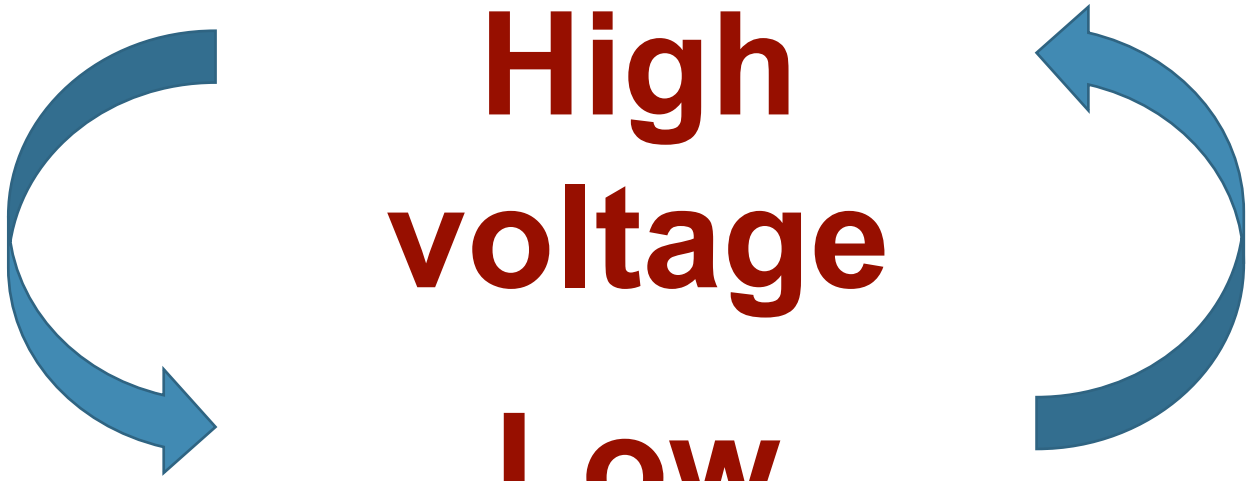
Мақсат

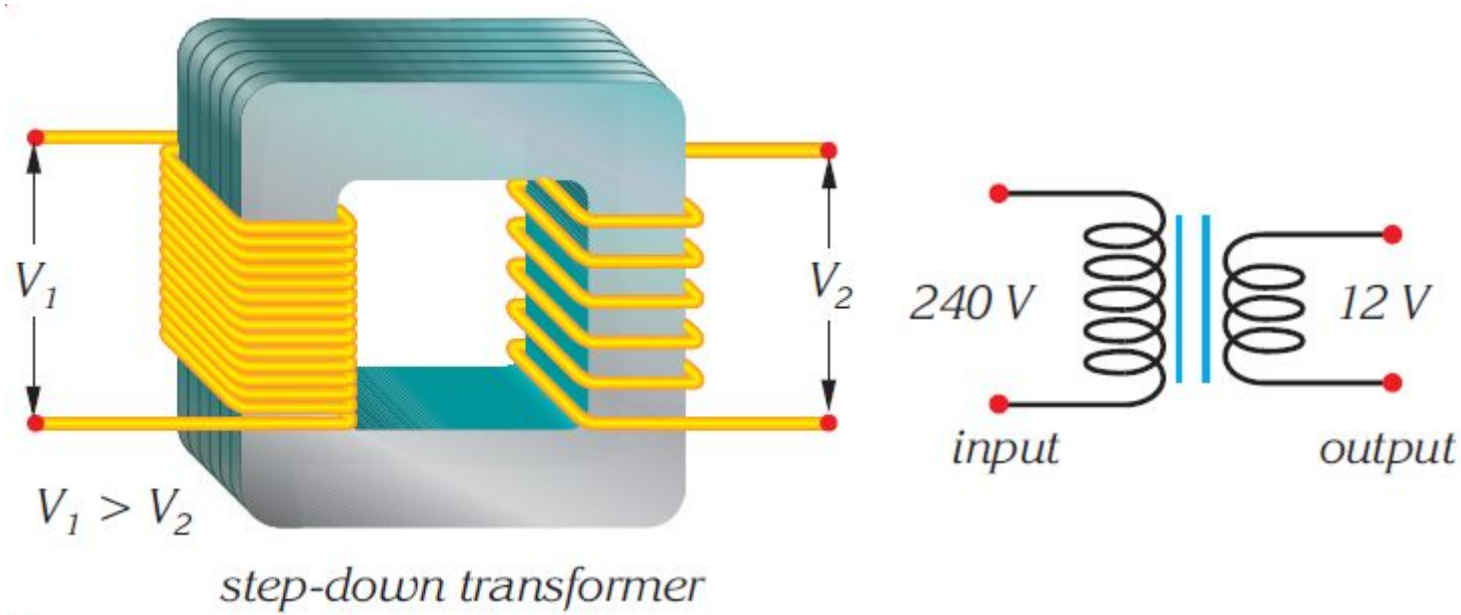
8.4.3.7 электромагниттік индукция құбылысын түсіндіру;
8.4.3.8 Қазақстанда және дүние жүзінде электр энергиясын өндірудің мысалдарын келтіру.

You will describe electromagnetic induction;
You will give examples of electricity production in the world and in Kazakhstan.

Two types of transformers



Step-down transformer

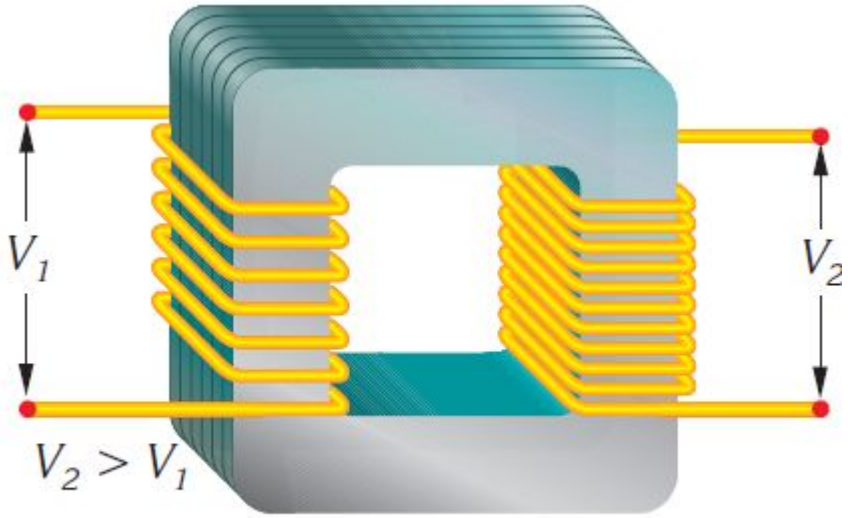


High voltage

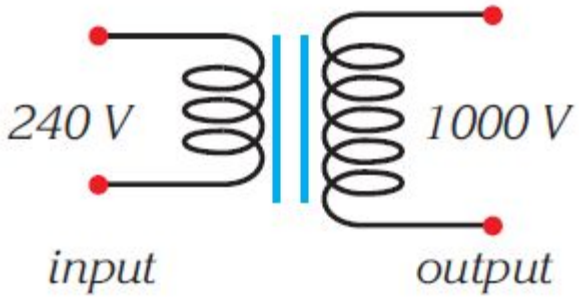
Low voltage

A *step-down transformer has fewer turns in the secondary coil than in the* primary one and its output voltage is less than its input voltage.

Step-up transformer



step-up transformer



High voltage

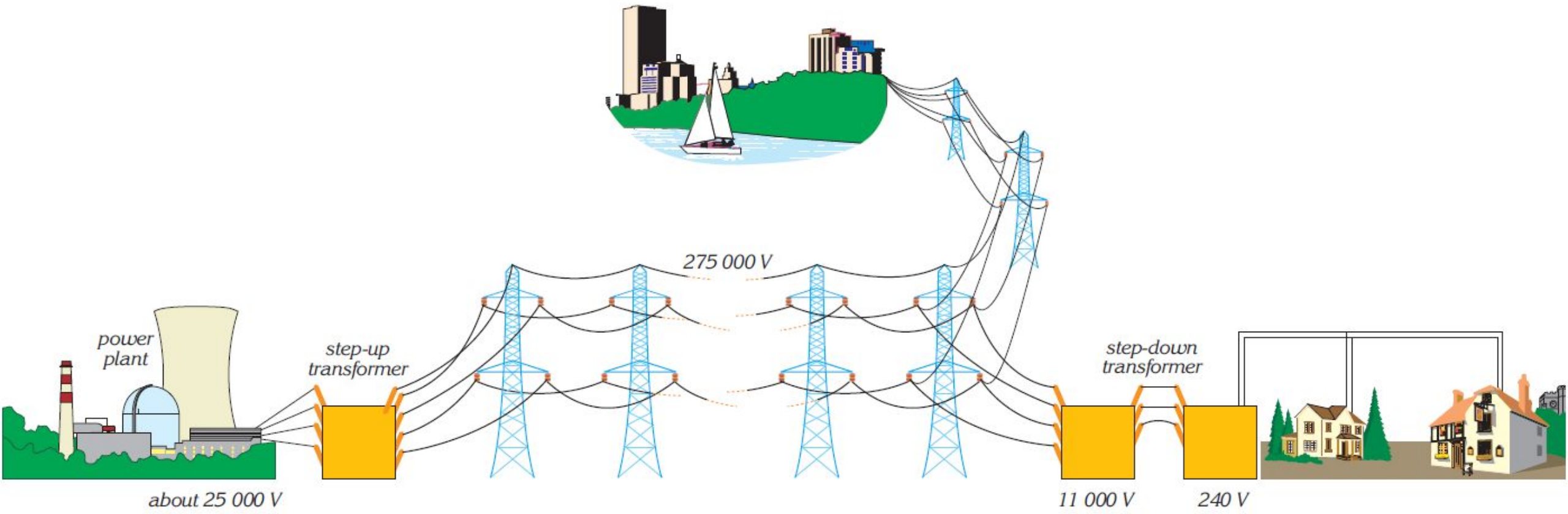
Low voltage

A *step-up transformer has more turns in the secondary coil than in the* primary one, and its output voltage is higher than its input voltage.

Let's think

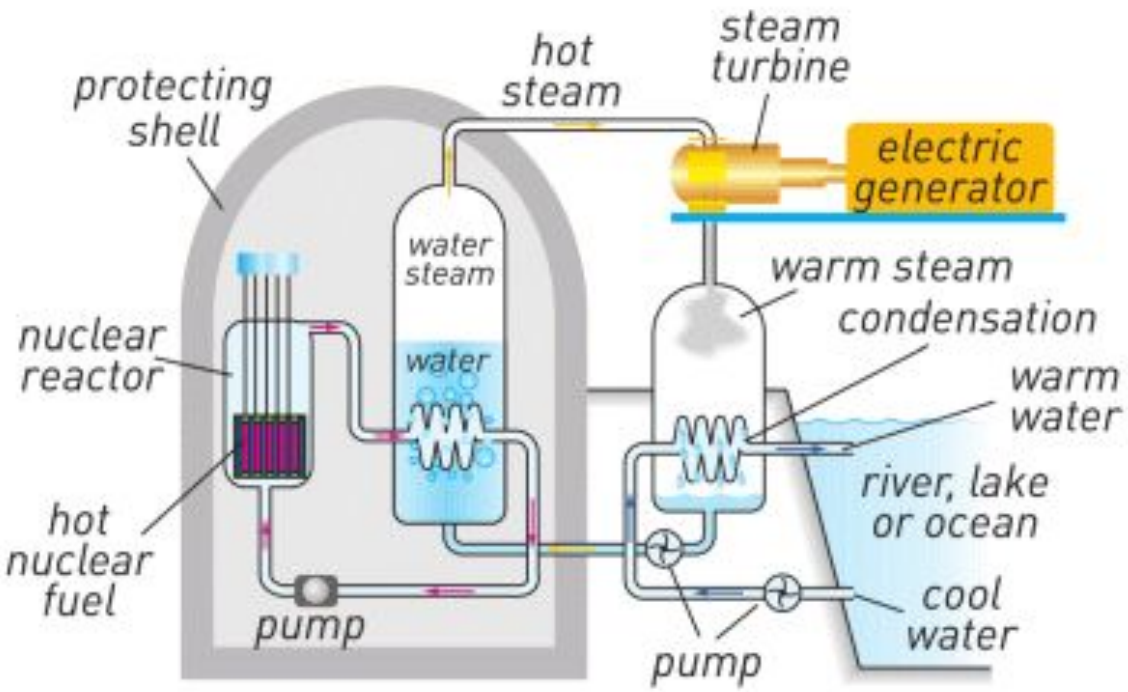
Why is electric energy carried at very high voltages? [V vs I]

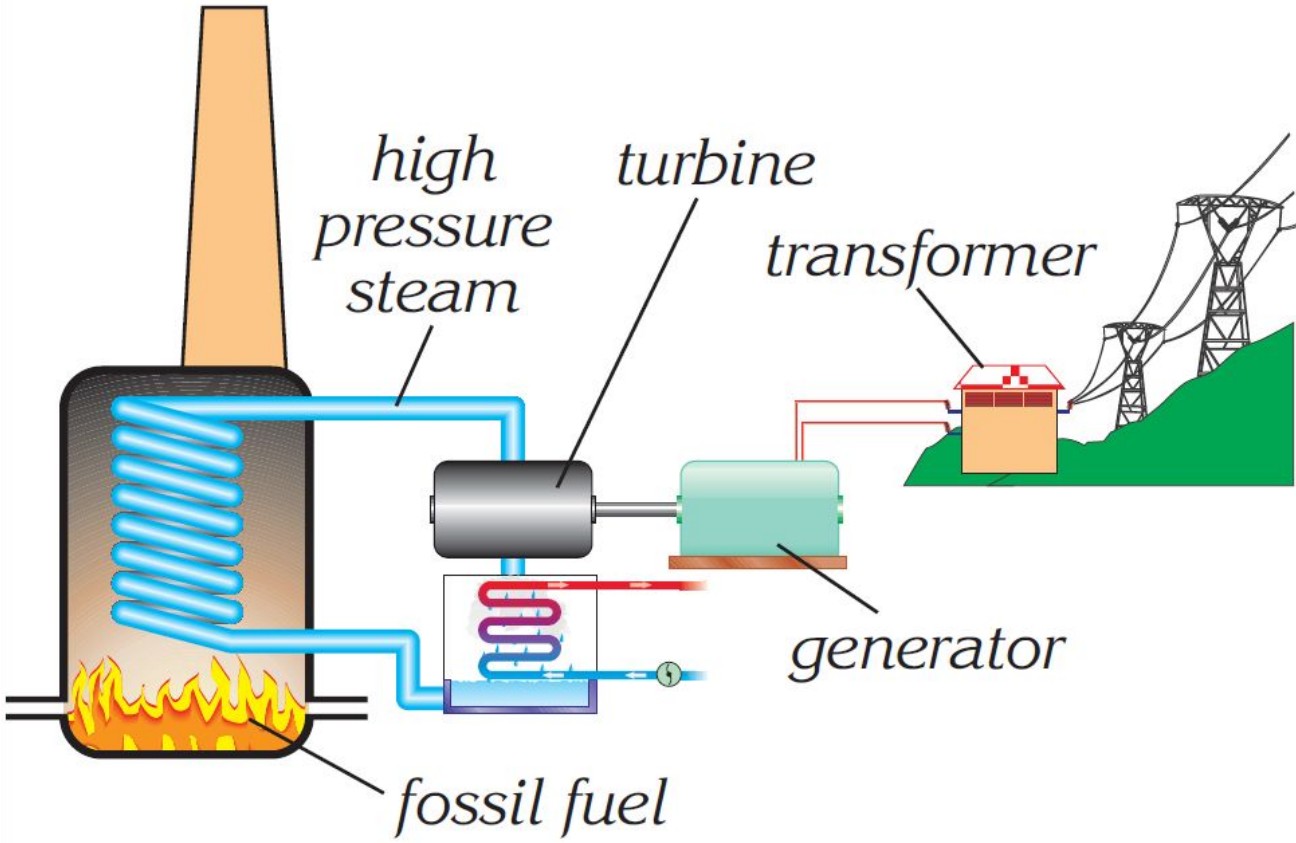
National grid system: Transmitting electrical energy



Transformers must be used at each end of the wires to step-up and step-down the voltage. Thus A.C. current must be used in grid systems, since transformers don't work on D.C. currents.

Energy transformations





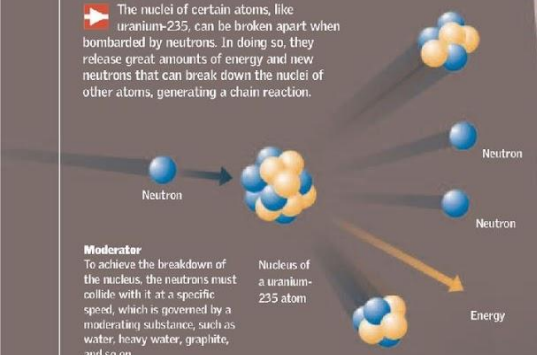
In power stations electric energy is produced by driving (causing mechanical motion of) an A.C. generator. In hydroelectric power stations falling water, in thermal and nuclear power stations high pressure–steam and in wind–mills wind drives the generator.

Nuclear Energy

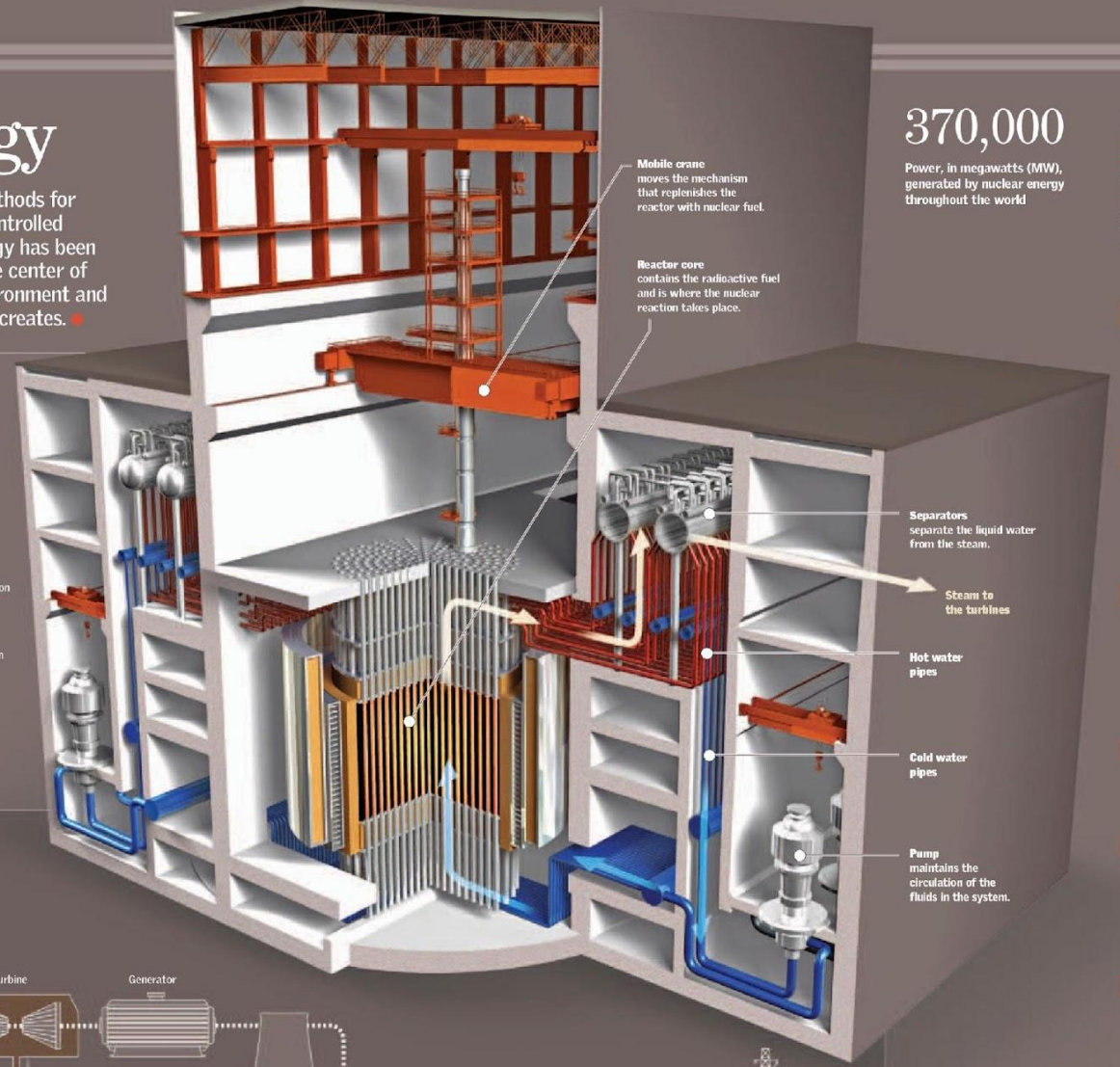
One of the most efficient and cleanest methods for obtaining electric energy is through a controlled nuclear reaction. Although this technology has been used for half a century, it continues to be at the center of debate because of the risks it poses to the environment and health and because of the highly toxic waste it creates.

Fission

The nuclei of certain atoms, like uranium-235, can be broken apart when bombarded by neutrons. In doing so, they release great amounts of energy and new neutrons that can break down the nuclei of other atoms, generating a chain reaction.

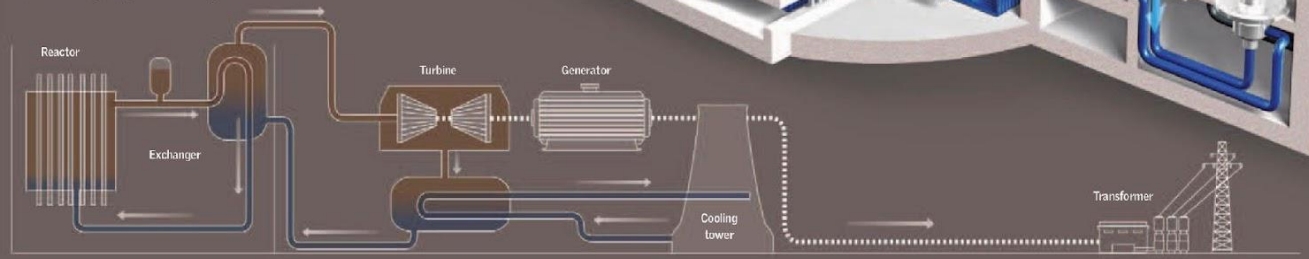


Moderater
To achieve the breakdown of the nucleus, the neutrons must collide with it at a specific speed, which is governed by a moderating substance, such as water, heavy water, graphite, and so on.



Generation of Energy

The purpose of nuclear fission is to create very hot steam to operate turbines and electrical generators. The high temperatures are achieved by using nuclear energy from the reactor.



1. **Water** Pressurized water, together with the moderator, is pumped through the core of the reactor, and the temperature of the core increases by hundreds of degrees.
2. **Steam** The resulting steam enters an exchanger, where it heats water until it too is converted into steam.
3. **Electricity** The steam enters the turbines and makes them run. The turbines drive the generator that produces electricity.
4. **Recycling** The steam condenses into liquid water and is reused.
5. **Transport** Before transmitting electricity, a transformer increases its voltage.

370,000
Power, in megawatts (MW), generated by nuclear energy throughout the world

436
The number of nuclear plants operating throughout the world. More than 30 are in various stages of construction.

Uranium

In nature, uranium appears associated with other minerals. In addition, only 0.7 percent of uranium is the isotope uranium-235, necessary for nuclear fission. The proportion of uranium-235 must be increased 3 to 5 percent in a process called enrichment.

1. The original mineral is treated until a substance called yellowcake is obtained that is 80 percent uranium.

2. During conversion, first uranium tetrafluoride (UF4) and then uranium hexafluoride (UF6) are obtained.

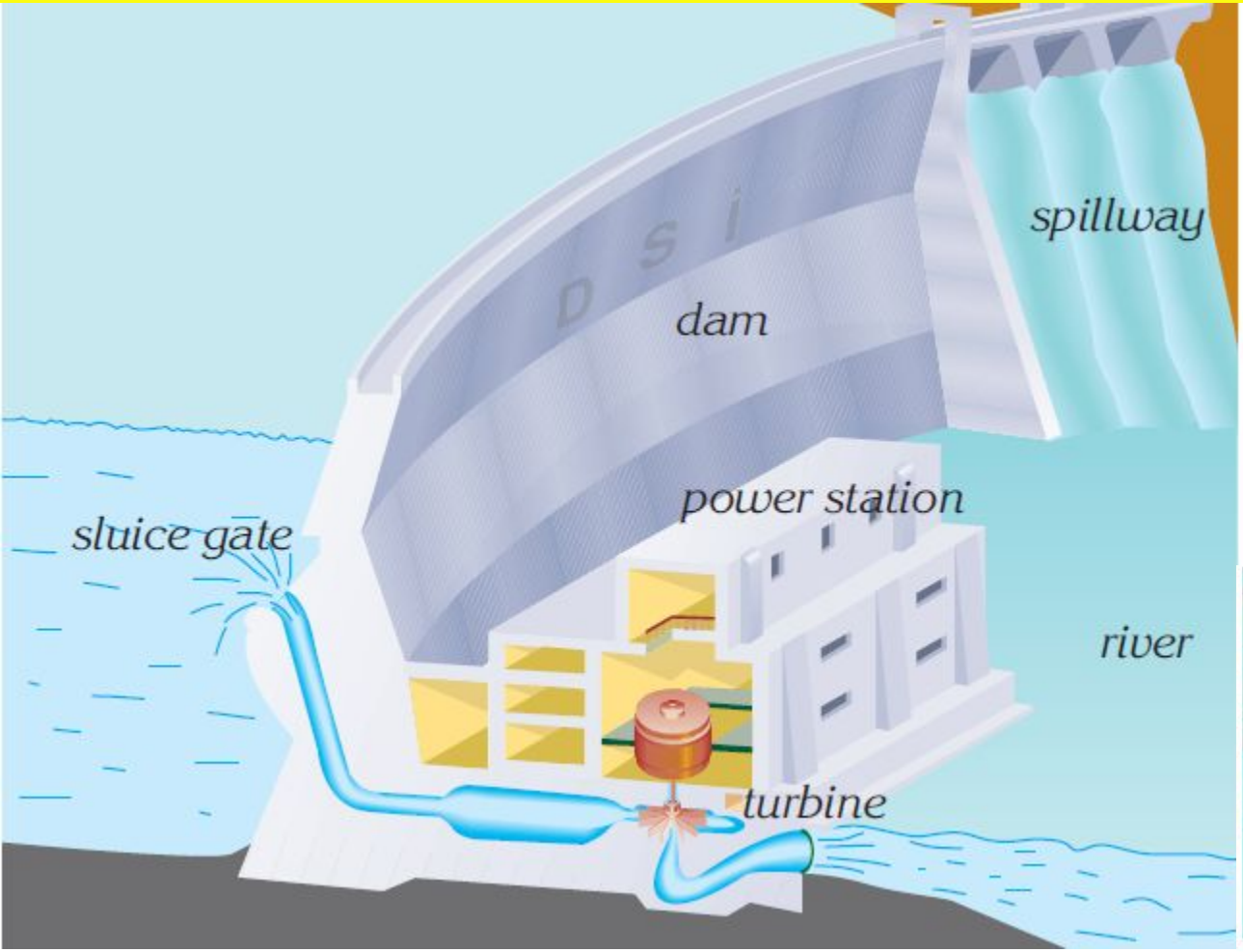
3. The gaseous uranium hexafluoride is spun repeatedly in a centrifuge until it attains the desired concentration of uranium-235.

4. The enriched uranium gas is solidified again.

5. Through compaction, pellets of enriched uranium are obtained that can be used as fuel in nuclear reactors.

6. The pellets are put into hollow bars that are later placed in the core of the nuclear reactor.

Power stations: Hydroelectric



potential energy of water → kinetic energy → electrical energy

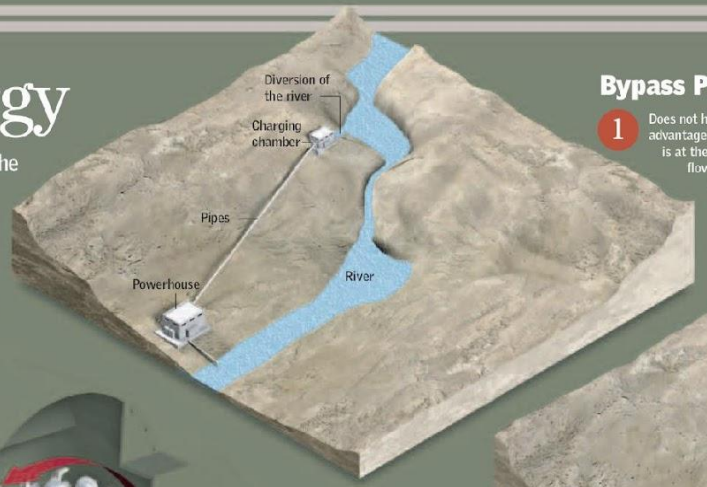
turbines

generators

Hydroelectric power stations use the energy from falling water to produce electricity.

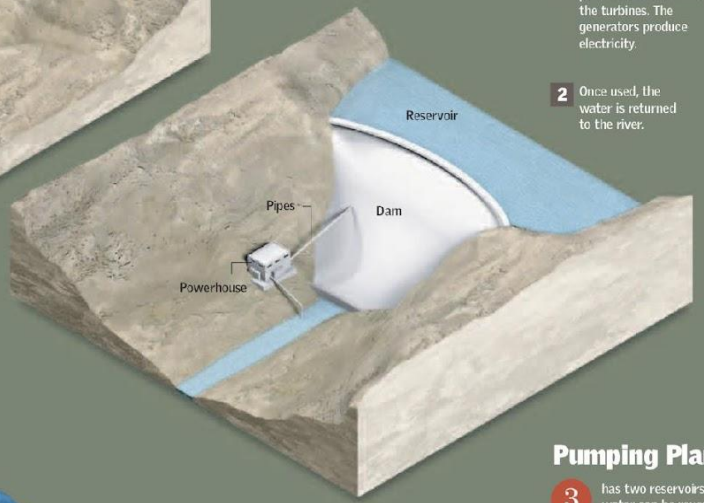
Hydroelectric Energy

About 20 percent of the world's electricity is generated by the force of rivers through the use of hydroelectric power plants. This technology, used since the 19th century, employs a renewable, nonpolluting resource, although the technology's impact on the environment is high. According to the United Nations, two thirds of the world's hydroelectric potential is being used, especially in North America and Europe.



Bypass Plant

1 Does not have a reservoir. It simply takes advantage of the available flow of water and thus is at the mercy of seasonal variations in water flow. It also cannot take advantage of occasional surplus water.

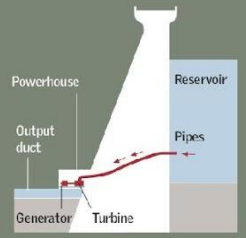


Plants with Reservoirs

2 The presence of a reservoir, formed by a containment dam, guarantees a constant flow of water—and, therefore, of energy—independent of variations in water level.

1 The water enters the powerhouse and turns the turbines. The generators produce electricity.

2 Once used, the water is returned to the river.

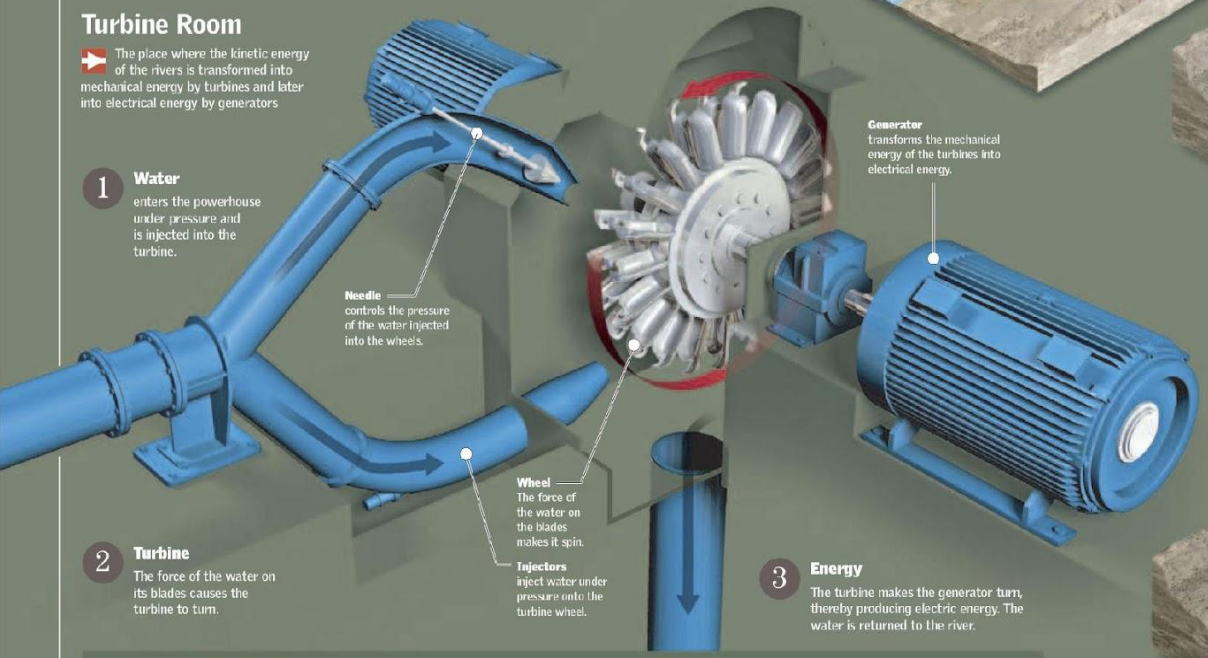


China

The world's largest producer of hydroelectricity (95,000 MW installed), followed by the United States, Canada, and Brazil

Turbine Room

The place where the kinetic energy of the rivers is transformed into mechanical energy by turbines and later into electrical energy by generators



1 **Water**
enters the powerhouse under pressure and is injected into the turbine.

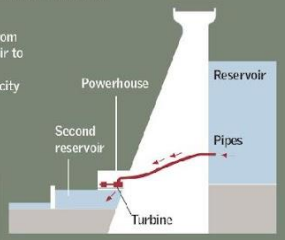
2 **Turbine**
The force of the water on its blades causes the turbine to turn.

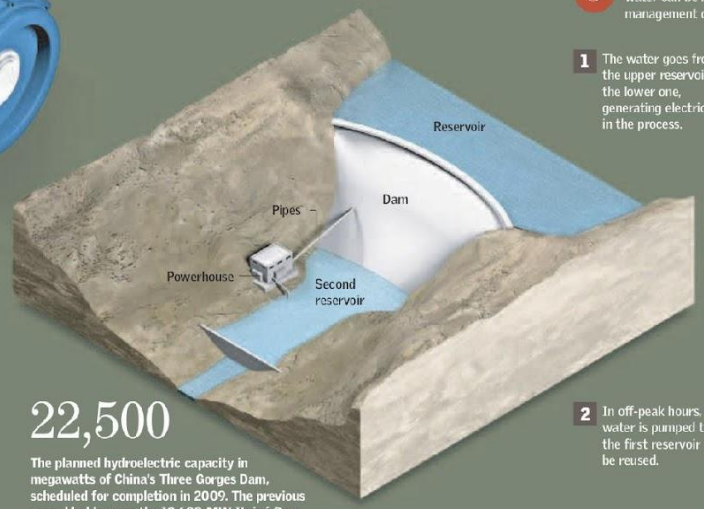
3 **Energy**
The turbine makes the generator turn, thereby producing electric energy. The water is returned to the river.

Pumping Plant

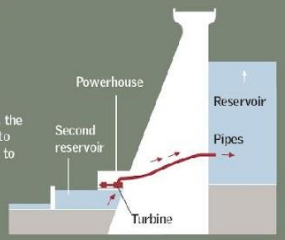
3 has two reservoirs located at different levels. In this way, the water can be reused, which allows a more efficient management of water resources.

1 The water goes from the upper reservoir to the lower one, generating electricity in the process.





2 In off-peak hours, the water is pumped to the first reservoir to be reused.



22,500

The planned hydroelectric capacity in megawatts of China's Three Gorges Dam, scheduled for completion in 2009. The previous record holder was the 12,600-MW Itaipú Dam on the border between Paraguay and Brazil.

From the Dam to the City

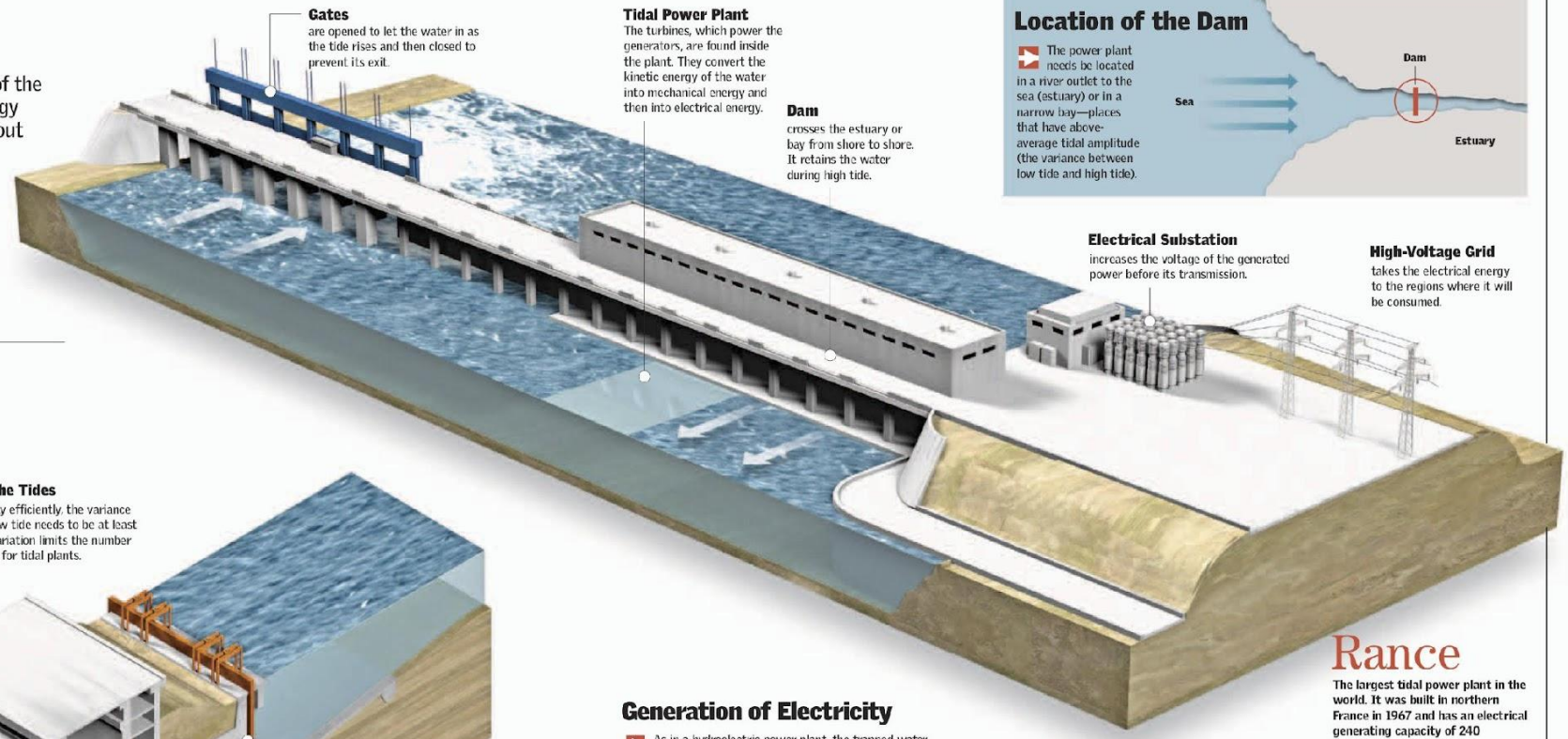
Electricity generated by the power plant is sent to a transformer, where its voltage is increased for transmission.

The electrical energy circulates through high-voltage power grids over great distances.

A transformer lowers the voltage of the electricity before distributing it to homes.

Tidal Energy

The variations in the tides and the force of the oceans' waves signify an enormous energy potential for generating electricity without emitting polluting gases into the atmosphere or depleting resources, as happens in the case of fossil fuels. Tidal plants are similar to hydroelectric plants. They have a water-retention dam (which crosses an estuary from shore to shore) and a powerhouse where the turbines and generators to produce electricity are located.



Location of the Dam

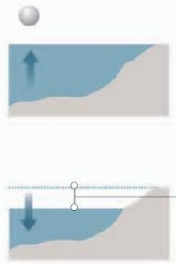
The power plant needs be located in a river outlet to the sea (estuary) or in a narrow bay—places that have above-average tidal amplitude (the variance between low tide and high tide).

The Tides

Responding to the Moon's gravitational pull on the Earth, the oceans' tides rise and fall twice a day.

High Tide
The Moon attracts the waters of the sea, and the tide rises.

Low Tide
When the Moon is to one side of the Earth, the water recedes.



Amplitude of the Tides
To produce electricity efficiently, the variance between high and low tide needs to be at least 13 feet (4 m); this variation limits the number of possible locations for tidal plants.

12 hours 25 minutes

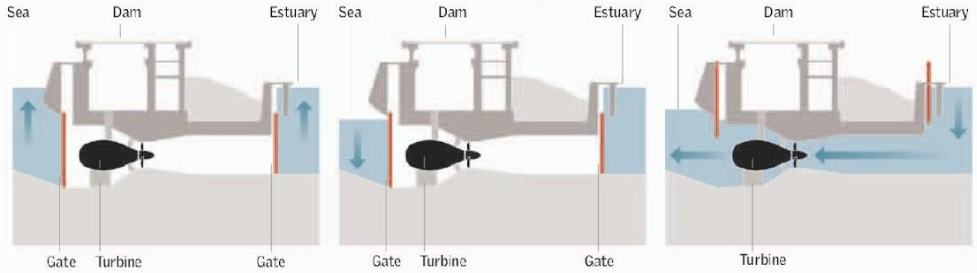
The approximate time between two high tides or low tides, depending on the geographic location and sometimes on other factors, such as winds and ocean currents

Rance

The largest tidal power plant in the world. It was built in northern France in 1967 and has an electrical generating capacity of 240 megawatts.

Generation of Electricity

As in a hydroelectric power plant, the trapped water turns a turbine that operates the generators.



1 **High Tide**
During high tide, the level of the water rises in the estuary. The gates of the dam are opened to let the water in.

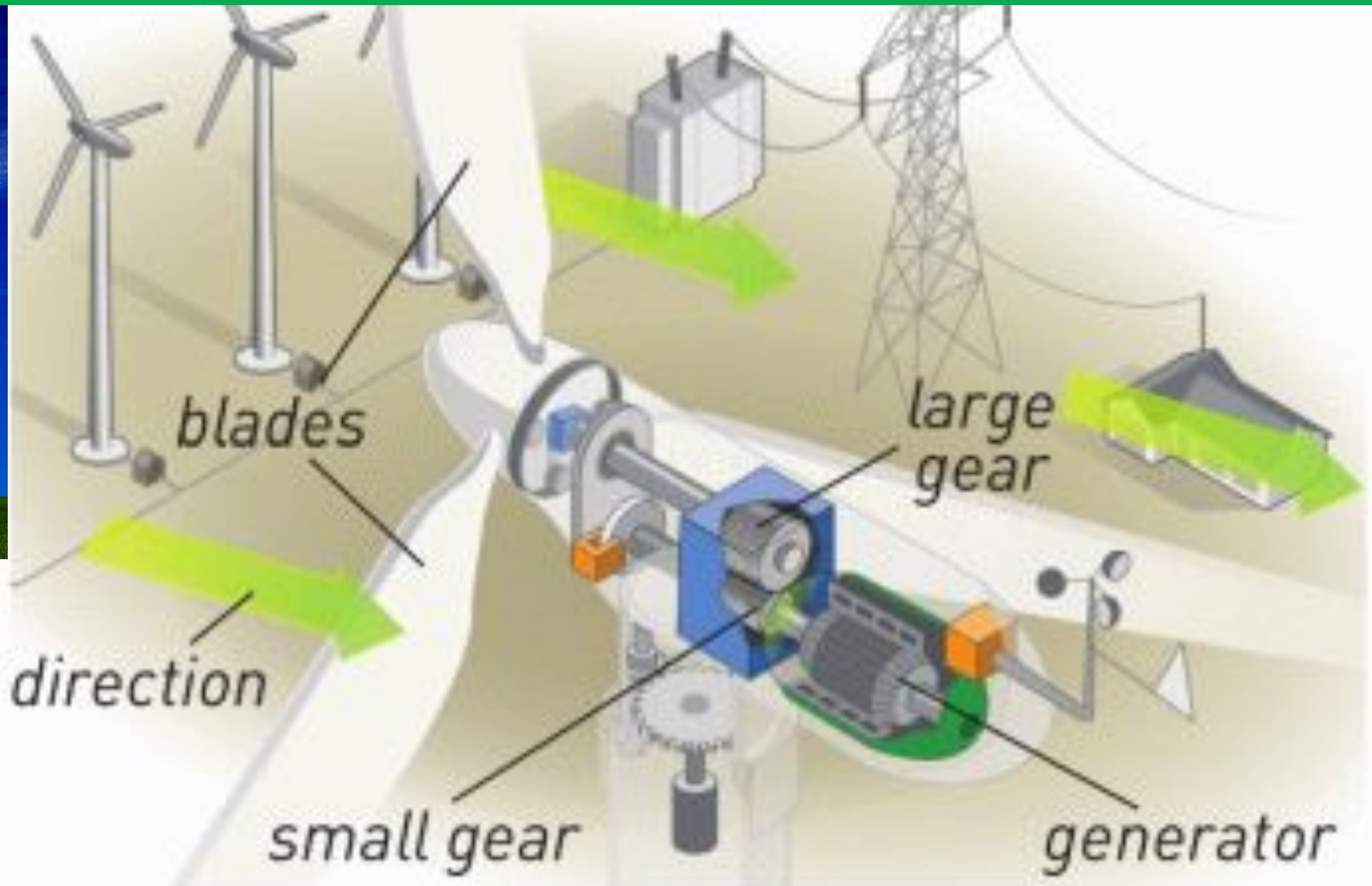
2 **Water Reservoir**
Once high tide is complete, the water level in the estuary begins to drop. The gates of the dam are closed to prevent the trapped water from escaping.

3 **Generation**
During low tide, the trapped water is released and it passes through the system of turbines that power the electrical generators.

Wind power

In locations where the wind blows continuously, windmills can be used to generate electricity. The blades of windmills rotate as wind blows onto them, driving the generator connected to them inside the head. The stronger the wind blows, the more energy windmills produce.

kinetic energy → electrical energy



Wind Energy

One of the most promising renewable energy resources is the use of wind to produce electricity by driving enormous wind turbines (windmills). Eolic power is an inexhaustible, clean, nonpolluting source of energy with more advantages than disadvantages. The most important disadvantages are our inability to predict precisely the force and direction of winds and the possibly negative impact that groups of large towers could have on the local landscape.

The Turbine

converts the wind into electrical energy through the use of simple technology based on mechanical gears.

Low-speed axle turns slowly, between 20 to 35 revolutions per minute (rpm).

Multiplier With gears, it multiplies by 50 the speed of rotation of the high-speed axle.

High-speed axle turns at around 1,500 rpm, allowing it to operate the generator.

Generator produces electric energy from the mechanical energy of the axle.

Computer controls the conditions of the wind turbine and its orientation.

Blades measure, on average, 130 feet (40 m) in length. Three-blade rotors have proven to be the most efficient design.

1 The wind
moves the blades of the wind turbine, producing mechanical energy, which is then converted into electrical energy.

Brakes are activated when the winds surpass 74 miles per hour (120 km/h), preventing damage to the wind turbine.

Cooling system cools the generator with a fan. Also uses oil to cool the multiplier lubricant.

The blades
are movable. They can be oriented both to take maximum advantage of the wind and to slow down the turbine when the winds are too strong.

When facing the wind, their shape causes a pressure difference between the two faces of the wind turbine's blades. The pressure on the blades produces a force that turns the rotor.

Wind Turbines

These modern, large wind turbines, between 150 and 200 feet (45 and 60 m) high, tend to be grouped in windy, isolated, mostly deserted regions. The most modern wind turbines can generate 500 to 2,000 kW of power.

High terrain, free of obstacles, is ideal for wind turbines, because the wind blows freely there and reaches the wind turbines without turbulence.

The wind turbines are grouped into wind farms to maximize the potential of transmitting energy from only one location. This has the advantage of lowering costs and reducing environmental impact on the landscape.

The Journey of Electricity

The energy produced in wind farms can travel through the main power grid together with energy generated by other sources.

Wind turbines

The transformer increases by several thousand volts the voltage from the turbines.

The collection plant receives the energy from all the transformers.

Substations receive the energy from the collection plant and increase the voltage by hundreds of thousands of times for transmission to distant cities.

Nearby cities receive the energy directly from the collection plant.

74,000
megawatts is the installed capacity of wind farms in the world. The leading country is Germany, followed by Spain and the United States.

2 Energy
The electric energy produced by the generator goes down the cables to a converter.

3 Grid
After leaving the wind farm, the electric energy can be incorporated into the main distribution grid.

4 Homes
The electricity reaches the residential distribution grid and finally homes.