Chapter 1: Energy resources

1. Introduction

What is energy?

Energy is life!

Because energy is the source of everything! Nothing can be done without it. To run, to heat, to eat, we always consume energy. It's what allows all living organisms to thrive.

1.1 The 1st secret of energy

- -Energy is the ability to exert force.
- -It's that we obtain a force that allows things to move or transform.
- -it's our fuel to produce something.

1.2 The 2nd secret of energy

It can **neither be created nor destroyed**. Energy has been everywhere in nature since the creation of our planet.

It manifests itself in different ways: the heat and light of the sun, the force of water or wind... But it can be transformed! When we use it, it's not lost, it simply changes form... and name!

1.3 Where does energy come from?

Our main source of energy is the sun.

- The sun is a star. Yes, even if it only shines during the day!
- It's a huge ball of energy. It's almost **109 times bigger than the Earth**. Some of its energy reaches us in the form of light and heat.

2. Energy sources

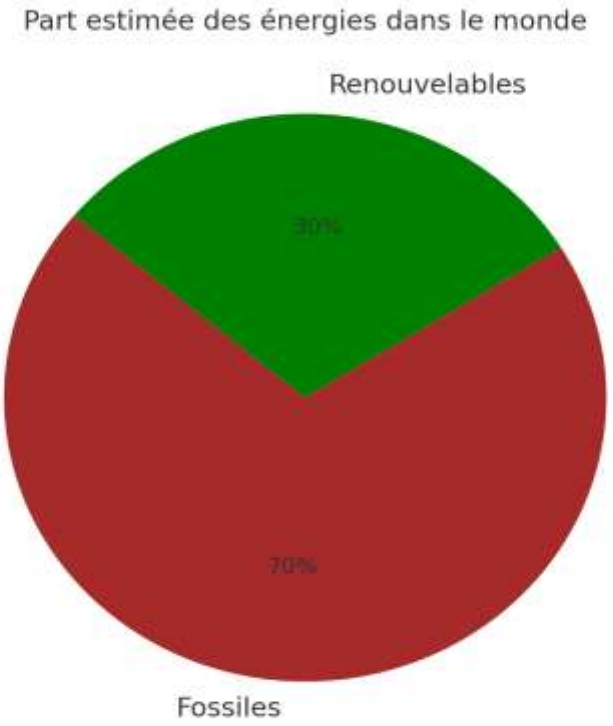
- **Quelles sont les sources d'énergie ?**
- **Renewable and non-renewable energies**
- Non-renewable energies are those that disappear when we use them. They are made up of substances that take millions of years to reconstitute.
- -Renewable energies are those that are almost inexhaustible. But some can also disappear if we don't protect them.

- ***Examples of non-renewable and renewable energies***

Oil produces thermal energy: heat. When the oil is completely consumed, there is no energy left. It's a non-renewable source of energy.

The sun also produces heat. It has been shining for billions of years. It's a renewable source of energy.

Estimated share of energy in the world



3. Non-renewable energies

- There are 2 main types of non-renewable energy: nuclear power and fossil fuels.

3.1 Fossil fuels

Coal, oil and natural gas come from the decomposition of plants and living organisms that have been buried underground. **Resources diminish** when they are used, as they take millions of years to form.

3.1.1 Oil

- -Although oil is a fossil fuel "rediscovered" in the 19th century, it has always been present in nature.
- Biblical texts already refer to it as "bitumen". For a long time, it was used to waterproof boat hulls.

- -Since ancient times, it has been spotted in the Middle East and other parts of the world when it oozes from the surface of the soil.
- -But no one suspected, until 1859, that it would become a source of energy capable of sparking a veritable industrial revolution and bringing humanity into the modern age.

a / The chemical composition of oil

- -Petroleum is a mixture of hydrocarbons and molecules called resins and asphaltenes, which also contain other atoms, mainly sulfur, nitrogen and oxygen.
- Some of these constituents are, at ambient temperature and pressure, gaseous (methane, propane, etc.), liquid (hexane, heptane, octane, benzene, etc.) and sometimes solid (kerosenes, asphalts, etc.).

b/ The intrinsic qualities of oil

Compared to other sources of energy used by man before its discovery:

- -First and foremost, it's a dense energy source: it offers a large amount of energy in a small volume.
- -It's also a liquid energy source: easy to pump, store, transport and use.

c/ What's the point of oil?

From the 1950s onwards, oil became the world's leading source of energy.

- -Its high energy density makes it the raw material for fuels used in transport (cars, lorries, planes, etc.).
- -It is also an irreplaceable raw material used by the petrochemical industry for countless everyday products, including plastics, paints, dyes and cosmetics.

- Oil is also used as a fuel for domestic heating and as a source of heat in industry.

Note:

As a result of the oil crises of 73 and 79, nuclear power and natural gas became increasingly important in electricity generation. Today we are also seeing increased use of coal for electricity generation.

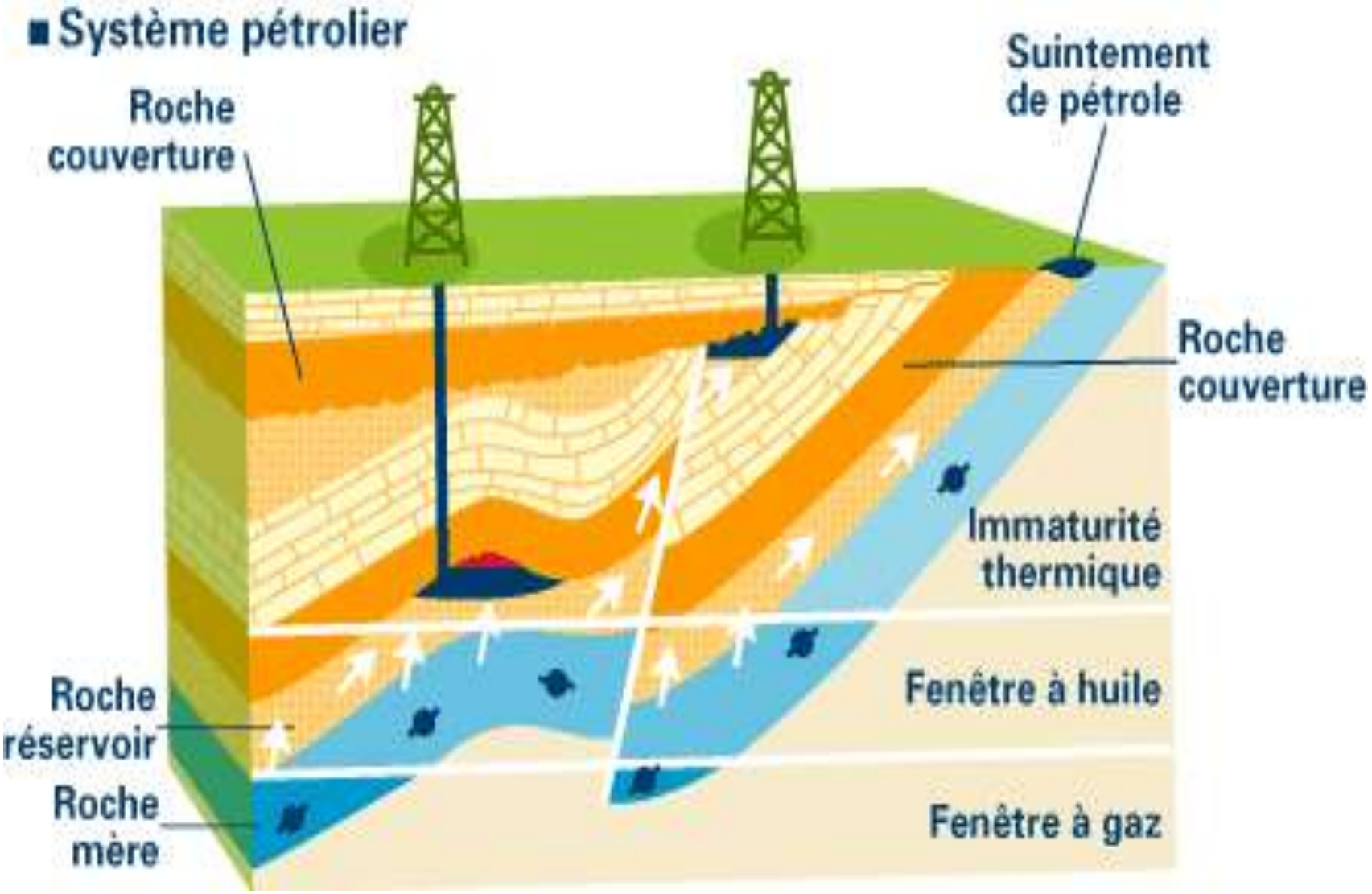
d/ How is oil formed?

- -It results from the thermal degradation of organic matter contained in certain rocks: the "source rocks" of oil.
- -**Source rocks**: The fossilised remains of aquatic or terrestrial plants and bacteria that accumulate at the bottom of oceans, lakes or deltas. Known as "kerogen", these organic residues are preserved in oxygen-free environments, mixing with mineral sediments to form the source rock.

-Over tens of millions of years, new sediments will continue to accumulate, dragging the source rock to great depths.

Generally between 2,500 and 5,000 metres, the high temperatures in these areas transform the kerogen (thermal cracking) into liquid petroleum accompanied by gas.

At depths of more than 5,000 metres, the oil "cracks" and is transformed into gas.


Système pétrolier
Roche couverture
Suintement de pétrole
Roche couverture
Immaturité thermique
Fenêtre à huile
Roche réservoir
Roche mère
Fenêtre à gaz

3.1.2 Natural gas

- -Like oil, natural gas is a fossil fuel or primary energy, and is not produced by transforming other energy sources.
- -It too is formed from the decomposition of organisms on the ocean floor. Lighter than oil, it is the lightest of the hydrocarbons.

a/ Chemical of natural gas

- -The main component of natural gas deposits is methane. Methane is a hydrocarbon composed of one carbon atom and four hydrogen atoms.

- -In order to be usable, natural gas may require operations to eliminate impurities (acids, carbon dioxide and hydrogen sulphide) presented with the gas as it leaves the well.
- -In all cases, it must be dehydrated (dried out).

b/ The intrinsic qualities of natural gas

- -This is mainly due to its energy efficiency and environmental benefits:

  Its combustion emits no dust, little sulphur dioxide (SO 2), little nitrogen oxide (NO 2) and less carbon dioxide (CO 2) than other fossil fuels.

- -What's more, the volume it occupies can be reduced by liquefying it.
- -it is colourless and odourless, but "odorised" so that it can be detected.

c/ The different uses of natural gas

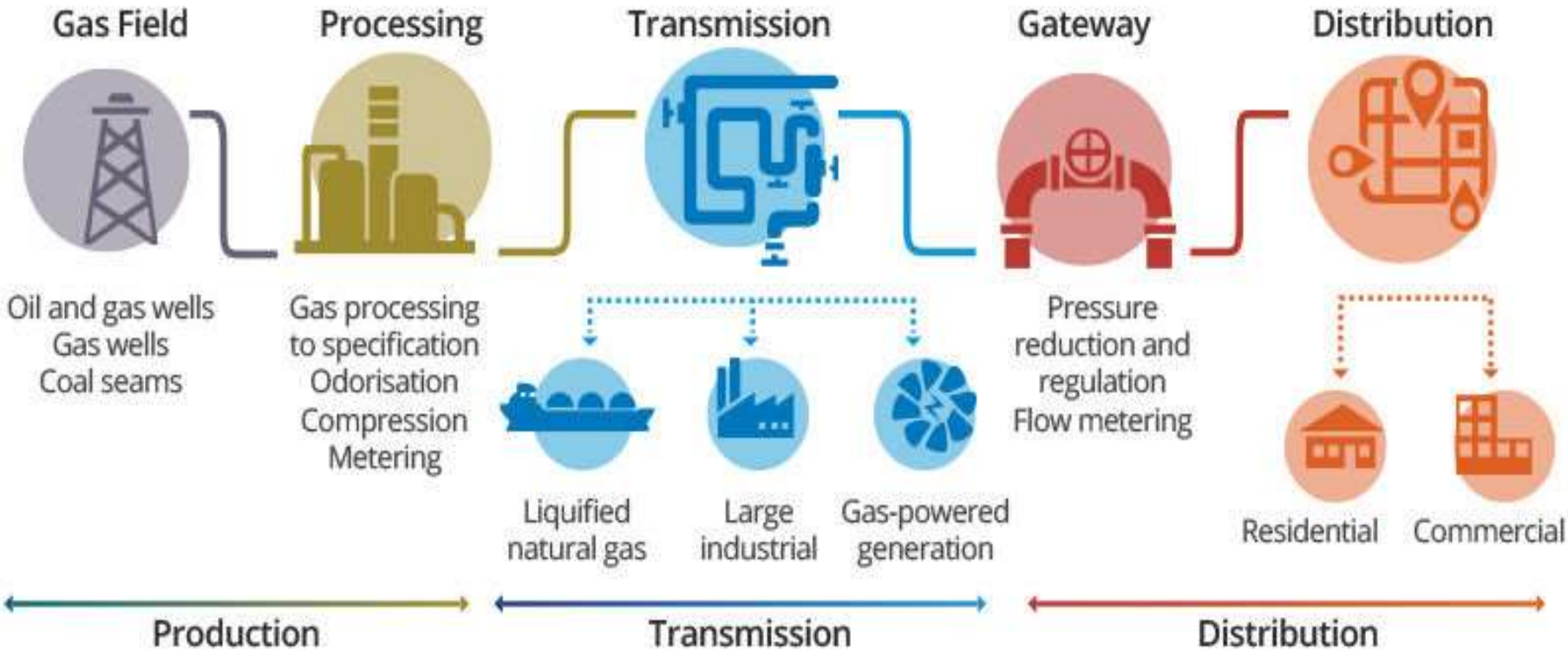
- -It is best known for its domestic use in heating and cooking.
- But natural gas is also being used in other areas, such as power stations and transport, because of its environmentally-friendly qualities.

d/ Extraction, production and processing, 3 key stages*.

- -Like oil, natural gas can be extracted from land or sea. Before it is delivered to the consumer, it undergoes several stages of processing.

- -It is first extracted from the reservoir rock and transported by pipeline to the treatment plants.
- -Next, a purification system eliminates by-products (nitrogen, carbon dioxide, helium, etc.) that are extracted with the gas but are not combustible, la chaine gaziere

NATURAL GAS SUPPLY CHAIN



Source: AEMO

3.1.3 The charbon (Coal)

- -Strongly associated with the Industrial Revolution, coal is often seen as an energy of the past.
- -Yet it remains the second most important source of primary energy in the world, and the leading source of electricity.

- -Its main advantage is that it offers abundant reserves and prices that are more stable and inexpensive than those of oil and gas.

  Today, its use has shifted from Europe to Asia, which has immense reserves.

a/ Where does coal come from?

- -The formation of coal in the subsoil dates back to the primary era known as the Carboniferous, 200 to 300 million years ago.
- -This is due to a profound transformation of plant organic matter,
- -Plant debris ferments under sediments, is superimposed in an atmosphere rich in carbon dioxide and is transformed into solid combustible substances (sedimentary rocks containing at least 50% carbon).

b/ How is it extracted?

- -There are 2 methods of coal mining, depending on the geological configuration of the deposit.
- -Open-cast mining is used when the deposit is shallow. Open-cast mines are amphitheatres similar to quarries.
- -Underground mining: this is used when the coal lies deep underground.

3.2 Nuclear energy

- Nuclear energy is produced by the nuclei of atoms undergoing transformations: these are nuclear reactions.
- Nuclear energy emerged in the late 1930s with the discovery of the fission reaction.
- However, it was not until December 1953, in the midst of the Cold War, that nuclear energy was used for civilian purposes.

a/ The principle

- Nuclear energy is produced through the fission of uranium atoms. The atom is made up of a nucleus composed of two elements: neutrons and protons.
- When a neutron collides with a nucleus, the nucleus splits into two and releases other neutrons and heat.

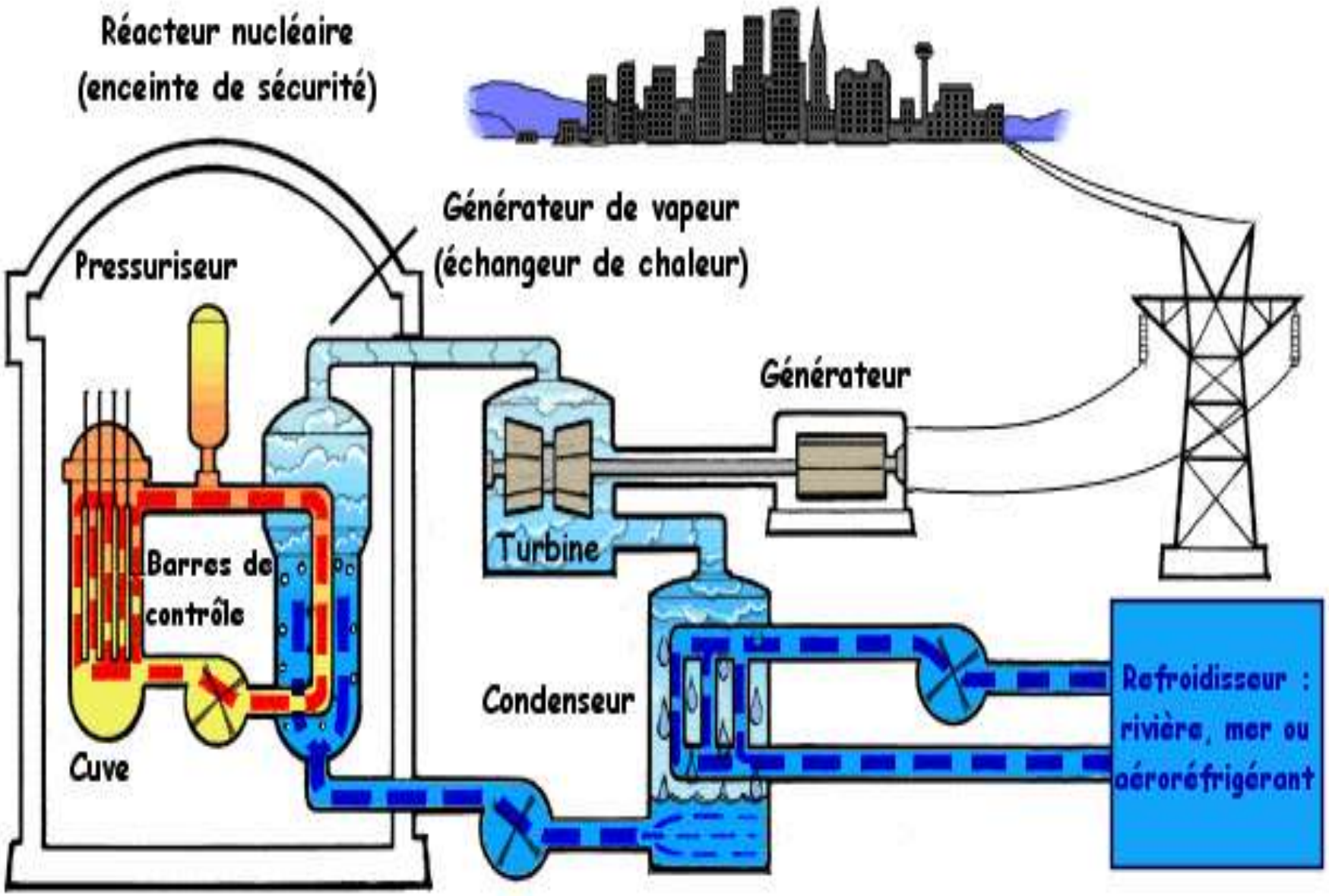
- These neutrons will in turn collide with other nuclei. This is **a huge chain reaction** that releases a large amount of heat and creates steam. This steam will be used to turn turbines to generate electricity.

b/ Nuclear power stations

Nuclear power stations: the nuclear reactors are located in the four cylindrical buildings in the centre left of the image. The four cooling towers on the right release water vapour (non-radioactive), produced to maintain the cold source of the thermal machine generating electricity.

- Nuclear power stations also use thermodynamic conversion cycles: in the nuclear reactor, the energy obtained from the fission reaction of uranium and plutonium is the source of heat used.
- A primary circuit cools the reactor and transfers the heat released to a steam generator (boiler) which produces the steam that powers the steam turbine.
- Currently, nuclear power stations generate approximately 15% of the world's electricity. They do not emit carbon dioxide (CO2), but they do produce radioactive waste, which must be contained.

principe d'une centrale nucléaire



4. Renewable energies

- The continuous increase in the price of fossil fuels, combined with the issue of global warming, is promoting the growth of renewable energies.

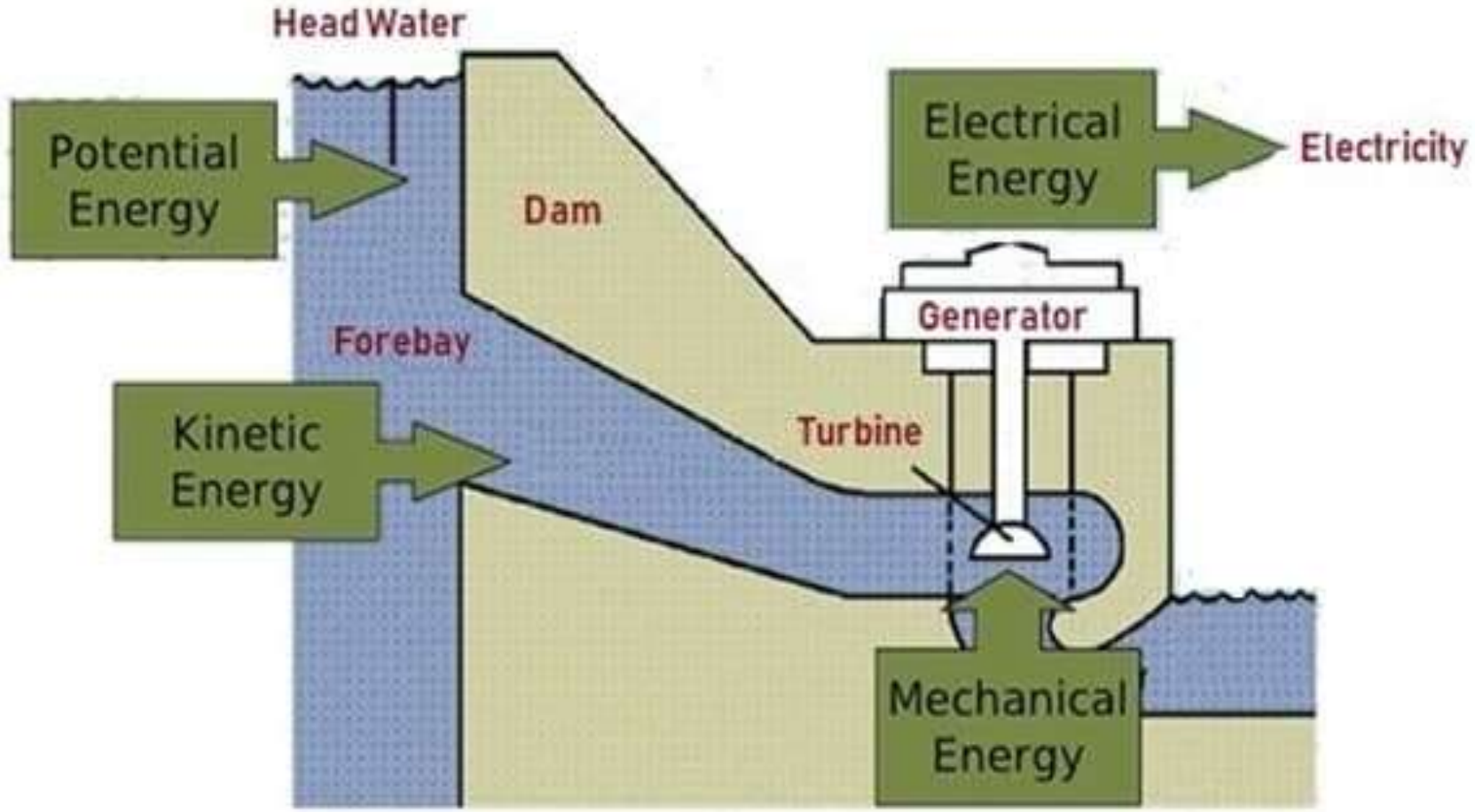
4.1 Hydropower

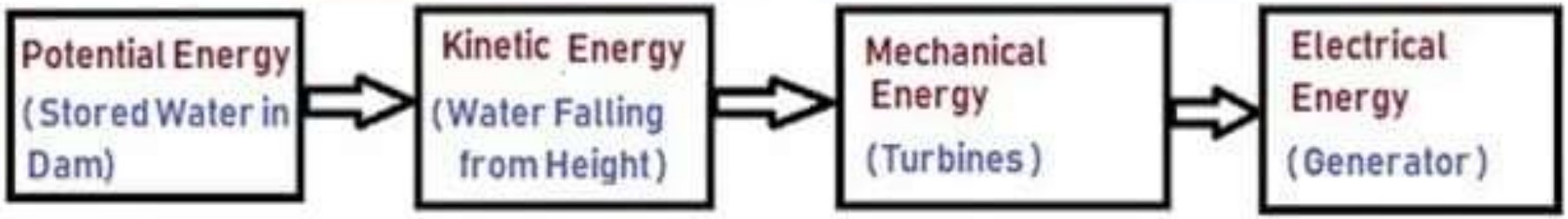
- **a/ Définition**

- Hydropower is a renewable energy source derived from the **driving force of water**. Several technologies can be used to harness the energy produced by falling or moving water. Water wheels can convert it directly into mechanical energy (water mills), while turbines and hydroelectric power plants convert it into electricity.•

b/ The principle :

- A hydroelectric power plant consists of three parts: the **dam** that holds back the water, **the power plant** that generates electricity, and the **power lines** that carry the electrical energy away. The amount of hydraulic energy, and therefore the electricity generated by the plant, depends on the **flow of the river and the height of the waterfall.**


Head Water
Potential Energy
Dam
Electrical Energy
Electricity
Generator
Forebay
Kinetic Energy
Turbine
Mechanical Energy

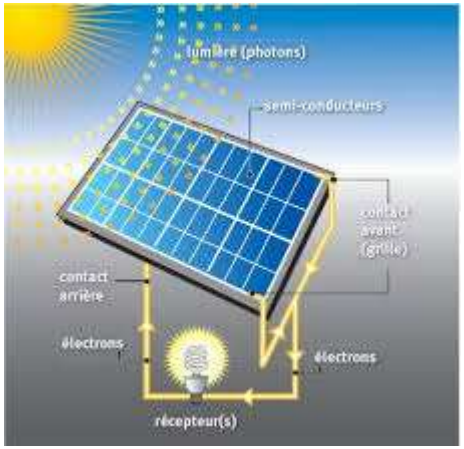

Potential Energy (Stored Water in Dam)
Kinetic Energy (Water Falling from Height)
Mechanical Energy (Turbines)
Electrical Energy (Generator)

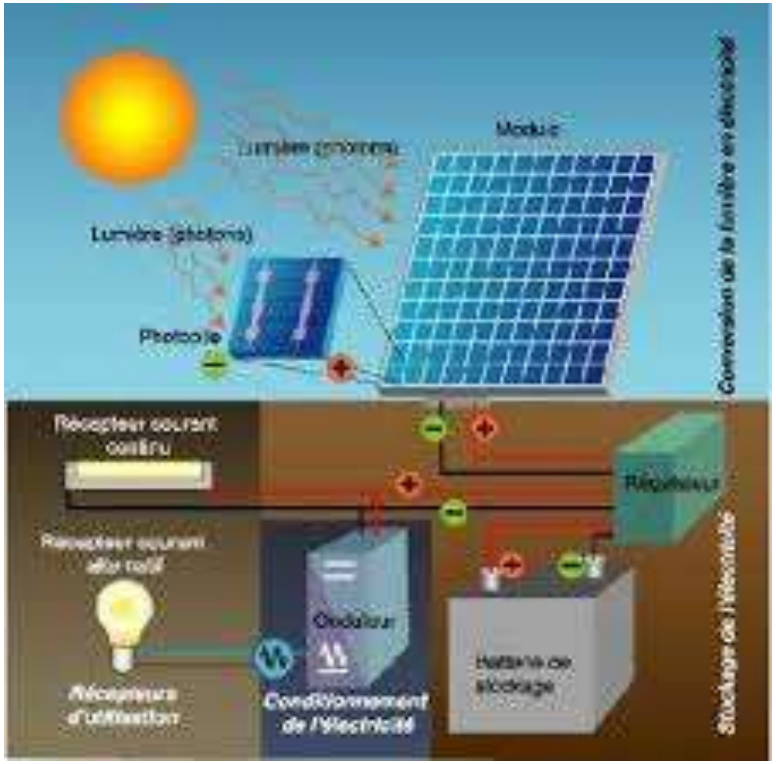
4.2 Solar energy

- **a/ Définition**
- This term refers to the energy provided by the sun's rays. The sun is the most powerful source of energy, and this energy is free—all we have to do is harness it! Solar energy comprises two sectors: the photovoltaic sector for producing electricity and the thermal sector for producing heat.•

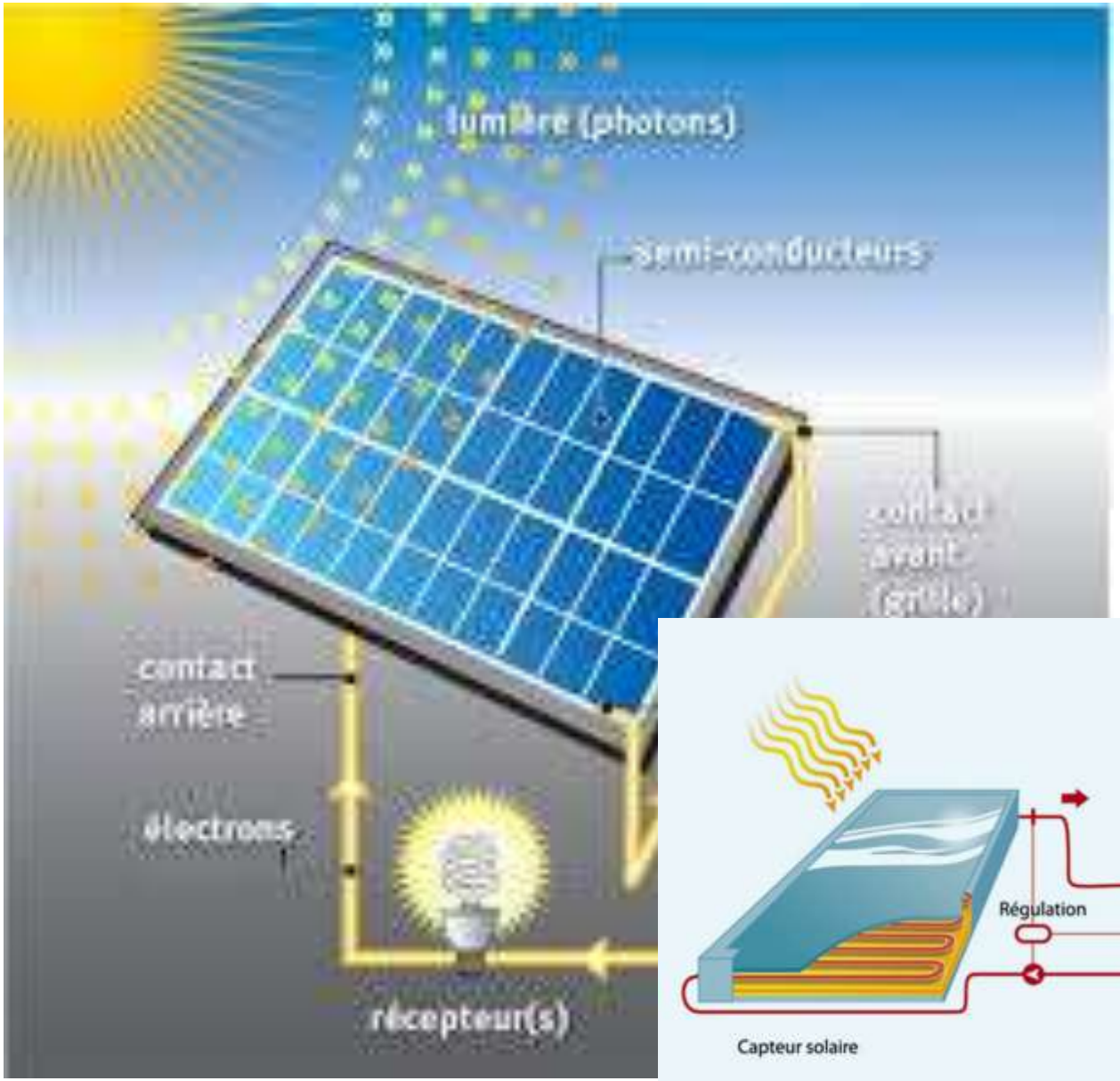
b/ The principle:

- Photovoltaic solar energy has the advantage of directly converting the sun's energy into electricity.Sun rays strike photovoltaic cells made of semiconductor material (usually silicon). The light causes **electrons to move within the material**, thus producing an **electric current**. This electricity is then used directly for household needs, stored in batteries, or fed into the public electricity grid.


lumière (photons)
semi-conducteurs
contact avant (grille)
contact arrière
électrons
électrons
récepteur(s)


Module
Lumière (photons)
Photons
Récepteur courant continu
Réseau
Récepteur courant alternatif
Onduleur
Conditionnement de l'électricité
Batterie de stockage
Récepteurs d'utilisation
Stockage de l'électricité

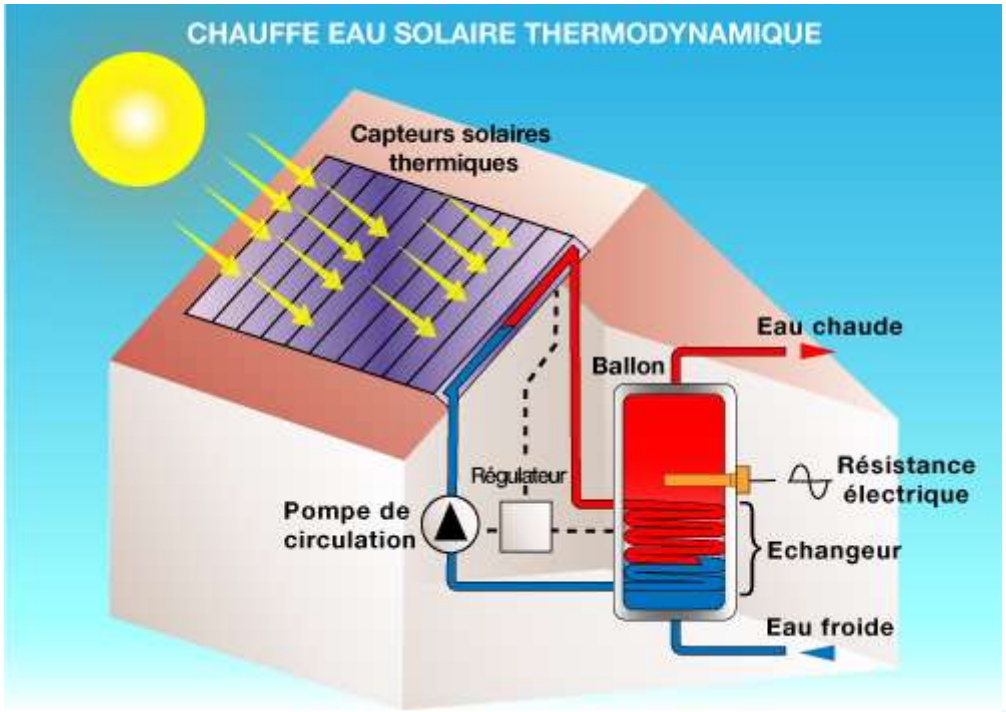

Réseau
Compteur production
Compteur consommation
Champ photovoltaïque
Onduleur

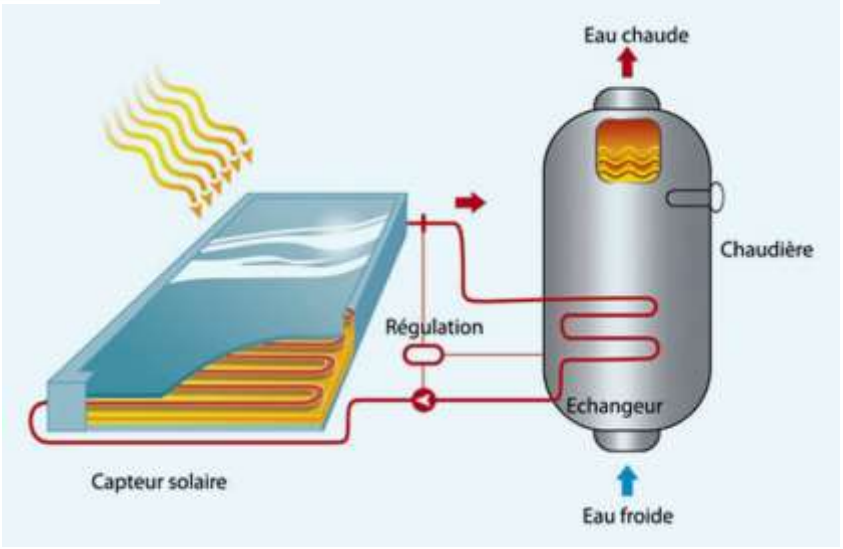

lumière (photons)
semi-conducteurs
contact
avant
(grille)
contact
arrière
électrons
récepteur(s)

Eau chaude
Chaudière
Régulation
Echangeur
Capteur solaire
Eau froide

Solar collectors:

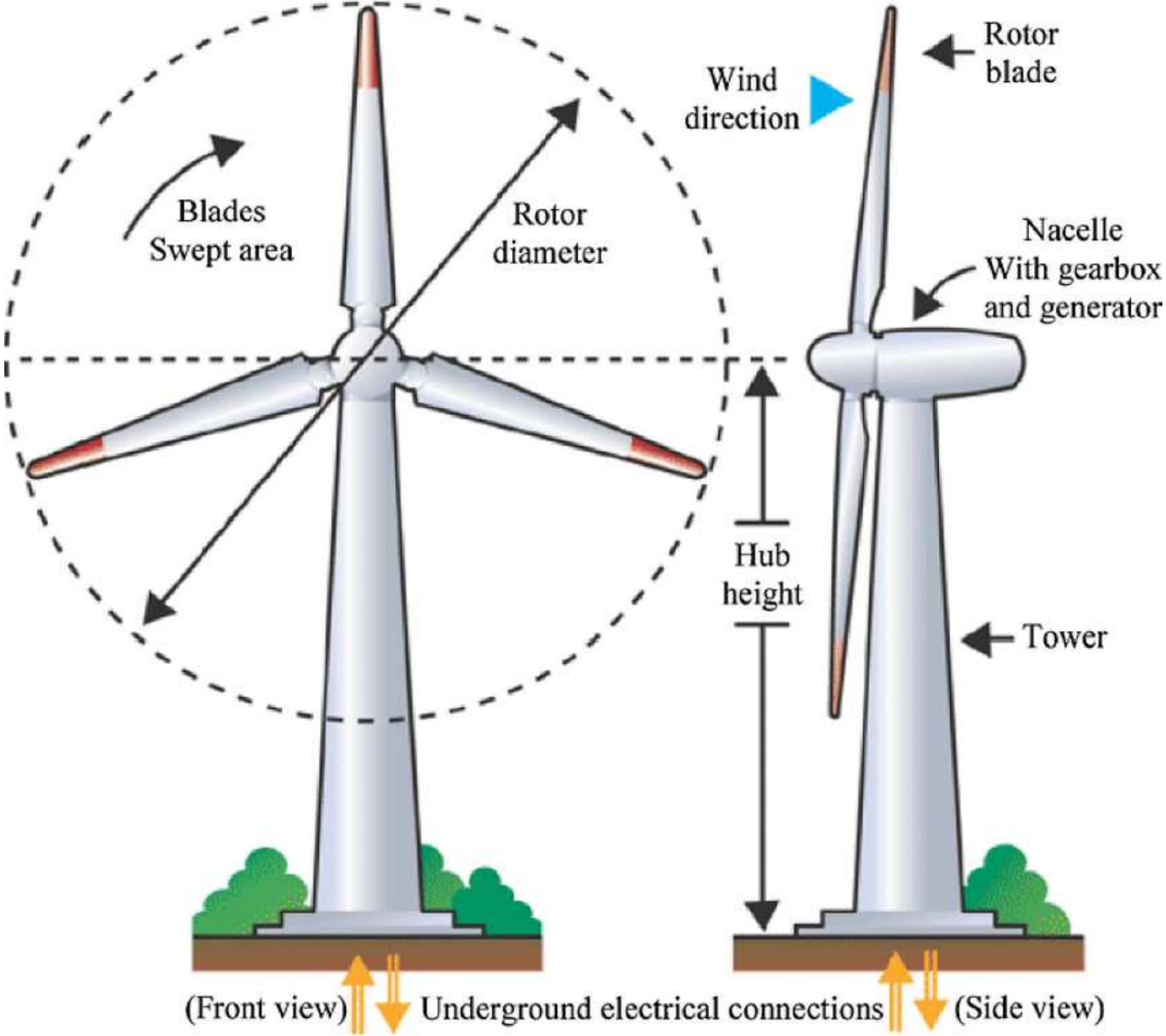
- Sensors absorb solar photons and convert them into heat. This heat is then transferred to a liquid or gas, which transports it to an energy storage tank.
- Solar thermal energy is mainly used for heating water (for domestic use or swimming pools) or buildings. In Europe, solar hot water accounts for 90% of the solar thermal market.


CHAUFFE EAU SOLAIRE THERMODYNAMIQUE
Capteurs solaires thermiques
Eau chaude
Ballon
Résistance électrique
Régulateur
Pompe de circulation
Echangeur
Eau froide


Eau chaude
Chaudière
Régulation
Echangeur
Capteur solaire
Eau froide

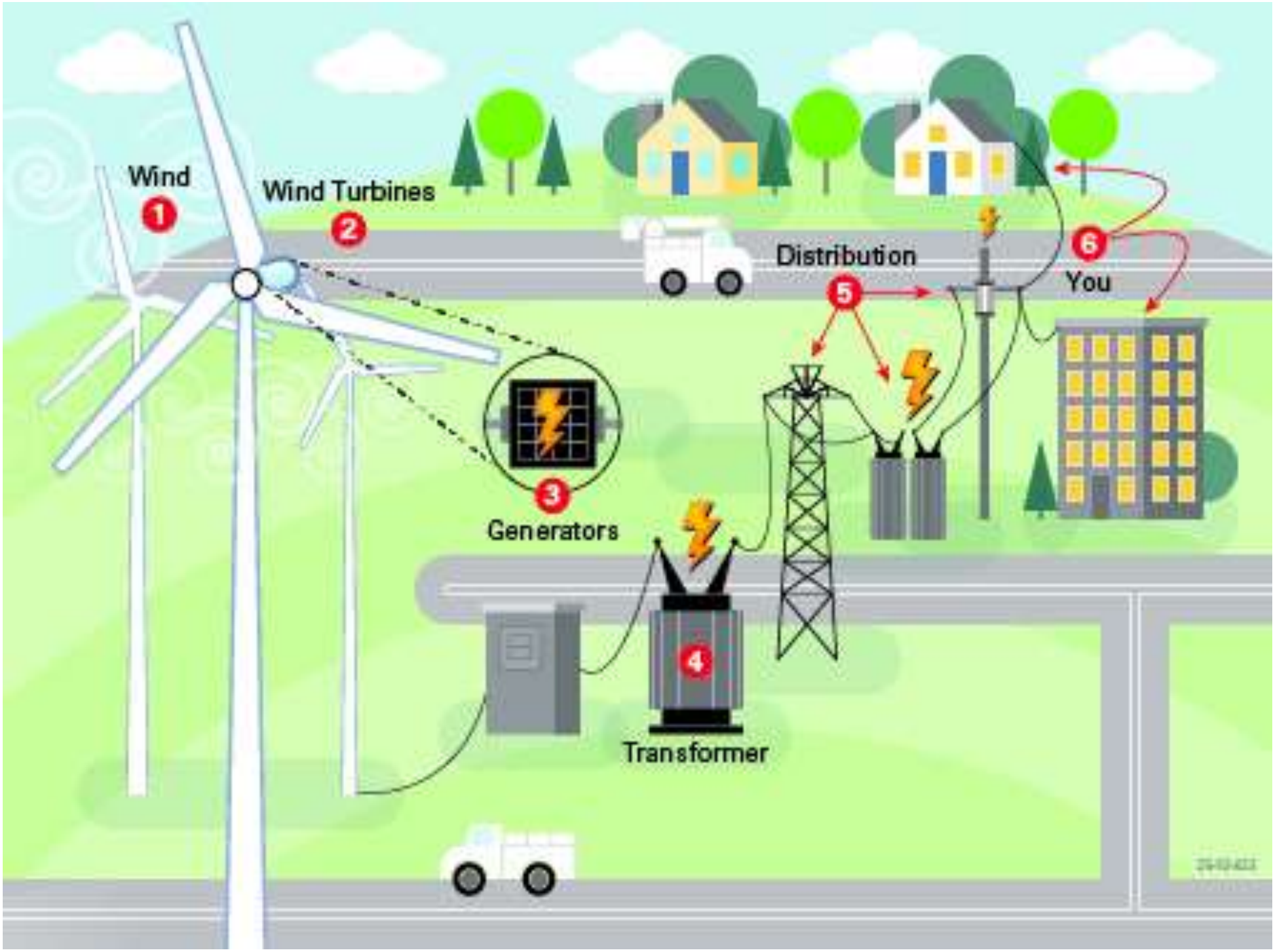
4.3 Wind energy

- **a/ Définition**
- Wind energy is produced by the **force exerted by the wind on the blades of a propeller**. This propeller is mounted on a mast 50 to 110 meters high, and the diameter of the circle swept by the 3 blades varies from 40 to 120 meters.


Blades
Swept area
Rotor
diameter
Wind
direction
Rotor
blade
Nacelle
With gearbox
and generator
Hub
height
Tower
(Front view)
Underground electrical connections
(Side view)

b/ The principle

- The wind turns the blades at a speed of between 10 and 25 revolutions per minute. The **mechanica**l energy produced is **converted** by a generator into electrical energy, the amount of which depends on the surface area swept. This energy is distributed to the grid via a transformer.


Wind
1
Wind Turbines
2
Generators
3
Transformer
4
Distribution
5
You
6

c/ Wind energy around the world

- Wind energy is evidently ideal for windy regions such as coastlines, deserts, and mountain ridges.

4.4 Geothermal energy

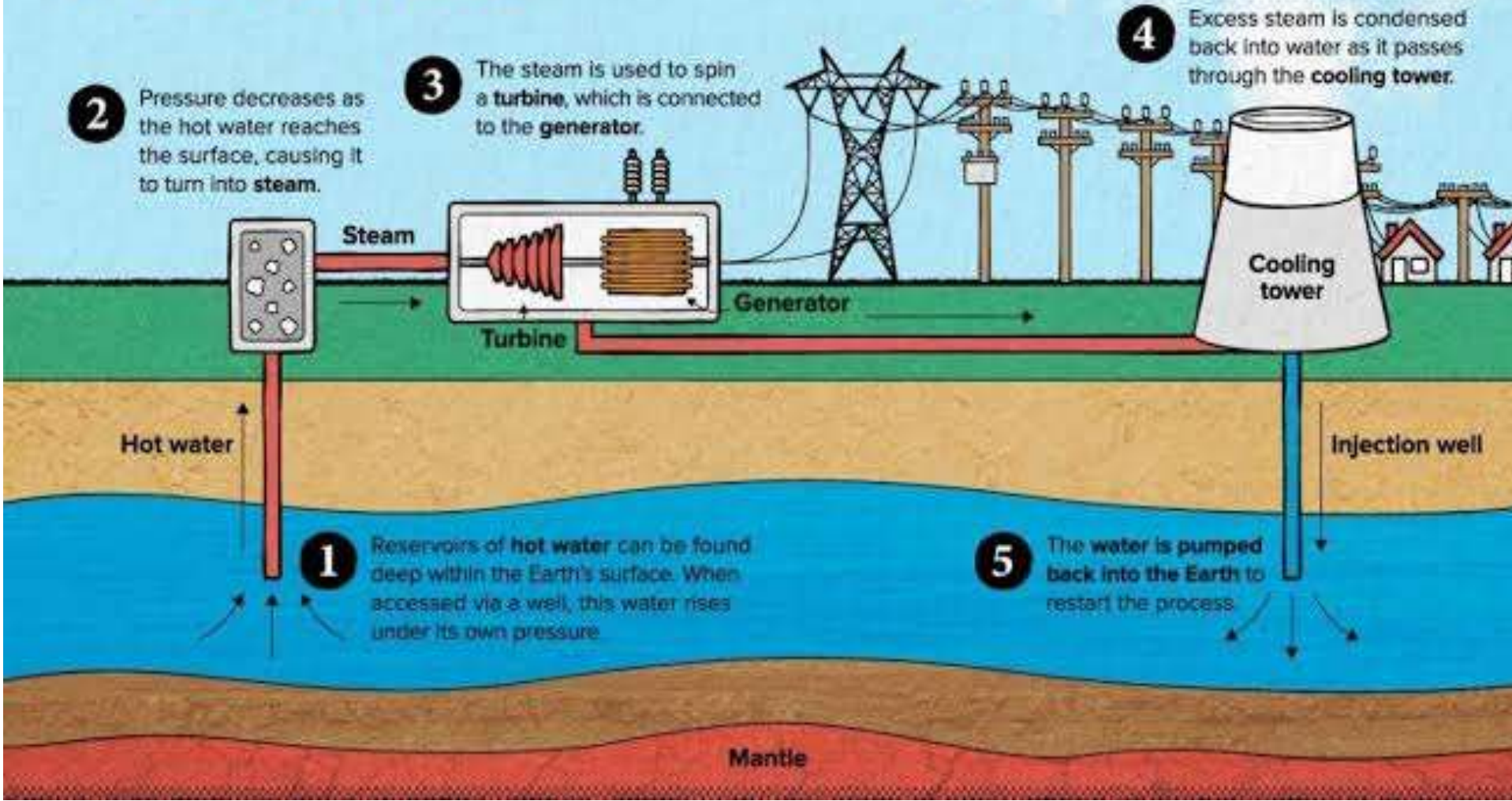
- **a/ Définition**
- •Geothermal energy uses the **higher temperature** of the **earth's subsurface** to produce heat or electricity.

A Visual Guide to

Geothermal Energy

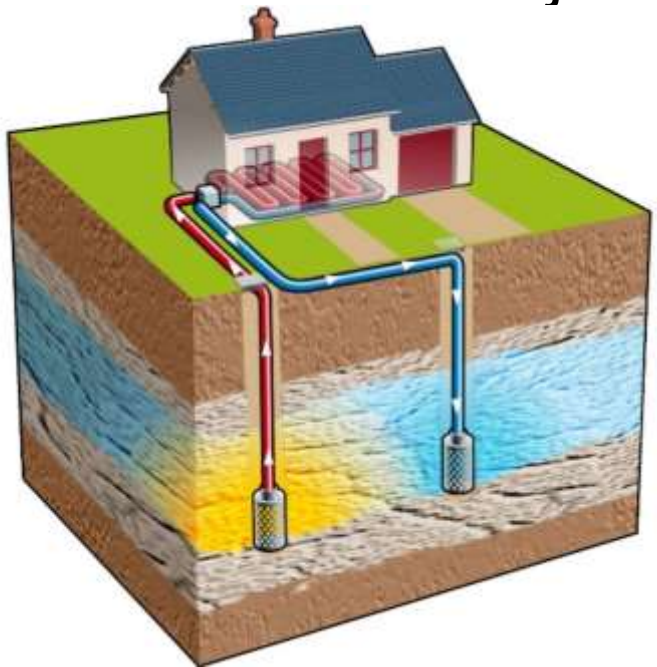
Geothermal is a lesser-known type of renewable energy that uses heat from the Earth's molten core.

▶ How it works

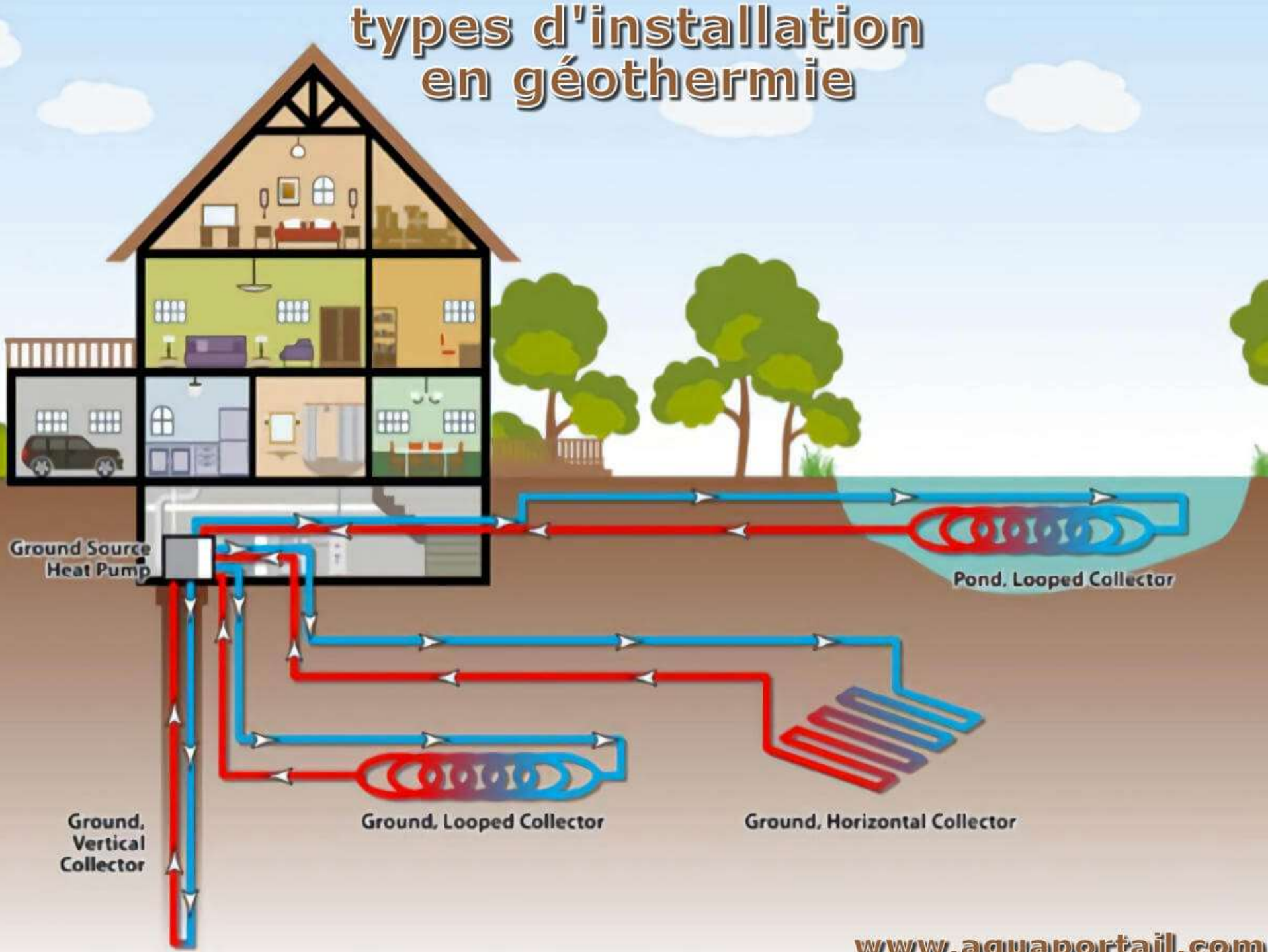


b / The principle

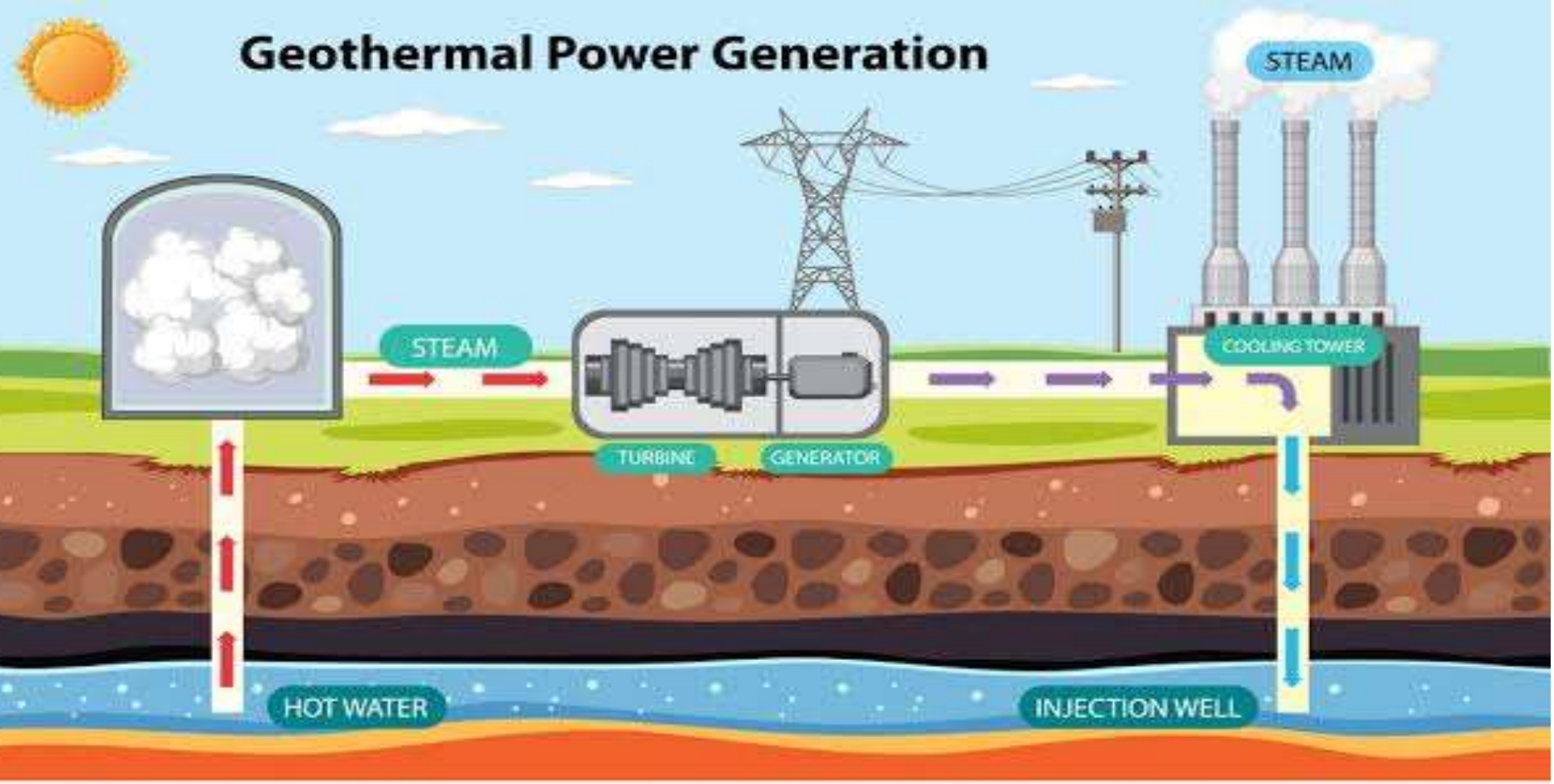
- **Low-temperature geothermal energy**: this is the most accessible form of geothermal energy. It provides supplementary energy for **heating buildings** and is most often used in conjunction with heat pumps.



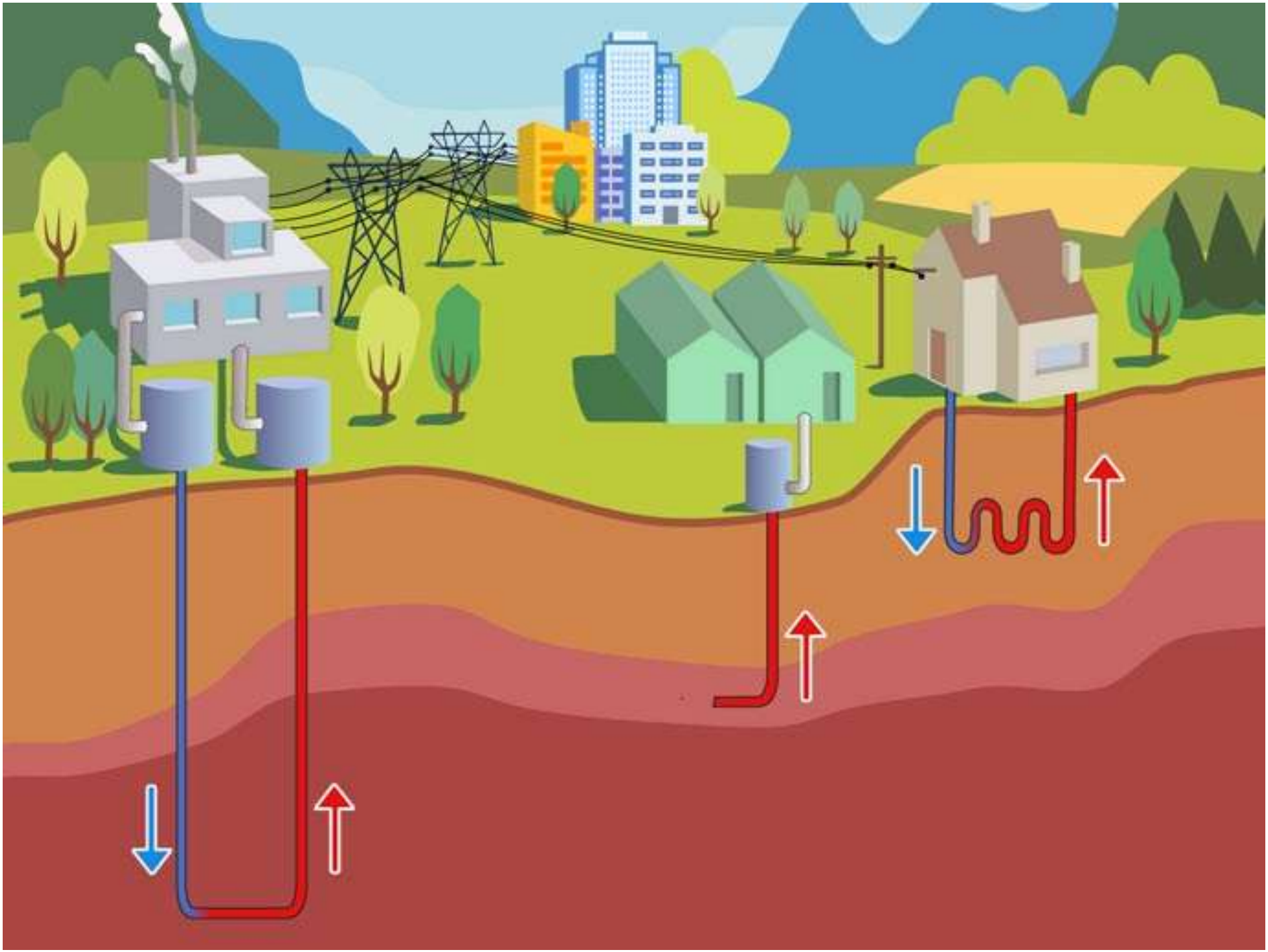
types d'installation en géothermie



- **High-energy geothermal energy**: High-energy geothermal energy is used to generate **electricity**. It exploits very hot hydrothermal sources (particularly in Iceland) or very deep boreholes, into which water is injected under pressure into the rock. The steam that is released provides sufficient pressure to power a turbine and generate electricity.



Geothermal power generation harnesses heat from the earth's core to create steam, which drives a turbine connected to a generator to produce electricity. Water is pumped underground to be heated by the earth's heat and returned to the surface as steam. This steam is then used to turn the turbine and generate electricity. Geothermal energy is renewable and emits little to no greenhouse gases, making it an attractive option for sustainable energy production.



4.5 Biomass energy

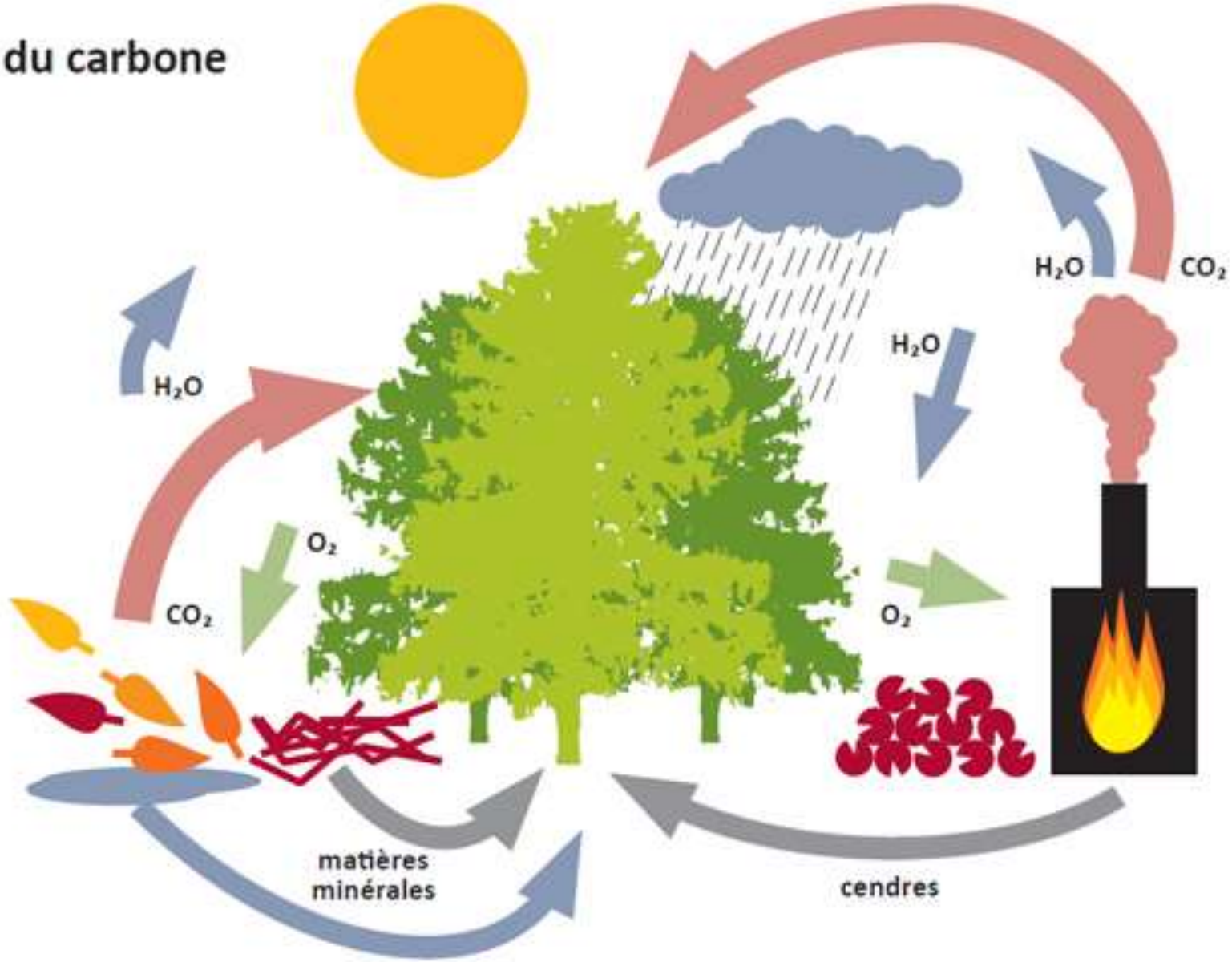
the energy of plants and trees!

- **a/ Définition**

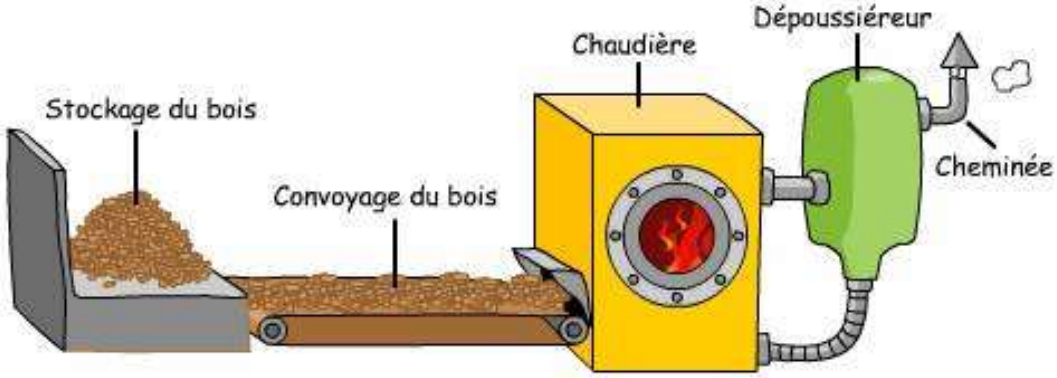
- "Biomass" refers to all **plant matter**, which constitutes a significant energy reserve captured by **photosynthesis** from the sun.

- Today, energy production uses "noble" plant products (beets, wheat, rapeseed, etc.)((betterave, blé, colza, etc.)) as well as plant waste (straw) and animal waste (manure).
- **b/ Biomass and greenhouse effect:**
- **Photosynthesis** converts part of the sun's energy into plant biomass while absorbing CO_2. When this biomass is burned, energy is released and CO_2 is released again (the total CO_2 balance is zero).

Le cycle du carbone



- **c/ Types of biomass**
- •We distinguish between :
- -**Lignocellulosic biomass**: wood, straw,



La chaufferie à bois

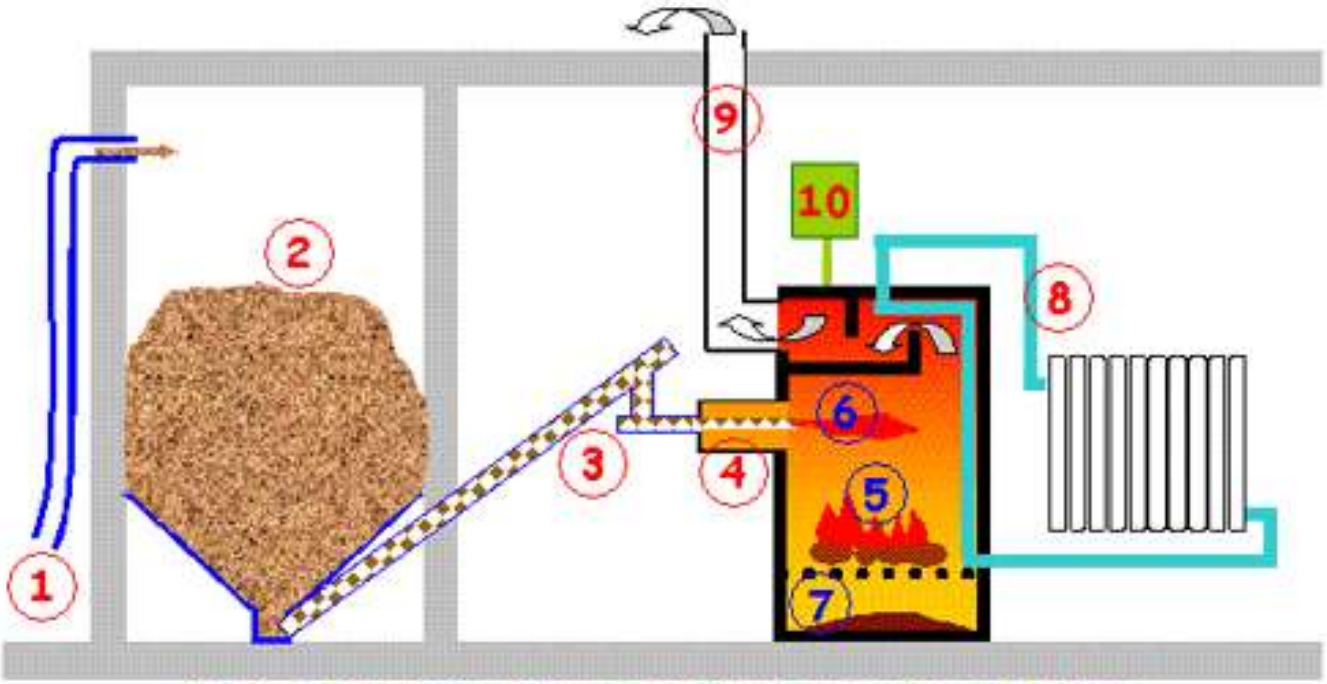


Schéma de principe d'une chaudière à granulés et à bûches

1. Raccord pour la livraison des granulés **2.** Silo de stockage
3. Vis sans fin d'alimentation **4.** Brûleur à granulés **5.** Foyer bûches **6.** Foyer granulés
7. Bac à cendres **8.** Circuit eau chaude et chauffage central
9. Cheminée **10.** Armoire de régulation

- **- alcohol-producing biomass** : beetroot, wheat, corn, etc (betterave, blé, maïs, etc).
- **- oilseeds** : rapeseed, soybeans, sunflowers, etc (colza, soja, tournesol, etc).