

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

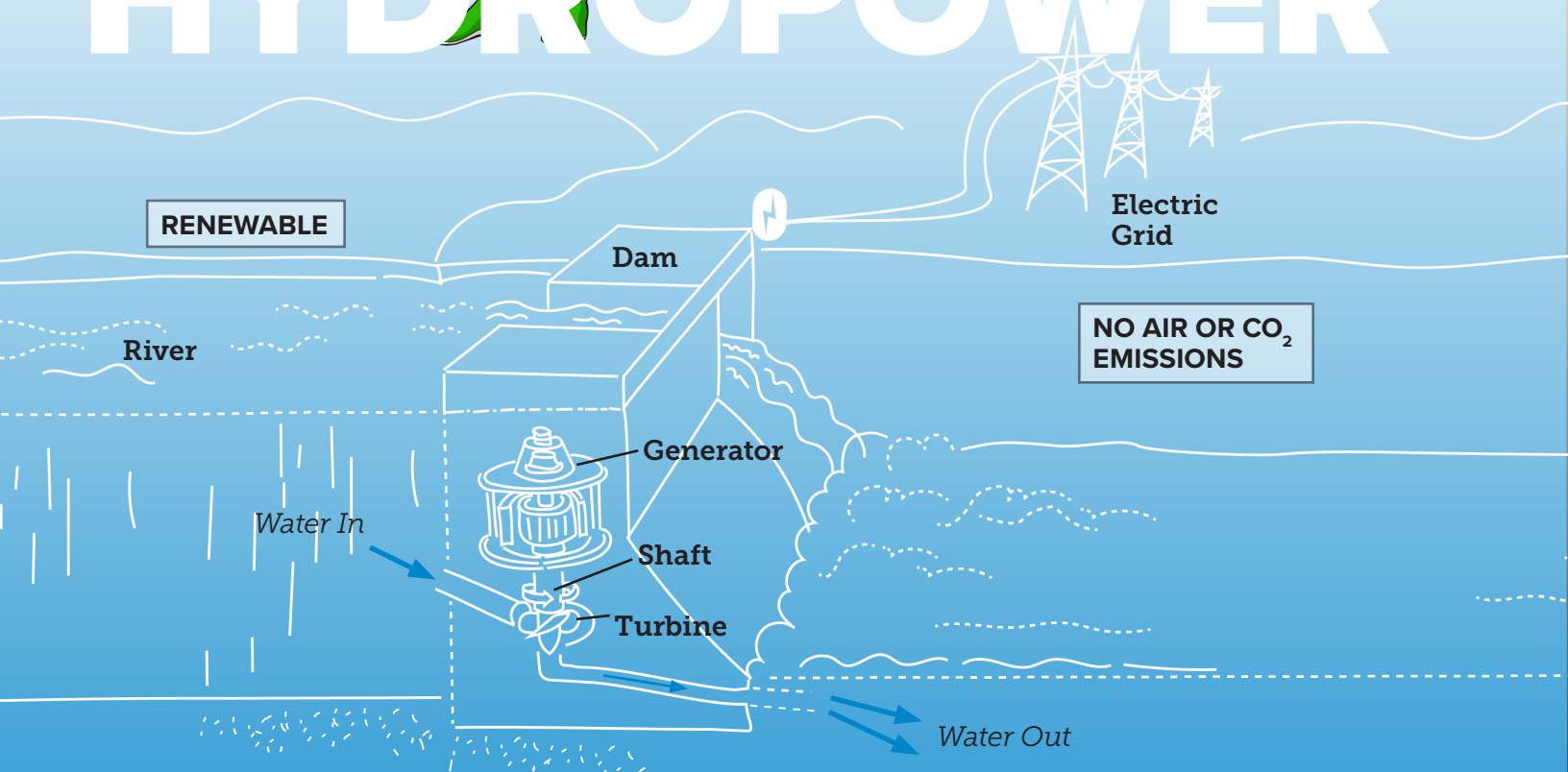
*We're Number 1!
Over half of the Northwest's electricity comes from renewable, carbon-free hydropower.*



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





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.

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.

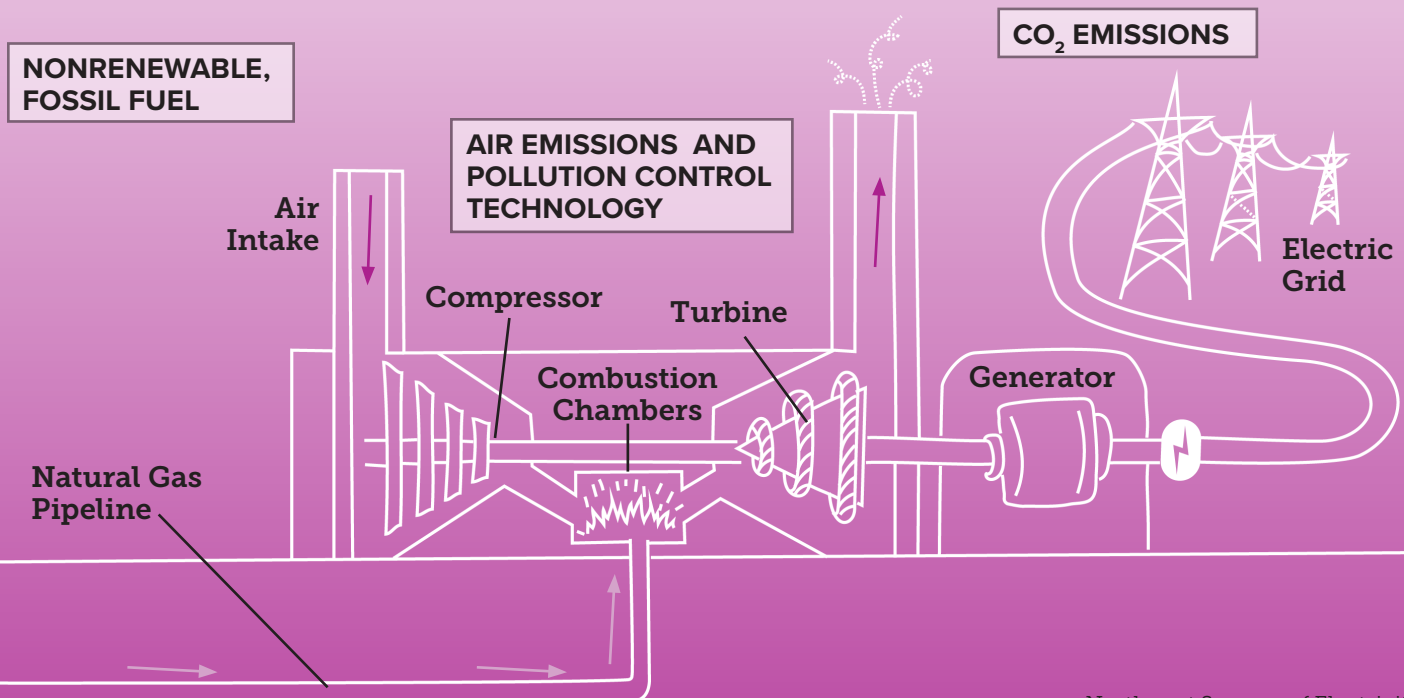
Power Generation:

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.

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.



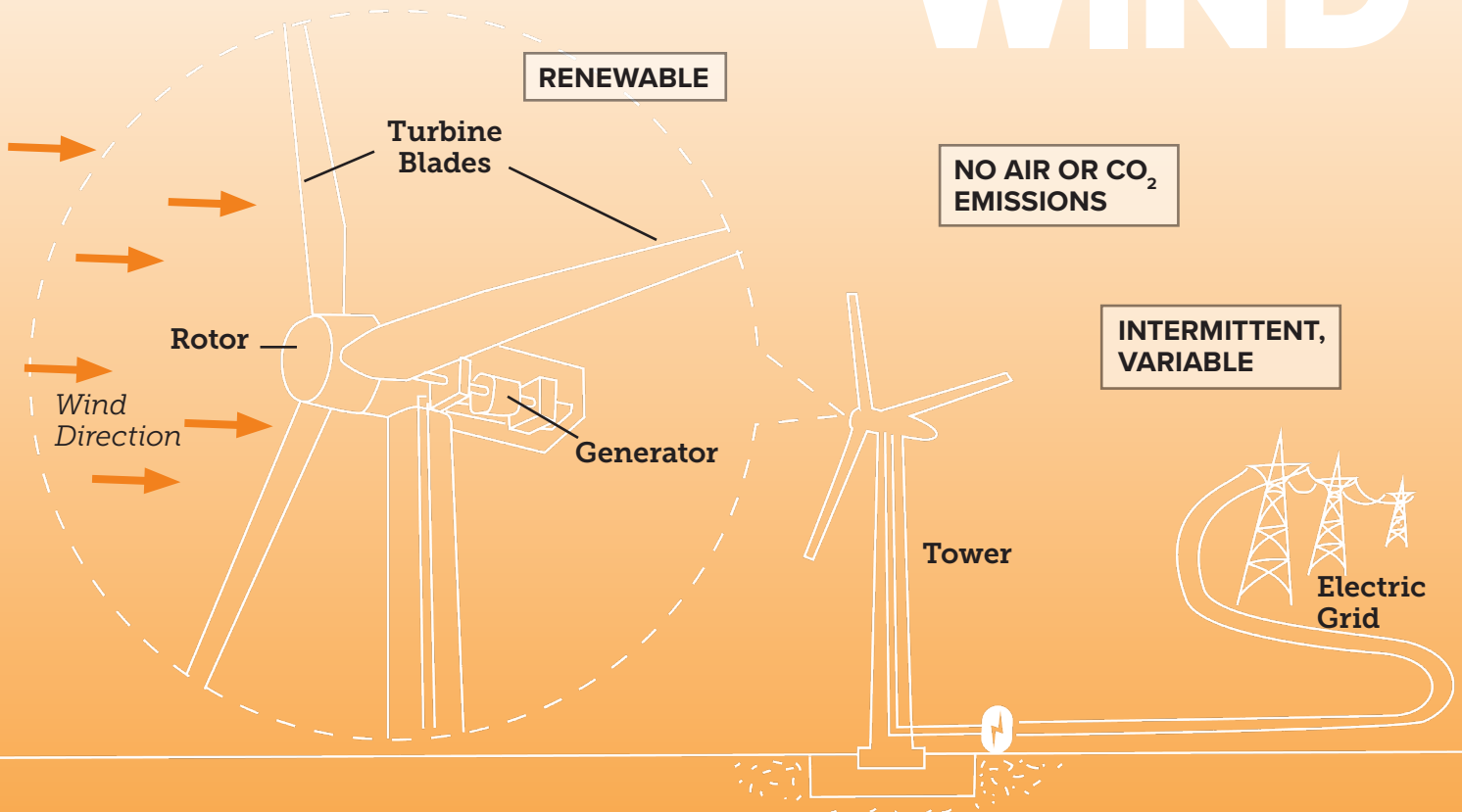
POWER UP

The Northwest is powering up with wind. Since 2005, wind power grew from 1% to 17% of the Northwest's ability to generate 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.



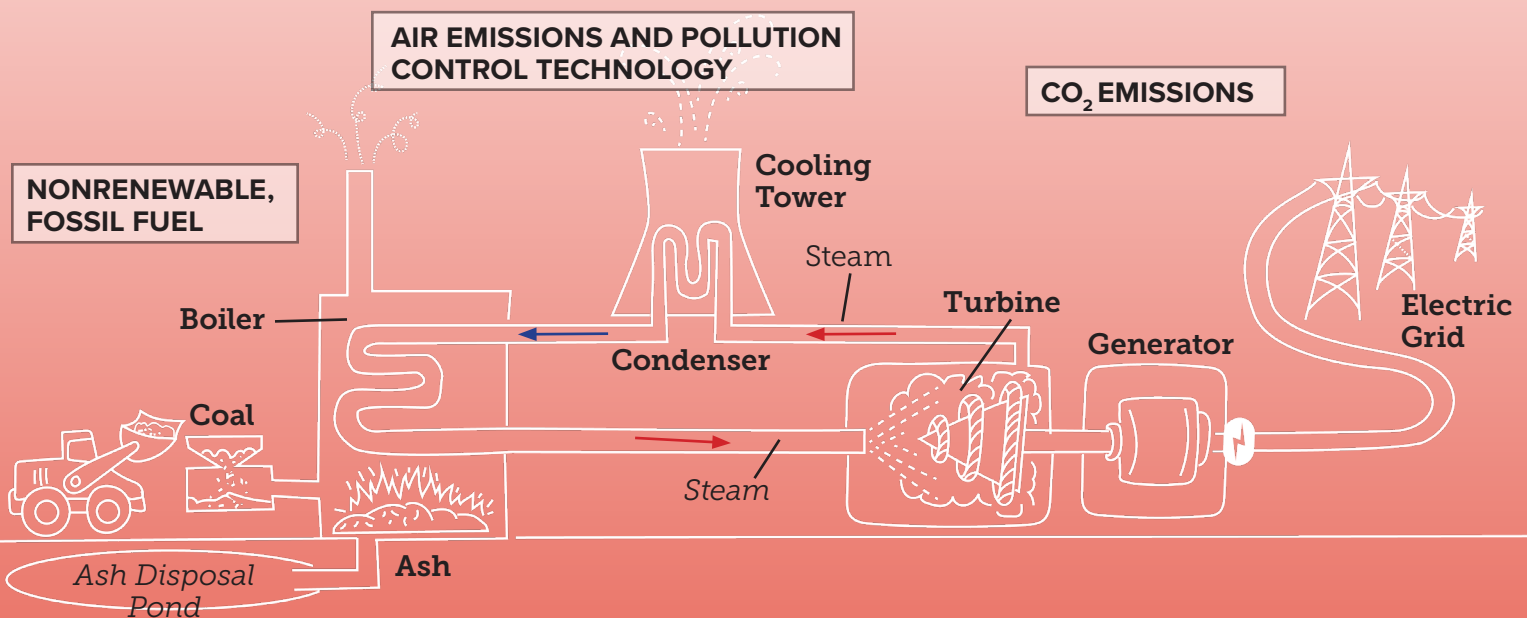
Key Features:

- 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

Power Generation:

Coal is **mined from the earth** and transported, often by freight train, to a generation plant. Here, boilers heat water to produce high-pressure steam that forces the turbine to turn. A generator produces electricity. The condenser converts steam from a gaseous to a liquid state (water).



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).

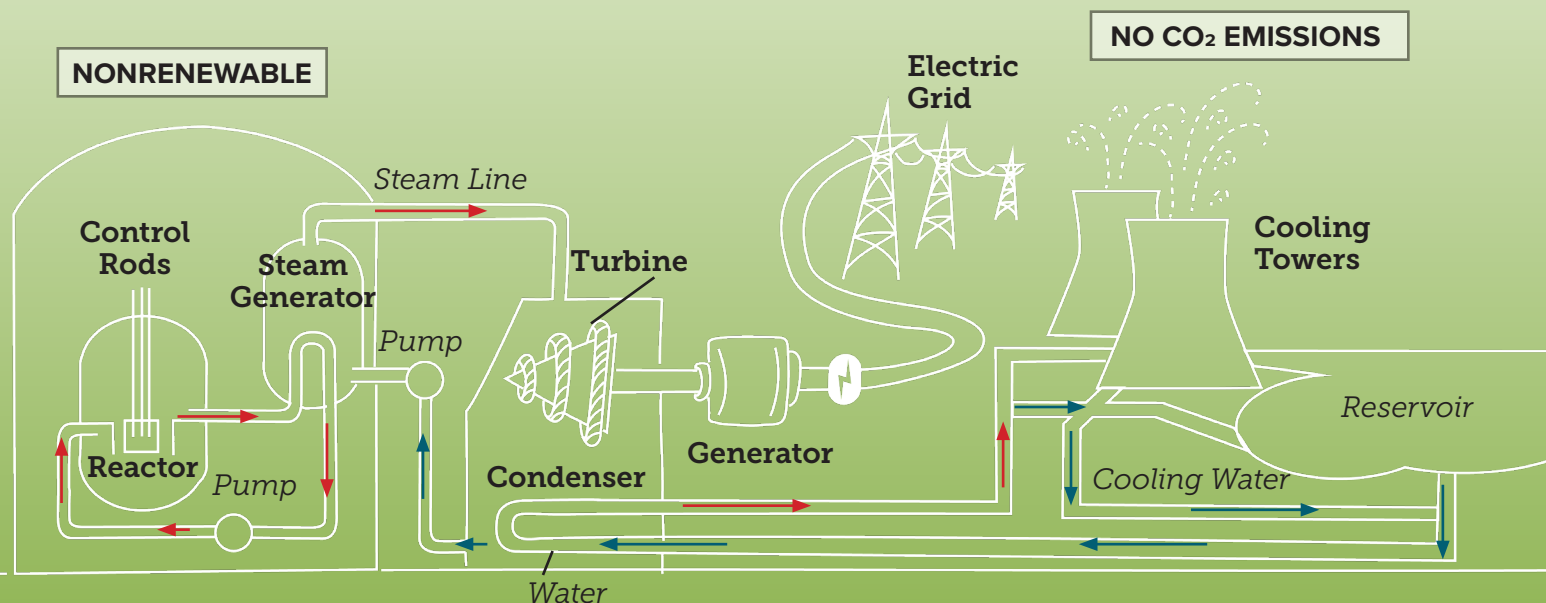
Hanford, Washington is the site of the only operating nuclear power plant in the Northwest.



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.



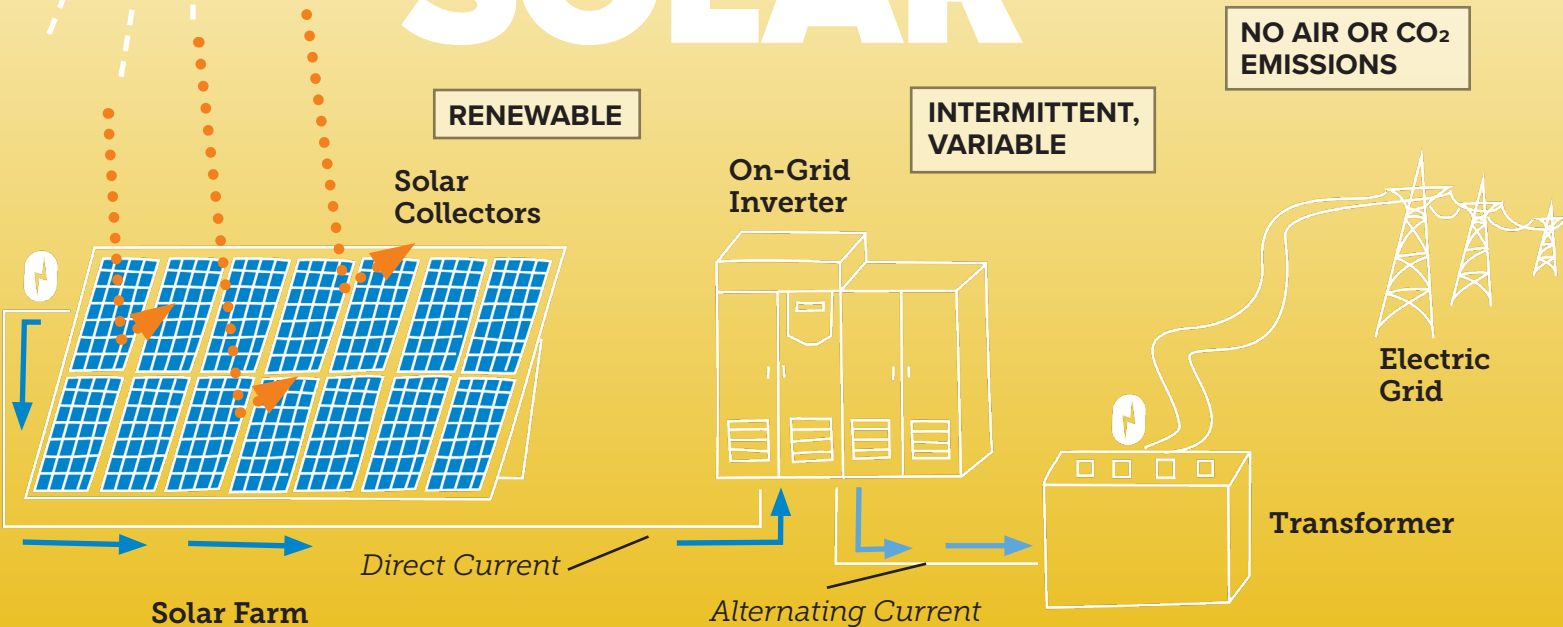
FORCE FACT

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



Generating Electricity from Geothermal

What:

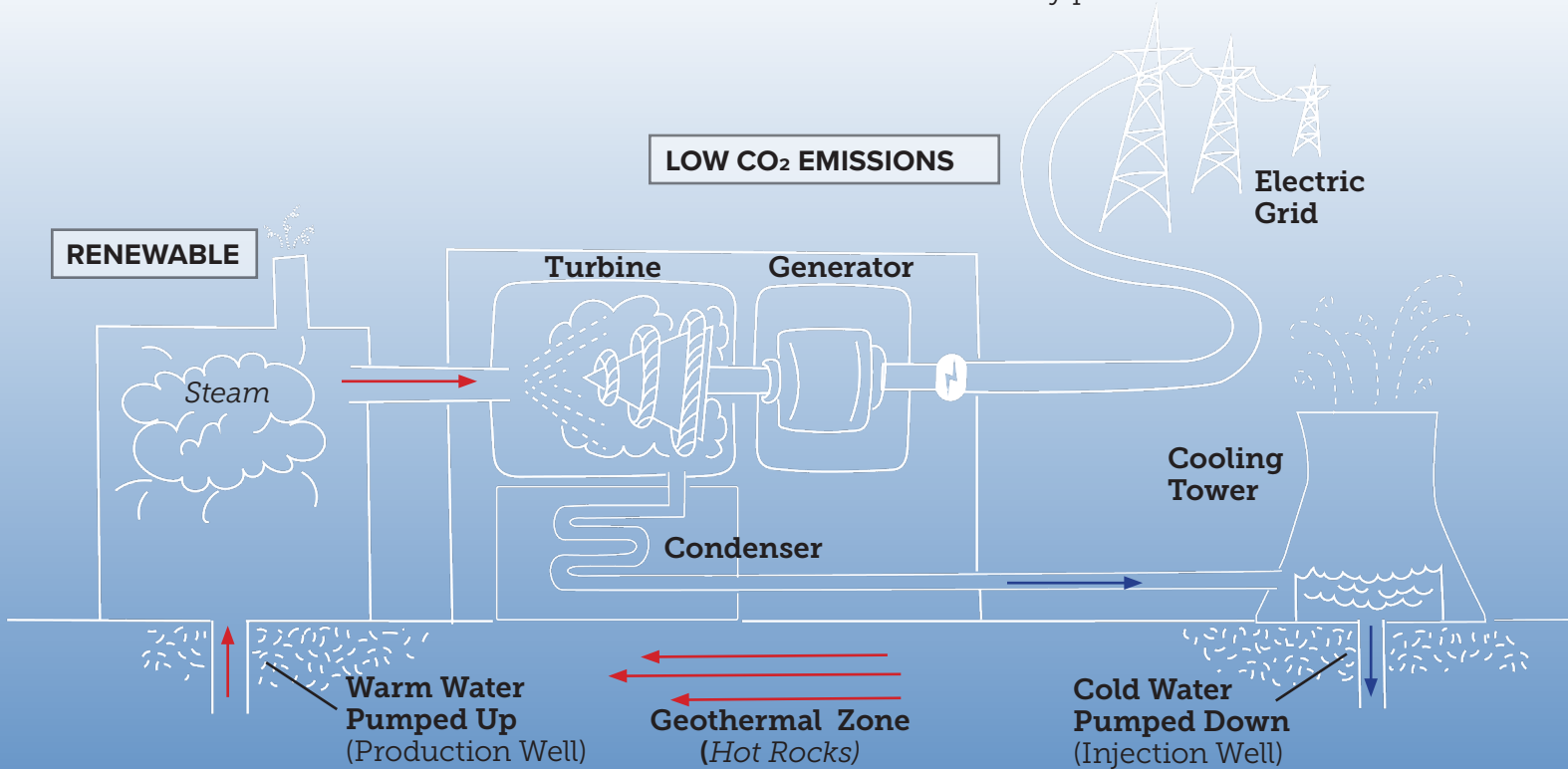
Geothermal energy originates from heat in the subsurface of the earth. Water and/or steam carry the geothermal energy to the surface.

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.

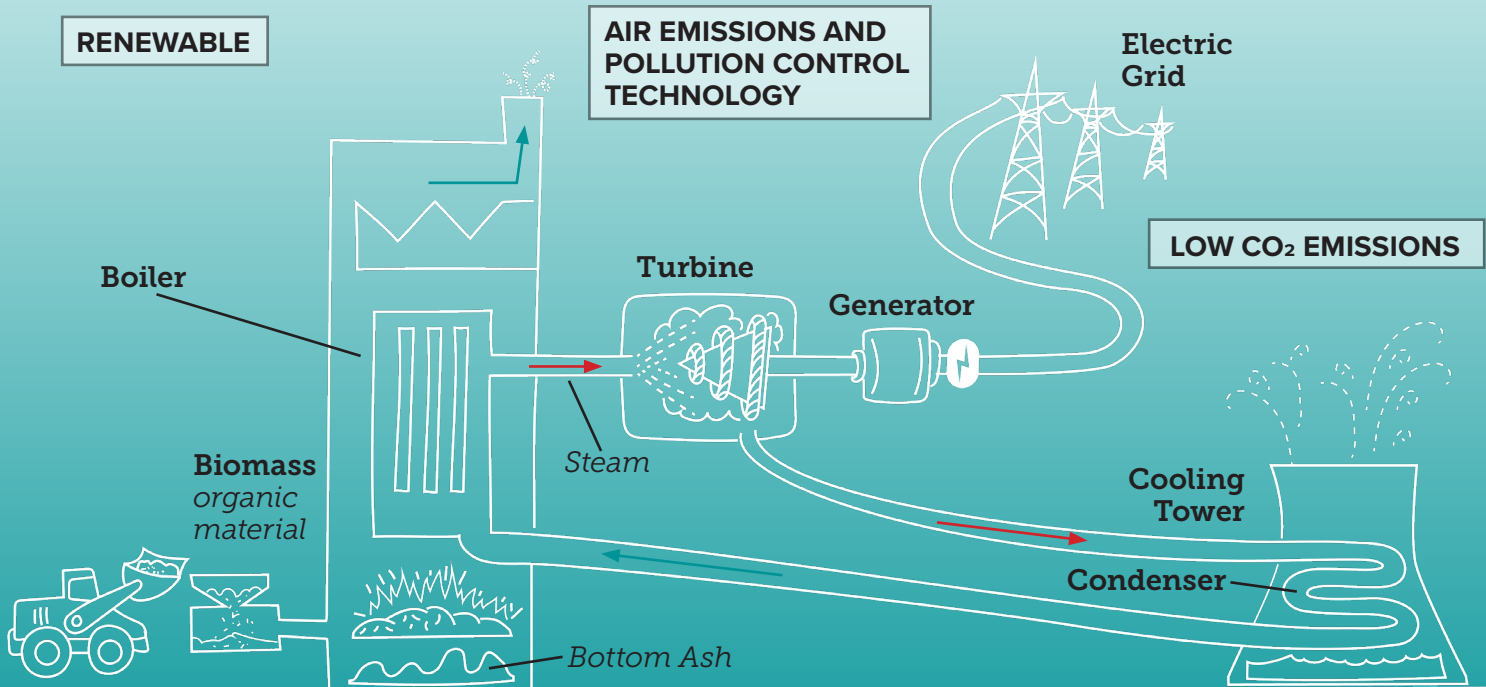
Power Generation:

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 CO₂ through photosynthesis, making it a **small source of carbon dioxide (CO₂)**.
- 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.

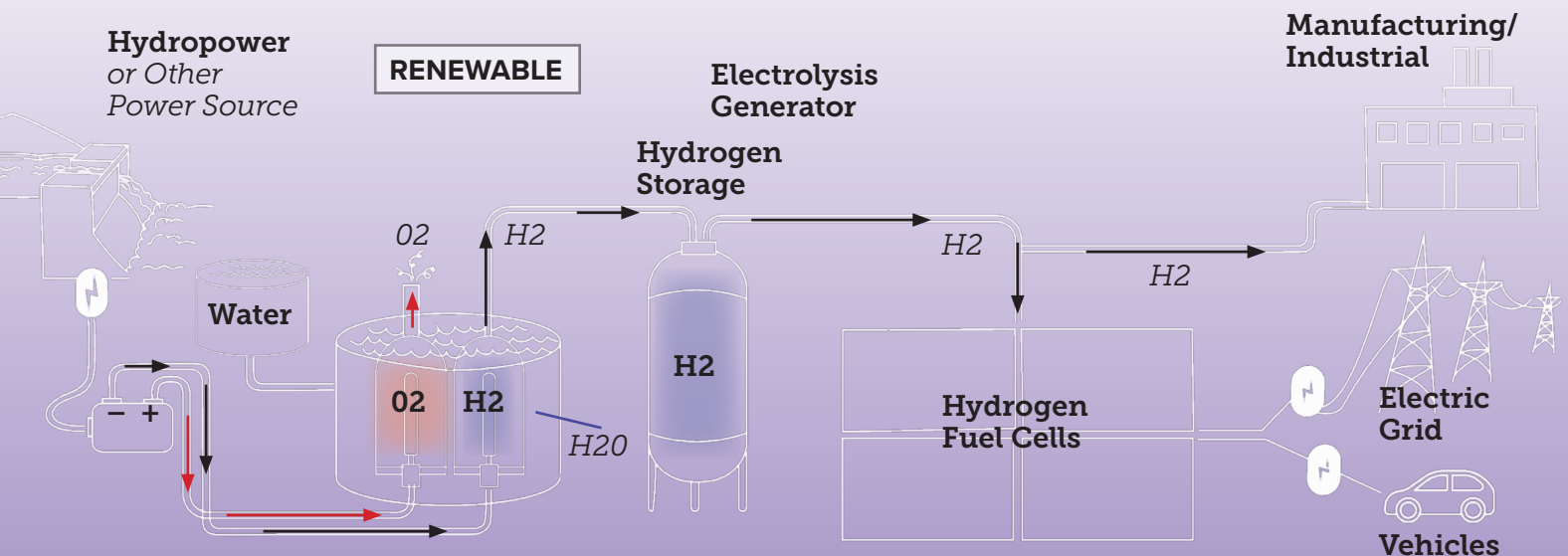
Key Features:

- 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.								