INTRODUCTION TO RENEWABLE ENERGY

INTRODUCTION TO RENEWABLE ENERGY

- Renewable energy refers to energy derived from natural sources that are replenished constantly.

- Unlike fossil fuels, renewables do not deplete over time and have minimal environmental impact.

INTRODUCTION TO RENEWABLE ENERGY

Key Types of Renewable Energy

Type	Source	Common Applications
Solar	Sunlight	Electricity (PV), heating (thermal)
Wind	Air movement	Electricity via wind turbines
Hydropower	Flowing water	Electricity via dams or run-of-river
Biomass	Organic material	Heating, electricity, biofuels
Geothermal	Earth’s internal heat	Heating, electricity
Ocean Energy	Tides, waves, temperature	Emerging tech for electricity

INTRODUCTION TO RENEWABLE ENERGY

Why Renewable Energy Matters

- Environmental Benefits: Low carbon emissions, reduced pollution.
- Energy Security: Diversifies supply, reduces dependence on imports.
- Economic Growth: Job creation in green tech and infrastructure.
- Sustainability: Supports long-term ecological balance.

Challenges in Adoption

- Intermittency (e.g., solar only works with sunlight)
- High initial costs (though decreasing)
- Grid integration and storage limitations
- Land use and ecological concerns

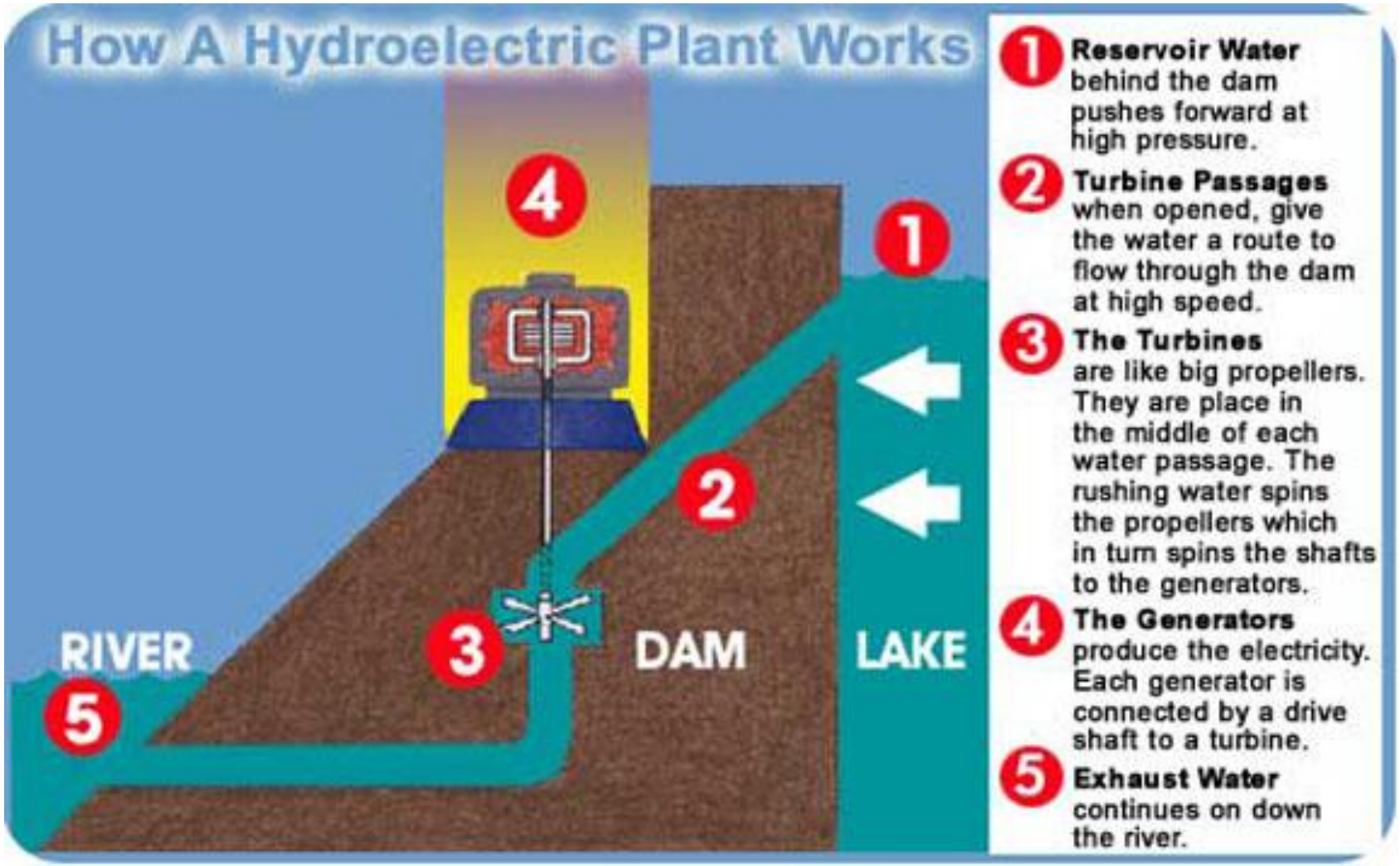
Global Trends & Policies

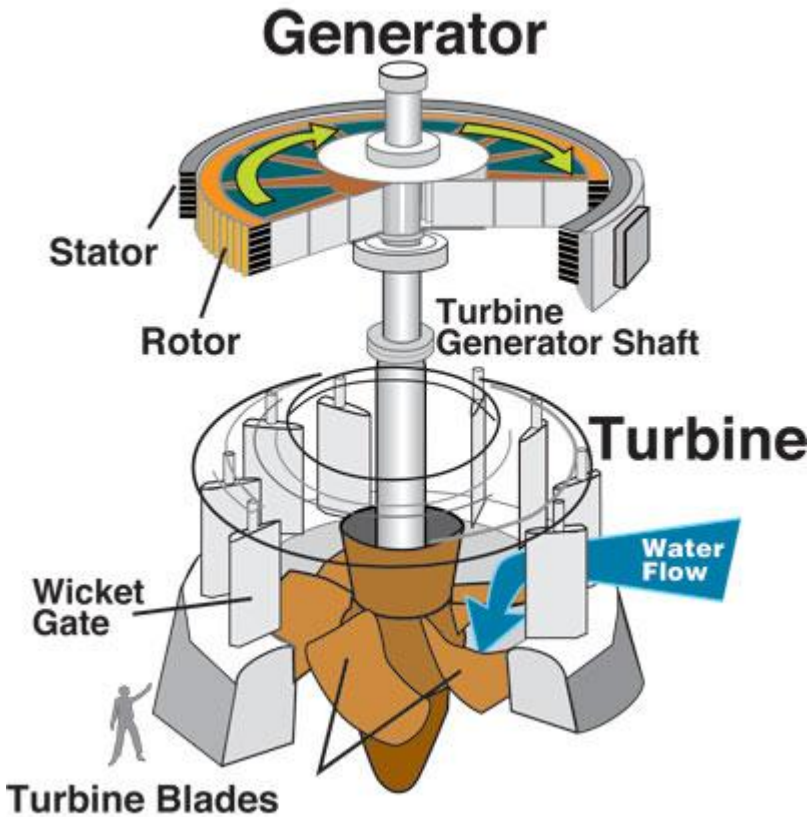
- Increasing investment in renewables worldwide.
- Government incentives: feed-in tariffs, tax credits, net metering.
- UN SDGs and COP climate goals promote clean energy transitions.

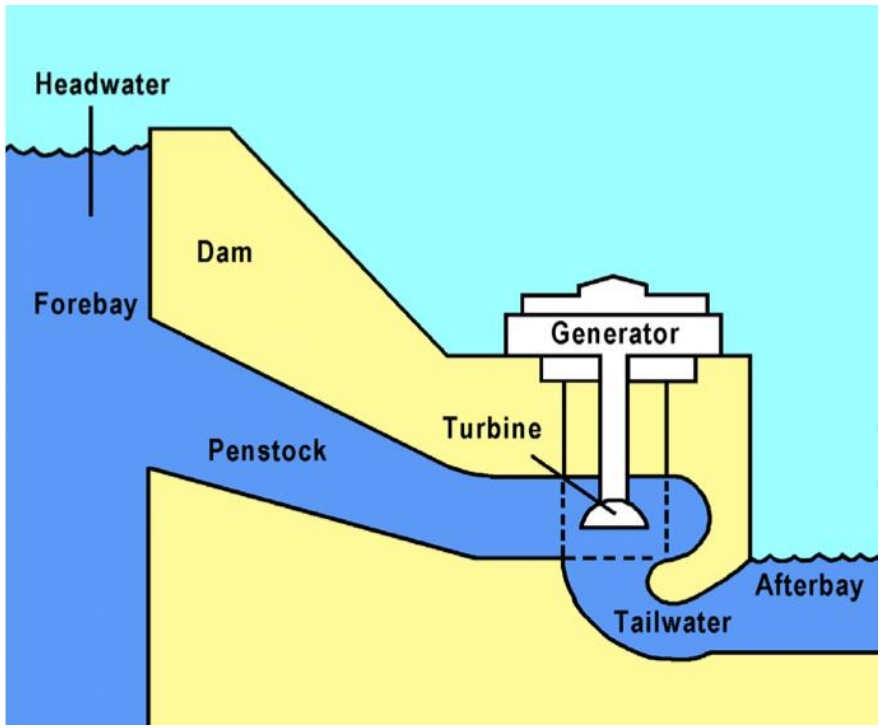
GENERAL PRINCIPLES OF HYDRO POWER PLANT

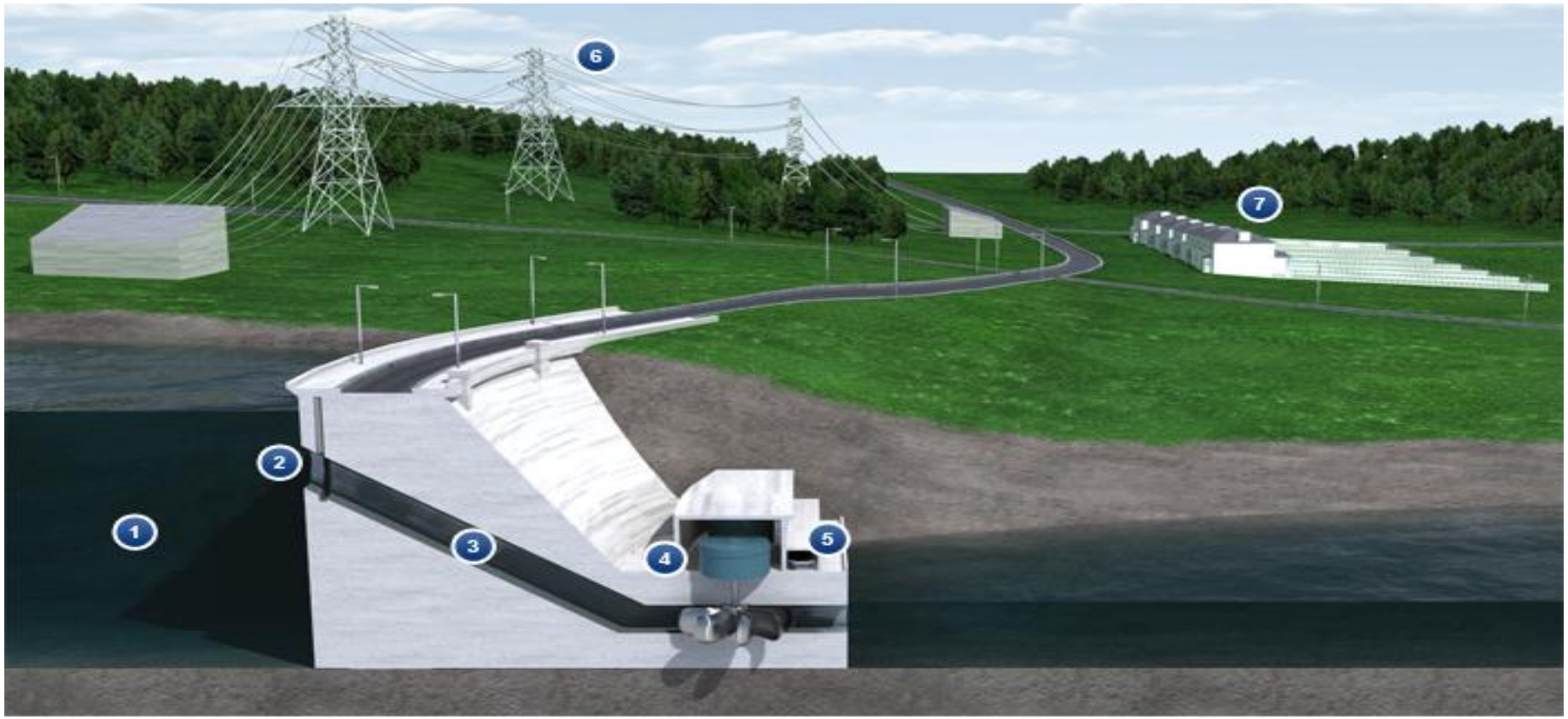
- A hydraulic turbine converts the energy of flowing water into mechanical energy.
- A hydroelectric generator converts this mechanical energy into electricity.
- In a large generator, electromagnets are made by circulating direct current through loops of wire wound around stacks of magnetic steel laminations.
- These are called field poles, and are mounted on the perimeter of the rotor.

- The rotor is attached to the turbine shaft, and rotates at a fixed speed.
- When the rotor turns, it causes the field poles (the electromagnets) to move past the conductors mounted in the stator.
- This, in turn, causes electricity to flow and a voltage to develop at the generator output terminals.


How A Hydroelectric Plant Works
1 Reservoir Water behind the dam pushes forward at high pressure.
2 Turbine Passages when opened, give the water a route to flow through the dam at high speed.
3 The Turbines are like big propellers. They are place in the middle of each water passage. The rushing water spins the propellers which in turn spins the shafts to the generators.
4 The Generators produce the electricity. Each generator is connected by a drive shaft to a turbine.
5 Exhaust Water continues on down the river.
RIVER
DAM
LAKE


Generator
Stator
Rotor
Turbine
Generator Shaft
Turbine
Water
Flow
Wicket
Gate
Turbine Blades


Headwater
Dam
Forebay
Generator
Turbine
Penstock
Afterbay
Tailwater



1. Reservoir
2. Intake
3. Penstock
4. Generator
5. Power house
6. Electricity transmission (power lines)
7. Consumer homes and businesses

DAMS

- The dam is made on a river to collect water. Whenever it rains, the water is collected into the dam so it serves as a water reservoir. The potential energy for further work is generated by the water level difference between the dams and the turbines because the water level in the dams is very high. Dams also control the water flow through penstocks.

TURBINES

- The next step is to convert this kinetic energy of water into mechanical energy. The water flows from a height throw the penstocks which are the channelled vessels to the turbines which have blades. The falling water has enough kinetic energy that when they strike hard with the blades of the turbines, they start spinning which means that the kinetic energy is converted into mechanical energy. The turbines resemble a lot with the windmills in which wind energy is used instead of water. But the turbines use potential and mechanical energy of falling water to convert into work.

GENERATORS

- The shafts of the turbines convert the mechanical energy into electric energy. Basically, the generators work on the principle of magnets which is that when you pass a magnet near a conductor, electric current flows through it.

ROTOR AND STATOR

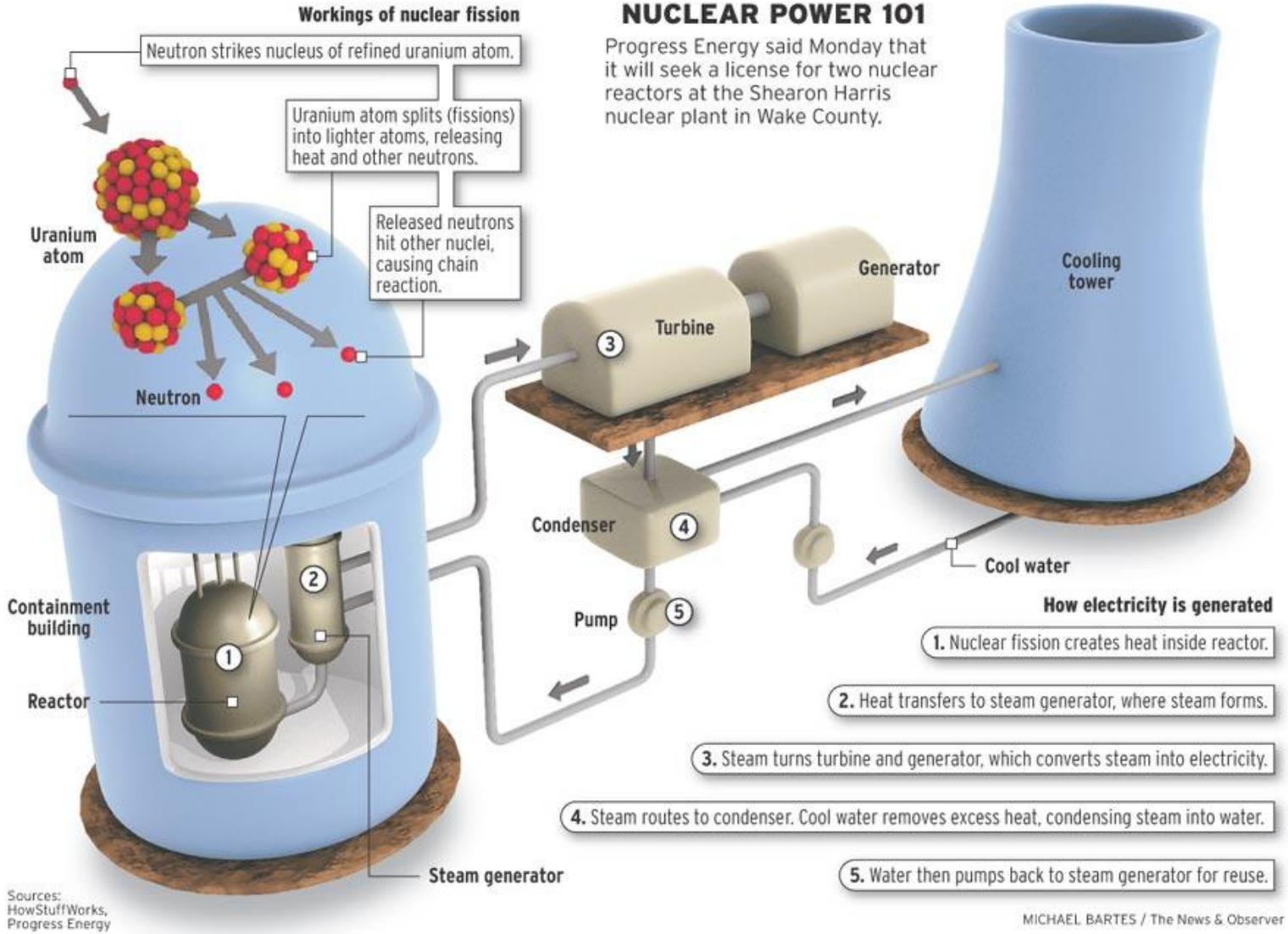
- The rotor having field pole rotates on a specific speed. When it rotates it passes the field poles across the stator to make sure that it has the same effect of electric field. The water should keep on moving constantly to make sure that the amount of electricity produced is great. Static water cannot generate electricity.

GENERAL PRINCIPLES OF NUCLEAR POWER PLANT

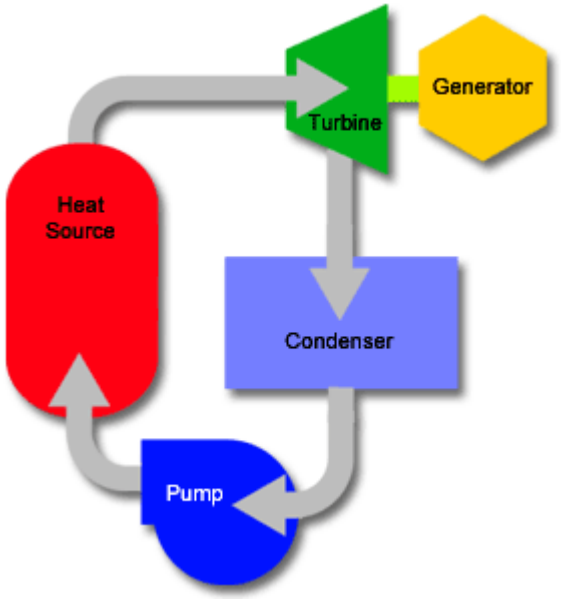
- There are two fundamental ways to generate nuclear energy;
- One way is to break up a heavy element into two lighter elements and produce heat, in a process known as nuclear fission;
- The other is to fuse two lighter elements together to form a heavier element and produce heat, in a process known as nuclear fusion;

- A nuclear reactor produces and controls the release of energy from splitting the atoms of uranium;

- Uranium-fuelled nuclear power is a clean and efficient way of boiling water to make steam which drives turbine generators.

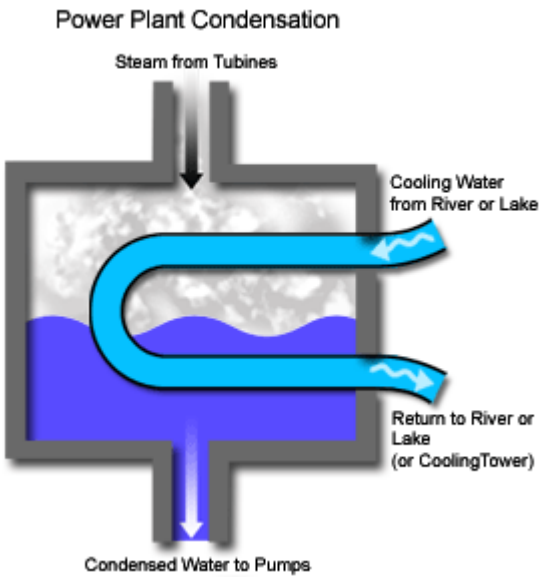

NUCLEAR POWER 101
Progress Energy said Monday that it will seek a license for two nuclear reactors at the Shearon Harris nuclear plant in Wake County.
Workings of nuclear fission
Neutron strikes nucleus of refined uranium atom.
Uranium atom splits (fissions) into lighter atoms, releasing heat and other neutrons.
Released neutrons hit other nuclei, causing chain reaction.
Uranium atom
Neutron
Containment building
Reactor
Steam generator
Turbine
Generator
Cooling tower
Condenser
Pump
Cool water
How electricity is generated
1. Nuclear fission creates heat inside reactor.
2. Heat transfers to steam generator, where steam forms.
3. Steam turns turbine and generator, which converts steam into electricity.
4. Steam routes to condenser. Cool water removes excess heat, condensing steam into water.
5. Water then pumps back to steam generator for reuse.
Sources: HowStuffWorks, Progress Energy
MICHAEL BARTES / The News & Observer

- Heat source: Provides heat to generate steam. In a nuclear power plant, the heat source is the nuclear reactor, often referred to as the reactor core.
- Turbine/generator: Uses the energy of the steam to turn a turbine/generator that produces electricity.



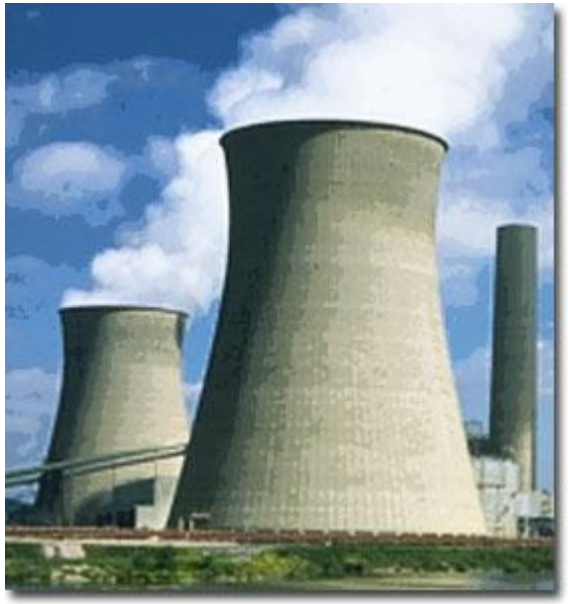
- Condenser: Condenses the steam back to water so that it can be returned to the heat source to be heated again.
- Pump: Provides the force to circulate the water through the system.

COOLING WATER



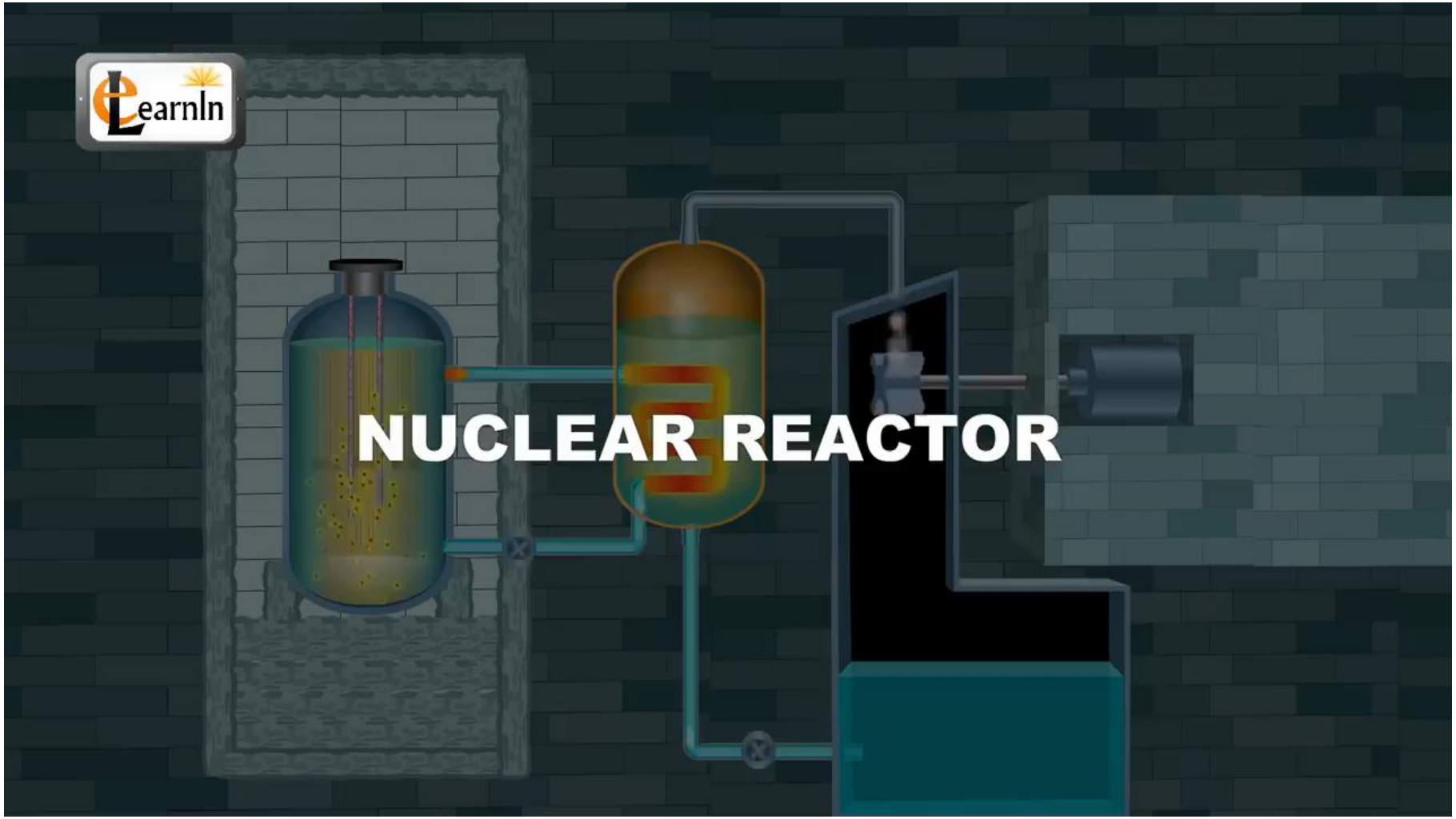
- Just as water vapour condenses on a cool drinking glass on a warm day, a power plant's condenser uses a cool surface to condense the steam from the turbine.
- This cool surface is provided by cooling water pumped from a nearby water supply such as a river, lake or ocean.

COOLING TOWERS

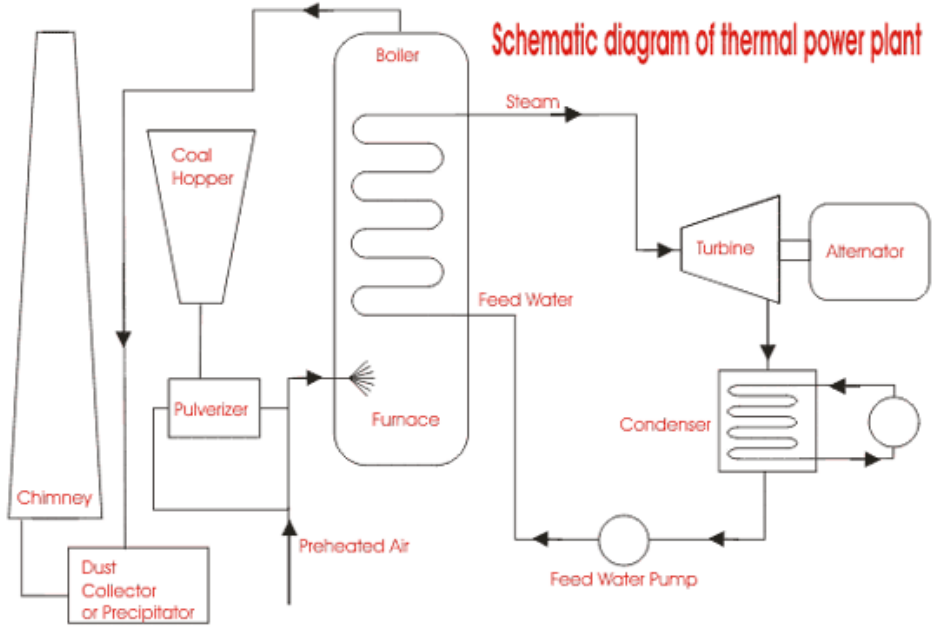


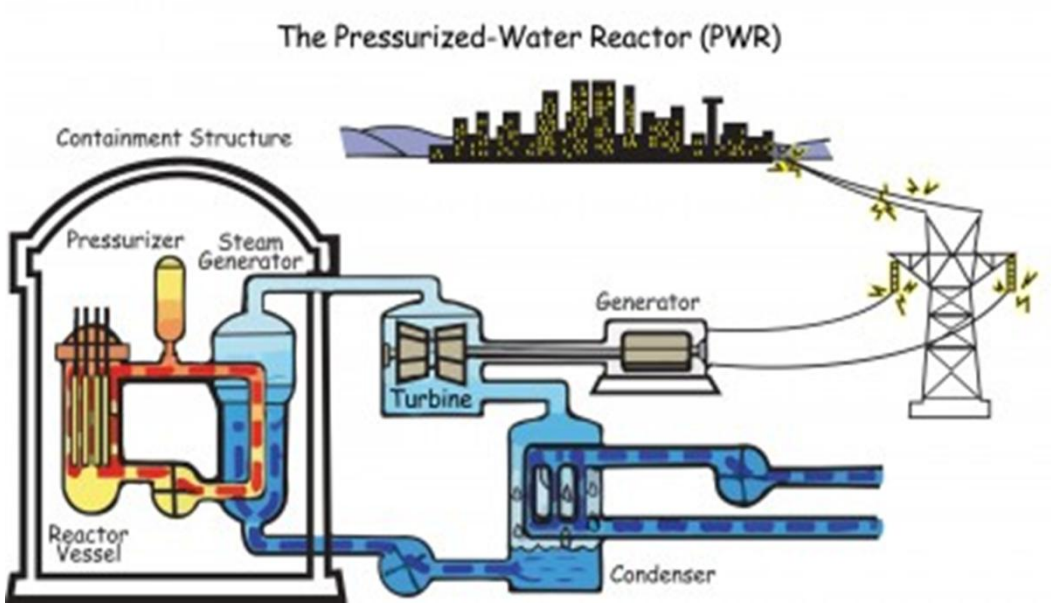
- A cooling tower is a large heat exchanger. This heat is carried up the stack and is visible as water vapour;
- Cooling towers are used at many large nuclear as well as non-nuclear power plants. Because cooling towers are part of a nonradioactive system, no radioactive material is released from them.

Working Principle of Nuclear Power

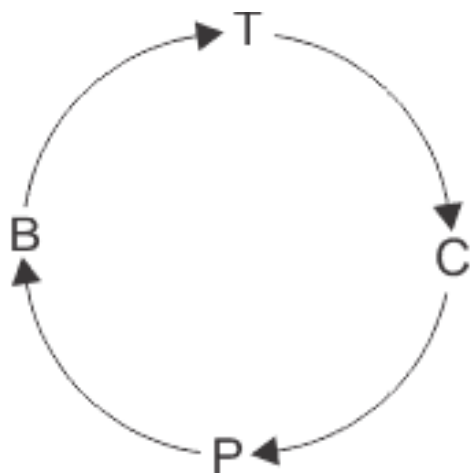


GENERAL PRINCIPLES OF THERMAL POWER PLANT





- Thermal power generation plant or thermal power station is the most conventional source of electric power;
- Thermal power plant is also referred as coal thermal power plant and steam turbine power plant;



Where,

T → Turbine

C → Condenser

P → Pump

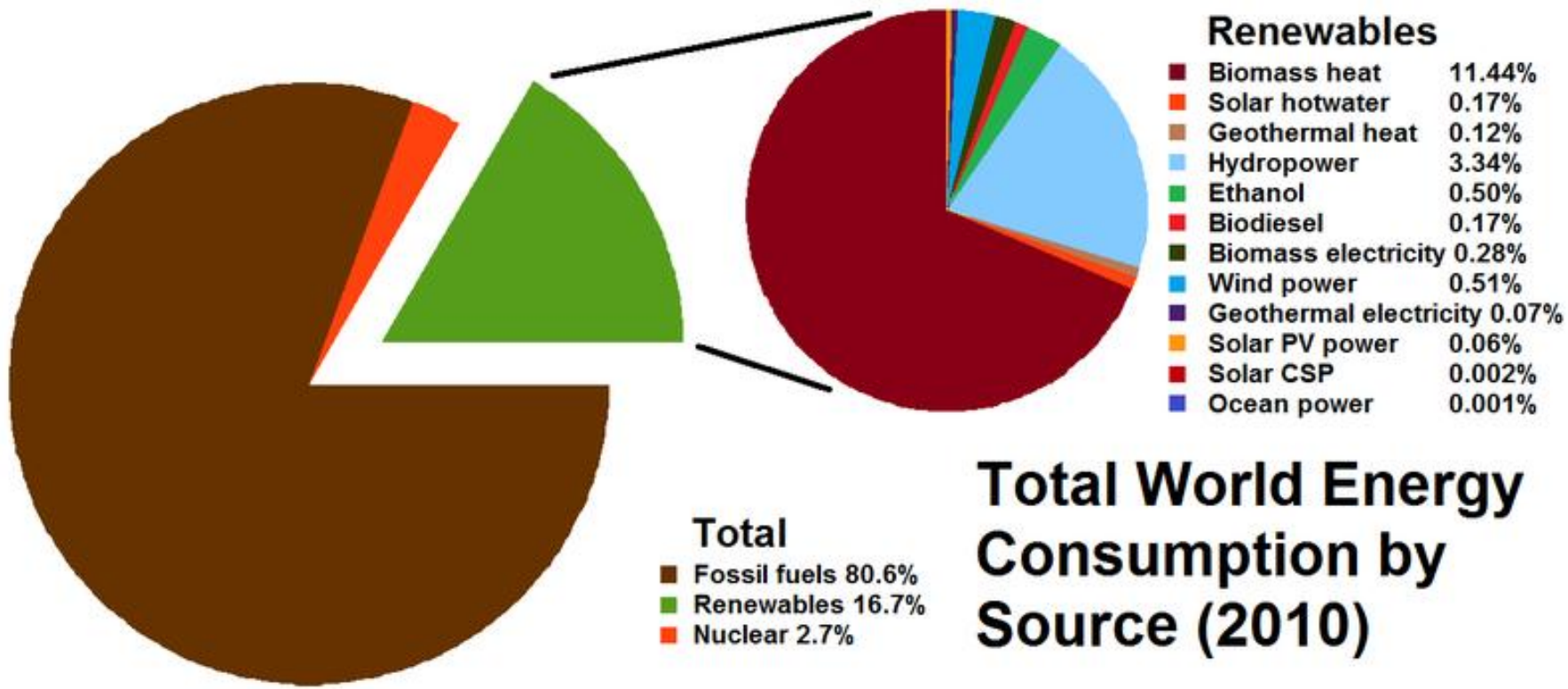
B → Boiler

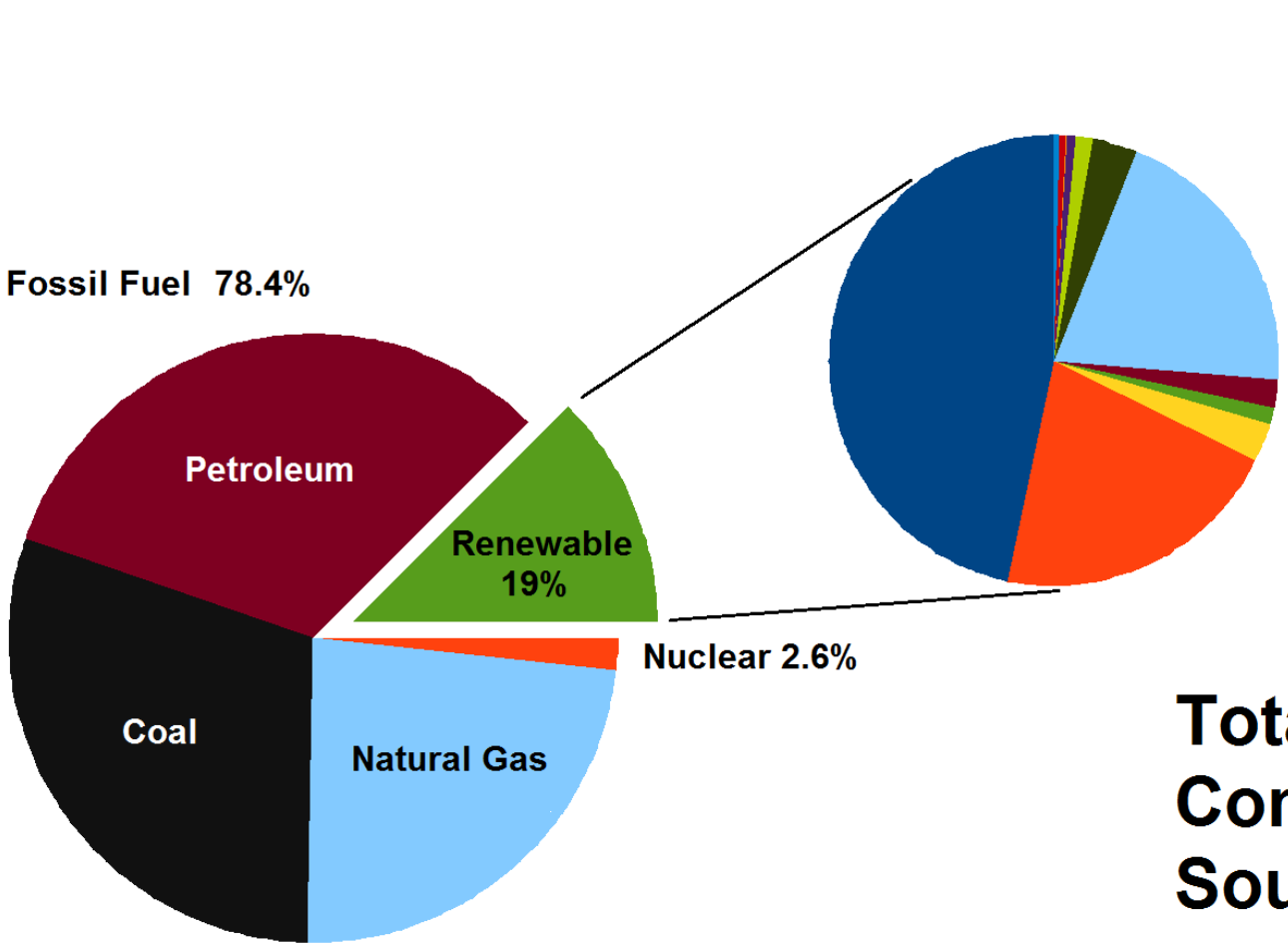
The working fluid is water and steam. This is called feed water and steam cycle. The ideal Thermodynamic Cycle to which the operation of a Thermal Power Station closely resembles is the RANKINE CYCLE.

Renewable Energy

The United States currently relies heavily on coal, oil, and natural gas for its energy. Fossil fuels are nonrenewable, that is, they draw on finite resources that will eventually dwindle, becoming too expensive or too environmentally damaging to retrieve. In contrast, **renewable energy resources are constantly replenished and will never run out.**

Types of Renewable Energy

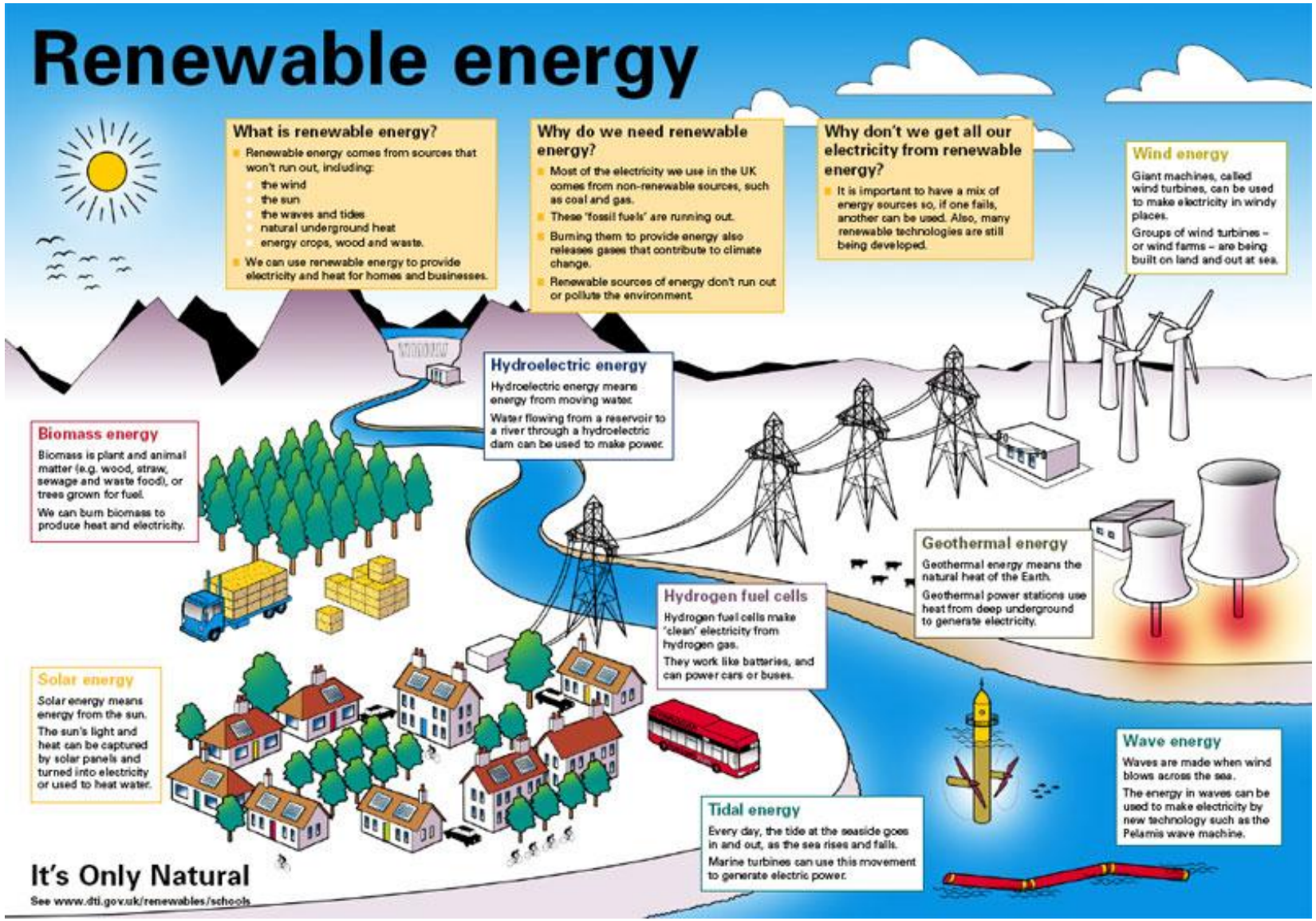

Renewables
Biomass heat 11.44%
Solar hotwater 0.17%
Geothermal heat 0.12%
Hydropower 3.34%
Ethanol 0.50%
Biodiesel 0.17%
Biomass electricity 0.28%
Wind power 0.51%
Geothermal electricity 0.07%
Solar PV power 0.06%
Solar CSP 0.002%
Ocean power 0.001%
Total
Fossil fuels 80.6%
Renewables 16.7%
Nuclear 2.7%
Total World Energy Consumption by Source (2010)



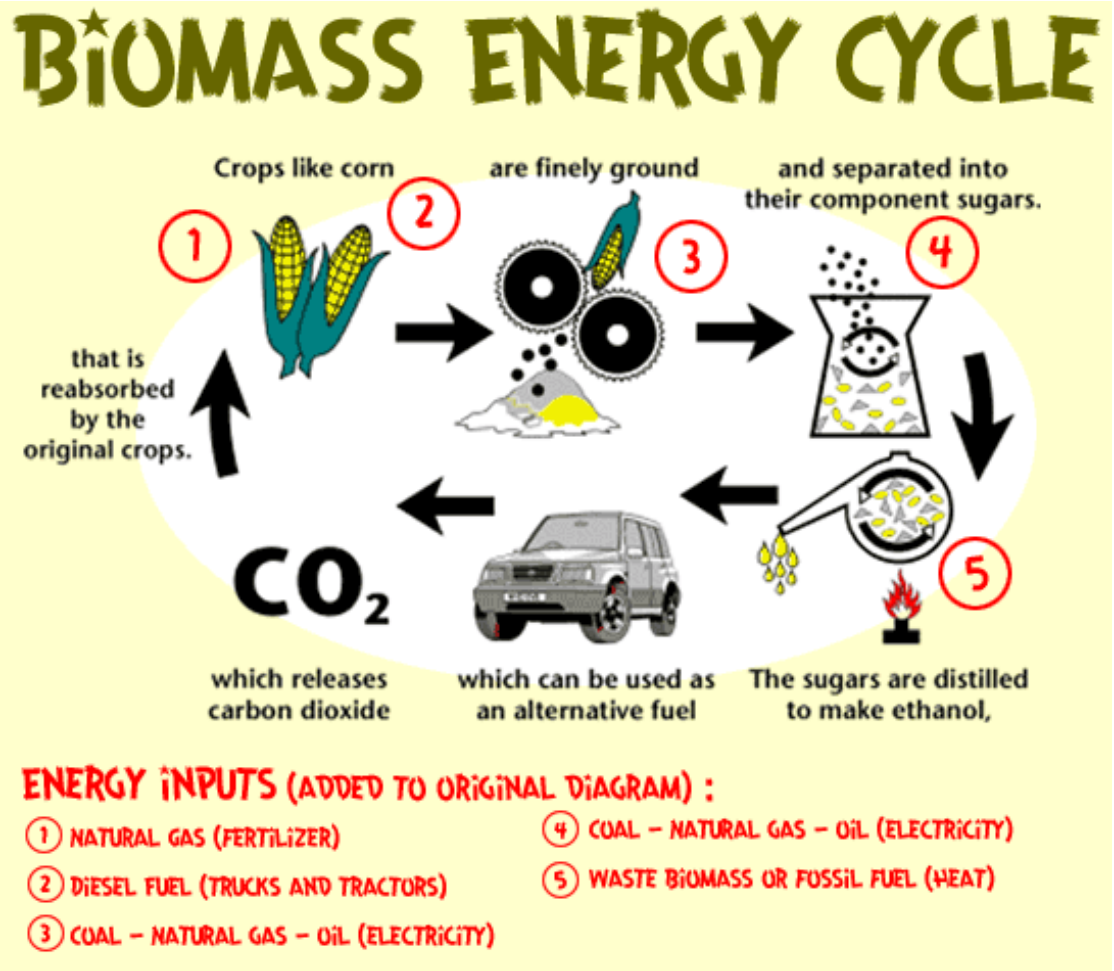
Renewable

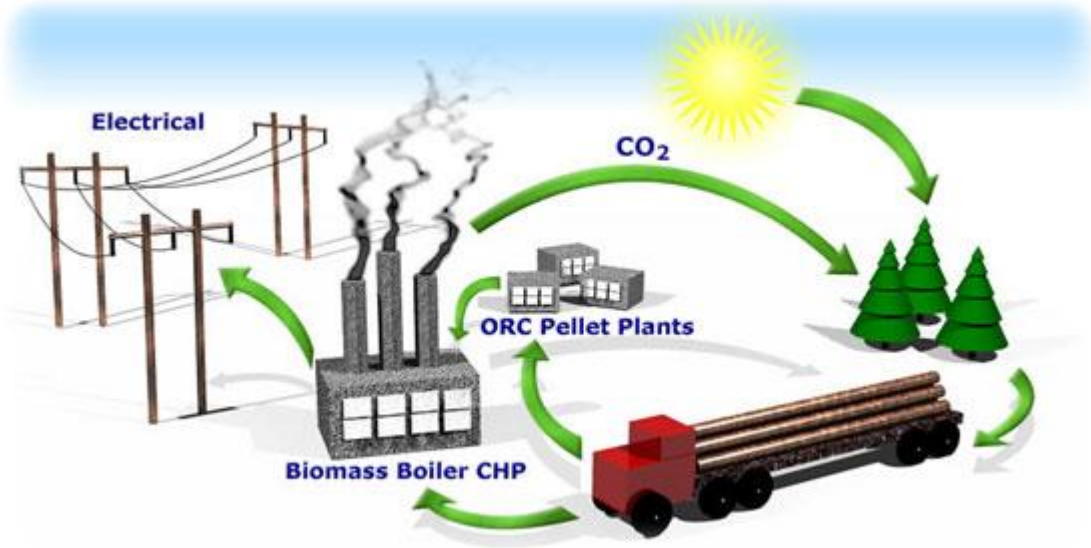
Traditional biomass	9%
Bio-heat	2.6%
Ethanol	0.34%
Biodiesel	0.15%
Biopower generation	0.25%
Hydropower	3.8%
Wind	0.39%
Solar heating/cooling	0.16%
Solar PV	0.077%
Solar CSP	0.0039%
Geothermal heat	0.061%
Geothermal electricity	0.049%
Ocean power	0.00078%

Total World Energy Consumption by Source (2013)


Renewable energy
What is renewable energy?
Renewable energy comes from sources that won't run out, including:
the wind
the sun
the waves and tides
natural underground heat
energy crops, wood and waste.
We can use renewable energy to provide electricity and heat for homes and businesses.
Why do we need renewable energy?
Most of the electricity we use in the UK comes from non-renewable sources, such as coal and gas.
These 'fossil fuels' are running out.
Burning them to provide energy also releases gases that contribute to climate change.
Renewable sources of energy don't run out or pollute the environment.
Why don't we get all our electricity from renewable energy?
It is important to have a mix of energy sources so, if one fails, another can be used. Also, many renewable technologies are still being developed.
Wind energy
Giant machines, called wind turbines, can be used to make electricity in windy places.
Groups of wind turbines – or wind farms – are being built on land and out at sea.
Hydroelectric energy
Hydroelectric energy means energy from moving water.
Water flowing from a reservoir to a river through a hydroelectric dam can be used to make power.
Biomass energy
Biomass is plant and animal matter (e.g. wood, straw, sewage and waste food), or trees grown for fuel.
We can burn biomass to produce heat and electricity.
Geothermal energy
Geothermal energy means the natural heat of the Earth.
Geothermal power stations use heat from deep underground to generate electricity.
Hydrogen fuel cells
Hydrogen fuel cells make 'clean' electricity from hydrogen gas.
They work like batteries, and can power cars or buses.
Solar energy
Solar energy means energy from the sun.
The sun's light and heat can be captured by solar panels and turned into electricity or used to heat water.
Wave energy
Waves are made when wind blows across the sea.
The energy in waves can be used to make electricity by new technology such as the Pelamis wave machine.
Tidal energy
Every day, the tide at the seaside goes in and out, as the sea rises and falls.
Marine turbines can use this movement to generate electric power.
It's Only Natural
See www.dti.gov.uk/renewables/schools

BIOMASS ENERGY





- Biomass is a renewable energy source not only because the energy it comes from the sun, but also because biomass can re-grow over a relatively short period of time;
- Biomass energy comes in many forms. These include burning wood, converting waste into energy, collecting methane for biogas, and using energy crops for biofuels;

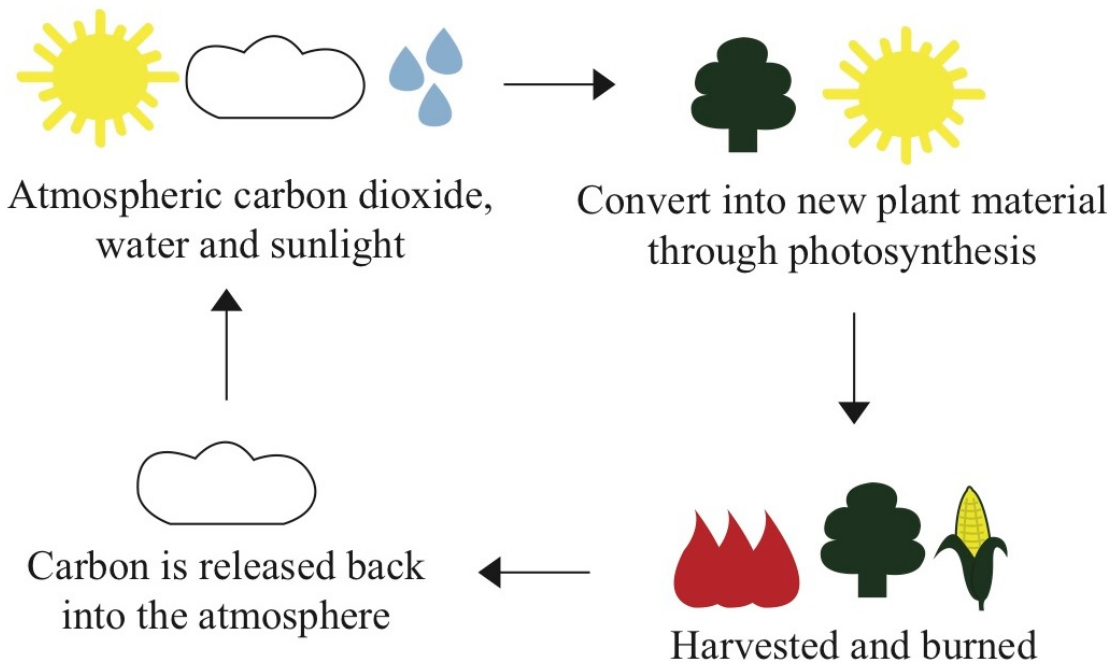
BIOMASS ENERGY SOURCES

- Wood Burning
  - Wood can be burned for electricity production by using the heat to create steam for spinning turbines. Some manufacturing plants even burn their own wood waste (paper, wood scrap, wood chips, sawdust, and bark) to contribute to power needs.

- Waste-to-Energy Plants
  - These plants can make use of heat energy by burning waste to produce steam which spins turbines to generate electricity;
  - Currently, waste-to-energy plants provide about 15 million kilowatt-hours. This is enough electricity to power around 1.5 million homes.

- Biogas Production
  - Biogas comes from microorganisms that digest (break down) organic waste which becomes a mixture of methane gas and carbon dioxide. This is called anaerobic digestion;
  - Biogas contains a much lower percentage of methane than standard natural gas.

Biomass Diagram

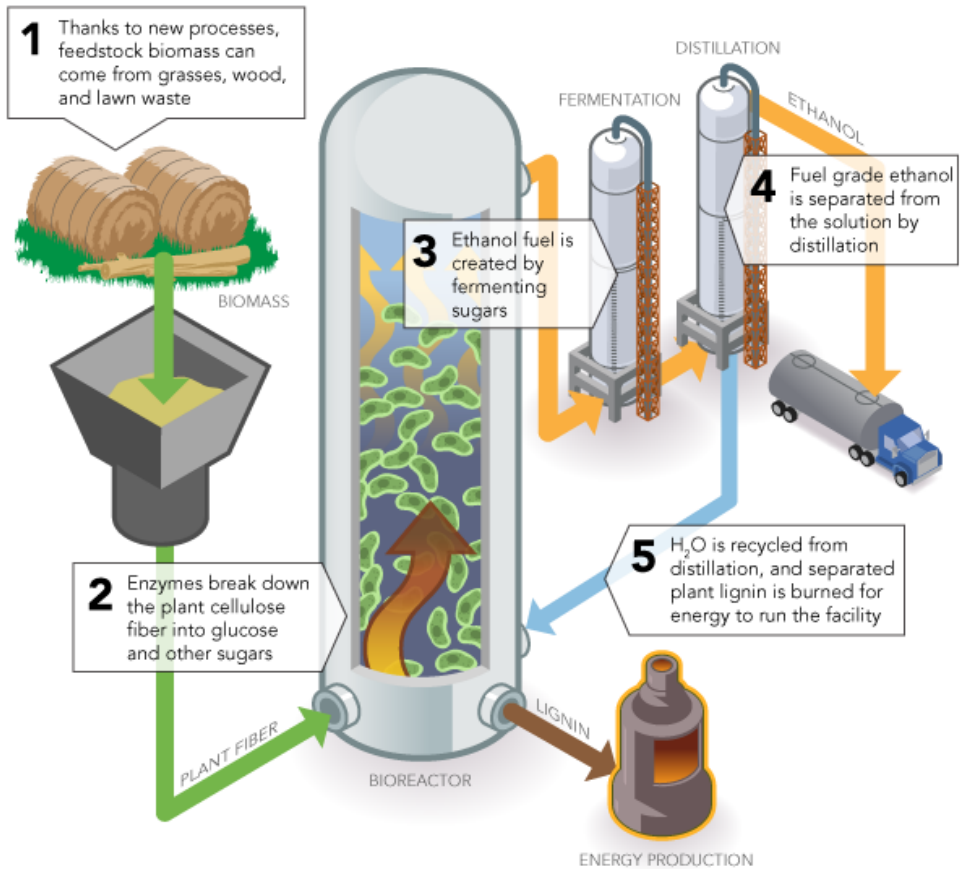


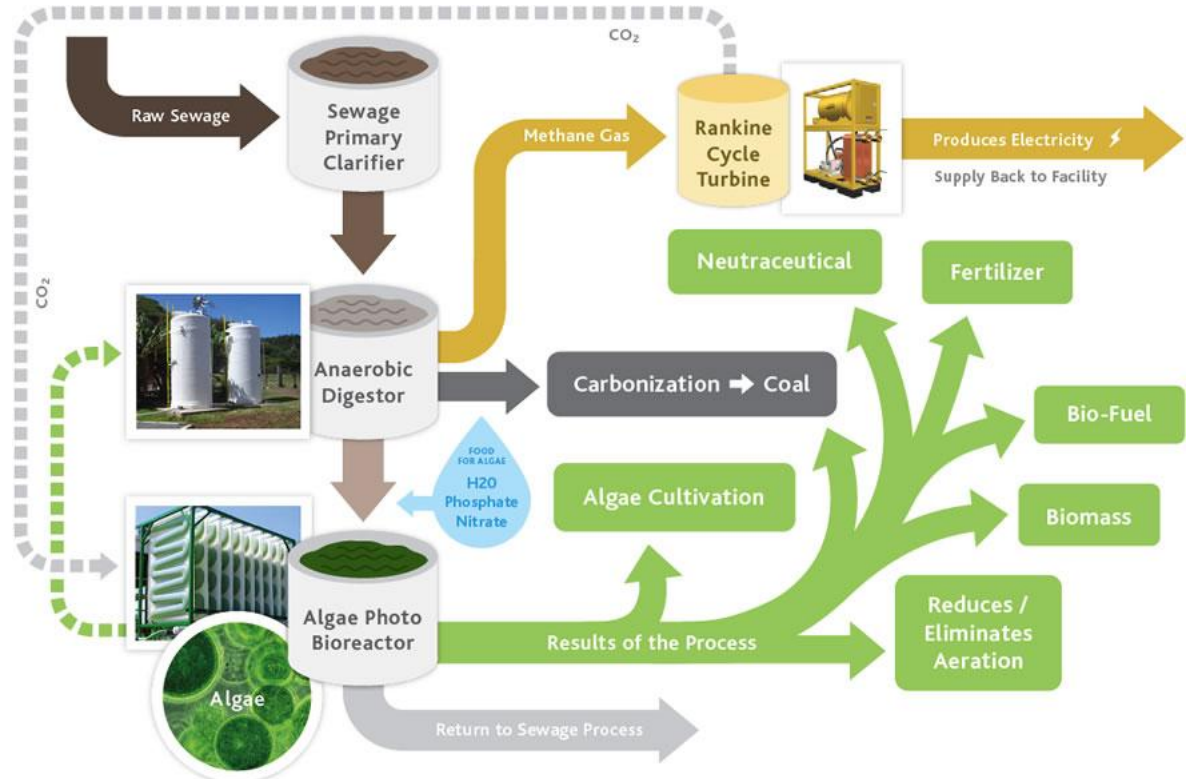
BIOFUEL ENERGY

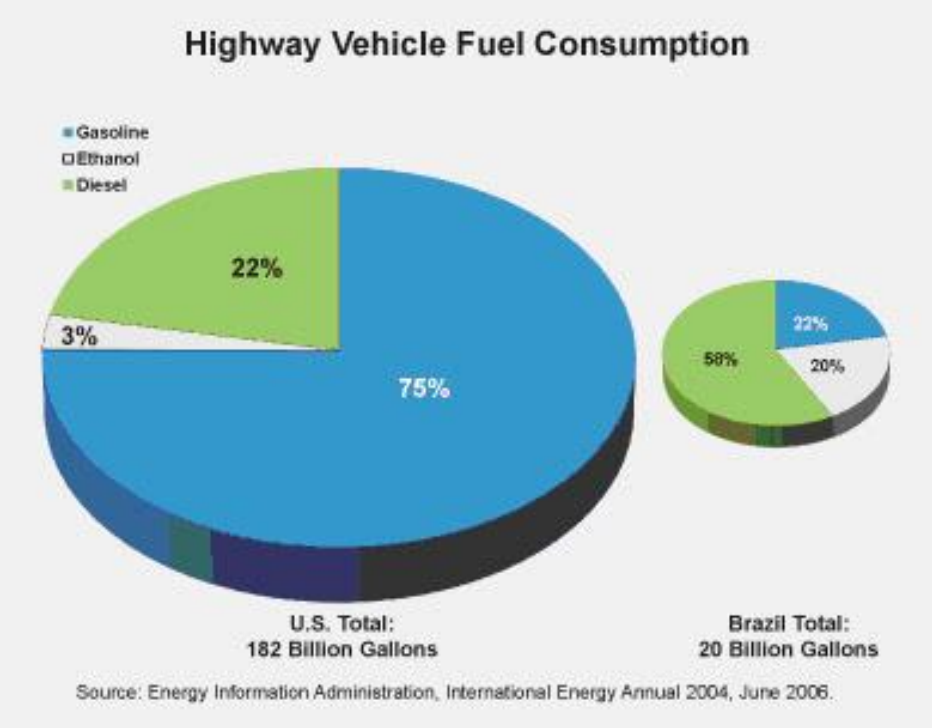
- Biofuels are energy sources made from living things, or the waste that living things produce, eg. sugar cane, corn, cellulose or vegetable oils;
- The strategic goal of biofuel is to supplement or even replace fossil fuels, the amount of which is constantly and rapidly diminishing;

- The most widely spread types of biofuel these days are ethanol and biodiesel;
- The key difference between fossil fuels and modern biofuel energy is that the latter is derived from plants that were alive recently, while coal is derived from biological material that has been dead for hundreds and thousands of years;

Ethanol from Biomass





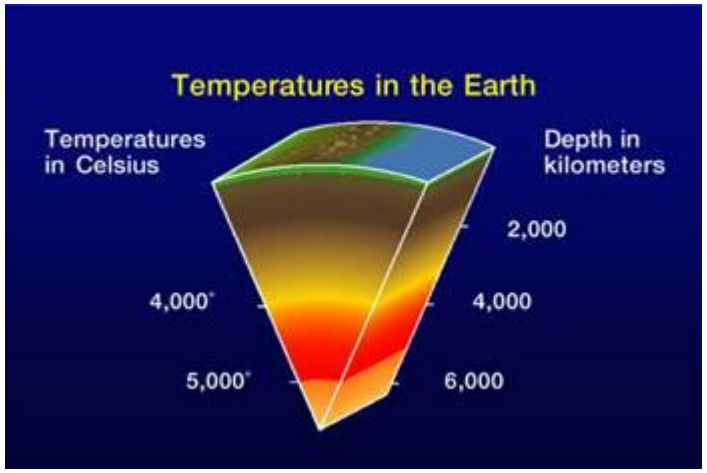


- ✓ Sugar crops (such as sugar cane or sugar beet), or starch (like corn or maize) can be fermented to produce ethanol, a liquid fuel commonly used for transportation;
- ✓ Natural oils from plants like oil palm, soybean, or algae can be burned directly in a diesel engine or a furnace, or blended with petroleum, to produce fuels such as biodiesel;
- ✓ Wood and its byproducts can be converted into liquid biofuels, such as methanol or ethanol, or into woodgas;

GEOTHERMAL ENERGY

- The meaning of “Geo” is Earth and “Thermal” is Heat;
- Geothermal energy is thermal energy generated and stored in the Earth;
- Heat flows outward from the center as a result of radioactive decay;

- Kalina Power Plant in Husavik, Iceland

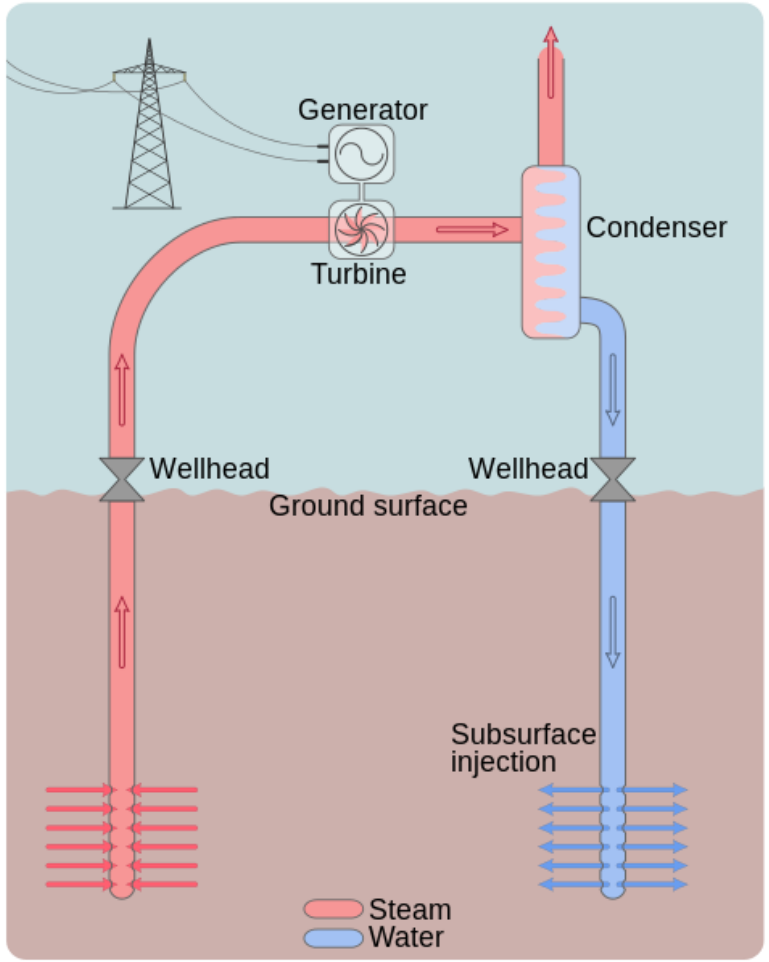


- Temperature at base of crust about 1000C, increasing slowly into the core;

TYPE OF GEOTHERMAL

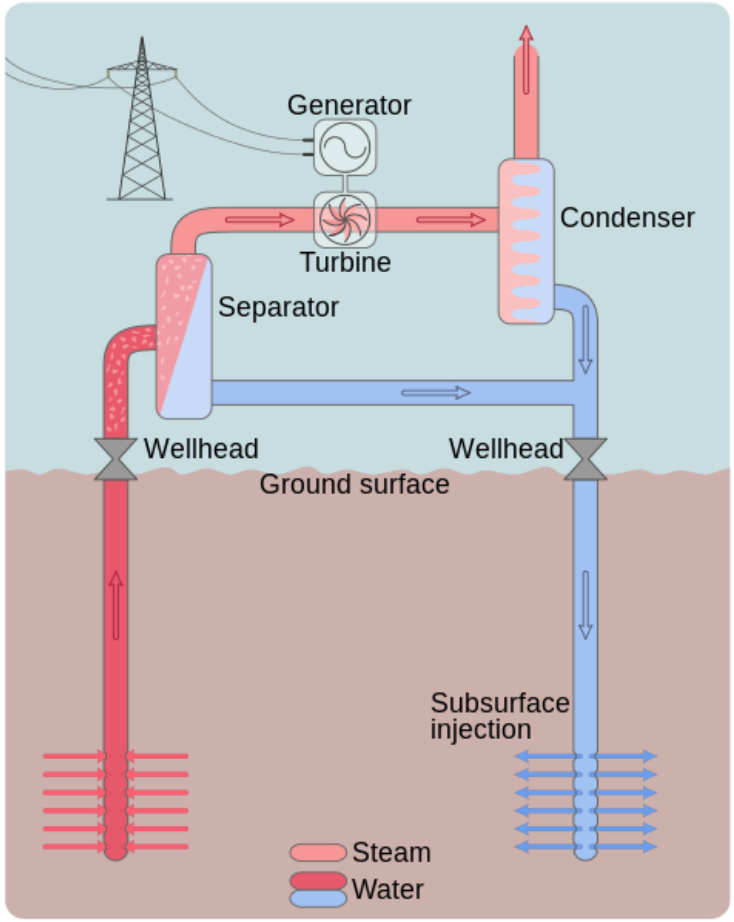
- Dry Steam System
- Wet Steam System
- Binary Cycle System

DRY STEAM SYSTEM

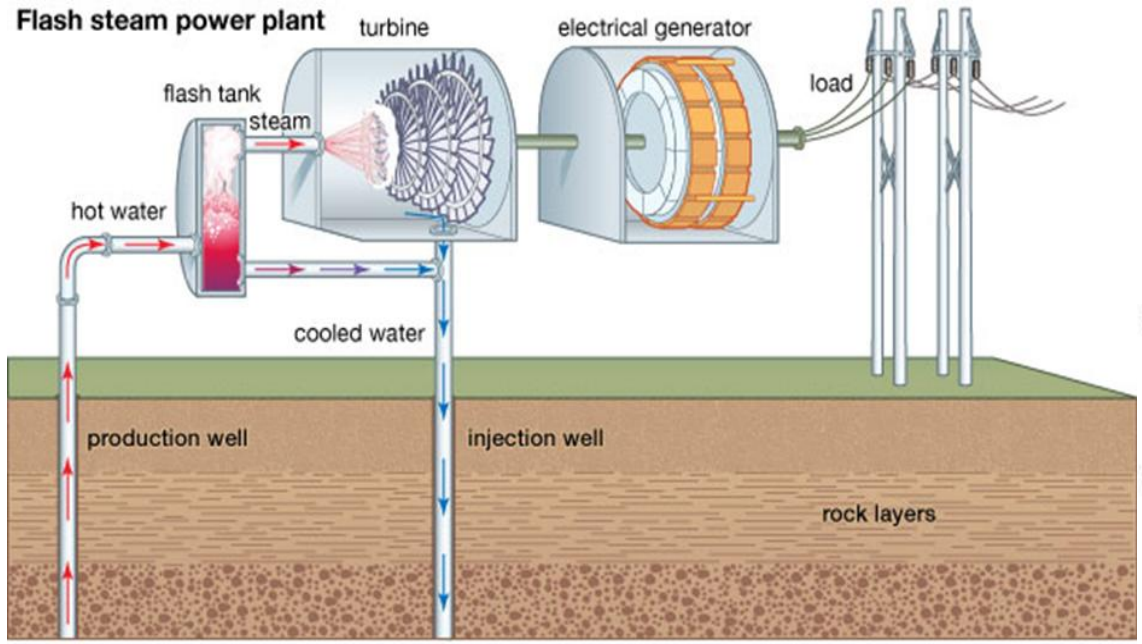


- Dry steam stations are the simplest and oldest design;
- They directly use geothermal steam of 150 °C or greater to turn turbines.

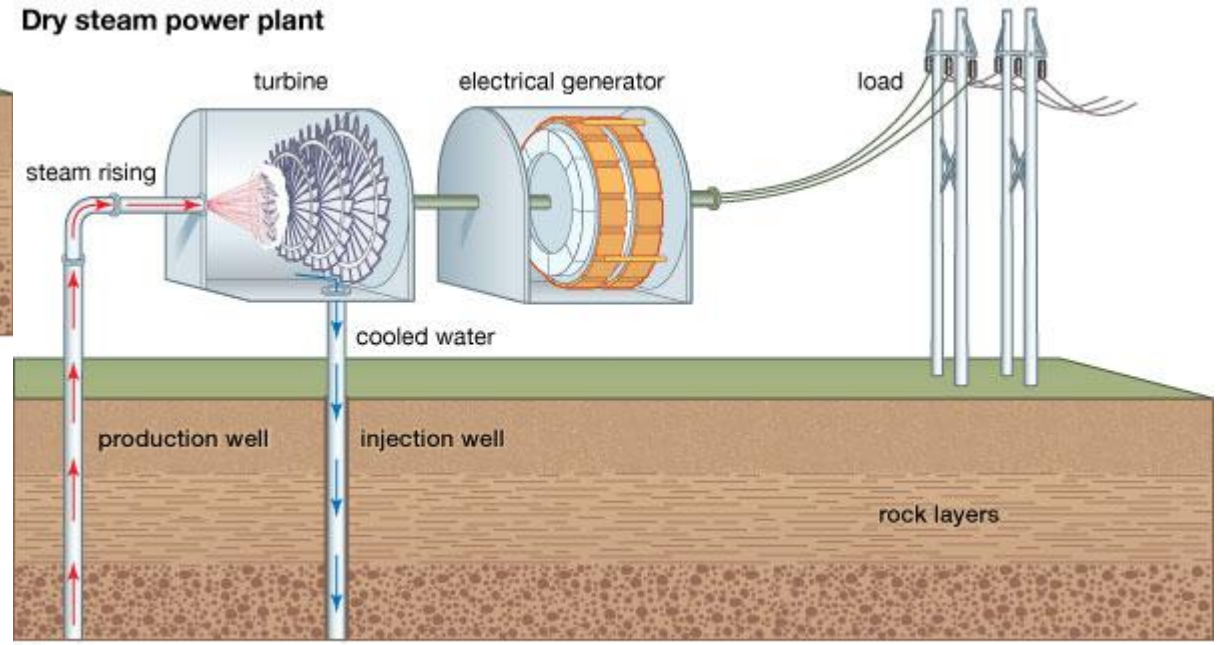
WET / FLASH STEAM SYSTEM



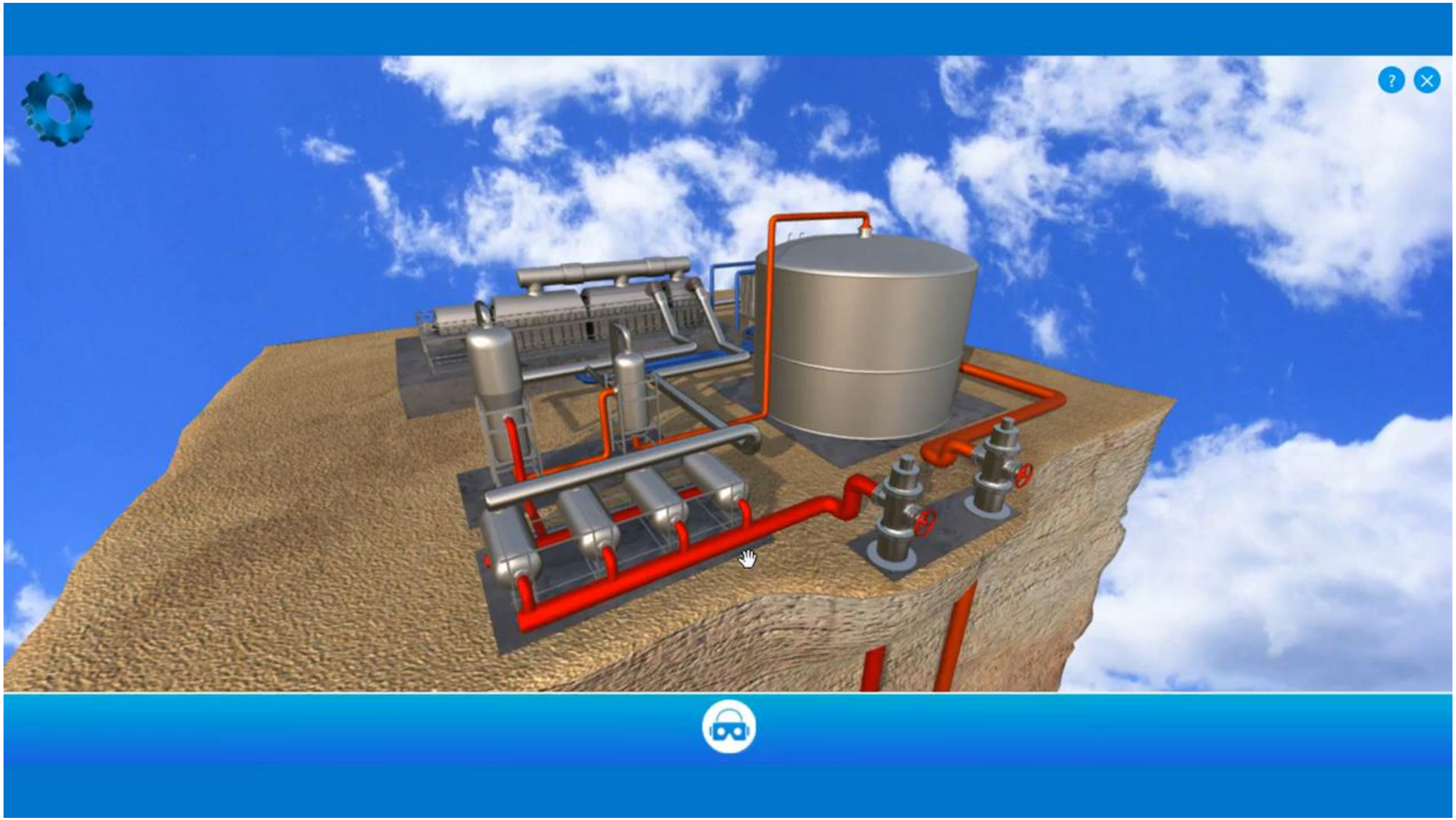
- The hot water flows up through wells in the ground under its own pressure;
- As it flows upward, the pressure decreases and some of the hot water boils into steam;
- The steam is then separated from the water and used to power a turbine/generator;
- Any leftover water and condensed steam may be injected back into the reservoir.



© 2011 Encyclopædia Britannica, Inc.

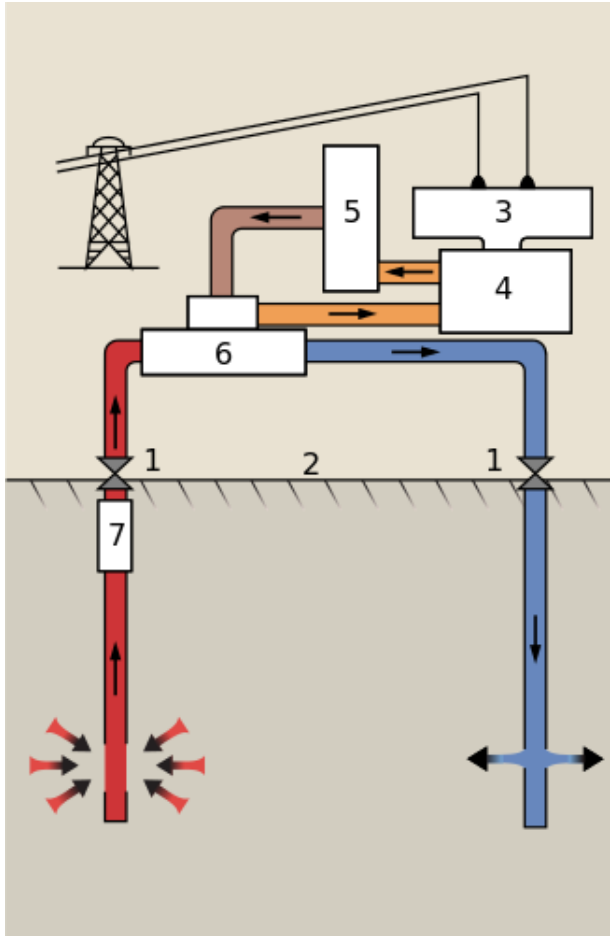


© 2011 Encyclopædia Britannica, Inc.



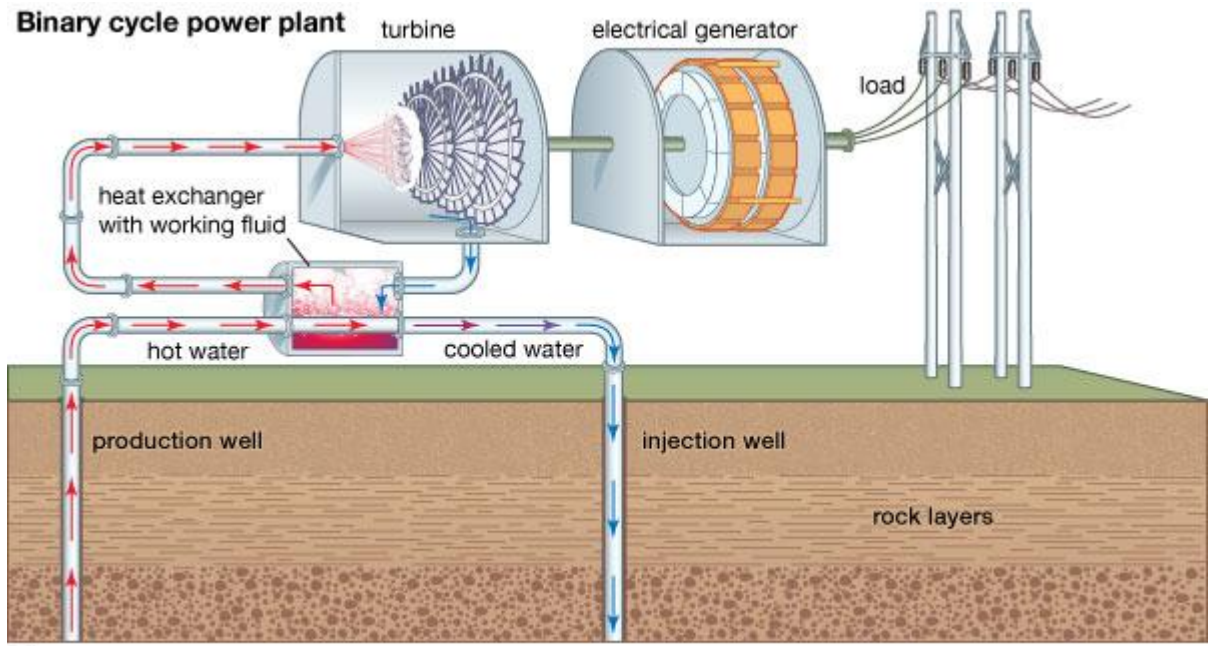
- Binary cycle power stations are the most recent development, and can accept fluid temperatures as low as 57 °C;
- The moderately hot geothermal water is passed by a secondary fluid with a much lower boiling point than water;
- This causes the secondary fluid to flash vaporize, which then drives the turbines;

BINARY CYCLE STEAM SYSTEM

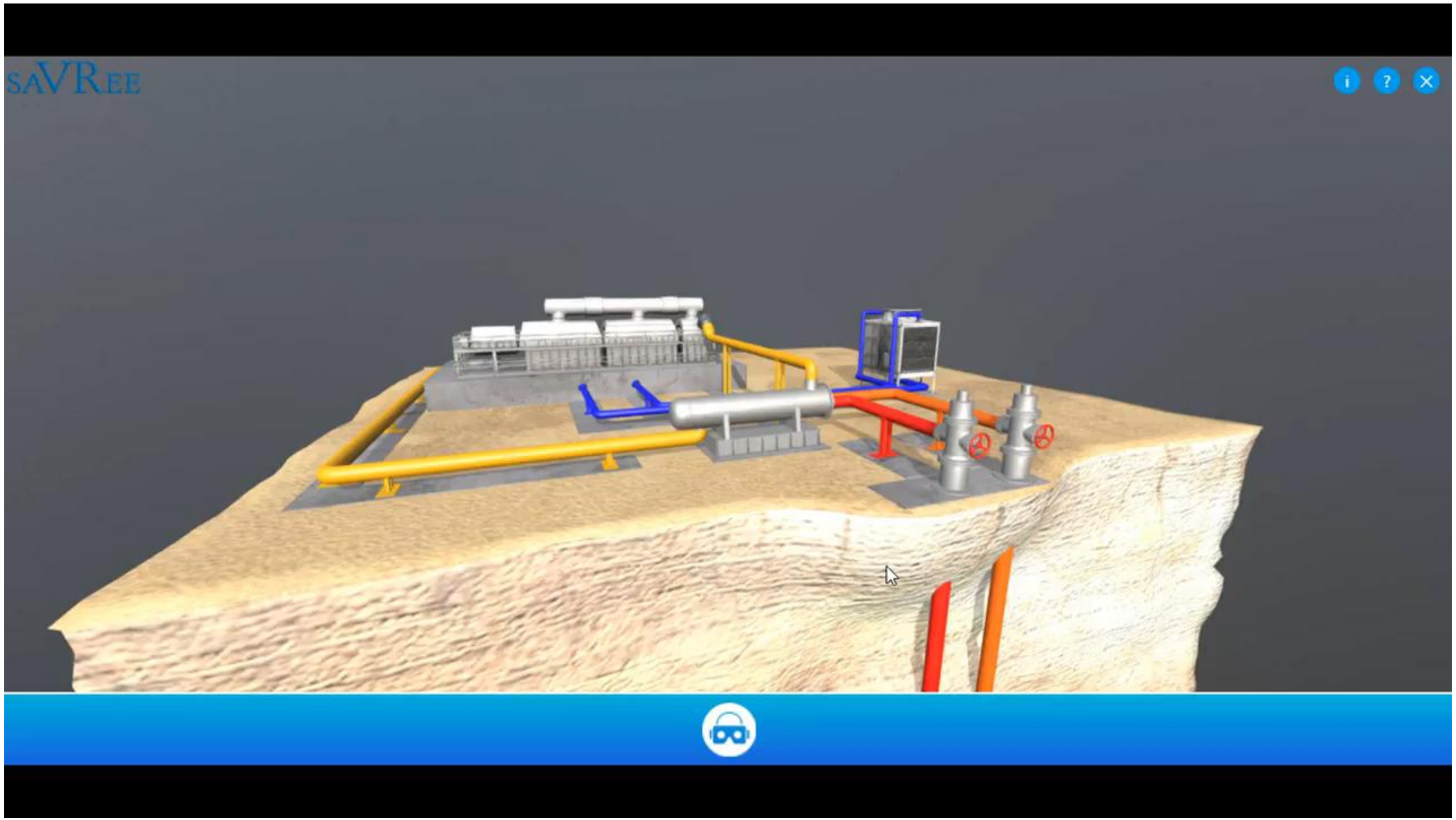


1. Wellheads
2. Ground surface
3. Generator
4. Turbine
5. Condenser
6. Heat exchanger
7. Pump

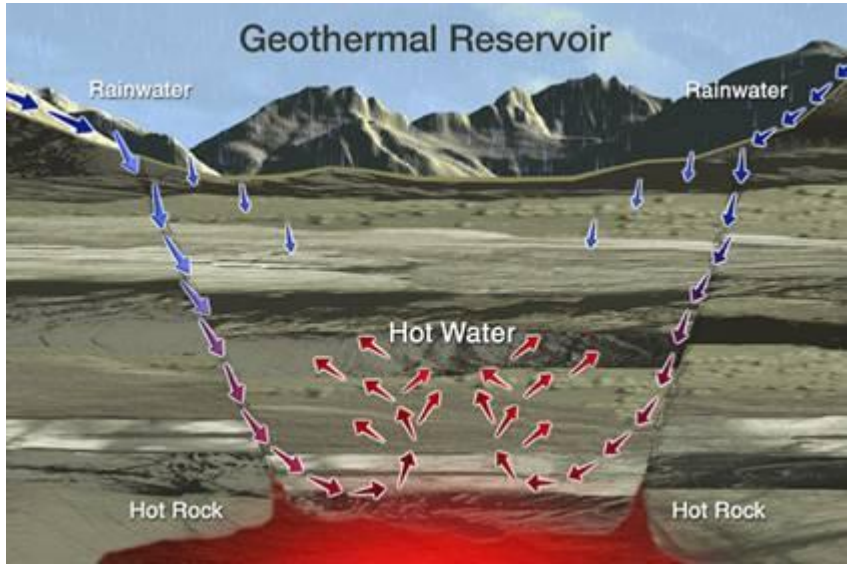
Hot water
Cold water
Isobutane vapor
Isobutane liquid



© 2011 Encyclopædia Britannica, Inc.


saVRee

- Heat from the Earth, or geothermal — Geo (Earth) + thermal (heat) — energy is accessed by drilling water or steam wells in a process similar to drilling for oil;

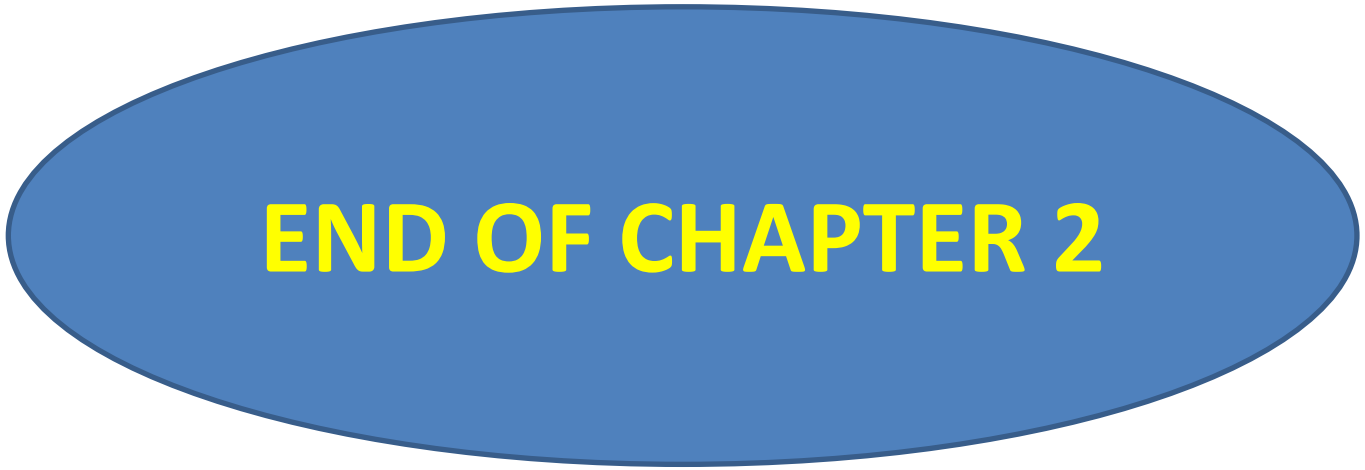


IMPORTANCE OF RENEWABLE ENERGY

- Environmental Benefits
  - Clean sources of energy that have a much lower environmental impact than conventional energy technologies;
- Energy for our children
- Renewable energy will not run out. Ever. Other sources of energy are finite and some day will be depleted;

- Jobs and the Economy
  - Most renewable energy investments are spent on materials and workmanship to build and maintain the facilities, rather than on costly energy imports;
  - Renewable energy technologies developed and built in the United States are being sold overseas, providing a boost to the U.S. trade deficit;

- Improved Public Health and Environmental Quality
  - The air and water pollution emitted by coal and natural gas plants is linked to breathing problems, neurological damage, heart attacks, and cancer;
  - Replacing fossil fuels with renewable energy has been found to reduce premature mortality and lost workdays, and it reduces overall healthcare costs;


END OF CHAPTER 2