НАЦИОНАЛЕН ДОВЕРИТЕЛЕН ЕКО ФОНД
NATIONAL TRUST ECO FUND

UfU

CLIMATE AND ENERGY EFFICIENCY

WE STUDY THE CLIMATE, WE SAVE ENERGY, WE THINK OF THE FUTURE

Climate change and energy efficiency activities in school

The translation of this publication into English was made possible by the Bridging European and Local Climate Action project on behalf of the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety.

Supported by:

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

European Climate Initiative EUKI

based on a decision of the German Bundestag

CONTENTS

Dear colleagues,

By working with the initiative **Towards the introduction of climate action in the educational curriculum of Bulgarian schools and kindergartens**, you join a large network of teachers, educators, specialists, managers, volunteers from all over Europe and from many other countries around the world who already realise and know three things with certainty:

- there is climate change,
- it is severely affected by human activity
- and every inhabitant of the planet can personally, individually and specifically contribute to reducing this impact simply by behaving responsibly in everything they do.

It is both feasible and realistic to implement this initiative because it is related to the daily lives of children and young people in the kindergartens and schools where they learn. We specifically deal with **the way we use energy** at school and in kindergarten. In many schools in other countries, volunteers or professionals from non-governmental or other professional organisations play the role of educator, helping students choose energy-saving behaviour. We concluded that, for a lasting result in Bulgaria, the initiative should be entrusted to teachers.

The goal is to motivate children in schools and kindergartens in Bulgaria to use energy wisely and to control their actions, bearing in mind the „footprint" they leave on the environment, on our planet.

The initiative in Bulgarian schools in particular is part of the large European Climate Initiative (EUKI), established and led by the Federal Ministry of the Environment of the Republic of Germany. It is implemented under the BEACON (Bridging European and Local Climate Actions) project in partnership with six other European countries - Germany, Czech Republic, Greece, Portugal, Poland and Romania. The work ahead, however, has a much broader basis and perspective and will contribute to the efforts of nations across the globe.

What are the expectations of all those participating in the Bulgarian initiative?

Our expectations are that children from **kindergarten until adolescence** will develop **behaviour leading to energy saving,** which in turn contributes to reducing the greenhouse gas emissions into the atmosphere that are causing climate change.

How are we going to do this together?

By linking the knowledge and skills that children acquire through the current curricula with our **real daily lives and behaviour,** and by making sense of each activity - planning, action, understanding its consequences - for each one of us, for our wider community at school, the family, the local community, our generation.

What are the practical actions?

We stay **after school.** In traditional school practice, this expression „after school" refers to the most enjoyable part of school experience. It is when students rehearse in the school orchestra or play basketball in the yard, or join their hobby group, or just stand in the yard and talk, or take a longer route to walk each other home ...

Modern practices in schools, and even more so in kindergartens, involve limited „after school" time, but instead allow for spending a meaningful extra hour with a favourite teacher on something interesting outside the regular programme of activities. This is the form of working with students we are talking about. The group with which these activities are conducted is provisionally known as an **energy team.**

The purpose of this series of educational packages, which are designed for Bulgarian kindergartens and schools, is to provide basic information and preparation for the work of the energy teams as a form of extracurricular activity „after school" or during playtime in kindergartens.

It is important to note here that the initiative has been implemented for the last three years, albeit in a more limited sense, initially in four and then in fifteen Bulgarian schools.

The results show the savings of energy and of financial costs for electricity and heating, respectively, amounting to an average of 7% per school year. However, we have not been able to measure in percentages how much the activities with the children have improved their civic awareness, leadership skills, breadth of knowledge about the world and satisfaction…

How were these publications created?

The whole series contains one set of educational materials for preschool and reception, and five for primary schools - a general one and four designed for teachers of Physics, Chemistry, Biology and Geography. They contain much broader ideas and knowledge than the specific ones on the topic of energy saving, which will be interesting to use when working with children in school and kindergarten.

The authors of the materials are university professors with rich experience in improving teacher training and qualifications in Bulgaria, writing textbooks and manuals, making educational policy in Bulgaria and, most importantly, they have a taste and desire for innovation and a curiosity about the modern world.

After running the initiative for a full school year in more than forty schools and about ten kindergartens across the country, what you have in your hands is an improved and expanded edition, designed for everyone in the country who has an interest and desire to save energy and financial resources by developing a conscious understanding of and responsible behaviour towards climate change and energy. And, of course, for those who have a taste for innovative ideas and their implementation.

Why did the National Trust Ecofund take up this initiative?

The National Trust Ecofund has existed for twenty-five years. During all this time, it has **primarily financed investment projects** that contribute to the protection and improvement of the environment in Bulgaria. The fund has experience in several areas, such as water quality management, waste management and pollution prevention, air purity protection, biodiversity protection. For the last ten years, the focus has been on the energy efficiency of public facilities. Over this period, the fund has financed projects to improve the energy efficiency of the buildings at more than one hundred and twenty schools and about fifty more kindergartens across the country.

In the last five years, the question of **how to use the buildings in which we have already invested hundreds of thousands of leva** has become very relevant for us. Unless they are managed and used rationally, the funds invested are not effective. We are therefore interested in **the ways the users of these sites contribute to achieving the goals of public investment through their behaviour.**

We began with educational institutions, with children, and we are now ready and intend to implement these initiatives for all the sites in which we invest public funds for energy efficiency - administrative buildings, community centres, sports facilities, dormitories, universities, etc.

For the National Trust Ecofund, this activity is not simply a project, but a permanent initiative and an expression of the fund‘s long-term efficiency policy.

Guidance for applying the nine steps of the energy team's work.

Step 1.

You will form an **energy team -** a group of children who become responsible for how energy is used in school. This is a group of students or children from kindergarten, formed at their request and with the consent of their parents. Each school or kindergarten will make their own decisions about how the energy team is created and who leads it. You decide! Experience has shown that a group of 12-15 children is most suitable.

Step 2.

In parallel with this or shortly before the formal creation of the energy team, you will initiate an **energy tour** of the school or kindergarten. This will involve school professionals who understand the management of the building, including technicians and financial managers. You will find places where energy „runs out" and you will find out what can be done to improve the situation.

The energy tour requires measuring devices, which the children will use later on. Previously gathered information about how energy has been used in the last three school years is also needed for the completion of the tour report. Two measuring instruments are required.

Digital thermometer. The temperature is measured at the end of the cable. The tip is sensitive. The device starts measuring as soon as it is turned on. It is kept away from the body so as not to be affected by body temperature.

To obtain the average room temperature, it is best to measure it in the middle at a height of 1 metre. The device is used to identify discrepancies in temperature distribution and to detect possible symptoms of a room being under- or overheated.

In this regard, it is important to consider the relevant regulations for the temperature in different rooms.

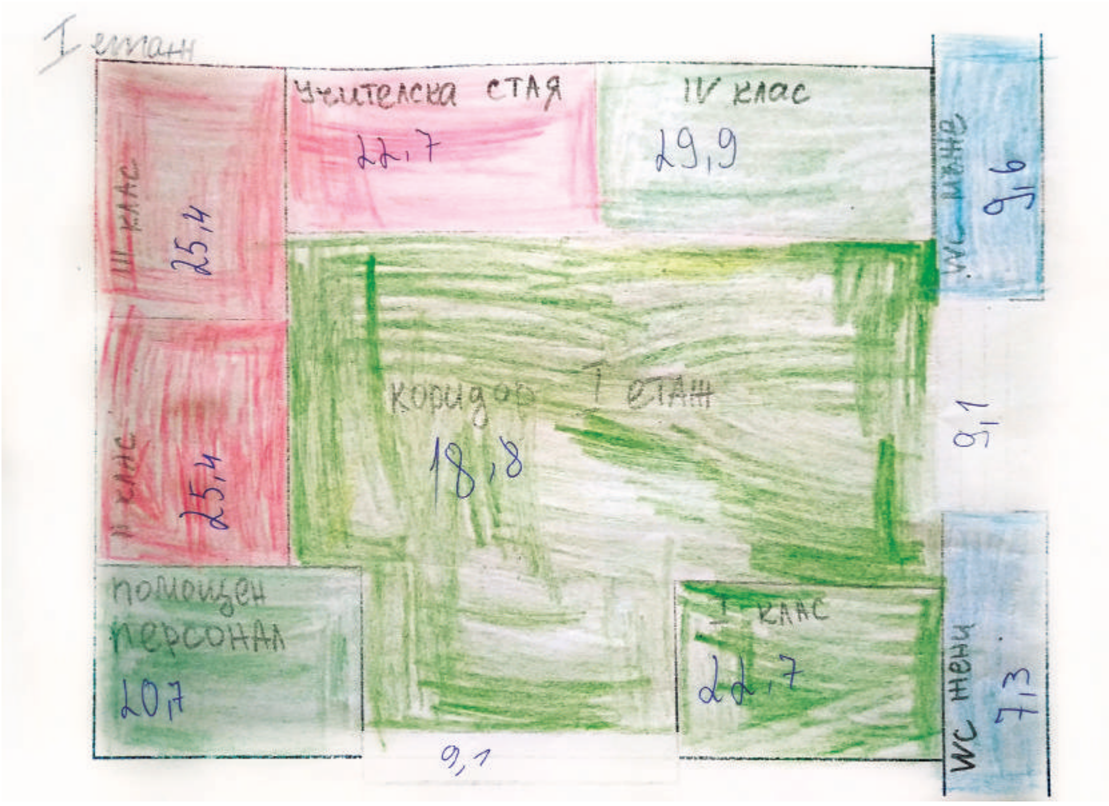
Luxmeter. Measures light in „lux". Pay attention to the power of lighting on school desks and consider when it is necessary to turn on lamps. A work desk needs 300 lux of light.

Step 3.

You will spend time with the energy team in order to **gain an understanding** of what climate change is, how energy production affects it and how energy can be saved in everyday life - based on your work and the knowledge of children from the regular curriculum. These are the activities described in these publications in detail as practical activities run in parallel with step 3.

Step 4.

You will do a **second energy tour** of the school, this time with the student energy team, to make an energy profile of the school for the children. The children make a map of the premises marked with the results of the energy tour.



Step 5.

With the children you will **measure the temperature** and light in the building, as well as the level of carbon dioxide in the premises during school hours. You will learn to analyse and summarise information. At this stage, three more measuring instruments come into operation.

Data logger thermometer. Measures and stores temperature information for a longer period of time. Initially, it has to be programmed using Testo software, then put in a suitable place (not exposed to sunlight, not very close to the ground (due to the cold), close to the centre of the room if possible). This should be placed in a normal classroom, will show potential opportunities for saving energy at night, at the weekend or during holidays and will indicate the need for adjustments in the heating settings accordingly. Measurements are made for 1-2 weeks, including weekends and holidays, so that the heating settings for future holidays can be adjusted. Computer analysis by Testo.

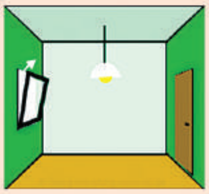
Measuring the CO_2 concentration in the air in ppm (parts per million). This plugs into a socket, beeps and starts measuring.

As with other appliances, it is best not to put it in the corner so that the average value can be obtained.

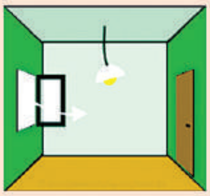
In order not to affect the device, you should not stand near it or breathe directly into it.

At 2,000 ppm the room must be ventilated.

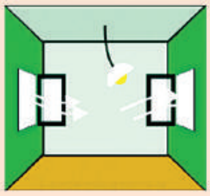
CO_2 measurements show how fast the CO_2 concentration rises, how different ventilation methods have different effects and, accordingly, which ventilation method saves the most energy.



At an angle



Shock ventilation



Cross-ventilation

Vatmeter. Measures the power and current consumption of an individual electrical appliance. Often students do not know how much energy is being used. The measurements allow them to discover and compare the electricity consumption of appliances and to understand that appliances left on stand-by when not in use waste energy unnecessarily.

Step 6.

With your help, the energy team will identify **energy-saving measures.** These are measures for regulating the temperature on the school premises, for regulating the use of electric lighting, for ventilation methods, for the use of electrical appliances.

Step 7.

And now - the **children go into action:** showing their classmates, teachers and parents what needs to be done to save energy. **We change behaviour!**

Step 8.

You will also gain understanding with them about measures which do not solely depend on student behaviour, but also require **small investments**, and you will share these with the school's management.

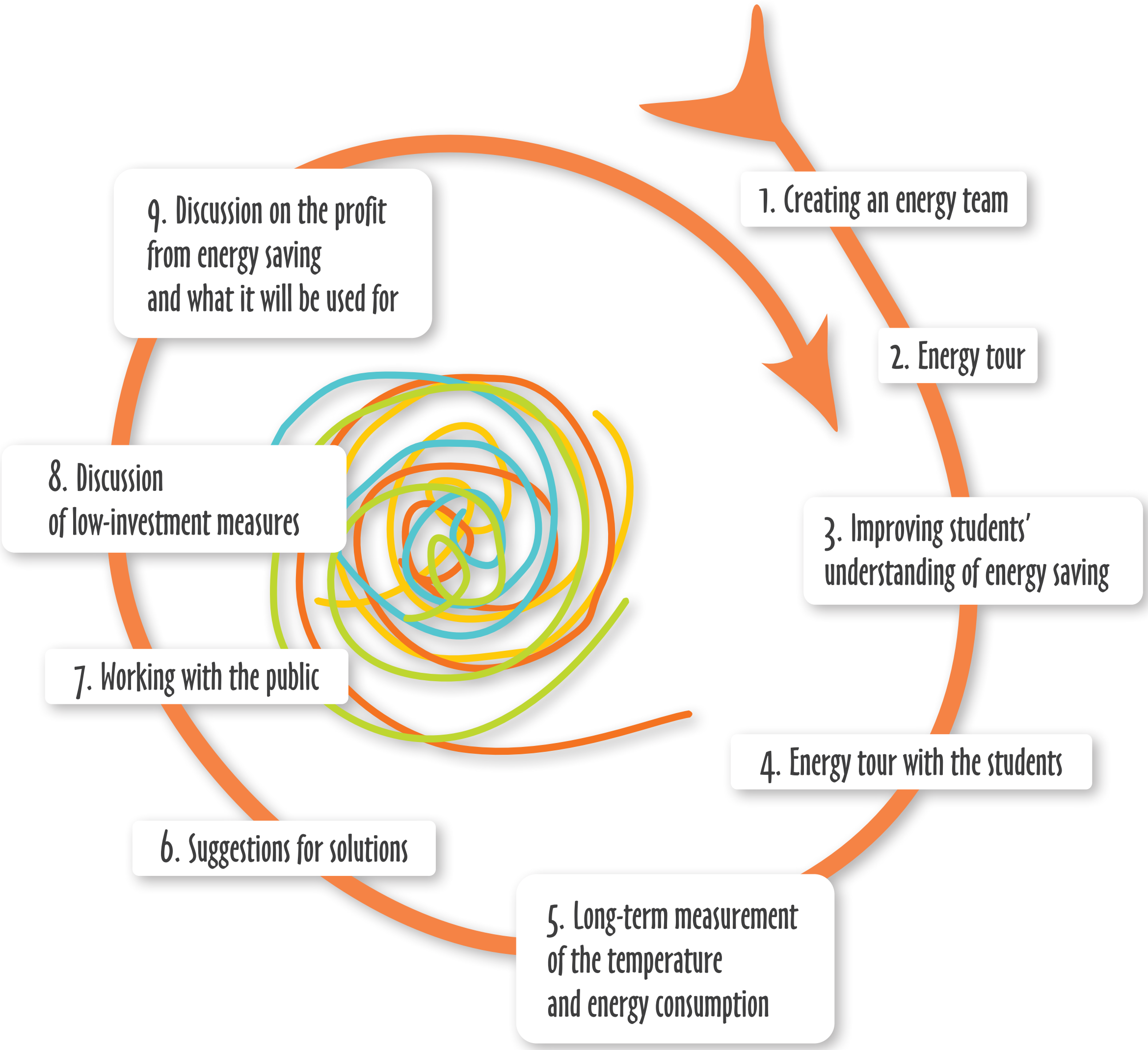
Step 9.

At the end of the school year you will compare the information on energy consumption with that of the same months last year, you will calculate the energy and financial expenditure saved and **you will suggest how to spend** these savings.

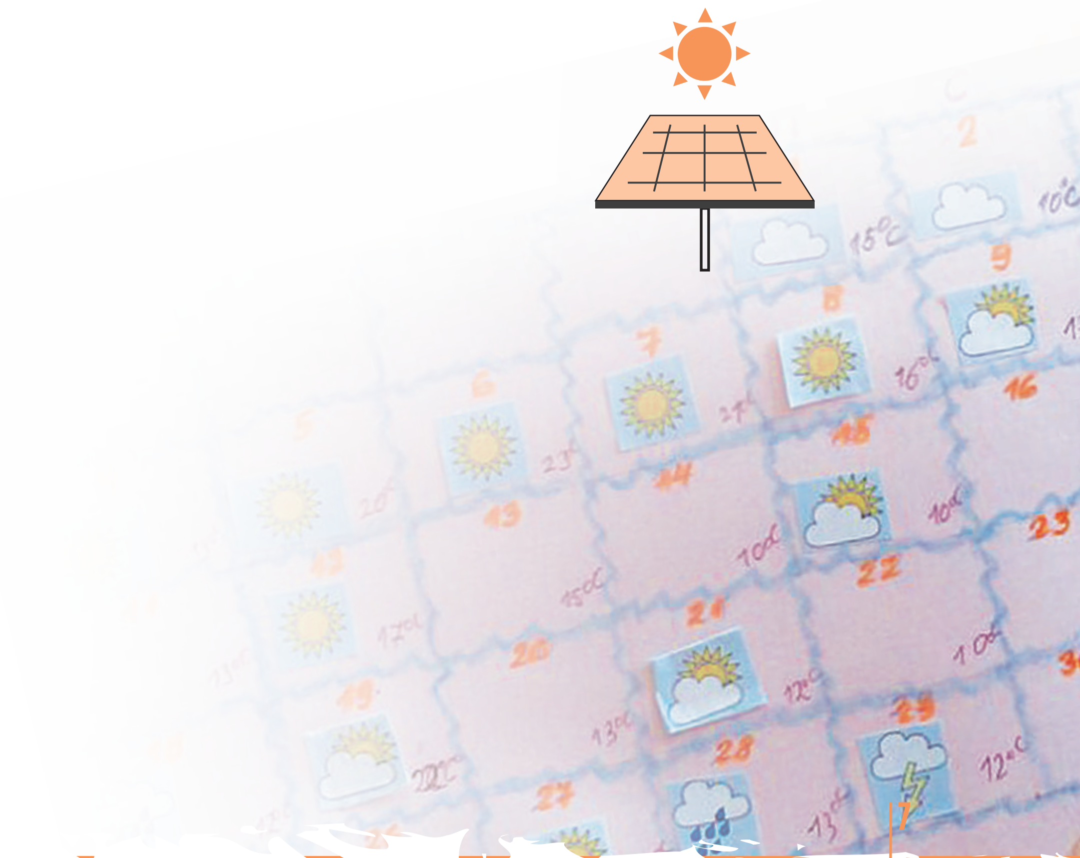
All materials from these publications, as well as all sample worksheets and templates are available on the internet: *http://education.ecofund-bg.org/en/documents-materials/*

Kamelia Georgieva, Team leader

kgeorgieva@ecofund-bg.org



1. CLIMATE



1. Climate

1.1. Air and water

Its distance from the Sun, its spheroidal (geoid) shape, the presence of an atmosphere and the speed of rotation of the planet around its axis are givens, the combination of which turns the Earth into a unique celestial body in the cosmos as we know it. There is water on the planet in its three states (solid, liquid and gaseous), and the chemical composition and thermal regime of the atmosphere create conditions for the existence of terrestrial lifeforms. There are various scientific theories about the origin of life, but in all of them, there is no doubt that water and the gas shell of the planet are fundamental factors in creating appropriate physicochemical living conditions. They form two of the main geospheres - atmosphere and hydrosphere - and are the basis for the creation of the rest: lithosphere, biosphere and pedosphere. Each of the geospheres is characterized by particular properties, patterns and dynamics, the exploration and study of which are the object of Chemistry, Physics, Biology and Earth sciences.

Air is the natural mixture of gases that forms the Earth‘s atmosphere. As a result of global or local geographical factors, it forms air currents. These are a system of winds with relative stability over time. The currents are part of the system of general atmospheric circulation (trade winds, anti-trade winds, monsoons, westerly winds, etc.), or are of local importance (for example, see breeze, foehn, bora, mountain and valley winds, etc.).

Air masses are connected with these currents. They are located in the lowest part of the atmosphere - the troposphere. They have relatively homogeneous physical properties formed over a homogeneous surface (forest, desert, sea, etc.) and the same radiation conditions (intensity of sunshine and angle of incidence of the sun‘s rays on the Earth‘s surface). Air masses participate in the general circulation of the atmosphere and are separated from each other by atmospheric fronts. When moving, they largely determine the weather over the areas of passage. Based on latitude, there are Arctic (north) and Antarctic (south), temperate, tropical and equatorial air masses. They, in turn (excluding the equatorial), are divided into oceanic (marine) and continental types. Thanks to the air currents and masses, the peculiarities of the climate are formed, ocean and sea currents are constituted, biological species are spread, etc.

Water is the basis of life. It is a chemical compound of hydrogen and oxygen (H_2O). In the temperature range 0-100°C at a pressure of 1atm, it is a colourless liquid, tasteless and odourless. It has characteristic physicochemical properties and has its highest density at 3.98°C. Water is the main component of the hydrosphere. It is contained in the air in the form of water vapour and is part of a number of minerals that make up rocks (lithosphere). It seeps into the soil (pedosphere) and is an integral part of living organisms (biosphere).

About 65% of a person’s mass is water. In nature, it usually contains different amounts of salts, organic matter and gases. The salt content per unit mass of natural water (g salts / kg water) determines its salinity. The salinity of sea and ocean water is about 35g of salt per 1kg of natural water. In practice, water with a salt content of less than 0.5 g / 1 kg of water is fresh water.

From the point of view of the economy, water (water resources) is perceived as part of a territory’s natural capital. From a geographical perspective the Earth’s waters can be grouped as: river, lake, swamp, dam, ocean and sea, glacial and snow, groundwater, soil moisture and others. Much (more than 70%) of the Earth‘s surface consists of water - salt or fresh. The distribution of water is approximately as follows - 97.4% is salt sea or ocean water, 2% ice and 0.6% fresh water in lakes, rivers and groundwater resources. About 2 billion people currently living on the Earth experience shortages of clean water (Fig. 1.1).

Fig. 1.1. Access to clean drinking water is difficult in many regions of the world.

Of the total volume of water resources on Earth, only about 2-3% is fresh water, with about 0.3% technically available for use. Water resources are used in various branches of the world economy. Theoretically, on a global level, they are inexhaustible because they are constantly renewed by the process of the water cycle. Their depletion due to loss of quality is more significant than their quantitative depletion. For example, when 1m^3 of water used and polluted by anthropogenic activity enters nature, it leads to the pollution of about 40-50m^3 of naturally pure river water and renders it unsuitable for human use.

By means of the properties of air and water, the individual geospheres of the planet interpenetrate and interact via a huge set of chemical and physical processes, which are determined by a number of geographical factors (latitude, altitude, distribution of water basins, etc.). The movement of air and water between the geospheres makes the Earth a complete planetary system in which the exchange of substances and energy takes place. Changes in the parameters of air, water or any of the geospheres cause a series of changes in the other elements of the system.

1.2. Atmosphere – composition and structure

The atmosphere is the air envelope surrounding the globe. It is connected to it by gravity and follows the planet in its diurnal and annual rotation. Its mass is estimated at about 5.15.10^{15} t, which is about 10^{-6}% of the Earth's mass.

The atmosphere has a diverse chemical composition relative to the altitude of the individual layers. Near the Earth's surface, dry air consists of 78.084% nitrogen (N_2), 20.956% oxygen (O_2), 0.934% argon (Ar), 0.033% carbon dioxide (CO_2). The remaining 0.003% are other inert (noble) gases (Ne, Kr, He, etc.), hydrogen (H_2), nitrogen oxides (N_2O, NO_2), carbon monoxide (CO), ammonia (NH_3), methane (CH_4), ozone (O_3) and others. The water vapour content varies from 0.2 to 2.6%, depending on the latitude and natural area (Fig. 1.2). Various solid and liquid particles, called aerosols, are almost always present in the air. These are drops, water crystals, smoke, dust and so on. Due to the force of gravity, about 4/5 of the mass of air is concentrated in the troposphere - the closest layer of air to the Earth's surface. The highest layers of the Earth's air envelope are dominated by the lightest elements - hydrogen and helium - and their mass is negligibly small.

Fig. 1.2. There is more water in the atmosphere in the form of water vapour than is contained in all rivers on Earth.

The atmosphere does not have a well-defined upper limit - at an altitude of about 3,000 km its density approaches the density of matter in interplanetary space. The atmosphere partially absorbs and scatters solar radiation. There is a constant exchange of heat and moisture between it and the Earth's surface. It hosts circulating processes and is characterized by electrical conductivity and the presence of electric and magnetic fields. It is an important factor in the progression of a number of physical processes on land and in the upper layers of bodies of water. The atmosphere is directly related to the weathering (erosion) of rocks, the formation of sea currents and so on. Depending on the change in temperature and chemical composition, the Earth's atmosphere is divided into layers on top of each other (Fig. 1.3):

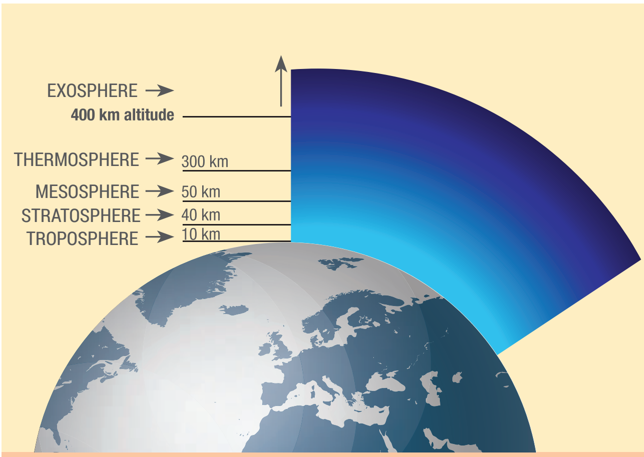


Fig. 1.3. Layers in the Earth's atmosphere

- troposphere
- stratosphere
- mesosphere
- thermosphere
- exosphere

The atmosphere plays an important role in the development of life on our planet. The composition, movements and physical processes in the atmosphere are studied in meteorology. Climatology is the science that studies the long-term weather regime at the Earth‘s surface – the climate. Its natural character is determined by three main groups of climate-forming factors:

- radiation (solar energy);
- circulation (constant air currents);
- physical geography (latitude, altitude, features of the terrain, vegetation, snow and ice cover, ocean and sea currents, distance from the territory’s water basins, etc.).

Human activity is also a factor determining the characteristics of the climate at different levels. The climate peculiarities are characterized by the following climatic elements: air temperature, amount of precipitation, wind speed, cloudiness, duration of sunshine, etc.

1.3. Processes in the atmosphere

The Earth is heated by the sun‘s rays. There are hot layers in the Earth`s core too, but the heat is isolated from the Earth‘s crust.

Solar energy heats the Earth‘s surface, which in turn radiates heat and heats the air. Part of the incident light on the Earth‘s surface is reflected. A quantitative factor for the reflected energy is the albedo - the ratio between the amount of reflected light from a given surface (radiosity) and the amount of incident light (irradiance). It is measured in percentages and has a value from 0 to 100%. The albedo depends on the light’s angle of incidence and the type of surface. The green parts of the plants have low albedo - 10%, yellowed leaves - 28%, and the highest value of albedo goes to the snow - 90%.

The warming of the Earth‘s surface and atmosphere depends on the duration and intensity of sunshine. The angle of incidence of the sun‘s rays is different for different parts of the globe and depends on the geographical location of the territory relative to the equator. The areas around the equator heat up the most, where the sun‘s rays fall perpendicularly, whereas heating decreases towards the poles. The Earth‘s surface heats up, but also radiates heat that heats the ground air. The heated ground air rises by convection and expands, reducing the value of atmospheric pressure. Areas with different atmospheric pressure are formed in different places on the Earth‘s surface. This causes air masses to move from places with higher to places with lower pressure: this is called wind.

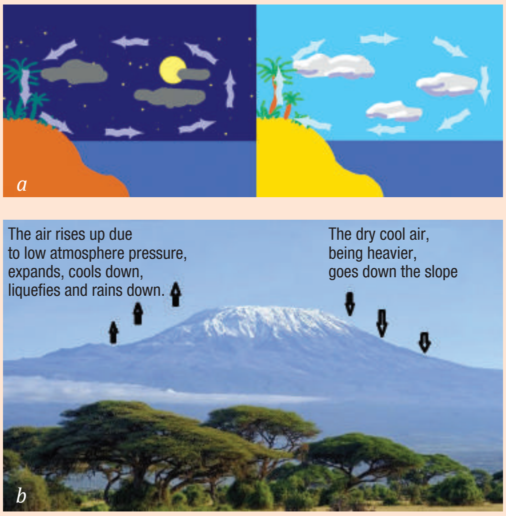


Fig. 1.4. a, b Winds arise from uneven surface heating and differences in atmospheric pressure.

The direction of the wind can be both horizontal and vertical. It depends on the type of surface, the terrain and other factors. For example, the breeze is formed due to the unequal heating of land and water (Fig. 1.4, a), as during the day the wind blows from the sea to the land, and back again at night. In the same way, a warm mountain wind blows during the day from the valley to the mountains, and at night a cold wind blows from the mountains to the valley (Fig. 1.4, b).

Mountains play an important role in shaping the climate, mainly through changes in air temperature and precipitation. At higher altitudes, the air temperature decreases and the amount of precipitation increases. Mountain ranges also cause the effect of rain shadow when they impede the movement of humid atmospheric masses. For example, the highest mountain in Africa, Kilimanjaro (Uhuru Peak, 5895m), is covered with snow and ice, although it is located at a latitude close to the equator, where the flow of solar energy is greatest. In the same continent, the Dragon Mountains (Thabana Ntlenyana Peak, 3482m) in South Africa block the humid air masses coming from the Indian Ocean and create rain shadow, which is the reason for the formation of the Kalahari semi-desert area.

The processes in the atmosphere - heating and cooling of the air and the Earth's surface - change the atmospheric pressure and this is the cause of air movement. Other key factors in atmospheric processes are the evaporation and condensation of water vapour, the rotation of the Earth around its axis, ocean and sea currents and more.

Water heating causes evaporation, which is different for different earth surfaces. Water vapour rises, thickens, cools, condenses and forms water droplets. These form clouds, which can be of different types, depending on the temperature and altitude of the atmosphere. When the drops become larger, they return to earth in the form of rain, hail, and snow.

Many of the physical characteristics of water are different from those of other known substances. These unique properties of water determine the course of processes in nature so as to provide the most suitable living conditions for all plants and animals.

Here are some of the important climate characteristics of water:

- difficult to evaporate, has a high heat of vaporization value (three times greater than alcohol);
- difficult to melt (five times greater specific heat of fusion than gold at its melting temperatures);
- difficult to heat (large specific heat capacity);
- temperature anomaly between 0°C and 4°C - significant for aquatic animals;
- excellent solvent, and is an insulator when pure distilled (deionized water);
- difficult to conduct heat (660 times weaker than copper), heated by convection (ice is also a good insulator).

Life originated in water and its unique properties make it an indispensable component of all organisms (about 70% of the mass of organisms is water).

1.4. Biogeochemical cycles

Water, carbon, oxygen and nitrogen are essential for the organic world, but their quantity is limited. Only their repeated use has ensured and can ensure the existence of life in the future. Their renewal in the environment is carried out both as a result of the vital activity of organisms and as an outcome of geological processes.

Water cycle

Water in nature is in constant motion, which generally consists of several processes (Fig. 1.5):

- evaporation from water basins and plants;
- cooling of water vapour and condensation, during which they return to the Earth's surface;
- runoff of water on land through rivers back into the seas and oceans.

Under the influence of gravity a small proportion of water infiltrates the Earth's crust as groundwater.

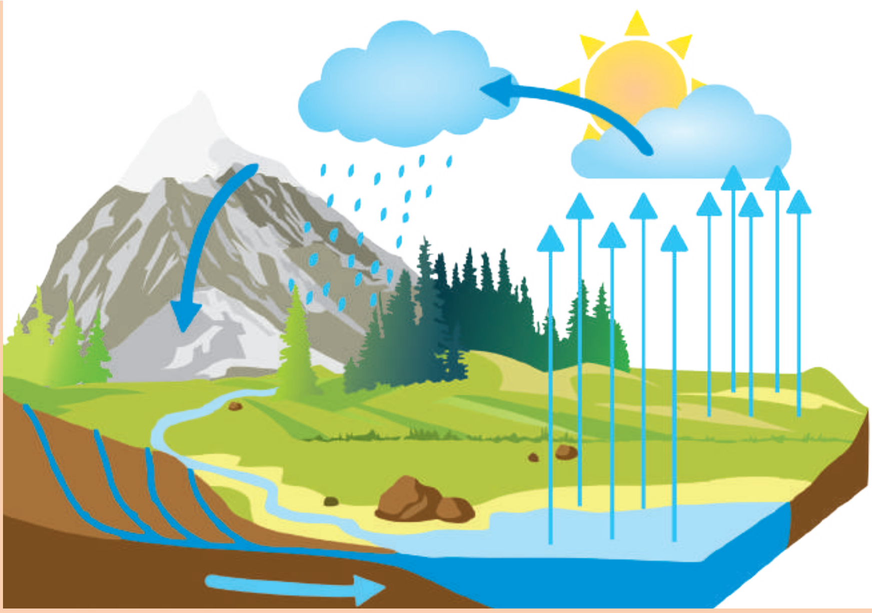


Fig. 1.5 Water cycle in nature

Under the influence of global warming, we witness the melting of ice (continental and mountain glaciers), which turns into water. This process results in an increase in the level of the ocean and sea basins. This endangers the lives of much of the world's coastal population.

Access to fresh water is a major factor in human existence. All vital processes of the body are related to water - it dissolves nutrients, removes waste products, ensures metabolism and is an environment in which biochemical processes take place.

Other processes take place in the atmosphere as well. We will also consider substances involved in the carbon and nitrogen cycles.

The carbon cycle in nature

The conversions of carbon and its compounds in the cycle take place in the biosphere, lithosphere, hydrosphere. The introduction of carbon into the cycle occurs through the basic life process of photosynthesis. This is the first stage of the conversion of carbon into complex organic compounds. In this process, plants under the action of sunlight and chlorophyll, using carbon dioxide from the air and water, synthesize organic matter (glucose), which releases oxygen into the atmosphere.

$$6CO_2 + 6H_2O \xrightarrow{\text{chlorophyll, light}} C_6H_{12}O_6 + 6O_2$$

Annually, plants synthesize about 115 billion tons of organic matter (proteins, carbohydrates, fats), while releasing about 200 billion tons of oxygen. In this way, through photosynthesis, plants ensure the existence of all organisms on Earth.

Photosynthesis is the only way to restore oxygen to the atmosphere and is an important process in the reduction of the concentration of carbon dioxide. Animals and fungi cannot synthesize organic substances from inorganic ones. They use substances synthesized by plants for food. The remains of organisms are exposed to putrefactive bacteria and CO_2 is released into the atmosphere through a number of decomposition intermediates.

In organisms, the process of respiration also takes place. As a result, the organism „burns“ organic matter (proteins, carbohydrates, fats). One of the products of this process is carbon dioxide, which is returned to the atmosphere. Through respiration, humanity emits about one billion tons of CO_2 into the atmosphere every year. The main processes in the carbon cycle are volcanic activity, the burning of fossil fuels and other human activities, as a result of which huge amounts of carbon dioxide are released into the atmosphere (Fig. 1.6).

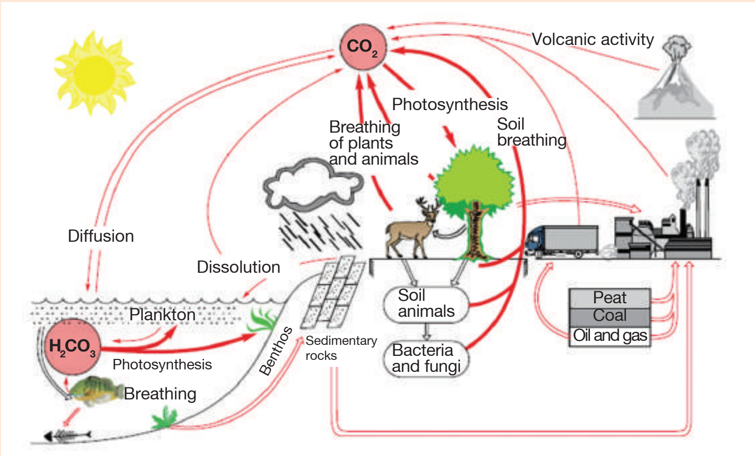


Fig. 1.6. Carbon cycle

Large amounts of carbon are released from the biosphere by being incorporated into inanimate compounds. During the decomposition of plant and animal organisms, solid, liquid and gaseous products are formed, which are incorporated into the lithosphere. In the upper layers of the Earth‘s crust these are coal, oil, natural gas. The carbon in these so-called fossil fuels has been removed from the cycle for about 300 million years, while man began to use them to produce heat and energy in the industrial age. Thus the carbon fixed millions of years ago is returned to the atmosphere as CO_2 as a result of human activity (Fig. 1.6). Much of the carbon is found in limestone rocks in the form of carbonates. They are formed as sedimentary rocks and also have an organic origin. When these rocks are weathered or used in certain industries (cement and glass), CO_2 is also released into the atmosphere.

The world ocean, which covers 70% of the Earth‘s surface, is also a „reservoir“ of carbon. Although only to a small extent, carbon dioxide dissolves in water, and some of the dissolved gas interacts with it:

$$CO_2 + H_2O \rightleftarrows H_2CO_3$$

A constant dynamic equilibrium is maintained between carbon dioxide from the air and water. Part of the dissolved carbon dioxide is used by algae for the process of photosynthesis, another part for the formation of skeletons and shells in the form of calcium carbonate ($CaCO_3$), and a third for the binding of metal ions in carbonates. A small part of this carbon dioxide is returned to the atmosphere (Fig. 1.6).

Humanity’s activity has a significant impact on the changes in the dynamic equilibrium that exists in the cycle of nature. Increasing the concentration of CO_2 in the atmosphere has negative consequences for life on the planet.

Nitrogen cycle in nature

Nitrogen in the atmosphere cannot be used by the vast majority of organisms. It becomes available to plant organisms through **fixation** - a process of converting nitrogen into easily digestible compounds for plant organisms. The complex conversions of nitrogen in these processes begin in the atmosphere through the action of lightning during thunderstorms. Under these conditions, nitrogen binds to oxygen to nitric oxide and, subsequently, to NO_2. Nitrogen dioxide, as an acid oxide, forms nitric acid with water droplets. In the soil, nitric acid binds to its compounds of sodium, potassium, calcium in salts to form nitrates:

$$N_2 \rightarrow NO \rightarrow NO_2 \rightarrow HNO_3 \rightarrow \text{nitrates}$$

In the form of nitrates, nitrogen is easily absorbed by plants and then by animals to build proteins. In fact, biological processes are crucial for nitrogen fixation from the Earth‘s atmosphere. Animals and plants return some of the absorbed nitrogen to the soil. After their death, the proteins of these organisms are mainly converted into ammonia and ammonium salts by the action of bacteria. These processes release a significant amount of energy, thanks to which bacteria maintain their vital activity.

There are also microorganisms that easily convert nitrates into ammonia. From it, plants and animals synthesize necessary amino acids and proteins, which are subsequently converted back into ammonia and ammonium salts. Under the action of denitrifying bacteria, some of the nitrates in the soil decompose and release nitrogen, which is then returned to the atmosphere.

Nitrogen-fixing bacteria are extremely important for the nitrogen cycle. These are the only terrestrial organisms that can use atmospheric nitrogen by incorporating it directly in the organic compounds synthesized by them (Fig. 1.7).

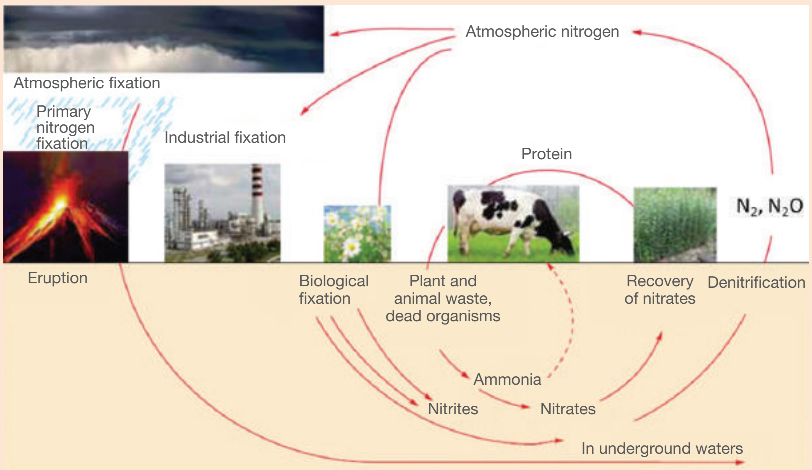


Fig. 1.7. Nitrogen cycle in nature

This natural cycle of nitrogen in nature is partially disrupted by so-called industrial fixation - the use of nitrogen from the atmosphere for the industrial production of a number of nitrogenous substances.

The use of nitrogen fertilizers, the burning of fuels and the use of explosives lead to significant changes in this phenomenal order that exists in nature. The processes described are presented in Fig. 1.7.

In presenting the carbon and nitrogen cycles we have outlined the main processes involving their compounds. These are natural processes that occur in nature.

The anthropogenic factor has a serious impact on the violation of the existing balance, which leads to the serious environmental problems faced by humanity in the modern world. The products of fuel combustion are nitrogen oxides, which are the basis for the phenomenon of smog, as well as acid rain. Excessive use of nitrogen fertilizers also results in the release of significant amounts of nitrous oxide (N_2O). Compared to carbon dioxide, it generates a 296 times stronger greenhouse effect and is considered one of the main „enemies“ of ozone in the stratosphere. These processes have a significant impact on climate change.

1.5. Importance of climate for biodiversity

1.5.1. Biosphere. Ecosystem

The history of earthly life begins with the origin of the first cell. For about 3.5-4 billion years, the microscopic cell formed a huge variety of organisms on the planet, which changed the appearance of the planet. A dynamic system was formed - the biosphere, including all living organisms, the environment in which they live and the products of their vital activity (Fig. 1.8).

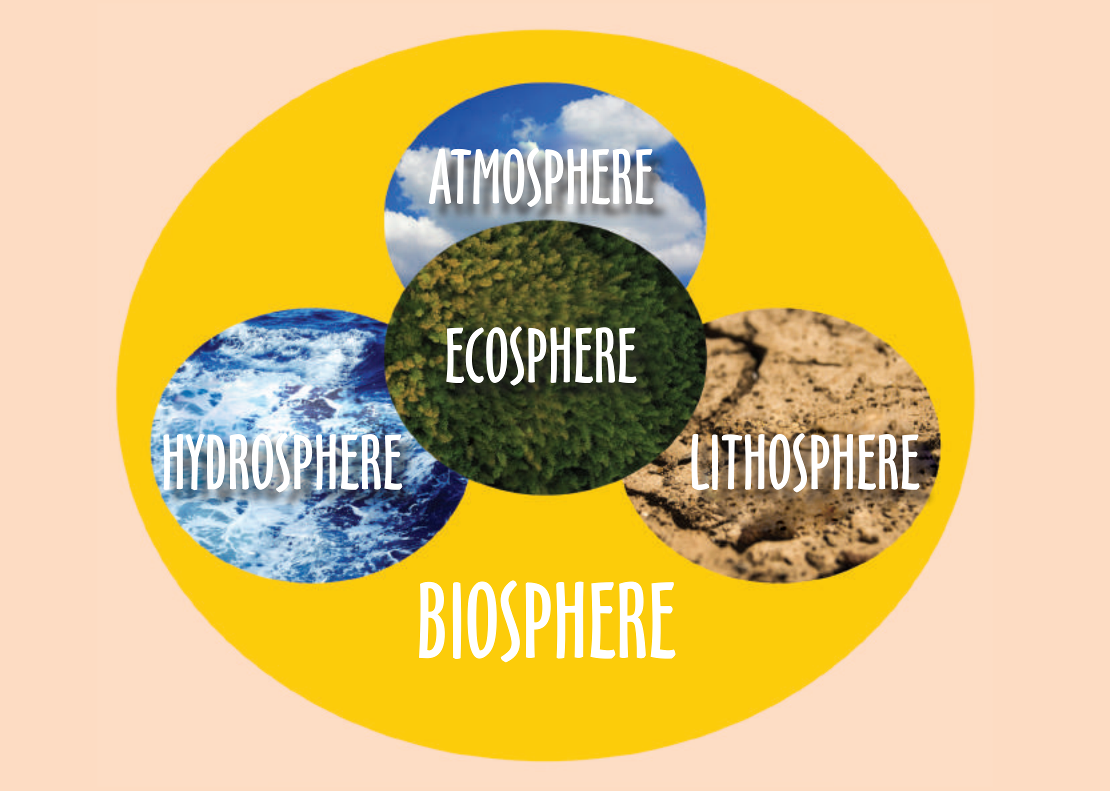


Fig. 1.8. Biosphere

The boundaries of the biosphere are determined by the distribution of living organisms in the three shells of the Earth - lithosphere, hydrosphere and atmosphere. The lower limit of the biosphere is at a depth of up to 4km in the lithosphere and up to 11km in the hydrosphere. The upper limit of altitude reaches 20-22km, where spores of microorganisms can still be found. The boundaries of the biosphere are actually limited by the amount of oxygen, light, and temperature.

The main structural unit of the biosphere, providing biological diversity, is the **ecosystem** - a sustainable unity of populations of different species of organisms and the environment they inhabit. The ecosystem is where the cycle of substances and energy necessary for the vital activity of organisms takes place.

All organisms in an ecosystem are interconnected by food relationships, which ensures the continuous cycle of substances and the conversion of energy. Photosynthetic organisms are the **producers** of nutrients - they absorb solar energy and, through the process of photosynthesis from CO_2 and water, convert it into chemical energy from the organic substances synthesized by them. The organic matter produced is used for food by animals that are consumers in the ecosystem. Fungi and some bacteria (so-called reducers) process dead organic matter and this provides them with the energy they need for life processes. Thus, the separate populations connected in food chains and webs ensure the maximum use of resources and the very existence of the ecosystem (Fig. 1.9).

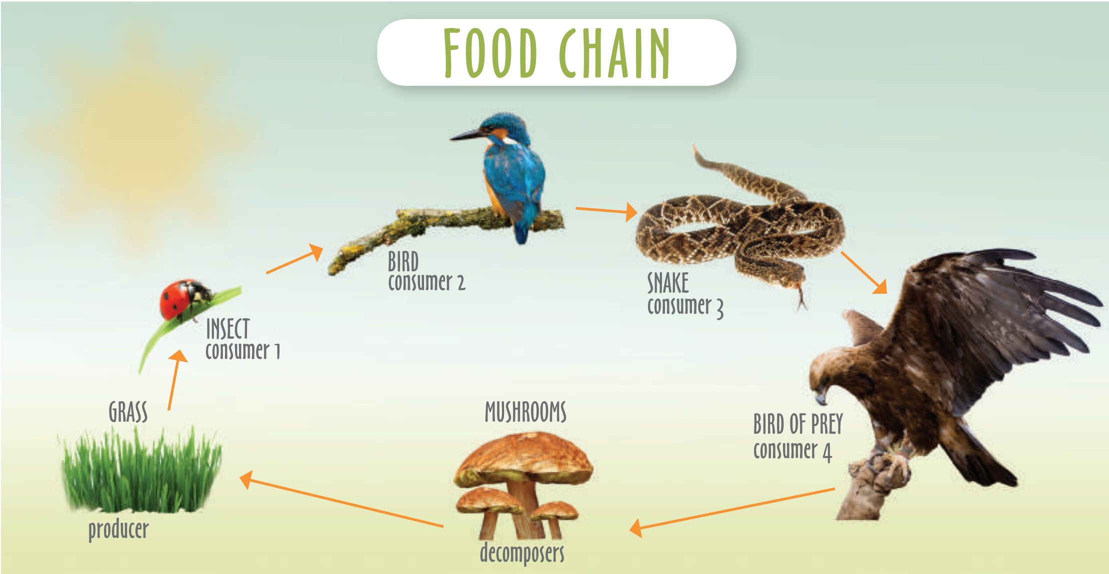


Fig. 1.9. Food chain

A stable ecosystem has a unique species composition, which is in accordance with the climatic conditions and consumes all the products produced to maintain the vital activity of its constituent populations. Achieving a balanced state in the ecosystem requires a long stage of development, accompanied by a constant change of populations, the destruction of some and the creation of new food relationships. For example, the development and achievement of stability in a deciduous forest (an ecosystem characteristic of our climatic conditions) requires more than a century of continuous change in its species composition (Fig. 1.10).

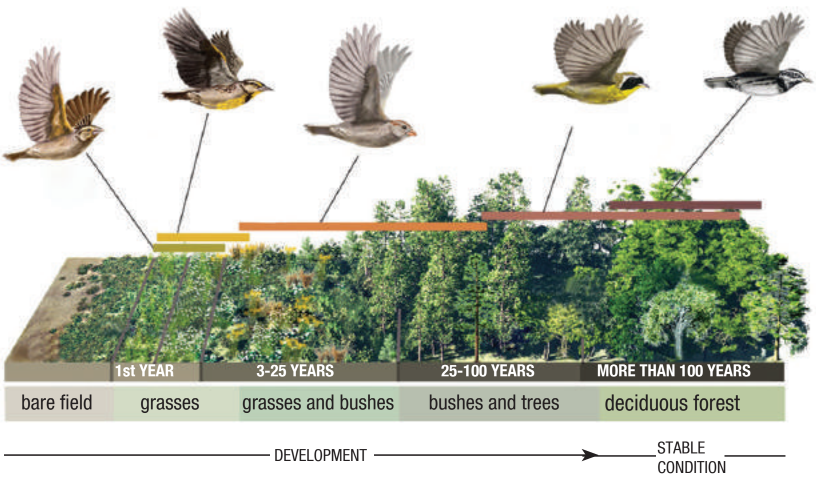


Fig. 1.10. Development of deciduous forest

In stable ecosystems, the nutritional links between organisms and the diversity of organisms in them ensure the functioning of the ecosystem in the event of short-term fluctuations in environmental parameters. Changes in temperature, the amount of water, light and other environmental factors lead to disturbances in the stability of the ecosystem and to a reduction in its species diversity. An unstable ecosystem is very vulnerable to climate change.

1.5.2. Living and non-living nature - both sides of the coin

Today, there is no doubt about the fact that the organismic world has evolved in close connection with the changes that have taken place on the planet. Organisms that could not adapt to changing conditions have disappeared. Sudden climate change in the planet's living conditions has caused huge losses in nature - there is evidence that more than 95% of all species of organisms that once lived on our planet have become extinct. (Table 1.1.). One of the most powerful catastrophes occurred about 250 million years ago, when as a result of powerful volcanic activity, the ozone layer was destroyed, the amount of CO_2 in the atmosphere increased and the average sea water temperature rose to 40°C. Under these conditions, about 96% of marine and terrestrial animal species disappeared.

Table 1.1. *Major natural disasters in the world*

Period (million years ago)	Cause	Species extinction
500–488	Thinning shell of greenhouse gases, an ice age occurs	75% of animals, 50% of fungi
450-400	Reduction of CO_2 and greenhouse gases - an ice age occurs	60-70%
375	Reduction of the amount of O_2 in water	70%
200	Powerful volcanic activity, increasing the amount of CO_2 and temperature	80%
252	Powerful volcanic activity, increasing the amount of CO_2 and temperature	96%
66-65	Heavy dust in the atmosphere, which prevents the penetration of sunlight	75%

The evolution of organisms has also had and continues to have an impact on the planet. The origin and development of life took place in the absence of oxygen in the primary atmosphere - it consisted mainly of ammonia, methane and oxides (mostly carbon dioxide). With the appearance of the first photosynthetic organisms about 2.5 billion years ago, the accumulation of molecular oxygen began, which is why the modern composition of the atmosphere is considered to be a product of the vital activity of organisms.

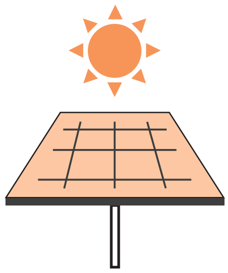
The atmosphere is a key factor in sustaining terrestrial life - it protects the body from cosmic radiation and creates the necessary thermal comfort for the development of organisms and biodiversity on the planet. Life on the planet evolved within certain temperature limits, which ensured the very existence of organisms.

The ozone layer in the upper layers of the stratosphere plays an important role in retaining harmful UV rays, which are a powerful mutagenic factor - under their influence changes occur in the structure of the DNA molecule that stores hereditary information. Changes in the density of this layer over the course of the history of organisms are probably the reason for the formation of new species, on the one hand, and for the emergence of harmful mutations and the extinction of many species of organisms on the other.

An increase in the amount of ozone in the surface layers of the atmosphere has a negative effect on the intensity of photosynthesis, which leads to a decrease in plant biomass and endangers the lives of other organisms on the planet.

Both the modern composition of the atmosphere and the soil layer of the planet are a product of the vital activity of organisms. It takes 1,000 to 10,000 years to form a 30-centimeter layer of soil in a temperate climate, a long process that means the soil can be considered a non-renewable land resource.

2. CLIMATE CHANGE



2. Climate change

2.1. Causes of climate change

Greenhouse effect

The Earth receives energy from the sun through radiation. Once heated, the Earth's surface warms up the ground layer of air by convection, as the thermal conductivity of the air is very small. However, the absorption of some of the infrared rays emitted from the Earth's surface by greenhouse gases, as well as the condensation of water vapour, which releases heat, play a more significant role in warming the air.

The greenhouse effect is the process in which the ground air layer is heated due to the retention of part of the heat radiated from the Earth's surface when it is warmed up by the sun. It can be natural (independent of human activity) and anthropogenic (created by industrialization, transport and other factors).

Of the total amount of solar energy falling on the Earth, only about half is absorbed by the Earth's surface, about 20% is absorbed by clouds and the atmosphere, the same amount is reflected back by clouds, about 4% is reflected by the Earth's surface, and part of it dissipates in the atmosphere (Fig. 2.1).

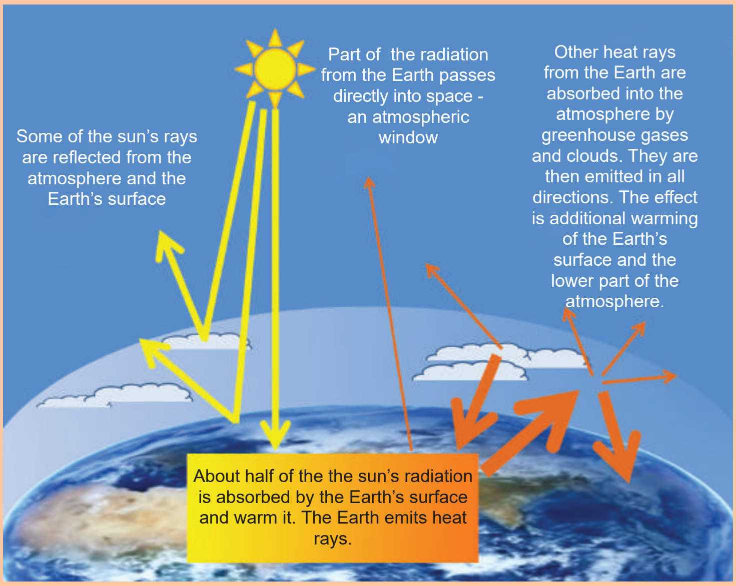


Fig. 2.1. Model of the natural greenhouse effect

The heated Earth's surface radiates heat back, mainly to the infrared region, part of which passes through the atmosphere and another part of which is absorbed by the molecules of so-called greenhouse gases. The molecules of these gases also emit heat energy, which warms the atmosphere.

The Earth's atmosphere consists mainly of nitrogen and oxygen, which are „transparent" to this radiation - they do not interact with it and transmit heat rays - this effect is often called „the atmospheric window". This atmospheric window covers a narrow band around 10 micrometer waves. On the other hand, the polyatomic gas molecules of carbon dioxide CO_2, nitrous oxide N_2O, methane CH_4, water H_2O and others absorb some of the heat radiation. The CO_2 molecule absorbs the most intense rays with a length of 15 micrometers, and the water molecule absorbs rays with a length of 7.5 micrometers. Increasing the amount of CO_2 and water narrows the „atmospheric window". Heat is then emitted in all directions, with part of it passing into space, but another part returning to the surface and warming it again. The main greenhouse gases in the atmosphere are water vapour, carbon dioxide, methane (with a 20 times stronger effect than carbon dioxide), nitrous oxide, ozone, fluorocarbons, perfluorocarbons, sulphur hexafluoride. The contribution some of these make to the greenhouse effect is presented in Table 2.1.

Table 2.1. *Contribution of some gases to the greenhouse effect*

Gas	Contribution (%)
H_2O	36 -72%
CO_2	9-26%
CH_4	4-9%
O_3	3-7%

Natural greenhouse gases make up about 1% of the atmosphere. Without this effect, the average temperature of the Earth would drop by about 30°C, which would make life impossible. There would be no liquid water, for example. The effect is similar to when we wrap ourselves in a blanket, the blanket's retention of the heat released by our body warms us. As the amount of greenhouse gases increases, the greenhouse effect intensifies and this leads to the retention of too much heat in the ground air layer and an increase in average temperatures. According to the Intergovernmental Panel on Climate Change, IPCC (https://www.ipcc.ch), the average annual temperature on Earth has risen by about 0.6°C in the last 100 years, most likely due to higher levels of carbon dioxide.

The idea behind the mechanism of the greenhouse effect was first put forward in 1824 and 1827 by Joseph Fourier (Jean-Baptiste Joseph Fourier, 1768-1830), when he considered various processes for the formation of the Earth's climate. Fourier analysed the experience of the Swiss geologist and meteorologist De Saussure (Horace Bénédict de Saussure, 1740-1799) using a vessel painted a dark colour inside and covered with glass. In this experiment, different temperatures are measured inside and outside the vessel when exposed to direct sunlight. Fourier explains the increase in temperature inside a „mini-greenhouse" such as this compared to the outside temperature through the influence of two factors: blocking convective heat transfer (glass prevents hot air from flowing inside and cool outflow) and the different transparency of the glass in the visible and infrared range. Because glass is transparent to visible light and almost opaque to heat radiation, the accumulation of heat leads to an increase in the temperature whereby the amount of heat rays passing through the glass is sufficient to establish thermal equilibrium.

The term „greenhouse effect" was first used by the Swedish meteorologist Nils Gustaf Ekholm (1848-1923) in 1901.

One of the factors for climate change (global warming) is the increased greenhouse effect, primarily due to increased amounts of carbon dioxide. It accounts for about 70% of all greenhouse gases. The main source of carbon dioxide is the combustion of fossil fuels - coal, oil and natural gas.

The causes of climate change are generally considered in two aspects - as a result of human activity and natural processes.

Anthropogenic factors for climate change

- About 20% of carbon dioxide emissions are due to transport in Europe. Exhaust gases also contain other harmful emissions, such as sulphur dioxide (causing acid rain), as well as gases that stimulate the formation of ozone in the lower ground layers. Ozone also acts as a greenhouse gas.
- Industry requires huge amounts of energy. The production of machinery, metals, light industry, food and medicine has increased, releasing greenhouse gases, especially carbon dioxide.

- Deforestation reduces the natural uptake of the carbon dioxide involved in the photosynthesis of green plants. Under normal conditions, the composition of carbon dioxide in the air is about 0.03%. Part of it is also absorbed by the water in the oceans, which dissolves it.
- Ruminant farming involves the release of methane, which forms about 40% of the methane in the atmosphere. However, the bulk of methane comes from the exploitation of gas fields. The use of pesticides in plant cultivation significantly increases nitrogen compounds.

Fig. 2.2 presents the main sources of greenhouse gases

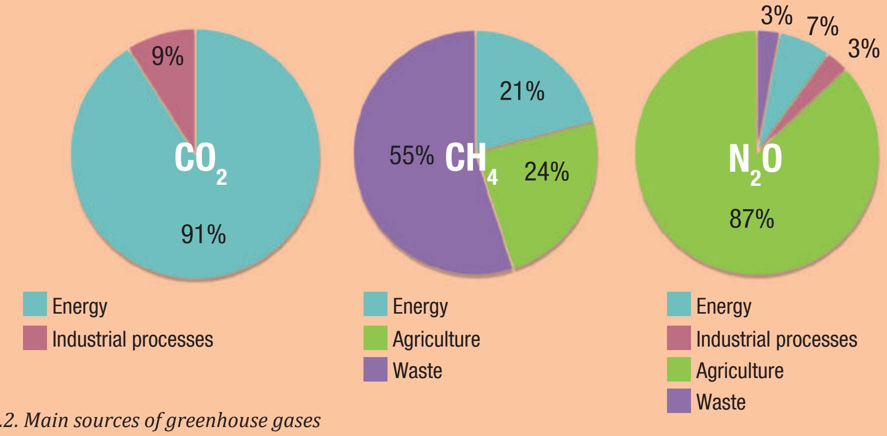


Fig. 2.2. Main sources of greenhouse gases

Non-anthropogenic factors for climate change

There is scientific data and evidence of periodic changes in the Earth‘s climate. Climatic regimes are long-term and are associated with alternating hot and cold periods - glacial and interglacial. Today we are in an interglacial period that began about 10,000 years ago. During the ice age, the Earth‘s surface was covered with thick ice and the water level was about 100m lower than now.

- One of the reasons for global climate change, according to some scientific theories, is that over a period of 26,000 years the Earth‘s axis performs periodic movements called precessions. It now points to the Pole Star (heading north), but slowly heads towards the constellation Vega. In thousands of years, the current winter will be summer for the northern hemisphere and summer will be winter.
- There is evidence that the Earth’s rotation around its axis also slows down, which has a cumulative effect - it build up over the years. The reason for the deceleration is the tides, which partly reduce the rotational energy of the Earth. The lengthening of the day over the last 2,000 years is 1.6ms on average.
- There are also changes in the shape of the Earth‘s orbit, as it comes closer to an elliptical shape, which implies colder winters and hotter summers, as well as a change in the inclination of the Earth‘s axis.
- The Earth‘s magnetic field is also changing, with the North Magnetic Pole’s recent significant movements and change in location from northern Canada to Russia.
- Catastrophic events (such as meteorites falling on Earth) would also affect the climate in the long term.
- Volcanic activity is also a factor that influences climate change and is independent of man. When a volcano erupts, many gases and solid particles are released, which change the heating of the Earth‘s surface. This enhances the greenhouse effect and hampers communication. There is evidence that volcanic activity is periodic, similar to solar activity.

- Changes in solar activity. Measurements from satellites outside the Earth's atmosphere show that there are changes in radiated solar energy. It changes in phase with the sunspot cycle. Cyclic changes in the ultraviolet range have been demonstrated. This part of the energy is absorbed by the stratosphere and radiated to the lower layers of the atmosphere.
- Along with atmospheric circulation, ocean currents carry large amounts of heat. Certain changes have been observed in these currents, such as the El Niño current, which lead to climate change in some affected areas.

2.2. Consequences of the greenhouse effect

A series of scientific reports in recent years has highlighted an increasing trend in the manifestation of the greenhouse effect. The international community, consisting of scientists and experts, is unanimous that the consequences of an increase in the greenhouse effect might be catastrophic for both humanity and life on Earth as we know it. A direct consequence of the increase in greenhouse gas emissions and the accumulation of greenhouse gases in the Earth's atmosphere is the increase in average air temperatures in certain parts of the Earth. Undoubtedly, in the first half of the 21st century, we live in a period of climate change, whose speed, dynamics and manifestations are unparalleled in historical times.

Global warming is a direct consequence of the now established greenhouse effect. In themselves, rising temperatures on the planet cause a series of changes in the natural systems that, given the systemic nature of the planet, are truly interconnected. Changes are problematic, as they disrupt natural processes, rhythms and cycles in nature - thus having the potential to cause catastrophic long-term consequences. That is why the scientific community is adamant that humanity is facing an incomparable universal challenge that threatens the life, health and well-being of all (Fig. 2.3).

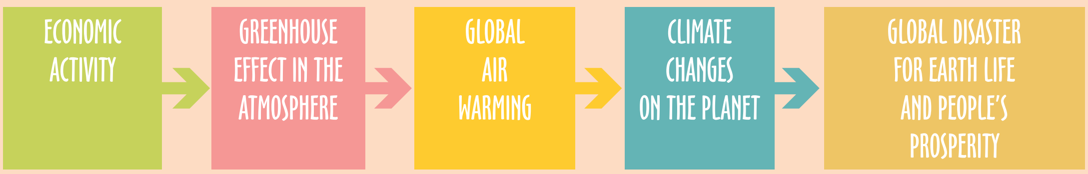


Fig. 2.3. Causal chain of climate change on Earth

Analysing the already manifesting consequences of climate change, two main categories of problem (with several subcategories) can be distinguished (Table 2.2). These problems occur simultaneously and stimulate an accelerating (hastening, amplifying) effect on each other. The research work of scientists from all over the world is constantly discovering new and new evidence of negative manifestations in the natural environment and in human society, which are the consequences of global warming.

Table 2.2. Consequences of climate change

Disruption of natural processes in nature		Threats to human life, health and well-being	
Problem	Consequence	Problem	Consequence
Change in natural living conditions (land and water)	Destruction of habitats of plants and animals, irreversible loss of biodiversity and genetic information, disturbance of ecological balance, etc.	High frequency of natural disasters and disasters	Fires, floods, droughts, hail, storms, etc. with human casualties and economic damage
Critical endangerment or extinction of plant and animal species	Irreversible loss of biodiversity and genetic information, disturbance of ecological balance, etc.	A direct threat to human health, emotional peace, happiness and prosperity	Diseases associated with heatwaves (hypertension, heart attack, depression, etc.), viral and bacterial pandemics
Spreading of invasive (incursive) species in vulnerable ecosystems	Destruction of local ecosystems, decrease in species diversity, start of degradation processes in the environment, etc.	Economic losses in agriculture, forestry, transport, energy, etc.	Harvest destruction, low bioproductivity, destruction of road infrastructure, high energy consumption, etc.
Climate change in terms of climatic elements (air temperature, precipitation, winds, etc.)	Change in the dynamics of natural processes in the lithosphere, pedosphere, hydrosphere, etc. - erosion, floods, fires, landslides, landslides, avalanches, etc.	Threat to civil society, climate conflict and climate migration	Violated democracy by restricting human rights, bloodshed and civil strife, migration crises, famine epidemics, etc.

2.3. Consequences of climate change for the organism world

No one can predict whether and to what extent global warming will be „safe“ for wildlife. What we know for sure is that climate change is already damaging ecosystems, leading to imbalances in the biosphere. There is evidence that the existing risks of species extinction and biodiversity loss are increasing.

Fig. 2.4. Arctic animals are losing their habitats

The consequences are already a reality - melting glaciers, disappearing polar ice (Fig. 2.4), dying coral reefs, changing ecosystems and deadly heatwaves. All this puts at risk unique ecosystems that can disappear forever from the planet.

The question arises as to whether ecosystems will have time to adapt to such changes or to faster and more intense ones.

2.3.1. Invasive species

Climate change (increasing greenhouse gases, global warming, pollution of the living environment by human activity) affects organisms - some of them fail to adapt and die or migrate to more suitable environmental conditions. This leads to the extinction of some species, or the emergence of new ones, which inevitably affects food relationships, and hence the stability of the ecosystem as a whole.

As a result of global warming, many „invasive" species (alien species) appear in our country, displacing typical Bulgarian species of flora and fauna and transmitting bacteria and viruses that cause unknown diseases in our latitudes (Fig. 2.5).

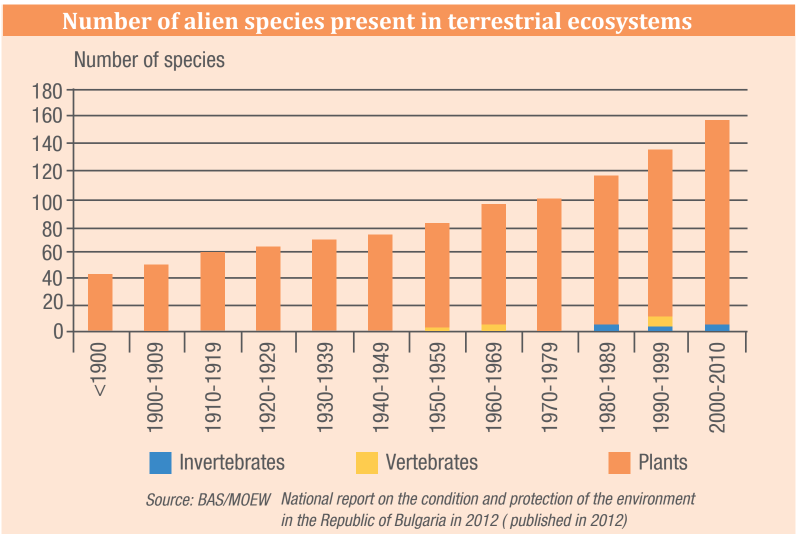


Fig. 2.5. Invasive species for Bulgaria

The invasive species is usually transferred from another physiographic region and, once it's present, breeding and spreading to new areas, it can cause damage to biodiversity and disrupt ecosystems, the economy and human health. Invasive species grow and reproduce very quickly due to the lack of natural enemies in the new habitat, causing major disturbances in the natural balance of natural ecosystems.

Fig. 2.6. The coniferous forests in the Rhodopes are endangered by an invasive species of parasitic fungus (Sphaeropsis sapinea).

2.3.2. Threats to agriculture

Crops have always been vulnerable to unpredictable weather due to the instability of agrosystems. In some regions, higher temperatures may increase yields, but the overall impact of climate change on agriculture is expected to be negative - reduced food supplies and higher food prices. Increased levels of atmospheric carbon dioxide on the one hand increase the intensity of photosynthesis, but on the other are a reason for the reduction in the amount of important plant minerals (containing zinc, iron, etc.) in the soil, which are vital for the normal development of agricultural crops.

Fig. 2.7. Drought threatens agricultural production

With climate change, agriculture faces a double threat - from floods and drought. Floods wash away the fertile soil layer on which fertility depends, while droughts reduce the water content, which makes crops even more vulnerable (Fig. 2.7).

Global warming leads to the spread of thermophilic pests towards the North and South Poles at a rate of about 3km per year. The number and variety of different pests is constantly increasing: new strains appear, which are actively spreading and are resistant to the means of protection used.

It has been proven that every year 10-16% of the world's yields are lost to pests. The losses for major crops from fungi and microorganisms alone are such that they could feed nearly 9% of the world's population. Studies show that losses will increase even more if the global temperature of the planet continues to rise.

2.3.3. Spread of new diseases

Global warming is not a fictional problem, but a reality with very serious consequences for human health. Smog is more easily formed in polluted urban areas, leading to lung disease. The smoke from forest fires further impairs air quality. Warmer fresh water facilitates the growth of pathogenic microorganisms and thus contaminates drinking water. Hot weather, floods and other extreme events damage and put the infrastructure and transport network at risk. Heatwaves cause rashes, cramps and exhaustion in humans, with the most serious consequence of impaired thermoregulation being heat stroke. Numerous studies show that heatwaves are accompanied by an increase in mortality.

Warming has completely transformed the environment in which we live. And if the direct results of this are easily visible, then the spread of dangerous diseases is often underestimated. Studies show that global warming and the floods it causes can lead to cholera epidemics in areas with poor hygiene. Cholera is spread by polluted water sources. During floods, polluted water spills over large areas, and subsequent drought concentrates the bacterium *Vibrio cholerae*, which causes this dangerous infectious disease, in smaller volumes of water.

As the ice melts, diseases that have been „asleep" in the ice for hundreds or thousands of years also thaw out. One of them is anthrax (blue pimple) - an acute infectious bacterial disease (caused by the bacterium *Bacillus anthracis*). In July 2016, a 75-year-old deer carcass thawed in the snows of Siberia and was the cause of the first outbreak of anthrax since 1941. More than 2,000 deer have died as a result of the spread of the infection, with 13 Siberians reported to have contracted anthrax.

As a result of global warming, some diseases typical of the tropics are also appearing in the northern regions - malaria has already reached Moscow and encephalitis ticks have appeared in Sweden. According to experts, the migration of infectious diseases from south to north is a particularly worrying trend and is associated with global warming and the spread of ticks and insects expanding their habitat.

Owing to warming in recent years, heat-loving species of ticks and mosquitoes that are carriers of diseases not typical for Bulgaria have migrated to our country. The Asian tiger mosquito (Fig. 2.8), a carrier of dangerous viral diseases (dengue, chikungunya, zika, etc.), was officially confirmed in the Burgas region in 2011, but by January 2016 there was already data on its spread to the Danube plain, the Upper Thracian lowlands and the valleys of the rivers Struma and Mesta.

Fig. 2.8. Asian tiger mosquito (Aedes albopictus)

2.4. Adaptation to climate change

Humanity is living in conditions of climate change with global repercussions that are already clearly affecting the lives of millions of people in dozens of countries. The topic of climate change and the means to combat it is widely covered, both on the social agenda (media, social networks, policies and strategies) and in the visionary policy of developed countries (education of the younger generation, changes in consumer behaviour, etc.). Today's children will spend their conscious lives in an environment affected by the consequences of global warming. That is why their education on the subject is key to an overall policy of preventing a global catastrophe caused by climate change.

The fight against climate change has two main aspects (Fig. 2.9). The first is related to a change in human consumer behaviour. The main guidelines for this change are:

- limiting the use of fossil fuels;
- introduction of renewable energy sources;
- increasing energy efficiency in consumption;
- introduction of a circular economy through high recyclability of materials.

At the same time, a number of developed countries are implementing measures to adapt to climate change because it is a fact and slowing it down will take time. Adaptation measures include a wide range of actions and measures, the most prominent of which are:

- conducting research to prevent or limit adverse processes and phenomena;
- development and introduction of technological innovations;
- changes in the economic profile of society;
- construction and modernization of infrastructure;
- organisation of information campaigns, etc.

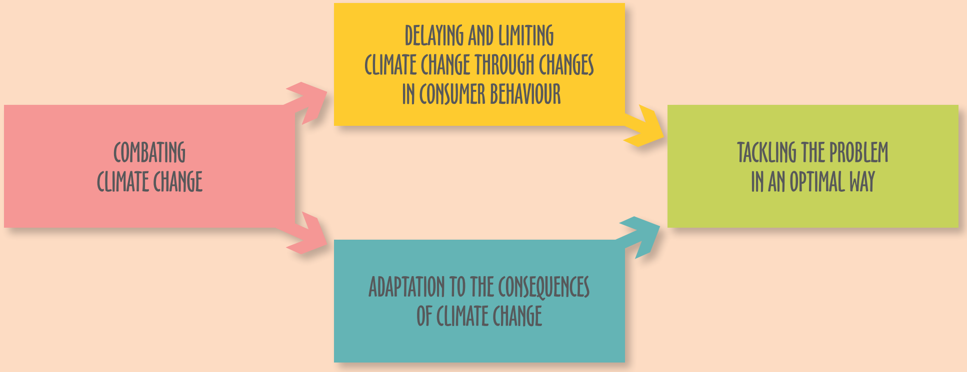


Fig. 2.9. Fundamental aspects of the fight against climate change

The fight against climate change by governments in developed countries is expressed through the implementation of groups of measures in four main areas (Table 2.3).

Table 2.3. *Groups of measures implemented by countries to combat climate change*

Goal	Concrete measures
Limiting the consumption of resources whose use exacerbates climate change	It is achieved through laws, prohibitions, higher taxes, information campaigns, etc.
Stimulating the consumption of resources that do not contribute to climate change	It is achieved through laws, subsidies, lower taxes, information campaigns, etc.
Implementation of technological innovations that reduce the consumption of resources whose use is a prerequisite for accelerating climate change	It is achieved by supporting research, lower taxes for users of new energy-efficient technologies and more.
Educating the population about the nature of climate change, the reasons for its occurrence and the danger it poses to people and life on the planet	It is achieved through effective education in school from an early age, information campaigns in the media, social networks and more.

2.5. Climate problems for Bulgaria - forecasts and measures taken

As a country that gets more than 40% of its electricity from coal combustion, Bulgaria also contributes to increasing global CO_2 emissions. One possible positive consequence of warming in our country will be the reduction of energy costs for heating, but this effect will be offset by the increase in the energy required for cooling.

2.5.1. Forecasts

Climate change in our region is not only associated with rising temperatures, but with more frequent extreme events - storms, torrential rains and floods. In Bulgaria, a warming trend has been observed since the early 1980s, when an increase in average annual air temperatures of about 0.9°C was registered compared to the norm in 1961. Each of the last three decades has been warmer than the previous one. Disasters involving torrential rain, heavy thunderstorms and hail have been on the rise since the mid-1990s. The highest rainfall was in 2014 (average annual rainfall around 1013/L/m2), which caused serious damage in many parts of the country.

Different scenarios regarding the expected rate of temperature increase in Bulgaria have been predicated - optimistic models, for example, simulate an increase in temperature by 4.5°C by the end of the century, while the pessimistic expectation is that the increase will be 8.5°C (Fig. 2.10).

An increase in temperatures by 4.5°C will lead to risks of limited water resources - precipitation is forecast to decrease by about 5-10%, which will cause more forest fires, landslides and floods. It is expected that 61% of the forests in Bulgaria in areas below 800m will be affected by drastic climate change. Spring crops and arable lands in Southeastern Bulgaria will be increasingly vulnerable, where rainfall is insufficient for normal plant growth and development.

In the pessimistic scenario, precipitation is forecast to decrease by about 40-50%, which will cause enormous damage.

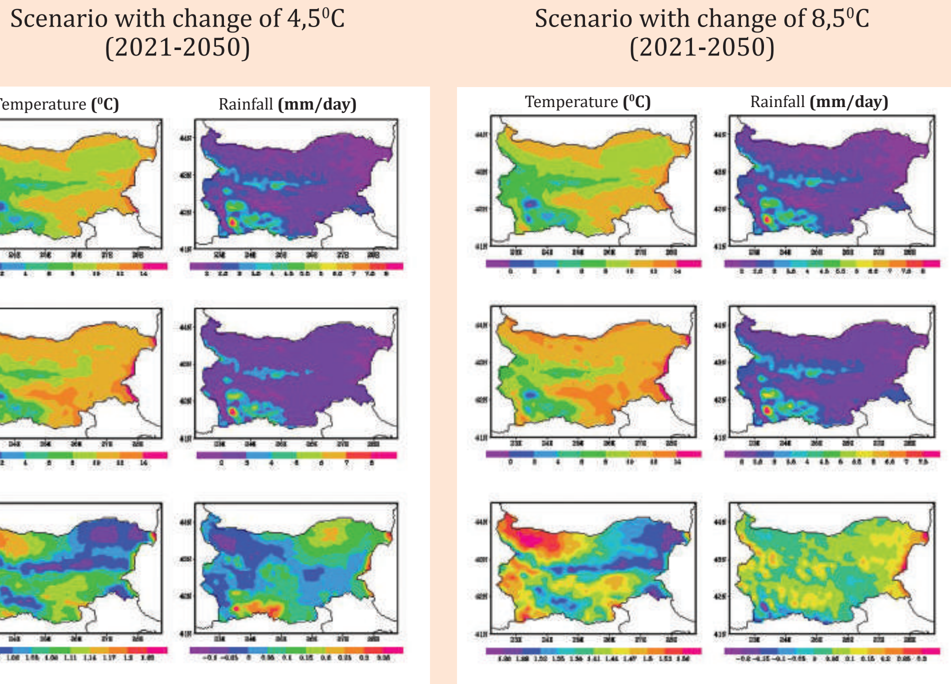


Fig. 2.10. Scenarios for temperature change in Bulgaria by 2050

2.5.2. Measures and actions taken

Bulgaria is actively participating in joint efforts to mitigate climate change and adapt to the changes that have already taken place. Because the processes related to climate change are of global proportions, our country, as a member of the EU, accepts and implements all the international commitments made in relation to climate change and global warming. Certain legislative measures have been taken in relation to these commitments.

The Climate Change Mitigation Act (in force since 11.03.2014) regulates the overall policy of the country in the field of climate change.

The National Action Plan on Climate Change (2013 to 2020) includes key objectives and measures to reduce greenhouse gases. It envisages certain financial costs for reducing emissions in key sectors (Fig. 2.11).

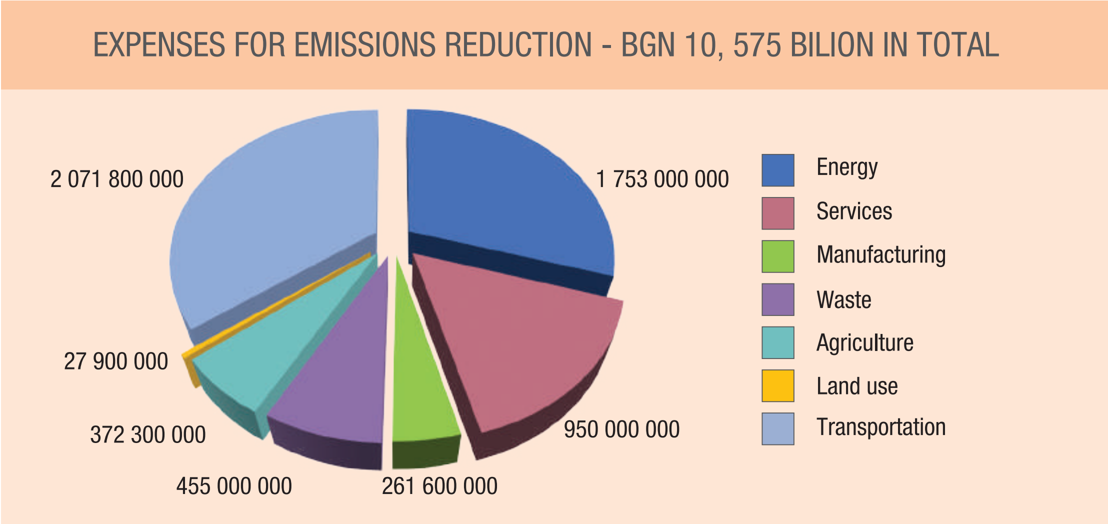
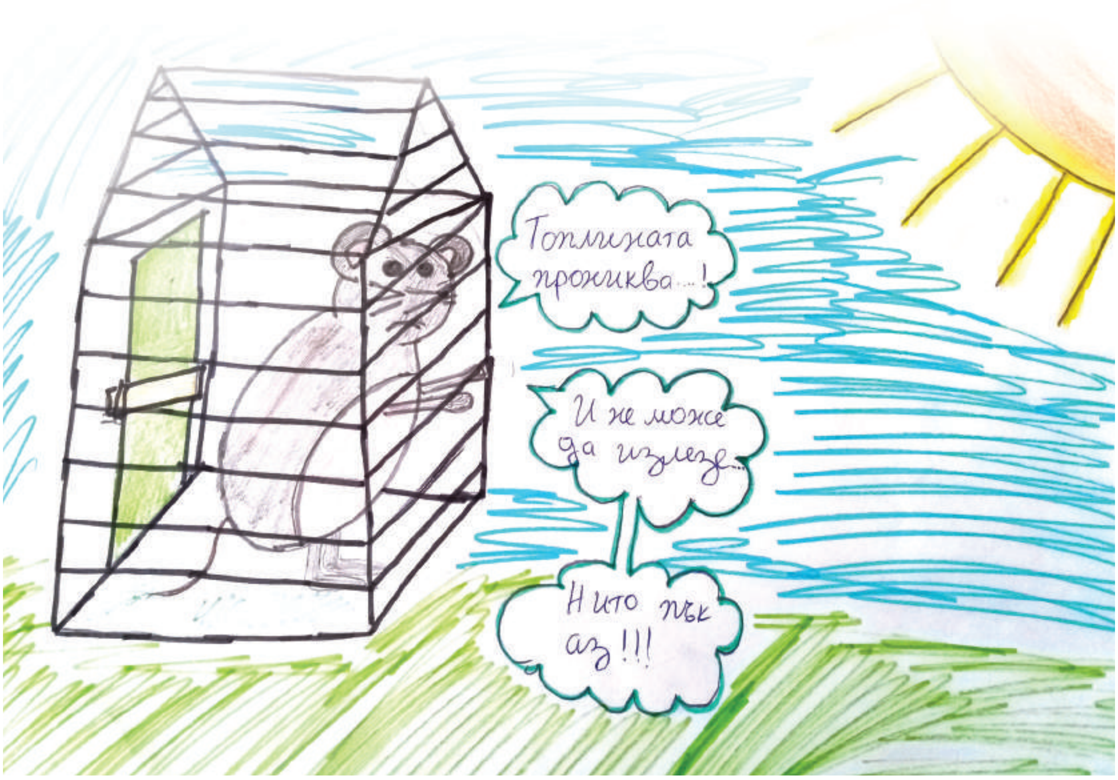


Fig. 2.11. Emission reduction costs

The long-term goal of the *National Strategy for Adaptation to Climate Change* is to take action to achieve highly effective economic, social and environmental sustainability and flexibility by 2030, so that Bulgarian citizens, the private sector and state institutions can prepare and protect themselves appropriately and reduce vulnerability resulting from climate change.



3. ENERGY IN NATURE

3. Energy in nature

3.1. Energy in living nature

The Sun is the main energy source for organisms. Annually, the Earth receives $1{,}66.10^{21}$ kcal of solar energy, of which terrestrial organisms use only about 1%. Although it seems small, this energy is enough to sustain them. Plants are our connection to cosmic energy and not only as a source of life for organisms in the biosphere. The fossil fuels that humanity uses as a source of energy are also byproducts of the photosynthetic activity of plants. For millions of years, the remains of plants and animals, trapped by layers of rock and sand beneath the Earth's surface, have been converted to coal, oil or natural gas by high temperature and pressure.

In the ecosystem organic substances are produced by photosynthetic organisms. They are the basis of every food chain. Consumers (animals, fungi, most unicellular organisms, as well as humans) use these substances for food. During respiration, nutrients are decomposed releasing the energy needed for their vital processes. Much of this energy is converted into heat and is lost to other organisms in the ecosystem. Thus, when transferred from one level to another, only 10% of the energy from the previous level is passed on. This limits the number of consumers in the ecosystem (Fig. 3.1).

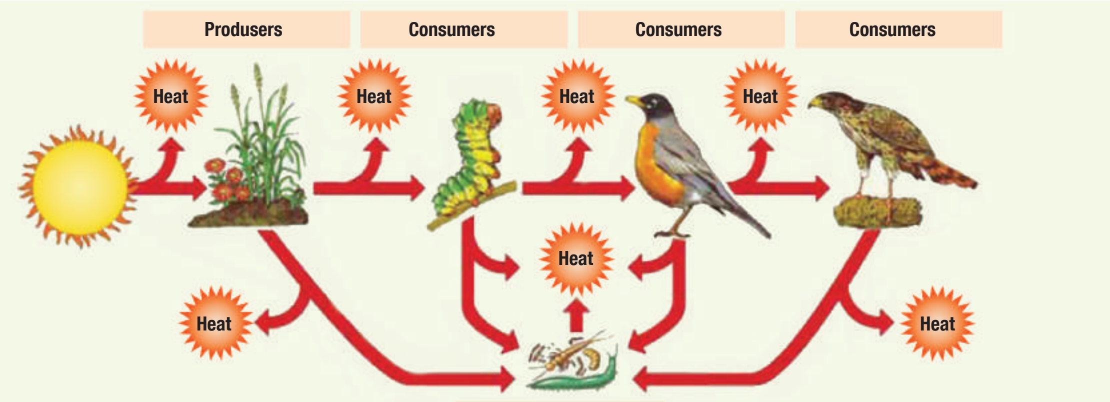


Fig. 3.1. Energy flow in the ecosystem

One possibility for the future of humanity is the use of photosynthesis as an alternative source of energy. There are already experiments to model the light phase of this unique process, during which water molecules decompose under the action of light, and the resulting hydrogen can be used as fuel. This would completely replace all other forms of energy used by mankind.

3.2. Non-renewable energy sources

Since the dawn of time, people have been using energy sources for their own needs. Early sources were fire from wood and water, and the industrial revolution thousands of years later brought in coal, oil and electricity. In the 20th century, the energy of fissile uranium nuclei was added.

People's energy consumption is also changing. According to *Physics Today*, the *Cambridge University Press* edition for 2018, energy needs have increased from an average of 8MJ per person per day for ancient peoples to the modern average of 300MJ per person per day for about 6.7109 billion earthlings. The world urgently needs new energy sources because fossil fuel energy (oil, natural gas and coal) has a heavy global environmental footprint, stimulating global warming.

The conversion of every kind of energy - with the exception of solar energy - into the most widely used kind, electricity, is shown in Fig.3.2.

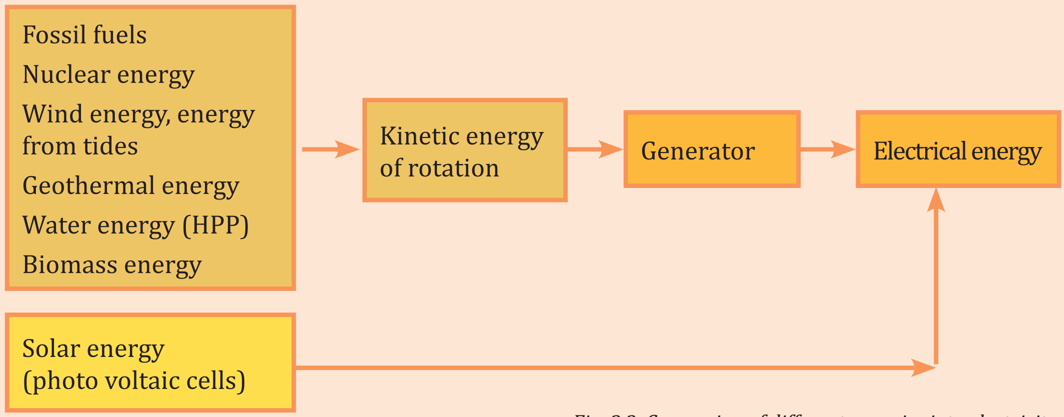


Fig. 3.2. Conversion of different energies into electricity

Non-renewable energy sources are mainly fuels - coal, oil and natural gas. We call them so because they are limited as a resource and their depletion is forecast to occur within 150-200 years. Nowadays, humanity cannot meet its energy needs without these energy sources. Their biggest drawback is the release of greenhouse gases such as carbon dioxide during combustion.

At the beginning of the industrial revolution, the primary energy resource was coal. This is a relatively inexpensive source of energy. It is the product of the decomposition of organic matter under layers of sand. This is first converted into peat and then, under high pressure and temperature in appropriate conditions, it is converted into natural coal. The age of coal varies. The highest quality and most calorific (approx. 6000-8000kcal/kg) are anthracite coal and hard coal (with an age of approx. 300 million years). Brown and lignite coal (aged from about 50 to 5 million years) have a lower calorific value (about 2500-5000kcal) and a higher ash, sulphur and moisture content, which is why they have low energy efficiency. When they are burned in thermal power plants, heat is released, which heats water to boiling and the resulting steam rotates turbines. The turbines are connected to an electric generator that produces electricity (Fig. 3.3). It is important to know that only about 30% of the energy obtained during combustion goes to heating the water. In addition to dust and soot, the chimneys emit greenhouse gases - carbon dioxide, as well as carbon monoxide, sulphur dioxide and others. Recently, cleaning systems and filters to capture exhaust gases, dust and soot have become mandatory. Coal is also processed into aqueous-coal suspensions.

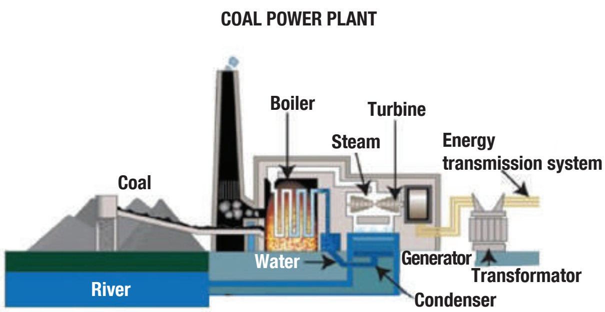


Fig. 3.3. Coal power plant

Oil, as a fossil fuel, is unevenly distributed geographically. There are large deposits in the Persian Gulf, the Caspian Sea, the North Sea, Western Siberia, North Africa, Equatorial Africa, the Malay Archipelago, Lake Maracaibo, the Gulf of Mexico, Alaska, Texas, etc. It is a product derived from the decomposition of single-celled organisms millions of years ago. Oil fields are located mainly in sedimentary structures - places on land or offshore, where for millions of years sedimentation processes have taken place.

Crude oil extracted from oil deposits is processed to produce gasoline, kerosene, paraffin, bitumen, diesel fuel and more. Oil is used mainly in transport, but also in thermal power plants for generating electricity. It is transported by oil pipelines or by tankers, which often break down and spill oil slicks in the oceans and seas. This is deadly to marine life and birds along the coast and causes eco-disasters. Oil production releases both carbon gases, nitrogen and sulphur oxides, as well as lead compounds, which are highly toxic.

Like oil, natural gas is formed from plant and animal residues processed by microorganisms. The largest natural gas fields are found in Western Siberia, the Persian Gulf, the Caspian Sea, the North Sea, the Arctic Ocean, Canada, etc. It is used both for fuel in power plants and for domestic use. Liquefied, it can be transported by tanker, but gas pipelines are most commonly used. Its combustion emissions are less than those of coal and oil.

Nuclear power plants are the most environmentally friendly. When operating in a safe mode, nuclear power plants do not emit harmful emissions and do not pollute the environment. They work with exhaustible resources - uranium ore, so we classify them as non-renewable energy sources. Energy is used to split the uranium nucleus into two lighter nuclei when fired with slow neutrons.

Nuclear energy accounts for about 17% of the world's electricity. It is unevenly distributed in different parts of the world. Most power plants are in Central and Western Europe. In Europe, France has the largest share of production. However, some countries in Europe are completely abandoning the production of such energy following a referendum - these are Austria (there is a plant built but not in use), Denmark and Italy (data from IAEA PRIS, https://pris.iaea.org/PRIS/home.aspx).

The use of nuclear energy has both advantages and disadvantages. In cases of improper operation or human error, severe accidents with irreversible consequences occur. The Chernobyl disaster (1986) and the Fukushima accident (2011) were both classified at the seventh highest degree on the International Nuclear Event Scale.

According to British Petroleum statistics, the estimated time for the depletion of fossil fuels is as follows:

- oil - 40 years;
- natural gas - 62 years;
- coal - 224 years;
- uranium primary cycle - 60 years.

3.3. Renewable energy sources

Renewable energy sources can be divided into 5 main types:

- solar;
- wind;
- water;
- geothermal;
- biomass.

All these energy sources are transformed solar energy.

The share of energy from renewable sources is still too small compared to energy from oil, coal and natural gas, but forecasts are for an increase in the share of energy from renewable sources (Fig. 3.4, a).

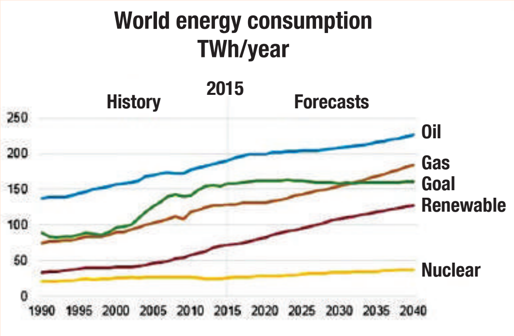


Fig. 3.4,a, World energy consumption

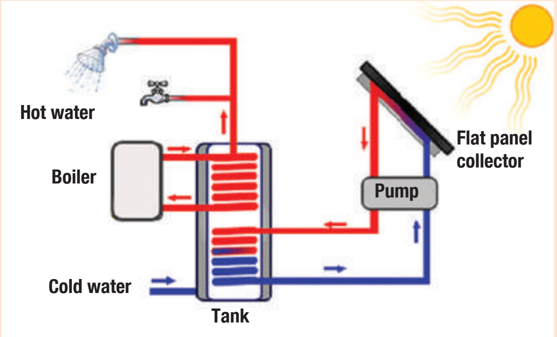


Fig.3.4,б. Heating water from the Sun

The flow of **solar energy** per unit area of land is a maximum of $1kW/m^2$. Solar energy systems use solar energy directly to generate electricity, water heating, heating and lighting. In practice, solar energy is called renewable because the resource is infinite in time. There are various technologies for transforming energy from the sun.

One way is to use energy directly to heat water for domestic use and heating. Solar energy is converted from the energy transferred by photons into heat (Fig. 3.4, b). This method is used in many households and the temperature can reach 92°C. Cold water is pumped into the collector panel, which consists of pipes laid into reflective surfaces. The panels can have a mobile slope that follows the change in the direction of sunshine.

The solar battery (cell, photovoltaic cell, photoconverter, photocell) is a semiconductor device that converts solar energy into electricity. Such batteries are used in watches, chargers, garden lamps, calculators and more. Solar energy for lighting can also be used through optical fibres on the principle of full internal reflection.

Wind energy is practically clean energy, which, unlike solar systems, does not take up much space. Investments in wind energy production have the lowest cost compared to all other industries. Research activities for suitable sites are associated with the analysis of wind strength and constancy. The strength of the wind is determined by the difference in pressure in different places - the greater the difference the stronger the wind. Another factor that determines the strength of the wind is height (as a rule, it increases with height). The location of wind turbines is determined by the presence of constant, stable air currents, with the probability of a constant direction. In the Northern Hemisphere, between the 30° and 60° north parallels, where Bulgaria is situated, constant winds are formed mainly from northwest to southeast under the influence of Coriolis forces and the influx of cold masses from the north during the winter months and warm air masses from the Atlantic Ocean towards the east. Global warming and deforestation lead to increased winds and reduced rainfall, which create preconditions for the construction of wind energy parks. In the mountains, the winds are stronger and more constant, but the kinetic energy of the wind that drives the propellers is proportional to the density of the air, which in turn decreases with height. The density also decreases with increasing humidity, which does not necessarily mean selecting locations next to areas of water. Cold air has a higher density, which means that cold air currents are suitable. The average efficiency of turbines does not exceed 20%.

The main negative impacts of wind farms on the environment are the following: impact on the environment due to the construction of infrastructure (approaches to the location of the park, high voltage lines, etc.), creating background noise and affecting birds by interrupting migratory routes.

Water energy has been used by man since time immemorial, mainly for spinning waterwheels in mills, threshing floors, etc. Water energy is now widely used in hydroelectric power plants (HPPs), using water turbines to generate electricity (Fig. 3.5).

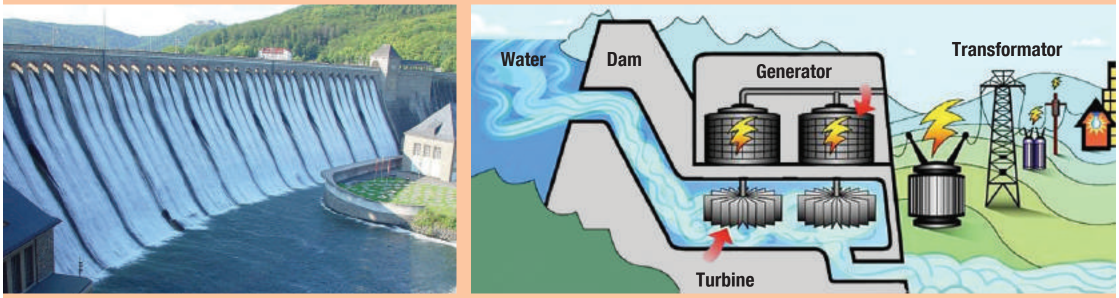


Fig. 3.5. Hydroelectric power station

This is a renewable source because water is a constant source of energy that can be easily exploited. The energy of water (potential) is converted into mechanical energy and part of it into electricity. Usually, several hydroelectric power plants are built along a river and are connected. At pumped-storage hydroelectric power stations, there are two reservoirs which have different water levels. In the lower level are the turbines and generators. At night, the hydraulic water pumps raise the water to a higher level, while throughout the day, during peak hours of electricity consumption, the water flows down to a lower level, generating electricity.

Energy that is transformed by the gravitational potential energy of the Sun-Earth and Moon systems is produced in **tidal power plants.** Globally, they produce over 300GW of green energy. These plants operate with high efficiency - 80% of the kinetic energy of the tides is transformed into electricity. They are most often used in France (La Rance), Canada (Annapolis), Russia, USA, Japan and elsewhere. They also create a lot of problems, even though they are underwater – problems with navigation, migration and the destruction of fish, changes in wave regimes and so on.

There is another type of water power plant located at the point where large rivers flow into the ocean. These are the so-called blue power plants operating on the principle of osmosis. A movement of water is generated by the osmosis between fresh and salt water. The semipermeable barrier allows water molecules from fresh water to migrate into the salt water until osmotic equilibrium is achieved, i.e. the equalization of salt concentrations in both parts. Such a plant operates successfully in Norway. The problem is the membrane is costly as it often has to be changed.

We call **geothermal** the thermal energy we receive from the Earth‘s core that can be used economically. There is a layer (3-4m), which is in a relatively constant temperature range of about 10-16 degrees. This heat is transferred from within the Earth, where the temperature is higher. There is also a breakdown of radioactive isotopes as well as chemical and gravitational energy released during displacements of the Earth‘s crust. In liquid parts, energy transfers are convective. There are several types of geothermal resources - hydrothermal with water as the heat carrier, dry hot resources in areas of thermal anomaly and low potential energy from temperature differences in the upper layer. Iceland is a country that meets most of its energy needs through the construction of geothermal installations. There is a similar infrastructure in other parts of the world with active tectonic borders - Russia, USA, Japan, New Zealand, Italy and others. In Bulgaria, geothermal resources are used for agriculture purposes in the Sandanski-Petrich valley (greenhouse production) and for the running of mineral springs and spa tourism (Hisarya, Velingrad, Kyustendil, etc.).

One of the ways we use this heat is through a heat pump, which works like a classic refrigeration system when used for heating. The other method often used is to convert steam energy into electricity. The steam is directed to a turbine, then cooled and reinjected into the ground (Fig. 3.6).

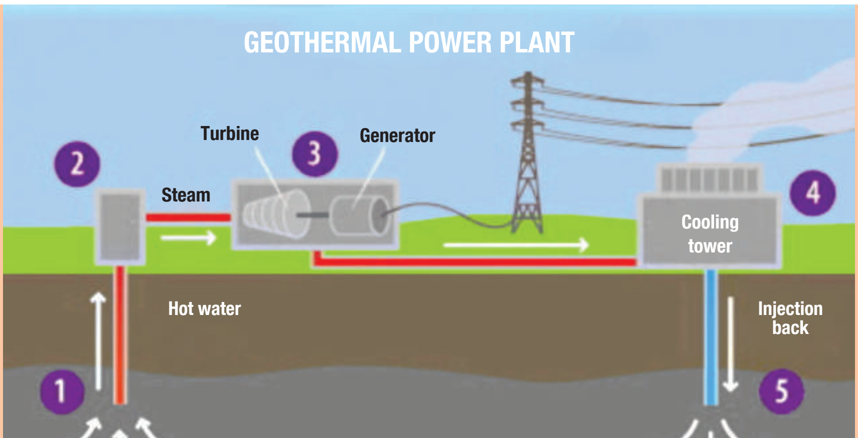


Fig. 3.6. Geothermal power plant

Biomass energy is a type of renewable energy that is associated with the use and recycling of various types of waste (wood, agriculture, food industry), plants planted for this purpose, sludges obtained from wastewater treatment, manure, composites, etc. It is low cost and affordable and helps to protect the environment (unless incineration emits carbon dioxide). Fig. 3.7 shows the biodiesel production cycle. Photosynthesis plays a major role in the process. Organic substances are combustible and decompose into carbon dioxide and water. Deforestation (or planting rice or palm trees) increases greenhouse gas emissions. There is also data, however, on soil depletion and the continuous sowing of crops.

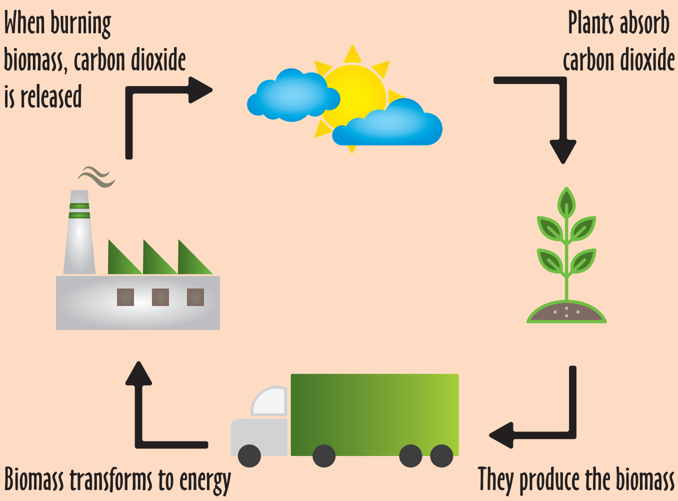


Fig. 3.7. Obtaining energy from biomass

Recently, more and more hope is being placed on highly efficient **fuel cells**. In the catalytic oxidation of some substances - hydrogen, methane, methanol - significant potential differences can occur. The hydrogen-oxygen fuel cell where water is the only waste product is a popular one.

In recent years, the distribution of energy from renewable sources is as follows: (Data from https://sciencing.com/uses-of-renewable-energy- sources-13636296.html):

- 50% – biomass;
- 35% – water energy;
- 8% – wind energy;
- 5% – geothermal energy;
- 2% – solar energy.

3.4. Energy consumption and environmental protection

In the last two centuries, the energy that people get from burning fossil fuels has been of the utmost importance. Initially, coal played a leading role, but gradually oil and natural gas caught up. At the beginning of the 21st century, national economies largely depend on fossil fuels – for electricity generation, transportation, heating of buildings and more.

The need for energy production is directly proportional to the need for consumption. The growing population of the Earth, the development of consumer society and globalization in general impose their needs on energy production. The connection between the installations that produce energy and the end users - enterprises, transport, institutions, households, etc. - is realised through the unique energy market (economic aspect) and through the electricity transmission network (infrastructure aspect). Objectively speaking, energy production and consumption are inextricably linked in a common system. A particularly important aspect in this respect is the peculiarity of energy as an economic sector, in that its „production“ cannot be stored in large „quantities“ and „volumes“, like other economic activities of material production. The times of production, transmission and consumption of energy are to some extent simultaneous. That's why energy production and consumption are distinguished by their common nature, reflecting their technological, economic, social and environmental aspects (Table 3.1).

Table 3.1. *Aspects of energy production and consumption*

Aspect	Essence	Perspective	Concerns
Technological	Reflects the achievements of scientific and technological progress in terms of energy generation capabilities.	It allows the consistent introduction of new „green“ technologies that diversify energy sources and gradually replace the capacity of „non-environmentally friendly“ energy production.	The new technologies that are being introduced require rare metals and synthetic substances to make them, rendering production more expensive and indirectly harmful to the environment.
Economic	Expresses the economic efficiency of energy generation in the context of a market economy.	Only competitive electricity generation can continue to have a long-term perspective for development and application in the energy system of market economies.	Energy production from renewable energy sources is more expensive than the use of fossil fuels - so it is vulnerable in a free (liberalized) energy market.

Aspect	Essence	Perspective	Concerns
Social	It focuses on the social role of energy for social development and for indirectly guaranteeing a high standard of living, a dignified existence and welfare.	Societies strive to ensure fair access to energy (electricity, heating) for their members through various tools such as regulating socially acceptable prices, building technological infrastructure, conducting information campaigns and more.	The introduction of new technologies in production and environmental regulations make the price of energy more expensive - socio-economic „segregation" of the poorer sections of the population is required.
Ecological	Stresses the negative environmental impact that individual energy-producing technologies have on the environment.	Developed countries stimulate the production of „green" energy from renewable energy through laws, subsidies and information campaigns. In the long run, these countries will minimize the negative impact on nature and ensure sustainable development.	Each form of energy production causes harm to varying extents and on different scales (local, regional, global): air pollution, radiation risk, destruction of river ecosystems, habitat damage, etc.

The presence of *Homo sapiens* on Earth as a species has led to a series of ecological catastrophes related to species extinction, destruction of natural landscapes, disturbance of ecosystems, etc. Defining himself as the „most reasonable" creature on the planet, man has left his ecological imprint on nature for thousands of years. There is indisputable scientific evidence of the scale on which humans have transformed significant areas of land. In most cases, this involves processes of desertification, erosion, deforestation, swamping, etc. Water basins are not excluded and have their own marks left by human activity - pollution, salinization, drying out and more.

With the development of medicine and science in general, the human population has increased exponentially over the last two centuries. Technological innovations allow man to transform the natural environment to a historically incomparable extent. Forests are cut down, agricultural lands are utilized (Fig. 3.8), dams are built, rivers are diverted, animals are killed (or settled in atypical places), settlements, roads, factories are built. It is difficult to make an inventory of every manifestation of anthropogenic activity that leaves traces on nature and degrades the quality of the environment.

Fig. 3.8. Intensive agriculture harms the environment.

Energy is among the industries with a huge environmental footprint. Energy generation is an important tool for the well-being of society, but at the same time it is a source of various types of environmental pollution and is the cause of various environmental problems. There is practically no type of energy generation that does not harm the environment in one way or another (Table 3.2).

Table 3.2. *Types of power plants and their ecological effect*

Type	Natural resources	Negative environmental impact
Thermal power plantcoal, oil, natural gas (non-renewable)	coal, oil, natural gas (non-renewable)	atmospheric, thermal and radiation, biological pollution; habitat destruction; major contribution to global warming.
Nuclear power plant	nuclear fuel - uranium core (non-renewable)	risk of high radiation pollution in case of an accident; habitat destruction; thermal water pollution; accumulation of radioactive waste; without contributing to global warming.
Hydroelectric power station	kinetic energy of water (renewable)	destruction of habitats and animal populations; thermal and biological water pollution; without contributing to global warming.
Wind power plant	kinetic energy of wind (renewable)	destruction of habitats and animal populations; without contributing to global warming.
Solar power plant	solar radiation (renewable) kinetic energy of tides, sea waves and currents	destruction of habitats and animal populations; without contributing to global warming.
Marine / Ocean HPP	kinetic energy of tides, sea waves and currents	destruction of habitats and animal populations; without contributing to global warming.
Geothermal power plant	heat from the Earth's crust	habitat destruction; without contributing to global warming.
Biomass energy production	plant biomass	destruction of habitats and animal populations; small contribution to global warming.

The intensity with which people affect the environment and harm nature reinforces the idea of the need to protect the environment. The future prosperity of humanity is linked to sustainable development, which minimizes the negative impact on the environment. Environmental protection is recognized as a universal mission to be implemented through a variety of actions:

Examples of activities for the protection of specific environmental parameters:

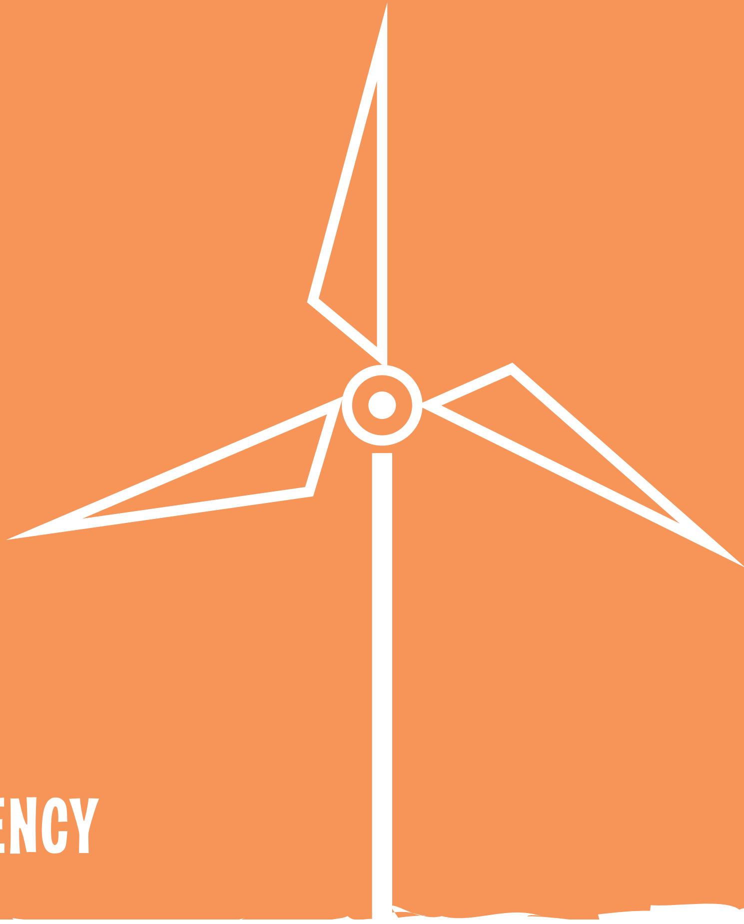
- territories and water areas are protected (reserves, parks, etc.) with proven benefits in terms of the natural environment;
- landscapes, habitats, plant and animal species defined as vulnerable or endangered are placed under legal protection;
- specific activities are prohibited for a specific period of time or territory: hunting, fishing, use of substances or equipment, etc.

Examples of activities to protect global environmental parameters:

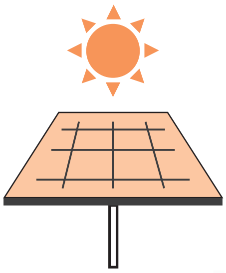
- introduction of „green“ technologies;
- promoting recycling;
- change of consumer behaviour through information campaigns and education;
- achieving energy efficiency, implementation of renewable energy sources, etc.

Undoubtedly, the protection of the environment goes along with the ecological optimisation of energy production and consumption as well as the introduction of mass exploitation of renewable energy sources (Fig. 3.9) and the achievement of maximum energy efficiency in domestic and economic life.

Fig. 3.9. Geothermal power plants have relatively little negative impact on the environment and do not contribute to global warming.



4. ENERGY EFFICIENCY



4. Energy efficiency

4.1. Consumption of electricity and heat at home, practices to reduce energy costs

Energy is a property of bodies (systems) working or changing the state of their environment. There are different types - mechanical, thermal, electrical, atomic, chemical, biochemical, etc., depending on the type of systems that possess it. In the SI system, the energy is measured in joules - J. The unit eV for low energies can also be used, such as 1eV = $1{,}6.10^{-19}$J. The unit of calories is also used for heat, with 1cal = 4.1868J. The calorie is mainly used to indicate the energy value of food. To express energy from fuels, we use the tonne of oil equivalent (toe), which is the energy released burning one ton of crude oil - about 42GJ. A kilowatt-hour is used to account for consumed electricity. This is the electricity converted by electrical appliances for one hour at a power of 1000W or 1kW. It is important to know that energy can never be fully utilized because there are losses associated with its transmission and transformation. (Fig. 4.1).

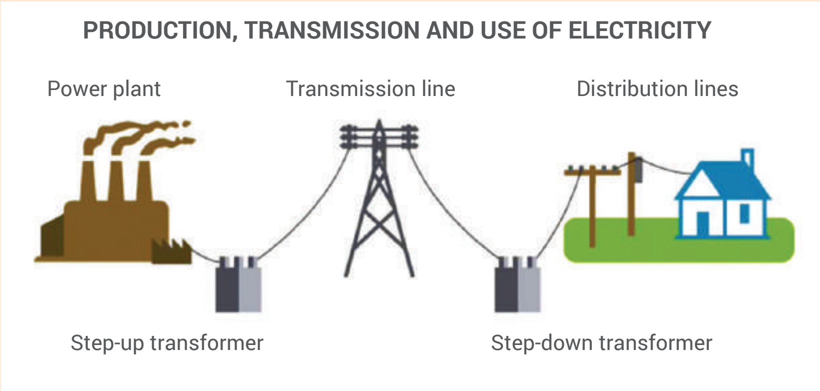


Fig. 4.1. Production, transmission and use of electricity

Thermal energy constitutes the largest share in everyday life (for heating and cooling of buildings) - 40% for Europe, followed by electricity. Fig. 4.2 shows the percentage distribution of electricity in the average household. Part of this also goes into heating residential buildings and premises. About 11% of electricity is used for lighting. A measure of light energy is light output - the luminous flux is obtained at a consumption of 1W, measured in lm/W (lumen per watt).

Light sources can be incandescent and fluorescent. In incandescent lamps the light output is only 5% - 10-15 lm/W. Fluorescent lamps have a yield of about 70-100 lm/W and a long operational life, but also some significant disadvantages - at low temperatures they have problems with ignition, they contain mercury etc.. Compact fluorescent lamps are also used, most commonly for advertising displays. They are filled with inert gas and operate at high voltage. The inner side is coated with phosphor. A voltage between the anode and cathode causes them to emit UV radiation, which in turn causes the phosphor to luminesce. Halogen lamps have a longer life, are more economical and have an output of about 25-30 lm/W. They are gas discharge lamps with special emitting additives - halides of some metals. They are ionized and have a different spectrum of radiation. Xenon lamps for car headlights are metal halide. The most modern light sources are **LED lamps:** „The lamp of the future" or „eternal lamp" - so-called LED bulbs. They have a guaranteed life of 30,000 hours, which is nearly 30 times more than an ordinary light bulb and 3 times more than fluorescent lamps. Their efficiency is also about 10 times higher than that of incandescent lamps - they can illuminate an entire house with the energy that would otherwise be needed for a single room. A LED (light emitting diode) is a semiconductor diode in which there is a p-n junction and areas with positive (holes) and negative (electron) current carriers. It emits incoherent light in a narrow spectrum when the current flows through it. Electrons and holes move towards each other during the transition, meet and neutralize each other, forming a neutral zone. The difference in the energy levels of electrons and holes determines the energy of the emitted photon. One technological problem is the production of white LED (based on phosphorus), which is made using blue and UV LED (Nobel Prize for 2014).

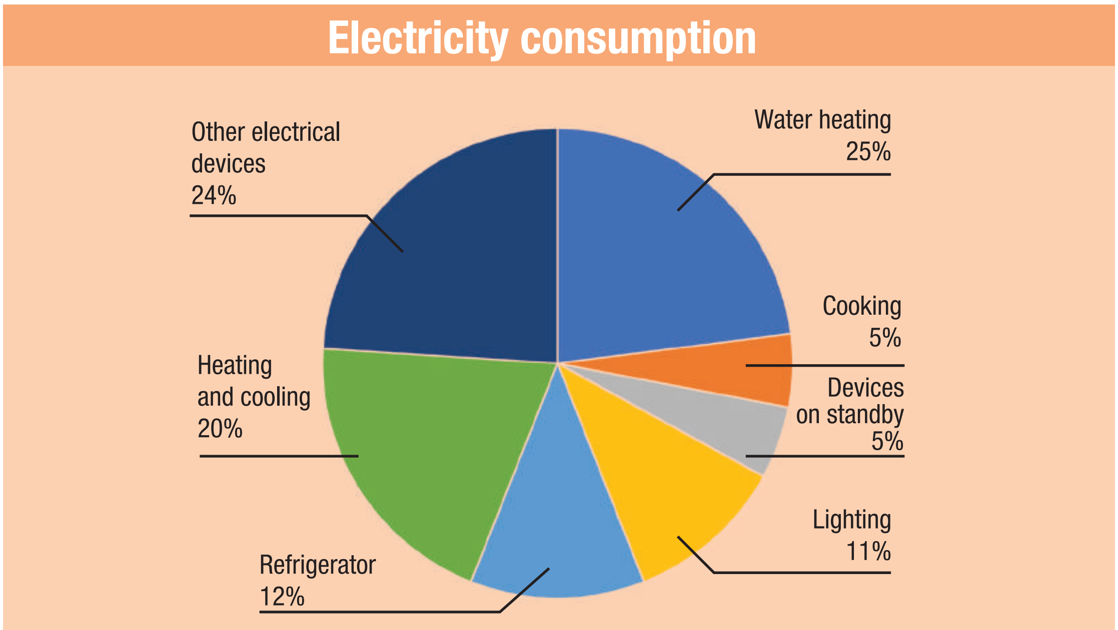


Fig. 4.2. Electricity use in households

In 2013, Europe introduced a label for the efficiency of electrical appliances. Here's what it looks like for lamps (Fig. 4.3).

„Green architecture" is about increasing the energy efficiency of buildings. The topic is important because buildings account for 50% of energy consumption (followed by transportation with 25%). Buildings consume 70% of electricity, 12% of drinking water and contribute 33% of the increased carbon dioxide in the atmosphere, using 25% of the wood taken from forests and 40% of extracted stone, sand and gravel.

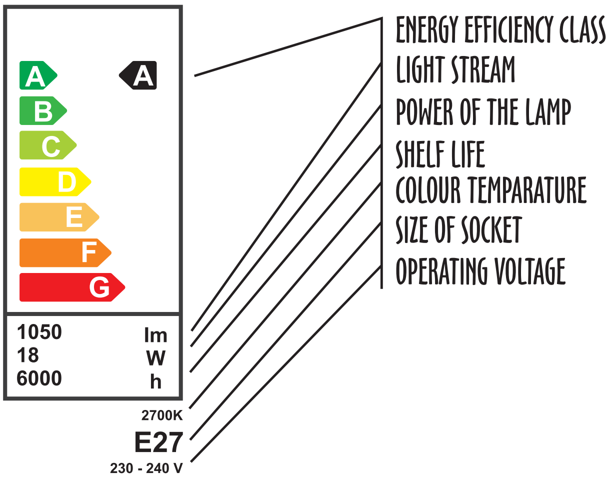
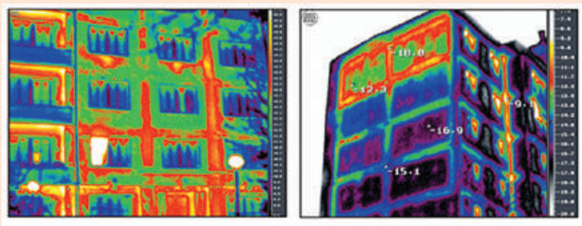


Fig. 4.3. Lamp efficiency label

The most important factors for energy efficiency are climatic factors, shade, microclimate parameters in the room (indoor air conditions - temperature, humidity, the presence of dust and bacteria), occupants' habits, condition of the building envelope, infiltration, internal heat and the condition of heating, ventilation and air-conditioning systems (Fig. 4.4).

Thermography of Sofia City Hall - a massive brick building. Places with high heat losses are depicted in red.



Computer thermography allows accurate measurement and indication of the temperature at each point. Clearly the influence of internal thermal insulation is visible.

Fig. 4.4. Thermography of a building

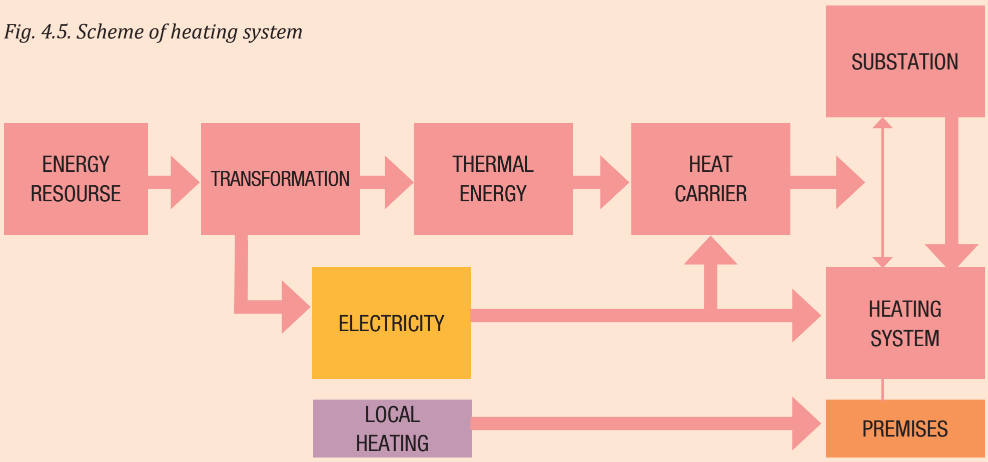
Of the climatic factors, the most significant are daily and annual changes of temperature (determined by the average monthly temperatures). An indicator of **heating degrees days** has been established - the sum of the temperature differences between the average temperature in the building and the average daily outdoor temperature during the days of the heating season at a given limit temperature.

Heat loss through the walls is manifested as the **thermal conductivity** of the building (W/m^2.K) at a temperature difference of 1K. It depends on the thermal conductivity of the material and its thickness. The quantitative heat loss of a building, measured by a thermographic method, is shown in Fig.4.5. *(Data from http://napravisam.net/?p=9728)*

The thermal insulation of walls, floors and ceilings (polystyrene foam - styrofoam, fibre, etc.), installation of double-glazed windows and gas between glass panes with low thermal conductivity (e.g. argon, krypton, carbon dioxide) are methods of reducing heat loss. A schematic diagram of a heating system is given in fig. 4.5. Heating installations can use water, steam and air. The most common way of giving off heat in a room is either convective or radiant.

All measures and legal provisions for energy efficiency are aimed at the sustainable construction of buildings and facilities - a system of practices and technologies that optimise the consumption of resources, energy and raw materials (water, air), in order to reduce the human footprint on the environment. The approach is based on new and innovative practices, materials and methods for the production and consumption of energy and resources, as well as on the overall role and place of man in nature.

Fig. 4.5. Scheme of heating system



4.2. Recycling, circular economy

The objects we use in our daily lives are made of materials, mostly obtained through modern chemical technologies. Raw materials of different origins are transformed into useful products through a number of operations. Besides the raw materials, chemical technologies also need energy sources. Table. 4.1 presents data on the energy used for the production of various materials - metals, glass, plastics, paper, etc.

Table 4.1. *Energy used for the production of materials (http://www.tectonica-online.com/topics/energy/embodied-energy-materials-enrique-azpilicueta/table/31/)*

Material	Energy used, MJ/kg	Material	Energy used, MJ/kg
Paper	25-50	Silicone	91
Cement	7	Butadiene styrene (for rubber)	102
Flat glass	19	Primary polyethylene	77
Stainless steel	54	Polyethylene (more than 70% recycled raw material)	0,09
Steel (20% recycled raw material)	35	Primary polypropylene	80
Steel (100% recycled raw material)	17	Polypropylene (more than 70% recycled raw material)	24
Aluminium	215	Neoprene (polychloropropene)	120
Aluminium (30% recycled raw material)	160	Polyvinyl chloride (PVC)	80
Aluminium (100% recycled raw material)	23	Polyvinyl chloride (more than 70% recycled raw material)	2,10
Copper	90	Polytetra-fluoroethylene (Teflon)	295
Copper (20% recycled raw material)	70	Polycarbonate	85

As can be seen from Table 4.1., the production of materials involves using significant amounts of energy. The data presented also show that the inclusion of secondary raw materials (recycled raw materials) significantly reduces the amount of energy used.

In the countries of the European Union, as well as in our country, data on the consumption of extracted energy, on air and water pollution, as well as on accumulated waste and its origin are collected and published. It is noteworthy that industry in our country benefits from only 26.7% of the energy produced (Table 4.2). The largest share goes to non-industrial consumption, which includes transport, household energy and so on.

Table 4.2. *Energy used by industry in Bulgaria (2016) (data from https://www.eea.europa.eu/themes/industry/industrial-pollution/industrial-pollution-country-profiles-2018/bulgaria-industrial-pollution-profile-2018)*

Industry	Used energy, %
Chemical industry	8,66
Metallurgy	2,50
Non-metallic productions	5,80
Mining	1,21
Other industrial activities	8,54
Non-industrial costs	73,3

In recent years, the so-called principles of „green" chemistry are being applied to the new chemical production cycle and these are directly related to saving resources and increasing the energy efficiency of processes. Here are some of them:

- Avoid disposing of waste and contaminants rather than cleaning them up and dealing with the consequences;
- Synthesis methods to include less hazardous waste products;
- Achieve energy efficiency by avoiding high temperatures or pressures;
- Use catalysts for lower energy costs or for more accessible and safe reagents;
- Raw materials should be renewable (recyclable) where possible, technically and economically.

The growing population of the Earth and the need to produce ever-increasing quantities of products is leading to the depletion of many natural resources and raw materials. At the same time, many products become waste after use, which requires storage or processing. A way out of this situation is being sought through the transition from a linear to a circular economy (Fig. 4.6.).

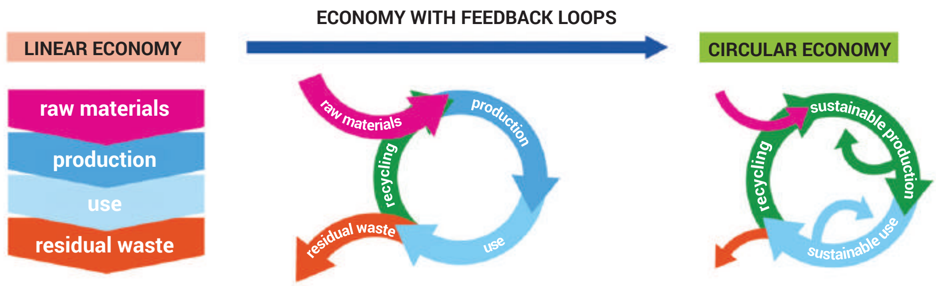


Fig. 4.6. Transition from linear to circular economy

In a linear economy, the products used are turned into waste, which is disposed of in landfills. The transition to a circular economy involves looking for ways to reuse some products by repairing them, reusing them in another form or re-incorporating them into the production process through recycling. This saves both raw materials and energy. It also reduces the amount of pollution from production itself or from the waste after the products are used.

The ideas of „green chemistry" support those of a „circular economy where nothing is thrown away" and are key to efforts to use all resources efficiently.

Waste management plays an important role in preserving and protecting the environment on the one hand and in saving energy on the other. Its main purpose is to prevent or reduce the harmful effects of waste. Despite its great variety, waste can be divided into several large groups - household, industrial, construction and hazardous.

For example, the electrical appliances we need, modern telephones and computers make up the fastest growing category of waste. They contain various substances: plastics; precious metals such as gold and copper, but also those toxic to the environment, such as mercury. Nitrogen trifluoride gas NF_3 is used for liquid crystal monitors and has a 17,000 times stronger greenhouse effect than carbon dioxide. It can be seen that such small devices contain waste from almost every group.

Waste management activities are ranked in order of importance. The greatest attention is paid to the **prevention and reduction of waste** (Reduce). Today, **preparation for reuse** (Reuse) and **recycling** (Recycle) are also important. The remaining waste is recovered in other ways, to obtain energy, for example, and only as a last resort is it disposed of (Fig. 4.7).

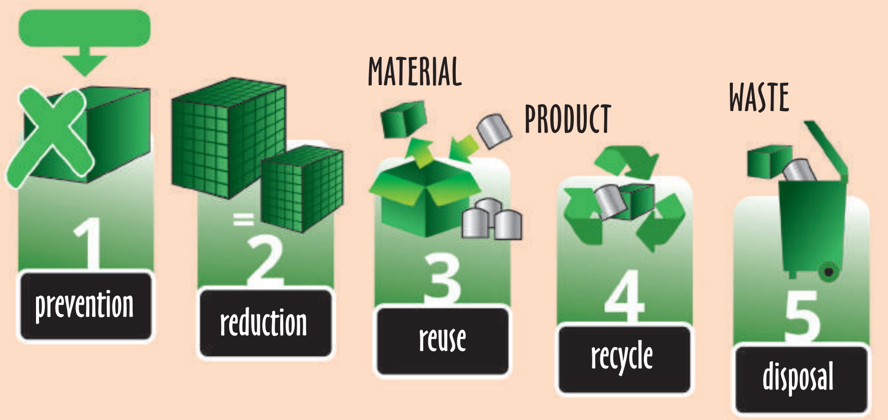


Fig. 4.7. Main activities in waste management

Table. 4.3 presents data on the household waste generated, recycled and disposed of in the European Union and in Bulgaria.

***Table 4.3**. Waste (kg per resident per year)*

Waste	EU	Bulgaria
Generated	492	460
Recycled	132	103
Disposed of	162	318

4.3. Energy-saving behaviour at school and at home

Why is it important to save energy?

It is important for every individual (and every organisation) to contribute to the protection of the environment and to combating climate change. One of the most effective ways in this direction is consumer behaviour aimed at saving energy. It is extremely important to realize that when we save energy at home, at school or anywhere, we help both the environment ecologically and society (or the family) economically (Fig. 4.8). Everyone should be aware of their personal contribution to the protection of planet Earth and the creation of a functioning green economy in the context of sustainable development.

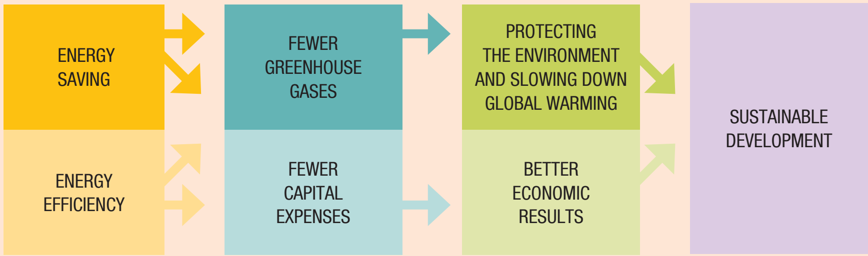


Fig. 4.8. Effects of energy saving and energy efficiency

While protecting the environment and slowing global warming are indirect effects, the direct effect of saving energy through prudent use is seen in reducing household expenses and institutions' costs for the use of electricity and heat. This frees up financial (capital) resources that can be used (invested) for other purposes to improve people's quality of life.

An additional benefit of reducing energy consumption is the possibility of achieving energy independence in the context of the European Union's geopolitical objectives. The introduction of local renewable energy sources (RES) and the optimisation of energy consumption are prerequisites for the overall development of a number of European countries (Fig. 4.9). At present, a number of EU member states are economically dependent on imports of fossil fuels from countries in the Gulf region, North Africa, the former Soviet Union, etc.

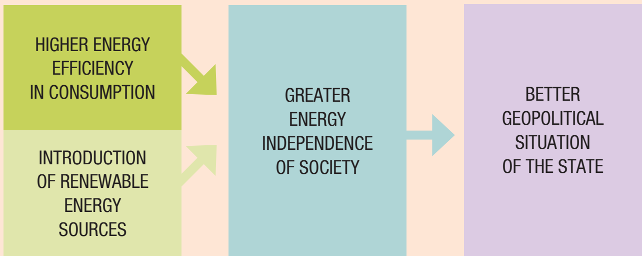


Fig. 4.9. Energy efficiency - a path to energy independence

Energy-saving behaviour at school and at home

In the EU countries, more and more institutions are focused on saving energy and achieving energy efficiency, and the appropriate uses of energy in order to protect the environment and save money are embedded in children's education from an early age. Bulgaria is one of the countries with relatively low energy efficiency, and a large part of the population and business representatives do not exhibit consumer behaviour that is aimed at reducing energy consumption. The main limiting factor in the use of energy in Bulgaria is economic - the prices of electricity and fuels. In many cases, people or institutions would be content with less energy if they used the energy properly. At the same time, they would optimise their economic results. That is why changing consumer mentality in Bulgarian society is a challenge that must be overcome.

Achieving energy efficiency and energy-saving consumer behaviour is the result of purposeful action and overall awareness of the issue at both institutional and personal levels. At the institutional (and national or local) level, the following energy efficiency strategies can be undertaken:

- Policies for achieving thermal insulation of existing buildings through renovation, replacement of doors, windows, flooring, etc.;
- Advocating the idea of designing and constructing buildings in line with the idea of energy efficiency: wide southern exposure, access to natural light, conditions for easy ventilation, etc.;

- Implementation and use of energy-efficient technologies (energy-saving appliances, LED lighting fixtures, boilers with solar panels, etc.);
- Introduction of ecological and energy education from early childhood; information campaigns for the society, business, etc.;
- Policies to stimulate energy-efficient technologies and buildings (lower taxes, state subsidies, etc.) and to limit energy inefficiencies (higher taxes, fines, etc.).

The personal contribution made by each child or adult undertaking specific actions both at home and at school can be identified through compliance with the following rules:

1. Use electrical appliances only when they are really needed (TV, computer, lighting (Fig. 4.10), water heater, etc.).
2. Save water - especially hot water! Make sure plumbing is in good working order and don‘t ignore tips for limiting water consumption when brushing your teeth or when you don‘t turn off the tap completely. The supply and heating of each drop of water absorbs energy.
3. Close doors and windows when it is cold to prevent heat loss.
4. Ventilate wisely so as to save energy heating rooms at home or at school. It is better to open several windows wide and ventilate for 2-3 minutes than for a window to be slightly ajar for a long period of time.
5. Dress sensibly according to the season so that there is no need for excessive heating or cooling.
6. When buying appliances, pay attention to their energy class and the extent to which they are classified as energy efficient. Equip yourself as a matter of priority with appliances that minimize energy consumption (Fig. 4.11). Investing in more expensive but more energy-efficient appliances will have a positive economic effect in the long run.
7. Explore the possibilities for the thermal insulation of your home (and school), as well as for the installation of solar panels to provide hot water for consumption.
8. Use energy according to these energy rules and monitor the difference in the amounts on your monthly electricity (and heat) bills. Analyse the amount of savings and invest them wisely (Fig. 4.12).

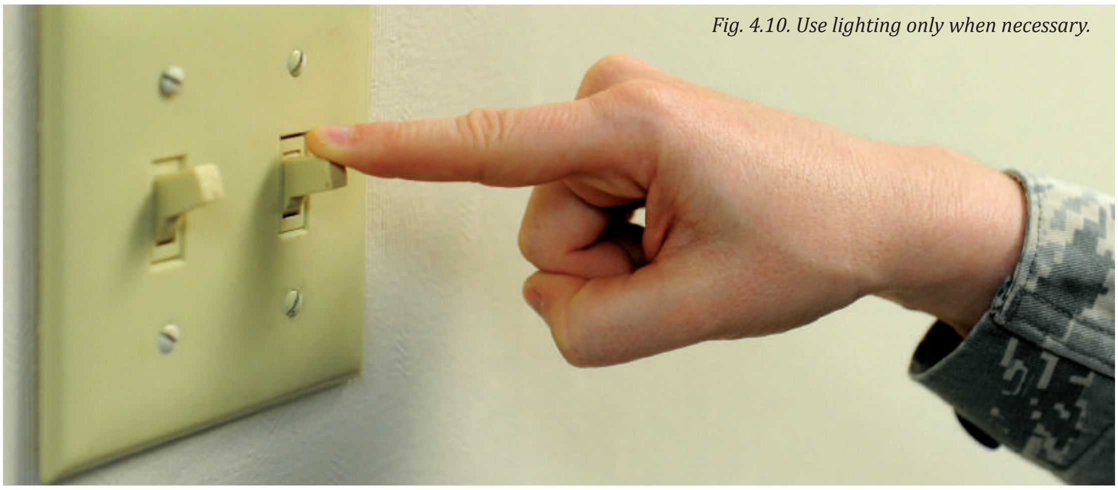


Fig. 4.10. Use lighting only when necessary.

With the advancements of information technology, it is now possible to integrate „smart“ appliances with applications on a smartphone. In this way, a „smart“ home is created, in which energy is saved - electrical appliances are switched on and off remotely; sensors monitor electrical appliances only when needed; alarms are set to signal technical problems, etc. Modern energy-saving technologies are an ally in the fight for lower energy consumption, greater energy efficiency and limiting climate change.

Fig 4.11. Energy-saving light bulb

Fig. 4.12. Reasonable energy consumption saves money.

5. SUSTAINABLE DEVELOPMENT AND CLIMATE CHANGE

5. Sustainable development and climate change

The dynamic development of human society is linked to the natural resources of the planet and inevitably affects natural processes. The rapid growth of the Earth's population in the last century, the development of science and the economy are leading to catastrophic changes in the planet, which threaten not only the organism world, but also man himself - his health and even his existence. The anthropogenic impact on the climate is becoming more and more intrusive, more and more energy is needed for the development of our society in the modern world. Mankind is wasting the Earth's natural resources so recklessly that life for future generations is seriously endangered. As early as the 1970s, environmentalists drew public attention to limited resources and rapid growth. At that time, a sustainable economy taking care of ecological systems was referred to as an alternative. The term „sustainability" was also introduced to describe an economy that is in sync with the main ecological systems, and subsequently „sustainable development".

5.1. Historical roots of the idea of sustainable development

Historically, the term „sustainable development" has been associated with forest management. The aim is for the productive power of the forest and its respective timber yields to be synchronized in such a way as to ensure the highest possible yield in the long run, without disturbing the ecological condition of the soil and the place where the forest is located. In other words, as much timber is cut as can be replaced from additional afforestation processes. Ideas for sustainable and prudent use of natural wood resources are gradually developing in different countries - Britain, Germany since the 18th century - and are among the prerequisites for the development of forestry and forest management.

Since the publication of Rachel Carson's book *Silent Spring* in 1962, emerging environmental movements have focused on the link between economic growth and development on the one hand and environmental degradation on the other. Kenneth E. Boulding, in his 1966 publication *The Economics of the Coming Spaceship Earth*, identified the need to adapt the economic system to the ecological system and its limited resources. One of the first cases of the term „sustainable" being used in the modern sense was by the Club of Rome in 1972 in a report on the limits of growth, written by a group of scientists led by Dennis and Donella Meadows of the Massachusetts Institute of Technology. Describing the desired „state of global equilibrium", the authors write: „We are looking for a model of a global system that is sustainable without sudden and uncontrolled disintegration and able to meet the basic material demands of all its people."

In 1980, the International Union for the Conservation of Nature published a global strategy that introduced the term „sustainable development" and included one of the first references to „sustainable development" as a global priority. In 1987, the United Nations' World Commission on Environment and Development published the report *Our Common Future*, also called the Brundtland Report. The report includes what is now one of the most widely accepted definitions of sustainable development:

„Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

Renowned Austrian scientist Fritjof Capra offers the following explanation of the definition: "The key to a functioning definition of environmentally sustainable development is the belief that sustainable human communities must not be rediscovered, but can be created on the example of the ecosystems in nature that are sustainable communities of plants, animals, fungi and microorganisms. The most important property for the Earth is to preserve life. That's why a society that develops in a sustainable way is such that its way of life, as well as its social, economic and physical structures and technologies, do not interfere with the inherent ability of nature to preserve life. Sustainable societies develop their life patterns over time in constant contact with other life systems. Therefore, sustainable development does not mean a static state, but a dynamic process of interdependence."

The concept of „sustainable development“ has been used more widely worldwide since the United Nations Conference on Environment and Development in Rio de Janeiro in 1992. This also paved the way for the modern ideology of the world community and the tools for a new environmental policy, inseparable from economic and social development.

5.2. Indicators for sustainable development

Achieving sustainable development can only be done consciously by people, as we are the ones who direct the course of processes and phenomena. Once this process is consciously managed, people should reach a consensus regarding the expected results and the ways to achieve them. There is no doubt that in the presence of contradictions and conflicts it is unthinkable to talk about achieving sustainability at all. Thus, sustainable development is associated with a society that, in response to changes in internal and external conditions, is able to establish a new balance corresponding to these changes, both within itself and in the whole environment in which it exists.

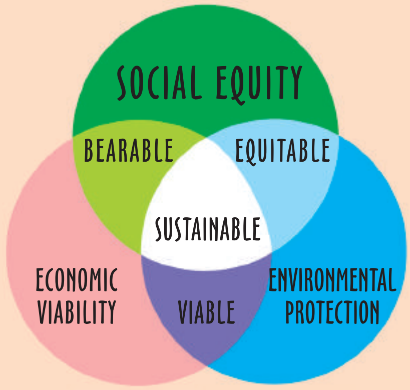


Fig. 5.1. Areas of sustainable development
(based on http://sust-tour.rayanasolutions.com/item-m935193310170.html)

The main dimensions of sustainable development are three interrelated elements - economic, social and environmental. All three pillars of sustainability are based on these and are identified as: **environmental sustainability, social justice and economic viability** (Fig. 5.1).

On August 2, 2015, after eight rounds of intergovernmental negotiations between UN member states, the new *Post-2015 Development Agenda* was agreed by consensus. The document is entitled *Transforming the World: A 2030 Agenda for Sustainable Development.* The document was formally adopted on 25 September 2015 by global leaders during the New York Summit on Sustainable Development (25-27 September 2015). It sets out 17 sustainable development objectives, relevant sub-objectives and means and actions for implementation, namely:

1. Ending poverty in all its forms everywhere.
2. Ending hunger, providing food, improving nutrition and promoting sustainable agriculture.
3. Ensuring health and promoting well-being for all of all ages.
4. Providing quality education and promoting lifelong learning opportunities.
5. Achieving gender equality.
6. Ensuring access to water and sanitation for all.
7. Ensuring affordable, reliable and clean energy for all.
8. Promoting sustainable and inclusive economic growth, full and productive employment and decent work for all.
9. Building sustainable infrastructure, promoting inclusive and sustainable industrialization and innovation.
10. Reducing inequalities within and between countries.
11. Turning cities and towns into safe and sustainable places.
12. Ensuring sustainable production and consumption patterns.
13. Take urgent measures to combat climate change and its impact.

14. Conservation and sustainable use of the oceans, seas and marine resources for sustainable development.
15. Protecting, restoring and promoting the sustainable use of terrestrial ecosystems, sustainable forest management, combating desertification, preventing and reversing soil erosion and preventing biodiversity loss.
16. Promoting peaceful and inclusive societies for sustainable development, providing access to justice for all and building effective, accountable and inclusive institutions at all levels.
17. Strengthening the means for implementation and revitalization of the global partnership for sustainable development (Fig. 5.2.).

Fig. 5.2. Global goals for sustainable development in the 21st century

As can be seen, two of these goals are related to climate change and energy consumption.

Sustainable development is a major goal of our modern society. The idea of sustainability means synchronizing economic growth with environmental protection. (Fig. 5.3.).

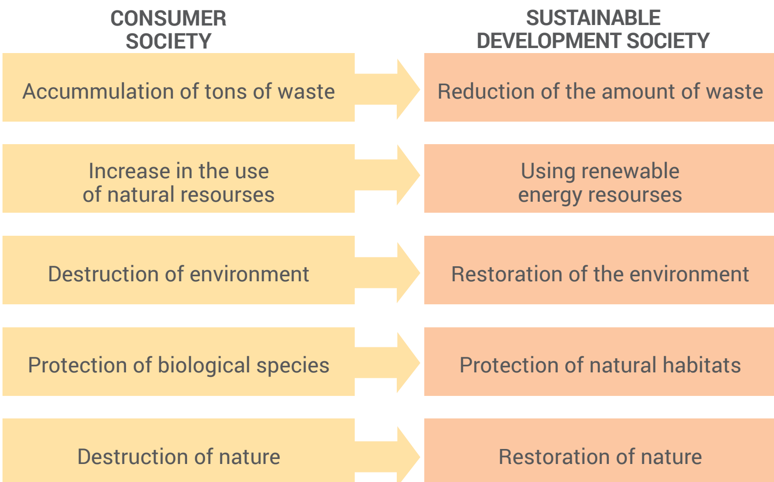
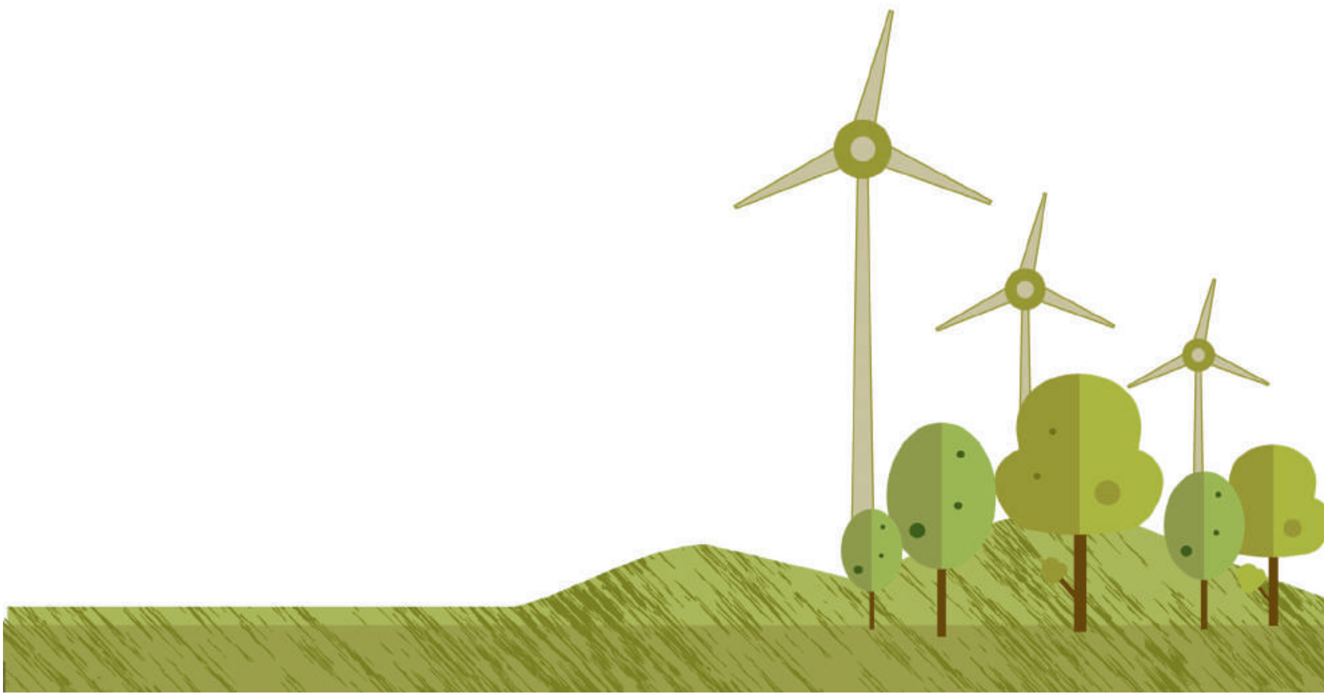


Fig. 5.3. Society today and in the future

It is obvious that the model of our modern consumer society is not sustainable in the future. A complete change in human thinking and behaviour is needed and the foundations of this change must be laid in education.

References:

1. ***Bulgarian law on climate change mitigation,*** 2017
2. ***Bulgarian law on energy efficiency,*** 2018
3. ***Bulgarian law on renewable energy sources,*** 2018
4. ***Bulgarian law on renewable energy sources,*** 2018
5. ***Bulgaria's National Inventory Report 2018 – Submission under UNFCCC. NATIONAL INVENTORY REPORT 2018 GREENHOUSE GAS EMISSIONS IN BULGARIA 1988-2016,*** April, 2018
6. ***Benev, A.*** Biomass energy. Nauka, 2008, (4), 32.
7. ***Beltrán, S. G., Kochova, L., Pugliese, G, Sopoliga, P.*** Energy Efficiency of Buildings. IUSES Project – Smart Use of Energy in schools, Intelligent Energy for Europe.
8. ***Blewitt, John.*** Understanding Sustainable Development, 2nd ed.. London: Routledge, 2015.
9. ***Capra, F.*** The Hidden Connections. A Science for Sustainable Living, London: Harper Collins, 2002.
10. ***Climate change.*** Editing by prof. dfn Veselin Alexandrov, NIMH-BAN, 2010
11. ***Climate Change in Europe: facts and figures,*** http://www.europarl.europa.eu/news/en/headlines/society/20180703STO07123/climate-change-in-europe-facts-and-figures, as of 14 April 2019
12. ***Energy and environment.*** Secondary school textbook, with the financial support of the European commission, INFORCE-EUROPE, Sofia., 2010.
13. ***Finn, Donovan.*** Our Uncertain Future: Can Good Planning Create Sustainable Communities?. Champaign-Urbana: University of Illinois, 2009.
14. ***Fourier, J.*** Mémoire Sur Les Températures Du Globe Terrestre Et Des Espaces, 1827.
15. ***Fourier, J.*** Remarques Générales Sur Les Températures Du Globe Terrestre Et Des Espaces Planétaires. Annales de Chimie et de Physique,1824, 27: 136–67.
16. ***Holt, Rinehart and Winston.*** Earth Science, Boston, 2011.
17. ***Houtan, G.*** Global warming, Academic pulishing house "Prof. Marin Drinov", Sofia, 1996.
18. ***Introduction to climate change.*** National trust ecofund, 2015.



19. ***IPCC, 2013: Summary for Policymakers. In: Climate Change 2013: The Physical Science Basis.*** Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
20. ***IPCC, 2014: Climate Change 2014: Synthesis Report.*** Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.
21. ***IPCC Expert Meeting on the Future of the Task Group on Data and Scenario Support for Impacts and Climate Analysis,*** World Meteorological Organization, Geneva, Switzerland 26–27 January 2016.
22. ***Kirkova, E.*** Chemistry of the elements. Sofia, University publishing house "St. Kliment Ohridski", 2013
23. ***Kutsarov, S.*** Solar to electrical energy convertors „Engineering review ", 2008, (2). http://www.engineering-review.bg/bg/preobrazuvateli-na-slanchevavelektricheska-energiya/2/970/).
24. ***Laufer, D.*** Climate protection by behavioral improvement of the building users in European schools and public buildings – UfU (Berlin), 2015
25. ***„Living planet"*** report by WWF, in cooperation with Global Footprint Network, 2008.
26. ***National environment strategy 2009-2018,*** 2008, Project of the MoEW
27. ***Penin, R.*** Glossary of Physical Geography and Landscape Ecology, Bulvest 2000, 2007.
28. ***Peter Wiedemann.*** Climate protection and climate policy. Educational and information materials, Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), Public Relations Division, Berlin, 2008.
29. ***„Planétaires".*** Mémoires de l'Académie Royale des Sciences. 7: 569–604.
30. ***Renewables 2018.*** Global Status Report: http://www.ren21.net/status-of-renewables global-status-report/
31. ***Sachs, Jeffrey D.*** The Age of Sustainable Development. New York: Columbia University Press, 2015.
32. ***Stefanov, G.*** The role and position of NGOs in the climate action process on international, European and national level , WWF, presentations, 2019.

List of published photos from schools participating in the programme

All published photos are property of the National Trust Ecofund

Inside front cover – "Veselin Hanchev" Primary School, *Stara Zagora*
Page 4 – "Hristo Maximov" Primary School, *Samokov*
Page 5 – "Hristo Botev" High School, *Pavel banya*
Page 5 – "General Skobelev" Primary School, *Skobelevo, Pavel banya municipality*
Page 7 – "Vasil Levski" Primary School, *Gabrobo*
Page 19 – PMG "Vasil Drumev" High School, *Veliko Tarnovo*
Page 30 – "Hristo Botev" High School, *Pavel banya*
Page 31 – "Hristo Botev" High School, *Pavel banya*
Page 42 – "Ekzarh Antim I" High School, *Kazanlak*
Page 51 – "St. Paisii Hilendarski" Primary School, *Kazanlak*
Page 52 – "Otets Paisii" High School, *Samokov*

List of teachers, participating in the project

1. **Albena Aleksandrova**
   NGDEK "St. Konstantin-Kiril Filosof" – *Sofia*
2. **Alexandra Danova**
   79 High School "Indira Gandi" – *Sofia, Lyulin region*
3. **Aneta Ivanova**
   "Ivan Vazov" High School – *Stara Zagora*
4. **Aneta Pencheva**
   NGDEK "St. Konstantin-Kiril Filosof" – *Sofia*
5. **Anna Mihalkova**
   7 High School "Sv. Sedmochislenici" – *Sofia*
6. **Atanas Trifonov**
   "Nikola Velchev" Sports School – *Samokov*
7. **Bilyana Katsarska**
   "Nikola Velchev" Sports School – *Samokov*
8. **Bonka Borisova**
   "Neofit Rilski" Primary School – *Kilifarevo, municipality Veliko Tarnovo*
9. **Borka Mladenova**
   40 High School "Lui Pasteur" – *Sofia, Lyulin region*
10. **Darinka Boneva**
    "Emiliyan Stanev" High School – *Veliko Tarnovo*
11. **Desislava Misheva**
    79 High School "Indira Gandi" – *Sofia, Lyulin region*
12. **Desislava Staykova**
    "Vasil Levski" High School for foreign languages – *Burgas*
13. **Diana Doncheva**
    "Kulata" Primary School – *Kazanlak*
14. **Dimitar Pavlov**
    "Ivan Mirchev" Primary School – *Stara Zagora*
15. **Donika Dimitrova**
    "Ekzarh Antim I" High School – *Kazanlak*
16. **Dora Marinova**
    40 High School "Lui Pasteur" – *Sofia*
17. **Elena Dimitrova**
    "Hristo Botev" High School – *Pavel banya*
18. **Emiliya Genova**
    "Bratya Miladinovi" Primary School – *Burgas*
19. **Galina Kirova**
    PMG "Vasil Drumev" High School – *Veliko Tarnovo*
20. **Galya Popova - Adirkova**
    "Nikola Velchev" Sports School – *Samokov*
21. **Ganka Mushikova**
    "Ekzarh Antim I" High School – *Kazanlak*
22. **Genka Mincheva**
    PMG "Vasil Drumev" High School – *Veliko Tarnovo*
23. **Gergana Miteva – Stefanova**
    "Hristo Botev" Primary School – *Pavel banya*
24. **Greta Koseva**
    "P.R. Slaveikov" Primary School – *Veliko Tarnovo*
25. **Greta Stoyanova**
    "Alexander Georgiev – Kodzhakafaliyata" Primary School – *Burgas*
26. **Iskra Georgieva**
    "Vasil Levski" Primary School – *Edrevo, municipality Nikolaevo, region Stara Zagora*
27. **Ivalina Nikolova**
    "Neofit Rilski" Primary School – *Gabrovo*
28. **Ivanichka Petkova**
    "St. Patriarch Evtimii" Primary School – *Veliko Tarnovo*
29. **Kameliya Krumova**
    "Ivan Vazov" High School – *Stara Zagora*

30. **Kirilka Torlashka**
“Neofit Rilski” Primary School – *Gabrovo*

31. **Liliya Borisova**
90 High School “Gen. Jose de San Martin“ – *Sofia, Lyulin region*

32. **Lilyana Minkova**
“Otets Paisii” High School – *Samokov*

33. **Magdalena Shurelova**
“Petko Rosen” High School – *Burgas*

34. **Malinka Yosifova**
97 High School “Bratya Miladinovi“ – *Sofia, Lyulin region*

35. **Mariana Boyadzhieva**
“Georgi Raychev” Primary School – *Stara Zagora*

36. **Mariana Djigova**
Professional highschool of restaurant and hotel business – *Pavel banya*

37. **Mariana Yordanova**
“General Skobelev” Primary School – *Skobelevo, municipality Pavel banya*

38. **Marianka Borisova**
“St. St. Kiril and Metodii” Primary School – *Radanovo, municipality Polski Trambesh*

39. **Mariya Dikova**
97 High School “Bratya Miladinovi“ – *Sofia*

40. **Mariya Ivanova**
“Otets Paisii” High School – *Samokov*

41. **Mariya Karcheva**
NGDEK “St. Konstantin-Kiril Filosof” – *Sofia*

42. **Milena Atanasova**
“Hristo Botev” High School – *Pavel banya*

43. **Nadya Stoeva**
40 High School “Lui Pasteur“– *Sofia*

44. **Nadya Yankova**
“Otets Paisii” High School – *Samokov*

45. **Neli Dimitrova**
“Vasil Levski“ Primary School – *Petko Karavelovo, municipality Polski Trambesh*

46. **Penka Gogova**
“Hristo Botev” High School – *Pavel banya*

47. **Penka Popova**
“St. Patriarch Evtimii” Primary School – *Veliko Tarnovo*

48. **Penka Yoteva**
“St. St. Kiril and Metodii” Primary School – *Gabrovo*

49. **Polina Hristova**
“Tsanko Tserkovski” High School – *Polski Trambesh*

50. **Radka Dimitrova**
“St. Paisii Hilendarski” Primary School – *Kazanlak*

51. **Rumyana Gamalova**
“Otets Paisii” High School – *Samokov*

52. **Silvana Lobutova**
“Otets Paisii” High School – *Samokov*

53. **Silviya Yanakieva**
“Otets Paisii” High School – *Samokov*

54. **Slaveika Budinova**
“Otets Paisii” High School – *Samokov*

55. **Snezhana Kaneva**
“Hristo Smirnenski” Primary School – *Tulovo, municipality Maglizh*

56. **Snezhana Stefanova**
“P.R. Slaveikov” Primary School – *Veliko Tarnovo*

57. **Stefan Venkov**
“Neofit Rilski” Primary School – *Veliko Tarnovo*

58. **Stiliyana Kazalova**
“Ivan Vazov” High School – *Stara Zagora*

59. **Tanya Ilieva**
“St. Patriarch Evtimii” Primary School – *Veliko Tarnovo*

60. **Tanya Kostova**
“Hristo Smirnenski” Primary School – *Tulovo, municipality Maglizh*

61. **Teodora Mineva**
Professional highschool of restaurant and hotel business – *Pavel banya*

62. **Tsvetelina Asenova**
79 High School “Indira Gandi“– *Sofia, Lyulin region*

63. **Valentina Nikolova**
“St. St Kiril and Metodii“ High School – *Gabrovo*

64. **Vanya Zheleva**
“Kulata” High School – *Kazanlak*

65. **Vasilka Baytasova**
“Hristo Maximov” Primary School – *Samokov*

66. **Veneta Kirkovska**
“Kiril Hristov” Primary School – *Stara Zagora*

67. **Violeta Gyoneva**
“Georgy Raychev” Primary School – *Stara Zagora*

68. **Violeta Mihaylova**
7 High School “Sv. Sedmochislenici“ – *Sofia*

69. **Yana Ashikova**
“Petko Rosen” High School – *Burgas*

70. **Yordanka Nedelcheva**
90 High School “Gen. Jose de San Martin”– *Sofia, Lyulin region*

71. **Yovka Ivanova**
“Petko Rosen” High School – *Burgas*

72. **Zhivka Georgieva**
“Vasil Levski” Primary School – *Gita, municipality Chirpan*

NOTES

WE STUDY THE CLIMATE, WE SAVE ENERGY, WE THINK OF THE FUTURE

TOWARDS THE INTRODUCTION OF CLIMATE CHANGE AND ENERGY EFFICIENCY EDUCATION IN SCHOOLS

ENERGY TEAM IN SCHOOL

Climate change and energy efficiency activities in school

CLIMATE
AND ENERGY EFFICIENCY

AUTHORS:
DIMITAR ZHELEV, ELENA BOYADZHIEVA, MAYA GAYDAROVA, MILENA KIROVA, SNEZHANA TOMOVA

REVIEWERS:
PROF. DR. ADRIANA TAFROVA AND PROF. DR. IRINA KOLEVA

GRAPHIC DESIGN AND PRINT: *"LAMBADZHIEV STANDART" LTD*

GRAPHIC CONCEPT AND ILLUSTRATIONS:
LILLY SAMOKOVSKA

TRANSLATION: *TEODORA STANISHEVA*

EDITOR OF THE ENGLISH VERSION: *TOM PHILLIPS*

COMPILER OF THE SERIES: *KAMELIA GEORGIEVA*

DISTRIBUTED FREE OF CHARGE

http://education.ecofund-bg.org/en/documents-materials/

ISBN 978-619-7593-32-7

NATIONAL TRUST ECOFUND

Sofia, 67B "Shipchenski prohod" Blvd

+359 2 973 36 37, ecofund@ecofund-bg.org

www.ecofund-bg.org; www.myclimate.org

CLIMATE AND ENERGY EFFICIENCY

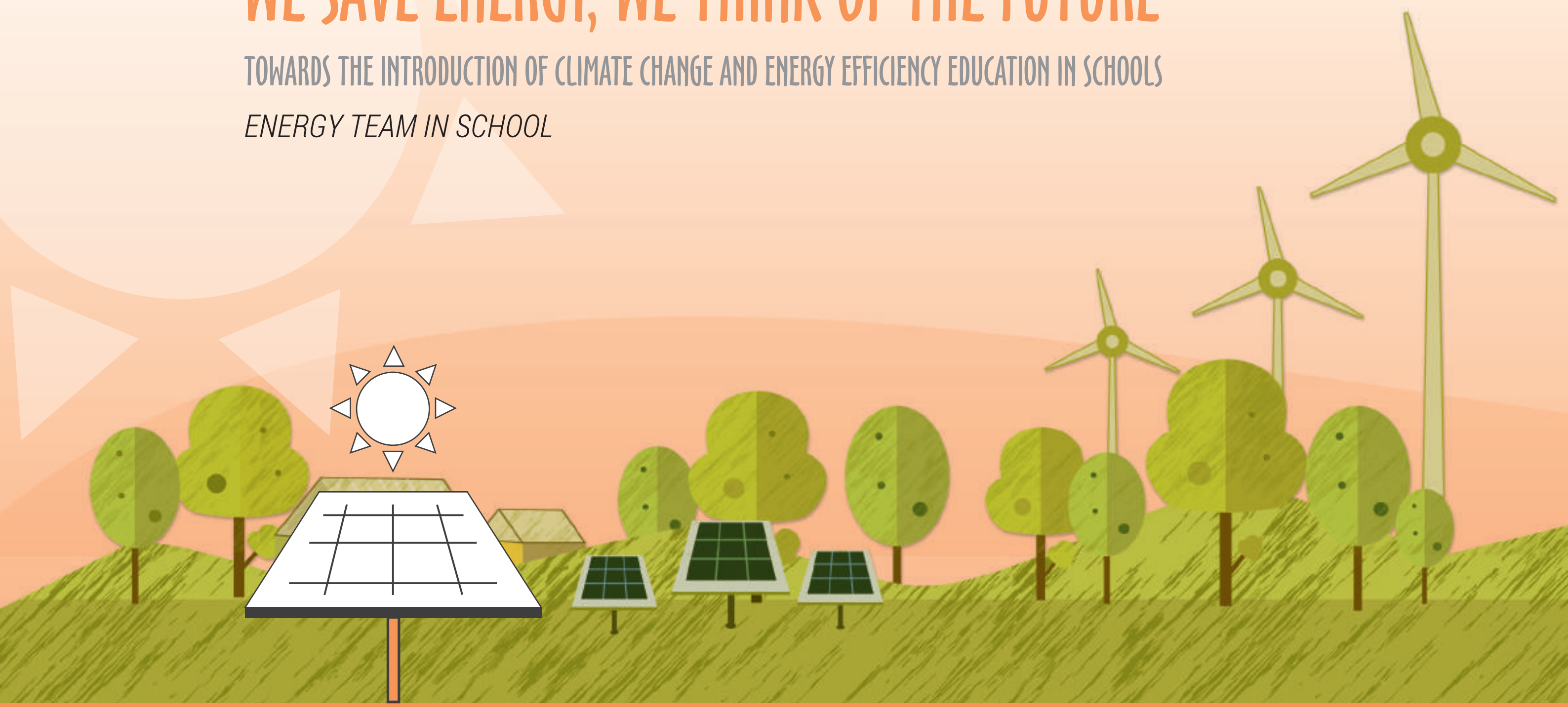
1

Climate change and energy efficiency activities in school

WE STUDY THE CLIMATE, WE SAVE ENERGY, WE THINK OF THE FUTURE

TOWARDS THE INTRODUCTION OF CLIMATE CHANGE AND ENERGY EFFICIENCY EDUCATION IN SCHOOLS

ENERGY TEAM IN SCHOOL



This project is part of the European Climate Initiative (EUKI). EUKI is a project financing tool of the German Federal Ministry of Environment, Nature Conservation and Nuclear Safety (BMU). The EUKI calls for project ideas which are implemented by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. EUKI's main goal is to encourage cooperation on climate topics in the European Union, in order to mitigate greenhouse gas emissions.

For more information please visit: ***www.euki.de***