SUSTAINABLE ENERGY RESOURCES

And their use in Serbia

ГИМНАЗИЈА
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STEM

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01

Energy

Types of energy and conservation of energy

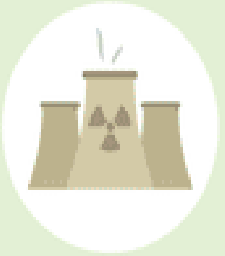
ENERGY

In physics, energy is defined as an ability to do work, and work is defined as a motion against an opposing force. There are various types of energy: kinetic, potential, thermal, electric, nuclear, chemical energy and more. It has a vast application in our everyday lives.

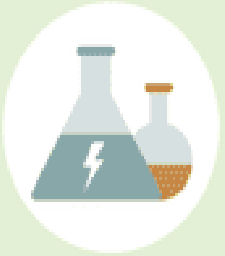
SOME TYPES OF ENERGY

Mechanical Energy

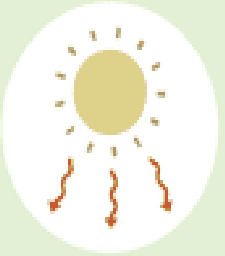
Thermal Energy



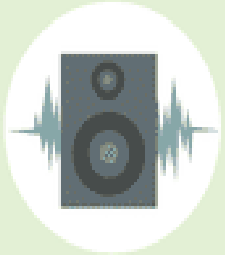
Nuclear Energy



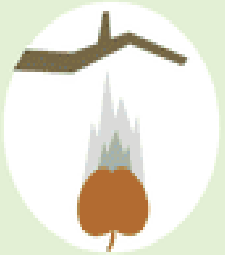
Chemical Energy



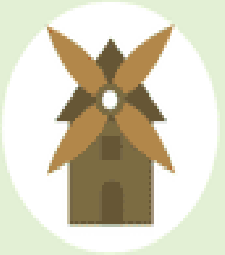
Electromagnetic Energy



Sonic Energy

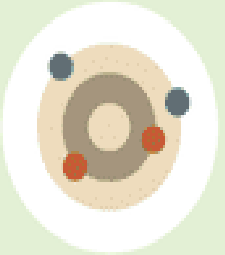


Gravitational Energy



Kinetic Energy

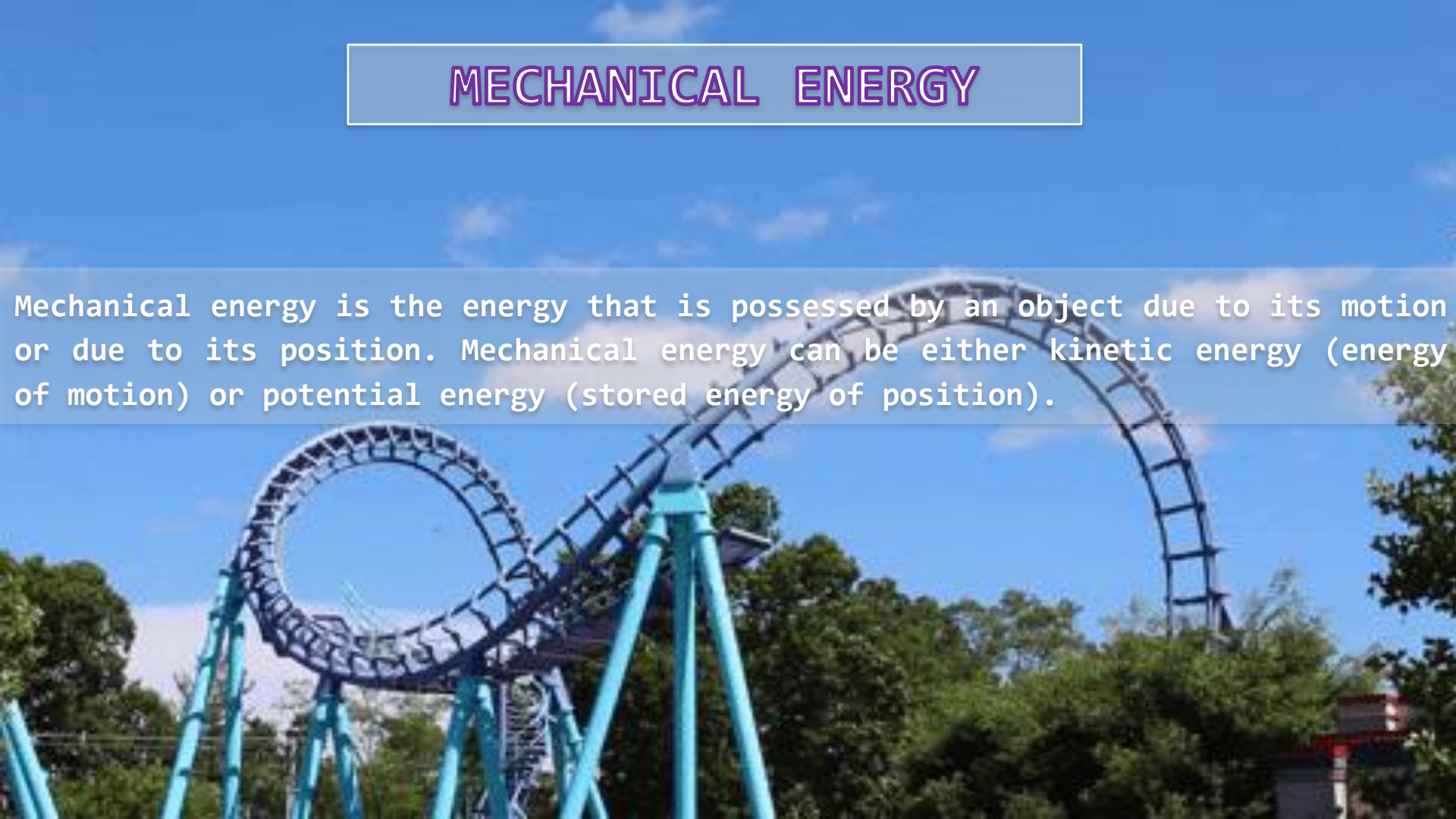
Potential Energy



Ionization Energy

MECHANICAL ENERGY

Mechanical energy is the energy that is possessed by an object due to its motion or due to its position. Mechanical energy can be either kinetic energy (energy of motion) or potential energy (stored energy of position).



POTENTIAL ENERGY

Potential energy is the energy stored in an object. It depends on its relative position or location.

For instance, an apple on a tree possesses potential energy.

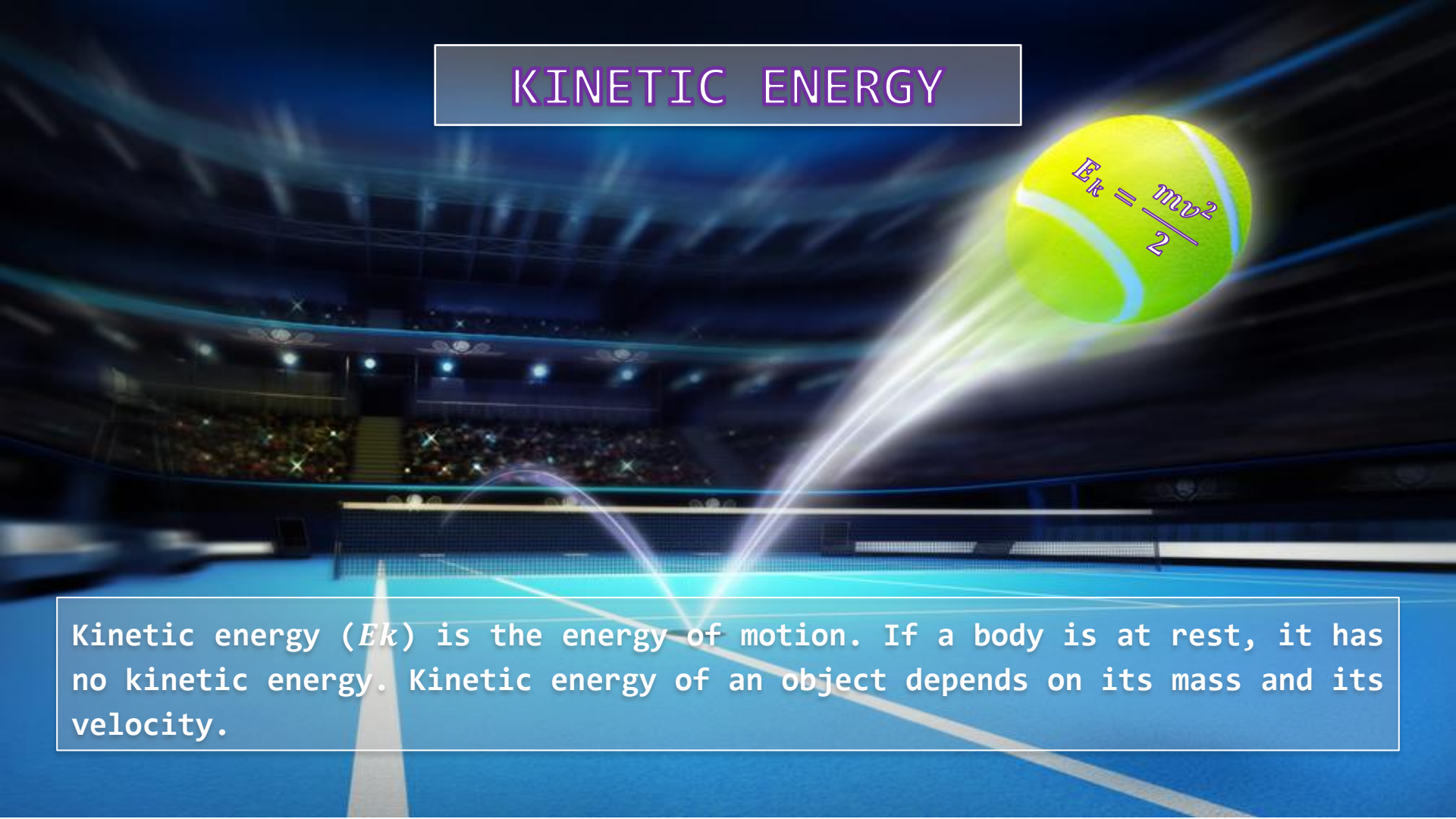
Potential energy can be calculated using this formula:

$$E_p = mgh$$

E_p – potential energy
m – the mass of an object
h – height relative to the ground
g – gravitational acceleration

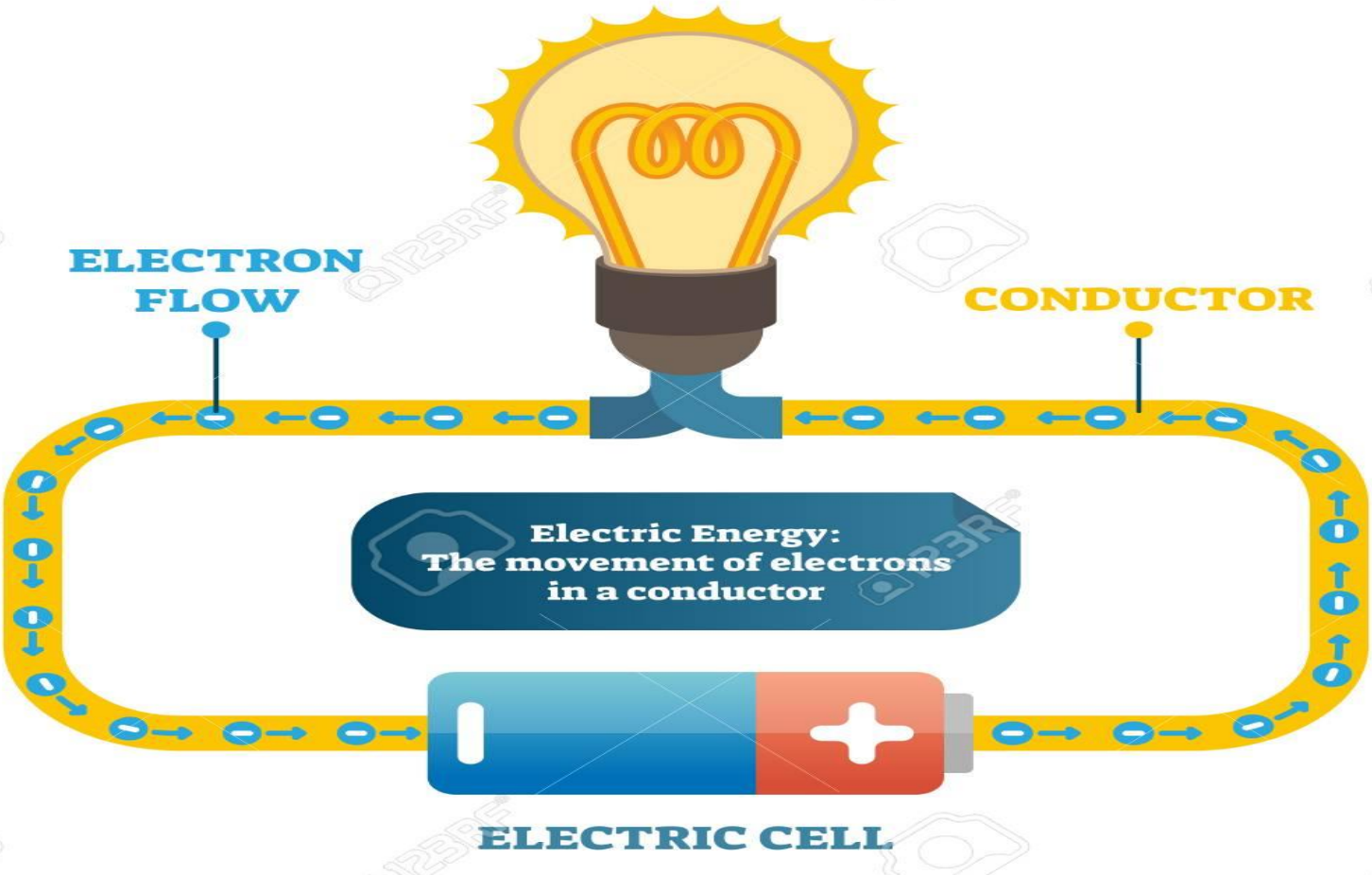
An object that is situated at some height above the ground level, has gravitational potential energy.

KINETIC ENERGY

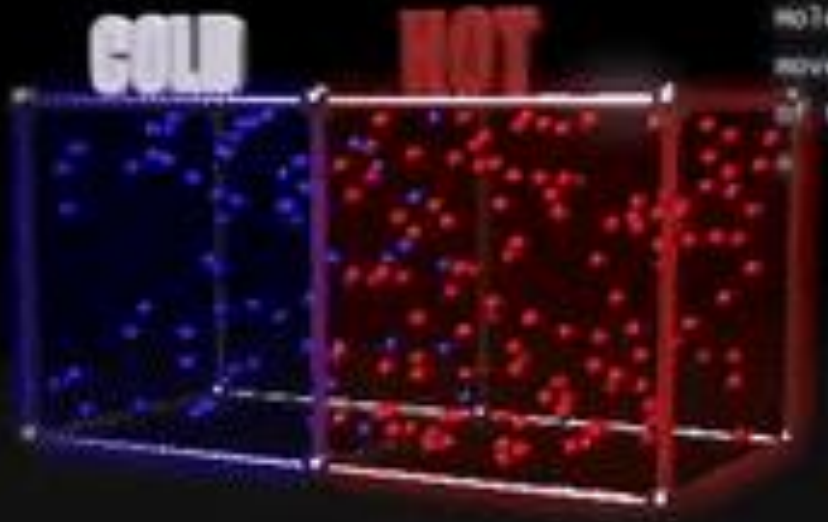


Kinetic energy (Ek) is the energy of motion. If a body is at rest, it has no kinetic energy. Kinetic energy of an object depends on its mass and its velocity.

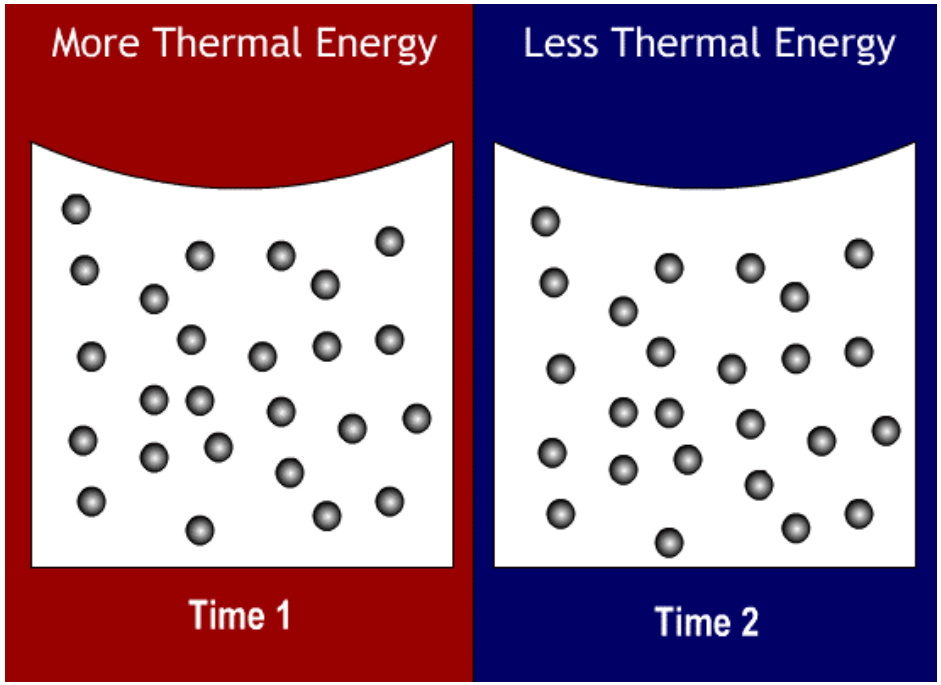
ELECTRIC ENERGY

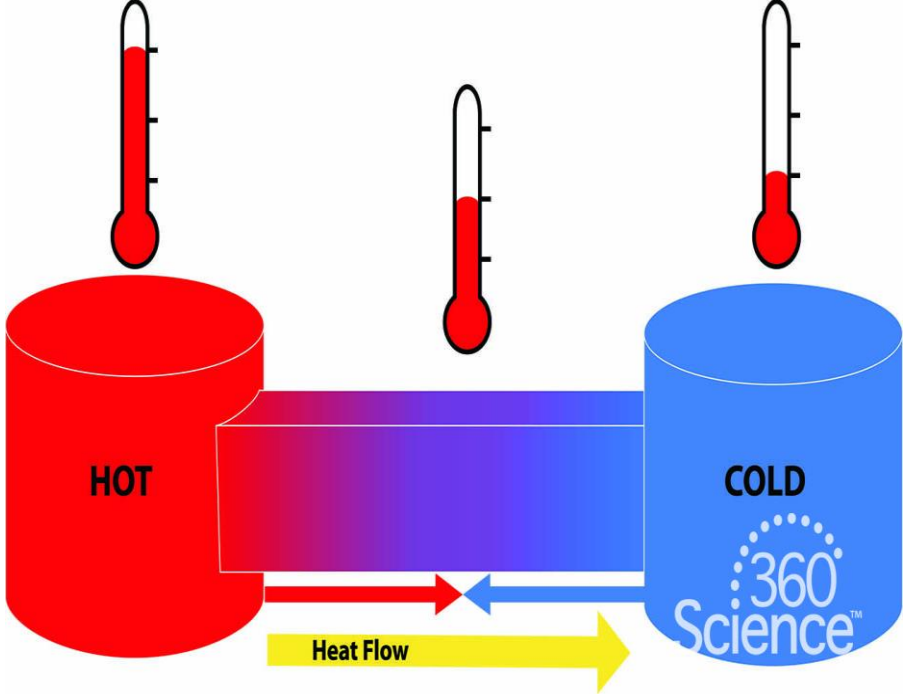


THERMAL ENERGY



Molecules of the hot substance moves more rapidly than those of the same substance with

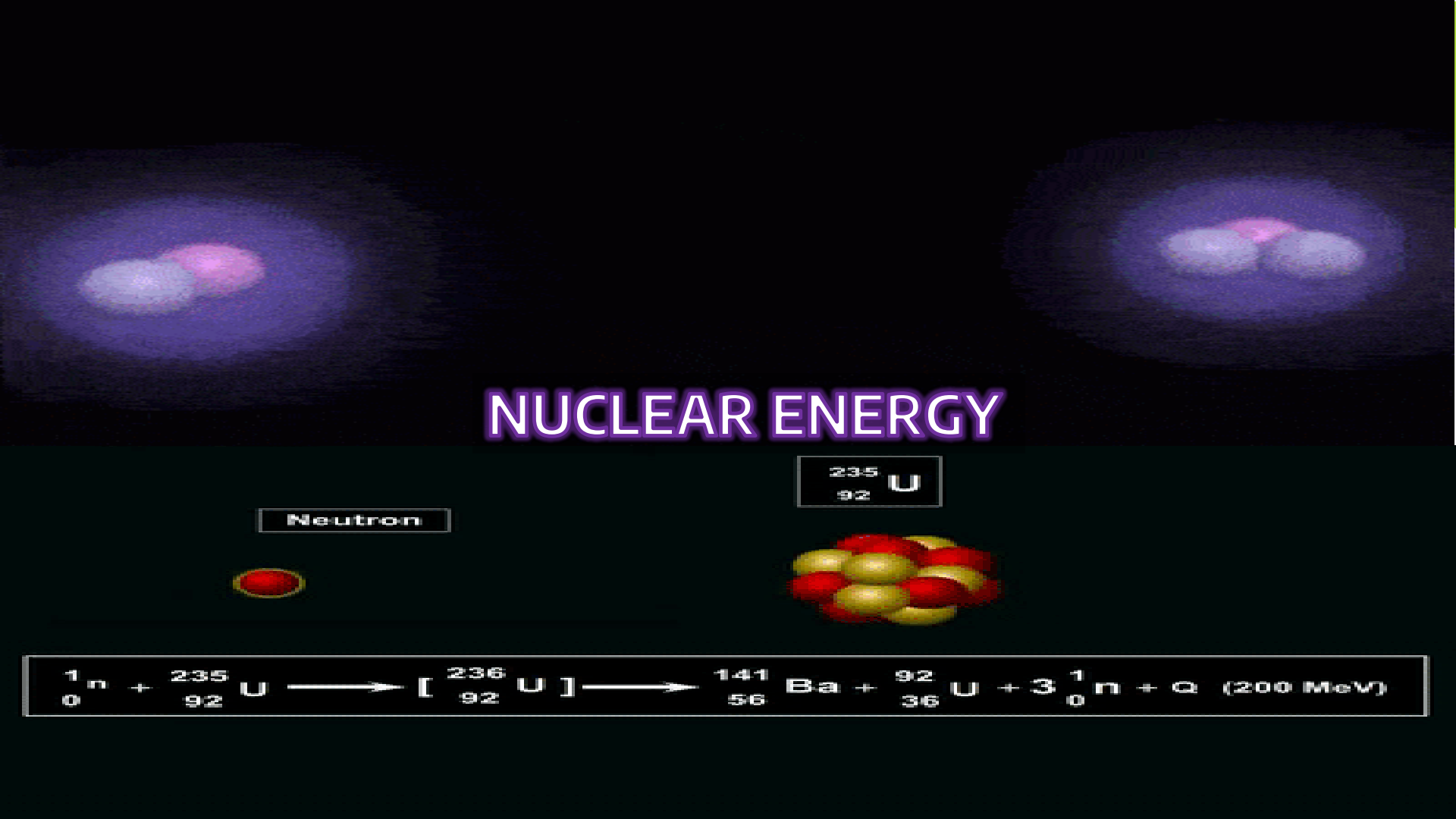




Thermal energy of an object is the sum of kinetic and potential energy of the small particles (molecules, atoms or ions) that the object consists of.

Thermal energy is in direct corelation with temperature. The hotter an object, the greater its thermal energy gets.

NUCLEAR ENERGY

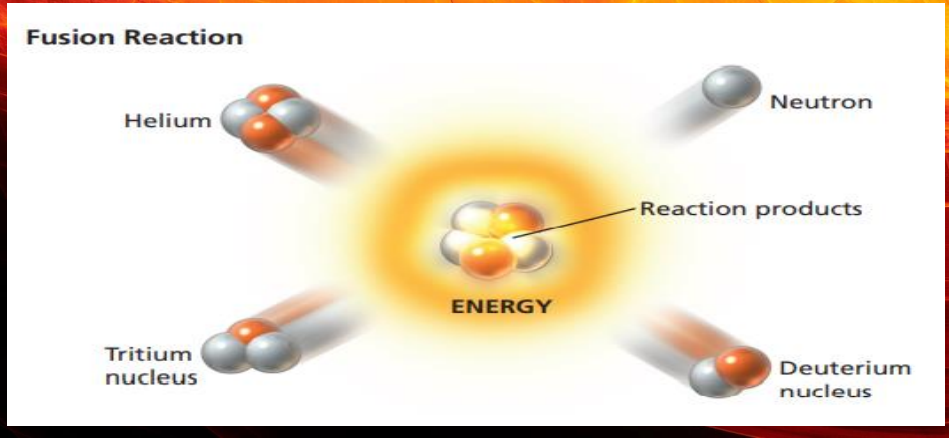


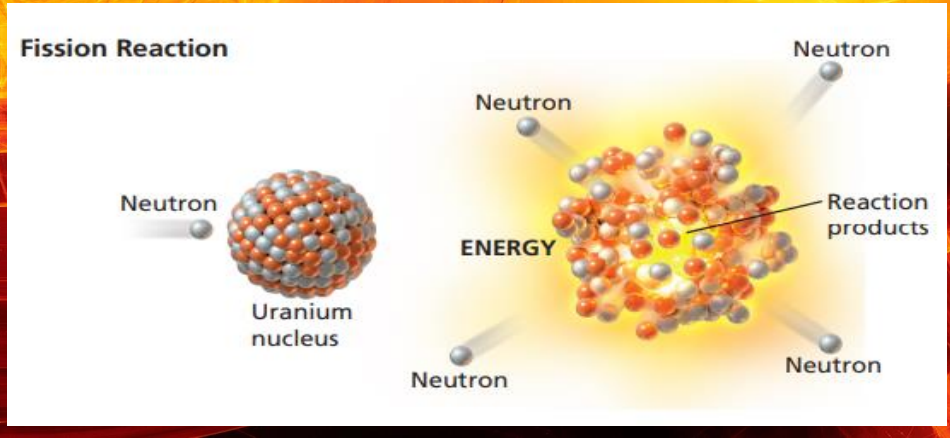
$$^{1}_{0}n + {}^{235}_{92}U \longrightarrow [\,{}^{236}_{92}U\,] \longrightarrow {}^{141}_{56}Ba + {}^{92}_{36}U + 3\,{}^{1}_{0}n + Q \quad (200\ MeV)$$

Nuclear energy is one of the most mysterious, but also most powerful sources. It is generated through the nuclear fission or the nuclear fusion. Nuclear fission is the splitting of atoms, and nuclear fusion is their combining.

These nuclear reactions produce extreme amounts of energy and in a controlled facility, we can use it for generating electricity. However, these fission reactions leave radioactive products (waste) that needs to be stored in a place which will minimize their harmful radiation. Nuclear energy is still debatable because of the difficulty of storing these radioactive byproducts.

Unlike fission, fusion does not leave nuclear waste that needs to be taken care of and stored in a safe place so it can not adversely affect human health. Fusion technology is currently in the final stages of research and it is believed that fission reactors will be replaced by fusion reactors in the future.





CONSERVATION OF ENERGY

Energy can be neither created nor destroyed. It can only be transferred from one object to another or converted from one type to another.

For example, if an apple is falling from a tree, its potential energy is converted into its kinetic energy.

02

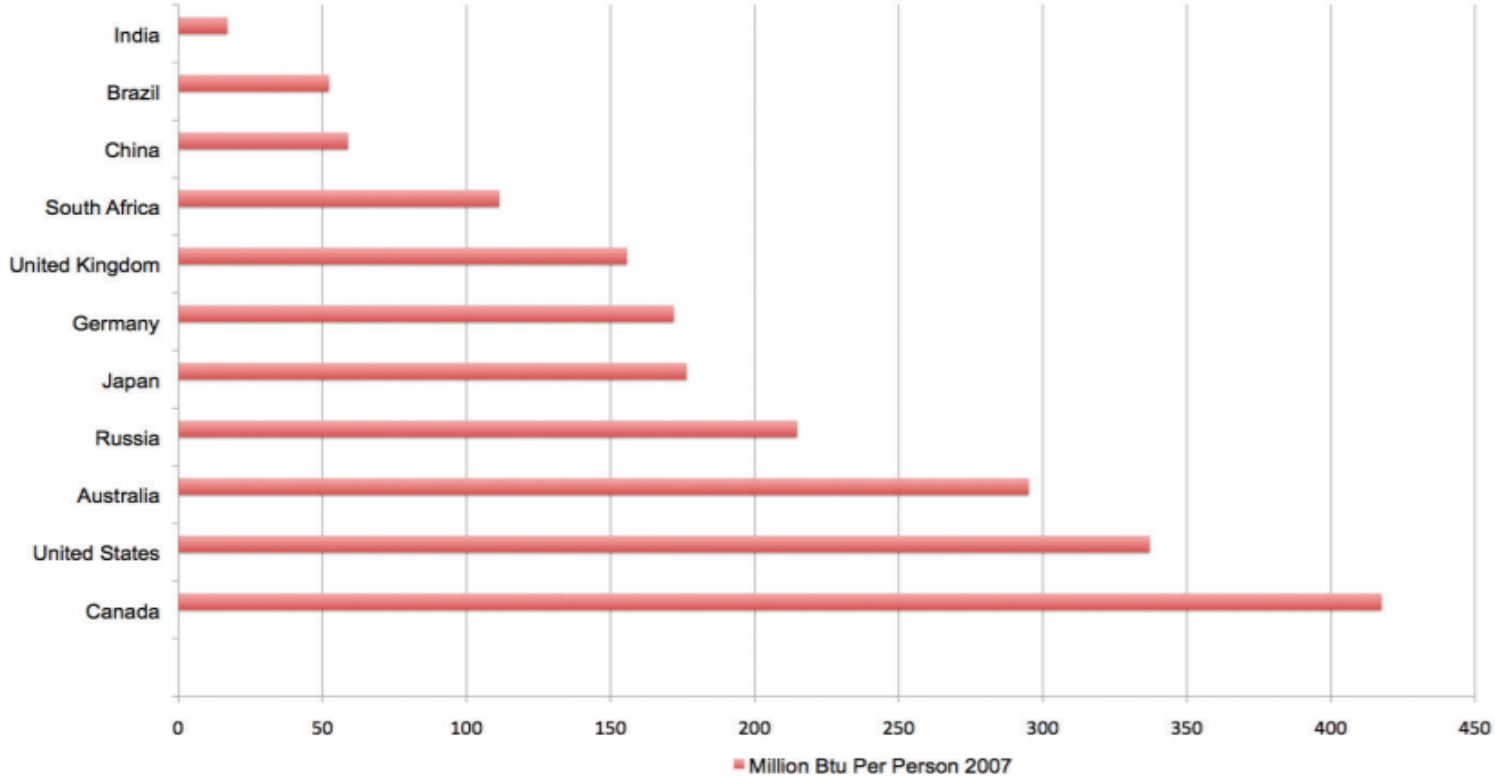
Energy resources

About Energy resources in the world and how we use them.

Energy is an important aspect of our lives and it is necessary for modern life: we use it for cooking, for heating, for powering light bulbs and other sources of illumination, for powering our mobile phones and other gadgets... But, where does this energy come from?

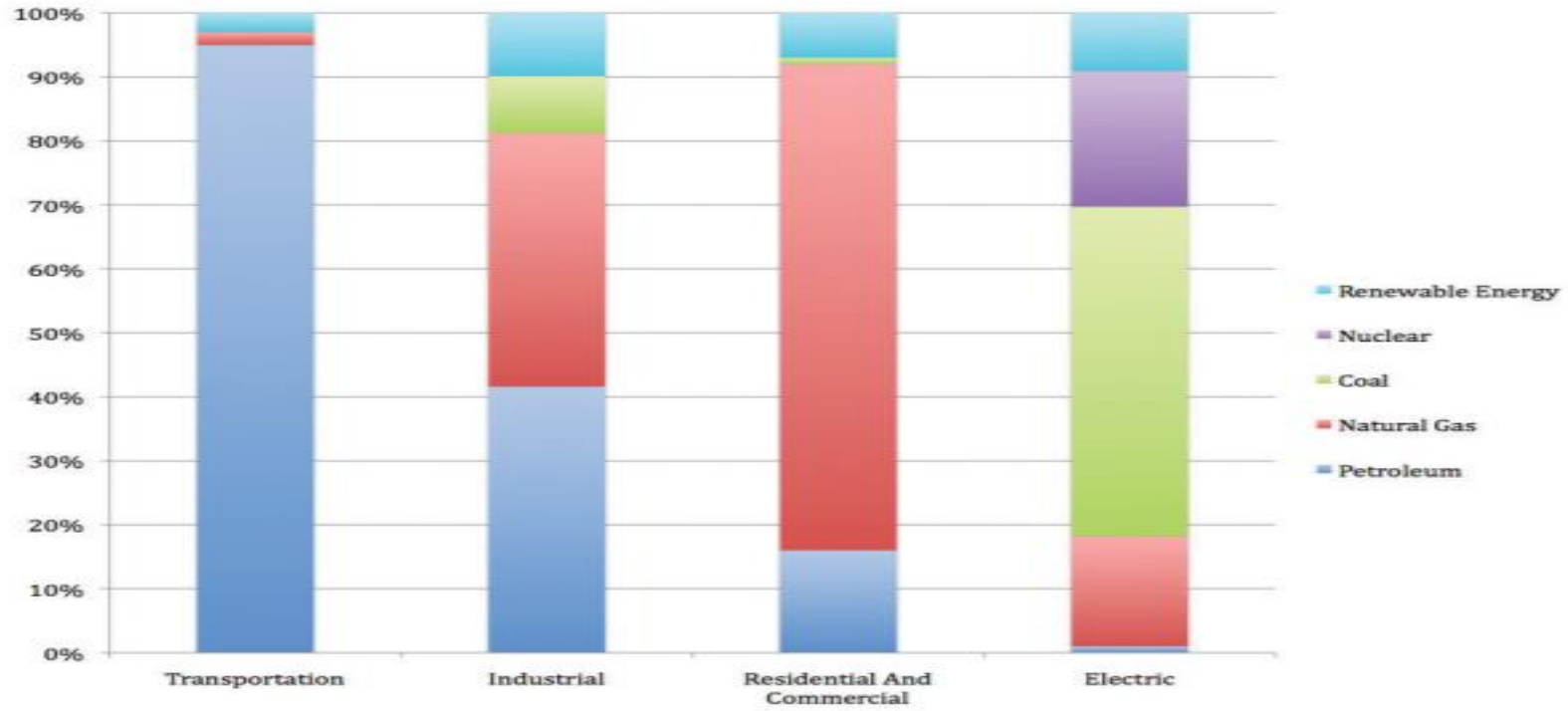
Around 84% of the world’s energy production comes from fossil fuels, 7% from hydro- and 4% from nuclear energy resources. Wind, solar, bio, wave, tidal and geothermal energy resources combined are responsible for only 5% of global energy production.

ENERGY USE PER CAPITA



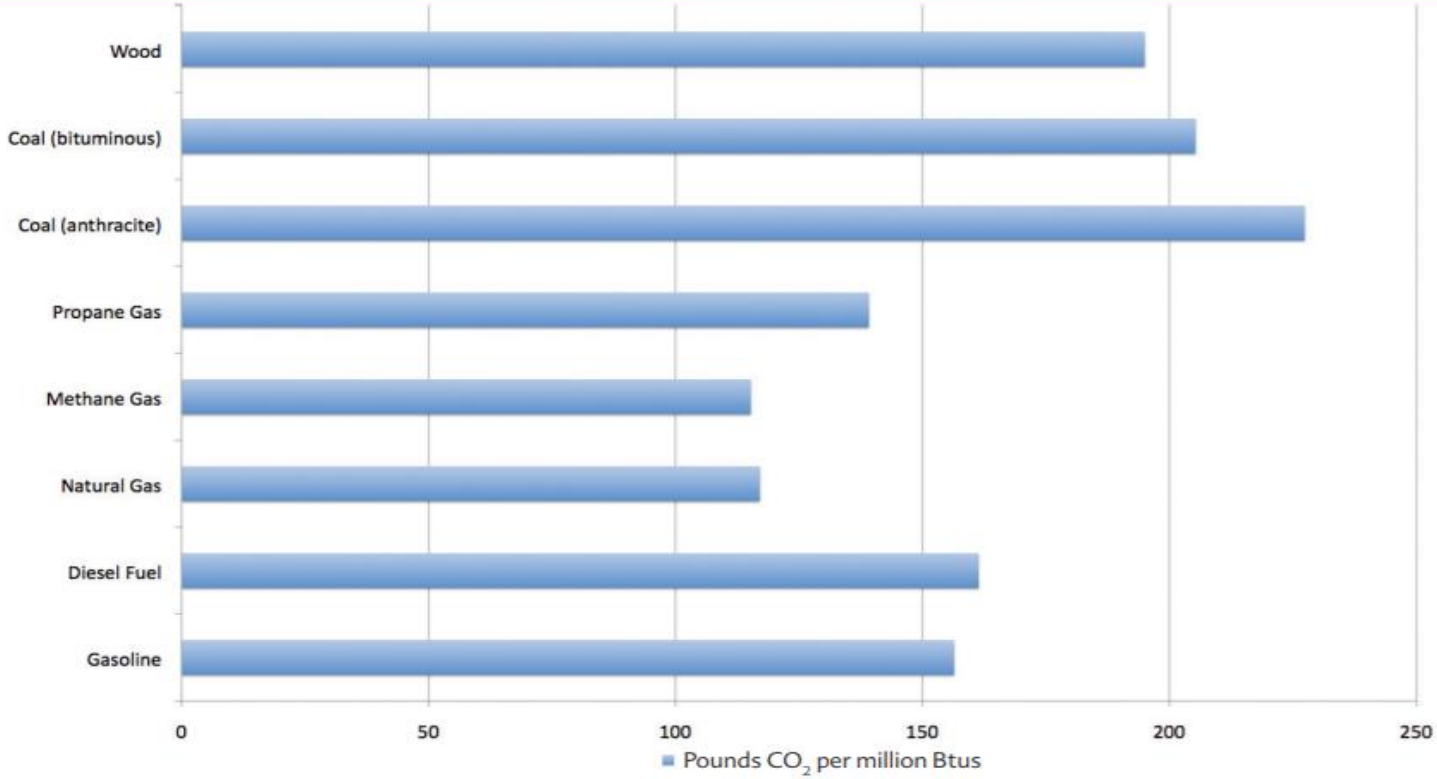
The U.S. Energy Information Administration (EIA) monitors national and global energy use. In 2007, EIA calculated that American citizens consumed an average of 337 million Btu compared 172 Btu per German citizen and 156 Btu per British citizen. Data can be downloaded from EIA's International Energy Statistics website: http://www.eia.doe.gov/emeu/international/contents.html

ENERGY USE BY SECTOR



In the United States we use our energy resources in different ways. Coal is used to produce electricity for homes and businesses. Natural gas is used predominantly in homes, while petroleum dominates the transportation sector.

EMISSION COEFFICIENTS



Fossil fuels, as well as wood, give off varying amounts of carbon dioxide in relation to the energy output. This graph shows that burning wood and coal produce more carbon dioxide compared to burning other fossil fuels for the same amount of energy output. Data for this graph can be downloaded from the U.S. Energy Information Administration emission coefficient page: http://www.eia.doe.gov/oiaf/1605/coefficients.html.

An energy resource is sustainable if it meets the needs of present generations without compromising the ability of future generations to meet their own needs.

Large factories emit enormous amounts of greenhouse gases, which pollute the atmosphere. Also, in some countries, people don’t have access to electricity. Sustainable energy should offer a solution to these problems by providing energy resources which do not pollute the environment, and make electricity accessible to everyone.

Generally, renewable energy resources (such as wind and solar energy, hydroelectric power and geothermal energy) are far more sustainable than fossil fuels. However, extracting energy from some renewable energy resources might result in damaging the environment. An example of that would be cutting trees in order to produce biofuels.

03

Renewable energy resources

A few types of renewable energy and how we use them. Their basic working principles of devices for their use.

SOLAR ENERGY

Solar energy is the ultimate source of energy on Earth. The sun drives water cycling, wind and weather patterns. It is also the source of energy for all life on Earth. Of course, solar energy is a term commonly used for the energy we obtain directly from the sun.

Sunlight, also known as solar radiation, is the most inexhaustible renewable energy source. The amount of energy that sun iradiates onto Earth every hour is greater than the amount of energy people use in a year.

There are two ways we can use sun’s energy – active and passive. Passive way involves using sun’s energy without mechanical or electric devices. For example, passive use of sun’s energy would be using it as a light or a heat source. On the other hand, active use of sun’s energy does involve using mechanical and/or electric devices. There are two main ways we can transform solar energy into electricity. One is using solar thermal power plants, and the other is photovoltaics.

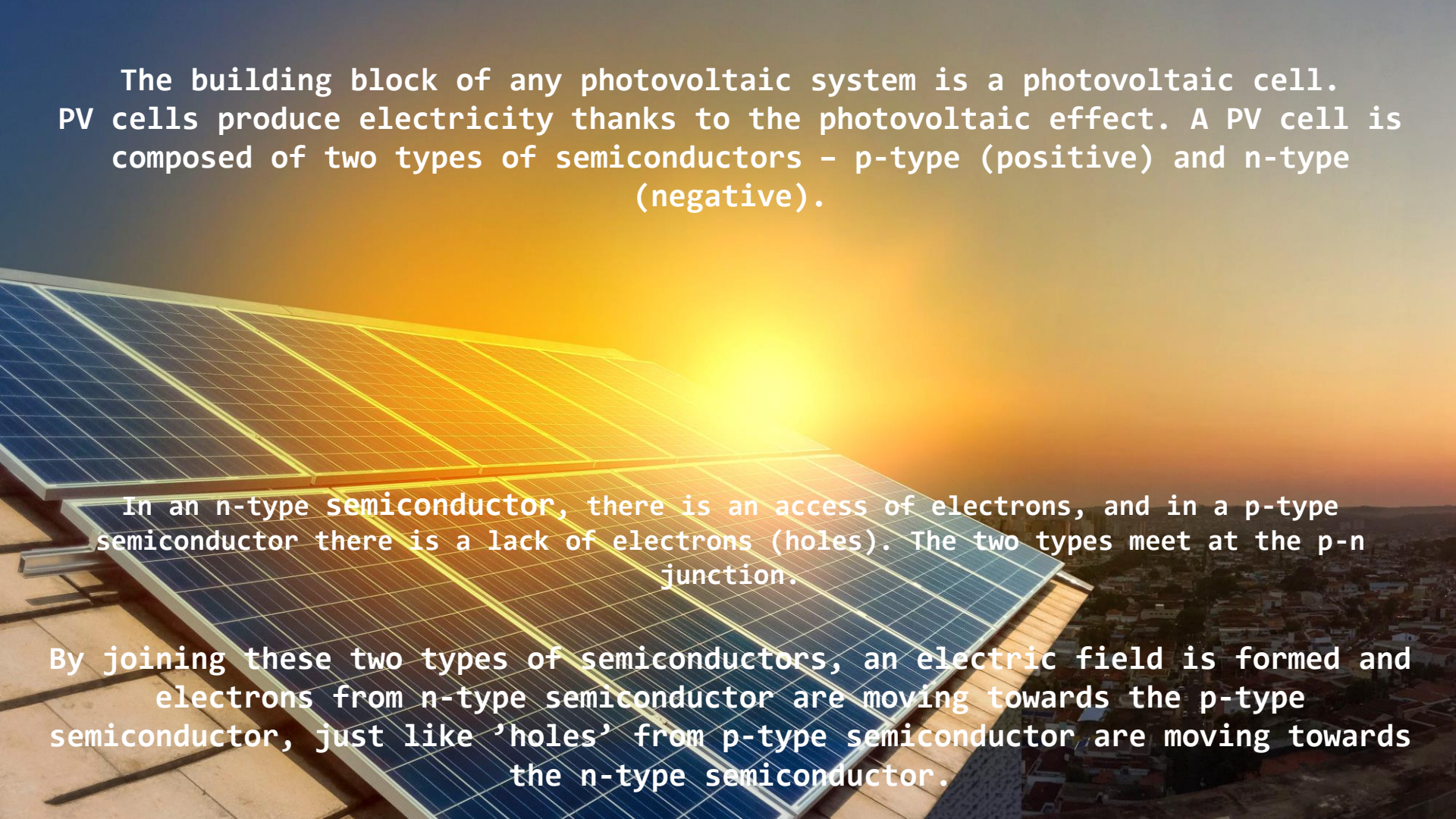
SOLAR THERMAL POWER PLANTS

At solar thermal power plants the sun’s rays are concentrated towards a liquid usually water. The sun’s rays heat the liquid and cause it to boil, producing steam which is then used for rotating turbines.

Mechanical energy of the rotating turbines is transferred to electricity by a generator. The solar energy is converted into heat energy, which produces steam and runs a generator producing electricity. There are several different types of solar thermal power plants: parabolic troughs, parabolic dishes, and power

PHOTOVOLTAICS

Photovoltaic (PV) energy is a form of active solar power that is created when light energy from the sun is converted directly into electricity on an atomic level. PV energy produces electricity without burning fuels and with no moving parts. PV technology is based on the fact that light can stimulate electric current in some materials.

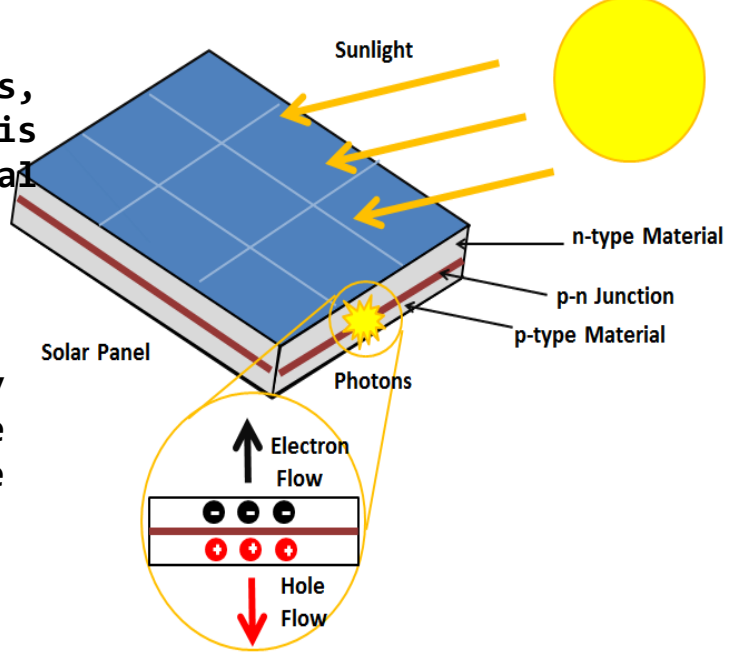


The building block of any photovoltaic system is a photovoltaic cell. PV cells produce electricity thanks to the photovoltaic effect. A PV cell is composed of two types of semiconductors – p-type (positive) and n-type (negative).

In an n-type semiconductor, there is an access of electrons, and in a p-type semiconductor there is a lack of electrons (holes). The two types meet at the p-n junction.

By joining these two types of semiconductors, an electric field is formed and electrons from n-type semiconductor are moving towards the p-type semiconductor, just like ’holes’ from p-type semiconductor are moving towards the n-type semiconductor.

When light of a suitable wavelength reaches these cells, energy from the photon (a particle of light) is transferred to electrons of the semiconducting material in the p-n junction.



This causes the electrons to jump to the higher energy state, called the conduction band. This leaves a hole in the lower energy band, that way there are two charge carriers.

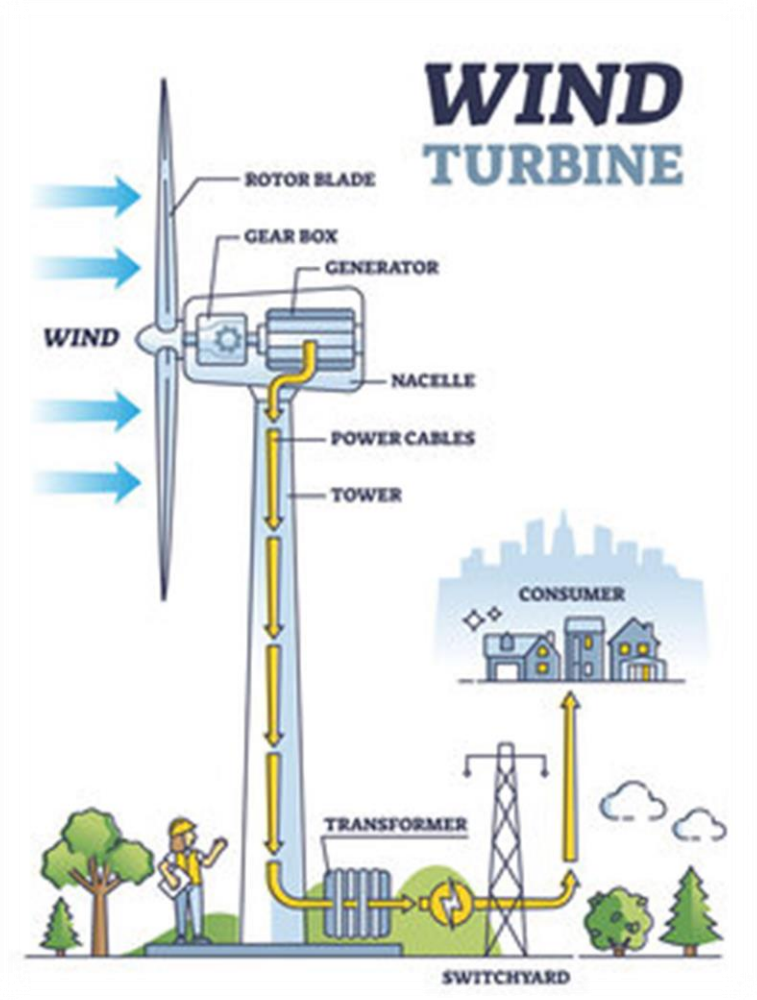
Photovoltaic power has proven to be extremely reliable. In an PV array (which consist of many PV cells) there are no moving parts and PV equipment can operate without any particular maintenance. There are also no expenses for fuel (sunlight is free).

However, there are some disadvantages concerning PV energy. Producing PV equipment can be quite expensive. Also, if PV projects occupy a large area, natural ecosystem is disrupted. Of course, these solar units cannot generate electricity at night and are less efficient during cloudy weather.

WIND ENERGY

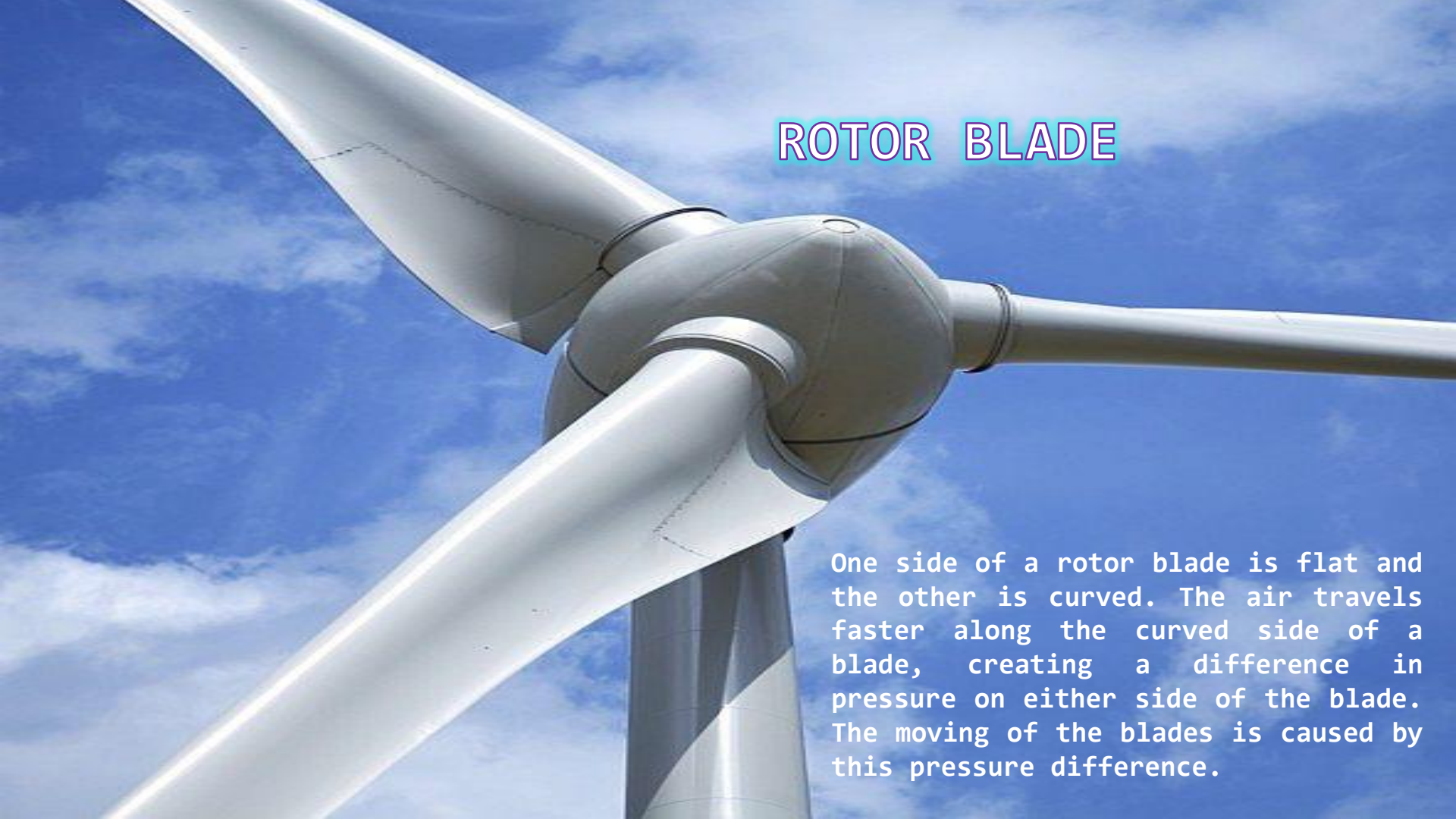
Wind power plants use airflow to move a turbine, transforming kinetic energy of moving air into electricity. Before the technology of production of electricity, wind energy was used for grinding grain, pumping or draining water and for propelling sailing ships. Nowadays, with modern technology, wind power can be used to produce electricity. In a zone of powerfull wind, wind farms can be constructed. Wind farms consist of an array of wind turbines, which are high towers which usually have three blades.

WIND TURBINE



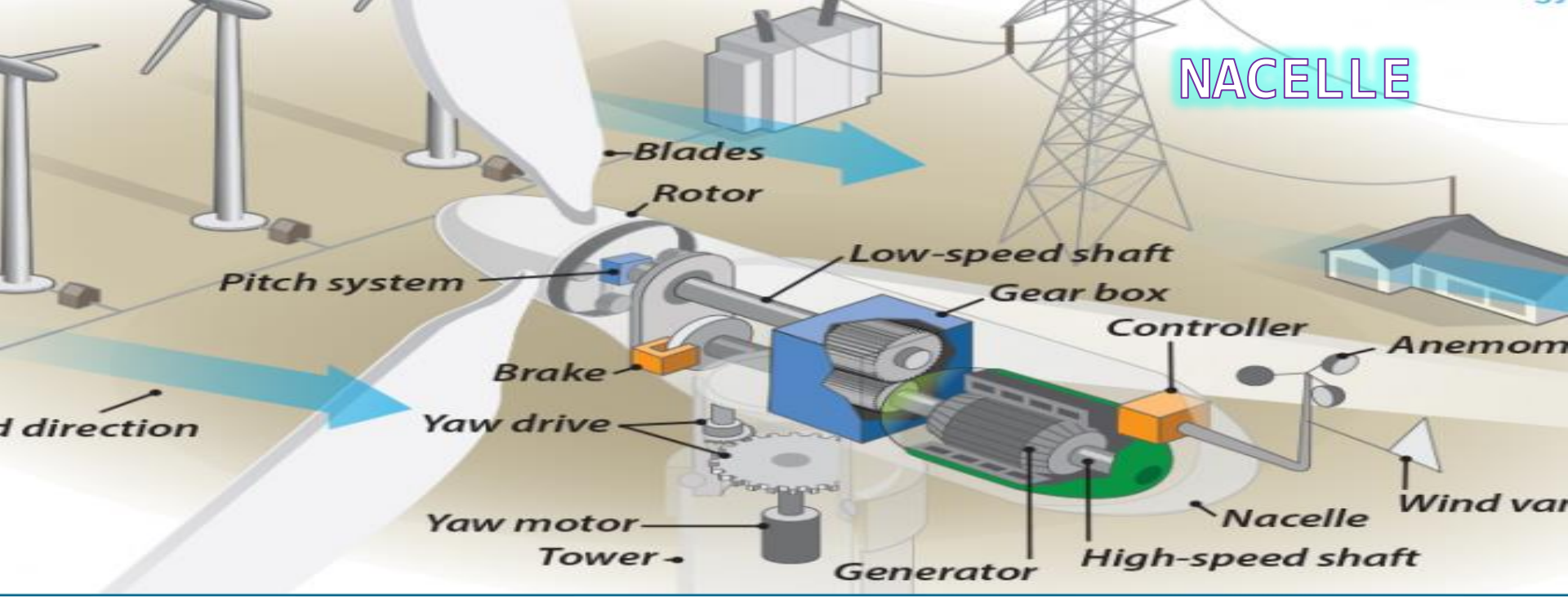
Modern wind turbines come in various sizes, but they usually consist of three parts:

- Rotor blades
- Nacelle
- Tower



ROTOR BLADE

One side of a rotor blade is flat and the other is curved. The air travels faster along the curved side of a blade, creating a difference in pressure on either side of the blade. The moving of the blades is caused by this pressure difference.

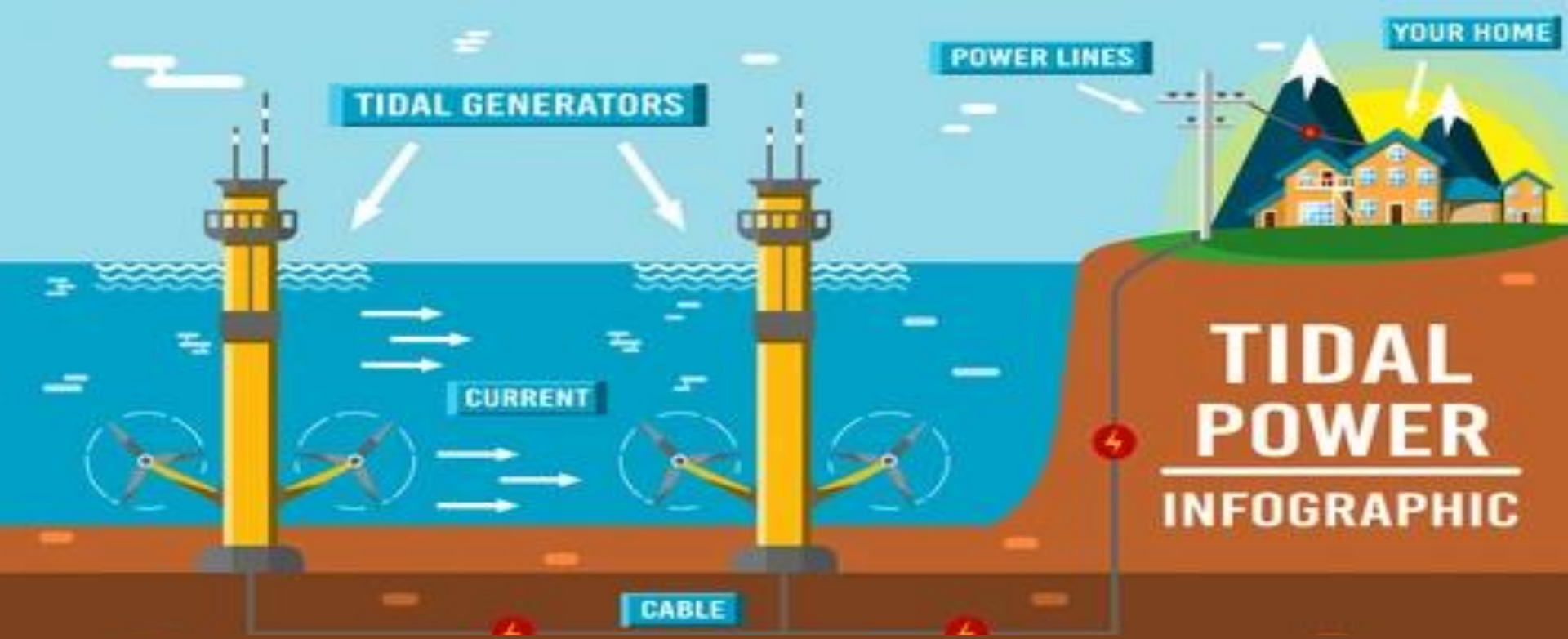


The nacelle contains a generator and a set of gears. The gears convert relatively small rotation speeds to the generator rotation speed of about 1500 rotations per minute. Generator transforms kinetic rotational energy into electricity.

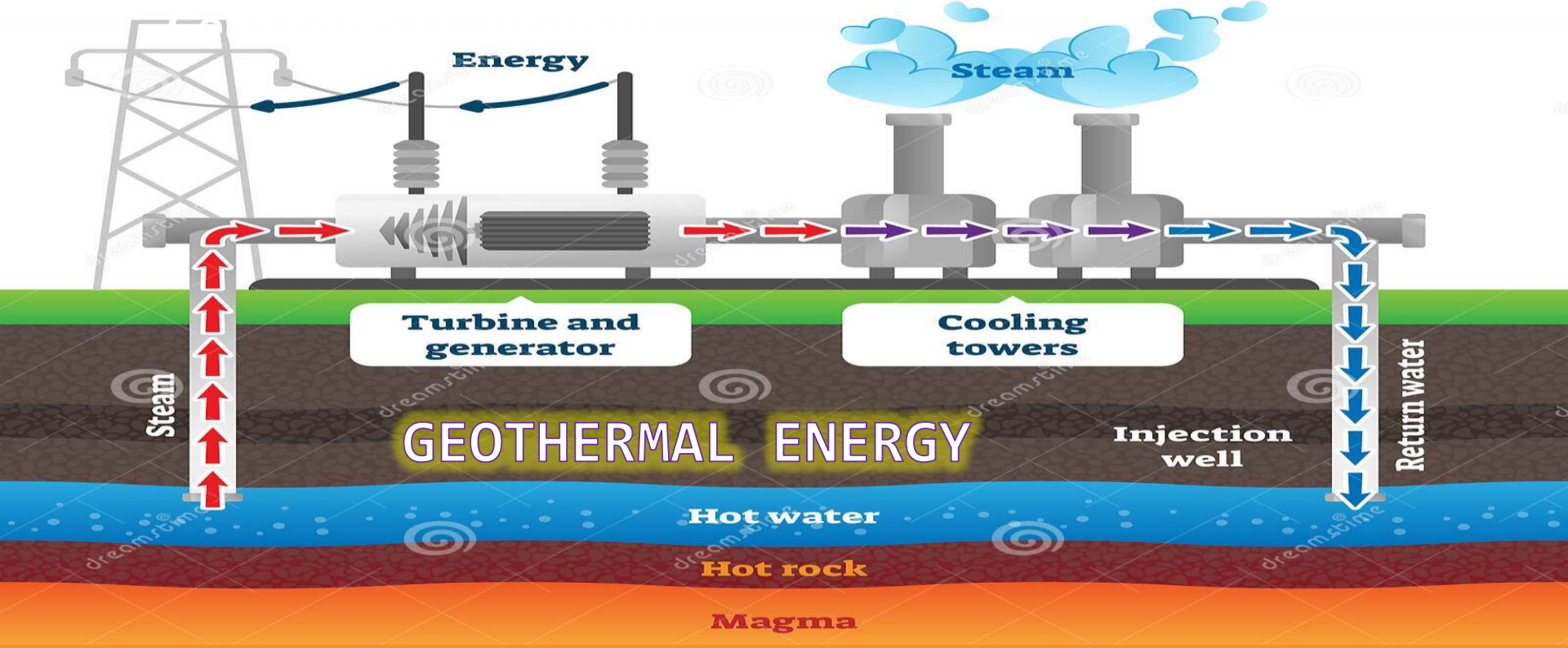
The nacelle and rotor blades are mounted on top of a tower. The height of the tower is constructed in the way to hold rotor blades at the height where the wind speed is maximal.

HYDROPOWER

Hydropower generates electricity by extracting mechanical energy from water. Water in environment often has both potential gravitational energy and kinetic energy which can be converted into electrical energy and electricity by generators.

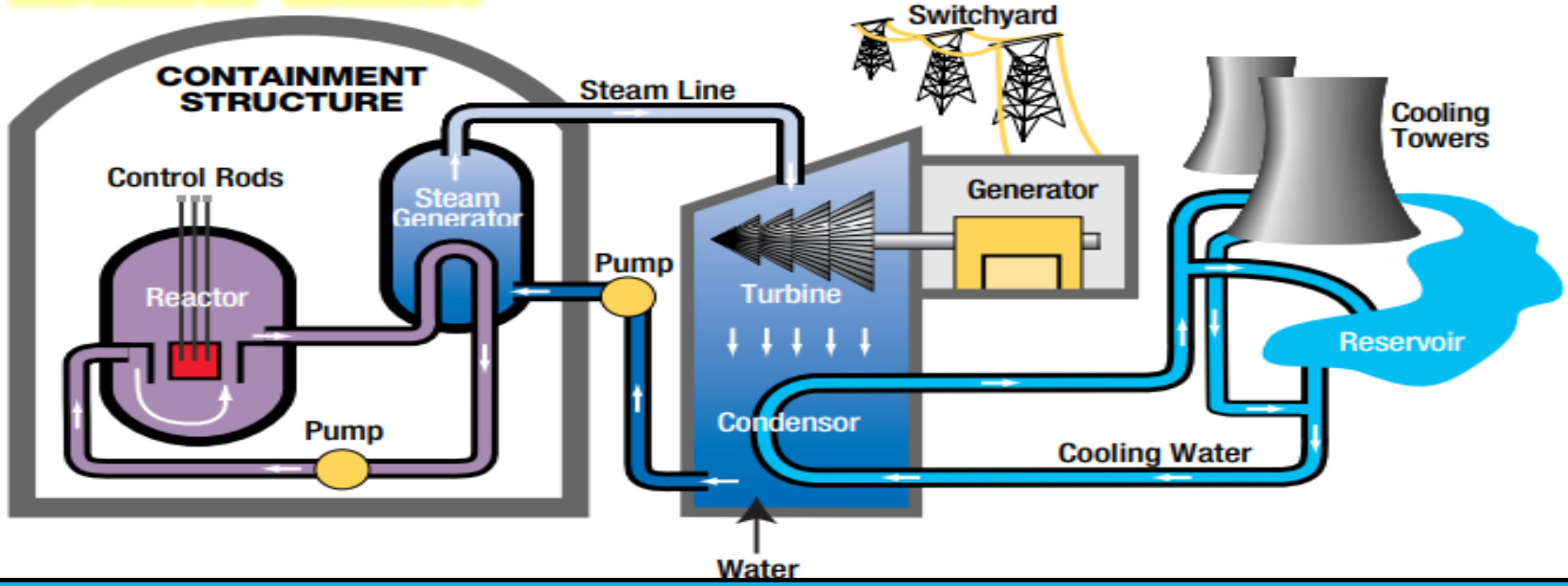


Tidal power harnesses energy from moving from tidal forces to generate electricity. It is a predictable energy source because tides occur at predictable times. In this sense, it has an advantage over solar or wind energy. However, tidal power is not used as commonly as other forms of renewable energy (solar, wind and hydropower) because the costs outweigh the advantages.



Geothermal energy is energy extracted from thermal sources that originate from deep underground. It can be used directly for heating, or for creating electricity. Deep underground, the Earth will remain hot for billions of years, so geothermal energy can be used for a long time. However, if not used carefully, geothermal energy may not be sustainable.

NUCLEAR ENERGY

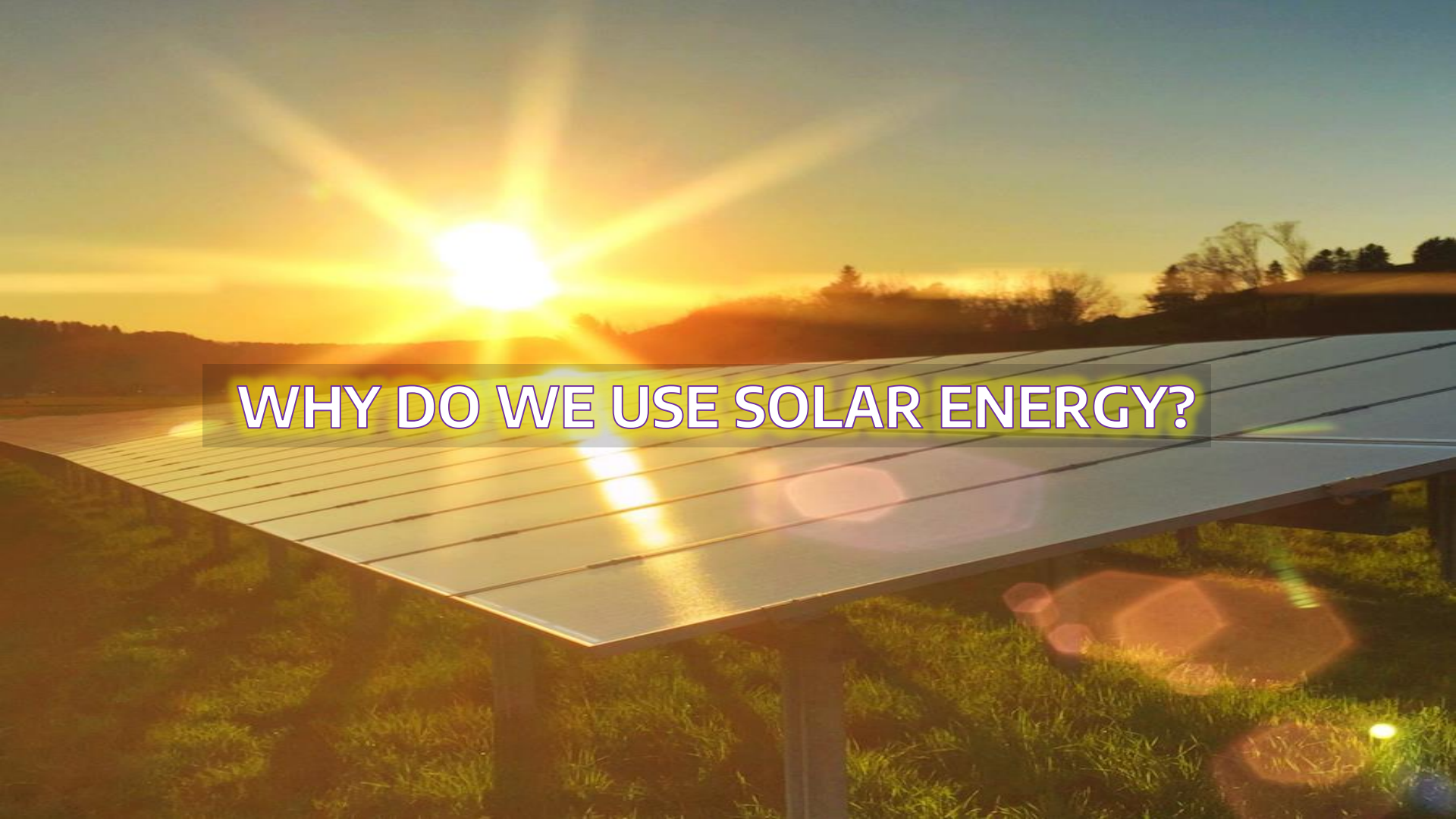


Nuclear power plants use the heat from fission or fusion reacions to heat water, vaporizing it. Water vapors flow to a turbine, making the rotor of the generator spin. The general changes in energy follow this sequence: nuclear energy to heat energy through a nuclear reaction, heat energy to kinetic energy in a fluid, kinetic energy in the turbine and rotor into electricity as a product.

04

Solar energy in Serbia

how and where solar energy is used in Serbia


WHY DO WE USE SOLAR ENERGY?

Sunlight is a source of energy that is responsible for the favorable climatic conditions and the existence of ecosystems on our planet.

Most of the energy available on Earth comes to us from the Sun. With the right technology, we can use this free, ecological and eternal source of energy.

Solar technology is already being used to improve living standards. Above all, it represents a logical choice in facilities in remote areas where the possibility of connecting to the electricity distribution network was only difficult or does not exist at all.

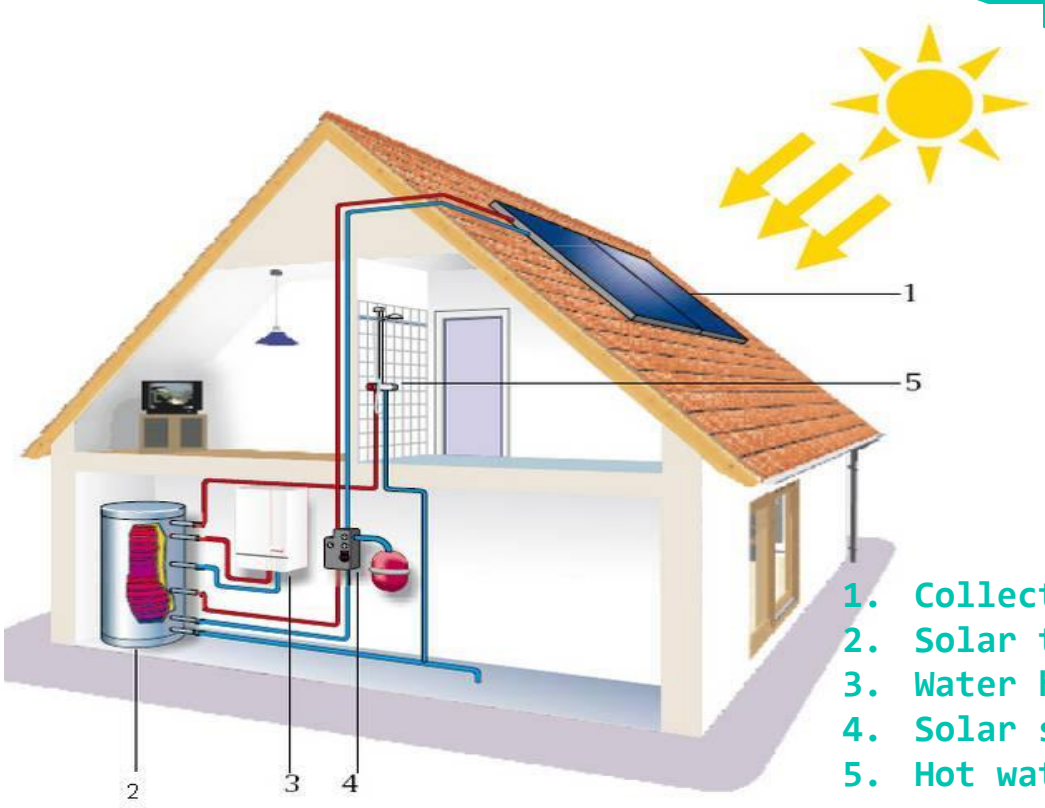
But that is not the only reason for its application. Solar technology also enables energy independence from the electricity distribution network in facilities with an existing connection.

By using this energy, we can ensure the production of hot water and electricity from a renewable energy source that does not emit harmful gases, and thus it also does not affect the environment.

EXAMPLE OF USING SOLAR ENERGY

Solar thermal energy systems for water heating are designed so that in the warmer half of the year they are completely responsible for water heating.

In the winter months, hot water is provided by boilers that run on oil, gas or wood, and on sunny days it is supported by a solar thermal energy system.



1. Collector
2. Solar tank
3. Water heater
4. Solar station
5. Hot water consumer

With solar van systems, collectors have larger area and also help with heating space during the fall and spring months.

Typically, solar energy can provide 10 to 30% of total energy needs of a van, depending on how good it is isolated and what is the required degree heating. There are also special solar houses which receive 50 to 100% of the total heating from solar thermal energy.

SOLAR FARM

The largest floating solar panel farm in the world is located in Singapore. It covers an area of 45 football fields and produces enough electricity to power five water treatment plants on the island.

The floating solar farm consists of 122,000 solar panels, and the clean energy obtained in this way will make Singapore one of the few countries in the world that has a water purification system that is fully powered by sustainable energy.

SOLAR FARM IN VELESNICA-KLADOVO SERBIA

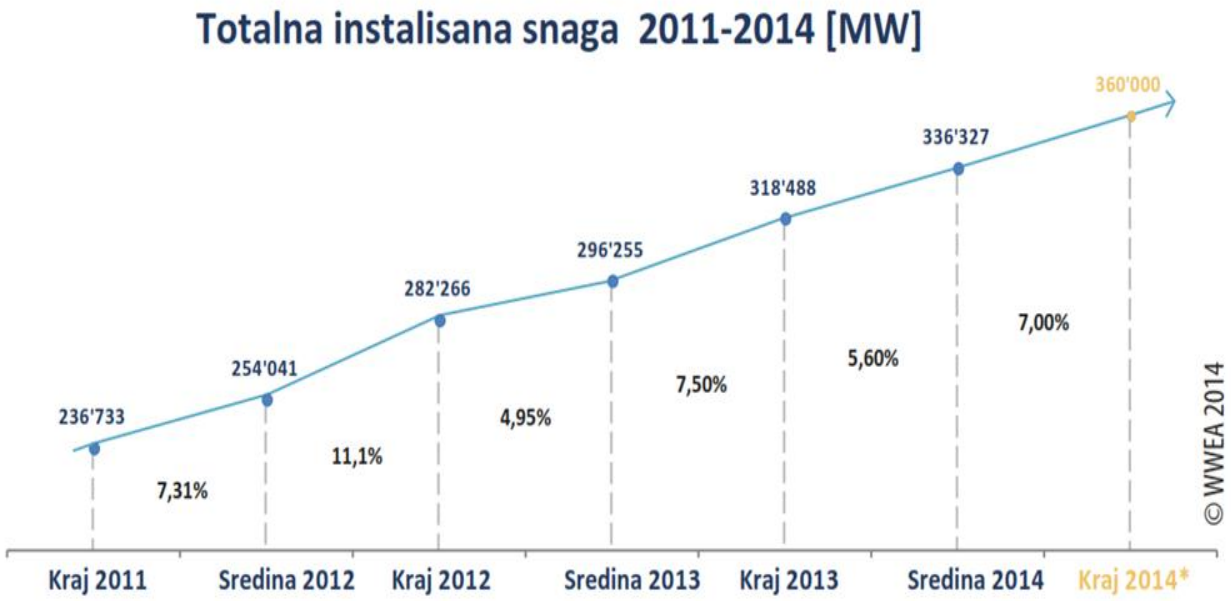
Solar energy in Serbia is mainly used for private purposes, but there are also solar power plants. The company Solaris Energy is the owner of the two largest operational solar power plants in Serbia with a capacity of about 2 MW (2x999kW). The solar park is located in Velesnica, in the municipality of Kladovo, where the largest Serbian hydroelectric power plant, Djerdap, is located. The solar park in Kladovo was built in 2014, and consists of 8462 photovoltaic panels and a substation.

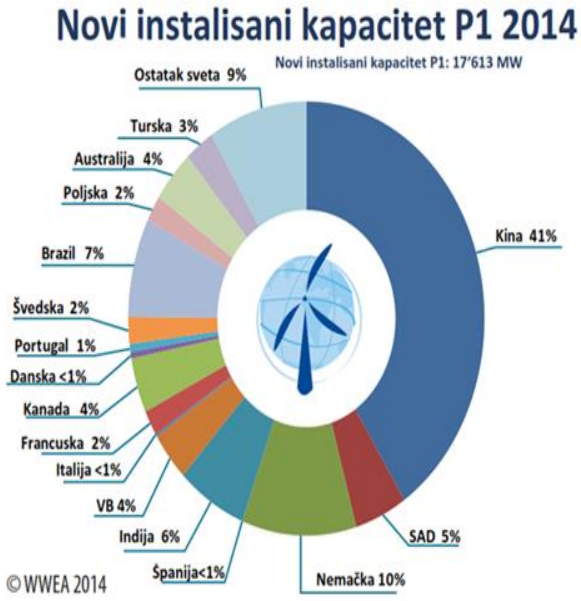
05

Wind energy in Serbia

how and where wind energy is used in Serbia

ELECTRICITY GENERATION CAPACITY





According to the data of the World Wind Energy Association (WWEA), the capacity for the production of electricity from wind reached 336327 MW in June 2014. 17613 MW of power was installed in the first half of 2014.

An interesting fact is that RES accounted for 79.1% of total new energy installations in 2014 - 21.3 GW out of 26.9 GW. The table on the right shows the installed forces in European countries.

	Installed 2013	End 2013	Installed 2014	End 2014
EU Capacity (MW)				
Austria	308.4	1,683.8	411.2	2,095
Belgium	275.6	1,665.5	293.5	1,959
Bulgaria	7.1	681,1	9.4	690.5
Croatia	81.2	260.8	85.7	346.5
Cyprus	-	146.7	-	146.7
Czech Republic	8	268.1	14	281.5
Denmark*	694.5	4,807	67	4,845
Estonia	10.5	279.9	22.8	302.7
Finland	163.3	449	184	627
France	630	8,243	1,042	9,285
Germany	3,238,4	34,250.2	5,279,2	39,165
Greece	116.2	1,865,9	113.9	1,979.8
Hungary	-	329.2	-	329,2
Ireland	343.6	2,049.3	222.4	2,271.7
Italy	437.7	8,557.9	107.5	8,662.9
Latvia	2.2	61.8	-	61.8
Lithuania	16.2	278.8	0.5	279.3
Luxembourg	-	58.3	-	58.3
Malta	-	-	-	-
Netherlands	295	2,671	141	2,805
Poland	893.5	3,389.5	444.3	3,833.8
Portugal*	200	4,730.4	184	4,914.4
Romania	694.6	2,599.6	354	2,953.6
Slovakia	-	3.1	-	3.1
Slovenia	2.3	2.3	0.9	3.2
Spain	175.1	22,959.1	27.5	22,986.5
Sweden	689	4,381.6	1,050.2	5,424.8
UK	2,075	10,710.9	1,736.4	12,440.3
Total EU-28	**11,357.3**	**117,383.6**	**11,791.4**	**128,751.4**

European Union: 128,751.4 MW
Candidate Countries: 3,799.5 MW
EFTA: 882.6 MW
Total Europe: 133,968.2 MW

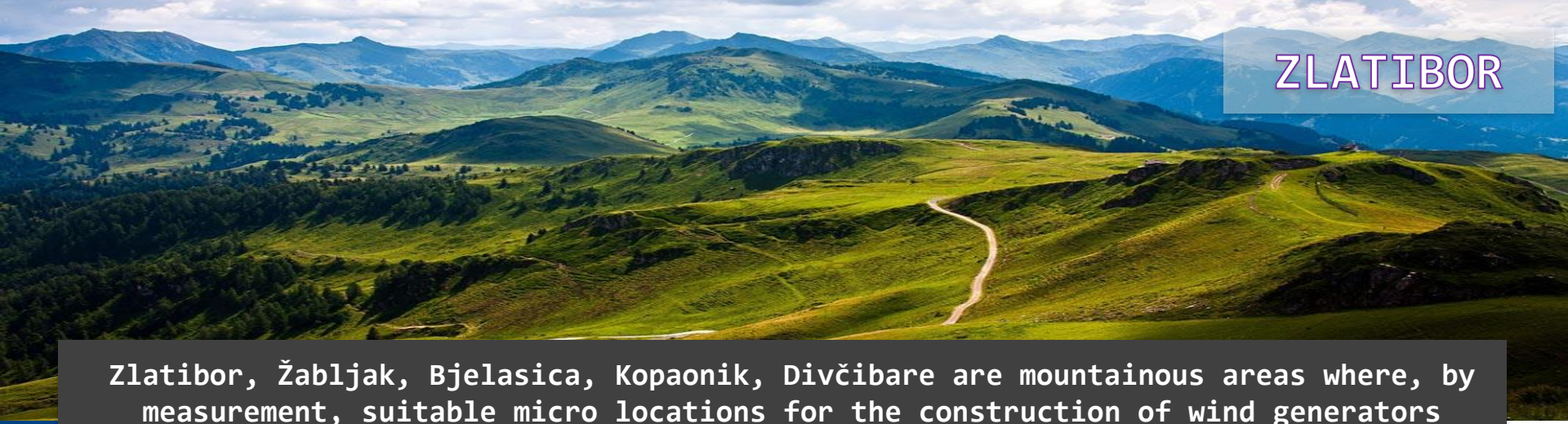
	Installed 2013	End 2013	Installed 2014	End 2014
Candidate Countries (MW)				
FYROM	-	-	37	37
Serbia	-	-	-	-
Turkey	646.3	2,958.5	804	3,762.5
Total	**646.3**	**2,958.5**	**841**	**3,799.5**
EFTA (MW)				
Iceland	1.8	1.8	1.2	3
Liechtenstein	-	-	-	-
Norway	110	771.3	48	819.3
Switzerland	13.3	60.3	-	60.3
Total	**125.1**	**833.4**	**49.2**	**882.6**
Other (MW)				
Belarus	-	3.4	-	3.4
Faroe Islands	4.5	6.6	11.7	18.3
Russia	-	15.4	-	15.4
Ukraine	95.3	371.2	126.3	497.5
Total	**99.8**	**396.7**	**138.0**	**534.7**
Total Europe	**12,228.5**	**121,572.2**	**12,819.6**	**133,968.2**

* Provisional data
** Former Yugoslav Republic of Macedonia
Note: due to previous year adjustments, 423.5 MW of project decommissioning, repowering and rounding of figures, the total 2014 end-of-year cumulative capacity is not exactly equivalent to the sum of the 2013 end-of-year total plus the 2014 additions.

POTENTIALLY SUITABLE LOCATIONS FOR THE CONSTRUCTION OF WIND TURBINES

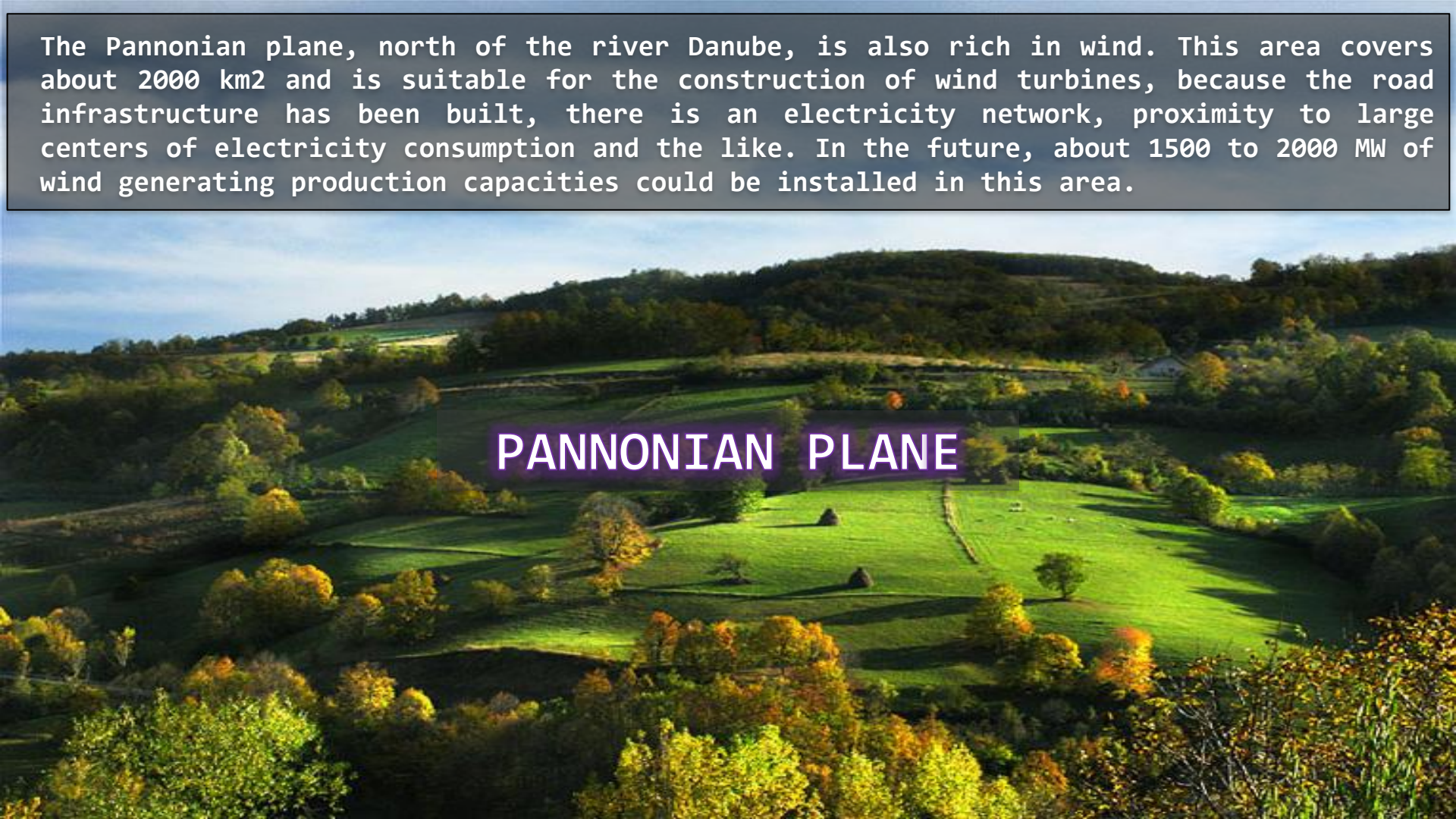
In addition, the highest consumption of electricity in Serbia is in the winter period, and this is precisely the period when the highest production of electricity is realized with the help of wind generators, because the wind blows with greater intensity in winter.

Eastern parts of Serbia - Stara Planina, Vlasina, Ozren, Rtanj, Deli Jovan, Crni Vrh, etc. In these regions, there are locations whose average wind speed is over 6 m / s. This area covers about 2000 km2 and in the future about 2000 MW of electricity cold be harness with enough wind power plants.



Zlatibor, Žabljak, Bjelasica, Kopaonik, Divčibare are mountainous areas where, by measurement, suitable micro locations for the construction of wind generators could be determined.

The Pannonian plane, north of the river Danube, is also rich in wind. This area covers about 2000 km2 and is suitable for the construction of wind turbines, because the road infrastructure has been built, there is an electricity network, proximity to large centers of electricity consumption and the like. In the future, about 1500 to 2000 MW of wind generating production capacities could be installed in this area.



WIND FARMS IN SERBIA

Serbia has a total of nine wind farms connected to the electricity generation system.

Name	Place	Municipality	Capacity (kW)	Number of generators	Begining of work	Status
" Bag I "	Devreč	Tutin	600	1	2011 _	Active
" Tower "	The tower	The tower	9,900 th most common	3	2016 _	Active
La Picolina _	Zagajica	Vršac	6,600	2	2016 _	Active
Malibunar _ _	Alibunar	Alibunar	8,000	4	2017 _	Active
Alibunar _ _	Alibunar	Alibunar	42,000	21	2018 _	Active
" Kitka "	Shelf	Kosovska Kamenica	32,500	9	2018 _	Active
" Kovačica "	Fat man	Blacksmith	104,500	38	2019 .	Active
" Košava I "	Izbište	Vršac	69,000	20	2019 .	Active
" Chibuk I "	Marble	Kovin	158,000	57	2019 .	Active
" Plandište I "	Plandište	Plandište	102,000	34	2021 _	Under construction
"The culprit "	The culprit	Golubac	104,000	38		Under construction
" Kostolac "	Kostolac	Pozarevac	66,000	20		Under construction
" Bajgora "	Bajgora	Kosovska Mitrovica	105,000	27		Under construction

The first park was built in Pešter, in the municipality of Tutin, in 2011. The largest wind farm is "Chibuk I", located in Mramorak near Kovin, and its capacity is 158 megawatts.

The total power of all wind power plants in Serbia is 430000 kilowatts (430 MW).

WIND FARMS IN SERBIA

Devrech I wind farm is the first wind farm in Serbia. It is located near the town of Leskovac in the municipality of Tutin on the Peshter plateau. It was put into operation in April 2011. It consists of 1 turbine, with a total capacity of 0.6 megawatts.

Kula Wind Farm is a wind farm in Serbia. It is located near the town of Kula in the municipality of Kula in central Bačka. It was put into operation in February 2016. It consists of 3 turbines, with a total capacity of 9.9 megawatts, which enables the supply of electricity to about 8,000 households.

La Picolina Wind Farm is a wind farm in Serbia. It is located near the town of Zagajica in the town of Vrsac in southern Banat. It was put into operation in October 2016. It consists of 2 turbines, with a total capacity of 6.6 megawatts, which enables the supply of electricity to about 12,000 households.

Malibunar Wind Farm is a wind farm in Serbia. It is located near the town of Alibunar in the municipality of Alibunar in southern Banat. It was put into operation in October 2017. It consists of 4 turbines, with a total capacity of 8 megawatts, which enables the supply of electricity to about 7,200 households.

WIND FARMS IN SERBIA

Alibunar Wind Farm is a wind farm in Serbia. It is located near the town of Alibunar in the municipality of Alibunar in southern Banat. It was put into operation in September 2018. It consists of 21 turbines, with a total capacity of 42 megawatts, which enables the supply of electricity to about 38,000 households.

Kovačica Wind Farm is a wind farm in Serbia. It is located near the town of Polička in the municipality of Kosovska Kamenica in the eastern part of the Autonomous Province of Kosovo and Metohija. It was put into operation in November 2018. It consists of 9 turbines, with a total capacity of 32.4 megawatts.

The Košava I wind farm is a wind farm in Serbia. It is located near Izbište in the town of Vršac in southern Banat. It was put into operation in September 2019. It consists of 20 turbines, with a total capacity of 69 megawatts, which enables the supply of electricity to about 45,000 households.

Wind farm "Chibuk I" is the largest wind farm in Serbia. It is located near the town of Mramorak in the territory of Kovin in southern Banat. It was put into operation in October 2019. It consists of 57 turbines, with a total capacity of 158 megawatts, which enables the supply of electricity to about 113,000 households.

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