the Palo Verde Generating Station. It is located about 50 miles west of Phoenix. Palo Verde is the largest nuclear plant in the United States. It has a power generating capacity of 3,733 megawatts. This one power plant produces about 28 percent of all the electricity generated in Arizona. Much of the electricity generated at Palo Verde is used in Arizona; however, utilities in Southern California buy a significant amount of the electricity generated at Palo Verde.

Almost all nuclear power plants use fuel rods of enriched uranium. The uranium nuclei are split through a controlled chain reaction. This process of fission releases the nuclear energy as heat energy. The heat is used to make steam. The steam turns a turbine. A turbine generator converts this kinetic (motion) energy into electric energy.

Arizona does have uranium deposits on the Colorado Plateau. Some parties would like to access those deposits while others are against it. The fuel rods used at Palo Verde Generating Station are made in Kentucky. The uranium with which they are made comes from various other states.

Student Reading: Fact Sheet
Nuclear Energy in Arizona *(Continued)*

Nuclear Energy and the Environment

All types of mines impact the land, plants, and wildlife. This is true for uranium mines, too.

Nuclear fission does not release any pollution or greenhouse gases. However, nuclear fission does result in radioactive byproducts. Radioactive leaks from nuclear power plants are rare. However, if they occur, they can create major health and safety problems. The most recent large-scale radioactive leak occurred at the Fukushima Daiichi Nuclear Power Plant in Japan following a massive tsunami in 2011.

Also, spent nuclear fuel is highly radioactive. Some of the elements in it remain radioactive for only a few years. Others remain radioactive for thousands of years. To be safe, this high-level radioactive waste must be stored carefully for thousands of years. Where and how to store spent nuclear fuel is a major concern related to nuclear power.