

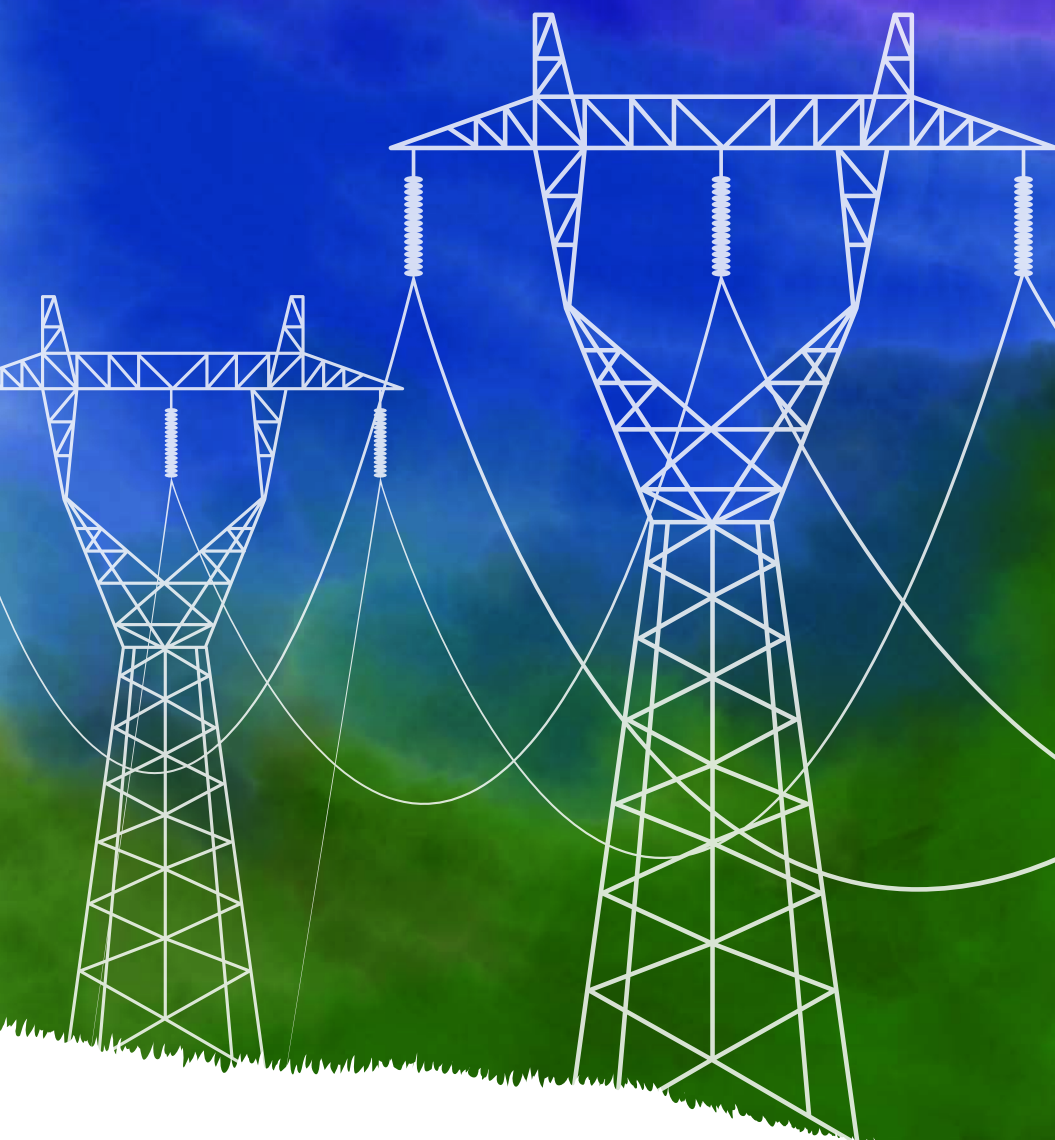
EXPLORE *Different Ways
to Generate Electricity*

DISCOVER *Where Electricity
in Our Region Comes From*

CHOOSE *Sources of Electricity
for Our Clean Energy Future*

Northwest Sources of **ELECTRICITY**

Powering a clean energy future





Welcome!

from Electricia, Surge & their pup Lumen

We're electricity superheroes. Our mission is to wisely generate and deliver electricity safely to you.

We're powerful, reliable and versatile with a current that flows at close to the speed of light.

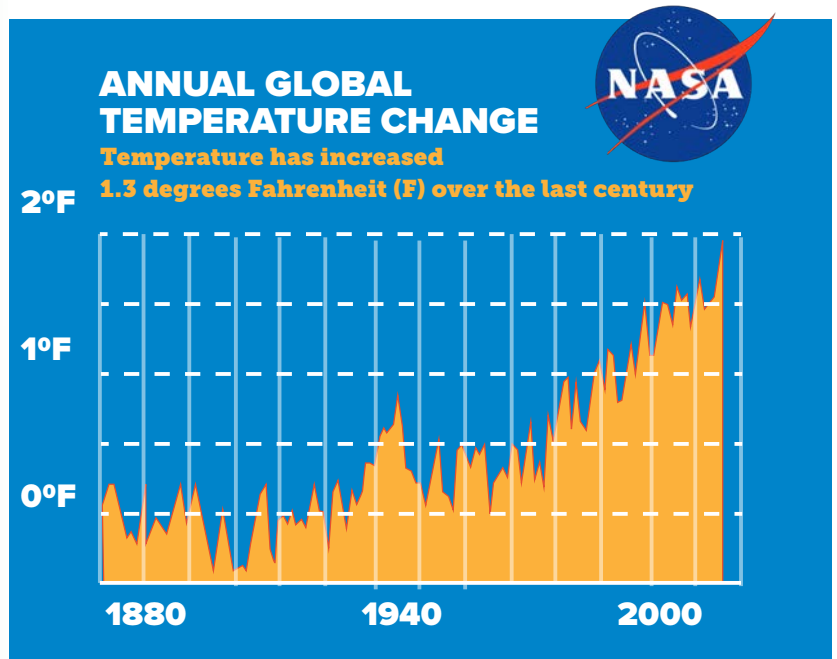
You don't see us, but you depend on us to recharge your cell phone, keep the lights on and power appliances. We're here for you 24/7!

Keeping electricity flowing is a team effort and we'd like your help. To join our power squad, read on.

CLIMATE CHANGE & Carbon-Free Electricity Generation

Earth's climate is constantly changing. 20,000 years ago, for example, the United States was covered in glaciers.

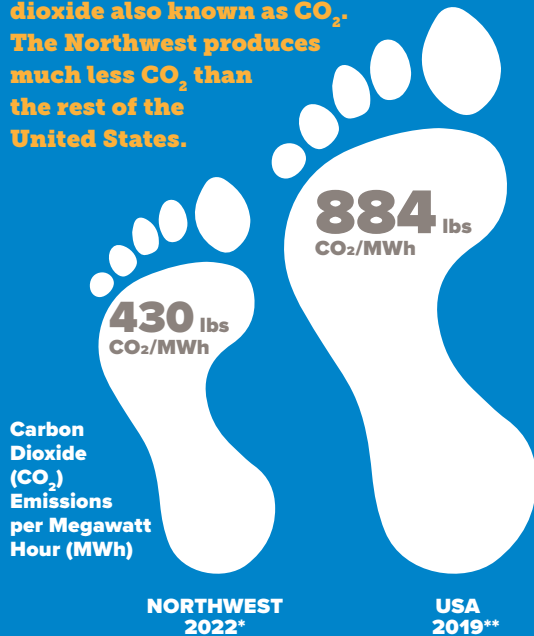
Scientists are observing the earth's average temperature is going up quickly. The average temperature in the Northwest rose 2° Fahrenheit (F) since 1900; and scientists project another 3° to 10°F by 2100. You now live in a climate with more wildfires and droughts, melting glaciers, and changes in when and how much it rains and snows.



Source: NASA's Goddard Space Flight Center

Our Carbon Footprint NORTHWEST VS. NATION

Hydropower is a carbon-free source of electricity, which means it doesn't create the greenhouse gas carbon dioxide also known as CO₂. The Northwest produces much less CO₂ than the rest of the United States.



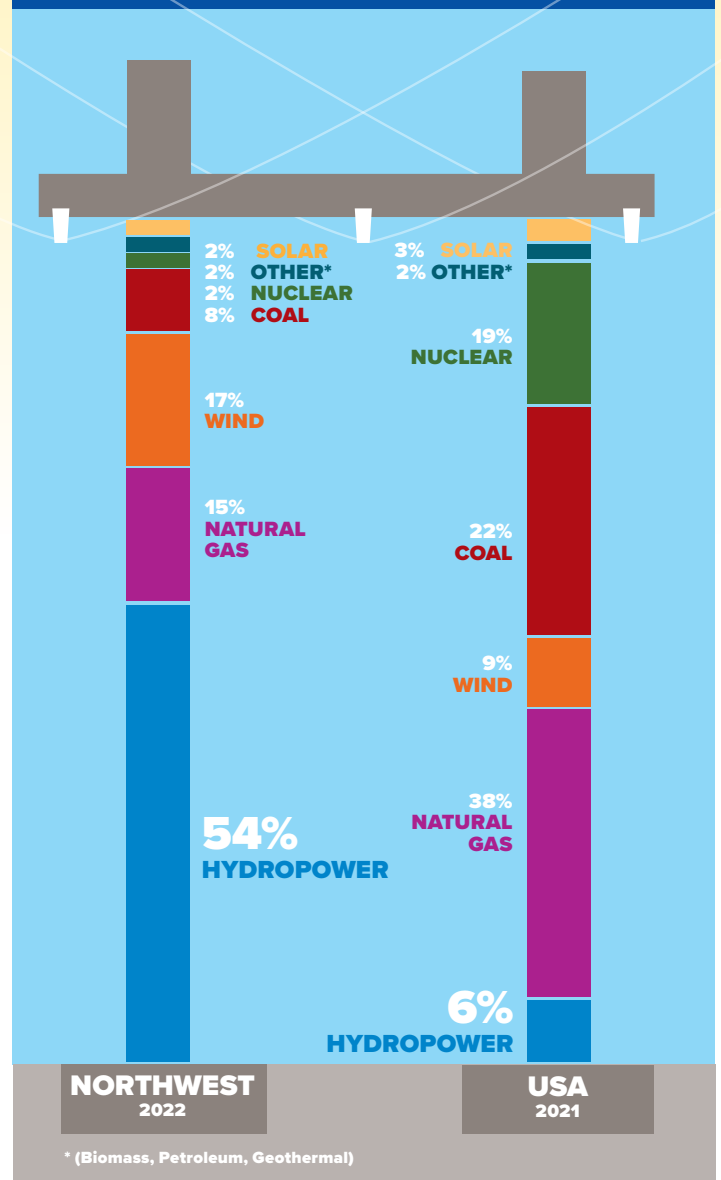
*Source: EPA

** Source: Statista

Humans contribute to climate change when our actions add certain gases to the Earth's atmosphere. These gases block heat from escaping and keep the planet warmer. Scientists call this the greenhouse effect.

In 2021, the Environmental Protection Agency (EPA) found that carbon dioxide (CO₂) accounted for about 79% of all U.S. greenhouse gas emissions from human activities. Further, about 31% of greenhouse gas emissions result from the generation of electricity.

Where Our Electricity Comes From



Sources: Northwest Power and Conservation Council, U.S. Energy Information Administration

Moving to carbon-free electricity, meaning no CO₂ emissions are released into the atmosphere, is a critical way to reduce greenhouse gas emissions. In the Northwest, we are lucky. Thanks to hydropower, 54% of our capacity to generate electricity is already carbon-free.

Generating Electricity

Every time we turn on a light switch or plug in a computer or other device, we are using electricity. The power grid delivers this electricity to our homes, businesses, and farms 24-hours a day, seven days a week. The supply of electricity from power plants must always match demand because the power grid can not store electricity.

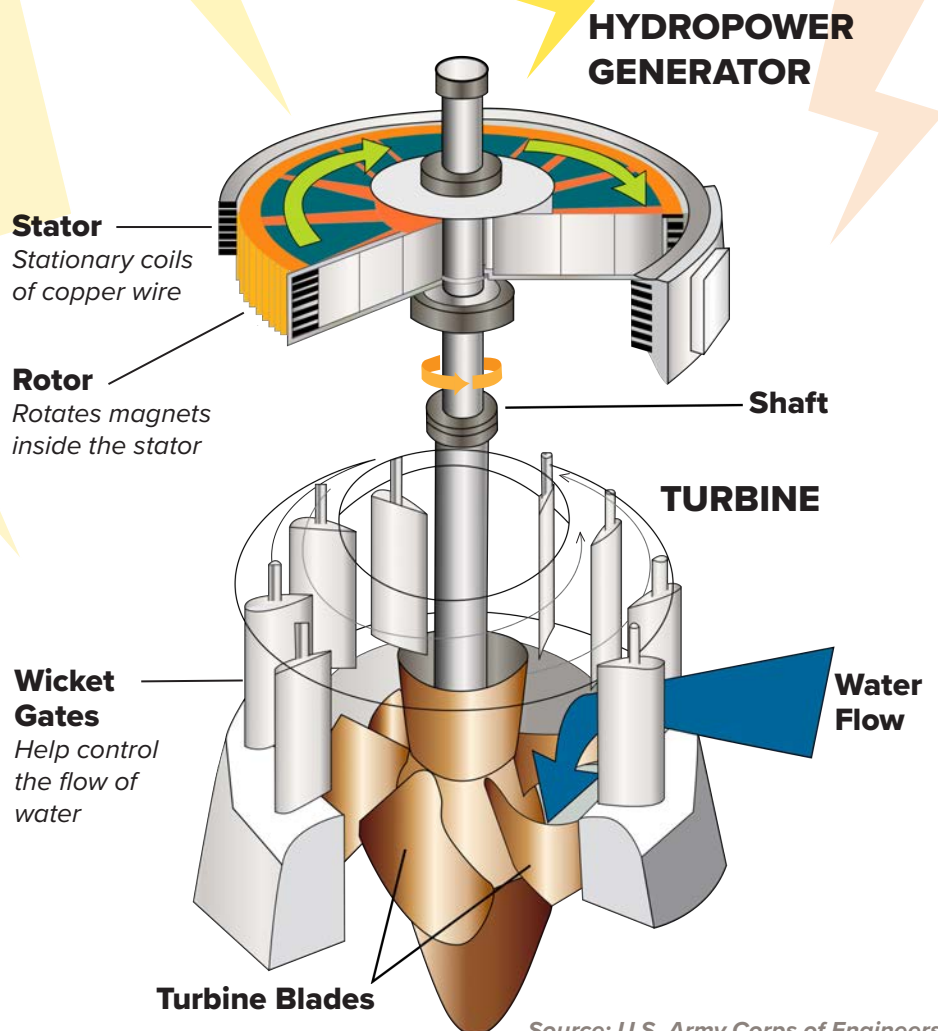
Sometimes called the largest machine in the world, the U.S. power grid has over 5,800 power plants and over 2.7 million miles of power transmission lines. Just as amazing, its reliability is 99.9%.

At power plants, turbines and generators are often used to produce electricity.

Here's a simple explanation of how turbines and generators work.

Turbine: There are many types of turbine designs. What they all have in common are blades that are attached to a shaft or rotor (hub). Each energy source has a unique way of forcing the turbine to rotate (turn). For instance, hydropower uses the force of moving water to turn a turbine. Natural gas power plants use heat, by burning gas, to turn a turbine.

Generator: The shaft or rotor being turned by a turbine spins coils of wire inside stationary magnets that are arranged in a circular ring. Alternatively, magnets can spin inside stationary coils of wire. This creates a magnetic field that causes electrons in the wire to move. The small electric currents created in each section of wire coil are combined to produce electricity that can be added to the power grid.

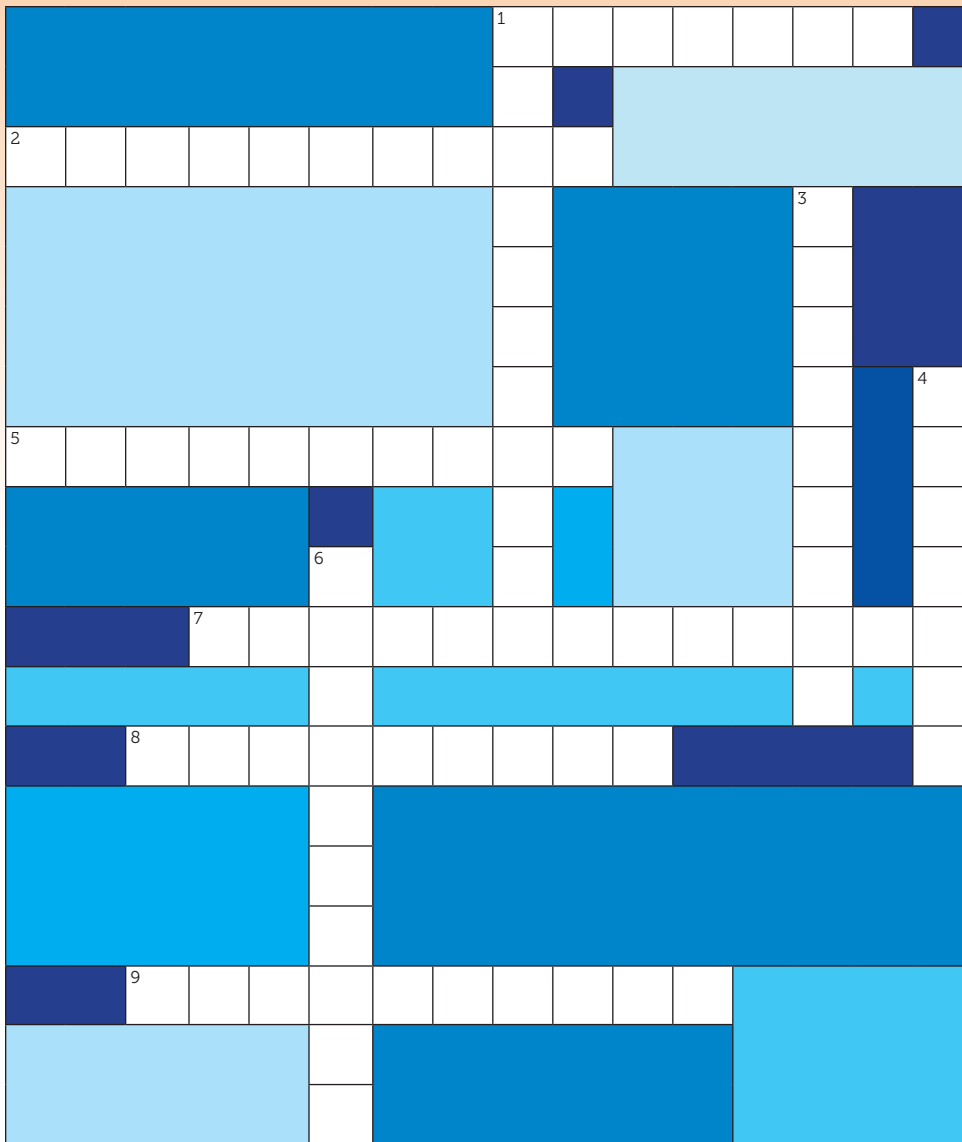


Source: U.S. Army Corps of Engineers

CLIMATE CHANGE & ELECTRICITY GENERATION CROSSWORD PUZZLE

Use the information you've learned so far to complete this crossword puzzle.

The word bank helps you solve the clues. Do not use spaces between words.



Word Bank

POWER GRID

CARBON FREE

TWENTY SEVEN

RENEWABLE

TURBINE

MAGNETS

NATURAL GAS

HYDROPOWER

CARBON DIOXIDE

GREENHOUSE

ACROSS

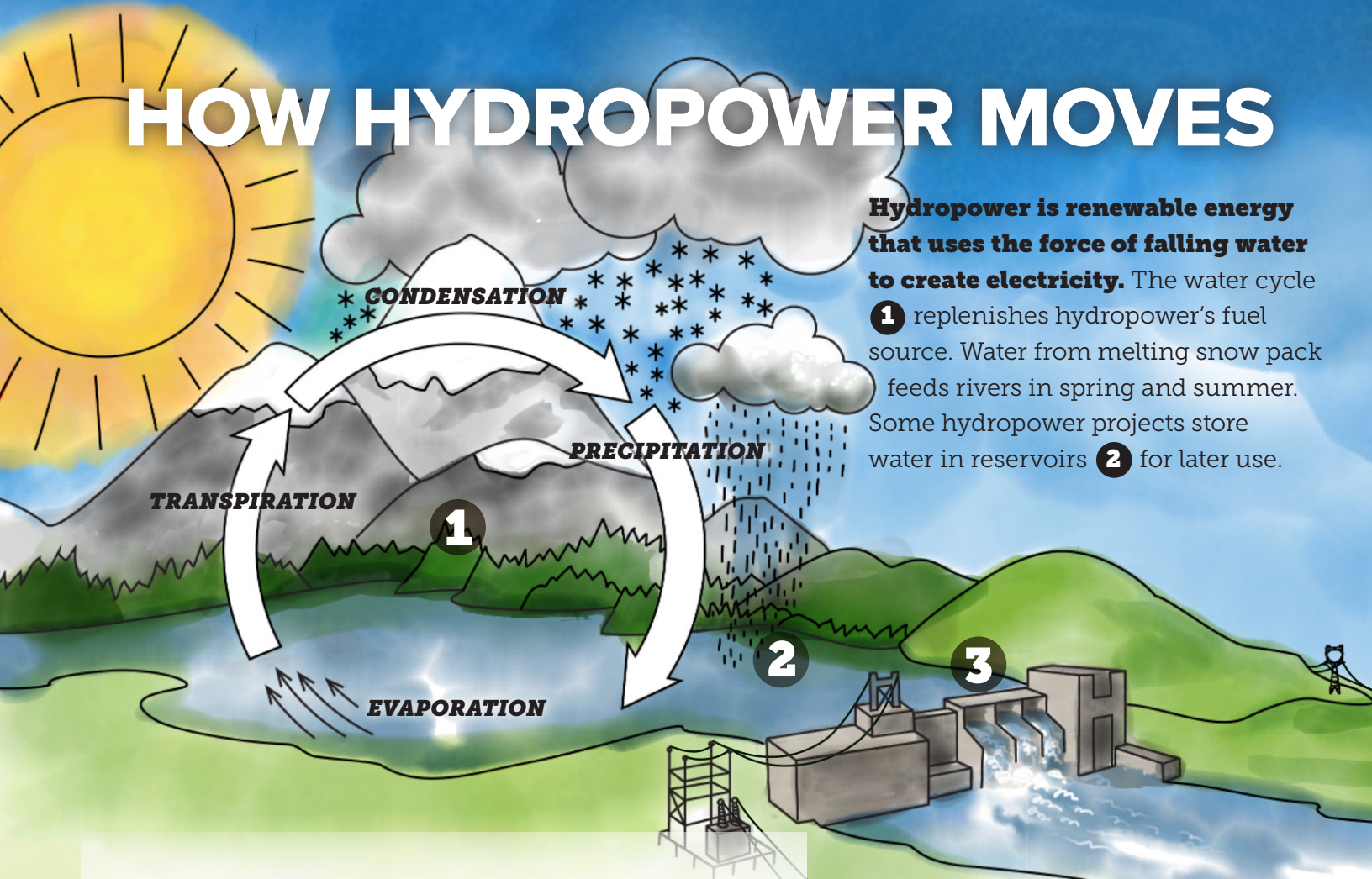
- 1) Fitted with blades, it uses steam, air currents or the force of water to turn.
- 2) _____ means no carbon dioxide (CO₂) emissions are released to the atmosphere.
- 5) The Northwest's largest electricity generation source.
- 7) Accounts for about 79% of all U.S. greenhouse gas emissions from human activities.
- 8) Type of electricity generation source that is carbon free and is constantly replenished.
- 9) Nationally, the largest electricity generation source.

DOWN

- 1) Nationally, the percent of greenhouse gas emissions that result from generating electricity.
- 3) The _____ delivers electricity to our homes, businesses, and farms 24-hours a day, seven days a week.
- 4) _____ spin inside stationary coils of wire to generate electricity.
- 6) Gas emissions that block heat from escaping the atmosphere and keeps the planet warmer.

HOW HYDROPOWER MOVES

Hydropower is renewable energy that uses the force of falling water to create electricity. The water cycle **1** replenishes hydropower's fuel source. Water from melting snow pack feeds rivers in spring and summer. Some hydropower projects store water in reservoirs **2** for later use.



THE WATER CYCLE

Providing Hydropower Its Renewable Fuel

Energy from the sun powers the water cycle

Draw a line below to match each definition with a word from the water cycle.

Heating water from oceans, rivers, lakes and even puddles turns water into a liquid gas (also called a vapor) that rises into the atmosphere.

Water vapor that rises into the atmosphere from the pores of plants and animals.

The process of water vapor turning back into liquid water. Clouds form during this stage of the water cycle.

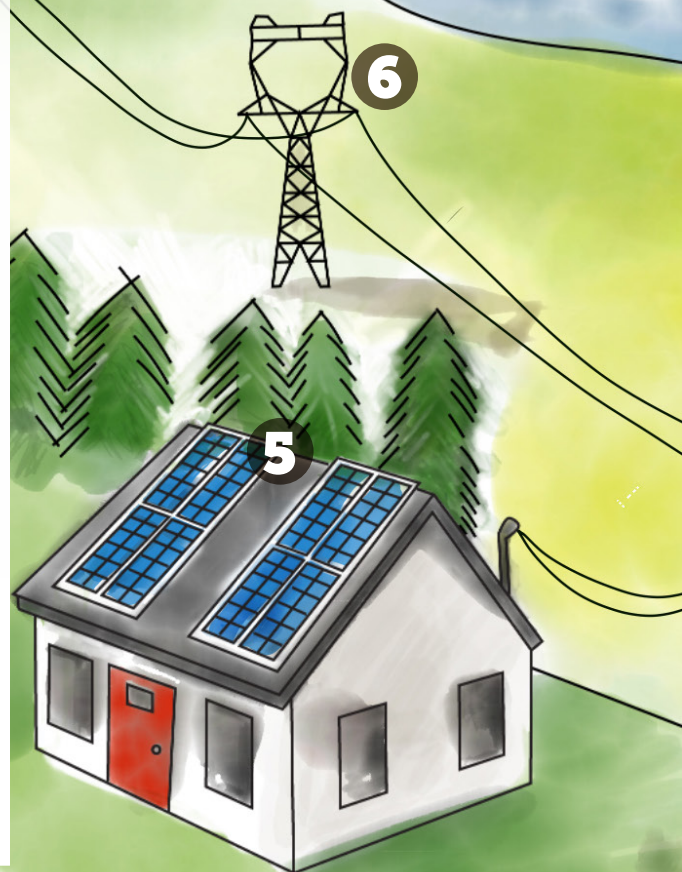
Water droplets return to earth as rain, snow, sleet or hail and the water cycle begins again.

CONDENSATION

EVAPORATION

PRECIPITATION

TRANSPIRATION



FROM NATURE TO YOUR HOME

The flowing river spins turbines at hydropower projects **3** to generate low-cost, reliable, carbon-free electricity. This provides flexibility to provide power when you need it and helps balance the variability of when wind **4** and solar **5** power are available. Some hydropower projects also support

boat transportation, irrigation, recreation, and water supply for our communities. High voltage transmission lines **6** carry electricity to substations **7** where the voltage is reduced. Smaller power lines **8** carry electricity to where we use it.

We're always on the move because electricity can't be stored on the power grid. The flow of electricity across thousands of miles of power lines never stops.

And because wind and solar power aren't always available due to weather, our renewable energy team relies on hydropower to keep the electricity flowing. Together, we deliver!!

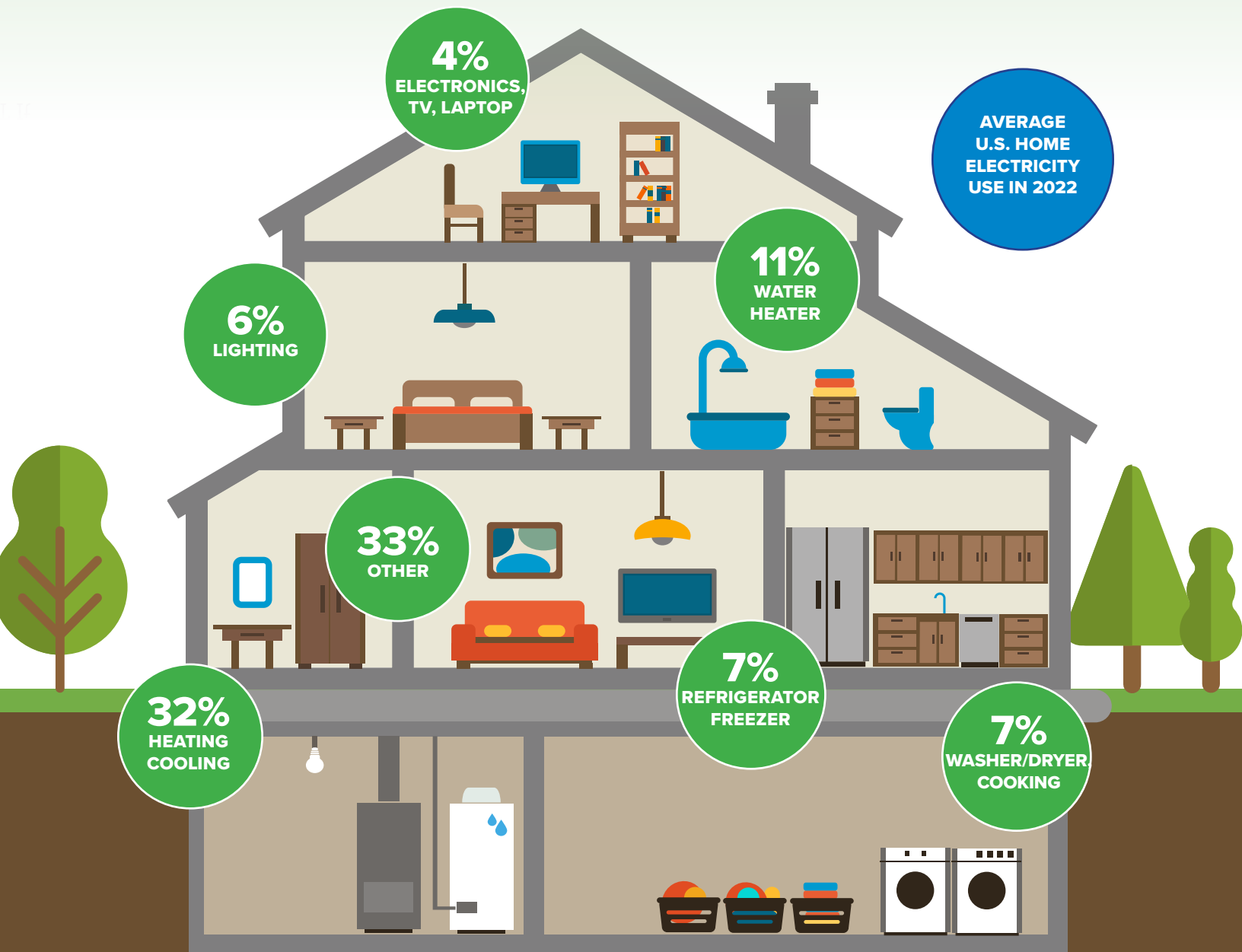


BE POWER WISE

Conservation is another way to support a carbon-free electricity future. When we use less power, fewer power plants are needed to meet our electricity needs.

Electricity conservation is a priority in the Northwest to meet growing demand. We now save enough electricity each year to meet the power needs of five cities the size of Seattle. Thanks to these savings, the Northwest avoids 22 million tons of carbon dioxide emissions going into the atmosphere each year.

Where do we use energy in our homes?



Source: U.S. Energy Information Administration

BE POWER WISE

CHECKLIST

HEY, POWER SQUAD! Meet with your family members and check off the energy conservation tips that you are doing now and others that you plan on doing soon to save energy. A little bit adds up!

Check the things you are doing, or will do, to conserve electricity

**I Do It
Now:
SCORE 2**

**I Will Do
It Soon:
SCORE 1**

Turn off electronics and other devices

When leaving a room, turn off TV, computer, lights, video games and other electronics

Unplug chargers when finished charging

Heating less water equals using the water heater less

Wait to run the dishwasher until it's full

Take shorter showers

Talk to my family about using low-flow shower heads

Help keep the heat in when it's cold outside, and the cool air in when it's hot outside

Keep doors closed to keep warm air in during cold weather, and cool air in during hot weather

Close curtains or blinds to keep sun out during hot weather and retain warmth indoors during cold weather

When it's time for new lights, appliances, air conditioning or heating systems

Talk to your family about using LED energy-efficient light bulbs

Show your family the EnergyStar logo and talk about what it means for conserving electricity, learn more at energystar.gov

Tally your scores for each column

ADD UP YOUR SCORES FOR YOUR POWER SAVER TOTAL!

+

Using less power adds up to protecting the environment.

Conservation (like turning the lights off when not using them) and efficiency (like converting from incandescent light bulbs to LED lights) makes it happen.

Thanks to these actions, the Northwest avoids more carbon dioxide emissions than what 4 million cars would produce air each year.

Are you in the Power Saver Squad?
Draw us your super suit!



YOUR POWER SAVER SCORE:

Power Hero: 16 - 18

Power Star: 11 - 15

Power Lifter: 6 - 10

Power Starter: 0 - 5

TOTAL

Generating Electricity from Hydropower

What:

Hydropower harnesses the force of falling water to generate electricity.

Power Generation:

The falling water forces a turbine to turn. A generator produces electricity.

POWER UP

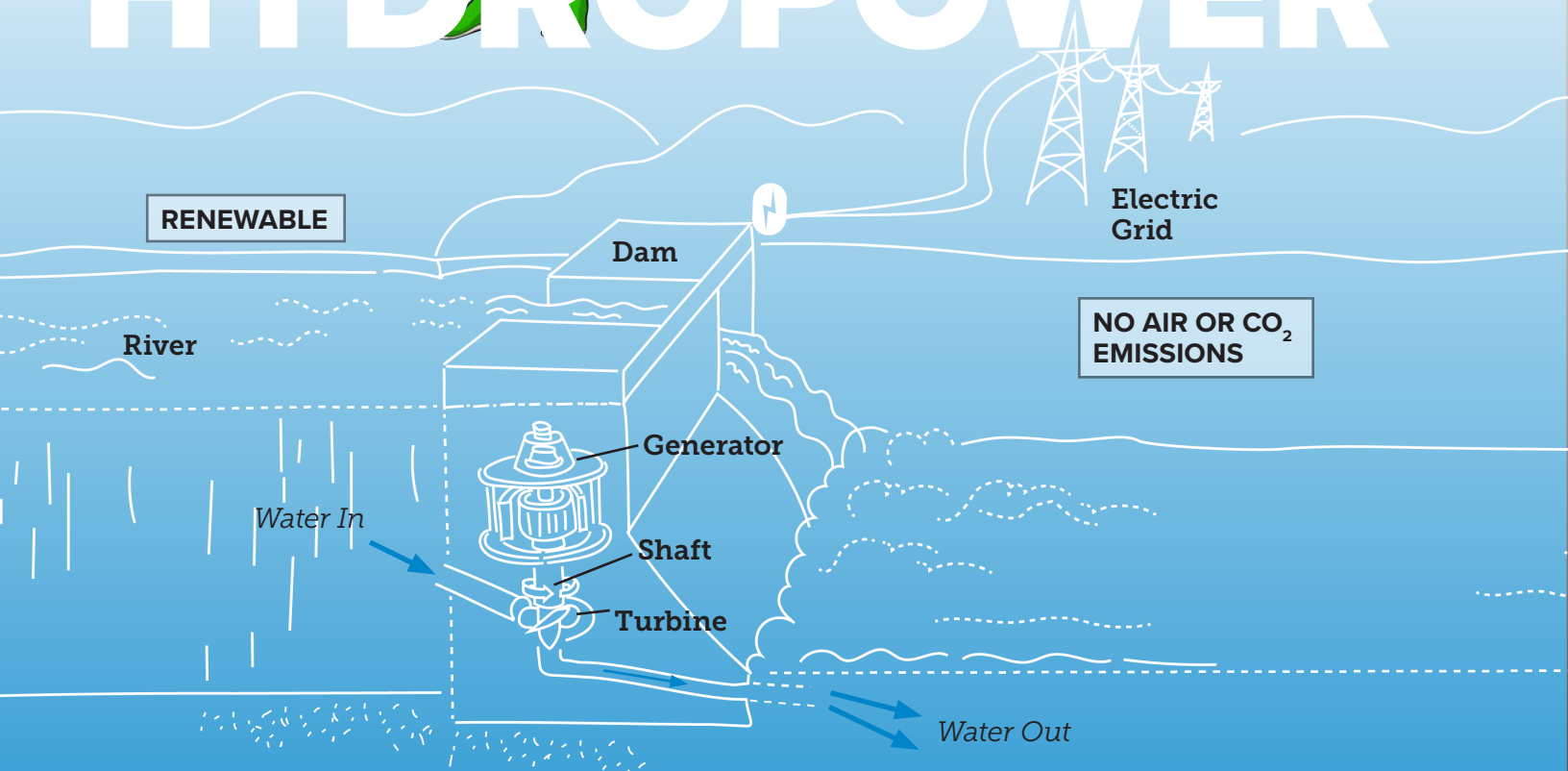
*We're Number 1!
Over half of the
Northwest's electricity
comes from renewable,
carbon-free hydropower.*



Key Features:

- Hydropower is a **renewable resource** that depends on the water cycle to replenish our rivers from snow and rain every year.
- Hydropower projects often include a dam to help control the flow of water.
- Hydropower **produces no carbon dioxide (CO₂) emissions** or waste products that contribute to air pollution or climate change.
- Storage projects operate with a reservoir that stores water for use when electricity demand is high. Run-of-the-river projects operate with minimal or no water storage. **Collectively, they provide a reliable source of energy year-round.**
- Projects with dams often include **technologies to support upstream and downstream fish passage.**

HYDROPOWER



Generating Electricity from Natural Gas

What:

Natural gas is a **fossil fuel** that is burned to generate electricity. Like coal and oil, natural gas is a product of decomposed organic matter deposited millions of years ago. It is colorless, odorless, and composed primarily of methane gas. It is most often extracted by drilling vertically from the earth's surface.

Power Generation:

All natural gas plants use a gas turbine. Natural gas along with a stream of air is combined to create combustion. Heat from the burning gas causes the turbine to rotate. A generator produces electricity.

FORCE FACT

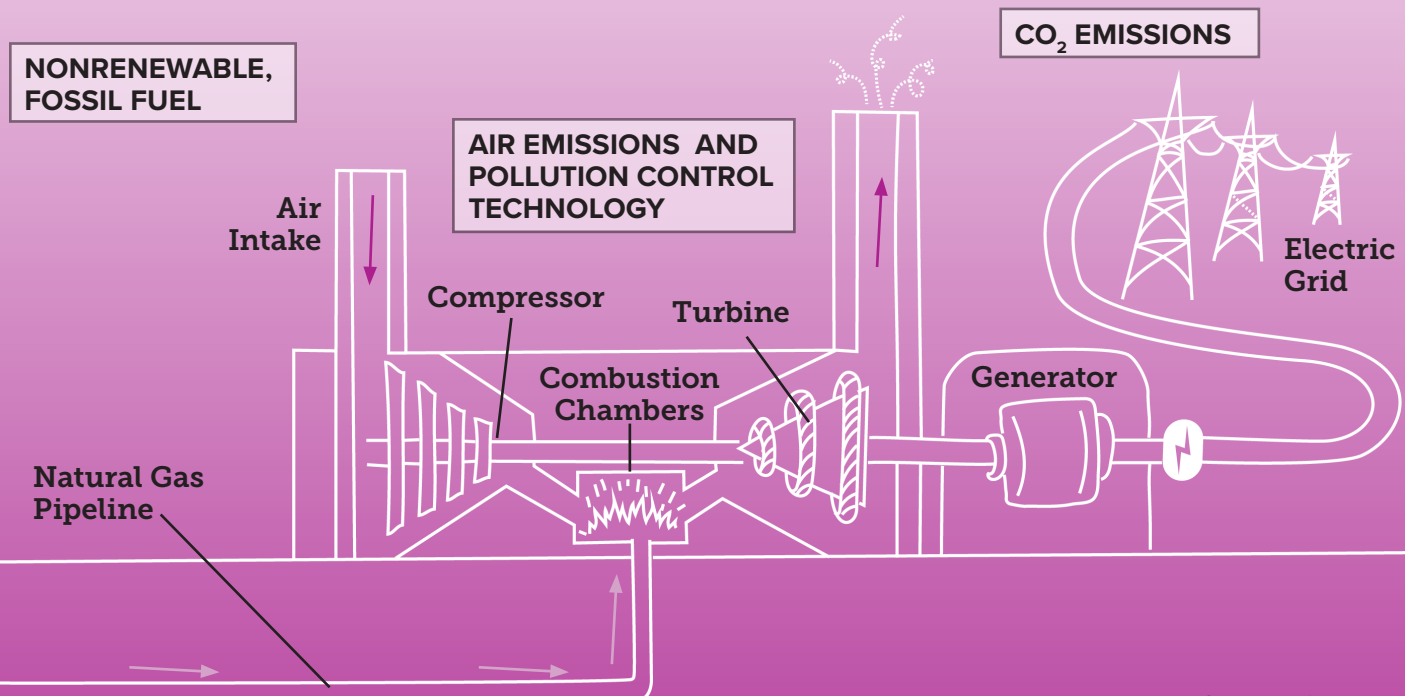
15% of the Northwest's ability to generate electricity comes from natural gas. To meet 100% carbon-free electric generation goals, fossil fuel power plants like these will need to be retired.



Key Features:

- Like all **fossil fuels**, natural gas is a **nonrenewable** resource.
- Pipelines are used to transport natural gas **reliably and continuously** to power plants.
- Natural gas power plants are a **large source of carbon dioxide (CO₂) emissions**, a greenhouse gas. They emit about half the CO₂ emissions of coal plants.
- The process of **extracting** natural gas contributes methane **air emissions** (another greenhouse gas).
- **Air emissions** from burning natural gas at power plants require technologies to meet air quality standards.

NATURAL GAS



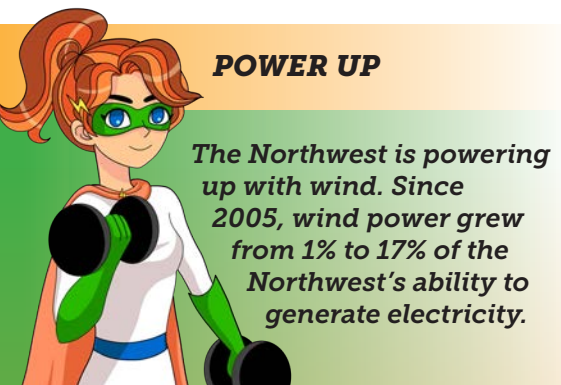
Generating Electricity from Wind

What:

Wind power harnesses the force of moving air to generate electricity.

Power Generation:

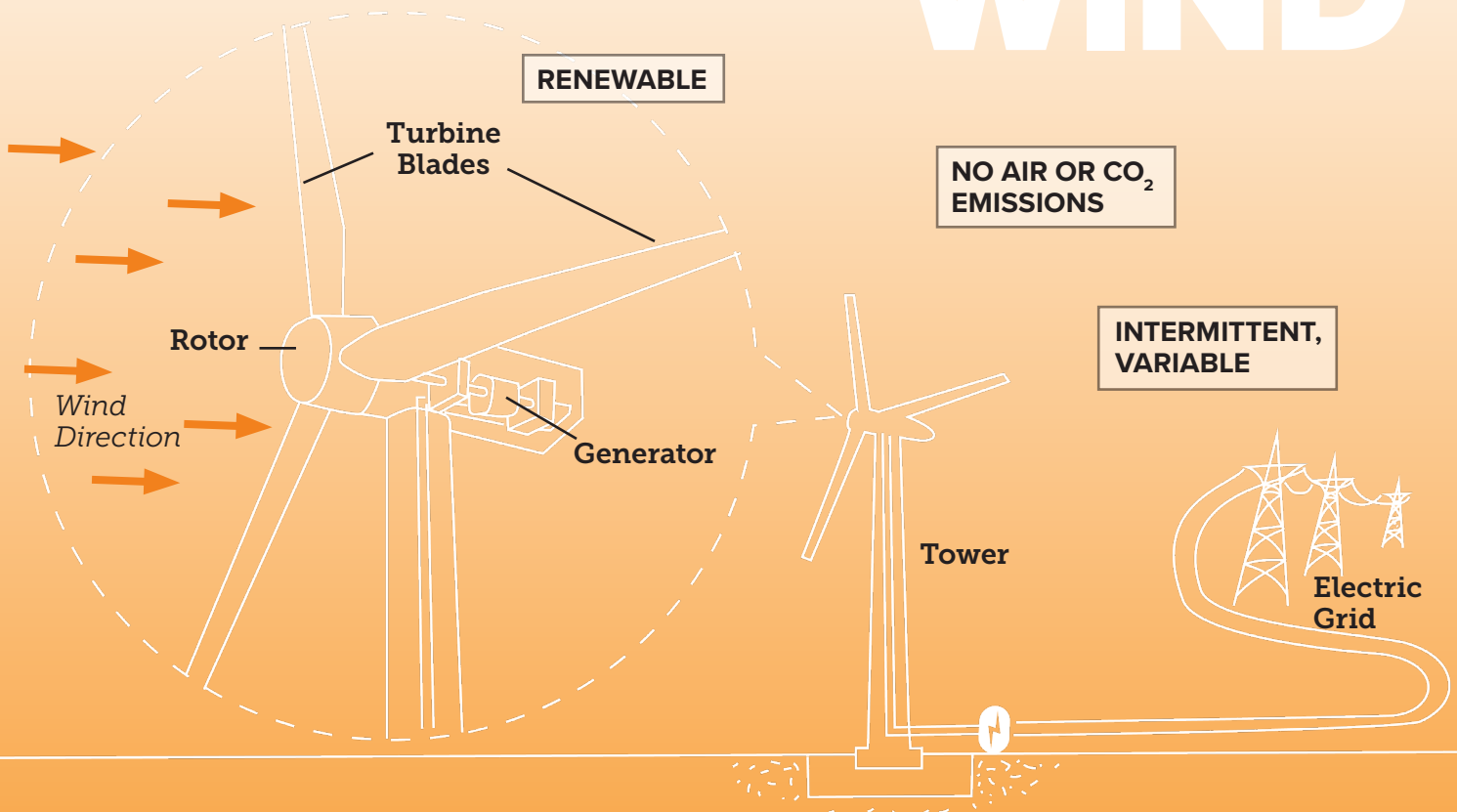
The force of wind against blades turns a rotor. As the rotor spins, it connects to the generator to produce electricity.



Key Features:

- Wind power is a **renewable** resource.
- This energy source **does not produce carbon dioxide (CO₂)** or other greenhouse gas emissions that contribute to climate change.
- Because wind power can only generate electricity when the wind is blowing, it's most effective in regions with strong and regular wind currents. Wind farms have only a limited ability to store power generated by using batteries. This makes wind a **less reliable power** source because its availability is **intermittent and variable**.
- Wind power farms include several towers with turbines that, together, supply electricity to the power grid. These farms take up large areas of open-space land, making avian mortality (the death of birds), a concern.

WIND



Generating Electricity from Coal

What:

Coal is a **fossil fuel** originally formed from prehistoric vegetation that accumulated in swamps millions of years ago. This was before dinosaurs roamed the earth. Looking like a shiny black rock, coal is a fossil fuel that comes from plants that were once alive. Coal formation begins with photosynthesis, the process that enables living plants to store solar energy. When plants die, energy is usually released as the plants decay. Coal forms when the decaying process is interrupted, and the stored solar energy is locked into the coal. Coal is extracted from the earth either by surface or underground mining.

FORCE FACT

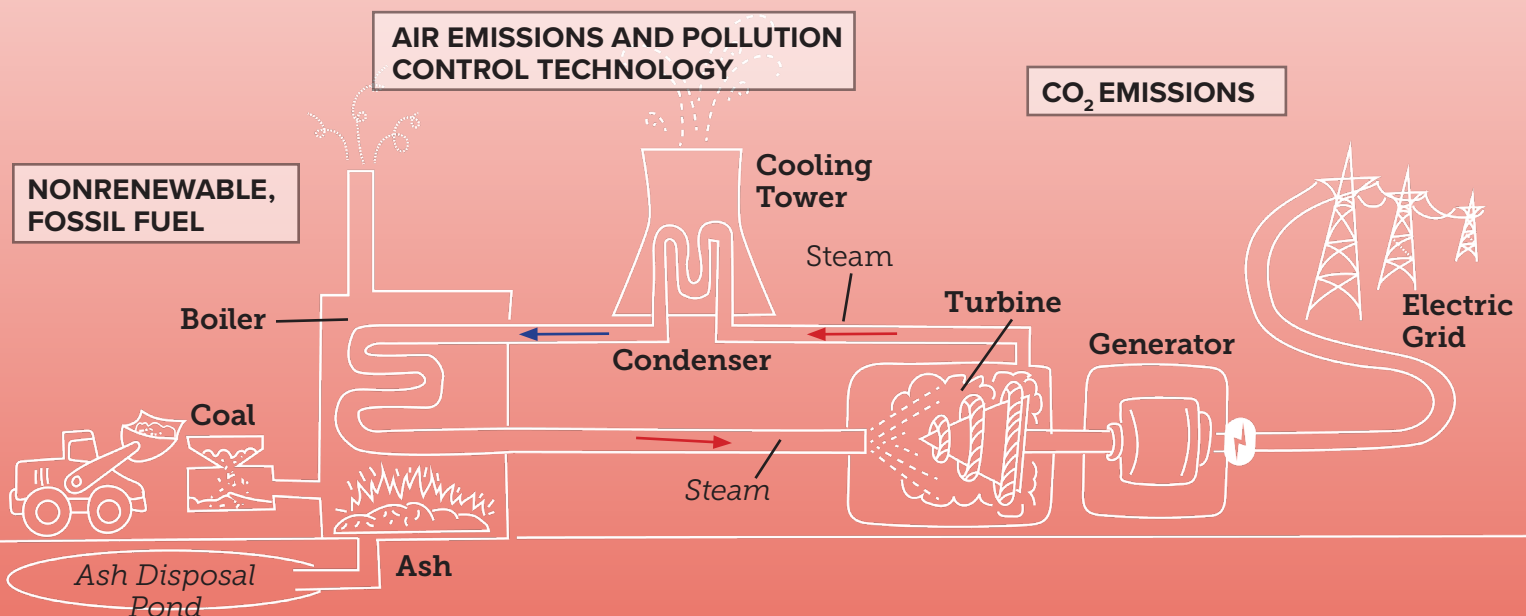
Seven coal power plants in the Northwest are being retired between 2020 and 2030.



Key Features:

- Like all fossil fuels, coal is a **nonrenewable** resource.
- It can be stored at power plants to provide a reliable, year-round source of electricity.
- Coal plants are a **large source of carbon dioxide (CO₂) emissions**. In 2022, coal accounted for 55% of CO₂ emissions from electric power generation.
- Challenges of burning coal include **meeting air quality standards from emissions** and disposing of **ash** that is a by-product of burning coal.

COAL



Generating Electricity from Nuclear

What:

Nuclear power plants use uranium as their fuel source. Uranium is found in rocks. Starting with surface or underground mining, a complex process is used to extract uranium ore from the rocks. Once extracted, the uranium is enriched and formed into small ceramic fuel pellets that are stacked and sealed in fuel rods. These are bundled together to make up a fuel assembly at a nuclear power plant.

Power Generation:

Nuclear fission is used to heat water by enabling atoms to split apart to form smaller atoms, releasing energy in the plant's reactor. The resulting high-pressure steam forces the turbine to turn. A generator produces electricity. The condenser converts steam from a gaseous to a liquid state (water).

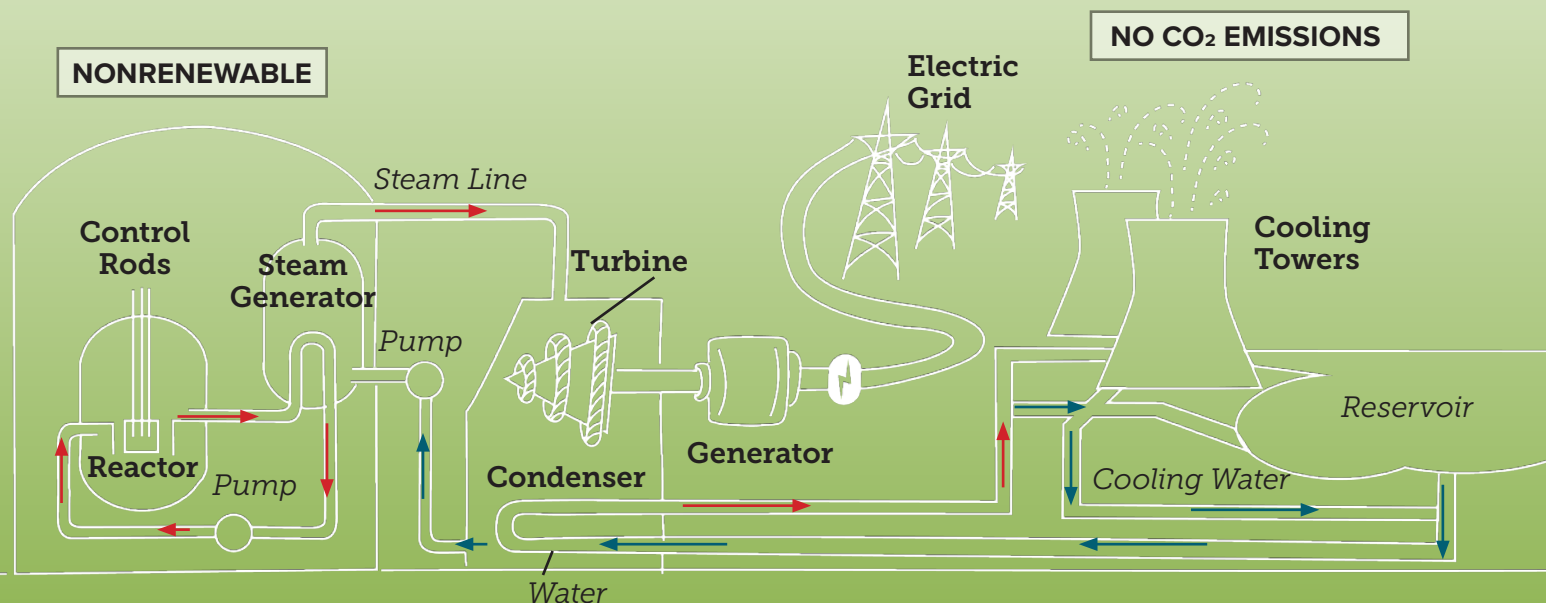
Hanford, Washington is the site of the only operating nuclear power plant in the Northwest.



Key Features:

- Nuclear energy is a **nonrenewable** resource that relies on mining a very rare type of uranium, U-235.
- The fuel rods with uranium are **stored at power plants to provide a reliable, year-round** source of electricity.
- Nuclear reactors **do not produce carbon dioxide (CO₂) emissions** or contribute to air pollution.
- Nuclear power creates **radioactive wastes** that must be safely stored. These wastes can remain radioactive for thousands of years and present a danger to human health if accidentally released to the environment. In addition, an uncontrolled nuclear reaction at the power plant could cause widespread contamination of air and water.

NUCLEAR



Generating Electricity from Solar

What:

Solar power converts energy from sunlight into electricity.

Power Generation:

Homes, businesses, and many solar farms use photovoltaic (PV) cells to generate electricity. A PV cell absorbs photons from sunlight and converts it to electricity with semiconductor material, usually silicon (the main component of natural beach sand).

Power not used by solar panels on homes and businesses can be put back on the power grid and distributed to others.



FORCE FACT

In 2019, just 2% of the Northwest's ability to generate electricity came from solar power.

Key Features:

- Solar power is a **renewable resource**.
- Solar generation **does not produce carbon dioxide (CO₂)** or other greenhouse gas emissions that contribute to climate change.
- Because solar power can only generate electricity based on available sunshine, it's most effective in regions with abundant sunlight. Solar farms have a limited ability to store power generated by using batteries. This makes solar a **less reliable power source** because its **availability is intermittent and variable**.
- Solar farms take up large areas of open space land.

SOLAR

RENEWABLE

INTERMITTENT,
VARIABLE

NO AIR OR CO₂
EMISSIONS

Solar
Collectors

On-Grid
Inverter

Electric
Grid

Transformer

Direct Current

Alternating Current

Solar Farm

Generating Electricity from Geothermal

What:

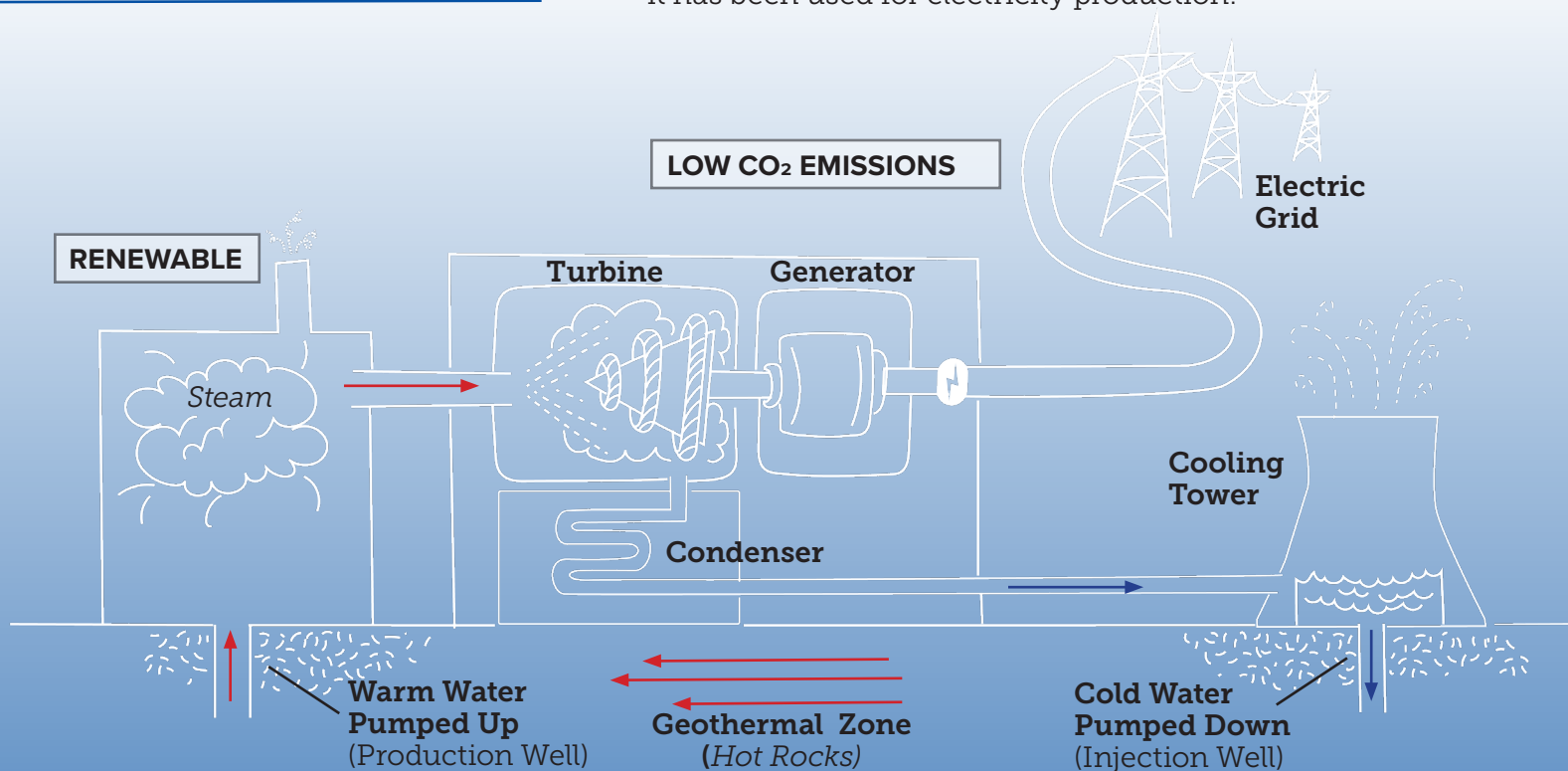
Geothermal energy originates from heat in the subsurface of the earth. Water and/or steam carry the geothermal energy to the surface.

Power Generation:

High-pressure steam produced from underground heat forces the turbine to turn. A generator produces electricity. The condenser converts steam from a gaseous to a liquid state (water).

Key Features:

- Geothermal energy is a **renewable resource** that is naturally replenished.
- This energy source is **reliably available** year-round.
- For electricity generation, locations with high or medium temperature resources from the subsurface are needed. These locations are often near volcanically active areas.
- Geothermal plants are a **small source of carbon dioxide (CO₂) emissions**, emitting about 5% of the carbon dioxide of an equally sized coal plant, and certain types produce near-zero emissions.
- The hot water pumped from underground is usually pumped directly back into the geothermal reservoir after it has been used for electricity production.



GEO THERMAL

Generating Electricity from Biomass

What:

Biomass is any organic material like trees, chipped wood, agricultural or food waste, and animal manure. It also includes burning trash as part of a city or town's solid waste disposal system.

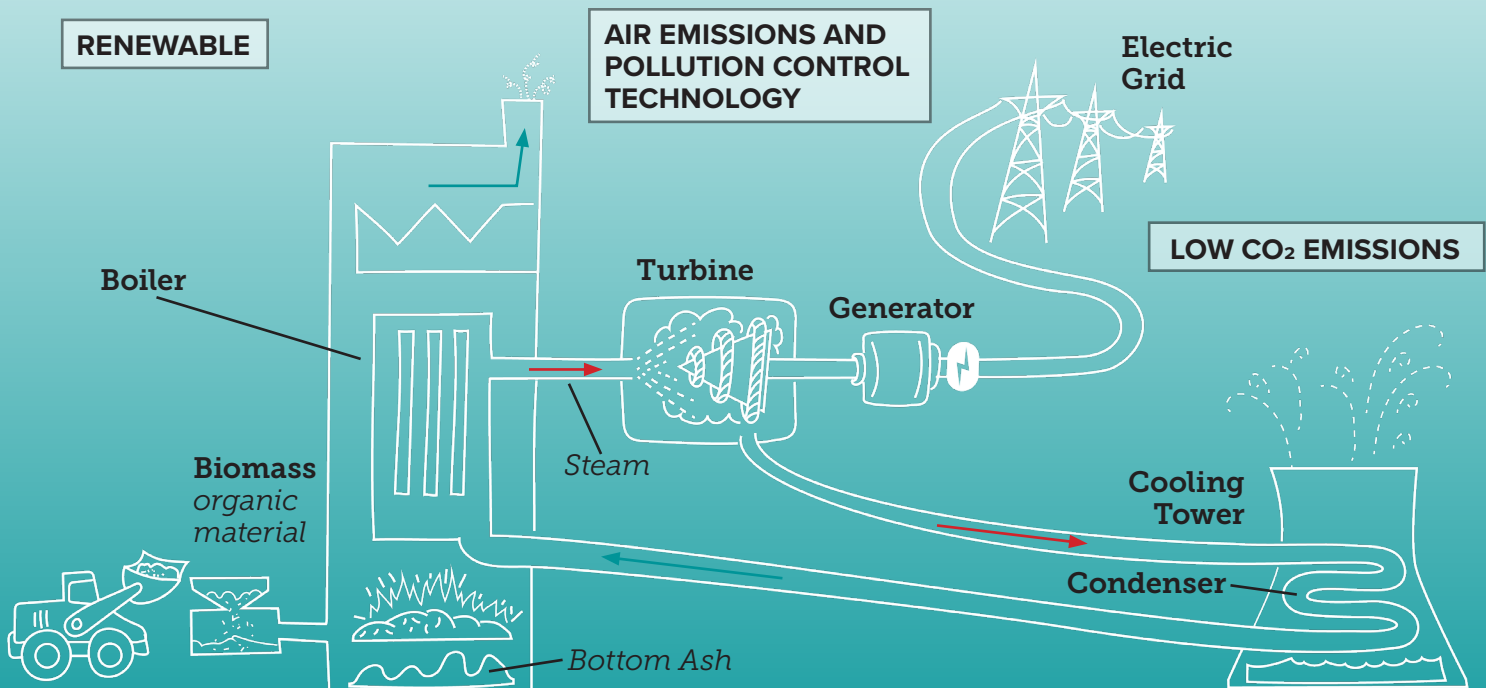
Power Generation:

Biomass power plants burn organic materials and trash to boil water. The resulting high-pressure steam forces the turbine to turn. A generator produces electricity. The condenser converts steam from a gaseous to a liquid state (water).

Key Features:

- Biomass is a **renewable** resource because organic material like wood and crops can be grown again and humans continuously create trash.
- Power plants are located where biomass is **reliably available**.
- The plants grown for biomass energy capture CO_2 through photosynthesis, making it a **small source of carbon dioxide (CO_2)**.
- Burning biomass can create ash that must be safely disposed and **air emission pollutants requiring technology** to meet clean air standards.

BIOMASS



Generating Power from Hydrogen

What:

Hydrogen can be used in a fuel cell to produce electricity for use in cars, in houses, for portable power, and in many industrial applications. Fuel cells can also provide electricity to the power grid when it most needs it and supply emergency power backup.

Power Generation:

A common way to produce hydrogen is through electrolysis, a process that separates water into oxygen and hydrogen. The hydrogen can then be used in a fuel cell to produce electricity.

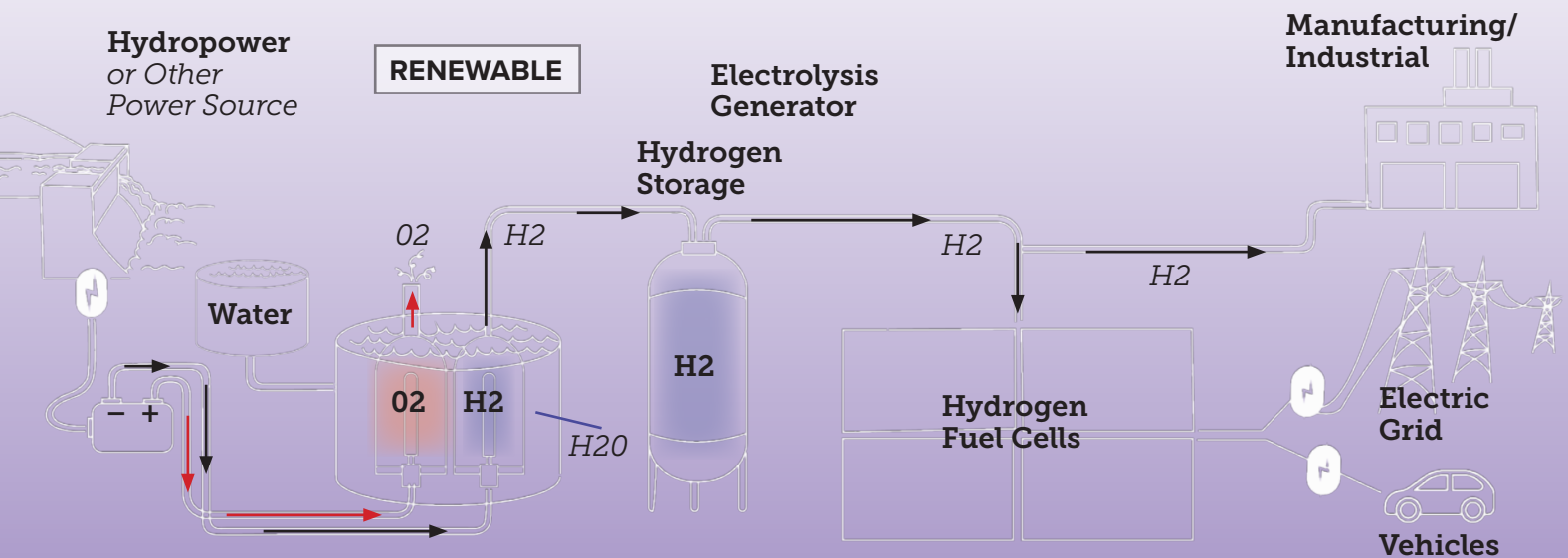
Key Features:

- Hydrogen is a **clean fuel** that, when consumed in a fuel cell, produces only water.
- Fuel cells produce **no carbon dioxide (CO₂)** or other greenhouse gas emissions that contribute to air pollution or climate change.
- Producing hydrogen is an energy intensive process that often uses natural gas. **Green hydrogen** means only renewable or other carbon-free energy such as hydropower is used, thus avoiding any contribution to climate change.
- Hydrogen is the lightest and most abundant element in the universe. On Earth it tends to bond with other elements, often forming hydrocarbons and water.



FORCE FACT

1 kg of hydrogen has the same energy potential as 1 gallon of gasoline, but weighs 1/3 as much.



HYDROGEN

COMPARE SOURCES OF ELECTRICITY

Electricity can be generated from many different energy sources.

From the electricity source descriptions, place an "X" in all the boxes that describe each energy source.

		Hydropower	Natural Gas	Wind	Coal	Nuclear	Solar	Geothermal	Biomass	Hydrogen Fuel Cell
Is it renewable?	This is a renewable source of energy.									
	This is a non-renewable source of energy.									
Is it carbon free?	It is a fossil fuel that is a large source of carbon dioxide (CO ₂) emissions (a greenhouse gas) released into the atmosphere and thus contributes to climate change.									
	It is a small source of carbon dioxide (CO ₂) emissions (a greenhouse gas) released into the atmosphere and is not a significant contributor to climate change.									
	It releases no air emissions that contribute carbon dioxide (CO ₂) or other greenhouse gas emissions and does not contribute to climate change.									
Is it available and reliable?	It is a fossil fuel source extracted from the earth and continuously available to meet the on-demand energy supply needs of power plants.									
	It relies on the availability of the sun or wind to produce power, which is why its called an "intermittent" or "variable" power source.									
	The water storage available behind some dams provides flexibility to meet electricity supply and demand needs.									
	This fuel source is produced from water.									
Challenges	It requires technology to reduce emission of pollutants into the air.									
	It requires safe disposal of ash that can pollute the environment.									
	It requires storage of radioactive wastes that can pollute the environment.									
	It is extracted from the earth through mining and/or drilling.									
	It often requires technologies to support up and downstream fish passage.									
	It requires renewable or other carbon-free energy source to avoid any contribution to climate change.									



FWEE MEMBERS

Sponsorship Level

Bonneville Power Administration
Centralia City Light
Chelan County PUD
Douglas County PUD
Grant County PUD
Inland Power
Okanogan County PUD
Pend Oreille PUD
Seattle City Light
Snohomish County PUD
Tacoma Public Utilities
U.S. Army Corps of Engineers

Contributing Level

Benton PUD
Bureau of Reclamation
Canyon Hydro
Grays Harbor PUD
Kleinschmidt Group
Mason County PUD 1
Mason County PUD 3
North Central Educational Service District
Northwest Hydroelectric Association
Northwest RiverPartners
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Thompson Industries
Worthington Products

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