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Odyssey
Oxford Debates for Youths in Science Education

Energy Issue: Nuclear Energy and Renewable Energy

Students'activities worksheets

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Introduction

Topic

Energy Issue: Nuclear Energy and Renewable Energy

Definitions

Below is your basic glossary, keywords, and background knowledge of the scientific concepts and processes that will be used to address the issue of energy for nuclear power and renewables.

Fossil Fuels: A source of energy formed in the earth's crust from decomposed organic material. The three most common fossil fuels are coal, oil and gas, which come from some living organisms and can be processed to produce energy. Carbon is made from plant residues and is used in the production of electricity and chemicals as well as in steelmaking.
Oil is formed from the remains of free planktonic organisms living in the open ocean. As sediments rich in these organisms are buried and compressed, the organic matter changes. Near the surface, bacteria convert part of the organic matter into methane (natural gas). Deeper burial temperatures of 50 ° to 150 ° C promote the formation of oil.
Industrial Production and Energy: Schoolbook 3rd Grade High Schoo (http://ebooks.edu.gr/modules/ebook/show.php/DSGL-C124/54/418,1553/)

Renewable Energy Sources (RES): RES or mild forms of energy, new energy or green energy are non-fossil renewable energy sources, ie wind, solar and geothermal energy, wave energy, tidal energy, hydraulic power, gases emitted from landfills, biofuels and biogas, as defined by Directive 2001/77 / EC (Source: Ministry of Environment and Physical Planning).
According to the Ministry of Environment and Energy:
Wind Energy: The kinetic energy generated by the force of the wind and converted into extractable mechanical energy and / or electricity. Wind turbines are engines that convert the kinetic energy of the wind into electricity. This conversion takes place in two stages. In the first stage, through the impeller, we convert the kinetic energy of the wind into mechanical by rotating the impeller shaft, and in the second stage, through the generator, we achieve the conversion of mechanical energy into electricity.
Hydroelectricity: Hydroelectricity is the energy that is based on the exploitation and conversion of the dynamic energy of lake water and the kinetic energy of river water into electricity. This conversion takes place in two stages. In the first phase, through the turbine oil, we convert the kinetic energy of water into mechanical energy in the form of rotation of the impeller rotation, and in the second phase, through the generator, mechanical energy is converted to electrical energy. All the projects and equipment used to convert hydraulic energy into electricity are called Hydroelectric Power (HEP). Capturing / storing quantities of water in natural or artificial ponds for a Hydroelectric Power Plant equals practically to hydroelectricity savings. The planned release of these quantities of water and their discharge into the turbines leads to a controlled production of electricity. Given

the availability of adequate water resources and adequate supply of the necessary rainfall, H/P becomes a major alternative source of renewable energy. (Ministry of Environment and Energy www.ypeka.gr/Default.aspx?tabid=484&language=el-GR)
Solar Energy: We characterize all the different forms of energy that come from the sun. The light and heat radiated are absorbed by elements and compounds on earth and converted to other forms of energy. Technology nowadays utilizes a small percentage of the solar energy on our planet's surface with the following:

- **Active Solar Systems:** Convert solar radiation to heat.

-Bioclimatic design and passive solar systems: They relate to architectural solutions and the use of suitable building materials to maximize the direct exploitation of solar energy for heating, air conditioning or lighting.

- **Photovoltaic Solar Systems:** Convert solar energy directly to electricity.

Geothermal Energy: Thermal energy originating from the interior of the earth and contained in natural vapor, surface or underground hot water and hot dry rock.

Hydrogen: Hydrogen makes up 90% of the universe and will be a new fuel that we will use in the future.

Biomass: Plant material and animal waste. It is the oldest source of renewable energy that has been used since our ancestors learned the secret of fire. Biomass is a renewable source of energy, not only because its energy comes from the sun, but also because biomass can be rebuilt in a relatively short period of time compared to the hundreds of millions of years it took to create fossil fuels.
Through the process of photosynthesis, chlorophyll in plants captures the energy of the sun by converting carbon dioxide from air and water from the soil into complex carbohydrates, consisting of carbon, hydrogen and oxygen. When these carbohydrates burn, they turn back to carbon dioxide and water and release the energy they capture from the sun.(https://www.ucsusa.org/clean_energy/our-energy-choices/renewable-energy/how-biomass-energy-works.html)
Although alternative energy and renewable energy sources work to reduce carbon dioxide emissions, there is a big difference between the two. Renewable energy comes from a natural source and is replenished naturally, without human intervention. Alternative energy does not include solar energy, but includes resources such as natural gas (often obtained by dam or pressure injection in underground cracks), cogeneration, fuel cells or any waste energy that is not naturally replenished, but it emits lower carbon emissions.Oil is not considered to be an alternative energy source as it is the main cause of carbon emissions and is not naturally replenished. Earth's oil reserves will eventually decline, though it may take centuries.

The term '**sustainable'** is generally understood as 'meeting the needs of the present without jeopardizing the ability of future generations to meet their own needs'. In the context of energy choices, the concept of 'sustainabilty' implies the ability to supply energy for unlimited periods of time

(i.e., for a very long time) without depriving it of future generations and in an environmentally friendly, economically viable way, safe and capable of being delivered reliably. Report by the United Nations Commission, BrundtlandReport1987. Accesshttps://sustainabledevelopment.un.org/content/documents/5987our-common-future.pdf
Note: In 1987, the World Environment and Development Committee (WCED), created in 1983, published a report entitled "Our Common Future".

The efforts of humanity must tend to achieve what we would call **'sustainable development'**. The term sustainable development was first used just a few years ago by scientists who were pioneers in agricultural ecology. Its importance is customizable depending on the field in which it is used. At any given time, the earth, as a whole and with its individual regions, has a limited ability to support the various forms of life, including human beings. A sustainable society thus regulates its economy and the size of its population so as not to exceed the potential of the planet to absorb environmental damage, rebuild its resources, and sustain life for thousands of years. Thus the needs of the population can be satisfied without exhausting the earth's capital and without jeopardizing the prospect of the present and future generations of mankind and other species. (Natural Resources Management SchoolT extbook, p. 22).

A very serious consequence of atmospheric air pollution is the **greenhouse effect that results in a change in the earth climate**. Gases derived from anthropogenic activities (industry, combustion, deforestation, etc.) create a dense layer in the lower layers of the atmosphere that allows the sun's rays to penetrate the atmosphere and heat the earth's surface. However, much of the energy received by the earth is trapped near the surface of the earth due to the dense layer of gases, and is reflected back to the surface of the earth, increasing the amount of heat trapped while part of that energy is re-emitted by the Earth in space. That is, this layer of gases permits the entry of solar rays (UV) into the earth's atmosphere, but prevents heat output (infrared rays), thereby leading to "greenhouse" conditions on the earth's surface, thus raising the temperature of the atmosphere .

Causes of Climate Change: People are increasingly influencing climate and land temperature through the use of fossil fuels, deforestation and livestock farming. These activities add huge amounts of greenhouse gases to the gases in the atmosphere, causing an increase in greenhouse effect and global warming.
Some gases in the atmosphere work like glass in greenhouses, trapping the sun's heat and preventing it from passing through space. Many of these gases exist in nature, but human activity results in increased concentrations of some of them in the atmosphere, in particular:

- carbondioxide (CO2)
- methane
- nitrogenoxide
- fluorinated gases

CO2 is the greenhouse gas most often produced by human activities and accounts for 63% of global warming due to these activities. Its concentration in the atmosphere today is 40% higher than at the start of industrialization. Other greenhouse gases are released in smaller quantities but trap heat

much more than CO2, and in some cases are much stronger. Methane accounts for 19% of global warming from anthropogenic causes and 6% for nitrogen oxide. (European Commission Press Release: Climate Action https://ec.europa.eu/clima/change/causes_el)

The **kilowatt hour** is a unit of energy. International symbol of this unit is kWh (W capital only), one of the original kilo - Watt - hour words in the International unit system. One **kilowatt** hour is the energy produced or consumed within one hour at a constant power of one kilowatt. One kWh is equivalent to 3.600.000 Joules ie 3.6 MJ. The megawatt-hour unit (MWh) is also used on a larger scale: one MWh = 1000 kWh = 3.6 GJ. On an even larger scale the Gigawatta unit (GWh) is used: one GWh = 1000 MWh = 3.6 TJ.

Capacity factor: Another way to measure the annual energy output of a specific machine (e.g. from a wind turbine) is to calculate the capacity factor. The capacity factor is defined as the fraction of annual energy production to annual maximum theoretical energy production. The capacity factor usually ranges between 20% and 70%, with the most common being 25-30%. (Skodras C. Mild and new forms of energy, eclass.uowm.gr.)

Structure of matter: The molecule, the smallest part of an ingredient that retains its properties. The molecules are made up of even smaller particles, atoms. The building blocks of matter are atoms and molecules (atom complexes) (Dalton's Atomic Theory). The mass of the individual is concentrated in a space called the nucleus. The nucleus is composed of protons (p), with a positive charge, and neutral neutrons (n). High School Chemistry, Research Officer - Working Group Address: Stelios Liodakis, http://ebooks.edu.gr/modules/ebook/show.php/DSGL111/482/3167,12765/, Textbook Publishing Organization.

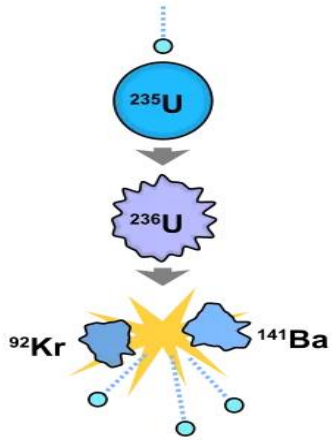
Nuclear isotopes: Atoms who have the same number of protons but different mass numbers are called isotopes. Isotopes of a chemicalelement do not change their chemical properties because the number of electrons does not change (since they are the same as the number of protons), but they differ in physical properties (eg. melting point, boiling point, diffusion rate). High School Chemistry, Scientific Officer - Working Group Address: Stelios Liodakis,http://ebooks.edu.gr/modules/ebook/show.php/DSGL111/482/3167,12765/, Textbook Publishing Organization.

Proton forces are exerted between the protons. So, what is the stability of nuclei? Why don't protons slip away from each other? In 1935 the Japanese physicist Yukawa, in order to interpret the formation of nuclei, proposed the existence of an unknown force until then. This force is exerted within the nucleus and is strongly attracted to overcome repulsion between protons. This power is called a strong nuclear power. Nuclear power is exercised only between adjacent protons and neutrons, it is tractive and equally strong for the proton-proton, proton-neutron and neutron-neutron pairs. Because of this equivalence, protons and neutrons are called by one word nucleons.
Nucleons in the nucleus have dynamic energy. We call this energy nuclear energy. It has been experimentally shown that the nucleus has a lower mass than the total mass of nucleons from which it is formed. This difference in mass is called a mass deficit. Einstein in the context of special relativity theory has shown that mass (m) and energy (E) are related to the equation: $E = m \cdot c2$, where c is the speed of light in the vacuum. That is, the dynamic energy of the nucleons in the nuclei corresponds to a certain amount of mass, exactly equal to the mass deficit. Spontaneous radioactive decay or the artificial production of one nucleus by bombarding another nucleus is a rearrangement of the constituents of the nucleus, that is, a nuclear reaction, however, it makes a very significant quantitative difference. The binding energy of nucleons in the nucleus, due to the

mass deficit and the high value of the speed of light, is about one million times greater than the binding energy of electrons to the atom.Therefore the dynamic energy converted to particle kinetics in a nuclear reaction is one million times greater than the corresponding in a chemical reaction. The two main nuclear reactions that release this huge amount of energy are nuclear fission and nuclear fusion.
Physics 3rd gradeHigh school, Nikolaos Antoniou, Panagiotis Dimitriadis, Konstantinos Kabouris, Konstantinos Papamichalis, LampriniPapatsimba, "DIOFANTOS" COMPUTER TECHNOLOGY AND PUBLISHING INSTITUTE, http://ebooks.edu.gr/modules/ebook/show.php/DSGYM-C201/531/3516,14435/

Nuclear fission is the breakdown of an unstable nucleus into two smaller nuclei with nearly equal masses. It is usually accompanied by simultaneous neutron emission and the release of huge amounts of energy. The core of the uranium isotope is cleaved when it is bombarded with neutrons and is usually broken down into a barium core and a crypt core, with three neutrons being emitted at the same time. Each of these can cause a new fission, so eventually a chain reaction can occur. The chain reaction may be slow and controlled, e.g. in a nuclear reactor of a nuclear fission power station.

Spontaneous Fission: According to quantum mechanics there is a small but finite chance that the nucleus will be split into two smaller ones without any external stimulation. This phenomenon is called spontaneous fission and is observed in heavy nuclei, although it is a rare phenomenon. With the supply of energy to the nucleus through a particle, and in particular a neutron, the probability of fission increases.However, increasing the probability of fission does not increase as much as the energy supply. Up to some critical excitation energy (energy threshold), the probability of fission increases slightly, and when exceeded, the increase observed is extremely sharp. Hermides K. (2016), Rapid Neutron Reproductive Reactors, Graduate Thesis, Department of Physics, AUTH.

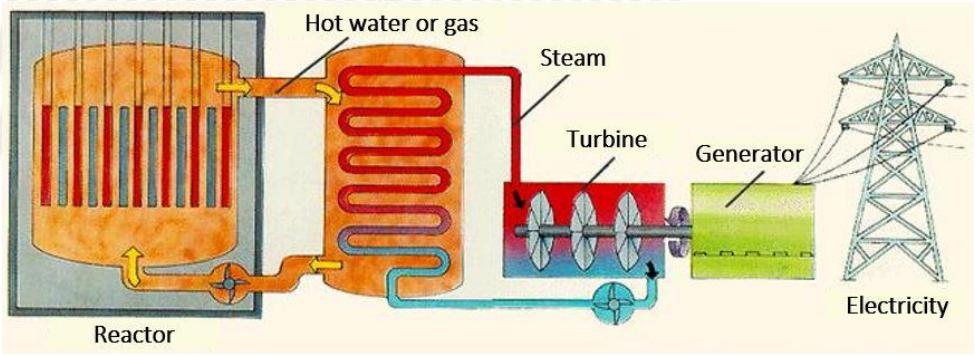


Example of fission caused by the bombardment of a uranium-235 core with thermal neutron. Three neutrons are released from the reaction.

Nuclear Energy Production - Nuclear Reactors:
It is known that **the operation of nuclear reactors** is based on the reaction of neutrons with the fissile material of the fuel that feeds them. All reactors in operation use uranium (U) based fuels, and in some cases there is plutonium (Pu). Antonopoulos-Domi M: Introduction to Nuclear Technology, Ziti Publications, (2005); Tsagas N .F .: Nuclear Technology, Aivazis Publications, (1986).

Nuclear reactor: It is a device properly designed to carry out a controlled self-sustaining fission chain reaction. The central part of the device, where the fissures take place is the heart or core of the reactor and consists of nuclear fuel, refrigerant, retarder and reflector. Then we have the control rods, the high pressure tank and the shielding.Exceptions are fast neutron reactors, where there is no retarder. They are used for: (a) electricity generation, (b) the preparation of isotopes for medical and industrial use, (c) for research purposes. Hermides K. (2016), Rapid Neutron Reproductive Reactors, Graduate Thesis, Department of Physics, AUTH.

Nuclear reactor stations operate in a similar way to other power plants. The difference is that nuclear power plants do not use carbon or gas to generate heat, but rather nuclear fission reactions. Heat from nuclear reactions converts water into steam, which leads to turbines that generate electricity. Inside a nuclear reactor, uranium rods are bundled and submerged in a giant pressure water tank.
The entire reactor is housed in a very durable concrete structure that prevents radiation from escaping into the environment. When the reactor is running, high-speed particles, called neutrons, hit the uranium atoms and separate them. This process is known as nuclear fission. This process releases a lot of energy and more neutrons, which continue to disrupt other uranium atoms, causing a chain reaction. This energy heats the water, which is fed into a steam generator.https://volton.gr/puriniki-energeia/



From nuclear fission to electricity / Source: noesis.edu.gr

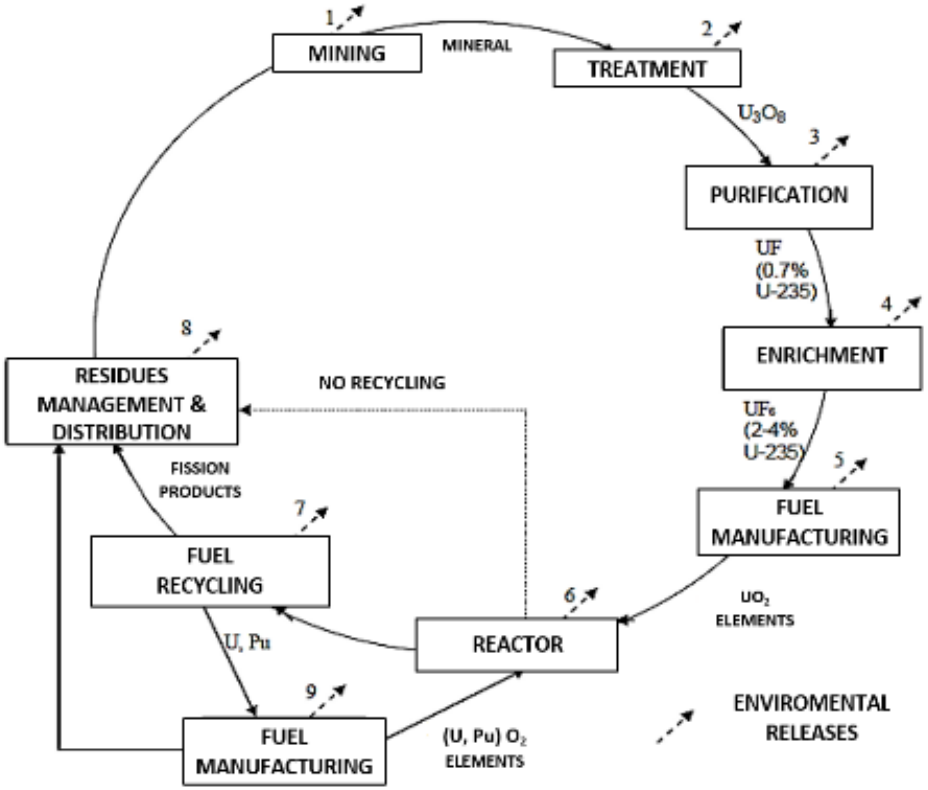
Enriched uranium takes the form of pellets packed in "fuelpins". The fuel rods are mounted on the reactor, "moderator" (water, heavy water, solid graphite, beryllium, or hydrocarbons) and buffers (or "control rods") are added. The whole system is often called the "core".

The cleavage of the U-235 nucleus produces subsidiary nuclei and neutrons. The daughter cores, fired with enormous kinetic energy, collide with other atoms and the fuel rods heat up. The neutrons produced, coming out of the fuel rods, enter the retarding material where they lose a significant portion of their energy (now called "thermal" neutrons). This loss of energy is intentional as their new (low) energy is only suitable to cause new fissures. Indeed, thermal neutrons re-enter the fuel rods and cause new U-235 core fissures, and so on. However, the number of neutrons must be controlled to avoid uncontrolled process and cause the reactor to melt from the heat released. For this purpose, control rods from special materials that effectively absorb neutrons but do not melt easily (Boron, Cadmium) are immersed in the reactor heart to control the rate of nuclear reactions.Most nuclear reactors today have a core that is submerged 6-7 meters deep in an open tank, full of refrigerant (usually water). The refrigerant circulates under pressure in the "channels" of the retarder. With its help, the thermal energy released by the fission of the nuclear fuel is removed and transferred to a heat exchanger. There it is used to generate steam, which puts into operation a turbine, which in turn rotates a generator. The nuclear reactor also emits intense radiation, which is used in the production of radioisotopes for medical use.
(Kappos, K. (2018); Recovery; NEI, “What is Nuclear Energy, https://www.nei.org/fundamentals/what-is-nuclear-energy, Nuclear Energy Institute, USA).

Nuclear Power: In the nuclear reactor, taking advantage of the high temperature that develops, we produce electricity with systems of heat exchangers, turbines and generators. In a nuclear reactor we distinguish: a) The central region where the reaction takes place. The fission material uranium-235 is found there either as a solution of salt, so the reactor is called homogeneous, or in the form of rods in various zones. The decelerator is also placed in this area. b) The neutron reflector. c) The protective layer of concrete 3m thick and d) Cooling systems.

In other words, **nuclear energy or atomic energy** is called the energy released when atomic nuclei are transformed. In other words, it is the dynamic energy that is trapped in the nuclei of atoms due to the interaction of the particles that make them up. Nuclear energy is released during fission or fusion of nuclei, and if nuclear reactions are controlled (as is the case in the heart of a nuclear reactor) it can be used to meet energy needs. (Textbook: High School Natural Resources Management. Section 9.11, p. 237)

'Nuclear fuel cycle' is a series of industrial and nuclear processes involved in the production of electricity in nuclear power reactors using uranium and plutonium. The cycle of nuclear fuel begins with the extraction of uranium ore from the ground and ends with the disposal of radioactive waste produced during normal cycle operation.



Cochran R.G. and Tsoulfanidis N.: The Nuclear Fuel Cycle: Analysis and Management, American Nuclear Society, Illonois, (1999)

- ✓ Mining and processing of uranium ore.
- ✓ The treatment product cannot be used directly as a nuclear reactor fuel. U3O8 is purified from the impurities it may contain by the decomposition of uranium and other materials (NO2, HF, CaF) and is converted to UF6.
- ✓ Enrichment: The enrichment process is the one that produces the highest content of 235U, which is usually 1.5 - 4%.
- ✓ Fuel Manufacturing: This is manufactured in the form of small pellets and packaged in thin fuelrods. The cladding is made of stainless steel or zirconium alloy. These bars form the fuelassembly elements in various geometrical shapes, depending on the type of reactor to which they will be inserted.

- ✓ During operation of the reactor part of the nuclei from the initial fuel composition is transformed by fission and / or neutron capture reactions into fission products (FissionProducts, FP), isotopes of the extracellular elements. (Transuranium, TRU).
- ✓ Reprocessing and Recycling: Exhausted fuel is separated into uranium, plutonium and high radioactive residues containing fission products and supranuclear elements in reprocessing facilities. The process enables recycling of uranium and plutonium into new fuels.
- ✓ Disposal of fuel: Currently, there are no facilities for the storage of spent fuel and residues from fuel reprocessing.
- ✓ Residues: Residues from the nuclear fuel cycle are categorized according to the amount of radioactivity as high, medium and low radioactivity.

Uranium is a metal with high density and high hardness. It is a radioactive element, chemically toxic and unstable. Natural uranium consists of the three isotope uranium 234 (U-234) at 0.0058%, uranium 235 (U-235) at 0.71% and uranium 238 (U-238) at 99.28%. These isotopes have the same number of protons (92) and different numbers of neutrons - 142, 143 and 146 neutrons - respectively. All the isotopes of uranium are radioactive and, because they are unstable through continuous metamorphoses, tend to become more stable by emitting ionizing radiation, ie alpha, beta and gamma radiation particles. The U-238 and U-235, through a series of transformers, end up in fixed and non-radioactive lead isotopes, Pb-206 and Pb-207 respectively.
Of the above isotopes of uranium, only U-235 is used as nuclear fuel and because its concentration in natural uranium is very small (0.71%), its enrichment is a necessary process, expensive and quite difficult. By enrichment we mean the process of increasing the concentration of U-235 and rejecting U-238. The separation of the two isotopes of uranium is not based on their chemical properties (because both isotopes have the same chemical behavior) but on their physical properties.
The first method of separating the two isotopes was a diffusion separation process through membranes in gaseous phase and high temperature. Uranium hexafluoride (UF6), which at a temperature greater than 57oC is converted to gas, passes through separating microporous membranes. The U-235 molecules, which have a smaller mass, pass through the membranes more easily and faster than the U-238 molecules. The result of the enrichment process is the accumulation - on both sides of the membrane separating surface - of a mixture rich in U-235 and poor in U-238 - it is the enriched uranium - and on the other, gas poor in U-235 and rich in U- 238 that is, the exhausted uranium. (http://users.uoa.gr/~nektar/science/environment/denriched_uranium.htm)
Enriched uranium: It is a type of uranium in which the percentage composition of 235U has been increased through the isotope separation process. 235U is fissile and therefore must be concentrated as much as possible in the natural ore due to the nuclear reactions it causes.

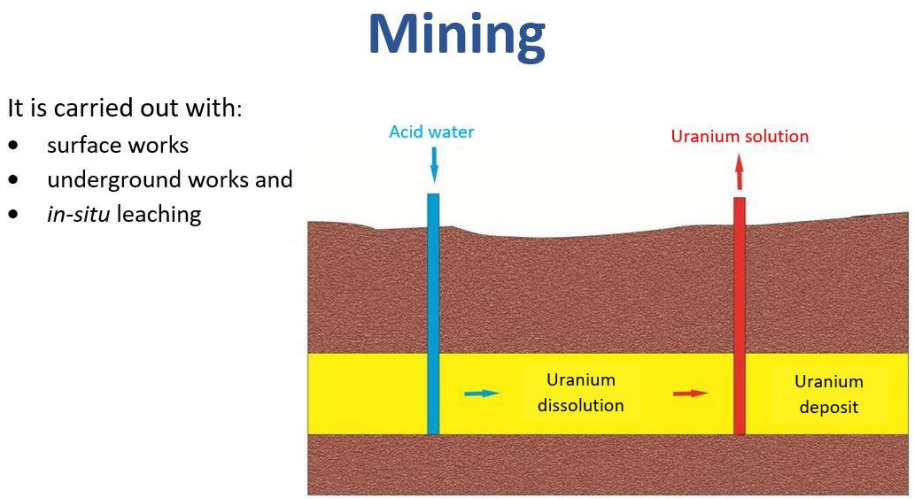
Depleted Uranium: The uranium from which most of the "fissile" U-235 isotope has been removed and stored in enrichment plants in many countries, along with uranium recovered from used fuel, contains enough energy for several hundreds of years without additional mining.

Transmutation is the transformation of one chemical element into another, through a nuclear reaction. Natural spontaneous transformations are constantly taking place in nature in radioactive materials.

Radon: It is a natural radioactive gas that results from the normal decomposition of uranium into rocks and soil. Like many gases, it is invisible. It is

also odorless and tasteless. Radon is present in the soil and in the air and, in some areas, dissolves in groundwater. CenterforNuclearScienceandTechnologyInformation, http://nuclearconnect.org/know-nuclear/talking-nuclear/radon

Uranium Mining Methods: In the case of in-situ leaching (ISL) - also called in-situ recovery (ISR) or disintegration mining - the ore containing uranium is not removed from its geological deposit, but liquid effluent is pumped through the wells to the well bearing uranium is pumped to the surface by other wells.In-situ leaching is of great importance for the exploitation of low mineral deposits due to low production costs. The rinsing liquid used for on-site rinsing, for example, contains carbon dioxide or - especially in Europe - sulfuric acid. This method can only be applied if the uranium deposition is in porous rocks, confined to impermeable rock layers.



Picture 1
Solution mining, *in-situ* leaching can be applied in special cases of metalliferous

KimonChristani. "Energy Sources and Energy Raw Materials", http://www.wise-uranium.org/uisl.html#FURTHER

Radioactive waste: These are the remaining "useless" products caused by human activities with radioactive materials. Radioactive materials are used daily:

- in medicine, for diagnostic tests and treatments in nuclear medicine (eg the use of radiopharmaceuticals), or in radiotherapy (eg cancer tumor irradiation, intrauterine implants),
- in industry, for radiographs, radiation of materials for sterilization, control of quality and functional parameters (eg measurement of level or thickness of materials),

- in research and education, e.g. for experiments in biology, chemistry, materials science
- in specialized applications, e.g. locating deposits.

Differentiation of nuclear waste from radioactive waste: Nuclear waste is a special category of radioactive waste and is the remaining nuclear fuel (usually uranium and its products), which becomes "useless" for the operation of a reactor. Nuclear waste, due to its hazard and the need for special treatment, is reported and treated separately. The internationally accepted method for the final management of nuclear waste is to deposit it at great geological depths. Publication by the Hellenic Atomic Energy Commissionhttp://bit.ly/2kKc24S

The final management of radioactive waste can be done in two ways:

- **By releasing into the environment,** since the radioactive substances have weakened to such an extent that the institutionalized levels of release are met. The release levels have been set with the criterion that any person in the population does not receive a radiation dose of more than 10 μSv (micro-Sievert) per year from the total release of radioactive substances into the environment. This category mainly includes medical and hospital radio active waste.
- **With disposal**, ie with permanent and final disposal without the intention of recycling, in an approved facility for disposing of radioactive waste. Hellenic Atomic Energy Commission (IAEA) ()http://bit.ly/2mbZT9f

Probably, there are more key-words in the power point presentations. Please, write them.

Introductory questions

After completing the 1st lesson or during the 1st lesson, where the introduction to the topic of controversy was introduced (through the material of the presentations and videos) you are asked to answer the following introductory questions.

1) Can you give a brief description of the challenges facing the planet regarding energy and make finding solutions to the energy issue an urgent need?
2) What energy sources have been used for hundreds of years?
3)What are considered renewable energy sources (RES)? Can you briefly list the pros and cons of RES?
4) Can you briefly list the pros and cons of nuclear power?

The projest has been funded with the support of European Commission within ERASMUS+ program

Activity sheet

Subject
Energy Issue: Nuclear Energy and Renewable Energy Forms
Topic
The use of nuclear energy is the only solution to the energy problem

Activity 1.

Based on your preparation for resolving the dispute over what form of energy can provide a solution to the energy issue, prepare a series of arguments, classifying them into those that are clearly in favor of the resolution, against the resolution and the arguments that can be used on both sides - that is, they are controversial. The questions given to you by the teacher in the "Introduction" support the creation of your arguments.

FOR	GREY AREA	AGAINST

Συγγραφέας Παναγιώτα Αργύρη, Μέλος του Ι.Ρ.Ε.Σ.Ε., Μαθηματικός, M.Ed. στη Διδακτική και Μεθοδολογία των Μαθηματικών, M.Sc. στα Οικονομικά Μαθηματικά

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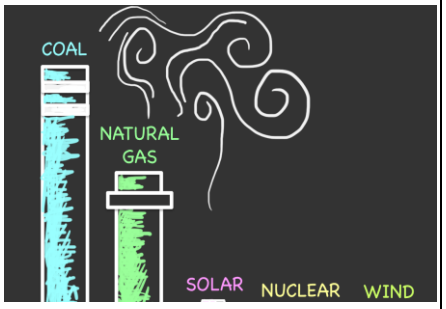
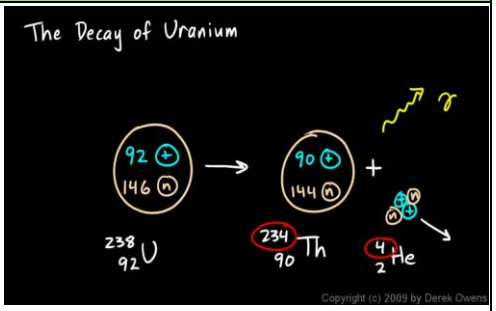
REAL INCIDENTS

Below you will find the information cards, story cards and question cards. Read carefully and analyze in order to formulate your arguments for the discussion.

INFO CARD 1	INFO CARD 2
Minimal CO2 emission from the nuclear fission It is recognized the urgent need to generate electricity under conditions that will protect people and the planet from the dangers of air pollution and climate change. The Intergovernmental Panel on Climate Change - IPCC's Special Climate Change Report concluded that the increase in electricity demand should be offset by the production of low carbon dioxide emissions, **including nuclear ones.** In numerous scientific comparisons, **nuclear fission** is one of the least polluting energy sources and has the lowest overall environmental impact. **Annually, about 450 nuclear power plants operate and prevent the emission of about 2 billion tons of CO2.** Finally, according to the OECD's Nuclear Energy Organization, nuclear power is **the most efficient solution to achieve the goal of reducing carbon dioxide emissions**, as only 50 g CO2 per kWh is produced. **Every 22 tons of uranium used saves about one million tons of CO2 (relative to carbon).**  *J.L. Conca, J. Wright. The cost of energy — ethics and economics. Waste Manag. (2010), pp. 1-13 (Phoenix, AZ, paper 10494, revised November 11, 2011, Pushker A. Kharecha, James E. Hansen. Prevented mortality and greenhouse gas emissions from historical and projected nuclear power. Environ. Sci. Technol., 47 (2013), pp. 4889-4895, https://www.ipcc.ch/sr15/*	**Nuclear energy from the decay of uranium and plutonium is sustainable**  Photo Nuclear power plants, which operate with commercial use of uranium, provide the with world clean, economical and reliable energy (OECD, 2018). Abrupt fission reactors with fast neutrons (fast reactors) convert uranium into an inexhaustible source of energy. These reactors collect about a hundred times more energy than the same amount of uranium mined compared to thermal reactors. They can also tear the split isotopes produced by the metamorphosis of the abundant "fertile" isotope U-238. In addition, mining small amounts of uranium over the next few centuries, including uranium mining from lower quality ores and, if necessary, seawater, could meet global energy needs for many centuries. Finally, the highest cost of uranium, uranium from seawater, and uranium from the erosive earthen crust of river water are resources, which, if used in a breeding reactor, will be enough for to feed the earth for another 5 billion years and, therefore, will make nuclear energy not only sustainable but renewable as well. *Nuclear Energy Agency & the International Atomic Energy Agency (2019), Uranium 2018: Resources, Production and Demand, OECD Publishing, Paris, https://doi.org/10.1787/uranium-2018-en, B.L. Cohen, Breeder reactors — a renewable energy source. Am. J. Phys., 51 (1983), p. 75, D. Lightfoot, et al. Nuclear fission fuel is inexhaustible CNS Climate Change Technology Conference, 2006, Ottawa, Ontario (2006), Charles E. Till, Yoon Il Chang. Plentiful Energy – The Story of the Integral Fast Reactor. (2011).*

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INFO CARD 3	INFO CARD 4
International scale of nuclear events & acccidents from energy production **Major Accident (Climax 7):** i) Chernobyl, Ukraine, 1986: Widespread effects on health and the environment, ii) FukushimaDaiichi 1-3, 2011: Radiation release and space evacuation. **Serious accident (Climax 6)**: i) MayakostOzersk, Russia, 1957 "Kyshtym". Complete implementation of local emergency plans. **Accident with consequences outside the area (Climax 5)**: i) Three Mile Island, USA, 1979, ii) Windscale, United Kingdom, 1957. Partial implementation of local emergency plans. Severe damage to the reactor core or radiological barriers. **Accident, mainly, in the installation, with local consequences (Climax 4)**: i) Saint-Laurent A1, France, 1969 (fuel rupture) & A2 1980 (graphite overheating), ii) Tokaimura, Japan, 1999 (criticality in the installation of fuel for experimental reactor). Public report of the set of defined limits. Significant damage to the reactor core or to the radiological barriers. Employee's mortality. **Accident, mainly, in the installation, with minimal consequences (Climax 3):** i) FukushimaDaiichi 4, 2011 (overheating of the fuel lake), Ii) FukushimaDaini 1, 2, 4, 2011 (cessation of cooling in the nuclear reactor), Iii) Vandellos, Spain, 1989 (vortex fire), iv) Davis-Besse, USA, 2002 (serious erosion). Acute health impact on an employee. Creating accident prediction plans or even malfunctions in the systems of nuclear reactors. **Incident (Climax 2):** Significant spread of infection. Employee overexposure. Incidents with significant security vulnerabilities. *The International Atomic Energy Agency (IAEA) was developed by the International Atomic Energy Agency (IAEA) and the OECD in 1990 to standardize the reporting of nuclear events or accidents to the public..*	**Adverse environmental effects from the method of uranium flushing**  There are significant disadvantages of on-site uranium flushing technology, which come from the risk of the flushing fluid leaking out of the uranium deposit. This results in subsequent contamination of groundwater and inability to restore natural groundwater conditions after the completion of leaching work. In addition, on-site leaching releases significant amounts of radon and produces certain amounts of wastewater effluent and sewage during the treatment. In the case of Königstein (Germany), a total of 100,000 tons of sulfuric acid were injected from the rinsing liquid. The liquid contains high concentrations of pollutants (cadmium, arsenic, nickel, uranium, etc.) and poses a risk to the aquifer, which is important for the region's drinking water supply. The impact of groundwater is much greater in the Czech Republic in-situ leaching location of Sratz pod Ralskem, where 28.7 million m3 of contaminated liquid is contained in the leaching zone, covering an area of 5.74 km2. In addition, the contaminated liquid has spread beyond the wash zone horizontally and vertically, thus contaminating another area of 28 km2 and another 235 million.3 of groundwater. Correspondingly, in Bulgaria, 2.5 million tonnes of sulfuric acid were injected into mineral deposits exploited by on-site leaching. *Vapirev,E I; Dimitrov,M; Minev,L; Boshkova,T; Pressyanov,D S; Guelev,M G: Radioactively contaminated sites in Bulgaria. In: Planning for environmental restoration of radioactively contaminated sites in central and eastern Europe, Vol.1: Identification and characterization of contaminated sites, IAEA-TECDOC-865, Vienna 1996, p.43-63, Tabakov,B: Complete Mining of Uranium Deposits in Bulgaria by In-Situ Leaching Mining Systems Used After Conventional Mining. In: IAEA (Ed.), Uranium in situ leaching. Proceedings of a Technical Committee Meeting held in Vienna, 5-8 October 1992, IAEA-TECDOC-720, Vienna 1993, p.105-114.*

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Information card 5 Facts and data	Information card 6 Facts and data

Hydroelectric power plants have a negative environmental impact

There have been many catastrophic floods in the last 100 years from hydroelectric plants. Typicalexamples are: a) in Sobradinho of Brazil, where 1,050 MW flooded to 415,000 hectares (1 hectare is 10000m2), b) in the he Venezuelan Guri complex, where 10,300 MW flooded 426,000 hectares, c) in Balbina (Brasil), where 2500 km2 was the Amazon rainforest that flooded with 250 MW, provoking an ecological disaster beyond logic and d) in Gabcikovo (Slovakia), where 720 MW flooded 5300 hectares.

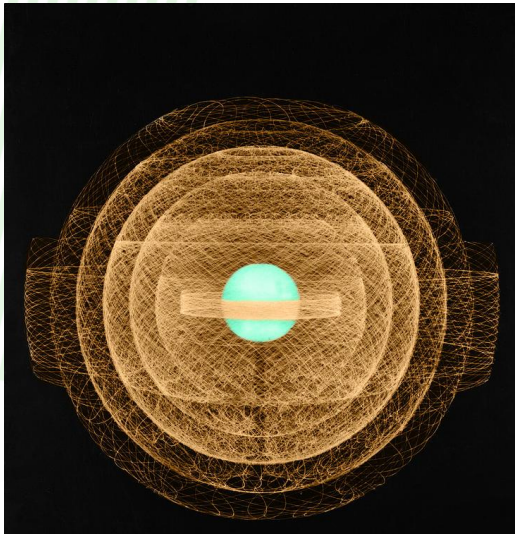
Photo

The environmental and economic impact of building a hydroelectric plant on a local river can be devastating because: a) the construction of dams leads to the loss of land habitats through floods, where as a result people are forced to relocate frequently, from some fertile and efficient area for agriculture, b) the dams destabilize freshwater ecosystems worldwide. For example, a significant percentage of fresh water fish in the world are threatened or extinct as a result of barrier construction, c) ocean fish such as salmon are also affected, as they can be blocked in their attempt to swim to give birth, d) the rotten organic matter that ends up in the dams releases large amounts of greenhouse gases, mainly methane, into the atmosphere.

PéterKádár, Power System Department Faculty of Electrical Engineering, Óbuda University: "Pros and Cons of the Renewable Energy Application"

Increased uranium demand U-235 poses risks to nuclear viability

Uranium mining and production increased by 25% in the period 2008-2010, to reach 56,670 tons. It is expected to increase by another 5% to 57,000 tons. According to the joint report on the uranium market, drafted by the IAEA and the International Atomic Energy Agency (IAEA), **the demand for uranium for the supply of plants will range between 97,645 and 136,385 tons in 2035, compared to 63,875 tons in 2010.** That is, uranium needs will increase by at least half over the next two decades, perhaps doubling, according to estimates. This happens, according to the two services, due to the increase in the size of all nuclear power plants internationally, which is estimated at between 44% and 99% by 2035. **This large scale of forecasts reinforces uncertainty about nuclear power as a viable source of energy.** This uncertainty is reinforced by the growing energy needs of emerging economies, especially in Asia.



Photo

NEA/IAEA (2019), Uranium 2018: Resources, Production and Demand, OECD Publishing, Paris, https://doi.org/10.1787/uranium-2018-en.
Nuclear Energy Data 2018
Available online at: http:// www.oecd-nea.org/ndd/pubs/2018/7416-ned-2018.pdf

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INFO CARD 7

Long time is required for the operation of nuclear power plants

The long run time for the construction of nuclear power plants is a deterrent to reducing air pollution immediately. An electric power plant takes an average of 14-15 years to be built (from the design phase to operation). According to the World Health Organization, about 7.1 million people die each year from air pollution, and 90% of these deaths are due to pollutants produced by combustion to produce energy. Based on simple mathematical calculations, we conclude that about 93 million people will die, as we wait for all the new nuclear plants to be built.

On the other hand, wind and solar farms take 2 to 5 years on average, from the design phase to the operation. Solar photovoltaic installation projects on the roof have a schedule of 6 months. **This indicates that the total transition to renewable energy sources as soon as possible would result in tens of millions of fewer deaths.**

Photo

Mark Z. Jacobson, Professor of Civil Engineering and Environmental Engineering, Director, Atmospheric / Energy Program, Stanford University
Textbook in press, Cambridge University Press
https://web.stanford.edu/group/efmh/jacobson/WWSBook/WWSBook.html

INFO CARD 8

Nuclear facilities are more reliable compared to RES facilities

The electricity grid is a complex system in which the supply and demand of energy must be equal at all times. Continuous supply adjustments are required for predictable changes in demand, according to the daily standards of human activity. The operation of the electrical network is in jeopardy due to the unexpected environmental changes that greatly affect the production of energy from RES (lack of sunshine-photovoltaic panels, water scarcity-hydroelectric plants, apnea - inhomogenerators etc.). Typical example: A technical problem in the world's largest offshore wind farm, along with other damage, caused the worst blackout in Britain in August 2019.

Photo

Publication:*https://energypress.gr/news/vlavi-sto-megalytero-aioliko-toy-kosmoy-odigise-se-mplak-aoyt-sti-vretania*

In contrast, nuclear energy has by far the highest capacity factor of any other energy source. This basically means that nuclear power plants generate more than 92% maximum power during the year. Nuclear power plants are usually used more often because they require less maintenance and are designed to operate for long periods of time.

Typical example: The HeyshameII plant in the United Kingdom operated for 940 days (record time) without having to refuel. Also, the operation of the nuclear plant does not depend on weather conditions or on foreign suppliers, which makes it a stable sourcecompared to other forms of energy.

Publication:*http://world-nuclear-news.org/C-Record-940-days-of-continuous-operation-for-Heysham-unit-1609164.html*

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INFO CARD 9 Facts and data	INFO CARD 10 Facts and data
Wind energy is the most efficient RES Wind energy production increased between 2000 and 2006, while it is widely used to generate electricity. At the end of 2006, the global capacity of wind turbines was 73.9 gigawatts. This figure represents about 20% of electricity use in Denmark, 9% in Spain and 7% in Germany. Most of the wind energy is converted into electricity. Through the rotation of the turbine blades an electric current is generated with the help of an electric generator. In windmills (an older form of technology), wind energy is used to convert mechanical machinery into physical labor, such as grain breakage or water pumping. Also, wind energy is used in large-scale wind farms for national electricity networks, as well as in small individual turbines for supplying electricity in rural homes.**Wind energy is abundant, renewable, widely distributed, clean and reduces the emissions of toxic atmospheric emissions and greenhouse gases. There are many thousands of wind turbines with a total capacity of 73.904 MW, of which Europe represents 65% (2006).** The year 2013 is a milestone for Spain, a host country for wind power generation. During 2013, the coverage of the electricity supply from wind energy reached 20.9%, while from the nuclear energy, the coverage of electricity was 20.8%. Since 2007, South and Central America have nearly 10 times increased electricity generation from wind energy. Brazil is the 3rd largest market for wind farms in the world. *Global Energy Group Council (GEGC) :Global Wind Report. Annualmarket update 2011* *https://gwec.net/wp-content/uploads/2012/06/Annual_report_2011_lowres.pdf*	 Photo **Hydroelectric energy as a means of generating electricity** Nine of the ten largest power plants in the world are **hydroelectric, using dams on rivers.** China's Three Gorges supply 22.5 GW, Itaipu in Brazil supplies 14 Gw, Guri in Venezuela (10. 2GW) and Xiluodu in China (13.9 GW). **Modern hydroelectric plants** have the significant advantage of handling seasonal (but also daily) high peak loads, as hydroelectric power plants can limit the flow of water through turbines to differentiate efficiency. The most advanced and expensive turbines are those of Kaplan, which have a variable step. They are efficient in a range of flow rates.Hydroelectric systems, run by rivers, are usually much smaller than dams, but may have a wider application. In 2015, hydropower provided about 3995 TWh of 1210 GWe (capacity 38%), emphasizing its generally high utilization (IRENA data). Hydropower supplies more than 16% of the world's electricity (> 95% in Norway). 57% in Canada, 59% in Switzerland, 56% in New Zealand, 47% in Sweden, 6% in the US, 6% in Australia). most of them are hydroelectric. *Researched and writtenby World Nuclear News (2016)* *https://www.world-nuclear.org/information-library/energy-and-the-environment/renewable-energy-and-electricity.aspx*

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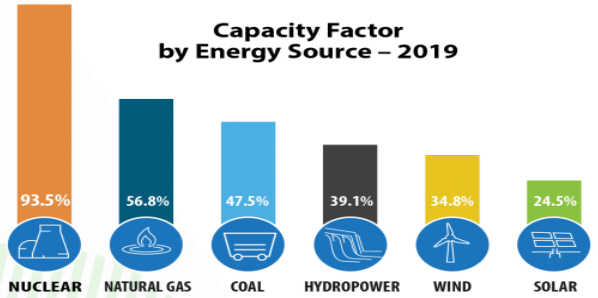
INFO CARD 11	INFO CARD 12
Threats because of nuclear reactor collapse On March 11, 2011, a magnitude 9.0 earthquake and a tsunami triggered the closure of six nuclear reactors at Fukushima 1 Daiichi. Unfortunately, radioactive particles (e.g. cesium-137, iodine-131) and gases were released into the air. Tens of thousands of people were exposed to the radiation and 170,000 to 200,000 people were evacuated from their homes. Of these, 1,600 to 3,700 lost their lives. The release of the radiation created a dead zone in the area for the next hundreds of years. It was also a source of water and food contamination, while the radiation spread worldwide within a week. It is estimated that due to the collapse of the reactor there will be deaths and the development of cancer-related diseases worldwide and, mainly, in East Asia. The cost of cleaning the Fukushima reactors and the surrounding area is estimated at $ 460 billion to $ 640 billion. *Johnson, G., When radiation isn't the real risk, 2015* *https://www.nytimes.com/2015/09/22/science/when-radiation-isnt-the-real-risk.html* Ten Hoeve, J.E., and M.Z. Jacobson, Worldwide health effects of the Fukushima Daiichi nuclear accident, Energy and Environmental Sciences, 5, 8743-8757, 2012, Denyer, S., Eight years after Fukushima's meltdown, the land is recovering, but public trust is not, Washington Post, 2019. The effects on human health due to the worst global nuclear accident (Chernobyl, Ukraine, 1986) are dramatic. Although only 30 people were killed instantly, several thousand more could die over the next 30 years as cancer mortality rates rise in Europe. *D of the 2008 UNSCEAR Report* *http://www.unscear.org/docs/reports/2008/11-80076_Report_2008_Annex_D.pdfhttps://www.iaea.org/newscenter/focus/chernobyl*	 **Nuclear power plants have the highest capacity** (Photo) The largest nuclear power plant in the United States, the Palo Verde nuclear power plant has a rated capacity of 3,942 MW between its three reactors. In 2010 its annual production was 31,200,000 MWh, resulting in a capacity factor: (31,200,000 MWh) / [(365 days) * (24 hours / day) * (3,942M2) = 0.904 = 90.4% *https://www.eia.gov/nuclear/state/arizona/* Horns Rev 2 offshore wind farm has a nominal capacity of 209.3 MW. Since January 2017, it has produced 6416 GWh, since it was put into operation 7.3 years ago, i.e. an average annual production of 875 GWh / year and a capacity factor of 47.7%. Capacity factors in open wind farms in Denmark. energynumbers.info Since 2017, the Three Gorges Dam in China is, with its nominal capacity of 22,500 MW, the world's largest power plant with installed capacity. In 2015, it created 87 TWh, for a capacity factor of 45%. *https://www.usbr.gov/lc/hooverdam/faqs/powerfaq.html* For renewable energy sources (solar, wind and hydroelectric power), the main reason for the reduced capacity factor is generally the availability of the energy source.The plant may be able to generate electricity, but its "fuel" (air, sunlight or water) may not be available. The production of a hydroelectric plant can also be affected by the requirements to keep the water level too high or low and to provide water for the fish. However, solar, wind and hydroelectric plants have high availability factors, so when they have fuel, they are almost always able to generate electricity. *https://web.archive.org/web/20080313142528/http://www.awea.org/faq/basicen.html*

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Oxford Debates for Youths in Science Education

INFO CARD 13

Inability to resolve the energy issue due to the long time between the planning and operation of nuclear reactors

The time lag between designing and operating a nuclear reactor includes the periods for locating a site, obtaining an installation permit, purchasing or leasing land, granting a construction permit, securing funding and insurance for construction, installation, obtaining a construction permit, the connection for the production of energy, in order to obtain the final operating license.
The programming times for all nuclear facilities ever built were 10-19 years or more. Specifically:

Nuclear Reactors	Planning time to operate in years
Olkiluoto 3 in Finland	20
Haiyang 2 in China	13-14
Taishan 2 in China	12-13

Many claim that Messmer plan in France in 1974 resulted in the construction of its 58 reactors in 15 years. But this is not true because, for example, 10 of these reactors were completed between 1991 and 2000, so the total programming time for these reactors was at least 32 years, not 15.

Mark Z. Jacobson (2019) Evaluation of Nuclear Poweras a ProposedSolutiontoGlobalWarming, Air Pollution, and Energy Security In 100% Clean, Renewable Energy and Storage for EverythingTextbook in press, CambridgeUniversityPress
https://web.stanford.edu/group/efmh/jacobson/WWSBook/WWSBook.html

INFO CARD 14

Energy security in the EU

The emergence of energy security is at the top of the agenda of the European Union and all countries as it is related to their social well-being and coexistence. The goals set by EU's approach to this issue are:

• Decrease, as much as possible, of energy resources imports such as natural gas and oil.
• Differentiation, numerically and geographically, of the states from which the energy supply is made.
• Enhancing domestic energy production.
• Reinforcement and utilization of RES and de-dependence on oil.
• Strengthen energy saving policies.
• Differentiation of energy mix.
• At the transnational and regional level, energy agreements are concluded with various states that can combine interests.
Finally, a very important dimension of energy security is the economic part.

The age-old problem of states regarding energy remains the volatility of the price of oil and whether states will be able to supply it to meet their needs. The price and supply of oil have been the trigger for many important global events.

Paterelis, D. (2016) The issue of Energy Security and its management by the European Union, Postgraduate Program, School of Industrial Management and Technology, Energy and EnvironmentalManagement

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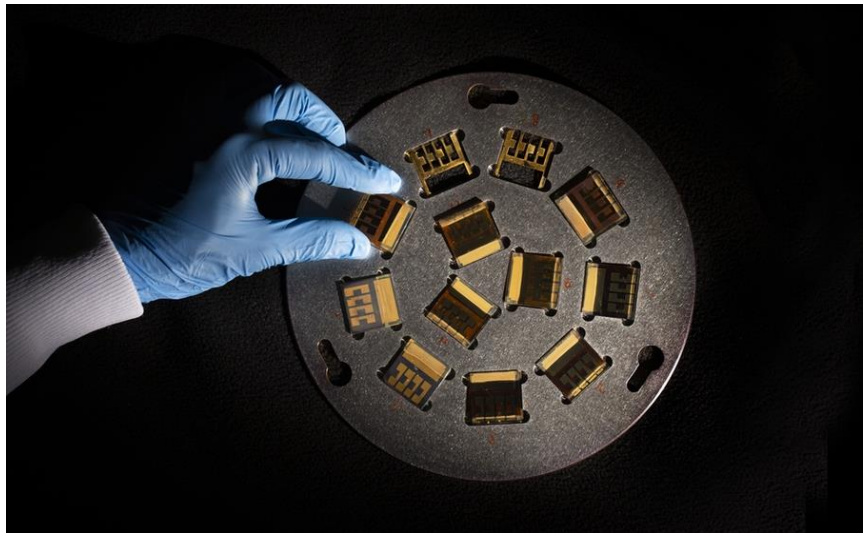
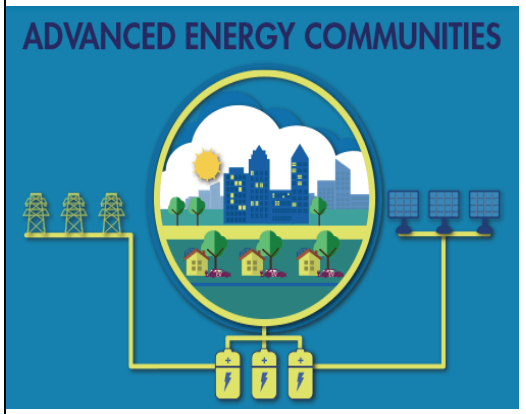
INFO CARD 15	INFO CARD 16
Increased need for energy production-Urgence to resolve the energy issue Despite strong support for increasing electricity production from renewable sources in recent years, the contribution of fossil fuels to energy production has remained virtually unchanged. The International Energy Outlook for the International Organization for Migration (IEA) (2018) publishes the **"Sustainable Development Scenario", which is consistent with the provision of clean and reliable energy and the reduction of air pollution through nuclear reactors.** The World Nuclear Association has proposed a more ambitious scenario than this. Harmony programmme plans to add 1,000 GWe of new nuclear power by 2050 to generate about 25% ofelectricity in air quality. World Energy Outlook, 2018, OECD International Energy Service.  *Photo*	**Energy from renewable sources (RSE) in the European Union (EU) has increased significantly**  Between 2007 and 2017 the amount of energy from renewable sources (RSE) produced in the EU-28, increased by a total of 64%, a rate equivalent to an average annual increase of 5.1%.This development was the result of legally binding targets for increasing the share of energy from RSE, which were implemented by the Directive 2009/28 / EC. The most important RSE in theEU-28 was the wood and solid biofuels, as well as renewable waste. In 2016 they accounted for 49.4% of primary energy production from RSE. Hydroelectric energy had the second most important contribution to the energy mix from RSE (14.3% of the total), followed by wind energy (12.4%). Currently, very low levels of tidal, wave and ocean energy are recorded. In fact, these technologies exist mainly in France and the United Kingdom. Additional statistics for energy review in the EU are: • Highest rates of renewable energy are available in Latvia and Sweden. • Renewable energy consumption is more than doubled between 2004 and 2017. • Wind energy becomes the most important renewable source of electricity. • Almost one-fifth of the energy used for heating and cooling comes from renewable sources. • 7.6% of renewable energy was used in transport activities in 2016. *Eurostat:* Energy statistics from renewable sources / Photo

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INFO CARD 17

Comparative values for the average construction costs of RES compared to nuclear facilities

In a report on the cost of nuclear power plants, the World Nuclear Association (2008) gave an average cost of building nuclear power plants equal to $ 1,500 per kilowatt ($ 1,500 / kW), with price range from $ 1,000 / kW to $ 2,500 / kW.$/kW. For comparison, the most recent lignite plants built by PPC in Greece cost € 2,000 / kW (or about $ 2,800 / kW). The case of Bulgaria is also typical of the new nuclear power plant in Belene, which began its construction in 1987. The Bulgarian Minister of Economy and Energy insists that the cost of the project is € 4 billion (€ 2,100 / kW or $ 2,940 / kW), the Russian manufacturer raises it to € 6.3 billion and the Bulgarian Institute of Market Economics to € 11.5 billion (€ 6,050 / kW or otherwise $ 8,470 / kW). For RES, the estimates until 2020 of the average cost are:

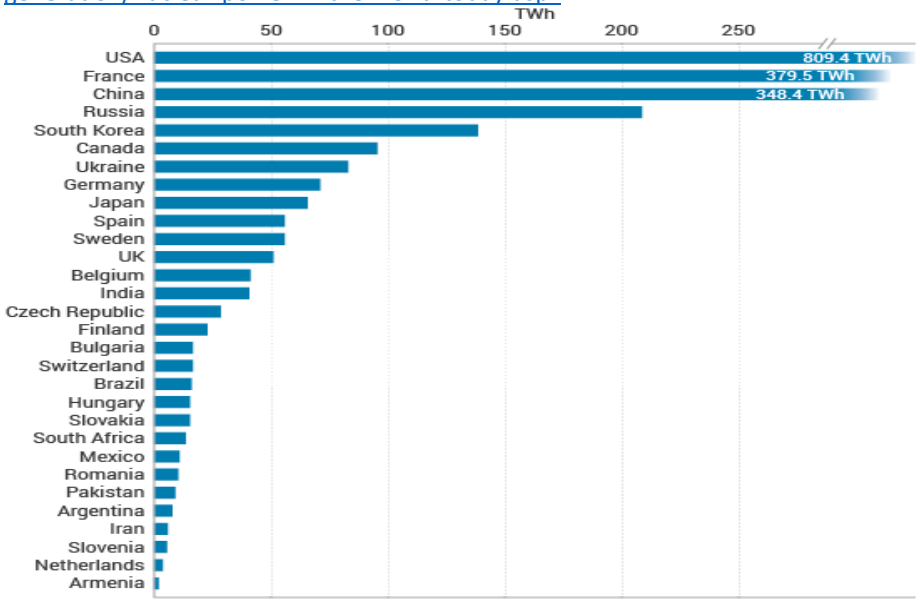
Wind: € 1,500 / kW
Biomass: € 3,100 / kW
Photovoltaic: € 1,300 / kW
Home photovoltaics: 2,000 € / kW
Photo

World Nuclear Association (2008). The economics of nuclear power. Nov. 2008, http://www.world-nuclear.org/uploadedFiles/org/info/pdf/EconomicsNP.pdf
OECD/ IEA NEA (2005). Projected Costs of Generating Electricity- update.
World Nuclear Association (2011). The economics of nuclear power. March 2011, http://www.world-nuclear.org/info/inf02.html
Greenpeace Post, March 2011: The Myth of Nuclear Energy

INFO CARD 18

Global review of nuclear energy production

About 11% of the world's electricity is generated by about 450 nuclear reactors. In 2017, the nuclear facilities provided 2487 TWh of electricity, in 2016 the supply was 2477 TWh. Thirteen countries in 2017 produced at least a quarter of their electricity from nuclear reactors. Specifically:
i) in France three-quarters of electricity comes from nuclear power, ii) in Hungary, Slovakia and Ukraine half of the electricity comes from nuclear power, iii) in South Korea more than 30%, iv) in the US, the United Kingdom, Spain, Romania and Russia about one-fifth, v) in Japan more than a quarter.
Detailed description of nuclear energy production per countryworldwide:
https://www.world-nuclear.org/information-library/current-and-future-generation/nuclear-power-in-the-world-today.aspx



Source: IAEA PRIS Database

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STORY CARD 1

Innovative ideas and developments in the use of wind energy

1. The air currents over the skyscrapers and the buildings in the cities are stronger and more stable than those on the ground. In order to take advantage of them, an amazing wind turbine was created that hangs in the sky. It consists of a hollow cylinder and a propeller-turbine, through which the best use of wind resistance is made. Wind farms are constantly innovating to develop wind turbines, which are becoming more efficient and competitive.

2. Air generators in skyscrapers
The first skyscrapers to include these wind turbines are those of the Bahrain World Trade Center, which are two bridges that connect the two buildings and support three huge turbines that are about 30 meters in diameter.

3. „Hive" wind turbines on the facades: This way of using the wind is able to produce energy in almost all

4. **Floating wind turbines:** These wind turbines are built in a way that exceeds the power of waves up to 30 meters high. The windmills flutter in the water, but do not sink, as they float on the same level, because they are tied by three ropes-wired a great depth of the bottom (700 meters). These wind turbines are very efficient because they use the sea winds, which are usually stronger and more stable than the surface ones.

5. **The largest wind farms**
The largest wind farm in the world is the Alta Wind Energy Center, located in California and consists of 586 turbines. London Array is the sixth largest wind farm in the world. It is located at the mouth of the river Thames at a distanceof 20 km from the coast. With 175 turbines, it can meet the demand for 2/3 of Kent'spopulation.
Access to the post: *https://www.activesustainability.com/renewable-energy/10-curious-facts-about-wind-energy/*

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STORY CARD 2

Risk of proliferation of nuclear weapons

The development of nuclear energy has historically increased the ability of nations to acquire or harvest plutonium and enrich uranium to produce nuclear weapons. The Intergovernmental Panel on Climate Change (IPCC) acknowledges this fact and states: "Obstacles and risks associated with the growing use of nuclear energy include operational risks and related security concerns, uranium mining risks, financial and regulatory risks, unresolved waste management issues, concerns about the proliferation of nuclear weapons and negative public opinion."

The construction of a nuclear power plant in a country that does not currently have a reactor allows the country to import uranium for use in the nuclear power plant. In this case, the country can secretly enrich uranium to create uranium-quality weapons and collect plutonium from uranium fuel rods for use in nuclear weapons. "This does not mean that some or any country will do this, but, historically, some have done so and the risk is high," notes the IPCC (Intergovernmental Panel on Climate Change).

Metz. B., O. Davidson, H. C. de Coninck, M. Loos, and L.A.Meyer (eds.). Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA,442 pp. http://arch.rivm.nl/env/int/ipcc/ (accessed June 26, 2019).

STORY CARD 3

Radioactive waste management - Sustainable nuclear fuel management solution

Most U.S. fossil fuels, 90% of which can be recycled to extend nuclear power for hundreds of years, are currently stored safely in impermeable dry barrels of concrete and steel. The US Waste Testing Unit (WIPP) near Carlsbad, New Mexico, can store commercial nuclear waste in 2km of crystalline salt. The salt formation extends from southern New Mexico across the northeastern direction to southwestern Kansas and is a clear example of how it could easily accommodate nuclear waste from around the world for the next thousand years on a granite background 400 meters below Olkiluoto.

Published by RichardRhodes (author of many books, including the recently published energy: It's a human story, and a human story winner of the Pulitzer Prize, the National Book Award and the National Book Critics Circle Award) at Yale School of Forestry & Environmental Studies

https://e360.yale.edu/features/why-nuclear-power-must-be-part-of-the-energy-solution-environmentalists-climate

Photo

The 1982 Nuclear Waste Policy Act codified the U.S. Department of Energy to develop a geological reservoir for used nuclear fuel, but this project has not been implemented due to lack of funding. Specifically, in 2002, the president and Congress approved Mount Yucca in Nevada as a venue for this repository. However, in 2010, the Yucca Mountain project closed without any technical issues or safety issues. Although decades of scientific studies have concluded that the proposed repository could safely protect future generations, unfortunately the work has not been completed due to the high cost.

(Information Bulletin of the Nuclear Energy Institute February 2018, https://www.nei.org/advocacy/make-regulations-smarter/used-nuclear-fuel (Access 14.8.2019).

STORY CARD 4

Energy storage technologies are a key factor in storing the "variable" amount of energy produced by clean renewable sources

Thermal storage is used to generate electricity valorizing the sun energy even when the sun is not shining. Appropriate solar installations store heat from the sun in water, molten salts or other liquids, which can be used even after sunset. For example, **California's proposed solar energy project Blythe uses a fused salt storage system with a solar tower to provide power to about 68,000 homes each year.** It has also been studied **the possibility of creating hydrogen from wind energy and storing it in wind turbine towers to generate electricity when the windisnotblowing.**

Mineral hydroelectric storage: Hydroelectric storage with a pump offers a way to store energy in the transmission phase of the network, storing excessive production for later use. Many hydroelectric power plants include two tanks at different altitudes. These store energy by pumping water into the upper tank when supply exceeds demand. When demand exceeds supply, water is released into the lower tank with water running down a turbine to generate electricity. The Federal Energy Regulatory Commission (FERC) has created a pricing structure called pay-for-performance that enables to make storage technologies more economical on a commercial scale. An investment tax credit will also help accelerate the development of storage technologies. **This means that with the support of government and industry, energy storage technologies can continue to grow and expand, helping to grow variable renewable energy sources and helping to store an ever-increasing amount of clean renewable energy sources in the future.**

Denholp P et al:The role of energy storage in the production of electricity from renewable sources. National Renewable Electricity Laboratory. http://www.nrel.gov/docs/fy10osti/47187.pdf, Union of Concerned Scientists. 2013. Improving Renewable Energy Sources: Energy You Can Rely on. http://www.ucsusa.org/assets/documents/clean_energy/Ramping-Up-Renewables-Energy-You-Can-Count-On.pdf, Solar Reserve http://www.solarreserve.com/what-we-do/csp-projects/ice-army-airfield/, "Ice Energy Storage System"Online http://www.ice-energy.com/ice-bear-energy-storage-system, Improving renewable energy sources: energy you can rely on.http://www.ucsusa.org/assets/documents/clean_energy/Ramping-Up-Renewables-Energy-You-Can-Count-On.pdfDSIRE: State incentive database for renewable energy sources and efficiency. 2013. Online address: http://www.dsireusa.org/https://www.ucsusa.org/clean-energy/how-energy-storage-works

STORY CARD 5

Exhaust fumes without waste or CO2 emissions for energy production

Sierra Energy aims to address all non-recyclable waste that ends up in landfills - from hazardous waste and plastics to daily rubbish and tires, generating clean energy by evaporating a pile of rubbish without waste or emissions. It uses FastOx gasification technology to heat all the waste to 4,000 degrees Fahrenheit, which is about twice the temperature at the heart of a volcano. While this may seem like a lot of energy, the system can generate heat simply by injecting pure oxygen into the furnace.

Access 3/8/2019, https://www.goodnewsnetwork.org/revolutionary-blast-furnace-vaporizes-trash-and-turns-it-into-clean-energy/

The projest has been funded with the support of European Commission within ERASMUS+ program

STORY CARD 6

Geothermal energy: A giant, permanent and untapped source of energy

The production of electricity from geothermal energy requires devices that can use the heat inside the earth's crust. Recently, a team of scientists at Tokyo Tech has made great strides in understanding and developing sensitive thermal cells, a type of battery that can generate electricity at 100 ° C or less using photosensitized solar cells. In these devices, the electrons move from a low-energy state to a high-energy state in the semiconductor, gaining thermal stimulation. Then, they are naturally transported to an electron transport layer, where they pass through an external circuit, pass through the opposite electrode and eventually reach the electrolyte.

The question is: Could it be used as a perpetual motor or would the power stop at some point? After testing, the team noticed that the electricity, in fact, stopped flowing after a certain time and suggested a mechanism that explains this phenomenon. The current stops because the redox reactions in the electrolyte layer stop due to the relocation of the different types of copper ions. However, they discovered that the battery could return to the same state of power generation (heat presence) with the opening of the external circuit (i.e. with a simple switch). **In conclusion, with such a design, heat, which is usually considered low-quality energy, will become a major source of renewable energy.** Further improvements to this type of battery are the goal of future research, with the hope that one day humanity's energy needs will be met.

S. Matsushita, T. Araki, B. Mei, S. Sugawara, Y. Inagawa, J. Nishiyama, T. Isobe, A. Nakajima.
A sensitized thermal cell was recovered using heat. Journal of Materials Chemistry A , 2019; DOI: 10.1039, Tokyo Institute of Technology. "Could the heat of the earth's crust be the final source of energy?", Journal ScienceDaily. www.sciencedaily.com/releases/2019/07/190717230347.htm

STORY CARD 7

Rocks on the seabed off the coast of the United Kingdom could provide long-term storage sites for renewable energy production

Processes that store energy cheaply and reliably for months contribute to a stable and reliable supply of energy from renewable sources - such as wind turbines and tidal turbines. One such method is **compressed air energy storage (**CAES), which uses the elastic dynamic energy of compressed air to improve the efficiency of conventional gas turbines. CAES systems compress air using electricity during off-peak times and then they store the air in underground caves. During peak demand, air is pumped from storage and supplied with gas to a combustion turbine to generate electricity. This method uses only one-third of the gas used in conventional methods. Two CAES commercial plants are currently operating in Huntorf, Germany and Macintosh in Alabama, although such plants have been proposed in other parts of the United States. In addition, engineers and geographers from the Universities of Edinburgh and Strathclyde used mathematical models to evaluate the potential of the compressed air trapping process in porous rocks in the North Sea. The results showthat porous rocks underwater can store about one and a half times the UK's average electricity demand for January and February, which means it can meet its electricity needs during the winter, when demand is higher.
Installing sources close to renewable energy sources - such as offshore wind turbines - will make the process more efficient, cheaper and reduce the amount of submarine cables required.

Posted in Nature Energy magazine. The studywasledby Dr. Julien Mouli-Castillo (University of Edinburgh School of Geosciences).

The projest has been funded with the support of European Commission within ERASMUS+ program

STORY CARD 8

Innovative renewable energy source with simultaneous collection of heat from the sun and coldness from the outside

Chen and his colleagues have developed a device that combines cooling radiation with solar absorption technology. The device consists of a German germ absorber on top of a radiator with layers of silicon nitrite, silicon and aluminum enclosed in a vacuum to minimize unwanted heat loss. Both the sunshade and the atmosphere are transparent in the area of the infrared medium, offering a channel for infrared radiation from the radiator to pass outdoors. "On a rooftop, we imagine that a photovoltaic cell can supply electricity, while the refrigerator can cool the house on hot summer days," says Chen.

Although this technology seems promising, Chen believes that there is still enough work to be done for commercial use. While the vacuum surrounding the device can be developed relatively easily, the transparent window produced by zinc selenium is still too expensive and the solar absorber and radiator could be designed from cheaper high-performance materials. Chen, also, believes that it is important to try using photovoltaic cells in place of a solar absorber, an idea that has not yet been proven. But despite these practical challenges, the team believes that this research shows that renewable energy has even more potential on the roof than previously thought. This method can help improve the efficiency of solar cells.

Zhen Chen, Linxiao Zhu, Wei Li, Shanhui Fan. Simultaneously and Synergistically Harvest Energy from the Sun and Outer Space. Joule, 2018; DOI: 10.1016/j.joule.2018.10.009

STORY CARD 9

Nuclear energy is evolving as a superpower of navigation

Naval nuclear reactors differ from power generators in that:

-They produce enough energy in a small volume and use high enrichment uranium> 20%

-They have a long core life, so they are recharged after 10 or more years. The new cores have been installed for the last 50 years on transport ships, and for the last 30-40 years on most submarines.

Indicative examples: The beginning was made in 1959 with the Soviet icebreaker "Lenin", which was the first ship to reach the North Pole. The main deterrent for the short period of operation of some nuclear ships (e.g. NS Savannah) was **the high operating costs**, which made the use of nuclear energy economically unprofitable. China has several nuclear-powered submarines. In February 2013, the Chinese company China Ship Building Industry Corporation received state approval and funding to begin research into nuclear technology and the safety of nuclear ships, in "polar" vessels, i.e. icebreakers (Photo). France has a nuclear-powered aircraft carrier and ten nuclear-powered submarines (4 SSBNs, 6 Rubis class SSNs). The United Kingdom has 12 submarines, all of which are nuclear-powered. China has ten nuclear-powered submarines.

Jane's Fighting Ships, 1999-2000; J Simpson 1995, Nuclear Power from Underseas to Outer Space, American Nuclear Society The Safety of Nuclear Powered Ships, 1992 Report of NZ Special Committee on Nuclear Propulsion Bellona 1996, The Russian Northern Fleet and Civil Nuclear Powered Vessels (on web) Bellona: http://www.bellona.org/subjects/Russian_nuclear_naval_vessels, http://spb.org.ru/bellona/ehome/russia/nfl/nfl2-1.htmhttp://spb.org.ru/bellona/ehome/russia/nfl/nfla

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STORY CARD 10

The floating wind farm of Scotland

The first merchant coastal wind farm, called Hywind, began sending electricity to the network. The facility, which includes 6 wind turbines and produces 30MW, has been in excellent working order. In fact, according to Statoil, the facility has had a 65% capacity-efficiency factor in the last 3 months. Hywind factor exceeds the average efficiency factor that several power sources have. According to the Energy Information Administration (EIA), the corresponding coastal wind farms in the United States had an average efficiency rate of 36.7% in 2017. Photovoltaic plants had a corresponding average of 27% in 2017. Even conventional hydroelectric plants have reached 45.2% last year. Comparing the 65% Hywind efficiency factor calculated in the wintermonths, where the winds are very strong, with the corresponding coefficients of the rest of the energy facilities of the previous year, is not correct. At the same time, the wind farm may have a lower efficiency, as the winds are not so strong during the summer months. However, Statoil reports that in similar wind farms, their rate reaches 40 to 60 percent during the winter months. This shows that there is an advantage to floating wind farms. Wind turbines can be placed more in the sea, where the winds are stronger and more stable. Hywind was built like the oil rigs, which have anchored the platforms at the bottom with suction anchors (suction anchors).

http://www.bbc.com/news/av/science-environment-40712926/world-s-first-floating-offshore-wind-farm-in-scotland

STORY CARD 11

European Parliament Resolution on the consequences of the use of weapons with enriched uranium

Photo

The European Parliament: a) shocked by the effects of the use of weapons enriched with uranium from NATO countries during the Gulf War (1991), Bosnia (1994-1995) and Kosovo (1999): numerous military and resident deaths of bombed areas and ecological disasters, b) considering that the devastating effects on health and the environment due to the use of enriched uranium are added to the damage caused by exposure to toxic chemicals (solvents, benzene, fuels) and the bombings of chemical plants, c) given that pollution caused by depleted uranium can gradually spread beyond the bombed area and have consequences for many decades after the bombing: a) requests a ban on the production, testing, use and sale of weapons with depleted uranium; supports the signing of an international treaty banning weapons with depleted uranium and b) calls on the Secretary-General of the United Nations to conduct an independent, thorough and transparent investigation into the effects of the use of depleteduranium on health and the environment and to provide comprehensive information on the situation in order to protect the populations of the affected areas.

According to Article 37, paragraph 2, of the Rules of Procedure of Members of Parliament FrancisWurtz, LucioManisco, AndreBrie, LauraGonzálezálvarez, JoaquimMiranda, Konstantinos Alysandrakis, PedroMarsetCampos, LuigiViniaOinomiopouli and EpisiomouliEppiliomidouni Eleni Papouianmnakis, HermanSchch European Union Left / Left of the Greens of the Northern Countries onthe Consequences of the Use of Weapons with Enriched Uranium ("BalkanSyndrome")*http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//TEXT+MOTION+B5-2001-0053+0+DOC+XML+V0//EL*

The projest has been funded with the support of European Commission within ERASMUS+ program

CARD QUESTION 1	CARD QUESTION 2	CARD QUESTION 3
Why is nuclear energy considered a "pure form of energy" that can solve the energy problem?	**Is nuclear energy considered a viable solution to the energy issue?**	**Is nuclear energy considered a viable solution to the energy issue?**
CARD QUESTION 4	**CARD QUESTION 5**	**CARD QUESTION 1**
Does nuclear energy have a negative effect on the environment?	**Are there risks to the viability of nuclear power?**	**What comparative data are available on the time required for the operation of nuclear power plants and RES? What conclusion do you draw?**
CARD QUESTION 7	**CARD QUESTION 8**	**CARD QUESTION 9**
What scientific evidence is there about nuclear power generation and RES worldwide?	**It is argued that wind energy will evolve as a solution to the energy issue due to new innovative ideas and innovative developments for its exploitation. Do you agree?**	**What comparative scientific data are available on the electricity generation of the various renewable energy sources?**

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CARD QUESTION 10	CARD QUESTION 11	CARD QUESTION 12
What scientific evidence is there about the storage of energy from RES, but also the storage of nuclear waste? Whatare the advantages?	The "variability" of RES energy, which depends on environmental conditions, is a very significant disadvantage. Do you agree or disagree? Justify.	Can nuclear power plants act as weapons promoters?
CARD QUESTION 13	**CARD QUESTION 14**	**CARD QUESTION 15**
Are there statistics on the use of RES in the EU?	What are the comparative data for the average construction costs of RES and nuclear facilities?	What scientific evidence is there for the effects of the uranium extraction method?
CARD QUESTION 16	**CARD QUESTION 17**	**CARD QUESTION 18**
What positive and negative evidence is recorded by hydroelectric power plants?	What comparative data are recorded for the highest RES and nuclear facilities?	What energy security issues have been raised in the EU and are making the energy issue a priority?

CARD QUESTION 19	CARD QUESTION 20	CARD QUESTION 21
"Nuclear weapons are a major deterrent to the use of uranium nuclear fission." Doyouagreewith this view? Resolution of the European Commission:	**Are there energy storage technologies from RES to work towards their utilization in case of unfavorable environmental conditions?**	**In what other areas can nuclear energy contribute positively?**

Prepare the arguments for the discussion. A group of students prepares arguments that support one view, or another has contradictory arguments. Use the suggested figure.

1ST ARGUMENT

Argument	Foreseen rebuttals from the other group	Responses to rebuttals

2ND ARGUMENT

.Argument	Foreseen rebuttals from the other group	Responses to rebuttals

3RD ARGUMENT

Argument	Foreseen rebuttals from the other group	Responses to rebuttals

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Odyssey
Oxford Debates for Youths in Science Education

Erasmus+

Energy Issue: Nuclear Energy and Renewable Energy

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CENTER FOR THE PROMOTION OF SCIENCE

IRESE

ENERGIA
AVASTUSKESKUS
ENERGY DISCOVERY CENTRE

Introduction: Energy in daily life

- **Humanity has been associated with the concept of energy since the first moment of its existence on Earth.**
- **The use and cost of energy affect individuals' daily lives.**

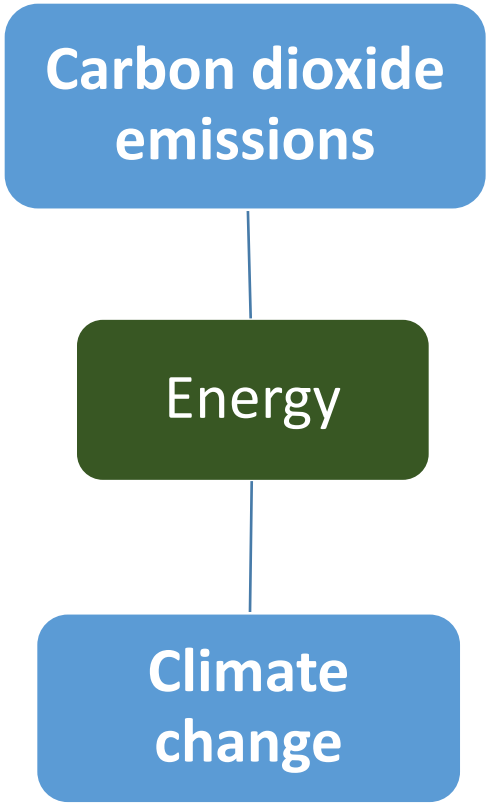
➢ **Can you provide examples of energy use?**

➢ **Are there any differences in today's modern world and in the past?**

Energy production is (to a large extent) linked to the use of fossil fuels

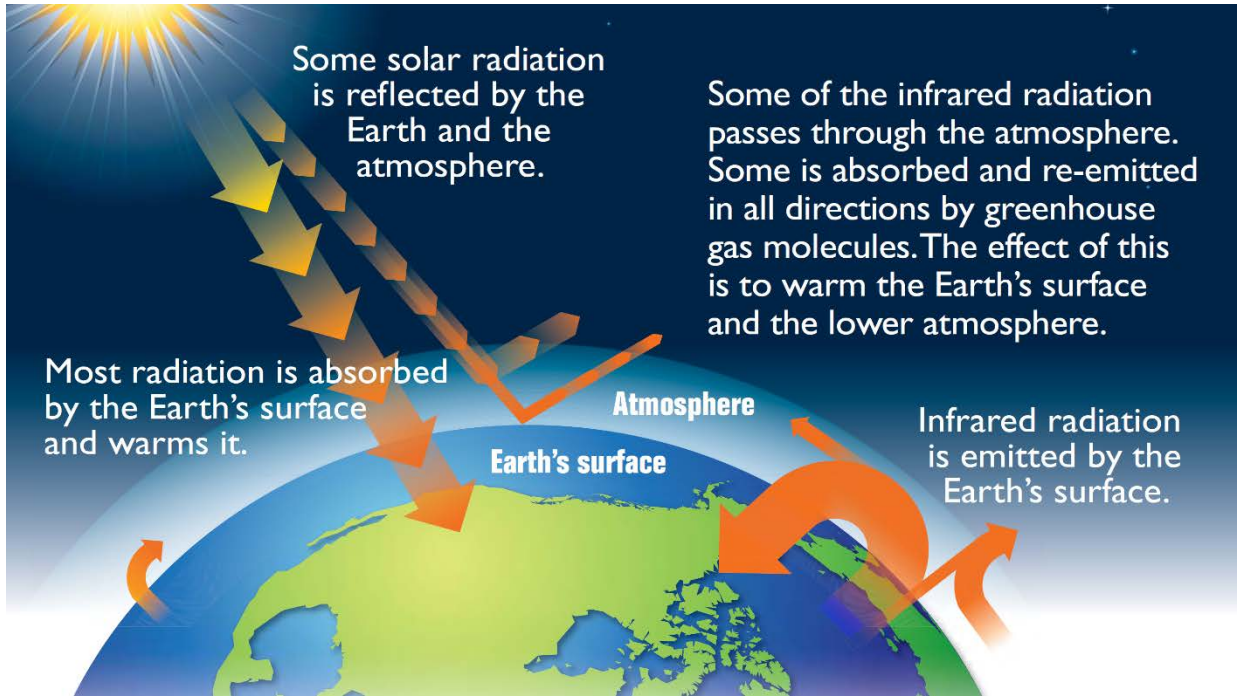
Fossil Fuels: A source of energy formed in the earth's crust from decomposed organic material. **The three most common fossil fuels are coal, oil and gas,** which come from some living organisms and can be processed to produce energy.

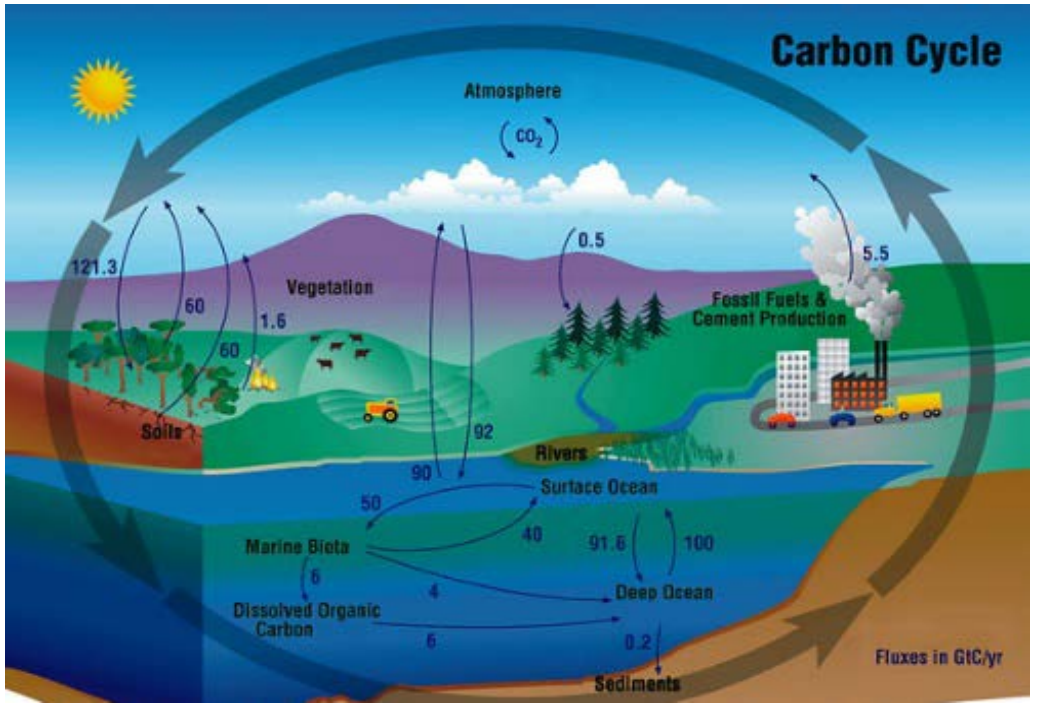
But fossil fuel power generation is directly linked to environmental pollution and, particularly, to air pollution.



Fossil Fuels & Climate Change

- One of the very serious consequences of atmospheric air pollution is **the greenhouse effect that results in climate change.** Gases from anthropogenic activities (industry, combustion for energy production).

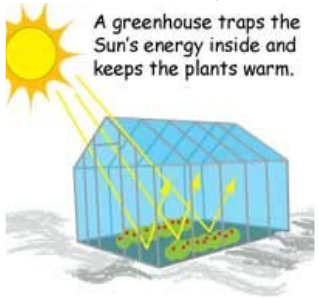




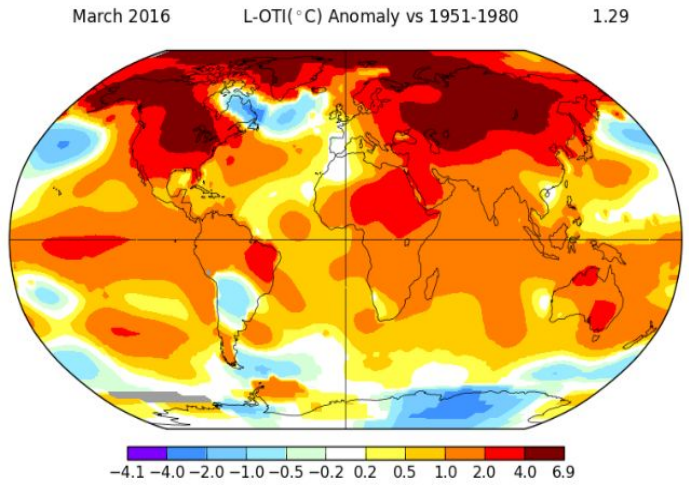
Causes of climate change

Humans are increasingly influencing the climate and temperature of the earth through the use of fossil fuels, deforestation and livestock breeding.

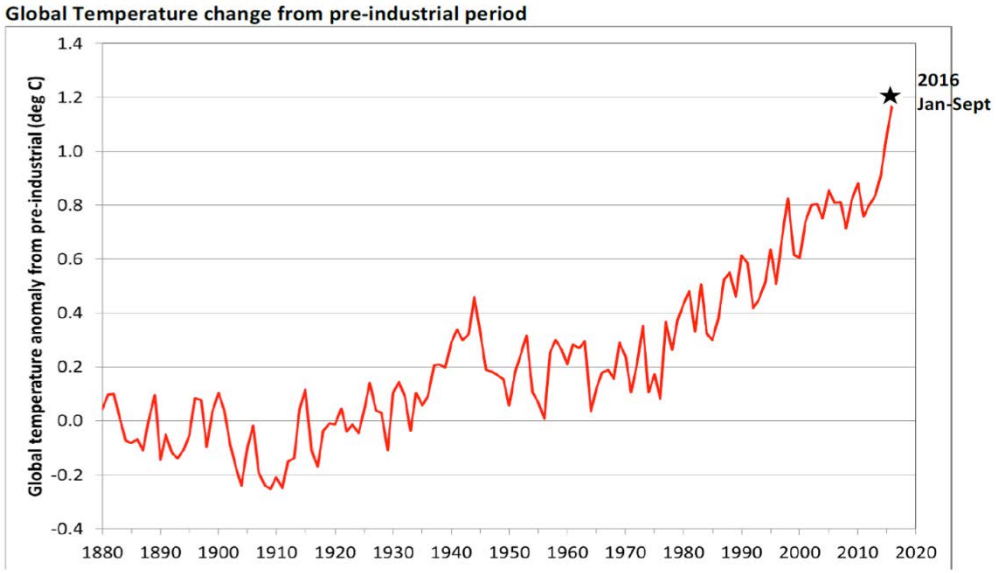
These activities add huge amounts of greenhouse gases to the gases in the atmosphere, causing an increase in the greenhouse effect and global warming.



Some gases in the atmosphere work like glass in greenhouses, trapping the sun's heat and preventing it from passing through space.



There is a pressing need to reduce pollutants in the atmosphere.



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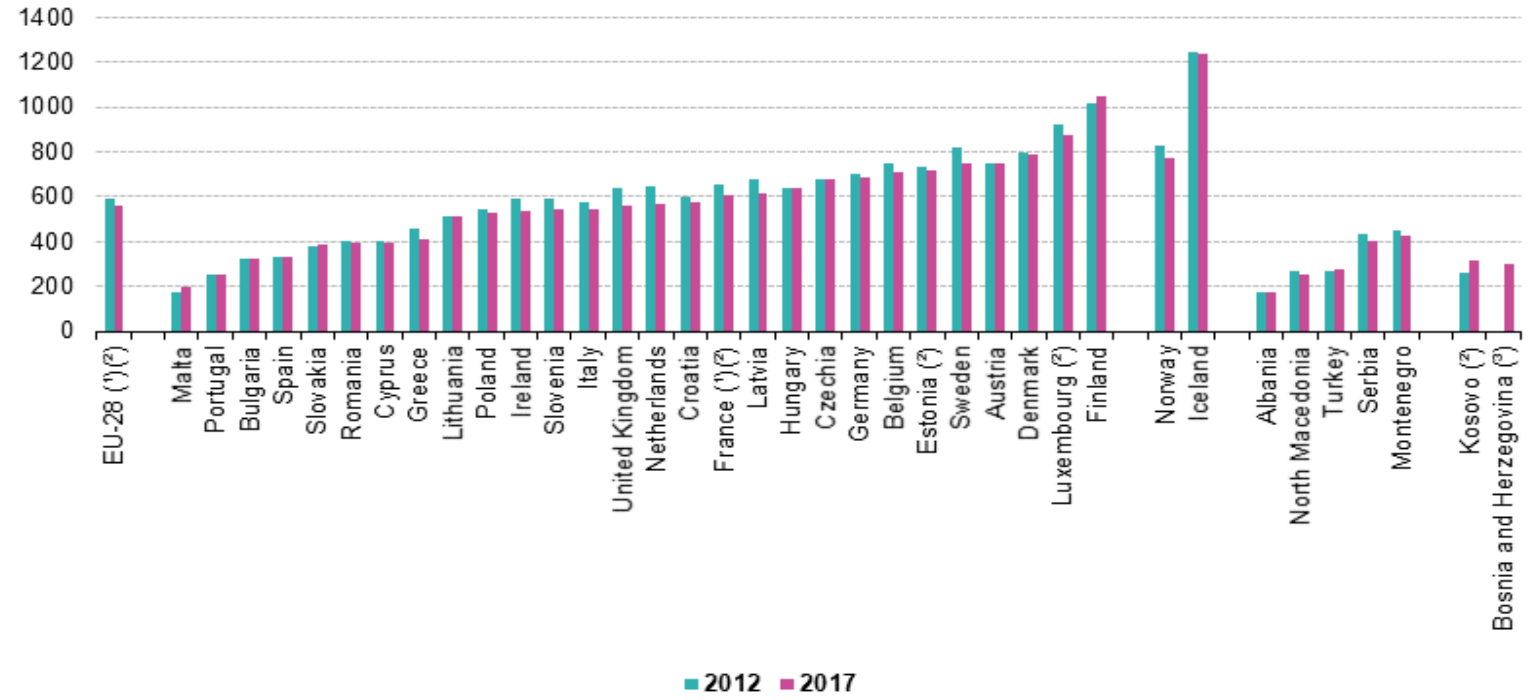
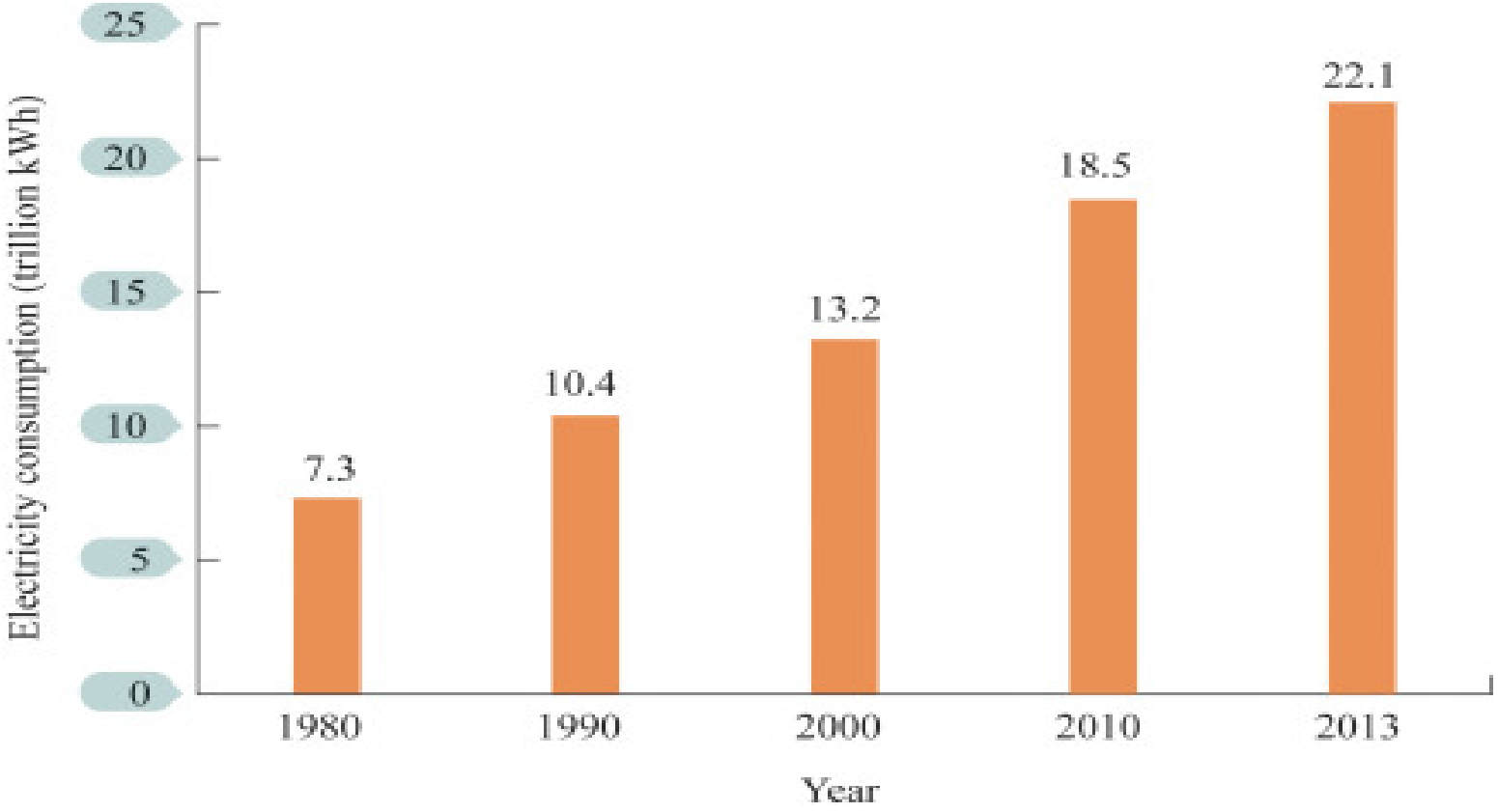
Continuous increase in the global population and increasing demand for electricity

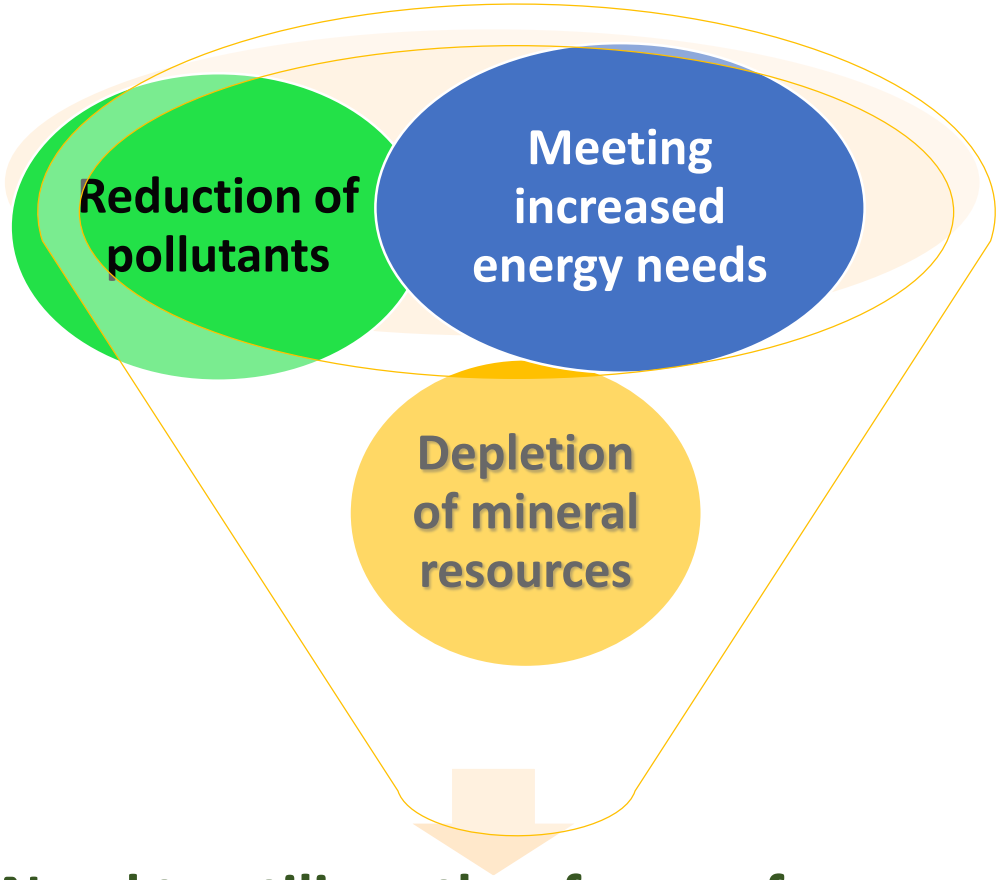
Fossil fuel stocks are running out.

Final energy consumption in households per capita, by country, 2012 and 2017
(kg of oil equivalent)



Electricity Consumption





Need to utilize other forms of energy. Modern societies are looking for solutions to the energy issue.

How can we meet growing demand for energy?

Are there viable and safe solutions for the environment?

Can the utilization of nuclear energy or renewables eventually meet the challenges facing the global community?

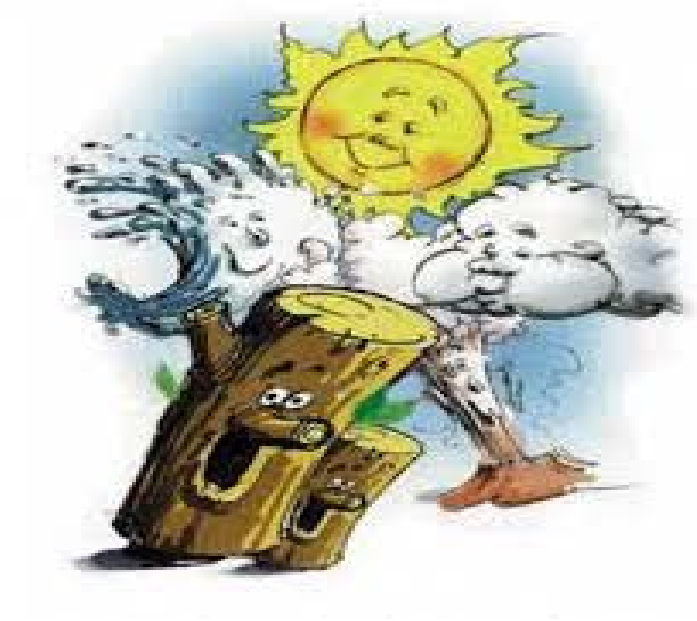
Terminology

Humanity's efforts must tend to achieve what we would call "sustainable development".

- At any given time, the Earth, as a whole and with its individual regions, has a limited ability to support the various forms of life, including human beings.
- **A sustainable society** thus regulates its economy and population size so as not to exceed the potential of the planet to absorb environmental damage, rebuild its resources, and sustain life for thousands of years. Thus, the needs of the population can be satisfied without exhausting the earth's capital and without jeopardizing the prospect of the present and future generations of mankind and other species.

- **The term's 'sustainable**' sense is 'meeting the needs of the present without jeopardizing the ability of future generations to meet their own needs'**. In the context of energy choices, the concept of 'sustainability'** implies the ability to supply energy for unlimited periods of time (i.e. for a very long time) without depriving it of future generations and in an environmentally friendly, economically viable way, safe and capable of being delivered reliably.

- ***Can you give a brief description of the energy challenges that the planet faces? Which of these challenges make finding solutions to the energy issue an urgent need?***



Renewable Energy Sources (RES) or mild forms of energy, new energy or green energy - are non-fossil renewable energy sources, namely wind, solar and geothermal energy, wave energy, tidal energy, hydraulics energy, gases emitted from landfills, biofuels and biogas.

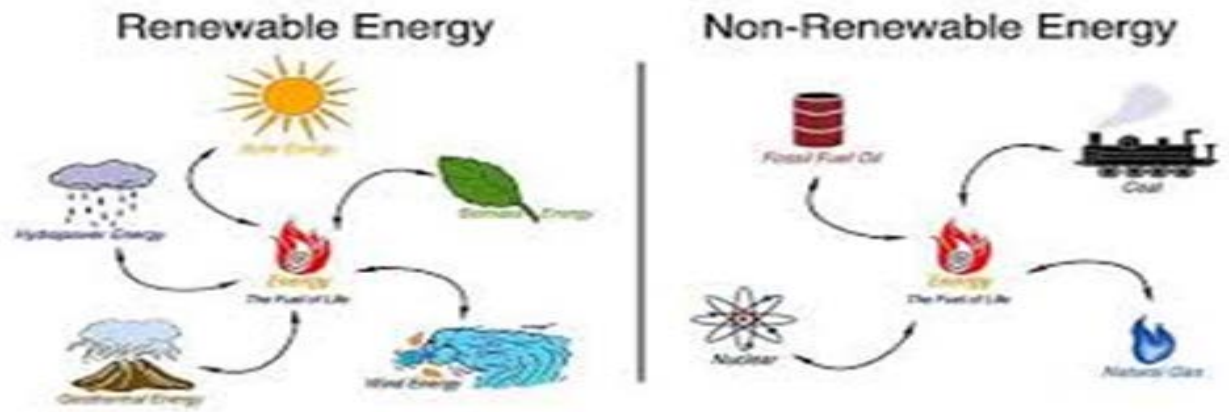
Detailed description of renewable energy sources

Photovoltaic

Wind farms

Biomass

Geothermal



Alternative energy sources or renewable energy sources

Renewable energy comes from a natural source and is replenished naturally, without human intervention.

Alternative energy does not include solar energy, but includes resources such as natural gas (often obtained by barrier or pressure injection in underground cracks), cogeneration, fuel cells or any waste energy that is not naturally replenished, but it emits lower carbon emissions.

Oil is not considered an alternative energy source as it is the main cause of carbon emissions and is not naturally replenished.

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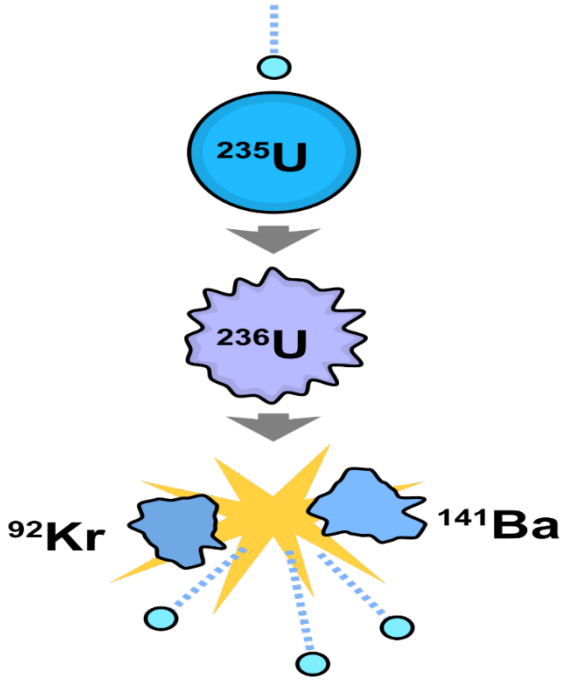
Can renewable energy replace fossil fuels?

- *What sources of energy have been used for hundreds of years?*
- *What are Renewable Energy Sources (RES)?*
- *Can you briefly record the advantages and disadvantages of RES?*

Nuclear energy explained: How does it work?



Radioactive waste: These are the remaining "junk" products caused by human activities with radioactive materials.

Difference of Nuclear Waste from Radioactive Waste: Nuclear waste is a special category of radioactive waste i.e. the residual nuclear fuel (usually uranium and its products) that becomes "useless" for the operation of a reactor. Nuclear waste, due to its risk and the need for special treatment, is reported and treated separately. The internationally accepted method for the final management of nuclear waste is deposition at high geological depths.

Final disposal of radioactive waste can be done in two ways:

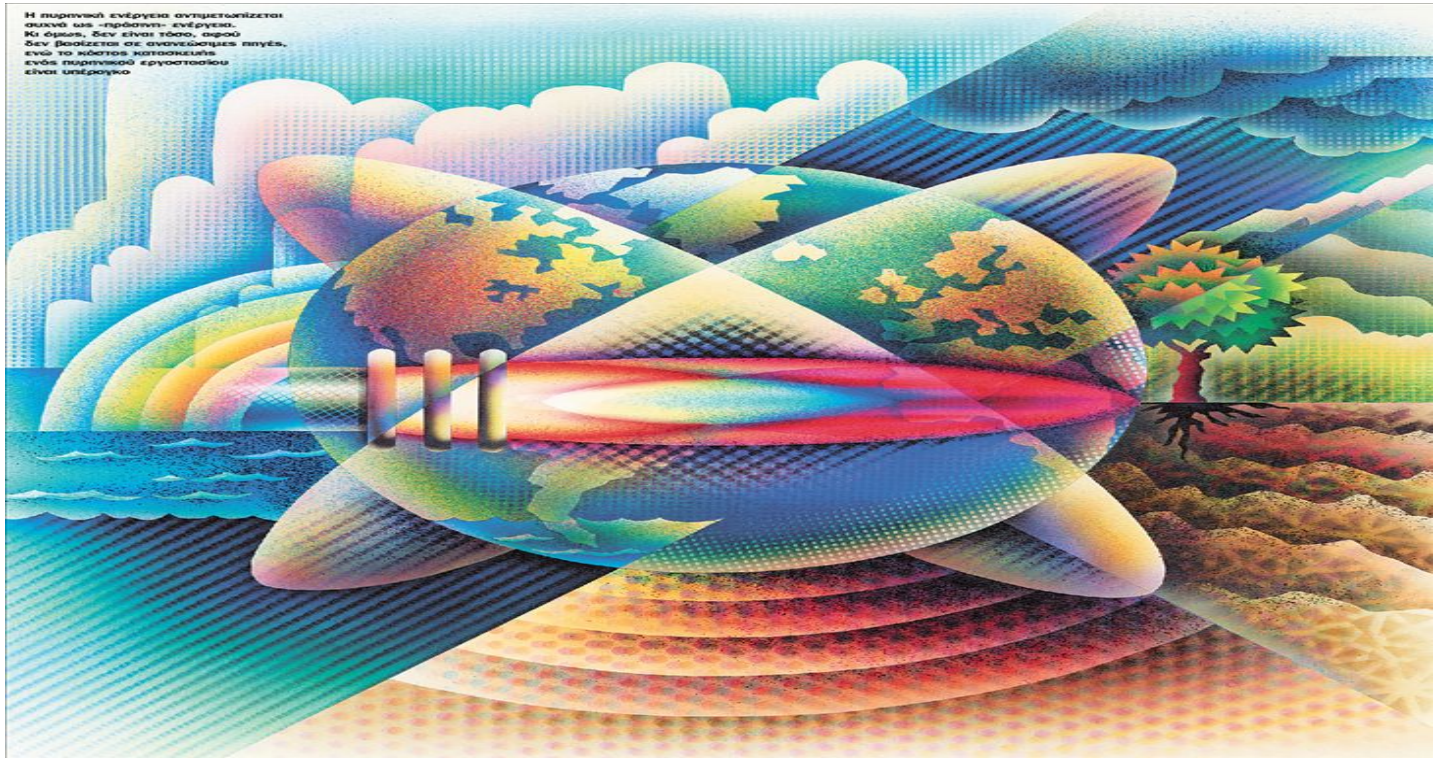
- With release to the environment, provided that the radioactive substances have been weakened to such an extent that the established levels of release are met. Release levels have been set so that any person in the population does not receive a radiation dose of more than 10 µSv (micro-Sievert) per year from all releases of radioactive substances into the environment. This category mainly comprises medical - hospital radioactive waste.
- Through disposal, that is, permanent and definitive disposal without the intention of recovery, at an approved facility for the disposal of radioactive waste.

3 Reasons Why Nuclear Energy Is Awesome!

But …

How fear of nuclear power is hurting the environment

- *Can you briefly record the pros and cons of nuclear power?*



The project has been funded with the support of European Commission within ERASMUS+ program

„ Energy Issue: Nuclear Energy and Renewable Energy ”

Teachers' guide

Methodological guidelines, lesson plan and indicative answers on worksheets

The training package: Energy Issue: **Nuclear Energy and Renewable Energy** was developed as part of the "Oxford Debates for Young People in Science" project.

It is a key material, facilitating the achievement of primary project goals, including increasing reasoning skills and interest in STEM, which in the future may result in taking up a scientific career.

When preparing students for the debate, one should not neglect the development of such skills as: communication excellence, argumentation or public speaking. Students should improve their ability to persuade effectively, argue properly, reason accordingly and speak out correctly. Composition of texts, using rhetorical means in oral statements, speaking in accordance with the rules of language culture, text interpretation, public speaking and presentation of texts, discussions and negotiations are of equally high importance.

In order to achieve the abovementioned goals, the implementation of thematic educational packages should be preceded by classes dedicated to preparation for debating as such. This can be accomplished in consultation with teachers of other subjects and the class teacher. The development of basic communication skills can be included in the class teacher's work plan, and the prepared lesson plans can be used during regular classes. Auxiliary materials can be found in the following documents:

1. **Warm up practice** – Annex No 2 to National frameworks for implementation of Oxford debates in STEM in school practice ;
   This document includes the following exercises: active listening, public speaking and debating skills.

2. **Lesson plans aimed at general development of debating skills** – Annex No 2 do National frameworks for implementation of Oxford debates in STEM in school practice ;

   This material consists of 7 lesson plans prepared by Dr. Foteini Englezou, president of the Hellenic Institute for Rhetorical and Communication Research. Scenarios are a guide to work. It is not necessary to follow all the lessons. The teacher can decide which scenarios (or their selected fragments) are most useful for working with a specific group of students. The document offers the following lesson plans:

   1. Communication skills
   2. Express your scientific argument, not your opinion
   3. Build a valid scientific argument
   4. Searching for evidence
   5. Enhancing students' linguistic skills
   6. Rebuttal and refutation
   7. Fallacies

3. **Methodological Guide for Teachers. ODYSSEY: Oxford Debates for Youths in Science Education**

The final stage of preparation for debates based on specific packages is to familiarize students with the principles of debating, described in detail in the abovementioned document. (https://odyssey.igf.edu.pl/wp-content/uploads/2019/11/%CE%9F4-IN-ENGLISH.pdf)

Energy Issue: Nuclear Energy and Renewable Energy

The training package: "Energy Issue: Nuclear Energy and Renewable Forms of Energy" consists of the following elements:

- Multimedia presentation
- Video file (recording / presentation) based on the presentation https://youtu.be/0EGeTJkmhQM
- 'Energy Issue: Nuclear Energy and Renewable Energy Sources' - material for students
- Worksheets (same for all packages)
- 'Energy Issue: Nuclear Energy and Renewable Energy Sources' - material for the teacher (with suggested indicative answers).

The training package is recommended to be implemented during at least three teaching hours / courses.

The use and cost of energy affect every person in daily life. Many related issues arise from energy use, such as greenhouse gas emissions, acid rain and climate change. One of the most important issues is that the economies of countries around the world use a high percentage of non-renewable energy sources (fossil fuels). However, the dependence on the depletion of fossil fuel reserves, due to the ever-increasing energy needs, raises, urgently, the need to use other forms of energy. Modern societies are looking for solutions to the energy problem, which, on the one hand, meet the energy needs of the world's population and, on the other hand, are sustainable and safe for the environment.

In the educational guide "Energy Issue: Nuclear Energy and Renewable Energy" students are asked to decide whether the use of nuclear energy or renewable sources can effectively meet the challenges that the global community faces. In particular, we refer to challenges, such as the growing demand for electricity, the sustainability of the Earth and the resulting environmental risks, formulating the corresponding arguments for or against each case, after the investigation and study of the issue. Their decisions on current energy issues, linked to the afore mentioned challenges, should be substantiated by the corresponding arguments in favor of or against in any case.

Given that: a) the unit of forms of energy is included in the textbooks and the curriculum of Physics in the B & C class of Gymnasium and A & B class of Lyceum, b) electricity is included in the Physics of the 3rd class of High School and in the 1st and 2nd class of Lyceum, the educational guide can be applied in the school classes of C class of Gymnasium up to A class of Lyceum in the context of: a) innovative actions and activities for science courses, b) groups, c) environmental programs of school activities, proposed by the Ministry of Education, and d) the creative research work of the A & B class of Lyceum, which are integrated in the weekly school schedule.

Lesson 1. Introduction to the Energy Issue:

The main goal is to introduce students to the topic of the energy issue and the need that exists in the modern world for its solution.

With the help of the supervisory material of the educational guide “Energy Issue: Nuclear Energy and Renewable Energy”, students are expected:

- to know the importance of energy in our daily lives, what is nuclear energy and how it works, what renewable energy sources are,
- to focus on the ways in which energy production contributes to climate change and the ways in which renewable sources can replace fossil fuels
- and at the same time to know the advantages and disadvantages from the use of nuclear energy and renewable energy sources.

In addition, students will approach the possibilities for the use of nuclear energy, in order to minimize its negative effects.

Finally, students will consider whether the use of nuclear energy or renewable sources can ultimately effectively address the challenges facing the global community in energy production.

Lesson 2. "Using nuclear energy is the only solution to the energy problem?". Constructing arguments for and against the resolution

The aim of the second lesson is to formulate as many arguments as possible (both for and against the resolution) that will be used by students during the debate, summarizing the work with the package.

Lesson plan

1. Organizational issues, checking the attendance list, familiarizing with the topic and objectives of the lesson **[5 minutes].**
2. Preparation of arguments: The teacher divides the class into teams of two. Each team receives **12 question cards** available in the educational package (materials for the student) and 2 copies of worksheet No. 1 (one for each student individually). Based on the questions, students formulate arguments for the presented thesis, against the thesis and those that are debatable and can be used in the discussion by both parties. Students work together, but each student individually completes his/her worksheet. There are examples of selected arguments for worksheet 1 are in the answer key. **[25 minutes]**
3. **Teams: proposition and opposition are formed [10 minutes].**

Team selection may be executed in 2 forms, each of them having both advantages and disadvantages.

A) Students declare which arguments are closer to their beliefs. The teacher divides the class into teams (each with a similar number of students) in the manner reflecting their convictions.

B) The second method assumes a division similar to the one above, with the difference that ultimately the team consisting of the supporters of a given resolution becomes the

"opposition" team, while the opponents of the thesis become “proposition” team. The supporters of such a division assume that it teaches the participants of the debate to a greater extent to use arguments supported by facts and is less based on emotions. Alternatively, division into teams can also be done randomly.

Finally, team selection can also be made by the teacher in a subjective way, ensuring that each team has both leaders and students who require more help, so that both teams have similar “winning potential”. In order to save time for division, the teacher can do it at the beginning of the lesson, for example by distributing worksheets number 1 to the students, printed on sheets of different colour or marked in some other manner.

1. The teacher distributes worksheets number 2 to the students (one for each student) and explains the homework. An example of a filled-out worksheet is available in the answer key.
2. Students in each team read prepared arguments in accordance with the assignment to a given group. Each student receives 1 argument, which he/she will develop (as homework) according to the guidelines in worksheet No.2.
3. Each team also appoints 3 people who will present the arguments prepared by the entire group. Students decide the order of their speeches. During the debate, other team members who are not directly involved in the debate, fill out worksheet
4. Summary of the lesson, evaluation of students' work **[5 minutes].**

Lesson 3. Debate

During the final lesson, the teams conduct a debate according to the guidelines contained in the “ Methodological Guide for Teachers. ODYSSEY: Oxford Debates for Youths in Science Education” (https://odyssey.igf.edu.pl/wp-content/uploads/2019/11/%CE%9F4-IN-ENGLISH.pdf).

It takes 45 minutes in total to conduct a full debate. During the debate, the teacher does not comment on the arguments or indicate the fallacies made by the students on an ongoing basis.

An exercise-based debate should be structured as follows:

1. Opening of the debate by the moderator/chairperson [3 minutes].
2. Initial vote by the audience [2 minutes].
3. 1 st Researcher-Debater of the A research-team: Constructive Speech [4 minutes].
4. 1 st Researcher-Debater of the B research-team: Constructive Speech [4 minutes].
5. Cross-fire between the researchers-debaters (1) of both research teams [3 minutes].
6. 2 nd Researcher-Debater of the A research-team: Rebuttal Speech [4 minutes].
7. 2 nd Researcher-Debater of the B research-team: Rebuttal Speech [4 minutes]
8. Cross-fire between the researchers-debaters (2) of both research teams [3 minutes].
9. Preparation time for the Summary and Final Rebuttal by both research teams [2 minutes].
10. 3 rd Researcher-Debater of the A research-team: Summary Rebuttal [2 minutes].
11. 3 rd Researcher-Debater of the B research-team: Summary Rebuttal [2 minutes].
12. Grand Cross-fire between the researchers-debaters (1 & 2) of both research-teams [3 minutes].
13. 3 rd Researcher-Debater of the A research-team: Final Focus Rebuttal [2 minutes].

14. 3 rd Researcher-Debater of the B research-team: Final Focus Rebuttal [2 minutes].
15. Final vote by the audience / Short written feedback [3 minutes].
16. Presentation of the results by the moderator [2 minutes].

If the debate takes place during extra-curricular activities, then it is recommended to devote, for example, 90 minutes for this part. This will allow you to prepare the room for the debate, recall the rules, conduct the debate and discuss its course and finally evaluate the work of students.

In terms of classroom conditions, it would be ideal to allocate two adjoining lesson units to the debate. Taking into account the school circumstances, organizational difficulties and the inability to devote too many lessons to content extending the core curriculum, the debate can be conducted in one lesson, while maintaining high discipline in time. In this case, it is recommended that during the next lesson with the class additional 10 minutes are spent discussing the debate, pointing to strengths and mistakes made by the participants of the debate.

In this format, 6 students (3 from each team) actively participate in the debate. The teacher may also appoint a moderator from among the students and a time keeper. The rest of the students will receive worksheet number 3. Their task will be to listen carefully to the debate and to note the opposing team's strengths and areas for improvement, and to justify their choice. Completed worksheet no. 3 may be the basis for issuing a grade for activity in the lesson for students who did not take part in the debate directly, but participated in its preparation and were active observers of its course.

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Worksheet No 1 - Questions and Indicative Answers

The educational package contains a set of questions to help prepare arguments for discussion on the resolution. On their basis, prepare a set of arguments and group them into those that are clearly in favor of the resolution, against the resolution, and those arguments that can be used by both teams. Write them down in the appropriate parts of the table

FOR	„GREY AREA"	AGAINST
Why is nuclear energy considered a "pure form of energy" that can solve the energy problem? According to the OECD Nuclear Energy Agency, nuclear energy is the most efficient solution to achieve the goal of reducing carbon dioxide emissions, as only 50 gCO2 are produced per kWh. Every 22 tonnes of uranium used saves about one million tonnes of CO2). **Is nuclear energy considered a viable solution to the energy problem?** The use of fast neutron fission reactors (commonly referred to as "fast reactors") converts uranium into a truly inexhaustible source of energy, due to its ability to collect about one hundred times more energy than the same amount of uranium mined from commercially available thermal energy. reactors operating with thermal neutrons.	**What is the scientific evidence for nuclear power generation and RES worldwide?** Energy from renewable sources in the European Union (EU) has increased significantly (from 8.5% in 2004 to 17.0% in 2016). About 11% of the world's electricity is generated by about 450 nuclear reactors. About 60 more reactors are under construction, corresponding to about 15% of the existing capacity. In 2017, the nuclear facilities provided 2487 TWh of electricity, from 2477 TWh in 2016. **What comparative scientific data are there on the production of electricity from different renewable energy sources?** Wind energy is the fastest growing means of alternative electricity generation since the turn of the century. Global wind power capacity quadrupled between 1999 and 2005. Unlike wind and solar power generation, the added advantage for hydropower plants is that	**Why are nuclear accidents considered a major deterrent to the use of nuclear energy?** - The effects on human health of the worst nuclear accident in the world, Chernobyl, Ukraine, in 1986 are dramatic. - The release of radiation from the collapse of the Fukushima 1 Daiichi nuclear reactors has created a dead zone around the reactors that may not be safe to inhabit for decades to come. **Does nuclear energy have a negative effect on the environment?** There are very significant disadvantages of uranium leaching technology in situ, arising from the risk of the leaching liquid spreading out of the uranium deposit. This implies a subsequent contamination of the groundwater and the inability to restore the natural conditions of the groundwater after the completion of the leaching works **Are there any risks to the viability of nuclear energy?**

The "variability" of RES energy, which depends on environmental conditions, is a very significant disadvantage. Do you agree or disagree? Justify.

I disagree, because subsidy-funded energy storage technologies are being developed and expanded to help the growing development of "variable" renewable energy sources. Storing an ever-increasing amount of clean renewable energy in the future is a challenge to save the planet from climate change. Indicative examples:
(a) solar installations concentrate the sun's heat to store energy in water, molten salts or other liquids, which can be used even after sunset,
(b) the possibility of generating hydrogen from wind energy and storing it in wind turbine towers for electricity generation when the wind is not blowing,
c) hydroelectric storage with a pump offers a way of storing energy in the transmission stage of the network, storing excessive output for later use.

What scientific evidence is there regarding the storage of energy from RES, but also the storage of nuclear waste? What are the advantages?

- Compressed air energy storage method (CAES), therefore energy extraction in adverse environmental conditions.

they have significant mechanical inertia, helping to stabilize the grid. In particular, modern hydroelectric plants have the significant advantage of handling seasonally (but also daily) high peak loads, as hydropower plants can restrict the flow of water through turbines to differentiate efficiency. Geothermal energy can become a giant, permanent and untapped source of energy.

What comparative scientific data are available on the cost of energy from RES and nuclear power plants?

- Fuel costs are low for nuclear and zero for many renewable energy sources.

- Capital costs (including the cost of waste disposal and nuclear decommissioning) are moderate for wind turbines and solar photovoltaics (photovoltaic), higher for coal-fired plants and even higher for nuclear plants.

- The cost per kilowatt hour of electricity from renewable energy projects, such as offshore wind farms, is projected to fall by 2020 to a point equal to or lower than electricity from conventional sources.

Increasing uranium mining and production creates uncertainty to meet energy needs.
Uranium demand will increase by at least half in the next two decades, possibly doubling, as nuclear plant numbers increase.

What comparative data are available for the time required for the operation of nuclear power plants and RES? What conclusion do you draw?

Wind and solar installations take only 2 to 5 years on average, from the design phase to operation. Solar photovoltaic projects on the roof have a schedule of only 6 months. A nuclear power plant for 14-15 years. This means that there is no immediate solution to the energy issue from nuclear power generation and greenhouse gases will continue to threaten human health.

Can nuclear power plants act as weapons promoters?

The "Extended Summary of their Energy Report for 2014" expresses concern that the proliferation of nuclear weapons is an obstacle and a threat to the growing development of nuclear energy. In addition, nuclear power is evolving as a naval superpower with the construction of giant state-of-the-art warships, using naval nuclear reactors.

- The US Waste Isolation Testing Unit (WIPP) near Carlsbad, New Mexico can store commercial nuclear waste in 2 km of crystalline salt. The salt formation extends from southern New Mexico all northeast to southwestern Kansas and is an exemplary example that could easily house the world's nuclear waste for the next thousand years. Finland is digging even further into a permanent granite repository 400 meters below Olkiluoto. The above are indicative examples of the reduction of risks to the environment and health from the storage of nuclear waste in barrels.	**What comparative scientific data are available on the production of electricity from different renewable energy sources?** Wind energy is the fastest growing means of alternative electricity generation since the turn of the century. Global wind power capacity quadrupled between 1999 and 2005. Unlike wind and solar power generation, the added advantage for hydropower plants is that they have significant mechanical inertia, helping to stabilize the grid. In particular, modern hydropower plants have the significant advantage of handling seasonally (but also daily) high peak loads, as hydropower plants can restrict the flow of water through turbines to vary efficiency. Geothermal energy can become a giant, permanent and untapped source of energy.	

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Worksheet No 2 - examples of arguments

Based on the materials provided by the teacher, prepare arguments for discussion. One group of students prepares arguments supporting the resolution, the other one - opposing arguments. Use the proposed template.

ARGUMENT nº 1

Argument with reasoning	Foreseen rebuttals of the other group	Answers to rebuttals
Nuclear energy is a **sustainable** solution to the energy problem, but also a renewable energy source due to neutron fission technology. In particular, it is possible for fast reactors to produce more fissile material than is consumed and to supply the earth with nuclear energy indefinitely.	- Increased demand for electricity combined with increased demand for uranium does not make nuclear energy a viable solution to the energy problem. It is an unsustainable energy source, as uranium deposition on earth is finite, unlike solar and wind energy. In fact, this is becoming clearer as uranium needs increase by half in the next two decades, according to the Joint Uranium Market Report, prepared by the Nuclear Energy Agency (NEA) of the Organization for Economic Co-operation and Development (OECD) and the International Atomic Energy Agency (IAEA). .- We must take into account that energy produced from renewable sources in the EU has increased significantly. In particular, the share of energy from renewable sources has almost doubled: from around 8.5% in 2004 to 17.0% in 2016. This positive development was a result of the legally binding targets for increasing the	The OASA "Sustainable Development Scenario", which is consistent with the provision of clean and reliable energy and the reduction of air pollution, among other objectives, states that the production of electricity from nuclear energy increases by almost 90% (from 2040 to 4960 TWh and capacity increases to 678 Gwe). The Harmony project also proposes adding 1000 GWe of new nuclear capacity by 2050 to generate about 25% of electricity. Thirteen countries in 2017 generated at least a quarter of their electricity from nuclear. About 30 countries are considering, planning or launching nuclear energy projects to meet increased energy needs (Bangladesh, Belarus, Turkey and the United Arab Emirates build their first nuclear power plants). Finally, nuclear power offers significant advantages for climate and cost, taking into

	share of energy from renewable sources, the implemented by Directive 2009/28 / EC. In other words, the EU is promoting the use of energy from renewable sources through legal commitments.	account the high capacity factors and the extremely long service life of nuclear power plants (60 years or more for new generation units) and their low carbon footprint. For example, the average life cycle greenhouse gas emissions for a nuclear power plant are almost a quarter of the total emissions of a solar power plant. For the same installed capacity, the actual electricity generation from a nuclear power plant is more than three times that of a solar plant. Even in terms of land demand, a nuclear power plant, with its high energy density, occupies 20 times less area than is required for a solar installation of the same installed capacity.

ARGUMENT nº 2

Argument with reasoning	Foreseen rebuttals of the other group	Answers to rebuttals
Nuclear power is a **clean and reliable** source of energy, as on the one hand the electricity generated by the nuclear power plant emits the least greenhouse gas emissions, which are responsible for global warming. Nuclear power plants, on the other hand, can generate energy continuously for several months without interruption (World Nuclear News (WNN) Heyshame II in the United Kingdom, where it operated without having to stock up on 940 days, in 2016).	The long time for the operation of nuclear power plants, but also the long period of time between the planning and operation of nuclear reactors means that nuclear energy can not offer an immediate solution to reduce air pollution. - The adverse environmental effects of nuclear energy, for example, by the leaching method for uranium mining, have resulted in it not being considered a "clean solution" to the energy issue, but rather being an enemy of the environment.	Nuclear energy has by far the highest capacity factor compared to any other energy source. This basically means that nuclear power plants generate maximum power over 92% of the time during the year. Nuclear power plants are usually used more often because they require less maintenance and are designed to operate for longer periods before refueling (usually every 1.5 or 2 years). - Radioactive waste management methods (for example, the Yucca Mountain project, according to environmental studies is an important repository), could safely protect future generations. - The operation of the electricity grid is endangered, due to the unexpected environmental changes, which maximally affect the production of energy from RES (lack of sunshine-photovoltaic panels, water shortage-hydroelectric plants, apnea-wind turbines, etc.). In contrast, nuclear power plants are reliable and are not affected by unbalanced environmental factors.

		Hydroelectric power, using the potential energy of rivers, is classified as a major means of generating electricity from renewable sources, but it causes many environmental problems. For example, we report the loss of land habitats through floods.

ARGUMENT 3º.

Argument with reasoning	Foreseen rebuttals of the other group	Answers to rebuttals
Nuclear power is one of the safest forms of electricity generation for the environment and health. As in all other industries, nuclear power plants are designed to minimize the possibility of accidents and avoid any consequences if they occur.	Nuclear power is not a safe form of energy, as there have been three major accidents - Three Mile Island, Chernobyl and Fukushima with incalculable damage to the environment and human health.	- The risk of accidents is low and is reduced, due to continuous safety tests and improvements. - There are new nuclear waste management systems, for example the US Waste Testing Unit (WIPP) near Carlsbad, New Mexico. - Many catastrophic floods have occurred in the last 100 years from hydroelectric power plants, for example Sobradinho in Brazil. The environmental and economic impact of building a hydroelectric plant on a local river can be devastating. - Nuclear power is a source of low-carbon electricity to protect human health from pollutants.

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Worksheet no. 3

Name and surname: …… Class……. Team: Proposition/Opposition

During the debate, hear and observe carefully the speeches of the debates from the other team. Then, evaluate which speech convinced you the most and which areas of your opponents' speech should be improved.

1. In terms of **argumentation (**e.g. the quality of the arguments presented, credibility of the data and scientific evidence) in the rival team I was most convinced by the speaker No. .....

Reason:

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2. In terms of **the style of presentation and communication with the audience** (e.g. confident, persuasive, authentic and dynamic posture, moderate gestures, assertive voice variety, good eye contact with the audience, use of moderate humor, friendly and professional approach to all participants, effective use of body language) in the rival team I was most convinced by the speaker No. .....

Reason:

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Indicate the element of the rival team's performance that requires improvement. Justify your answer.

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Reason:

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