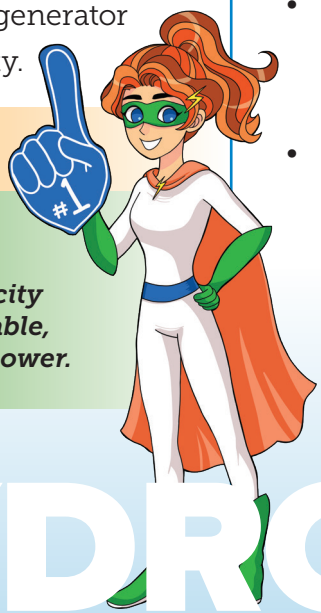
Generating Electricity from Hydropower
Conventional

What:
Hydropower harnesses the force of flowing water, potential energy, to generate electricity.

Power Generation:
The flowing water forces a turbine to turn. A generator produces electricity.

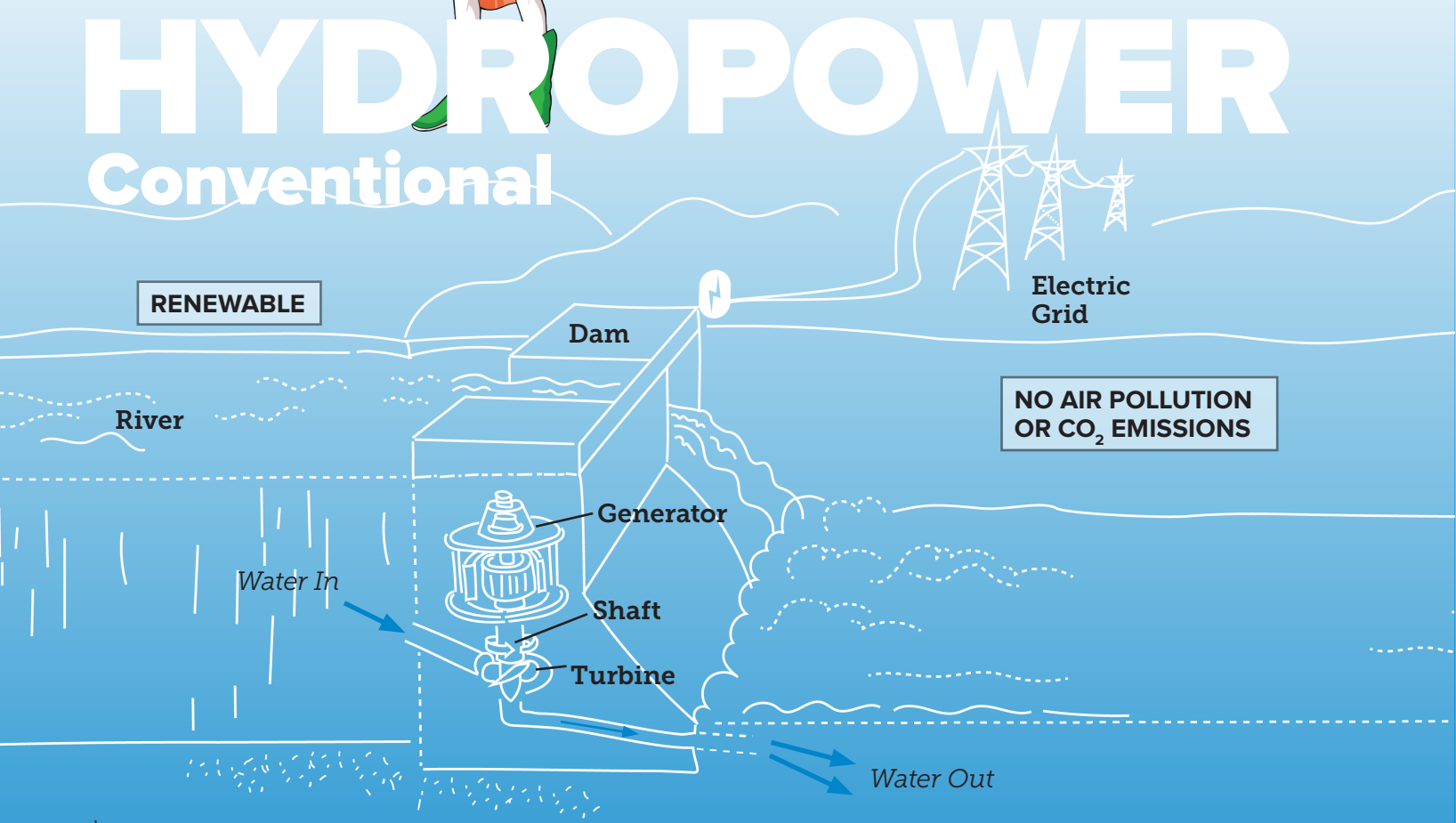
POWER UP

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 (CO_2) 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.**



Generating Electricity from Hydropower

Pumped Storage

What:

Pumped Storage Hydropower works like a giant water battery. Water is pumped from a lower to an upper reservoir when demands for power are low. The water is then released during high demands for power, using the force of falling water to generate electricity.

Power Generation:

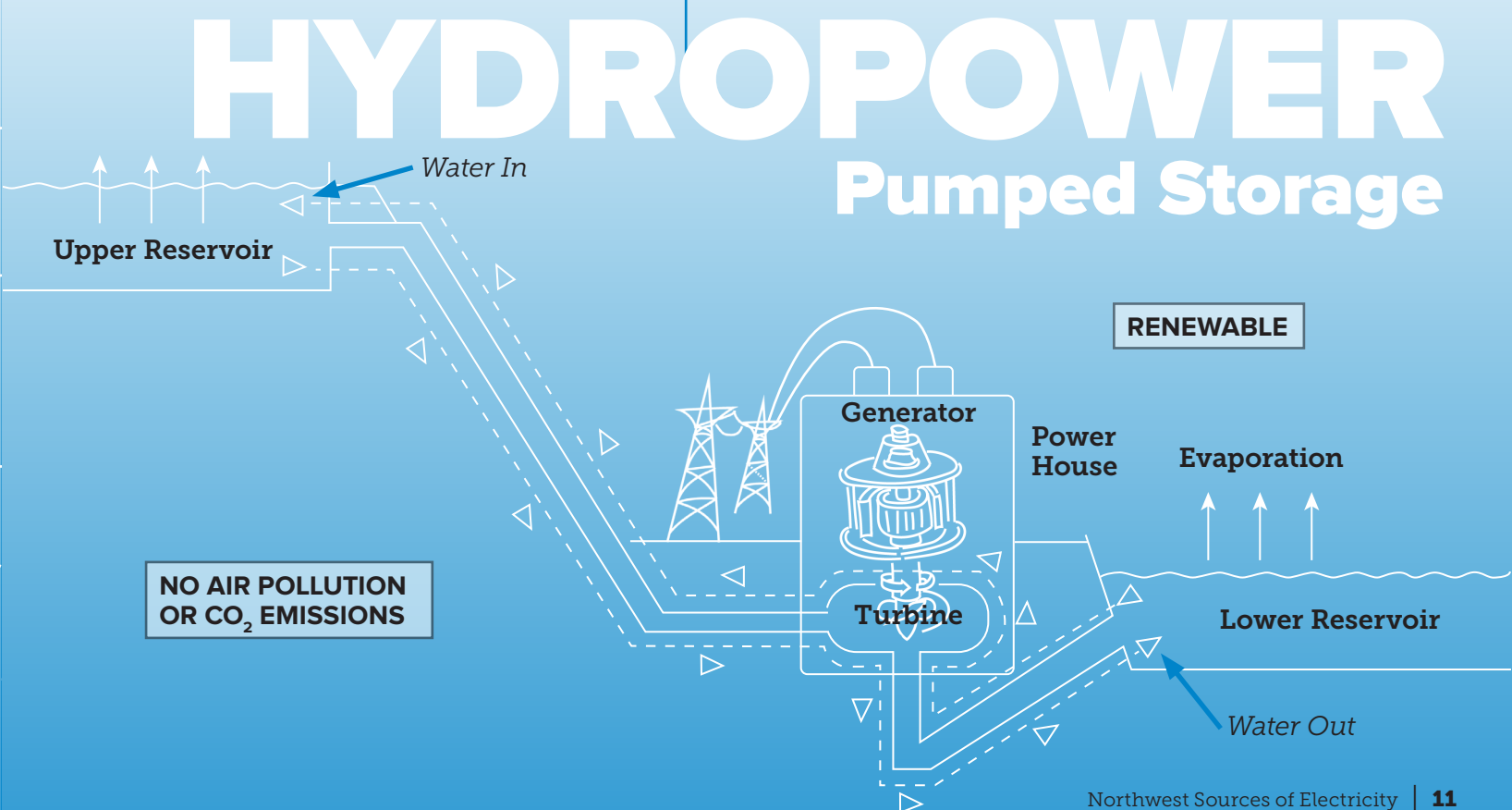
The falling water forces a turbine to turn. A generator produces electricity.

Key Features:

- Pumped Storage Hydropower is a **renewable resource**, using the water as a fuel source to refill the upper reservoir.
- During low electricity demand, a turbine is used to pump water to the upper reservoir for storage. Water from the upper reservoir is then released when electricity demand is highest, like when people are taking hot showers in the morning.
- As the released water flows downhill, it forces the turbine to move in the opposite direction to generate electricity.
- Although wind and solar power are also renewable resources, the wind doesn't always blow or the sun shine when electricity is needed. Pumped storage hydropower works in concert with wind and solar to help ensure electricity is always available.

FORCE FACT

The John W Keys III Pump Generating Plant at Grand Coulee Dam in Washington is the Northwest's only pumped storage project. The Swan Lake Energy Storage Project in Oregon will be the second when it is scheduled to open in 2030.



Generating Electricity from Hydropower
Low-head

What:
Low-head hydropower uses the force of moving water that does not fall far, such as in canals or pipes.

Power Generation:
As water flows through the pipe or canal with the help of gravity, it pushes a turbine. The spinning turbine is attached to a generator that makes electricity.

POWER UP

Jefferson PUD is designing a project to generate power from water flowing through the City of Port Townsend's gravity-fed 30-inch water pipelines. Grant PUD generates power at two irrigation canals in central WA.

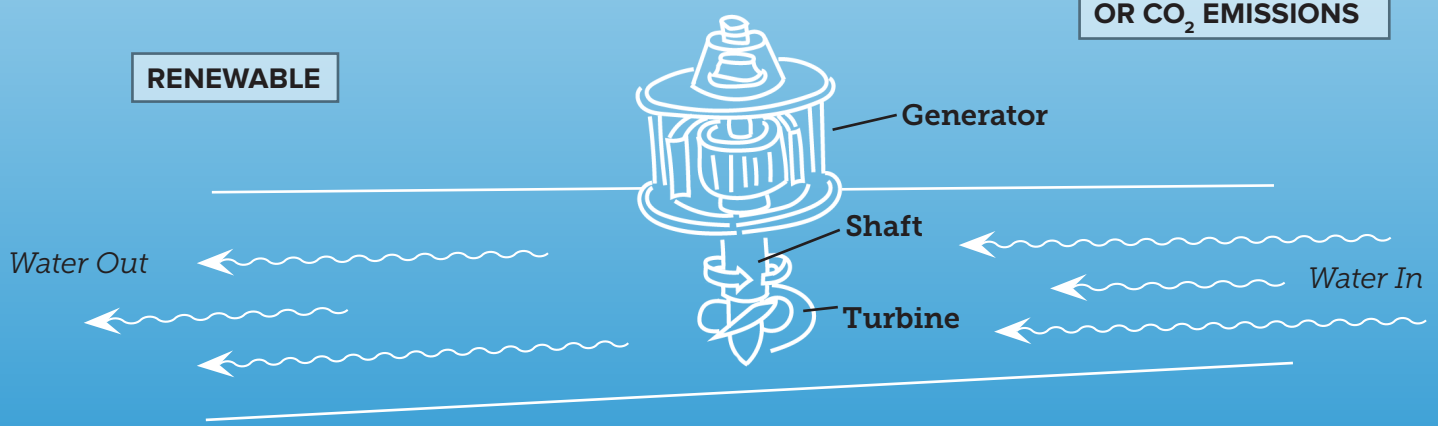
Key Features:

- A pipe filled with flowing water is used to generate electricity.
- Because the height from which water is falling (called head) is often less than 65 feet, the amount of power that can be generated is limited.
- Hydropower generation from canals and pipes (also called penstocks) **is a renewable resource** with **little or no impact on fish passage or other wildlife.**
- In some cases, this type of generation can provide reliable power all year-round.
- Cities and irrigation districts are adding low-head hydropower to their existing infrastructure to tap this unused potential electricity source.
- Flexibility to meet changing demand can be enhanced by pairing with battery storage technology.

HYDROPOWER
Low-head

NO AIR POLLUTION OR CO_2 EMISSIONS

RENEWABLE



Generating Electricity from Marine Energy

What:
Marine is an emerging technology that uses ocean waves and tidal currents to generate electricity.

Power Generation:
Buoys that bob up and down as well as sway back and forth, underwater turbines that spin in fast-moving tidal currents, and other technologies can capture the power of the ocean for conversion to electricity.

Key Features:

- Energy from the ocean provides coastal communities the potential for a vast, **reliable, carbon-free, and renewable energy source**. This can complement wind and solar power, whose availability is more variable and thus less reliable.

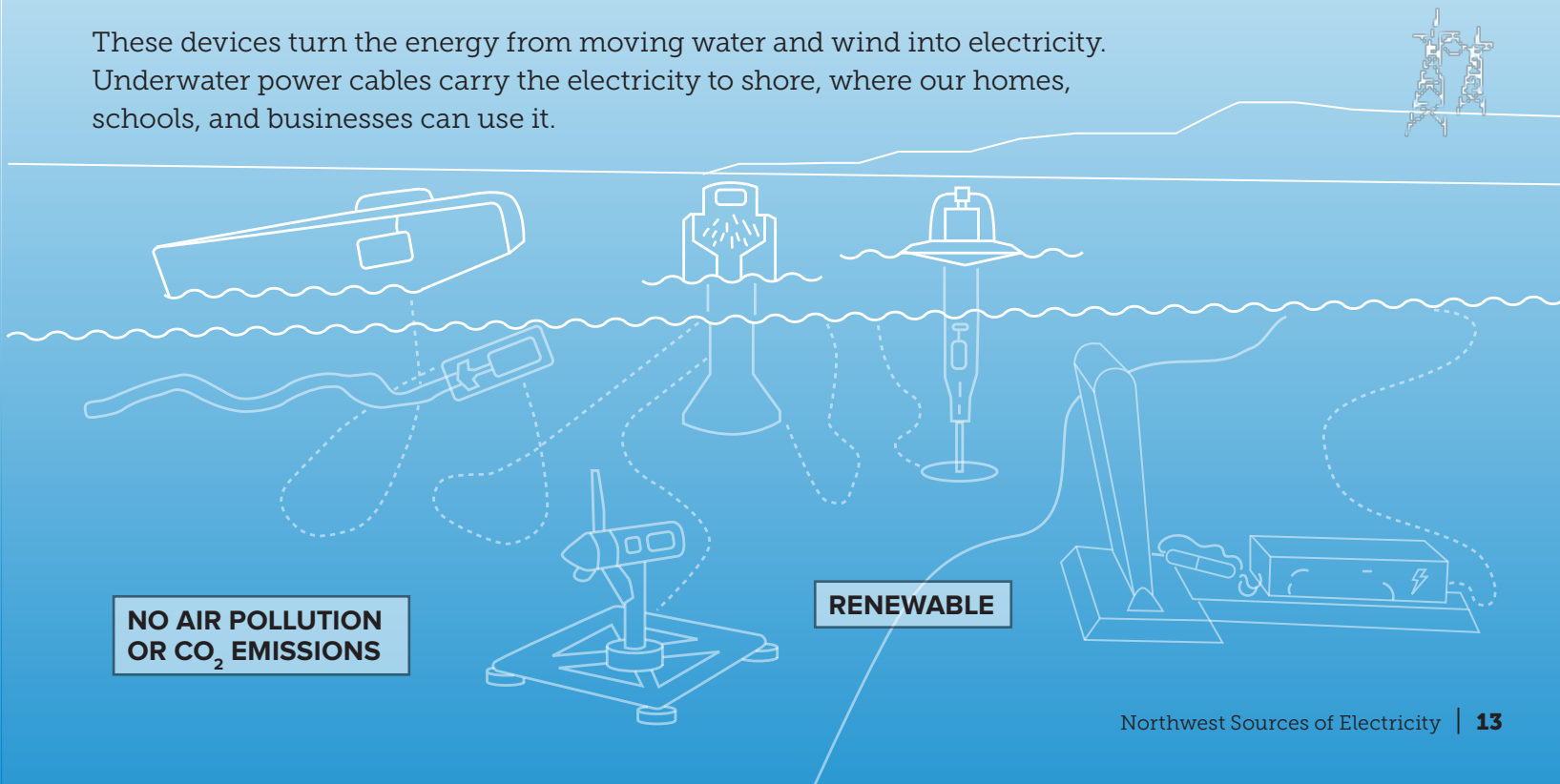
POWER UP

Northwest marine energy includes a testing facility in Newport, Oregon.

- Ocean waves and tidal currents can heave up and down, surge back and forth, or even swirl in circles, making it challenging to harness this energy to generate electricity.
- Marine energy designs must withstand turbulent and harsh conditions, including the huge force of changing wave action, corrosive salt water and shifting sediments that can damage devices.
- Protecting highly sensitive marine ecosystems such as migration of salmon creates additional engineering challenges.

MARINE ENERGY

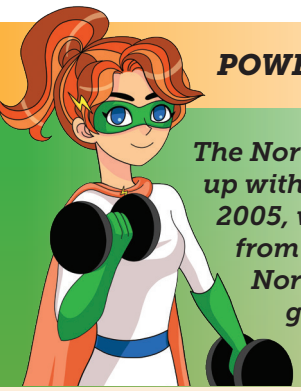
These devices turn the energy from moving water and wind into electricity. Underwater power cables carry the electricity to shore, where our homes, schools, and businesses can use it.



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.

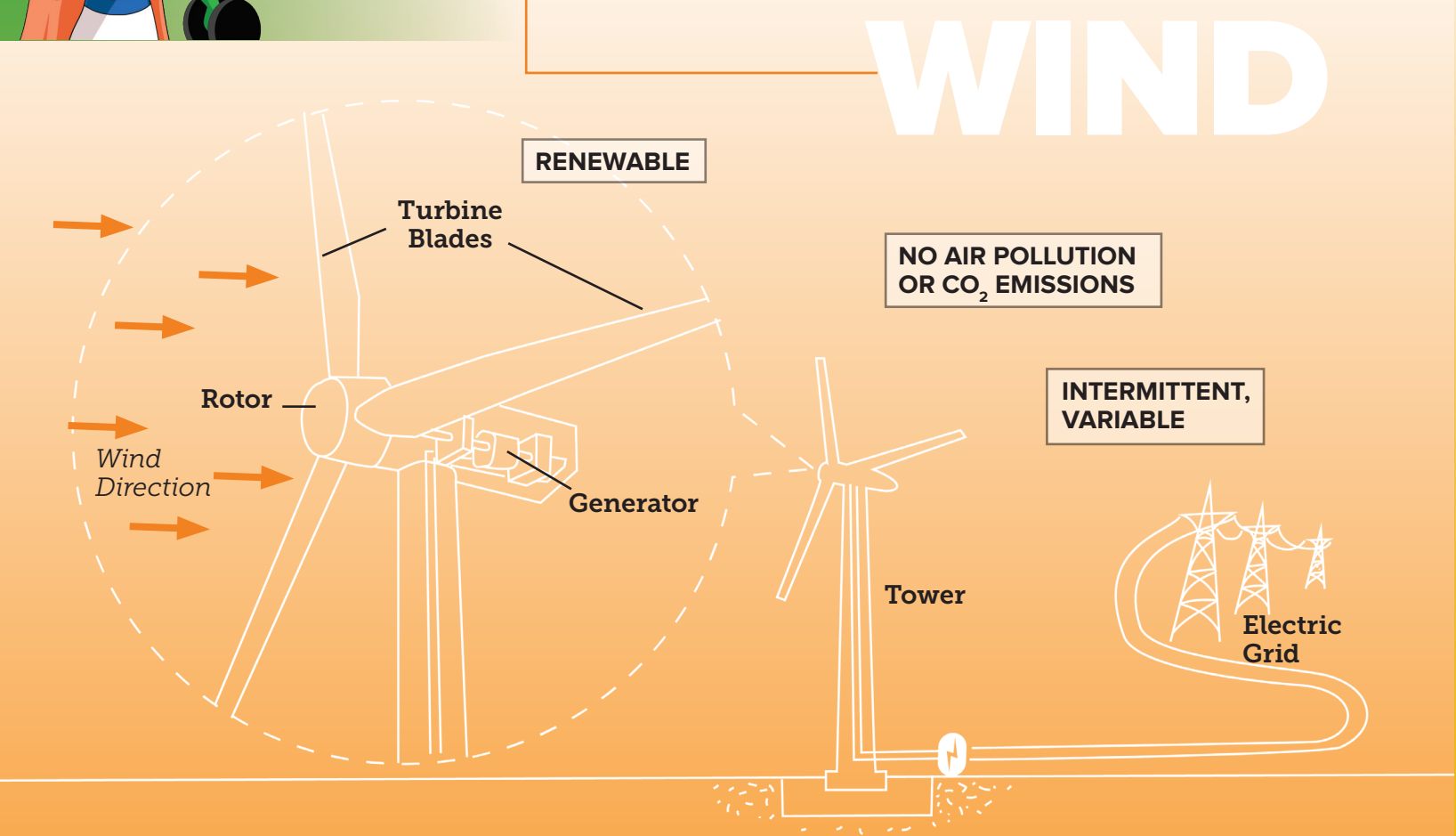


POWER UP

The Northwest is powering up with wind. Since 2005, wind power grew from 1% to 19% of the Northwest's ability to generate electricity.

Key Features:

- Wind power is a **renewable** resource.
- This energy source **does not produce carbon dioxide (CO_2)** 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.



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).

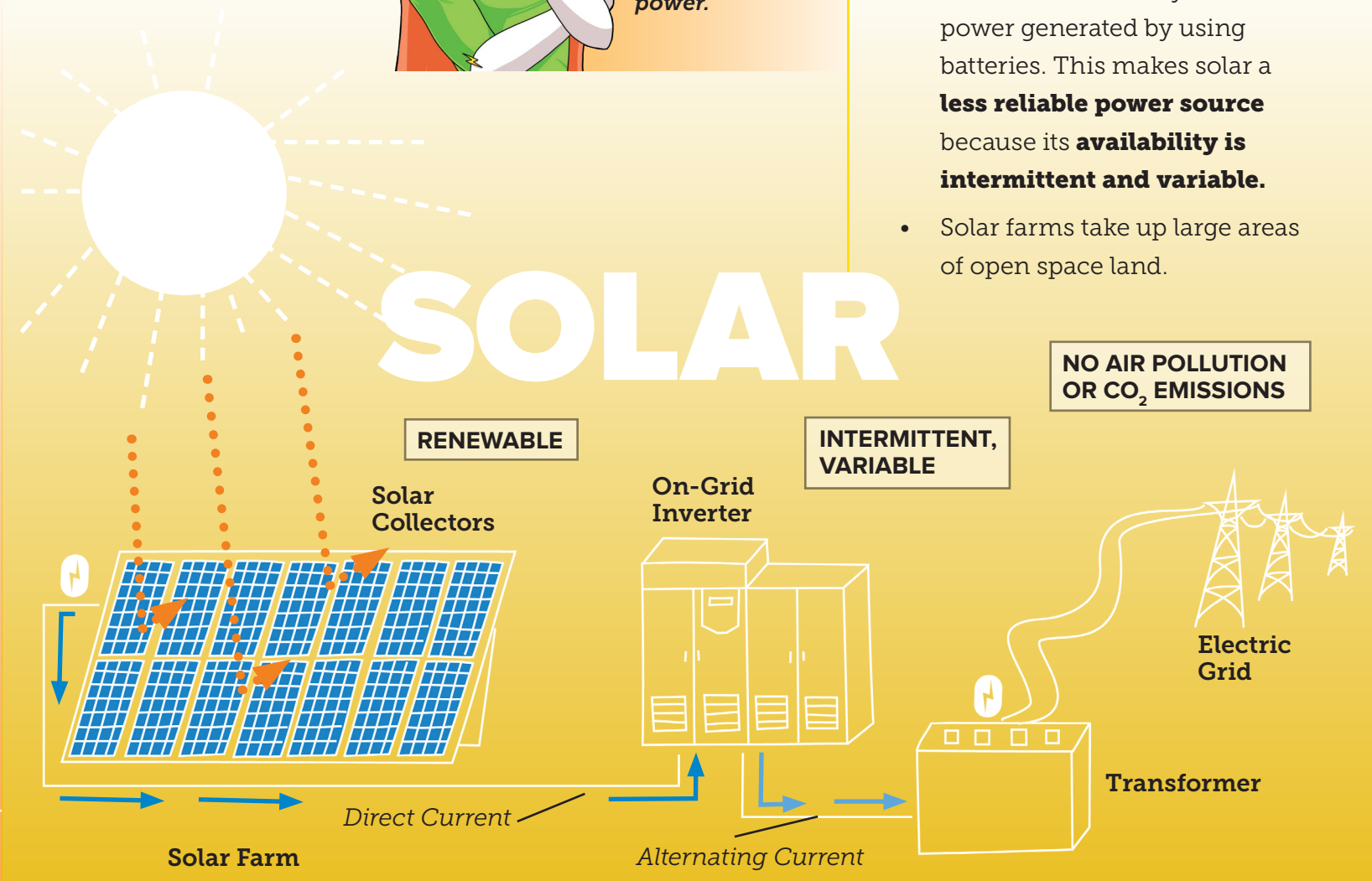
Power not used by solar panels on homes and businesses can be put back on the power grid and distributed to others.

FORCE FACT

In 2023, 3% 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 (CO_2)** 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.



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.

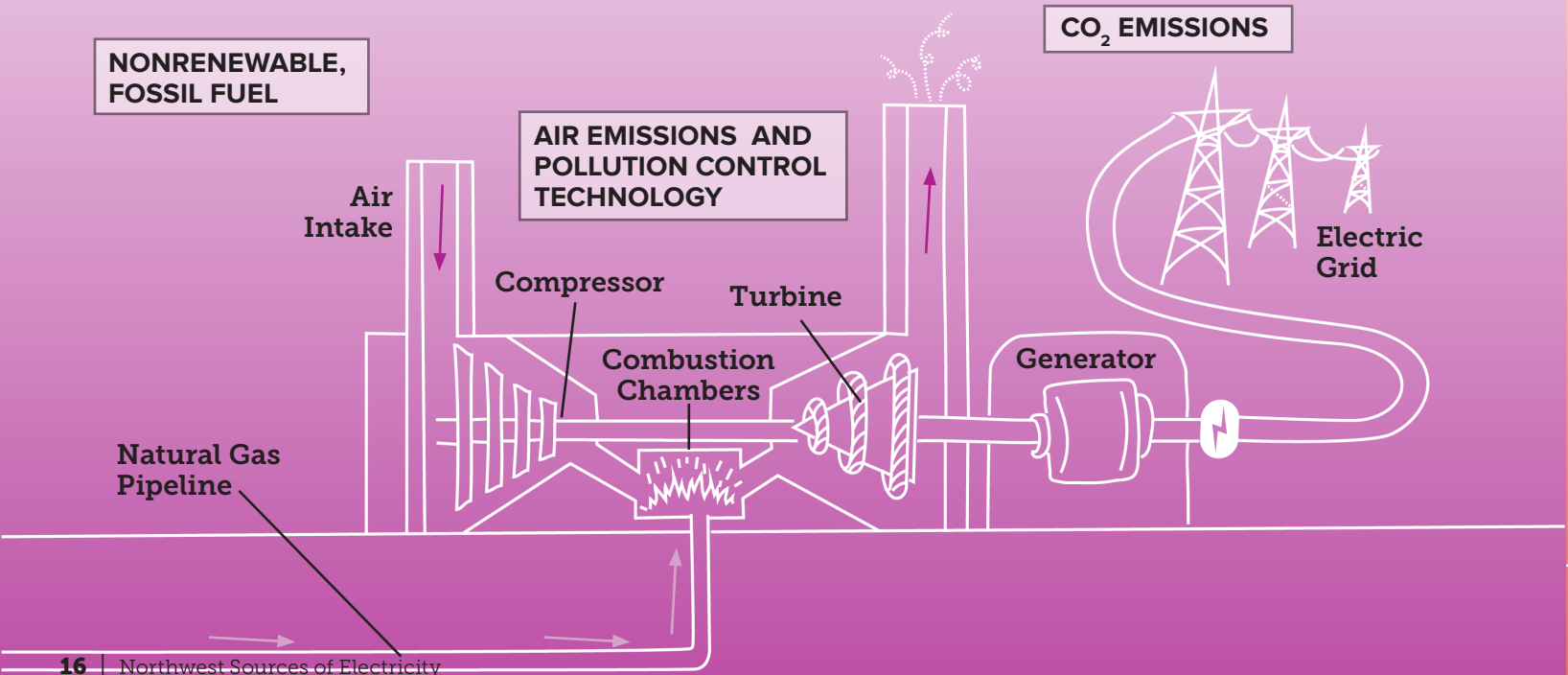
FORCE FACT

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 (CO_2) emissions**, a greenhouse gas. They emit about half as much CO_2 emissions as coal plants.
- The process of **extracting** natural gas contributes to 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 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

By 2026, there will be no coal power plants in Washington, Oregon, and Idaho.

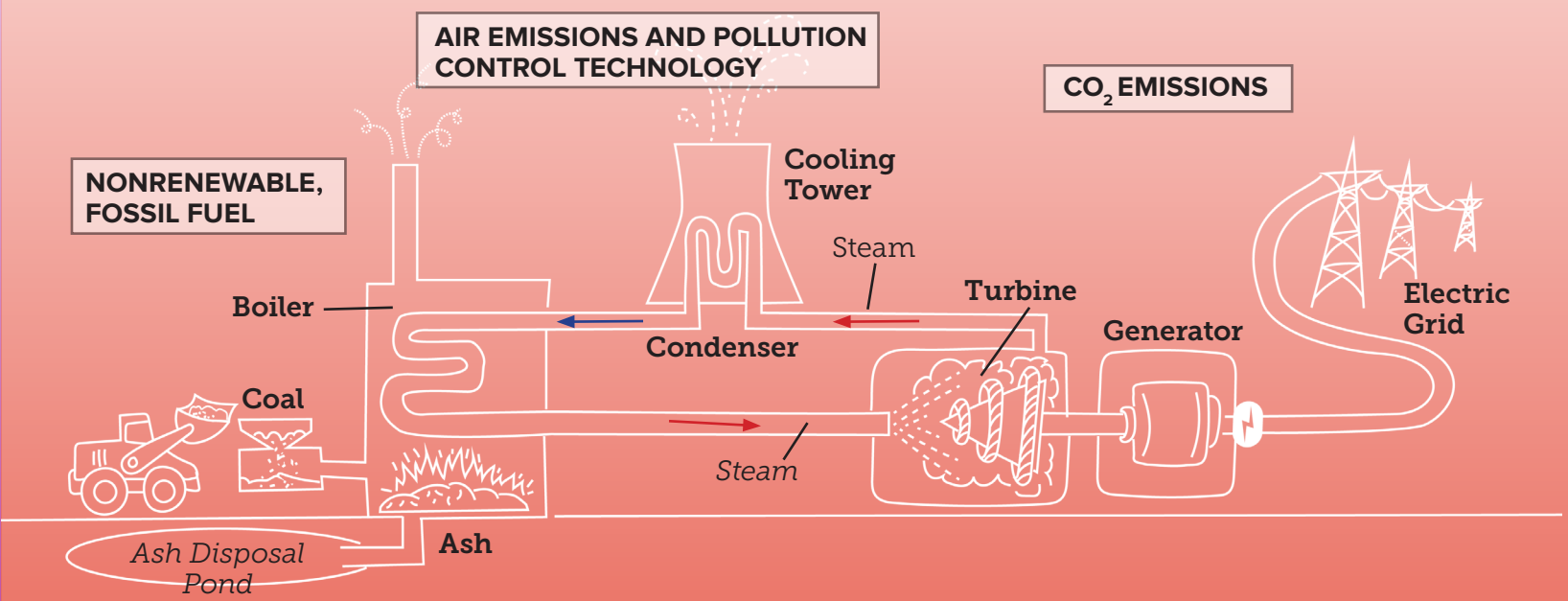
Power Generation:

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).

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 (CO_2) emissions**. In 2024, coal accounted for 16% of CO_2 emissions from electric power generation in the United States.
- 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, which occurs naturally in rocks, as their fuel source. To obtain it, uranium ore is extracted through surface or underground mining. After extraction, the uranium undergoes enrichment and is formed into small ceramic fuel pellets. These pellets are then stacked and sealed inside fuel rods, which are bundled together to create a fuel assembly used in the nuclear power plant reactor.

Power Generation:

Nuclear fission is used to heat water by splitting atoms in the plant's reactor. The resulting steam drives a turbine, which powers a generator to produce electricity. A condenser cools the steam, converting it back into liquid water so it can be reused in the system.

POWER UP

The only nuclear power plant operating in the Northwest is near Richland, WA. Development of Small Modular Reactors (SMRs) has begun that may provide additional nuclear power in the 2030s. SMRs are modular and scalable, offering flexible energy output while enhancing efficiency and safety.

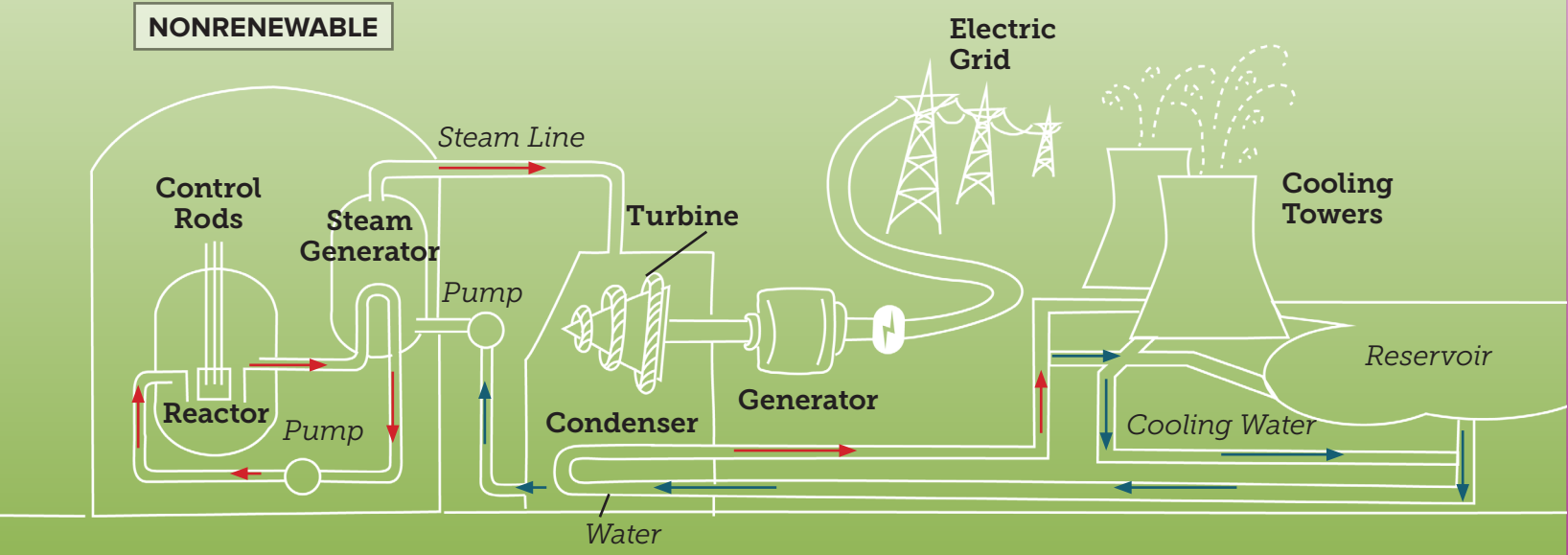
Key Features:

- Nuclear energy is considered a **nonrenewable** resource because it relies on uranium, a finite resource.
- Nuclear power plants are **a steady and reliable source** of electricity, operating continuously except during maintenance.
- Used nuclear fuel remains radioactive and must be safely managed. It is stored in specialized casks under strict regulations to prevent radiation exposure.
- Rigorous safety measures are used to prevent an uncontrolled nuclear reaction at a plant that would endanger human health and the environment.

NUCLEAR

NONRENEWABLE

NO AIR POLLUTION OR CO_2 EMISSIONS



FORCE FACT

The first-ever fusion power plant could be built in Chelan County, Washington!

Generating Electricity from Fusion

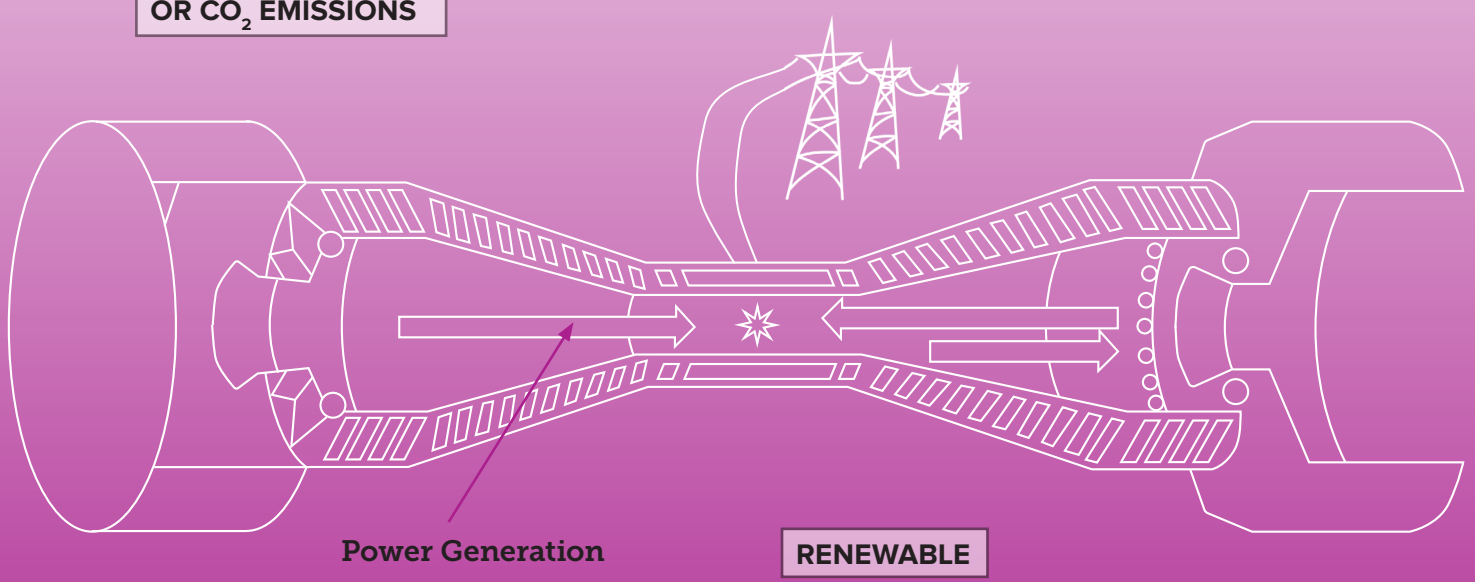
What:
Fusion is an emerging technology. It uses the same process as the sun to produce energy. When fusion is done on earth, it involves combining two atoms under intense heat and pressure to release an immense amount of energy.

Power Generation:
The heat generated from fusion is so intense it's almost 6 times the temperature of the core of our own sun. About 100,000,000 degrees Celsius (180,000,000 degrees Fahrenheit)! Fusion generators are designed to harness and turn this energy into electricity.

Key Features:

- Fusion makes energy and easy-to-manage byproducts.
- Fusion is **renewable, non-polluting and would not contribute to air pollution or climate change.**
- Fusion is different than nuclear power because it joins atoms instead of splitting them apart. With fusion there is no mining of uranium or radioactive waste to manage. Ingredients like hydrogen are everywhere!
- Fusion research started in the 1950's. Now, new technology is making it possible to build fusion power plants.

FUSION



Generating Electricity 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.

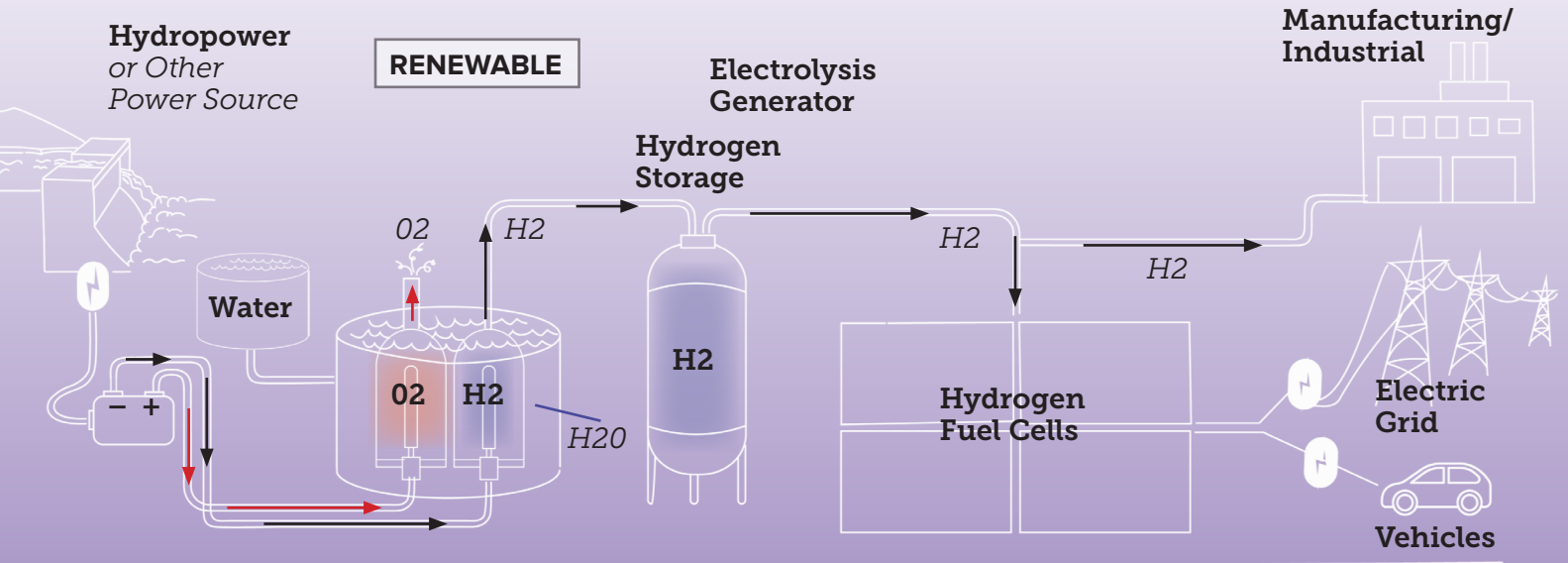
Power Generation:
A common way to produce hydrogen is through electrolysis, a process that separates water into oxygen and hydrogen. The hydrogen can then be used in a fuel cell to produce electricity.

Key Features:

- Hydrogen is a **clean fuel** that, when consumed in a fuel cell, produces only water.
- Fuel cells produce **no carbon dioxide (CO_2)** 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

Douglas County PUD is opening Washington's first green hydrogen plant in 2025 using power generated from renewable energy.



HYDROGEN

NO AIR POLLUTION OR CO_2 EMISSIONS

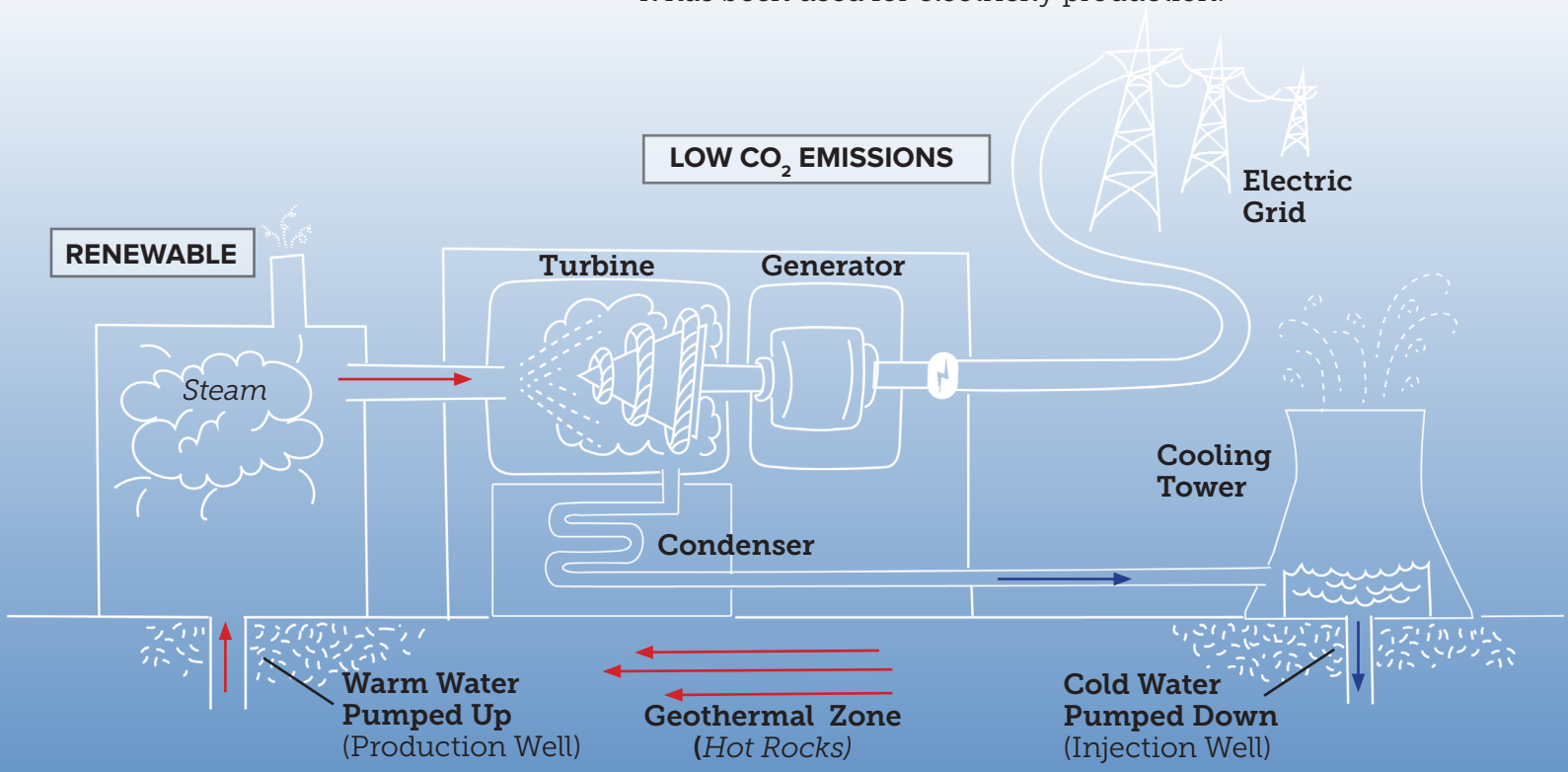
Generating Electricity from Geothermal

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 (CO_2) 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.



GEOTHERMAL

FORCE FACT

Snohomish County PUD partnered with the Tulalip Tribes and farmers to operate its Qualco Project, a biodigester.

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.

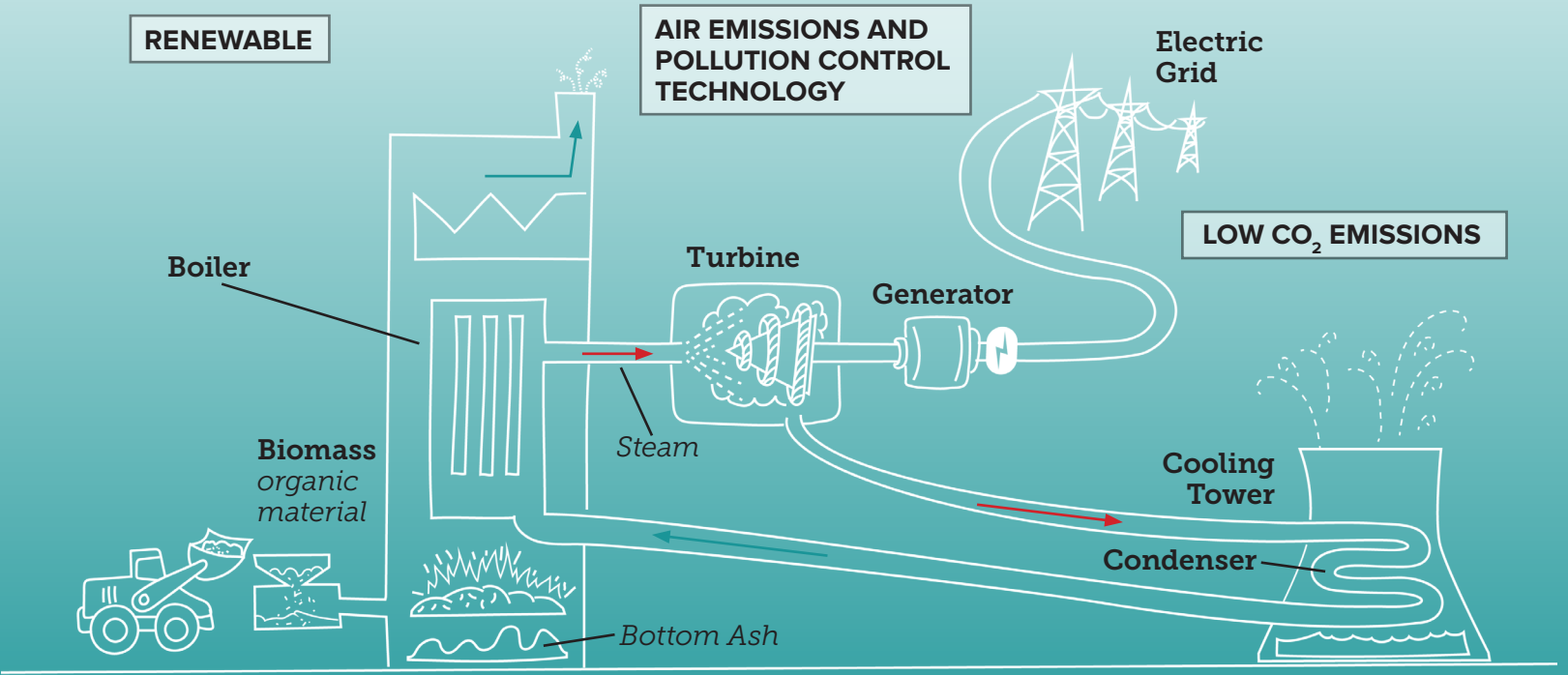
Power Generation:

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



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.									
	It is a small source of carbon dioxide (CO_2) emissions (a greenhouse gas) released into the atmosphere.									
	It releases no air emissions that contribute carbon dioxide (CO_2) or other greenhouse gas emissions.									
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 falling 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 must be safely stored in specialized casks.									
	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.									