NUCLEAR POWER PLANTS

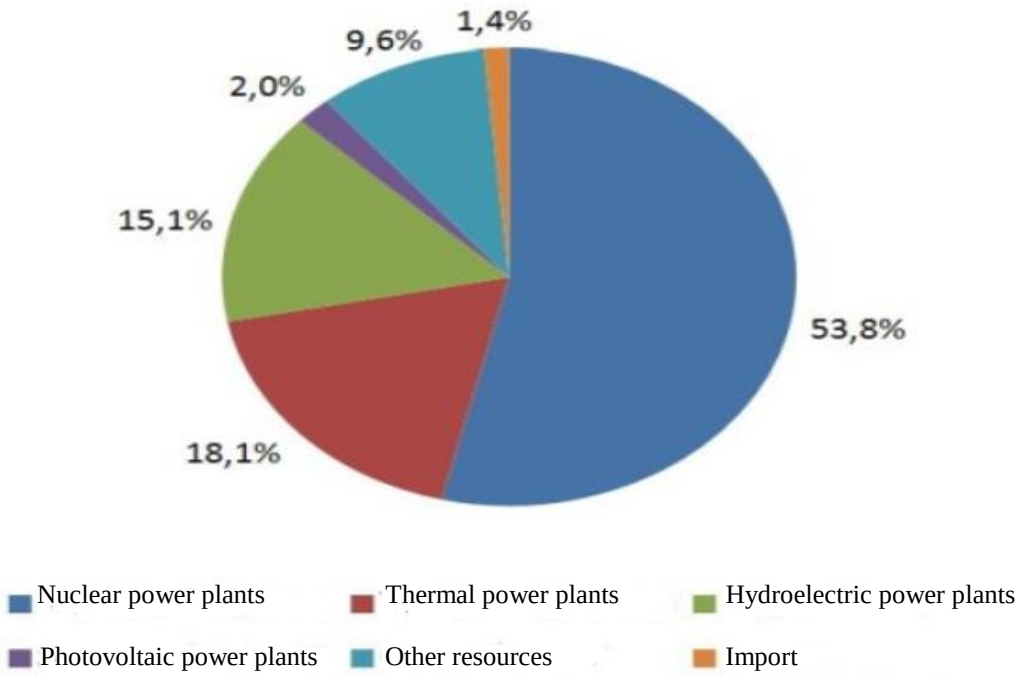
Educational text

According to International Atomic Energy Agency's Power Reactor Information Systems Database as of July 2015, 30 countries worldwide are operating 438 nuclear reactors for electricity generation and 67 new reactor plants are under construction in 15 countries. They provide 10.9 percent of the world's electricity production in 2012. In 2014, 13 countries relied on nuclear energy to supply at least one-quarter of their total electricity. Slovak Republic is one of them. Look at the table and chart below.

	France	*Slovakia*	*Hungary*	*Ukraine*	*Belgium*	*Sweden*	*Switzerland*	*Slovenia*	*Czech republic*	*Finland*	*Bulgaria*
%	*76.9*	*56.8*	*53.6*	*49.4*	*47.5*	*41.5*	*37.9*	*37.2*	*35.8*	*34.6*	*31.8*

Electricity consumption in Slovakia (2012)

Chart: energia.sk (information issued by SEPS, a.s.)

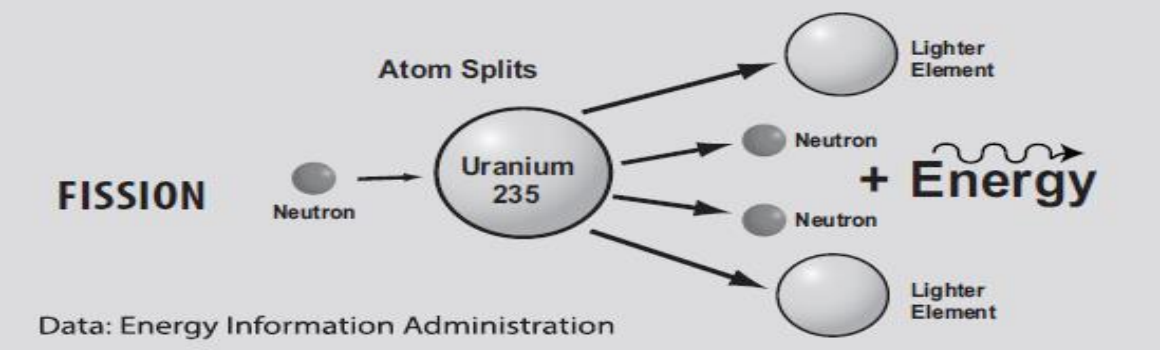


How does it work ???

Energy used to generate electricity in a nuclear power plant is released in a process known as a fission. **Fision** occurs when an atom's nucleus splits into smaller nuclei. During fission, the uranium-235 atom absorbs a bombarding neutron, causing its nucleus to split apart into two atoms of lighter mass, and more neutrons are released as well.

The newly released neutrons go on to bombard other uranium atoms, and the process repeats itself over and over. This is called a chain reaction and you can see this process in the picture 1.

Picture 1



Uranium-235 is commonly used for energy production because the nucleus splits easily when bombarded by a neutron.

The amount of energy is calculated by the equation $\mathbf{E=mc^2}$. Using this equation scientists calculated that fission can release a tremendous amount of energy. They started work to harness and use nuclear energy for peaceful purposes in nuclear power plants. Would you like to watch this process? Make double click on blue in the boy's bubble.

Double click

Components for nuclear power plant ???

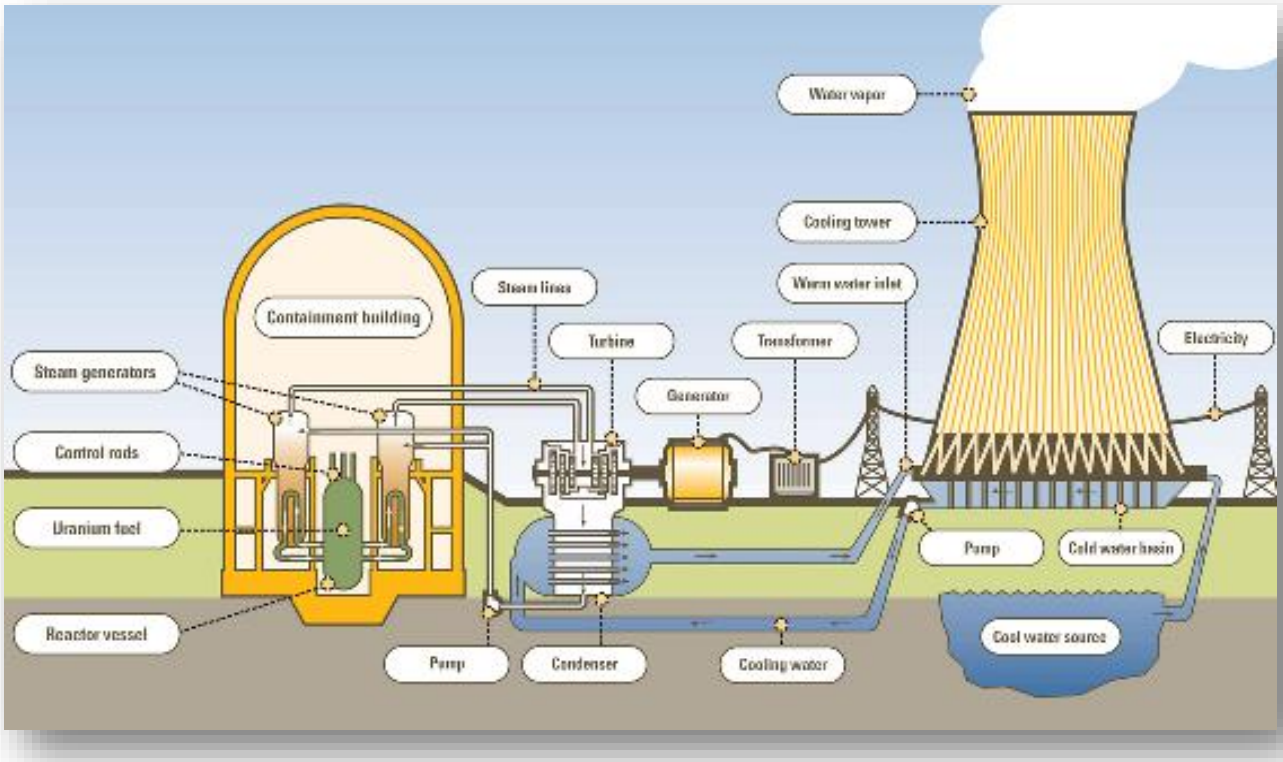
Containment building This is a thick-walled concrete and steel building designed to prevent radioactive gases, steam, and water from enetering the environment should a leak occur.

Nuclear reactor is a key device of nuclear power plant. Its main purpose is to initiate and control a sustained nuclear chain reaction. It is the center of a nuclear power plant . Its purpose is to release energy at a controlled rate. This allows the thermal energy produced during fission to produce the steam that turns a turbine and generates electricity. There are two common types of thermal reactors:

- ✓ BWR- boiling water reactor
- ✓ PWR- pressurized water reactor

The PWR is the most popular commercial reactor type worldwide. This reactor has primary, secondary, and external heat exchange systems, or loops. In the primary loop, heated water from around the reactor is sent to a steam generator or heat exchanger.

Inside a reactor, a controlled chain reaction takes place where one fision leads to one additional fission and so on. While there is the potential for accident due to high pressures or excessive thermal energy production, reactors cannot produce an explosive chain reaction like a nuclear bomb. Thermal energy can be used to convert water to steam for turning the blades of a turbine. The motion of the turbine turns a generator and makes electricity**.** Look at the picture where main features of nuclear power plants with PWR-type (Pressurized Water Reactor) reactor are pictured.



Steam generator converts feedwater into steam from heat produced in a nuclear reactor core. The steam in the secondary system flows into the turbine where it turns the generator and generates electricity. This steam is then condensed by water from the external loop before it returns to the steam generator where it is heated and repeats the cycle. It is used in PWR between the primary and

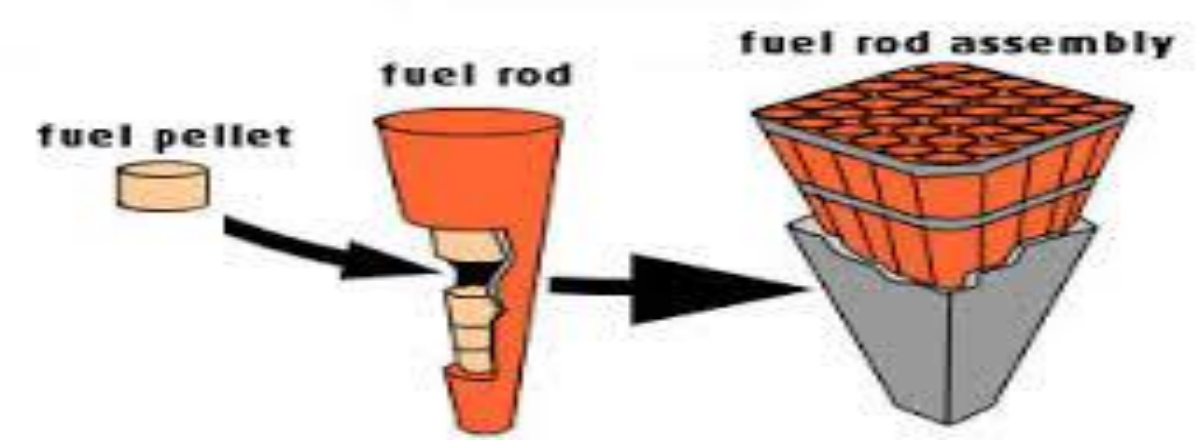
secondary coolant loops. The water from the primary loop does not physically mix with water and steam in the steam generator.

Pressurizer - maintains the primary circuit by certain pressure

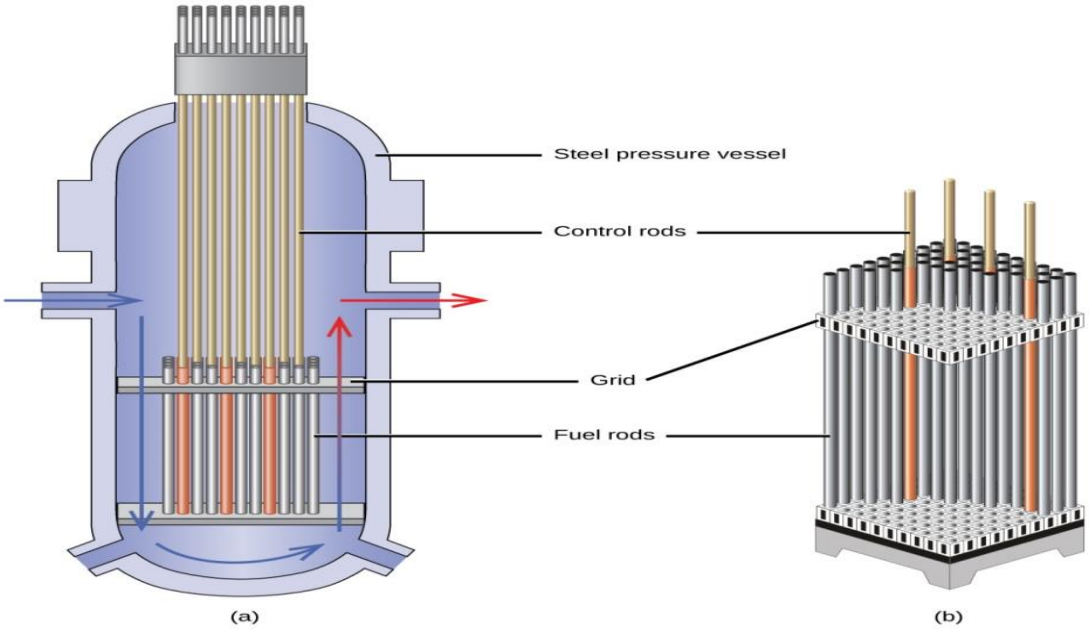
Reactor vessel - this holds the nuclear reactor and is dual-layered with a thick

Fuel - uranium is used as the fuel in nuclear power plants. This element is a naturally occuring radioactive, is very heavy and hard and is easily fissioned.

Fuel rods - these assembly rods are filled with the UO_2 pellets that have been enriched (nuclear fuel). They isolate the fuel from the water in the reactor vessel.



Control rods - they usually contain boron or cadmium, elements that absorb or capture neutrons to slow or stop the nuclear fission chain reaction. The control rods move up and down among the fuel rods, increasing or decreasing the number of neutrons exposed to the fel in order to control the



chain reaction and the fission process.

Moderator - is a substance that slow down neutrons so that a chain reaction can be maintained. The moderator is usually purified natural water or heavy water. However, the most common is graphite, a form of a pure carbon can also be used as a moderator.

Heat exchange system - a nuclear plant's thermal energy is used to make steam and generate electricity. The steam carries energy from the reactor vessel to the turbines. After the steam turns the turbines, it is condensed back into water and returned to the reactor vessel. This is done by the heat exchange systems, or heat exchanger.

Cooling tower - where warm water is sprayed in small droplets through a draft of dry air. The dry air causes some of the water to evaporate, which leaves the remaining water cooler. This is called evaporative cooling. The cooled water droplets are collected at the bottom of the tower and pumped back to the plant to be reheated. Cooling towers are designed to maximize tha draft of air they create. Usually the cooling towers are designed to maximize the draft of air they create. They are concave shaped and are the most visible feature of many nuclear plants and other power plants. They release only steam into the atmosphere, not radioactive substances or other emission as is sometimes thought.

Safety systems - there are two classes of safety systems: evolutionary and passive. These systems are designed to minimize operator errors. Their primary objectives are to shut down the reactor, maintain it in a shutdown condition and prevent the

release of radioactive material.

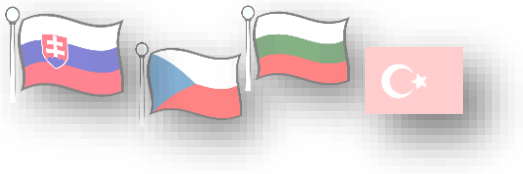
Advantages of nuclear power plant ???

- ✓ Uranium costs are low relative to coal and natural gas.
- ✓ The operating cost of a nuclear power plant is low, and will continue to be reduced as plants become more efficient and operate for longer period of time.
- ✓ Nuclear energy can provide baseload electricity where renewable sources are intermittent.
- ✓ New plant designs are safer and more efficient than those of older plants.

Disdvantages of nuclear power plant ???

- ✓ Uranium enrichment and nuclear fuel reprocessing technologies created during enriching and processing can be used in producing fissile materials for nuclear wapons.

Environmental issues ???

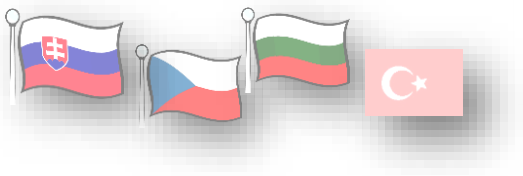


Positives:

- Nuclear power plants do not emit carbon dioxide and do not give off pollutants as soot, ash, or sulfur dioxide.
- There is a large supply of uranium fuel available – enough for several hundred to many thousands of years.

Negatives:

- It takes longer to build a nuclearpower plant than a coal or hydroelectric plant. Radiation released from nuclear reactions must be contained, and radioactive spent fuel and nuclear waste must be safely and securely stored. However, overall costs of construction and spent fuel storage are high.
- While environmental impact studies have been conducted to make prediction, it is unknown exactly how long-term storage of radioactive high-level waste, including nuclear spent fuel, will impact the environment.. There are limited material resources to make reactor components
- Perhaps the impact which is easiest to notice is the effect on the environment, particularly in terms of flora and fauna.
- To start with, the setting up of a nuclear plant requires a large area, preferably situated near a natural water body. This is usually accompanied with clearing of forests which disturbs the natural habitat of several creatures and gradually upsets the ecological balance of the region.



- Apart from this, studies have shown that due to the heat rejected into the water bodies, there have been significant drops in the populations of several species of fish in certain regions of US.
- Another significant effect is the increased amount of sulfur dioxide in the air which causes acid rain to form which then leads to contamination of surface water bodies of the region, reduction of productivity of the soil, and has several other negative effects on the region's vegetation and human health.

Nuclear power plants in Slovakia.

Nuclear power plants in Slovakia are located in Bohunice and Mochovce. You can see their position on the map of Slovak Republic.

In November 2014 the government approved a long-term energy plan based on greater use of nuclear power, some renewables, and reducing the use of coal. Four nuclear reactors are in operation in Slovakia generating half of electricity consumption and two more are under construction.

Nuclear power plant Bohunice

Nuclear power plant Mochovce

Nuclear reactors in operation in Slovakia

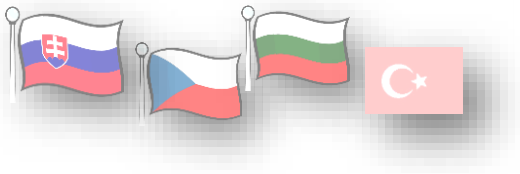
Reactor	Model	Power MWe	Put in operation	Expected closure
Bohunice V2-1	V-213	472	1984	2024
Bohunice V2-2	V-213	472	1985	2025
Mochovce 1	V-213	436	1998	
Mochovce 2	V-213	436	1999	
Total (4)		**1816 MWe**		

Fuel - All Slovak power plants are supplied with fuel contracted from TVEL in Russia.

Radioactive waste management – By the 2008 used fuel was disposed of without reprocessing. Since 2008 waste management policy has been changed and radioactive waste is recycling domestically. The interim wet storage facility for used fuel is located in Bohunice and its capacity is 1680 tonnes (14,000 fuel assemblies). Nowadays the idea of participating in a shared international repository project is seriously considered.

Preparation for decommissioning - This process started in 2012 and two Bohunice V1 reactors are included. This process of decommissioning will last 13 years at estimated expenses €500 million.

Crossword ???



By clickin on the hyperlink you may check your knowledge about nuclear energy and its generation:

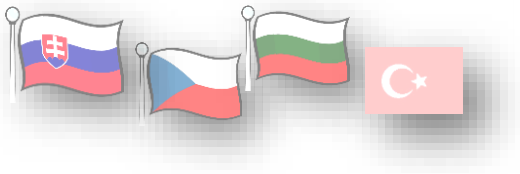
http://www.zssha.edu.sk/projekty/npp/

Test – nuclear power plants ???

Test: *(choose correct answer)*

1. Moderator in nuclear plants is used to
   (a) reduce temperature
   (b) moderate the radioactive pollution.
   (c) control the reaction
   (d) to reduce speed of neutrons

2. The most commonly used moderator in nuclear plants is
   (a) heavy water



(b) graphite.

(c) graphite and concrete

(d) deutrium

3. The main interest of shielding in nuclear reactor is protection against

   (a) neutrons and gamma rays

   (b) infra-red rays

   (c) alpha, beta, and gama rays

   (d) X-rays

4. In nuclear fission each neutron that causes fission releases

   (a) more than one new neutrons

   (b) at least one new neutron

   (c) one new neutron

   (d) no new neutron

5. The process by which a heavy nucleus is splitted into two light nuclei is known as

   (a) splitting

   (b) fusion

   (c) fission

   (d) chain reaction.

6. The following present serious difficulty in designing reactor shield

   (a) thermal neutrons

   (b) beta particles

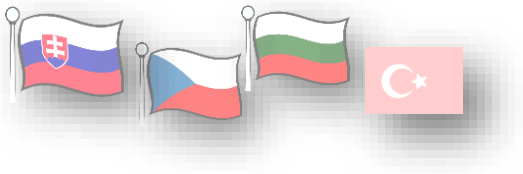
   (c) alpha particles

   (d) fast neutrons and gamma rays

7. Each fission of U235 produces following number of fast neutrons per fission

   (a) infinite

   (b) at least 2 — neutrons



(c) 1 – 2 neutrons

(d) 1 — neutrons

8. In nuclear fission

   (a) the original elements change into completely different elements

   (b) the molecules rearrange themselves to form other molecules

   (c) the electrons of the element change

   (d) none of the above.

Selfassessment: ***(Correct answers1d, 2b, 3a, 4a, 5c, 6d, 7b, 8a)***

Evaluating your needs:

If you did well on the test (8), but you still want to brush up on your skills, try studying the material on your own.

If you feel that you need guidance with studying (7-6), take part in a science course. This can be an efficient way to further your education. Pay attention to your teacher and keep the SLANT rules.

If you scored within (5-3), don't forget the math, physics, and calculator skills because you'll need them right away.

If you scored within (2-0), If you don't know how to solve simple equations or work confidently with negative numbers and decimals, get these skills first. Study much more at home and keep the SLANT rule at school!!!

http://www.nei.org/Knowledge-Center/Nuclear-Statistics/World-Statistics

http://large.stanford.edu/courses/2011/ph241/jaffer2/

http://www.nuclear-power.net/nuclear-power-plant/

http://www.exploringnuclearenergy.net

http://www.world-nuclear.org/info/Country-Profiles/Countries-O-S/Slovakia/