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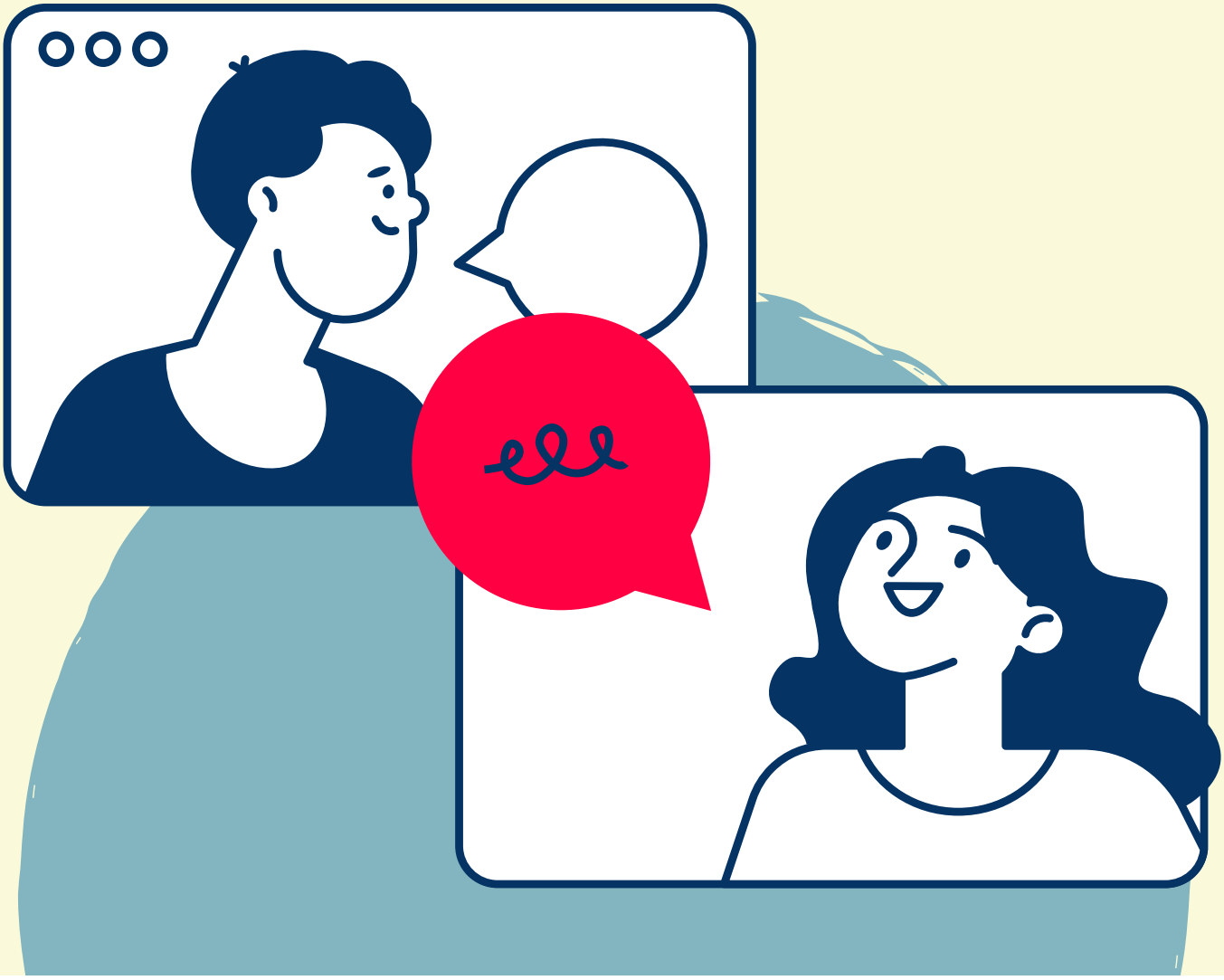
Handbook "Understanding climate change"

HOW DO WE WORK WITH STUDENTS TO FIND SOLUTIONS?



European Climate Foundation

With the financial aid of the European Climate Foundation.

Teach For Bulgaria

*The materials in this publication reflect the opinion of the author

Understanding climate change
Handbook for teachers in middle and high school

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WHAT IS CLIMATE CHANGE AND WHY IS IT IMPORTANT?

Climate change is one of the most obvious challenges of the modern world. Recently, we have become convinced that changes that once took place in hundreds of thousands of years are now happening in just a century. This acceleration is invariably due to the human factor, but a reprehensible finding alone will not contribute to improving the consequences of this. In order to reach adequate and possible solutions for all, it is important to know clearly the complex of reasons that have contributed to this situation, as well as the understanding and capabilities of each participant. This requires a set of different and diverse knowledge, skills and attitudes. And they should be present in our students' education.

The purpose of this handbook is to help and stimulate teachers and students to research together what the climate crisis is and what steps are needed to minimize its worst effects. This happens through a process of joint learning and building on what the students and the teacher already know.

Education is extremely valuable for raising awareness about global climate change and building qualities to fight against its negative effects. Studying climate change and the opportunities for a sustainable lifestyle helps build awareness, learn valuable skills, attitudes, and values that help tackle the problems caused by global climate change. And not only! The education of young generations today will determine the professions they will choose tomorrow. And our world needs more and more climate-conscious specialists and professionals from different fields.

WHAT IS THE GOAL OF THE HANDBOOK?

1. The main goal of the handbook is to increase and deepen students' knowledge in specific areas of the extensive topic of climate change and the ways in which we can reduce the harmful effects of human activity.
2. Students are expected to choose a specific area and explore in more detail all the factors that influence it, and then choose a possible aspect of the problem to seek a solution for.
3. The handbook is suitable for students from grades V – XII. It can be used in form teacher classes, electable subjects, or clubs that are connected to the environment.
4. The handbook contains 5 parts:

» Introduction: Introduction to climate change
» Nature
» Transport
» Energy and production
» Guidelines for implementation of own project.

5. Students are expected to go through the introductory section, as well as through at least one of the three topics for deeper research they choose with the teacher, relative to the context in which they live, in order to eventually complete their own project.

WHAT LESSONS DOES THE HANDBOOK CONTAIN?

1. Each thematic area contains:

» Three research lessons in which students explore in detail and depth the causes and all factors that influence the changes in the particular industry.

2. The design process guidelines for the implementation of own project include:

» Detailed instructions and worksheets for students;
» Further guidance for its implementation.

3. Each topic is presented in detail to the teacher with basic texts that explain the problem and the factors that influence it. The teacher receives brief summaries of the key points considered in the individual lessons.
4. Each lesson is written with specific instructions for activities to be done by the students; there are also student materials.
5. Glossary including the basic concepts of each lesson.

* The time set for the specific activities is indicative and you can judge how to adapt it to the needs of your students.

WHAT PRINCIPLES ARE AT THE HEART OF THE HANDBOOK?

1. The handbook and each section in it are based on the principles of project-based training. The basic logic behind each section is the acquisition of in-depth knowledge about the relevant topic and the passage through a process of finding and inventing a solution.

2. To make this happen effectively, each of the lessons is based on the following 6 principles:

» **Authenticity** – We work with real cases from our surroundings.

» **Challenge** – We work on higher thought processes and are provoked to seek answers and possible solutions to various questions.

» **Partnership** – Students and the teacher are partners in the learning process; together they explore and learn from each other. Students' opinions are heard and respected.

» **Reasoning** – We seek scientific arguments and real facts to support our claims and hypotheses. We work with scientific principles and look at the possibilities from different angles.

» **Awareness** – We often reflect on the learning process and develop our own skills in it.

» **Significance** – We work on real problems and engage all stakeholders.

Table of content

Introduction to climate change

LESSON 1

WHEN AND WHY PEOPLE STARTED TO STUDY CLIMATE CHANGE?

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OBJECTIVES AND KEY POINTS

This lesson carries students on a journey in time to become familiar with the development of climate change science. During the lesson, students also learn about basic concepts of the topic and understand the importance of the problem nowadays.

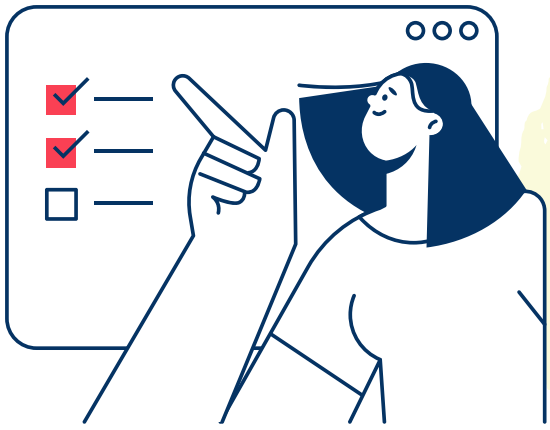
Climate change and the past

1. Students become familiar with basic scientific findings that form the basis of the arguments for global warming of the atmosphere as a result of human activity.

Climate change – what is it and how does it affect us

1. Students understand what greenhouse effect is and what its relationship to the Earth's atmosphere is.

2. Pupils understand the link between the concentration of greenhouse gases in the atmosphere and its temperature.



Materials and time required

- Printed worksheets/ Google doc
- Multimedia

The lesson lasts 40-60 minutes.

LESSON PLAN

Engagement –
True or False game

In this activity, you are expected to acquaint the students with the subject, to provoke their curiosity and to check what knowledge they already have on the subject. On this basis, you can give them the subsequent tasks and activities.

Activity flow:

1. Present the True or False game to students. Explain to them that you are going to show (using the OHP)/read them different statements, and they have to say whether they agree or disagree with them.
2. Read out loud the statements one by one.
3. Allow pupils to justify their answers and hear different views. Then announce and explain the correct answer.
4. Only then go to the next statement.
5. After the discussion, you can sum up the significance and scale of the subject of climate change :

Climate change has an impact on the world's natural landscape. This also concerns people and their lives, as we are an integral part of nature. Unfortunately, over the last 100 years, we have been witnessing an increase in greenhouse gas concentrations in the atmosphere, which creates the phenomenon of global warming, which in turn accelerates climate change, which is no longer a natural process, but provoked by human activity. We now have to look at what, how and when was discovered on this subject, in order to better understand the possible solutions.

Statements:

- Leonardo DiCaprio and Greta Thundberg traveled a month with a boat from Sweden to the United States to draw public attention to the issue of carbon emissions and climate change (False. Leonardo is a great supporter of Greta and calls her a "leader of our time", but Greta sailed without him on board the Malizia II racing yacht from Plymouth to New York.)

- Scientists believe that climate change poses an immediate and potentially irreversible threat to human societies and the planet. Recognizing that, in 2015, most of the countries around the world agreed to work together to limit global warming to 2°C. (True. 192 countries signed the Paris Agreement.)

- The terms “climate change” and “global warming” mean the same thing. (False. Climate change is a consequence of global warming.)

- When we talk about “greenhouse gases”, we mean “carbon emissions”. (False. In addition to carbon dioxide, there are other greenhouse gases; however, it is accepted that all greenhouse gases are reported as carbon dioxide equivalent (equivalent means that other greenhouse gases are compared to carbon dioxide).

- The main reason for global warming are greenhouse gases that people generate. (True. Greenhouse gases are naturally present in the atmosphere; however, the emissions resulting from human activities cause the phenomenon of global warming.)

- The presence of greenhouse gases in the atmosphere and their connection to the climate on Earth have been subject to scientific interest since the end of the XIX century. (True. Swedish scientist Svante August Arrhenius and the Irish physicist John Tyndall are among the first scientists to have observed this relationship.)

- The effects of climate change are the same for all people in the world, regardless of their geographical location. (False. As the climate is different in different places around the world, its change can also not be the same.)

Research

Students are made aware of the development of the science on climate change to assess the importance and scale of the problem. They work in groups with the aim of placing the main achievements, methods and conclusions of the climate change science along a time-line.

Activity flow:

1. Tell the students that you are about to learn when and why people have begun to deal with climate change and what have been the main achievements since XIX century.

2. To do this, they will work in groups.* Each group will receive questions and a text in which to look for the answers.

» Worksheet – Group 1
» Worksheet – Group 2
» Worksheet – Group 3

**Divide students into 3 or 6 groups depending on their number in class.*

3. In each copy, students will be given questions to answer briefly.

4. Their task is then to elect one representative of the group, who will summarize the main answers in front of the class.

5. Draw a time-line on the board and let each of the groups note the most important information that has been summarized by working with the text.

6. Then discuss the following issues in a discussion with students:

» What is climate change?
» Why have people started to pay attention to climate change?
» How did the conclusions reached during the different epochs differ?
» How has this knowledge been used and what are the results?
» What are the basic and unchanged facts and why?

7. Summarize the main conclusions of the discussion

- Climate science started its development two centuries ago.
- Even with the first achievements of the Industrial Revolution, scientists assumed that the massive carbon emissions that we generate and which remain in the atmosphere could lead to its warming.
- There has been a lot of speculation around the issue of climate change in societies around the world, but science has proven that the problem is real and requires swift action.

Wrap-Up

This is the time to close the first more detailed presentation of the subject of climate change and to summarize what the pupils have learned.

1. Explain to students that they have become aware of concepts and issues surrounding climate change through this activity.

2. Ask pupils the following questions and let each one of them think and write their answers on their own.

- 1 thing that struck me the most from what was read and discussed? Why?
- 2 things which have changed in my way of thinking on this subject?
- 3 things I would like to learn further?

3. Explain to them that we are not looking for a correct answer here, but would like to hear their own impressions and thoughts.

4. Summarize their responses, avoiding any judgment of what they share, and remind them that in order to have a genuine learning process it is important to hear different views and opinions, to share experiences and questions in order to build on our real understanding.

5. Tell them that the topic of the next lesson will be: Carbon emissions and climate change, with which we will deepen our understanding of the causes of climate change as a process.

Prepare answers to the following questions and share them with your class mates.

1. Which greenhouse gases does the text cover?
2. What is the greenhouse effect, and how does it work?
3. Are greenhouse gases beneficial and, if so, in what quantities?

XIX Century

In 1827, French mathematician and physicist Jean-Baptiste Joseph Fourier made us aware of the idea that the Earth's atmosphere has the ability to retain heat. The same way we retain heat in greenhouses used for growing vegetables. There are different gases in the composition of the earth's atmosphere. Among them, according to Fourier, there are such which turn our atmosphere into a greenhouse. Let us call them greenhouse gases.

Beakers

In the 1850's, Eunice Newton Foote, a US scientist, experimented with two closed beakers, full of different gases, placed in sunlight. One contained a mixture of nitrogen, oxygen and other gases, including carbon dioxide, and the other one – just carbon dioxide. Both had thermometers attached. While the sun's rays heated them, Foote noticed that the beaker filled with just carbon dioxide heated up faster and cooled down more slowly. The results made her think about the relationship between **carbon dioxide** and air temperature. There you have our first greenhouse gas.

The sun and the earth

Three years later, Irish physicist John Tyndall shared the same basic idea. He found out that part of the solar energy reaching the ground and reflected by it remains in the earth's atmosphere. He discovered that carbon dioxide, **methane and water vapor** have the capacity of absorbing this energy. There you have two more greenhouse gases.

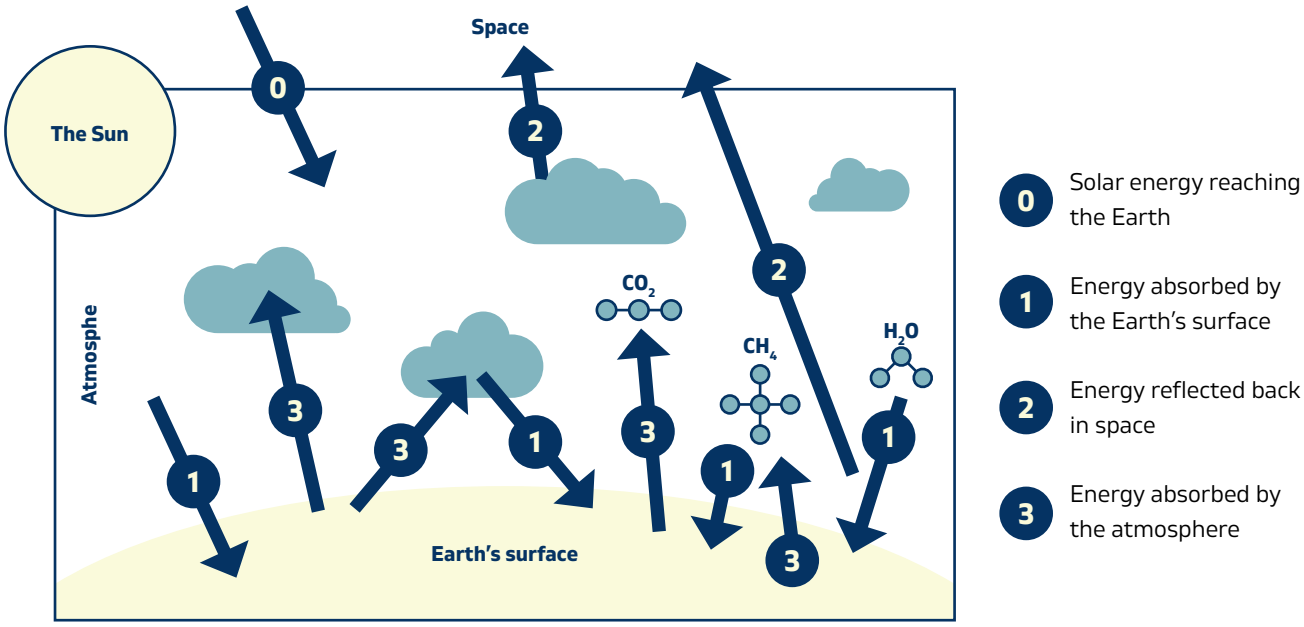


Figure 1: Solar energy and the Earth

Volcanoes

At the end of the XIX century, Swedish scientist Svante August Arrhenius worked on the relation between carbon dioxide and glacial periods. Scientists already know that volcanic activity leads to a significant amount of greenhouse gases, which, in turn, guarantee a sufficiently warm atmosphere for the normal life processes of the organisms. Arrhenius wondered what would happen if volcanoes did not erupt for a sufficiently long period of time. Would it not cause another ice age? And so he set about calculating how much the atmosphere would cool down if the amounts of carbon dioxide were half their volume. The result was a decrease **of the mean surface temperature** by 5 °C. This, in turn, would guarantee the planet entering an ice age.

Rock in space

In fact, if we stripped our planet from its atmosphere, we would have a bare rock floating in space, the surface temperature of which would be about minus 18 °C. Or as John Tyndall said in 1863: "Remove water vapor from the air for a summer night and you will certainly destroy every plant which cannot survive at or below 0 °C." Thanks to greenhouse gases, we enjoy an annual average temperature on the ground of about 14.4 °C. Their share in the composition of the atmosphere is striking – they are an extremely small part of its volume – between 0 and 4% for water vapor, 0,04% for carbon dioxide, and 0,00017% for methane.

Prepare answers to the following questions and share them with your class mates.

1. Why was precisely the Industrial Revolution the moment of change in the concentration of carbon dioxide in the atmosphere? What was the change that came about?
2. What is the link between the concentration of carbon dioxide in the atmosphere and its temperature?
3. What according to Guy Stewart Callendar can the change in the concentration of carbon dioxide in the atmosphere lead to?

XX century

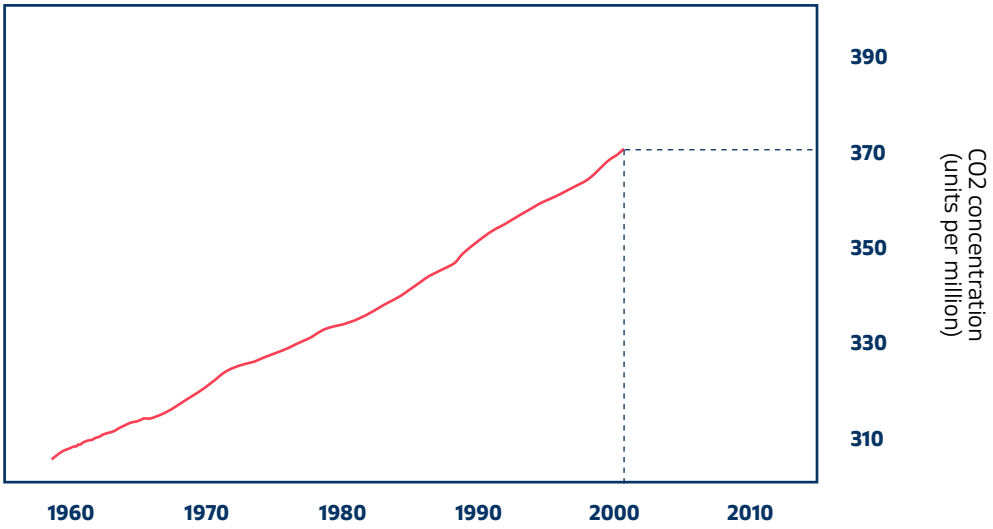
One of the important scientific figures of the XX century was the British engineer and inventor, Guy Stewart Callendar. In 1938, he published his theory that the warming of the Earth's atmosphere, resulting from an increased concentration of **greenhouse gases** in it, could lead to **a change in the Earth's climate.** He associates this increase in the concentration with the burning of **fossil fuels.**

Concentration

Concentration is recorded in the number of units of greenhouse gases per 1,000,000 units of atmosphere. When the units of greenhouse gases are around 180, there is an ice age and the planet's life is very different from what we know. When the levels are about 280 units, we enjoy a habitable planet. This has been the unchanging range over the last 800 000 years, from 180 to 280 units of greenhouse gases in the atmosphere. Since the start of the **industrial revolution,** levels have been constantly rising. Then, at the end of the XVIII century, a transition started from production and lifestyle related to human physical strength to machine-assisted ones. The brightest example was the coal-fired steam engine. Carbon is an essential element of coal and when burning it, we release it into the atmosphere.

The island

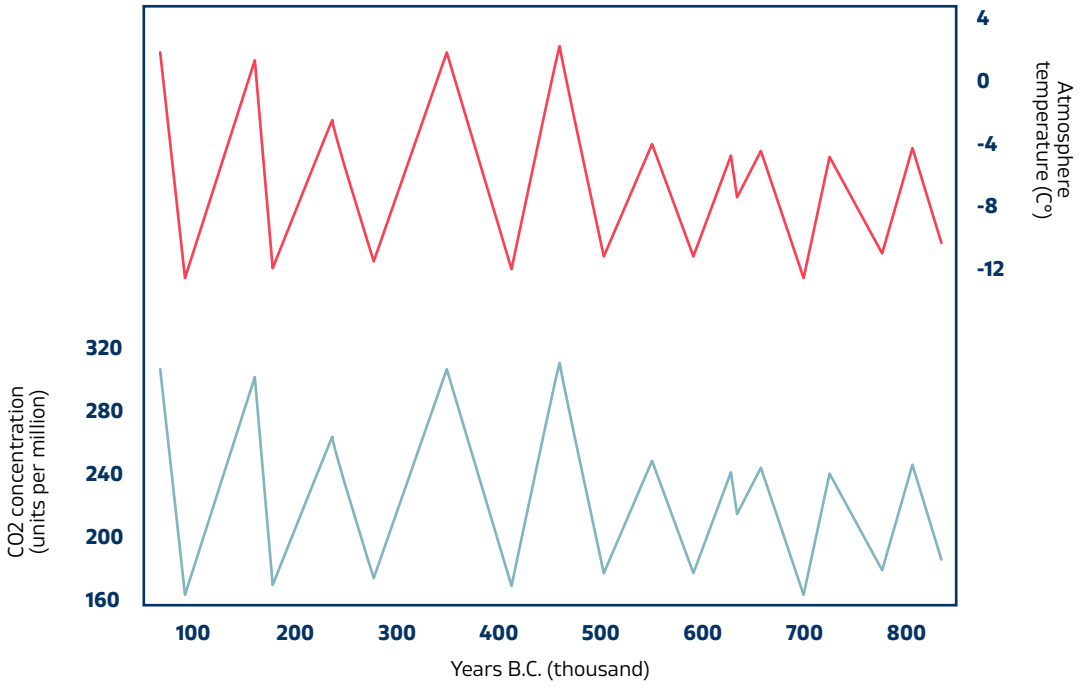
One of the important places we are examining to confirm the increase in the concentration of carbon dioxide in the atmosphere is at the heart of the Pacific Ocean. There, on the island of Mauna Loa, is the observatory where, in 1958, oceanography professor Charles David Keeling began measuring the concentration of carbon dioxide. The results were unambiguous. At the end of the XX century, the concentration of greenhouse gases reached 370 units.



Source: National Oceanic and Atmospheric Administration

The ice

Other important places we are studying to confirm the link between the concentration of carbon dioxide in the atmosphere and the temperature on Earth are the Antarctic and Greenland. Scientists there are taking out **ice balls,** some from depths of 3 kilometers. Air bubbles are trapped in the different layers of ice from the day when this layer was formed by the snow that fell then. Studying the chemical composition of the air, scientists measure the concentration of oxygen, nitrogen, carbon dioxide and, using **empirical data** on the heat they are able to retain, establish the temperature in the past.



Source: National Oceanic and Atmospheric Administration

Prepare answers to the following questions and share them with your class mates.

1. The Earth's climate has kept changing. But within certain limits. What was the reason for the first unprecedented change?
2. According to the information in the text, will the concentration of greenhouse gases in the atmosphere increase or decrease in the near future? Why do you think so?
3. What is carbon inequality and what is it due to?

The conclusion

Let us read about the United Nation's Intergovernmental Panel on Climate Change. Its has 195 member countries and thousands of experts from around the world contribute to its work by analyzing and compiling data on climate change. The experts' conclusion in 2021 was that human activity was undoubtedly the one which affected the planet's climate in an unprecedented way. This conclusion was reached after nearly 200 years of scientific research, including 30 years of work by the expert group.

The line crossed

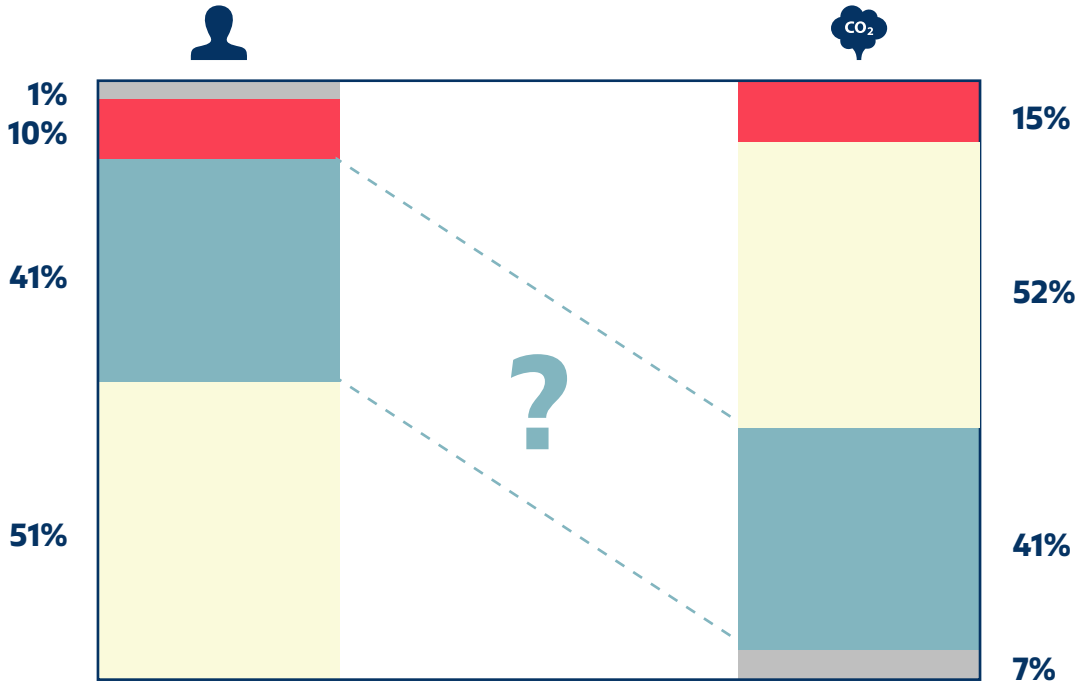
Modern lifestyle is driven by the increasing production and consumption of energy. The need for energy of growing economies such as China and India is growing by the day. At the same time, countries such as the United States have no intention of shrinking their economies.

More than 80% of the energy is produced by burning fossil fuels, which adds more and more greenhouse gases to our atmosphere and thus increases their concentration. At the beginning of the XXI century, this increase was 32% against the limit known for the last 800 000 years. Today, the increase is already by 50% against that limit.

Science is telling us that the higher the concentration of greenhouse gases, the warmer the Earth's atmosphere. Crossing the line, we are creating a phenomenon called global warming. It in turn leads to climate change on Earth.

Carbon inequality

According to an Oxfam International and Stockholm Environment Institute study, the human generated world contribution to increasing greenhouse gas emissions by consumption and rising income is allocated as follows:



Source: Oxfam Inernational and SEI (2020)

- The wealthiest 10% of the people are responsible for 52% of emissions and the richest 1% of them – for 15%.
- People with average income (40%) are responsible for 41% of emissions;
- The poorest 50% of people are responsible for 7% of emissions.

Let us not forget one more thing. The richest 10% of people live on each of the continents. When we talk about carbon inequality, we should understand both the poorer and richer communities within countries. India, for example, has the highest concentration of poor people in one country in the world, but also a very rich elite.

Introduction to climate change

LESSON 2

WHAT IS THE ROLE OF CARBON IN CLIMATE PROCESSES?

European Climate Foundation

With the financial aid of the European Climate Foundation.

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OBJECTIVES AND KEY POINTS

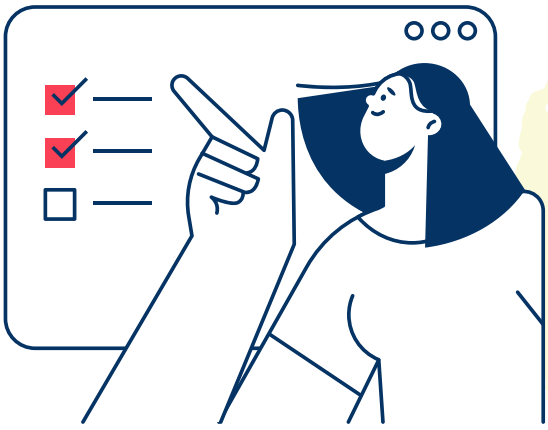
This lesson provides students with an opportunity to deepen their knowledge on the issue of carbon emissions and their link to climate change. In order to understand the specific nature of the problem, we will first distinguish between the carbon reservoirs and sources of carbon in nature from man-made sources. Then we will look at what carbon and carbon cycle are. Finally we will learn what carbon footprint is and why we are aiming to make it zero.

Climate change and carbon

1. Understand the carbon cycle and the reason the equilibrium of this cycle has been disturbed.
2. Understand the concept of carbon footprint.

Climate change – what is it and how does it affect us

1. Students explain the essence of the zero carbon emissions target by 2050.



Materials and time required

- Printed worksheets/ Google doc
- Glossary
- Multimedia

The lesson lasts 40-60 minutes.

LESSON PLAN

Engagement

Students examine images of natural and man-made elements and share their hypotheses about possible interrelationships. Students understand what carbon reservoirs are and which the anthropogenic carbon sources are.

Activity flow:

1. Show students the following images.
2. Let them identify what they see on the individual images.
3. Let them make a hypothesis as to how the displayed images are interlinked.
4. Summarize the main interrelations together:

» We saw individual images of rocks, atmosphere, the ocean, a forest, soil, agriculture, fossil fuels and energy production, transport, buildings, factories. The common element among all images is carbon dioxide. Some of the images show what we call **carbon reservoirs.** These are the places where it is stored and through which carbon passes during its cycle in nature. Since it passes, these reservoirs are **natural carbon sources.** They include rocks, the atmosphere, oceans, forests, and soil. Other images show **man-made carbon sources.** These include the fossil fuels for energy production, which are in turn used by industry, transport, and in buildings. Another source is agriculture and its related practices, including forest management.

» Man-made carbon becomes part of the natural cycle of this chemical element. In the next steps of this lesson, we will see how this affects carbon reservoirs and natural elements.

Study

Pupils work in pairs, with their main tasks being to familiarize themselves with:

- The topic of the carbon cycle;
- The disturbed balance in the carbon cycle;
- The goal of reducing carbon emissions to zero.

Activity flow:

1. Tell pupils that they will get to know in details the natural carbon cycle.
2. To do this, they will work in pairs.
3. Every student should get familiarized with the following text in Worksheet 4, which represents the carbon cycle in nature.
4. Once they get acquainted with the text, they should create an illustration showing the processes of carbon exchange in nature.
5. Let the individual pairs present their illustrations.
6. Allow time for discussion, in which everyone should share what he or she has missed out in his or her illustration, why, and how they would best explain the process of carbon transfer through natural elements.
7. Distribute copies of Worksheet 5 among students.
8. Let them discuss in pairs the reason for the Paris Agreement goals.
9. Let pupils try to build on their charts by adding the concept of zero carbon footprint.
10. Sum up that global warming is the result of the build up of greenhouse gases in the atmosphere that cannot be absorbed or taken in by the natural cycle. This calls for targets to be set to reduce greenhouse gas emissions.

Additional opportunities for students

» In addition to the materials available, each group may also conduct online research in order to deepen their knowledge about each stage of the natural carbon cycle.

» You can give them guidance on the keywords to use for the search, such as “climate change causes”, “carbon emission sources”, “carbon emissions worldwide”, “carbon footprint”.

» Recommend them main reliable sources on the topic in Bulgarian - WWF Bulgaria, Greenpeace Bulgaria, National Geographic Bulgaria, ratio.bg, Climateateka.bg, and Nauka.bg

Wrap-Up

This is the time to close the first more detailed presentation of the subject of carbon cycle and to hear more about what the pupils have understood.

1. Explain to students that they have become aware of terms and basic concepts related to climate change through this activity.

2. Ask pupils the following questions and let each one of them think and write their answers on their own.

» 1 thing that struck me the most from what was read and discussed? Why?
» 2 things which have changed in my way of thinking on this subject?
» 3 things I would like to learn further?

3. Explain to them that we are not looking for a correct answer here, but would like to hear their own impressions and thoughts.

4. Summarize their responses, avoiding any judgment of what they share, and remind them that in order to have a genuine learning process it is important to hear different views and opinions, and to share our real questions and uncertainties in order to ensure true enhancing of our understanding.

5. Tell them that in the next lesson they will be able to review their own carbon footprint and choose a sphere on which to focus in the next lessons.

Look at the images and describe what are the possible connections between them.

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Create an illustration that shows the carbon exchange processes in nature.

Carbon and its cycle

Carbon is an essential element for life on Earth. There is carbon everywhere and in everything around us. We may say that carbon is the backbone of life. The most carbon is locked in the rocks. They are followed by oceans, and soil, which has trapped more carbon than in all plants and the entire atmosphere taken together.

Earth's carbon is in a continuous cycle among rocks, water, soil, air and living organisms. In this sense, in nature every carbon reservoir is also its source. It is important to note that this cycle takes place in two ways, fast and slow.

The fast cycle

It is also called biological and includes carbon traveling among living organisms and the atmosphere and soil. Plants and phytoplankton are essential components of the rapid cycle. Plants absorb carbon from the air through photosynthesis, thus producing food for their growth. Through the food chain, carbon is then taken in by grazing animals and thence from meat-eating animals. From plants and animals, it is returned to the air though breathing. It also returns to the soil. When organisms die, their bodies, stems and leaves decompose. This process is carried out by fungi and bacteria whose biomass, together with **lignin** and **cellulose** in dead plants, are the main **carbon reservoirs** in the soil. By processing dead organic matter, bacteria also breathe and bring carbon back into the atmosphere. **Phytoplankton** also absorbs carbon from the air, again through photosynthesis, and from that point it passes along the ocean food chain.

Slow cycle

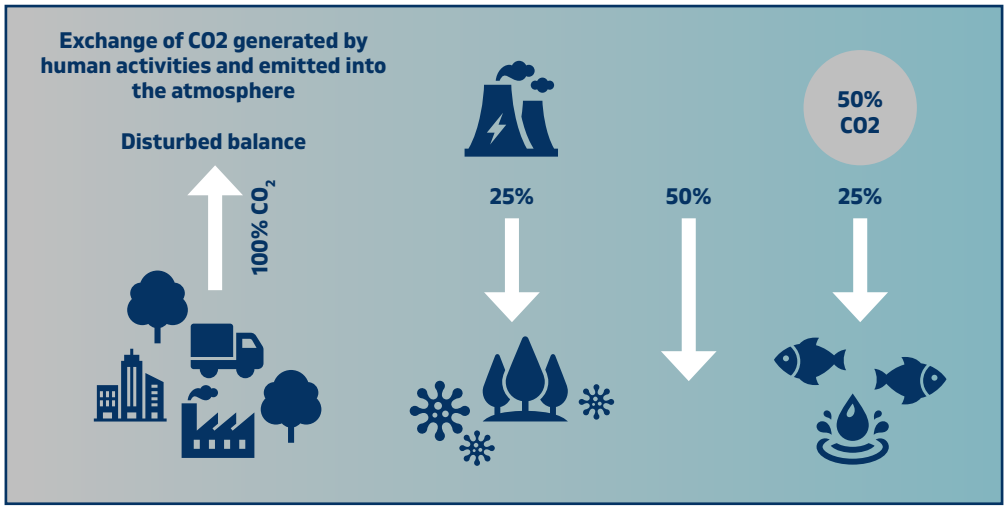
It is also called geological and we will present two examples of it. One is connected to a special acid called carbonic acid. It occurs when carbon binds with water in the atmosphere. With rain it falls on the rocks, dissolves them and thus elements such as calcium get into the ocean in an accessible form for **shellfish**. Acid is also formed when carbon dioxide is dissolved in water. This happens on the ocean surface. Thanks to the chemical reactions, carbon is again formed in an accessible form for food. Thus, using calcium and carbon, these organisms build up their shell. When they die, carbon sinks with them on the seabed. With time dead mollusks accumulate in layers and turn into limestone, thus storing carbon on the seabed.

The other example of geological cycle are volcanoes. When one tectonic plate sinks under another as a result of their collision, the carbon-rich rock of the sinking plate melts from the extremely high temperature and pressure. When this melted rock finds a way up, a volcano erupts and the atmosphere is saturated with carbon. It then binds with water or dissolves in the ocean and the process starts again.

Carbon footprint

What is curious in the carbon cycle described in **Worksheet 4** is that without human intervention the exchange between the natural elements is in equilibrium – the quantity of carbon released is equal to the amount of carbon **absorbed** or taken in.

What happens when we people intervene, adding carbon to the atmosphere? This is what we are doing by burning fossil fuels to meet our energy needs. This also happens as we use natural resources such as timber harvesting, and through the conversion of natural ecosystems into agricultural land for food production.



What happens is that 50% of the carbon added remains in the atmosphere, each year (according to *National Oceanic and Atmospheric Administration*). And for hundreds of years. This is humanity's so-called carbon footprint.

The equilibrium has been broken.

Zero emissions target by 2050

We do remember what science says, do we not? By disturbing the balance of the carbon cycle, by increasing the concentration of greenhouse gases, we are warming the Earth's atmosphere. This is how we are creating the phenomenon of global warming. It in turn leads to a climate change on Earth.

This change poses an immediate and potentially irreversible threat to human societies and the planet. Recognizing that, in 2015, most of the countries around the world agreed to work together to limit global warming to quite under 2 °C, signing the Paris Agreement.

The agreement sets out a number of conditions for reaching the 2 °C target, which include limiting the growth of carbon emissions as soon as possible, reversing the pace of emissions and bringing them to zero by 2050.

Introduction to climate change

LESSON 3

WHICH ACTIVITIES HAVE THE HIGHEST CARBON FOOTPRINT AND HOW DO WE MEASURE IT?

European Climate Foundation

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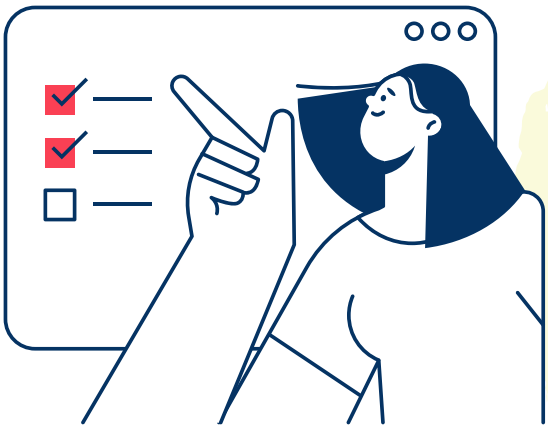
OBJECTIVES AND KEY POINTS

In the current lesson students calculate in practice their own carbon emissions and become familiar with major global sources. The lesson ends by students making a choice of one of the three topics in which to deepen their understanding and for which to propose a solution.

Calculation of carbon footprint

1. Students estimate their own carbon footprint.
2. Students explore which sectors have the greatest impact on the world's carbon footprint.
3. The class chooses one of three topics: **Natural carbon reservoirs and food industry emissions; Transport sector emissions; Energy sector emissions.**



Materials and time required

- Printed worksheets/ Google doc
- Multimedia
- Internet-enabled mobile devices

The lesson lasts 40-60 minutes.

LESSON PLAN

Engagement

In this activity, students are expected to calculate their own carbon footprint in approximate values in order for this to provoke reflection on their own actions and bring about opportunities to exert influence for the reduction of climate change.

Activity flow:

1. Tell pupils that they now understand to what extent their habits have an impact on climate change.

2. Distribute a copy of the test What is my carbon footprint? or present it on the board, instructing them to write their answers on a sheet.

3. Let everyone calculate what his or her predominant responses are.

4. Present the three categories – write them on the board and give students Post-it notes to indicate which categories they fall into.

5. Aggregate the total carbon footprint of the class and tell students that in the next lessons they will be able to discuss the individual actions that each of us can take. But also, that to achieve greater results and a noticeable reduction in the process of climate change, it is important to know the other factors that also influence it.

Research

Students understand which sectors have the highest carbon footprint (in percentage terms) and receive guidance on choosing a topic to focus on.

Activity flow:

1. Divide students into pairs. Give each of them a copy of a worksheet with a blank graph of the sources by sector.
2. Their task is to input the following sectors: Carbon emission sources: Energy for industry, energy for buildings, energy for transport, other energy, agriculture, land use and forest management, chemical industry and cement production, waste management , according to the magnitude of their respective annual carbon footprint.
3. Let different pairs share their answers and justify their proposed solutions.
4. Having listened to the pupils' hypotheses, you may present them the completed graph in Appendix 1 and outline what the main sources of carbon footprints look like at the global level.

- Every human activity, every product we use in our daily lives, absolutely everything has a carbon footprint;
- The carbon footprint is the total amount of greenhouse gases that are generated by our actions and that natural reservoirs fail to absorb or take in;
- The earth's greenhouse gases capture the heat in the atmosphere and warm the planet. The main gases we already know are carbon dioxide, methane and water vapor. Other important greenhouse gases are nitric oxide and fluorinated greenhouse gases;

» According to World Resources Institute researchers, the sectors that use the most fossil fuels are:

- Energy (74%), including the energy used in:
  - Industry (24%) – a major share of energy goes to produce the respective products;
  - Buildings (18%) – for their lighting, heating, appliances and equipment;
  - Transport (16%) – billions of people rely on petrol or diesel vehicles: their emissions are 12 percent of the total 16 percent;
  - Other energy (16%) – e.g. from mining;
- Agricultural, land use and forest management practices (18%);
  - Agriculture – plant growing and animal husbandry;
  - Land use – change in the land status, e.g. conversion of natural meadows, pastures or peatland into arable land or land for livestock farming;
  - Forest management – deforestation for the purpose of opening up space for croplands;
- Chemical and cement industries (5%);
- Waste management (3%).

» There are many alternatives to reducing these levels of carbon emissions. We will examine and discuss them together.

» "Greenhouse gases", "carbon emissions", "carbon footprint" can be used as synonyms in the context of the reduction of activities that cause climate change.

Wrap-Up

Closing lesson activities and choice of a topic for deeper research.

Activity flow:

1. Explain to pupils that in the coming lessons, they will look at how different areas of our lives affect global carbon emissions and what their impact on climate change is.

2. Reinforce the positive message that, together, we all can reduce our individual and collective carbon footprint, change the environment in which we live, slow down the pace of climate change and reduce its negative effects. Reading and exploring the subject is a first step toward climate awareness and recognizing which behaviors are harmful to the climate and which are useful and supportive.

3. Provide students with the possible topics on which they could delve deeper:

   - Nature and food;
   - Transport;
   - Manufacture and energy.

4. Invite them to look at the purple graph in Appendix 2 and to consider which of the topics listed is of greatest interest to them.

   - Sum up the message of the purple graph: The ways in which we construct buildings, infrastructure, cities and create products; the ways in which we create energy in which we move and feed ourselves affect the environment because they generate greenhouse emissions. There are many alternatives, and they are varied and have a high potential to create a more practical, eco-friendly and healthy future.

5. Ask the following questions:

   - Which of the three areas is a major source of livelihood in our region?
   - Which of the three would it be most valuable to learn more about?
   - For which of the three would it be most valuable to offer solutions?

6. Invite everyone to take part in a vote – each student is entitled to one vote for one of the three topics. The topic with the most votes will be explored within the classes to come.

7. Explain that in the next lessons they will be able to learn and study the topic in much greater detail. Then they will identify a specific aspect and a problem to find a solution for, and try to apply in the community where they live.

**You can use the chart to remind students of the concept of reduction of the carbon footprint and for them to see some of the solutions already in place in the global context.*

What is my carbon footprint?

Read the questions carefully and mark your answers

How do you usually travel?

1. By car, almost every day
2. By urban transport
3. I walk or cycle

How often do you fly?

1. Over 20 hours annually
2. About 20 hours annually
3. Under 20 hours annually

What do you usually eat?

1. Mostly meat.
2. Balanced quantities of meat, fish, dairy food
3. Vegetarian diet

How often do you eat meat (if at all)?

1. At every meal
2. Twice a week
3. Rarely

How often do you eat beef (in case you eat meat)?

1. At every meal
2. Twice a week
3. I eat meat, but not beef

How often do you eat dairy products (if at all)?

1. At every meal
2. At least 5 times a week
3. Once a week

How often do you eat out?

1. Every day
2. At least 3-4 times a week
3. Once a week

How often do you throw away food?

1. Every day
2. At least 3 times a week
3. Rarely

How often do you eat seasonal food or food made in Bulgaria?

1. Once a week
2. At least several times a week
3. Every day

How do you heat up your home?

1. Using coal and firewood
2. Using electricity
3. Using gas

Do you regularly switch off the lights at home?

1. No
2. Sometimes
3. Yes

Do you switch off appliances from the grid when you are not using them?

1. No
2. Sometimes
3. Yes

Do you have energy saving bulbs at home?

1. No
2. Some are energy saving, others are not
3. Yes

What temperature do you maintain your home at during winter

1. I do not know
2. Above 23 degrees
3. 22 degrees or lower

Do you like shopping for clothes and gadgets, and if so – how often?

1. Several times a week
2. Several times a month
3. Not very often

Have you bought a laptop or a TV during the past 12 months

1. Yes
2. Yes, but I had used the previous ones for more than 5 years
3. No

Have you bought a fridge, dish-washer, washing machine, or other piece of large home appliance during the past 12 months?

1. Yes
2. Yes, but I had used the previous appliances for more than 5 years
3. No

Have you bought a mobile phone or a tablet during the past 12 months

1. Yes
2. Yes, but I had used my previous device for more than 5 years
3. No

Have you bought home furniture during the past 12 months?

1. Yes, several pieces
2. Yes, just one piece
3. No

Do you recycle paper?

1. No
2. I do not throw away/use paper
3. Yes

Do you recycle metal (cans, tins)?

1. No
2. I do not throw away/use metal
3. Yes

Do you recycle glass?

1. No
2. I do not throw away/use glass
3. Yes

Do you recycle plastic?

1. No
2. I do not buy single-use plastic
3. Yes

Do you drink coffee or other drinks from a multi-use cup on a daily basis?

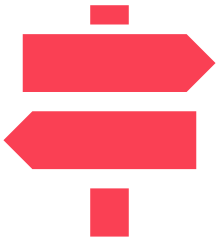
1. No
2. Sometimes
3. Yes

Do you compost the food you throw away?

1. No
2. Sometimes
3. Yes

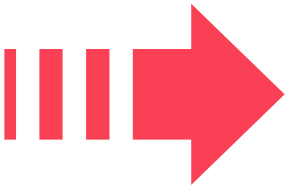
What is my carbon footprint?

Look at the key and calculate which answers predominate to see which category you fall into.



Predominant answers 1

There are many spheres of our daily life which coulda be more environmentally-friendly! You generate high carbon emissions – above 10 tons annually.



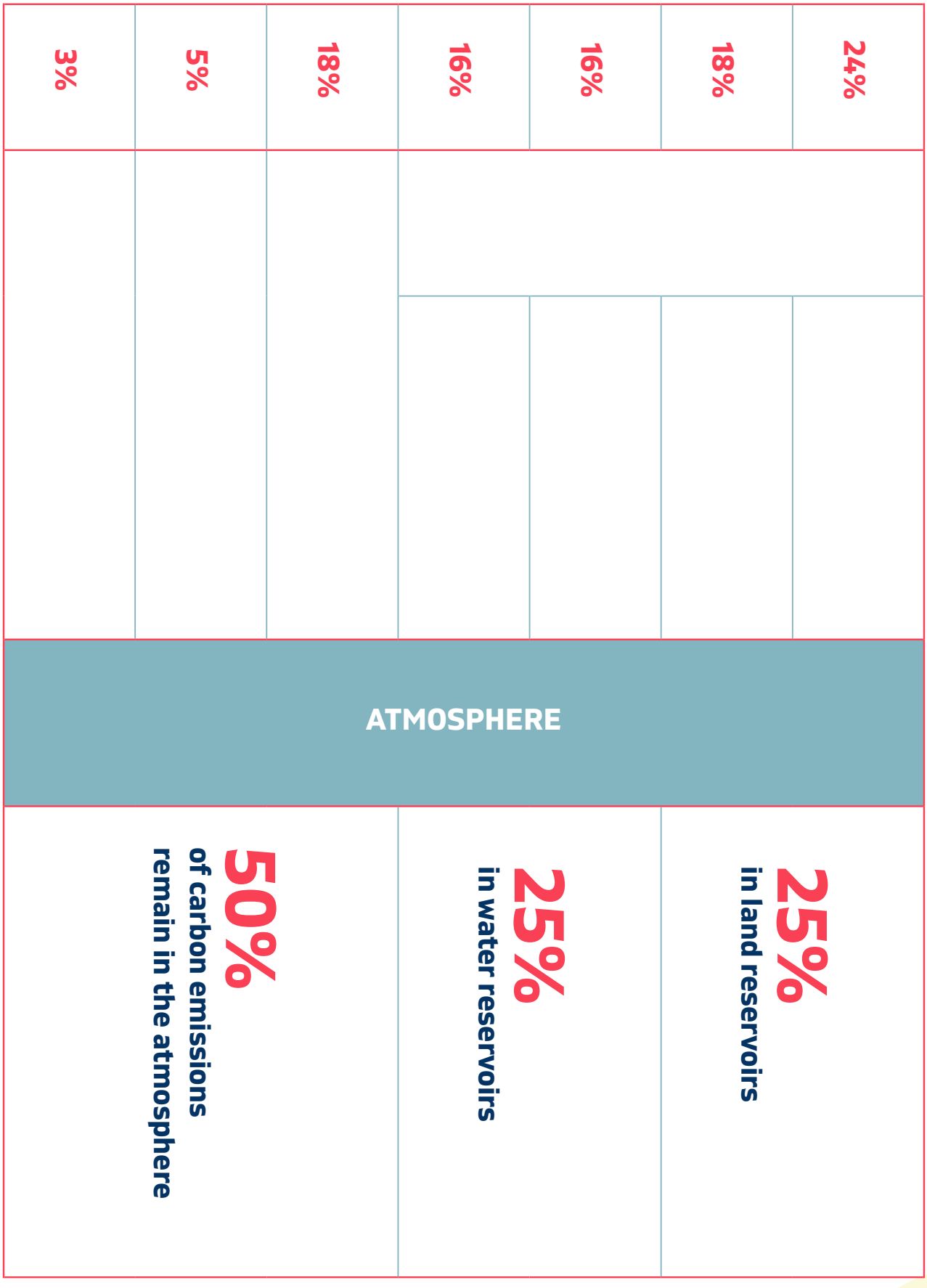
Predominant answers 2

You are moving in the right direction! You are generating an average level of carbon emissions – about 7-8 tons annually.

Predominant answers 3

Well done! You are living quite an environmentally-friendly life and generate under the average level of emissions – below 5 tons annually.

SOURCES OF CARBON EMISSIONS BY SECTOR



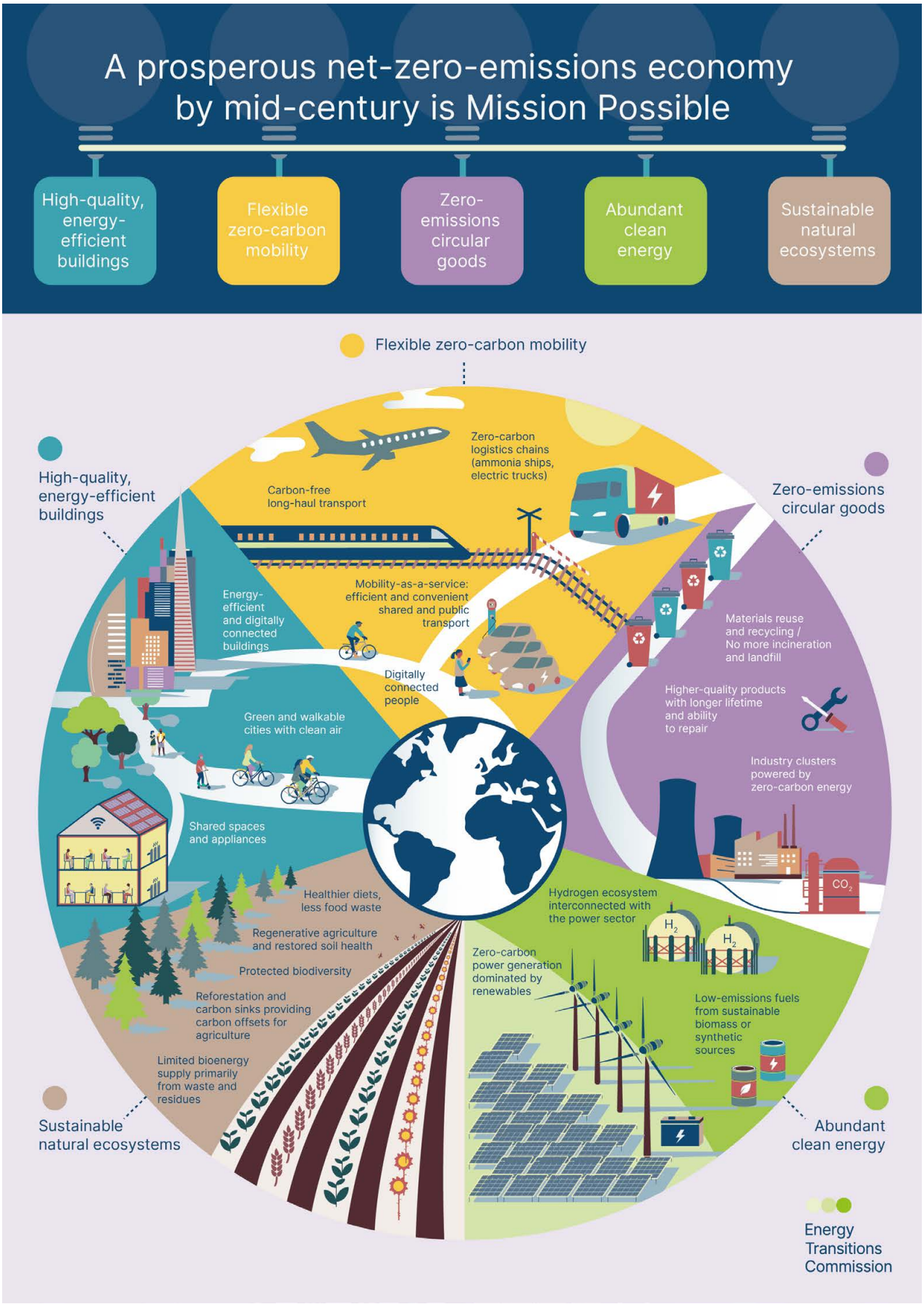
SOURCES OF CARBON EMISSIONS BY SECTOR

	Sector	Share	
ENERGY	INDUSTRY	24%	ATMOSPHERE
ENERGY	BUILDINGS	18%	
ENERGY	TRANSPORT	16%	
ENERGY	OTHER	16%	
	Agriculture, Land Use, Forest Management	18%	
	Chemical Industry, Cement Production	5%	
	Waste Management	3%	

25% in land reservoirs

25% in water reservoirs

50% of carbon emissions remain in the atmosphere


A prosperous net-zero-emissions economy by mid-century is Mission Possible
High-quality, energy-efficient buildings
Flexible zero-carbon mobility
Zero-emissions circular goods
Abundant clean energy
Sustainable natural ecosystems
Flexible zero-carbon mobility
High-quality, energy-efficient buildings
Zero-emissions circular goods
Sustainable natural ecosystems
Abundant clean energy
Zero-carbon logistics chains (ammonia ships, electric trucks)
Carbon-free long-haul transport
Energy-efficient and digitally connected buildings
Mobility-as-a-service: efficient and convenient shared and public transport
Digitally connected people
Green and walkable cities with clean air
Shared spaces and appliances
Materials reuse and recycling / No more incineration and landfill
Higher-quality products with longer lifetime and ability to repair
Industry clusters powered by zero-carbon energy
Hydrogen ecosystem interconnected with the power sector
Zero-carbon power generation dominated by renewables
Low-emissions fuels from sustainable biomass or synthetic sources
Healthier diets, less food waste
Regenerative agriculture and restored soil health
Protected biodiversity
Reforestation and carbon sinks providing carbon offsets for agriculture
Limited bioenergy supply primarily from waste and residues
Energy Transitions Commission

Natural carbon reservoirs and emissions of the food industry

LESSON 1

WHAT IS THE ROLE OF THE FOOD INDUSTRY IN CLIMATE CHANGE?

European Climate Foundation

With the financial aid
of the European Climate Foundation.

Teach For Bulgaria

*The materials in this publication reflect the opinion of the author

OBJECTIVES AND KEY POINTS

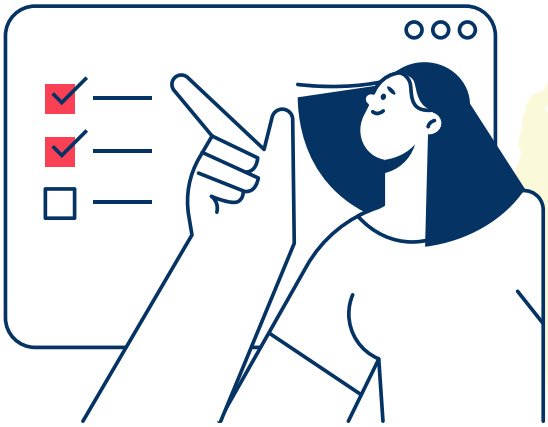
The agriculture, land use and forest management sectors account for 18% of the human-generated greenhouse gas emissions in the atmosphere. These sectors mainly serve the food industry. When we add the other servicing sectors of energy and transport to it, its footprint reaches 26%. The topic is extremely important and this lesson will help students understand how the food industry contributes to climate change.

Food industry and climate change – what is the link?

1. Students understand that food is not just a finished product, but a collection of the resources needed to create it.

2. Students understand what the carbon footprint of different food products is.

3. Students understand what the carbon footprint of the food industry is and what forms it.



Materials and time required

- Printed worksheets/ Google doc
- Color pens/pencils
- Multimedia

The lesson lasts 40-60 minutes.

LESSON PLAN

Engagement

In this activity you introduce students to the subject of food and its carbon footprint. The main idea is for students to ponder about the carbon footprint of different foods and to make a link between the effects of individual foods on human health.

Activity flow:

1. Distribute Worklist 6 and give students the task of choosing 5 favorite foods. Then they use a color code for each product and what they think is its carbon footprint.

2. The teacher then shows the correct codes and students check their prediction with the data received and correct the color code of the footprint in Worksheet 6.

3. The next task of the pupils is to create a food pyramid according to their carbon footprint. At the bottom of the pyramid students place the foods with the greatest footprint. Let them use the model of the healthy eating pyramid already studied. If necessary, they should be reminded with the help of the teacher.

4. Students compare the two pyramids and establish the link between healthy eating and the carbon footprint of food.

5. The teacher sums up:

At the end of the previous section, we said that everything that surrounds us has a carbon footprint. Food, a key element of our daily lives and a major source of energy in our lives, is no exception.

We have seen that the more resources are invested in the production of a particular food, the greater its carbon footprint. We have also seen that most of the foods that are better for our health are also with a smaller carbon footprint.

Note the fact that beef has nearly 3 times more carbon footprint than the red category (lamb, white cheese, and yellow cheese). Another interesting question could be: why is the difference between the beef and lamb on the one hand and the pork and chicken on the other so big? The answer lies in the fact that cows and sheep are ruminants, and they emit the greenhouse gas methane during their metabolism. This metabolism passes through fermentation carried out by bacteria emitting methane. Pigs and hens do not have such stomachs.

Methane is also released from paddy fields. The contribution of rice cultivation is 1.5% of total greenhouse gas emissions. This is quite a serious percentage for a single crop. However, consideration should also be given here to the calories that it supplies to the body, and the number of people for which it is a staple food. As is often the case, in developing our overall understanding of a matter, we should consider it at a systemic level. In this case, the percentage of greenhouse gas emissions for rice will no longer seem so high.

*The data provided in Worksheet 6 are the averages from 38,700 farms of 119 countries (Poore and Nemecek, 2018). There are different data available in literature, but in this case our aim is to make a rough comparison among food types, rather than having students remember the exact figure corresponding to a product's footprint.

Answers Worksheet 6

1	2	3
Product	**Assumed footprint Kg of CO2 per 1 kg of product**	**Actual footprint Kg of CO2 per 1 kg of product**
Beef		60
Lamb		24
Pork and chicken		7 and 6
Fish (farmed)		5
Eggs		4,5
Milk		3
White cheese/yellow cheese		21
Chocolate		19
Olive oil		6
Palm oil		8
Rice		4
Wheat and maize		1,4 u 1
Peas and root vegetables		0,9 u 0,4
Tomatoes		1,4
Bananas, apples, citrus fruit		0,7; 0,4; 0,3

Research

Students are aware of the main ways in which the food industry interacts and is interlinked with climate change. Their task is to study a text that highlights main parts of the issue and to create an infographic illustrating the problem.

Activity flow:

1. Explain to students that they now will have to explore in greater depth the impact that the food industry has on climate change.

2. What does the carbon footprint of food include? To this end, each student should read Worksheet 7.

3. Students perform the task after reading the text and present their work to their classmates and teachers. The teacher supplements the information with the text in the box below:

The food industry is burdening the atmosphere with ¼ of the total greenhouse gas emissions. We know that natural reservoirs are failing to absorb and take in our emissions. 50% of them remain in the atmosphere every year. It makes sense to work toward a change in the practices of the food industry. Particularly in light of the fact that 30% of all food produced goes to waste and that 821 million people are currently undernourished.

Wrap-Up

This is the time to close the first more detailed presentation of the subject of the link between the food industry and climate change.

Activity flow:

1. Explain to students that through this activity they have become aware of the basic elements of the food industry that have an impact on climate change.

2. Ask pupils the following questions and let each one of them think and write their answers on their own.

» 1 thing that struck me the most from what was read and discussed? Why?
» 2 things which have changed in my way of thinking on this subject?
» 3 things I would like to learn further?
» Do you already see more clearly the link between the food industry and climate change?

3. Explain to them that we are not looking for a correct answer here, but would like to hear their own impressions and thoughts.

4. Summarize their responses, avoiding any judgment of what is shared, and remind them that sharing questions, impressions and ideas only helps learning.

Read the instruction and fill in the table with your predictions about the carbon footprint of different food products.

From column 1, select 5 of your favorite products.

In column 2, assume their carbon footprint. To make your estimation, take into account how much resources are used to get this product to our table. Use the following color code:

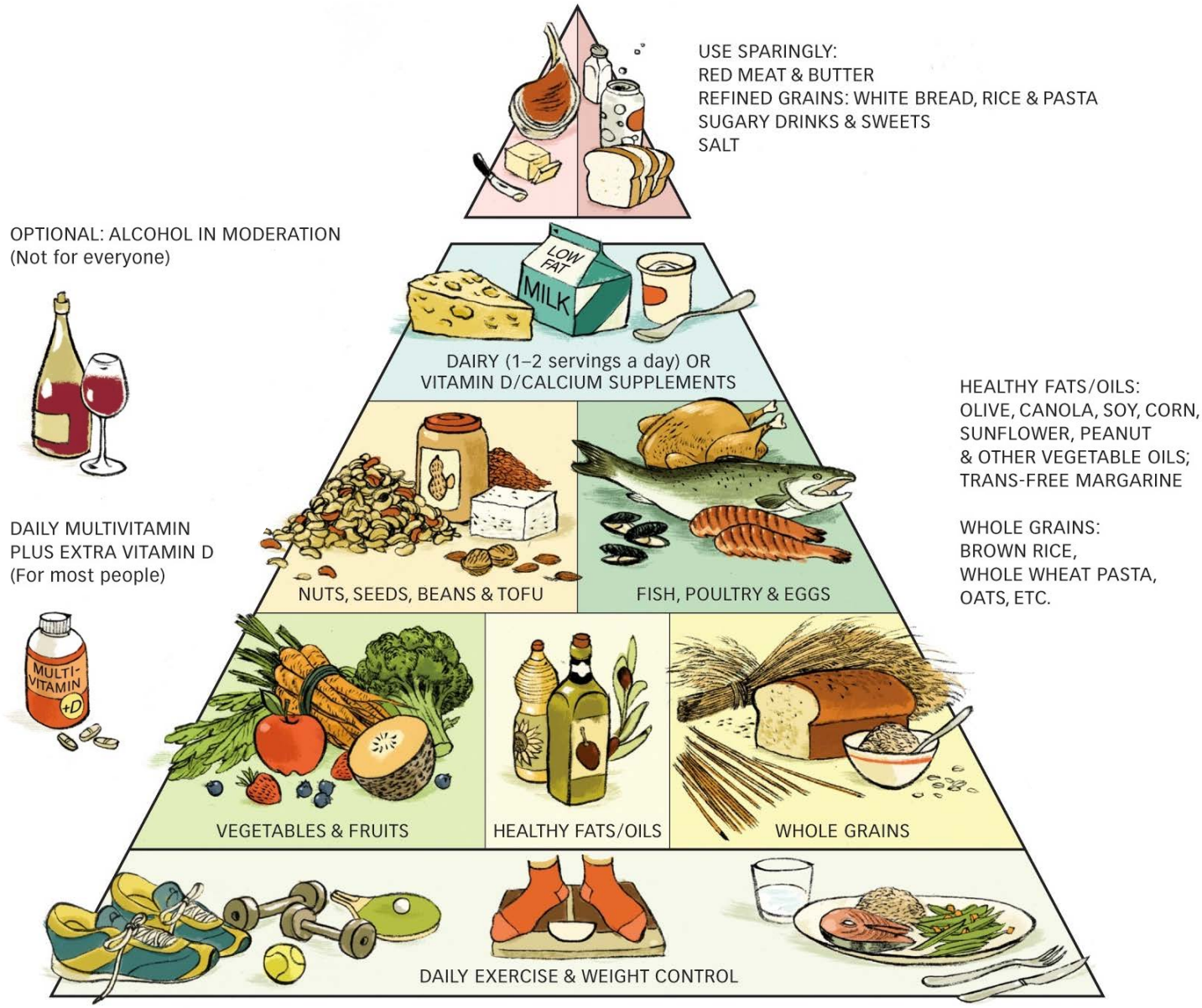
- Green, if you think that for 1 kg of the selected product 1 kg CO2 or less is emitted
- Blue, if you think that for 1 kg of the selected product 2 kg CO2 or less is emitted
- Yellow, if you think that for 1 kg of the selected product 10 kg CO2 or less is emitted
- Orange, if you think that for 1 kg of the selected product less than 20 kg of CO2 is emitted
- Red, if you think that for 1 kg of the selected product 20 kg CO2 or more is emitted

You will then learn the correct amount and note it in column 3.

1	2	3
Product	**Estimated footprint Kg of CO2 per 1 kg of product**	**Actual footprint Kg of CO2 per 1 kg of product**
Beef		
Lamb		
Pork and chicken		
Fish		
Eggs		
Milk		
Cheese		
Chocolate		
Olive oil		
Palm oil		
Rice		
Wheat, rye, maize		
Peas and root vegetables		
Tomatoes		
Bananas, apples, citrus		

THE HEALTHY EATING PYRAMID

Department of Nutrition, Harvard School of Public Health



Read the text and create a graph of your choice to represent the greenhouse gas emission sources associated with the food industry.

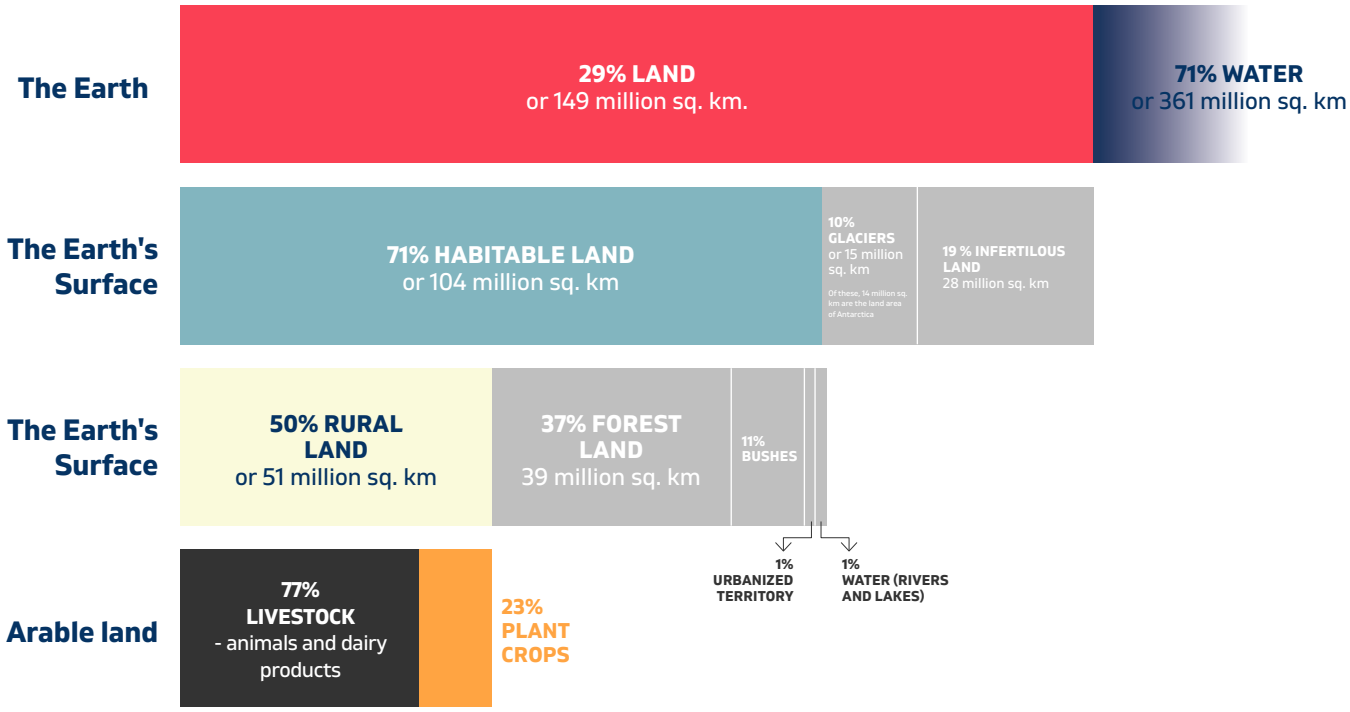
What part of the Earth is used for food?

How much of the land on the planet do we use to produce our food? We know that land constitutes 29% of our planet. Of this, 71% is suitable for food production. The rest are glaciers (10%) and other unsuitable terrains such as deserts, rocks, salt lakes, beaches and dunes (19%).

Half of this suitable land is used for agriculture. And nearly 80% of it is for livestock farming purposes. These include both terrains for animal rearing and grazing and the land used for the production of animal feed (fodder).

In other words, we use the vast majority of the land we use for food in order to feed the animals that we eat and whose products we eat. At the same time, we have seen that the greatest food carbon footprint comes precisely from animal products.

How does the food industry generate a carbon footprint?



How does the food industry generate a carbon footprint?

From the previous lessons, we have already learned that 18% of greenhouse gas emissions are due to the agriculture, land use and forest management sectors. Let us recall a number of practices that generate such emissions: animal husbandry and the management of its waste, deforestation for arable land, burning of plant waste in the production of rice, wheat, sugar cane.

A picture of a field and people working the land is now rather an artistic memory. Today, small farms, with sizes up to 20 decares (200 by 200 meters), produce 35% of the food and use only 12% of agricultural land (Food and Agriculture Organization, 2021). All the rest is the product of large food producers, who use the practices of so-called **intensive farming.** They mainly involve the almost complete mechanization of the process, as well as the use of products of the chemical industry such as nitrogen fertilizers.

Why are these practices of interest in terms of climate change?

On the one hand, we have emissions from the fuel used by the machinery, on the other hand, from the energy-intensive production of fertilizers, which requires very high temperature and pressure. In addition, emissions are also released after their use by farmers. The crops take only about half of the fertilizers applied (the Royal Society, 2020). Part of the other half is processed by the bacteria in the soil and is released as nitric oxide in the atmosphere. Here is another greenhouse gas that we are now familiar with. Nitrogen fertilizers alone account for 1.5% of total emissions from human activity.

In what other way does the food industry contribute to the carbon footprint?

When we talk about the food industry – the main consumer of the sectors listed above – the percentage is even higher. We also need to add the emissions caused by the energy used to process food, the energy used to transport it, the energy used to store it in shops – it often needs to be in cold conditions – the emissions from packaging production and their subsequent treatment. Adding all this, the percentage of emissions associated with the production of our food reaches 26% of the total human-generated emissions (Food and Agriculture Organization, 2018).

Natural carbon reservoirs and emissions of the food industry

LESSON 2

WHAT IS ROLE OF SOIL AND FORESTS PLAY IN CLIMATE CHANGE?

European Climate Foundation

With the financial aid
of the European Climate Foundation.

Teach For Bulgaria

*The materials in this publication reflect the opinion of the author

OBJECTIVES AND KEY POINTS

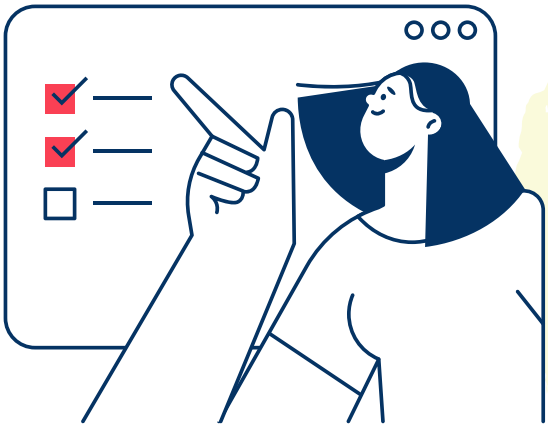
This lesson provides students with an opportunity to learn what the direct link between climate change, forests, and soils is.

Forests and soils as carbon reservoirs

1. Students learn about the limitations of soils and forests as carbon reservoirs.
2. Students understand the pressure people exert on these reservoirs.
3. Students learn about possible solutions to maintain the capacity of soils and forests as carbon reservoirs.

Agriculture, land use, and forest management practices – impact on land reservoirs

1. Students research the effects and impact of agriculture, land use, and forest management on forests and soils.



Materials and time required

- Printed worksheets/ Google doc
- Multimedia
- Internet-enabled mobile devices

The lesson lasts 40-60 minutes.

LESSON PLAN

Engagement

Objective and description: In this activity, you are expected to acquaint students with the subject and provoke their curiosity. This is a good opportunity to find out what they already know on the subject, and what additional knowledge and clarification they need.

Activity flow:

1. Make an introduction and tell students that the topic you will be looking at together is "Climate change, forests and soils". Tell them that before they start researching you want to hear their current perception and understanding of the topic. Ask them the following questions:

» Can you guess what the common thing between forests and soils is? What is this thing that connects them?
» In your view, what is the link between climate change, forests and soil?

2. Let each of them, within 3 minutes, provide their own hypothesis about the relationship between forests, soil, and climate change. You can remind students about the ideas discussed in Lesson 2 of the introductory section or help them with a further question: What is your relation to the carbon footprint?

3. Divide students into small groups (3-4 students). Let each of them share their hypothesis. Give them a group task to find a common thing among the associations of each group and to reach a group hypothesis. (10 minutes)

4. Allow each group to share its thoughts.

5. Summarize the main trends among the responses and, if necessary, add to these, in order to reach the understanding that:

- Forests and soils are the two reservoirs where carbon is stored on the planet on land. Furthermore, apart from storing it, they are also involved in its cycle, which is their relationship to climate change.
- Another thing that binds them is their involvement in the cycles of water and nutrients.

Research

Purpose of the research: Students work in pairs and learn about the link between forests and soils on the one hand, and climate change.

Activity flow:

1. Present the topic – forests, soil, and climate change.

2. Divide students in pairs, in which everyone gets acquainted with one of the two texts:

- Worksheet 9: Forests and climate change
- Worksheet 8: Soils and climate change

3. On the basis of discussions on the texts, give students the task of summarizing the answers to the following questions:

- How do farming, land use, and forest management practices affect forests and soils?
- What is the current capacity of forests and soils in their role as carbon reservoirs?
- What would happen if we continue to lose natural carbon reservoirs, such as forests and soils?
- What are the existing solutions to conserve forests and soils?

5. Allow students to discuss with each other and finally invite them to share the answers they have reached and to generate questions that remain in them after they become familiar with the material.

6. Hold a discussion with students on the question they have generated.

7. Sum up that:

It is important to remember that soil and forests are finite resources. At first sight, this may not seem to be the case. These resources are created, restored and renewed in a natural way. However, their reaching the age necessary in order to be valuable carbon reservoirs takes too long. In the meantime, we are constantly adding carbon to the atmosphere which intensifies global warming, which in turn may compromise their ability to form, recover, and renew.

How do farming, land use, and forest management practices affect forests and soils?

Those practices (adding chemical agents, deforestation, erosion) deplete natural reservoirs, thereby also reducing their carbon storage capacity.

What is the current capacity of forests and soils in their role as carbon reservoirs?

The current capacity is insufficient to compensate for the quantities that we, humans, emit into the atmosphere. Forests and soils are actively involved in the carbon cycle. This means that they also emit carbon. That is, they are not just reservoirs that take it. What is more, in the event of a forest fire, very rapidly, a lot of carbon is returned to the atmosphere. Much faster than the time during which it has accumulated in the woody biomass.

What would happen if we continue to lose natural carbon reservoirs, such as forests and soils?

Then we will have more carbon in the atmosphere, which will mean its even more intense warming. Less forest, more heat. This heat will in turn cause the Earth's surface to warm up. A big part of it is the permafrost. Territory in the Northern Hemisphere twice the size of Europe. These are areas where the temperature rarely rises above zero. There are such places around the world (Greenland, Alyaska, Russia, China, Eastern Europe). They contain significant amounts of carbon. When the ice melts, through its cycle, carbon will be released into the atmosphere, which will further increase global warming.

What are the existing solutions to conserve forests and soils?

A change in practices is key to the preservation of natural reservoirs. Agriculture should reflect the way in which food is produced and consumed in nature. Organic resources are in a constant cycle, providing enough nutrients without depleting the reservoirs.

We must stop looking at the reservoirs as systems from which to extract resources and start treating them as systems that support life on the planet. In other words, we need to change our attitude and behavior, and that means the values which we live by and which determine our mindset. Let us look beyond our nose, overcome our narrow-mindedness and live with care and love for ourselves and the world around us.

Wrap-Up

Short presentation: This is the time to close the topic and hear more about what the students have understood.

Activity flow:

1. Explain to students that during this activity they have become aware of the interaction between climate, soil, and forests as key players in the process of climate change.

2. Ask students the following questions and let each one of them think and write their answers on their own:

» 1 thing that struck me the most from what was read and discussed? Why?
» 2 things which have changed in my way of thinking on this subject?
» 3 things I would like to learn further?

Remind them that we are not looking for a correct answer here, but would like to hear their own initial impressions and thoughts.

Read the text and answer the following questions:

- How do farming practices, land use and forest management affect forests and soils?
- What is the current capacity of forests and soils in their role as carbon reservoirs?
- What would happen if we continue to lose natural carbon reservoirs such as forests and soils?
- What solutions are available to conserve forests and soils?

Summarize your answers and discuss them with your class-mate.

What is the soil?

This is the surface layer of the Earth, thanks to which we receive 95% of the food we consume (Food and Agriculture Organization, 2015). This is possible thanks to a soil feature, namely – its fertility.

Did you know that the formation of the fertile layer on which we grow our food today started 1000 years ago? Yes! It takes so long to produce 1-3 centimeters of fertile ground. Soil fertility depends on many factors: **physical (mechanical structure of the soil), biological (the richness of the world of organisms, actively participating in the soil carbon cycle) and chemical (acid:alkaline balance).**

What are the challenges before soil as a carbon reservoir?

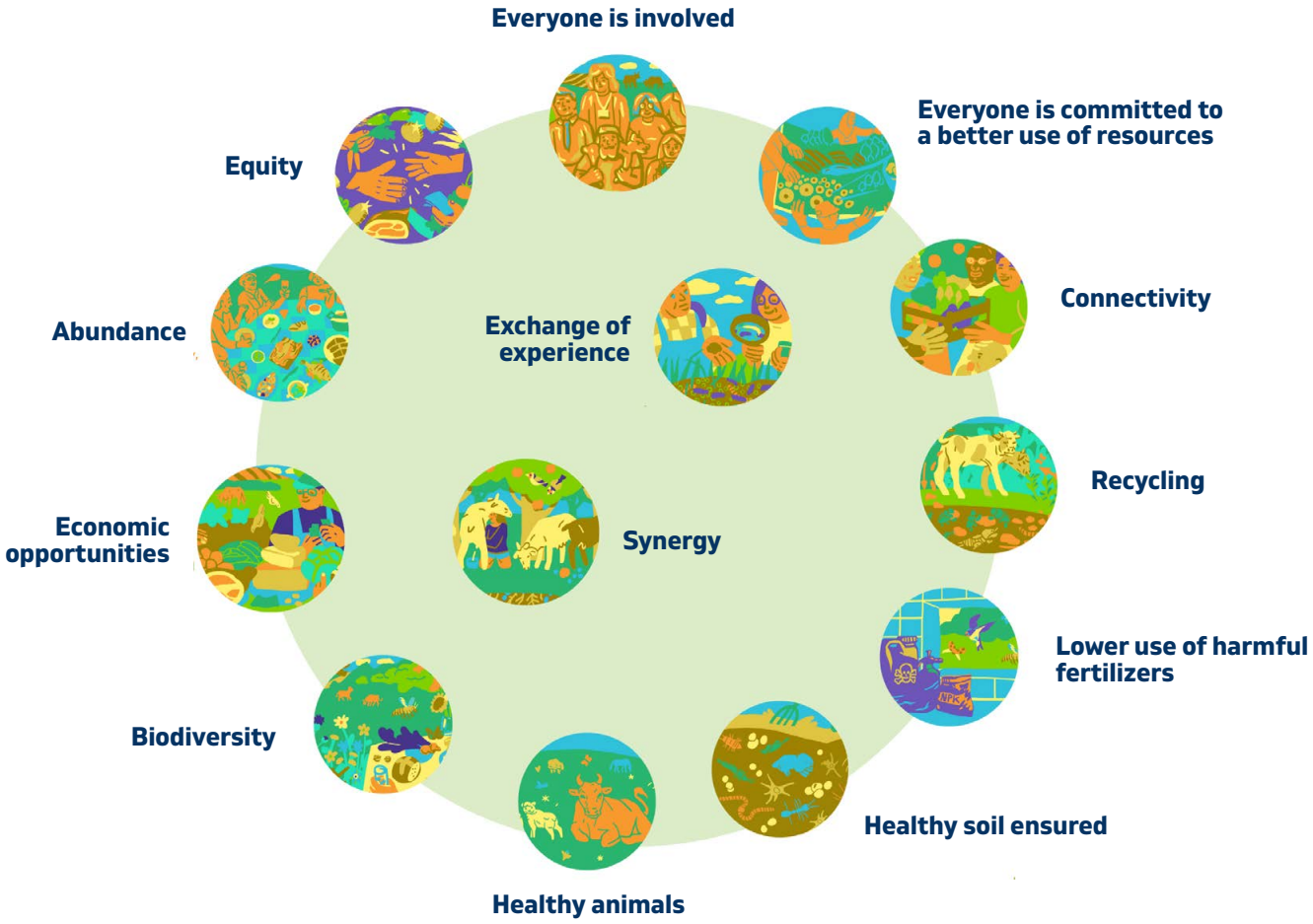
We remember that there is more carbon in the soil than in the vegetation and atmosphere taken together. In theory, this reservoir is limitless – soil can absorb an unlimited amount of carbon, but not at the rate at which human activity releases it into the atmosphere. It takes in around 3 billion tons of carbon dioxide per year. We emit around 35 billion tons per year[1]. It is obvious that soils alone cannot and will not be able to keep up with these rates.

Furthermore, we keep compromising the soil. Let us illustrate this by just two examples. The first one has to do with intensive farming which, in addition to already known nitrogen fertilizers, also affects us through the use of various plant protection products. These are the so-called **herbicides** (against plant pests) and **pesticides** (against animal pests). Apart from harmful organisms these added chemical agents also destroy beneficial organisms and micro-organisms which take care of soil fertility. The other example relates **to erosion** – the removal of the surface layer of the soil, which is nutrient-rich – the humus. It is also the result of farming practices such as mechanized plowing. Soil erosion is between 10 and 100 times faster than the reverse process – the formation of the surface layer. This negatively affects yields due to nutrient losses and the reduced water retention capacity of the soil. Erosion also negatively affects the soil's capacity to retain carbon.

[1] According to data for the last decade (Global Carbon Budget, Copernicus Publications, 2021).

What are the possible solutions?

On the one hand, they are linked to a change in agricultural practices. One such change relates to agroecology. With it, the unused portion **of the biomass** from the produce is returned in the soil as a resource. For example, in the case of sugar cane production, only 15% of the plant is used for the needs of the food industry. The remaining 85% are a resource that, instead of being burned, which is the usual practice, we can return as nutrients to the soil.



On the other hand, they also relate to our personal practices. To a very large extent, the world is fed from the field today. The resource for creating the food is out there, while we are most often to be found in the city. The question we should be asking ourselves is how can we return this resource back to where it came from? One possible way is by processing our household's plant and food waste – **to compost it** – thus being able to put it back into the soil and thus enrich its composition. There are different ways to achieve this, the most popular being through the "Bokashi" method or through the California rain worm.

Read the text and answer the following questions:

- How do farming practices, land use and forest management affect forests and soils?
- What is the current capacity of forests and soils in their role as carbon reservoirs?
- What would happen if we continue to lose natural carbon reservoirs such as forests and soils?
- What solutions are available to conserve forests and soils?

Summarize your answers and discuss them with your class-mate

What is a forest?

It is the master of the plant kingdom and a fundamental element in natural cycles – that of water, nutrients, carbon, and in the energy flow on the planet. The forest also has the unique property to create local climate conditions. Where there is wasteland, water may appear, and it brings life. The forest is the unique link between the underground soil and water world, the plant and animal world at the surface, the air composition and the physical conditions of the living environment.

Thanks to science, we already know that the forest is much more than a source of oxygen. We know that trees communicate with each other, by sharing information about their food needs or about a disease that afflicts them. What is more, **primary and old forests** preserve a rich biodiversity – a prerequisite for maintaining life in the challenging conditions to be brought about by climate change in the near future. A forest is no less living and complex than our own organism and its conservation is vital for the survival and survival of our species.

What are the challenges a forest is facing as a carbon reservoir?

In theory, the forest is a limitless reservoir. A living forest can absorb an unlimited amount of carbon. In practice, however, it is different. The forest cannot take in the carbon at the rate at which human activity is releasing it into the atmosphere. There are forests 4 times the territory of Europe on our planet. In other words – only 8% of its surface. They absorb around 10 billion tons of carbon dioxide every year. We emit 35 billion tons a year[1]. It is obvious that our forests alone cannot and will not be able to keep up with these rates.

Against the background of this information, we continue the practices of deforestation, to take away the planet's forests in order to maintain the modern food production and consumption model. We are thus compromising the fragile capacity of forests to take in our carbon emissions. In addition, when a wild fire occurs, the carbon slowly built-up in the woody biomass is very quickly released into the atmosphere. The forest turns from a carbon reservoir to a source of carbon.

[1] According to data for the last decade (Global carbon Budget, Copernicus Publications, 2021).

What can we do?

We must stop looking at the forest as a source for timber and start treating it as a life-supporting resource. We need to overcome the understanding that, by planting trees, we are compensating for the loss of forests. We are taking away the oldest, most beautiful trees from the forest because they bring us the highest profit. Their functions, such as carbon storage or the preservation of water sources, cannot be taken over by the young trees we plant.

Our understanding that afforestation is a significant solution to climate change is wrong. It is necessary in our fight against erosion and desertification, in order to prevent water losses and biodiversity, in order to improve living conditions in the urban environment. What we need to do in terms not only of the climate, but also of life, is to preserve the forests that we have today to enable them to work tomorrow as well, as a measure to limit the effects of global warming.

Natural carbon reservoirs and emissions of the food industry

LESSON 3

HOW IS CLIMATE CHANGE AFFECTING THE WORLD OCEAN?

European Climate Foundation

With the financial aid
of the European Climate Foundation.

Teach For Bulgaria

*The materials in this publication reflect the opinion of the author

OBJECTIVES AND KEY POINTS

This lesson provides students with an opportunity to learn what the link between climate change and the World Ocean is.

Climate change, the World Ocean, and the food industry – linkages and interactions

1. Students understand the role of the ocean in shaping the planet's climate.
2. Students learn about the impact of greenhouse gas emissions on the ocean.
3. Students learn what aquaculture is and how it can help to reduce emissions from the food industry, also contributing to the food supply to humanity.

Materials and time required

- Printed worksheets/ Google doc
- Multimedia

The lesson lasts 40-60 minutes.

LESSON PLAN

Engagement

In this activity, you are expected to acquaint students with the subject and provoke their curiosity. This is a good opportunity to find out what they already know on the subject, and what additional knowledge and clarification they need.

Activity flow:

1. Present students with the topic – "Climate change, the World Ocean, and the food industry – linkages and interactions". Tell them that before they start researching, you want to hear their current perception and understanding of the topic.

2. Ask students the following questions one by one:

» What you think is the link between the World Ocean and climate change?
» What is the link between the World Ocean and the food industry?

3. Hear the different answers provided by students and summarize that:

1. The link is that the World Ocean is one of the natural reservoirs of carbon dioxide and is involved in the carbon cycle.

2. The link is that the World Ocean supplies us with food, which involves carbon dioxide emissions.

Research

Students discover the links and interactions between climate, the World Ocean, and the food industry. They work in groups to summarize the role of the ocean in shaping the climate of the planet, the impact of greenhouse gas emissions on the ocean, the possible solutions that aquaculture offers.

Activity flow:

1. Divide students into pairs. Distribute a copy of the following texts and questions to each pair::

a. Worksheet 10: Oceans and climate change
» What is the role of the ocean in shaping the planet's climate?
» What is the impact of greenhouse gas emissions on the ocean?

6. Worksheet 11: Aquaculture
» What is aquaculture?
» What possible solutions does aquaculture offer?

3. Let students share their answers with each other and reach a common conclusion together on what is the negative impact of greenhouse gas emissions on the ocean? They can present their summary in a short graph, an image.

4. Listen to the different answers and allow students to build on what is shared.

5. Together with the students summarize that:

The ocean's ability to store (and release) heat over long periods of time gives it a major role in the earth's climate balance. The heat absorbed by the ocean moves from one place to another, but does not disappear. At one point, it leaves the ocean. This happens in the northern latitudes[1] by melting ice blocks floating on water or simply passing into the atmosphere when it is colder than the water. Thus, the ocean's heat can warm the planet even decades after it has been absorbed by it.

The teacher reminds that the oceans contain the most carbon on the planet, not counting the one trapped in rocks. A link is made to the two previous lessons, with a note that oceans only take around 3 billion tons of carbon dioxide in per year. A reminder is made that we emit around 35 billion tons per year. It is clear that our oceans cannot and will not be able to catch up with the rates at which we emit carbon dioxide into the atmosphere. Furthermore, there is also a much more serious problem with the ability of oceans to take the carbon in.

Wrap-Up

This is the time to close the first more detailed presentation of the subject of the ocean as a natural reservoir and emissions (by the food industry) and to hear more about what the pupils have understood.

Activity flow:

1. Explain to students that through this activity they have been made aware of the fundamental development of the topic about the oceans, their role in shaping the climate of the planet and the impact of greenhouse gas emissions on them.

2. Ask students the following questions and let each one of them think and write their answers on their own:

» 1 thing that struck me the most from what was read and discussed? Why?
» 2 things which have changed in my way of thinking on this subject?
» 3 things I would like to learn further?

Remind students, if necessary, that we are not marking these answers; the idea is for everyone to be made to think about what they have learned.

[1] We are talking about the northern latitudes, because we have given an example with the Gulfstream. It is an isolated section of ocean currents that the teacher can choose to provide in greater detail to his or her students.

Read the text and summarize the answers to the following questions:

- What is the role of oceans in shaping the planet's climate?
- What is the impact of greenhouse gas emissions on the ocean?

Summarize the answers and present them to your classmate.

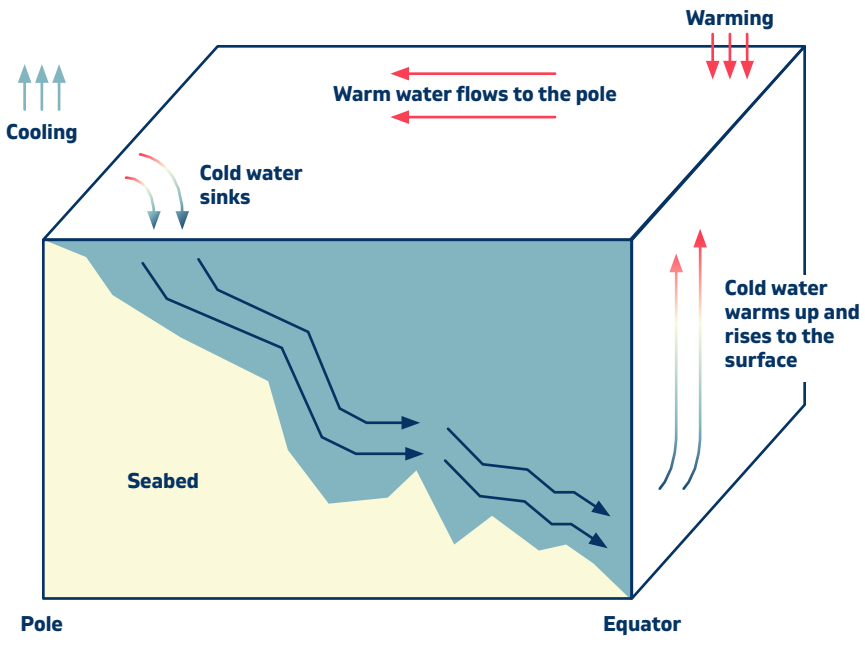
What is the ocean?

The ocean is the largest **solar collector** on Earth. It absorbs the warmth coming from the Sun and in the atmosphere. The ocean's moving waters play a major role in the Earth's climate.

Ocean currents on the surface are driven by winds. These currents transfer the heat accumulated by the ocean from the tropics to polar circles, thus determining the local and global climate. Gulf Stream is an illustration of this process. The current carries warm water from the Gulf of Mexico to the Norwegian Sea, and thus north-west Europe is much warmer than other places so much to the north.

In the northern latitudes, the water cools down and freezes, during which salt is separated from it and water becomes thicker. As a result, the water around the newly-formed ice sinks, and is replaced by the warmer water coming from the south, which in turn cools down and also sinks. This is the driver behind a deep ocean flow that moves in the opposite direction. And it is precisely in the ocean depth that we also find the high-nutrient-rich waters. When the deep currents reach the surface, they deliver this food to marine organisms in various places in the World Ocean.

Ocean water flow



What is the role of oceans as carbon reservoirs and what are the challenges?

When we warm the Earth's atmosphere with the greenhouse gases we have introduced, the ice in the Northern latitudes thaws more easily, which changes the place where the cold northern northern waters meet with the warm stream coming from the south. The meeting point takes place earlier, more to the south. This means that the warmth may not go far enough to the north, which may change the climate in North-West Europe. A change in the path of ocean currents will also have a significant impact on the food chain and on the reproduction of water life.

In addition to the possible change in ocean currents, most of the carbon dioxide in the atmosphere also poses another problem for the World Ocean. Unlike soil and forests, even in theory, this reservoir is not limitless. There is a limit to how much carbon dioxide can be absorbed by the ocean, so that the conditions of the existence of marine organisms are not exceeded.

To illustrate this limit, we will use the **acid-base balance** of water. Since the beginning of the industrial revolution the ocean has become 30% more acid. This means that we have more hydrogen in the water. It is combined with carbon that otherwise serves as food for shellfish, leaving their plate empty. The joke aside, scientists have already discovered in the waters around the Antarctic, sea butterflies, these are small snails, that are dissolved in the water because they fail to build their shells and skeletons. And they are a very important part of the food chain, because animals from shrimps to whales feed on them. Ocean acidification causes a disruption of the food chain.

What can we do?

The most effective solution for reducing emissions is not to have emissions at all. One method of **intensive fishing** is **trawling.** Scientists have estimated that this method emits as much carbon into the atmosphere as the entire aviation industry (The Sierra Club, 2021). An international ban on trawling could save us around 1 billion emissions per year, or around 2% of the total emissions.

The supply of wild fish could be compensated by aquaculture methods. It is farming seafood in man-made conditions, providing us a rich diet and low-carbon-emission food. Its approximate carbon footprint is about 5 kg per 1 kg of finished product.

Read the text and summarize the answers to the following questions:

- What is aquaculture?
- What possible solutions does aquaculture offer?

Summarize the answers and present them to your classmate.

Aquaculture – the need to feed the world in a changing climate[1]

Our planet has never been under greater pressure to increase food production. This pressure is expected to increase – by 60% over the next few decades. At the same time, climate change threatens food production around the world. Questions arise regarding the security of supplies and feeding humanity.

Why look at the World Ocean??

And there is nothing bigger than the World Ocean on Earth. Marine aquaculture – the cultivation of plants and animals in the oceans – is an important source of nutrients. Scientists tell us that it is also a possible solution to the challenges posed by climate change. By reimagining where and how we grow our food, we will be able to design a different climate future.

What solutions does it offer?

Today, the bulk of our food is grown on land. However almost all of the fertile land is already occupied. Our oceans, on the other hand, even though they cover 2/3 of the planet, deliver only 2% of the food on our table. They can give us much more, but that must be done in a smart way.

According to scientists, if we grow seafood to secure the protein we need, instead of raising animals for meat on land, we could save a territory for growing food twice the size of India. In addition, the cultivation of seafood also saves us considerable amounts of carbon. Most of the food in sea farms has about 1/10 of the footprint of beef.

What are the additional climate benefits?

Scientists have also demonstrated the ability of seaweed to mitigate the local effects of ocean acidification – one of the most significant impacts of climate change on ocean and coastal ecosystems. Thanks to photosynthesis, algae turn carbon dissolved into their surrounding water into food for themselves and oxygen for the atmosphere. Studies in China, Chile and the USA have shown reduced water acidity levels where algae are grown.

[1] Published in The Nature Conservancy, 25 January 2022. Abridged translation.

What is the way to promote this solution?

Aquaculture is an opportunity to change the way we produce our food and its impact on the planet. It provides livelihood for coastal communities and provides food for them as well as for export. It can also create new trade relationships in a changing world and climate. It is important to put these sea farms in the right places, to feed the animals there efficiently, to use precise new technologies and automation, to optimize supply to markets, to use renewable energy in production. To make this production sustainable.

But let us not forget. No sector can cope with the challenges on its own. Consumers must support sustainable aquaculture. Governments, global businesses, investors, farmers, scientists and activists must work together to realize the full potential of aquaculture. Only in this way will it be able to feed humanity in a changing climate.

What are the scientific perspectives?[2]

Apart from lowering the acidity of local areas in the ocean, algae are alternative sources of food, especially for vegetarians. Scientists believe that their commercialization can offset the carbon footprint of other aquaculture products. However, even this does not exhaust the benefits of seaweed. Scientists today are working on exciting ideas for the near future, one of them being to grow brown seaweed not only for food, but as carbon reservoirs bringing them down to the seabed.

[2] This idea is not part of the article mentioned. It is from the materials of the Sierra Club.

Transport

LESSON 1

WHAT IS THE IMPACT OF TRANSPORT ON CLIMATE CHANGE?

European Climate Foundation

With the financial aid of the European Climate Foundation.

Teach For Bulgaria

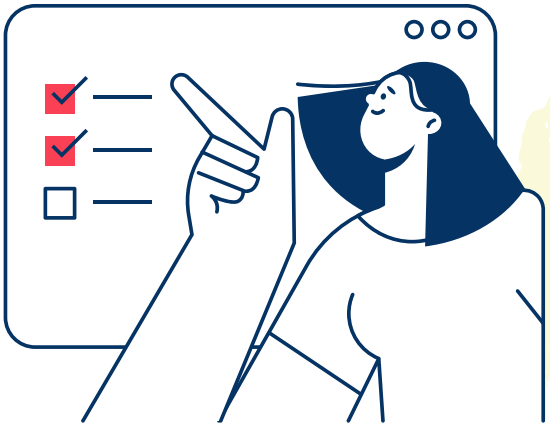
OBJECTIVES AND KEY POINTS

The first lesson from the Transport chapter will familiarize students with the carbon emissions of the transport sector, the different modes of transport in the context of individual carbon emissions, alternatives and key details that everyone has to recognize at the individual level.

Objective and key points

1. Students will be made familiar with information about the greenhouse gas emissions generated by the transport sector.

2. Students will learn about the contribution of the different transport modes in the total share of emissions from the sector.



Materials and time required

- Printed worksheets/ Google doc
- Multimedia

The lesson lasts 40-60 minutes.

LESSON PLAN

Engagement

The aim of this activity is to provoke the students' interest in this matter by making a link with their own lives and their way of transportation.

Activity flow:

1. Make a brief introduction to the transport topic by asking the class how they come to school.
2. Note down the results by category: on foot, by bike, bus, tram, metro, car.
3. Invite them to quickly calculate how many minutes/hours a day/week/month they spend traveling by different modes of transport.
4. You can sum up that *the different modes of transport greatly facilitate the way we move, and that they are a secure, relatively easily accessible convenience in the modern world. This convenience affects the environment and today we will learn the extent of its impact.*
5. At the end of the class, you can come back to the results and ask students whether they would reconsider the way they move in order to make it more eco-friendly in our everyday life.

Research

Transport is one of the most carbon intensive activities that each of us carries out on a daily basis, so the aim of activity is to make us think about our individual responsibility.

Activity flow:

1. Divide pupils into teams and set them the task in Worksheet 12 to rank in ascending order the different vehicles depending on the amount of carbon emissions that each one emits per kilometer for one passenger.

Transport mode	Initial assumption	Updated arrangement pursuant to information from the info-graphic
tram		
bicycle		
truck/minibus		
scooter		
airplane		
car		
on foot		
bus		

2. Show the class the infographic containing information about carbon emissions per kilometer traveled by one passenger for them to compare their assumptions.

3. Ask students why they have ordered the vehicles in this way, what has surprised them in the graph, what similarities and differences they find between their ranking and that in the graph?

   Then share with students the graph showing the shares of the different modes of transport in these emissions.

4. Ask students to comment on the figures in the chart. After you listen to a few students, summarize:

The graph shows us that transport emissions are constantly increasing. In its strategy, called Sustainable Development Scenario, the International Energy Agency set targets for reducing emissions from passenger road transport after 2020, from freight road transport – after 2025, from air and water transport – after 2018. This scenario has been developed to meet the Paris Agreement's goals of limiting temperature increase to 1.5 oC. We can see that, nevertheless, transport emissions are increasing. Among the reasons for this are population and income growth, making it more affordable for many people to own cars and travel.

The second thing that stands out is that nearly 75% of all transport emissions are related to road transport and 45% of them – to passenger transport. Therefore, our efforts must be focused primarily on this segment of the transport sector. These efforts are also directly linked to the move toward cleaner energy sources, which will also make it sensible to use electric cars as solutions for road passenger transport.

How could we limit the growth in transport emissions?

5. Divide students in groups again. Share with them Worksheet 13 containing information on how to optimize our transport emissions. They should read it individually before starting the group discussion.

6. Once every pupil has got familiar with the text, give instructions about the group discussion and tell students how much time they have for work. It is recommended to allow at least 10 minutes for the discussion. Students can use the following questions for guidance:

» Can you carpool to school;
» Can you walk to school;
» Is there appropriate cycling infrastructure in place where you live;
» Do you have access to a tram or trolleybus instead of a bus;
» What kind of buses are there in the respective municipality; if you are in Sofia, do you use the metro?

The aim is for each group to come up with alternative transport solutions for their journey to school.

7. Listen to the different answers and proposals provided by students and summarize that

- People's individual transport has a serious impact on the environment and climate change.
- The choice we make every day influences our own carbon footprint.
- There are different options for a more eco-friendly commute for different locations. The solutions are not the same.
- Carpooling and the use of public transport are very good alternatives when we cannot walk or cycle.
- Trams, trolleybuses and electric buses are the future of public transport.
- Choosing a train for medium distances (instead of a car) reduces emissions by about 80%. Choosing a train over an internal flight by airplane reduces emissions by 84%.

Wrap-Up

This is the time to close the first more detailed presentation of the subject of transport and to hear more about what students have understood.

Activity flow:

1. You can discuss the following main points from the lesson and then discuss students' impressions and thoughts.

Transport is an exciting and multi-layered subject that plays a major role in climate change. History has shown that the industrial development of societies has led to overconsumption of fossil fuels and overuse of transport services. Huge amounts of CO2 accumulated in our atmosphere have led us to review our transport habits and to make changes reducing our personal carbon footprint.

2. Ask pupils the following questions and let each one of them think and write their answers on their own.

» 1 нещо, което ми направи най-силно впечатление от прочетеното и обсъденото? 1 thing that struck me the most from what was read and discussed? Why?
» 2 things which have changed in my way of thinking on this subject?
» 3 things I would like to learn further?

3. You can sum up and discuss with the students their impressions, reminding them that what they share will not be marked, but the idea is to enhance their understanding

Additional material

Short text History of transport – you can use it to enhance students' understanding of the increased convenience for people regarding the transport sector.

» With industrial progress, and especially after the transport innovation around World War II, the world changed completely due to the changes in the transportation methods.

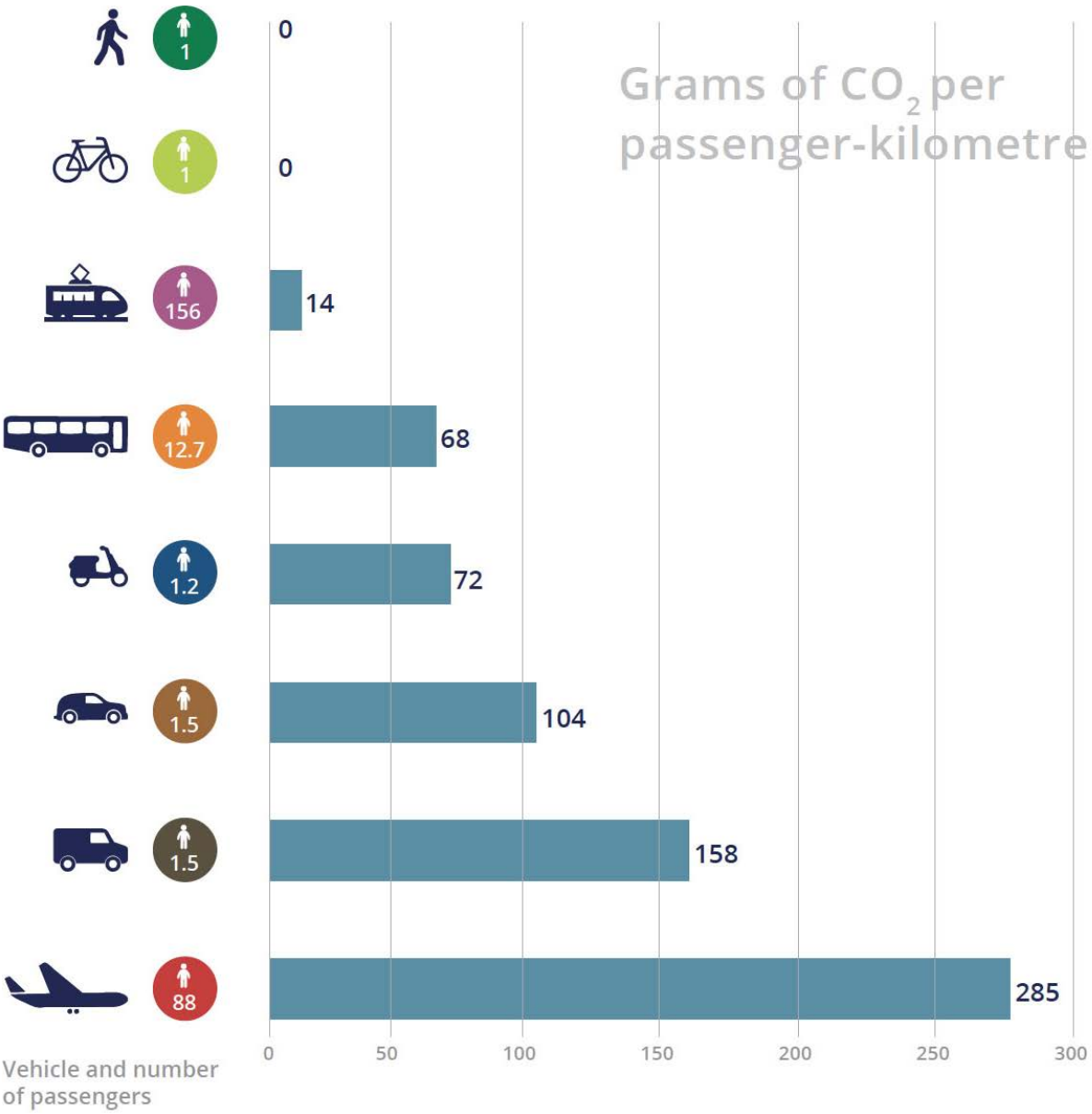
» Flights became commonplace; the number of individually owned cars kept increasing; fewer people choose public transport, walking or cycling.

» Freedom of movement to long distances is an immense asset for democratic societies, but also has its down sides in the context of climate change. This will be in the focus of our next few lessons.

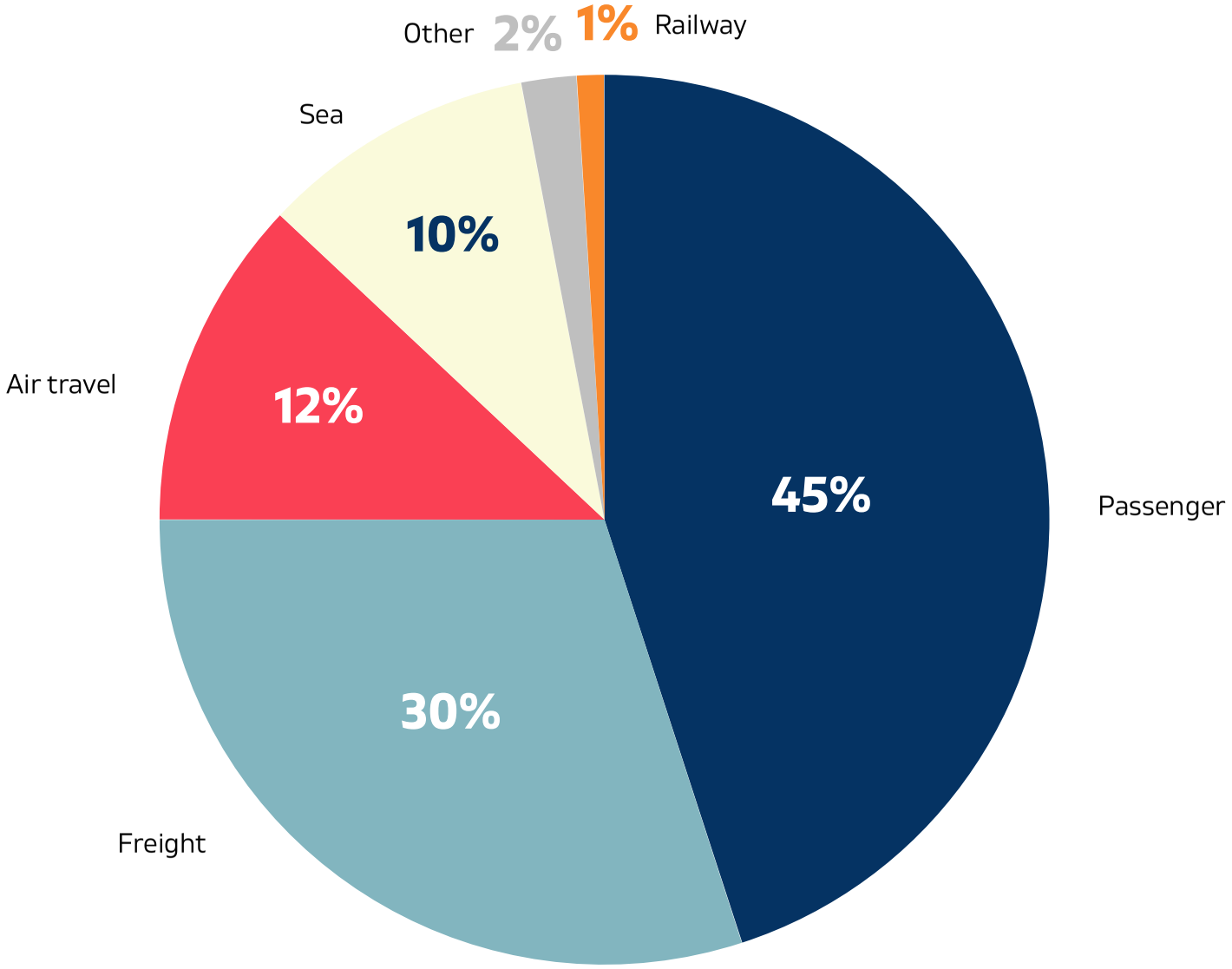
1. Rank 1 to 8 in ascending order of carbon emissions emitted per kilometer per passenger.

2. Update your assumptions after going over the new information from the infographic.

Bug Transport	First assumption	Actual ranking
tram		
bike		
van/truck		
scooter bike		
plane		
car		
on foot		
bus		


Grams of CO_2 per passenger-kilometre
1
0
1
0
156
14
12.7
68
1.2
72
1.5
104
1.5
158
88
285
0
50
100
150
200
250
300
Vehicle and number of passengers

Global CO2 emissions from transport 2018



According to data from the International Energy Agency

→ APPENDIX 2

Read the worksheet and explore possible solutions to optimize transport emissions.

Then discuss the following issues in a group:

- Could you carpool to school?
- Could you walk more on foot?
- Is there appropriate cycling infrastructure in place where you live?
- Do you have access to a tram or trolleybus instead of a bus?
- What kind of buses are there in the respective municipality; if you are in Sofia, do you use the metro?

As we already know, transport is responsible for 16%[1] of global greenhouse gas emissions. Transport is also the sector with increasing emissions. Despite the various scenarios to limit them, we expect this growth to be constant by 2050. The International Energy Agency estimates double the number of emissions from the transport sector. In some countries, mostly richer, where people travel frequently, transport is also the sector with the greatest individual carbon footprint.

But which are the vehicles with the smallest footprint?

We have already seen a short presentation at the beginning of this lesson. So, the most efficient ways to move are on foot, by bicycle or by train. Of course, after the modernization of Bulgarian State Railways, because traveling with them is a real challenge at the moment.

Emissions can also naturally be quite different, mainly depending on:

- The length of the journey – short or long distance;
- The electricity source in the country's electricity grid (more on this – in the Energy lessons);
- The type of car and the number of passengers in it – the more powerful a car, the more fuel it uses.

Here is another thing that we did not see at the beginning of the lesson. Walking and cycling are also associated with emissions. This is because, in these cases of transport, we use our own energy and not the energy of the means of transport. And this energy is obtained from the food we take. It in turn has a different carbon footprint according to its type. As a rule, vegetable foods have a smaller footprint than animal source food. Especially in cases where the food has been produced near the place where we live. The reason is that less resources are used to produce certain plants – root crops, legumes – than to produce dairy or meat products. And the more resources, the higher the carbon footprint. Thus, the footprint associated with cycling varies between 16 and 50 grams of CO2 per kilometer depending on our diet.

[1] According to 2016 data by Climate Watch, World Resources Institute.

What do we choose, if we need to go further and cannot take the train? Planes and single-passenger car journeys are the most carbon-intensive travel options. Which of the two is preferable depends on the distance. If the journey is less than 1,000 km, the airplane has a higher footprint than an average car. If the journey is over 1,000 km, the airplane is the better choice than a single-passenger car journey.

Some general conclusions:

- Walking or cycling – we reduce emissions, pollution and improve our health.
- Trains are the best climate choice for medium and long distances.
- If there is no train, coach transport is a solution.
- International travel by train or boat is preferable to aircraft.
- Shared car travel (carpooling) reduces emissions from road passenger transport.

Transport

LESSON 2

WHAT ARE TRANSPORT'S INVISIBLE USES?

European Climate Foundation

With the financial aid of the European Climate Foundation.

Teach For Bulgaria

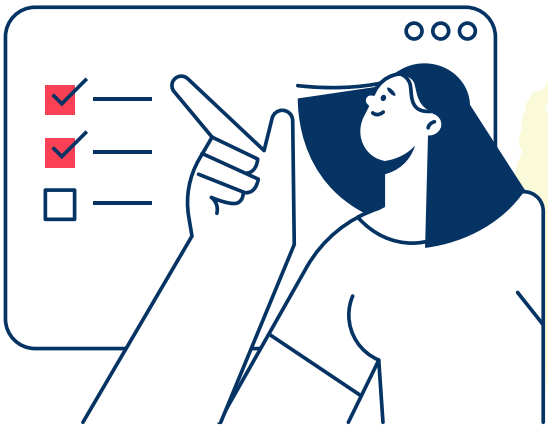
OBJECTIVES AND KEY POINTS

In Lesson 1, we discussed that climate change requires personal responsibility for our day-to-day transport choices. In the current lesson, we will examine in what other, often invisible, ways we use the transport service without thinking about it. For example: Package deliveries; consumption of exotic fruit and vegetables, including out of season ones; regular shopping for clothes – all these activities and products require transport and therefore have a high carbon footprint, especially when we practice them too often.

Objective and key points

1. Pupils learn about the indirect ways in which we use the transport service.

    a. We will examine what we buy, where these products come from and what distance they travel.
    b. We will learn more about the emissions of the different modes of transport.
    c. We will discuss ways to reduce our individual carbon footprint through self-regulation of our consumption behavior.



Materials and time required

- Printed worksheets/ Google doc
- Multimedia
- Internet-enabled mobile devices

The lesson lasts 40-60 minutes.

LESSON PLAN

Engagement

The main idea is to move smoothly into the subject of indirect transport use through questions about the various goods that pupils know. The questions allow you to understand to what extent students realize that many of the goods we use in our daily lives travel from the other end of the world, thereby further increasing their carbon footprint.

Activity flow:

1. Explain students that in this lesson you will keep looking at the different sources of the carbon footprint that accumulates.

2. Give them a few objects and ask them which of them – through the entire production process until they reach the Bulgarian market – leaves the largest carbon footprint?

- Jeans produced in Bangladesh
- T-shirt produced in Greece
- Avocado produced in Ecuador
- iPhone made in China

3. Listen to the different answers provided by students and the grounds for their assumptions.

4. Sum up that today you will be looking for answers to these questions.

Research

In this activity, students will carry out a more detailed study on the journey of a product known to every student – jeans. Tracing their journey from the country of production to the shelves of the shops in our town is a complex process, so students are not expected to reach a clear solution to the task, but to an idea of how to limit the CO2 footprint of their own consumer habits.

Activity flow:

1. Let the class work in pairs. Each pair should choose a favorite jeans brand and trace its origin and journey.

2. Tell the whole class the steps that their group research should follow:

» Distribute the worksheet for the research.
» Students examine the text Modes of transport in world trade and their emissions in Worksheet 15
» They list the raw materials from which the jeans have been produced and their likely countries of origin.
» They calculate the kilometers the product must have traveled to reach Bulgaria.
» They describe the likely transport that must have been used for this.
» They calculate the share (%) in the weight (ton) of the product (one ton is the normal weight of the cargo being transported).
» Students write down its approximate carbon footprint.

3. Let the students work for 20 minutes on this subject. It is likely that there will be no definite answer, and that contradictions and confusion may arise in the course of work. Let students share what has confused them in the process, how far they have reached and what conclusions they can draw.

4. Summarize as follows:

» The processes of tracking the transportation of goods are complex and the end-user not always has real information about them.

» Beyond the transportation of finished goods themselves, the transport of the raw materials from which they are produced is also included in the processes.

» Freight transport has the second largest share in transport, leaving a significant carbon footprint.

5. Ask students what this provokes in them using the following questions:

» Why is this information important?
» What can be done to reduce the transport of goods?

6. Hear their answers and the reasons why they think this is the case.

7. Show them the following proposed actions they can take in their own consumption and ask them whether they consider them possible.

» Wear the clothes you currently have at least 2-3 years. Never throw them away – try to donate them or, if they are not suitable for donation, use them in other ways or recycle them.
» Whenever possible, choose goods manufactured near Bulgaria or in Bulgaria.

8. Finally, summarize the main conclusions of the research:

» Most of the products we use in our daily lives have come a long way to reach us, which has a carbon footprint.

» The way we consume different types of product – technological, fashion, food products – has an impact on the environment because a lot of greenhouse gases are emitted, from the process of creating the product, through its transportation, warehousing, sending to stores, until it reaches us and our home. A separate topic is what happens when we discard this product at the end of its life – invite students to think further on this matter.

Wrap-Up

This is the time to close the first more detailed presentation of the subject of transport and to hear more about what the pupils have understood.

Activity flow:

1. Summarize the main ideas of the lesson.

The idea of this practical lesson was to gain an idea of how international trade benefits from transport services. Since the transport sector emits around 16% of global greenhouse gas emissions, it is important to know all the ways in which we use this service on a daily basis (not only regarding our commute to school and work). This also includes the hidden ways we rarely think about, such as the transport of goods and supplies that reach us.

2. Ask students the following questions and let each one of them think and write their answers on their own

» 1 thing that struck me the most from what was read and discussed? Why?
» 2 things which have changed in my way of thinking on this subject?
» 3 things I would like to learn further?

What is the carbon footprint of transporting individual goods?

- Choose your favorite brand of jeans as a pair
- Get acquainted with the text "Types of transport in world trade and their emissions"
- Search the Internet for answers to the questions in the table
- Use a calculator, google maps

1. What is the product you are researching?	
2. Where is it made of?	
3. The raw materials from which it is produced, what parts of the world do they come from?	
4. How many kilometers should it travel to reach Bulgaria?	
5. What is the probable transport with which it is transported?	
6. How many grams does it weigh?	
7. What fraction of a ton is it's weight?	
8. What is it's average carbon footprint?	

Use this information to calculate the footprint of the goods from the lesson.

The global appetite for trade is likely to have been stirred up by Marco Polo and his journey to China at the end of XIII century. Today, 730 years later, world trade turnover – the money it generates – is double the world's gross domestic product created. In addition, world trade is expected to grow annually by 3.5% until 2050. The reason for the constant increase in the volumes of traded goods is the globalization of the world in which we live. Trade means import and export, and they mean transport.

We are already starting to guess that trade also means CO2 emissions. They represent 30% of all emissions from the transport sector and 7% of global greenhouse gas emissions. In addition, these emissions are expected to increase 4 times by 2050

Reducing emissions by mode of transport

Today, the freight transport sector depends entirely on the burning of fossil fuels and reducing emissions seems to be a very serious challenge. This is also linked to the fact that maritime and air transport take place in international water and airspace, and their emissions are not the responsibility of a single country. Every country can make efforts only on its territory, which shifts the focus on emissions from road and rail transport.

In fact, only about 10% of world trade uses roads and railways within national borders. However, this means 30% of all emissions associated with trade in goods. Once they arrive at the port or airport, these goods are mainly transported using the national roads. This means that emissions can be reduced through national policies and laws, which is much easier than with international agreements such as the Paris Agreement.

The footprint of different modes of transport

This is the carbon footprint of freight transport depending on the mode of transport[1]:

- Aircraft emit 602 grams of CO2 per metric ton of cargo per kilometer of transport
- Ships emit 14 grams of CO2 per kilometer
- Lorries emit 62 grams of CO2 per kilometer
- Trains emit 22 grams of CO2 per kilometer.

[1] Average CO2-emission factor recommended by McKinnon for road transport operations

Trade is not just transport

It is not hard to realize that before a commodity is transported, it should be produced. This means CO2 emissions. In order to fully understand what the footprint of world trade is, we also need to examine the emissions associated with the production of goods in the producing country concerned. In the world commodity trade, there are goods with a primary footprint in the transport sector and others – whose footprint is primarily from the manufacturing sector.

In some cases, studying the footprint of a particular commodity may indicate that the emissions from its transport compensate for those from its production. For example, in the case of the trade in agricultural produce worldwide, production emissions are 80% and transport emissions are 20% (World Trade Organization, 2021). In other words, from the point of view of greenhouse gas emissions, it is better to import such a product than produce it in the country where it is needed.

For the needs of our lesson, we will only partially address emissions from trade, working with those from the transport sector alone.

Transport

LESSON 3

HOW CAN CITIES REDUCE THEIR CARBON FOOTPRINT?

European Climate Foundation

With the financial aid of the European Climate Foundation.

Teach For Bulgaria

*The materials in this publication reflect the opinion of the author

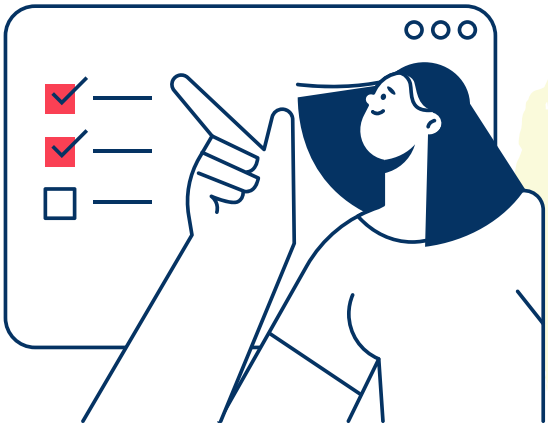
OBJECTIVES AND KEY POINTS

This lesson from the Transport section aims to familiarize students with the various possible environmental solutions to change the ways in which we move. What is most important for students to understand in this lesson is that the decisions that are taken depend on a number of factors, which is why there is no one-size-fits-all solution that can be applied everywhere.

Objective and key points

1. Students are aware of a variety of options for reducing carbon emissions from transport in different environments.

2. Students understand that there is no universally applicable transport solution. Each alternative depends on a number of circumstances in the particular environment in which it will be applied.



Materials and time required

- Printed worksheets/ Google doc
- Multimedia
- Internet-enabled mobile devices

The lesson lasts 40-60 minutes.

LESSON PLAN

Engagement

The main idea behind engaging is to introduce students to the complexity of the issue and present them with the task they are about to work on – playing a role in making decisions to improve the environment.

Activity flow:

1. Present the topic to students – reducing transport's carbon footprint in cities. Remind students that the use of road transport, which continues to grow, is one of the largest sources of carbon dioxide.
2. Ask them what alternatives and solutions they can think about.
3. Listen to their answers and challenge them with the question "Why do you think these solutions are not being applied on a larger scale?"
4. Summarize their responses and explain that they are about to assume the role of governors of several cities. As such, they will be expected to decide on the investment that will make the environment more environmentally friendly and convenient for the city's inhabitants.

Research

The aim of the "City Mayor" game is to develop critical thinking in assessing possible environmental solutions such as extending the urban transport infrastructure, increasing cycling and the use of electric scooters.

Activity flow:

1. Present the task they will have to work on:

   "You are about to become the Mayor of our city. Your task is to put forward concrete proposals to make transport infrastructure more environmentally friendly. Imagine that 80% of the people in your city mainly use cars, which generates a large number of greenhouse gases. Each group (Mayor) will have to choose in which|what environmentally friendly infrastructure solution(s) to invest: e.g. cycling lanes; public transport; electric cars; trains; parking areas."

2. Each student and each group is working on its own research by going through the following steps, as described in Worksheet 16:

» Make an internal division within the group of the different categories of vehicles to be examined.
» Internet research on existing infrastructure by transport mode – urban transport, cars, bicycles and electric scooters, coach.
» Making a group decision about the selection of infrastructure in which to invest and indicating the maximum number of advantages of their choice.

3. Let each of the groups present their choice.

4. Listeners have the task of helping the presenter find "gaps" in their strategy, i.e. to put forward suggestions for improvements.

5. Hold a discussion on the pros and cons of the strategy chosen by each group.

6. Summarize as follows:

Each town has its own different specificities – the way it has been built, pedestrian zones, infrastructure, public transport, metro, parking areas – and the existence or absence of all these details determines the environmentally friendly solutions for reducing the carbon emissions generated by transport.

7. Each group will read the text Urban solutions for a lower carbon footprint. You may ask them how they will upgrade their plan after they have read this information.

8. Together with the students summarize that:

Tackling transport's carbon emissions looks differently in different locations.

In cities and metropolitan areas, it will be key to improve urban infrastructure, which includes more opportunities for the use of electric urban transport, walking, cycling, or using an electric scooter.

In some parts of the world, people will continue to rely on their cars, but they can switch to electric cars, and they should use them for a long time and choose second-hand.

Building and improving railway infrastructure will be a key solution for inter-city transport.

Wrap-Up

This is the time to close the first more detailed presentation of the subject of transport alternatives and to hear more about what the pupils have understood.

Activity flow:

1. Summary of the topic

The issue of private transport is multi-layered and has different solutions in different parts of the world. Cities in different countries and continents are built according to different spatial plans, so different environmental transport approaches are required depending on the specific location.

2. Ask students the following questions and let each one of them think and write their answers on their own.

» 1 thing that struck me the most from what was read and discussed? Why?
» 2 things which have changed in my way of thinking on this subject?
» 3 things I would like to learn further?

Explore the design of the transport infrastructure of the city you are responsible for and consider the most urgent and affordable measures you can take with the investment you have.

1. Distribute among you the main categories to study: urban transport, cars, bicycles and electric scooters; travel outside the city.

2. Each of you, with the help the Internet should research and find information about the different categories.

3. Then discuss the answers and decide as a group on the most appropriate investment for the context.

Urban transport	What types of means of transport are used?	
	What are the prices?	
	What is their frequency (timetable)?	
	What is the area they cover?	
	How many people use them?	
	What are the main complaints by users of the urban transport network?	

Cars	What is the average number of car owners in the city?	
	For what distances are they most frequently used?	
	What are the fuel prices?	
	What are the parking fees?	
	What types of carpooling are used?	
	How many electric vehicles are there in town?	
	How many charging stations are there?	
Bicycles and electric scooters	Is it popular to move by bike in the city?	
	How many cycling lanes are there? What is their reach in the city?	
	Are electric scooters used?	
	What is their price?	
	How are they used?	
Out-of-city travel	Which are the most frequent destinations outside the city?	
	What are the ways to travel to them?	
	What is the price of the time to reach there?	

4. Present your investment, indicating a maximum number of advantages compared to the other options. Consider the following reference points in summarizing your arguments:

- What % of the traffic would this decrease?
- For whom is it appropriate?
- What are its other benefits for consumers?
- How will the carbon footprint of the city be affected?

5. And now read the text of Urban mobility solutions in Worksheet 17 and compare your thinking to some of the world solutions.

The most important change for the urban environment is the development of infrastructure to support electric urban transport and cycling. See some examples of successful emissions reduction in cities below.

Copenhagen, Denmark

Best cycling city. In November 2016, the number of bicycles in the Danish capital exceeded that of the cars. The first cycling policy was adopted in 2002, and today 50% of school trips or of the commute to work are made by cycling. Although urban transport is also popular, twice as many people use bicycles. In support of this choice, the city has built more than 400 km of cycling lanes, including cycle superhighways. These highways allow people living away from the center and in the suburbs to reach the city without stopping at traffic lights.

Today, 7% of the entire road infrastructure of the city is cycling lanes. They also fit in with modern architectural development. An example is the bicycle snake, a bridge for cyclists only, which follows the waterways in the capital.


author: Jakob Munk.

By comparison, Sofia's cycling lanes are 1.8% of the road infrastructure, and the city's population is 60% higher than that of the Danish capital.

What is also popular in Copenhagen is the creation of green bike paths where old railway lines had passed before. This is also the first city to start offering a system of shared electric bicycles.

Santiago, Chile

Seven million people, a transport system leading to air pollution, congestion, accidents. What did the city's government do, along with other organizations? They changed the places dominated by cars into pedestrian zones, they expanded the network of bike-sharing systems, developed tactical urbanism actions – presentation of a possible change in urban design. They did this through the creation of temporary squares at busy streets, using vibrant color paints to design different pavements in place of existing ones, the creation of temporary speed-limit areas. The result – a 30-fold increase in the distances traveled by bicycles on part of citizens of the capital. In 2015, a study by the Chilean Ministry of Transport and Communications found that 39% of 18 million journeys every day were made by bike and 29% – by urban transport. In addition, since 2018, 60% of the energy used by the Santiago subway has come from wind and solar power. In 2019, electric buses in the city became 400, making it the town with the second most electrified urban transport fleet (outside China).

Paris, France

Between 2001 and 2009 the city managed to cut its transport emissions by 12%, to increase the use of bicycles by 50%, and the use of the metro by 16%. The town has 700 km of cycling lanes, keeps tightening speed limits, and introducing mixed pedestrian and car zones with a limit of 20 km/h. Since 2020, deliveries to the central part of the city by diesel cars are no longer possible.

Belo Horizonte, Brazil

The city's fast transit bus network covers 38 km and was launched with the 2014 World Cup. It can transport 700,000 passengers a day, reducing travel time by 50%. The city government builds cycling lanes, extending the network to 360 km, creates a system for shared bicycles and has turned the city center into a pedestrian area.

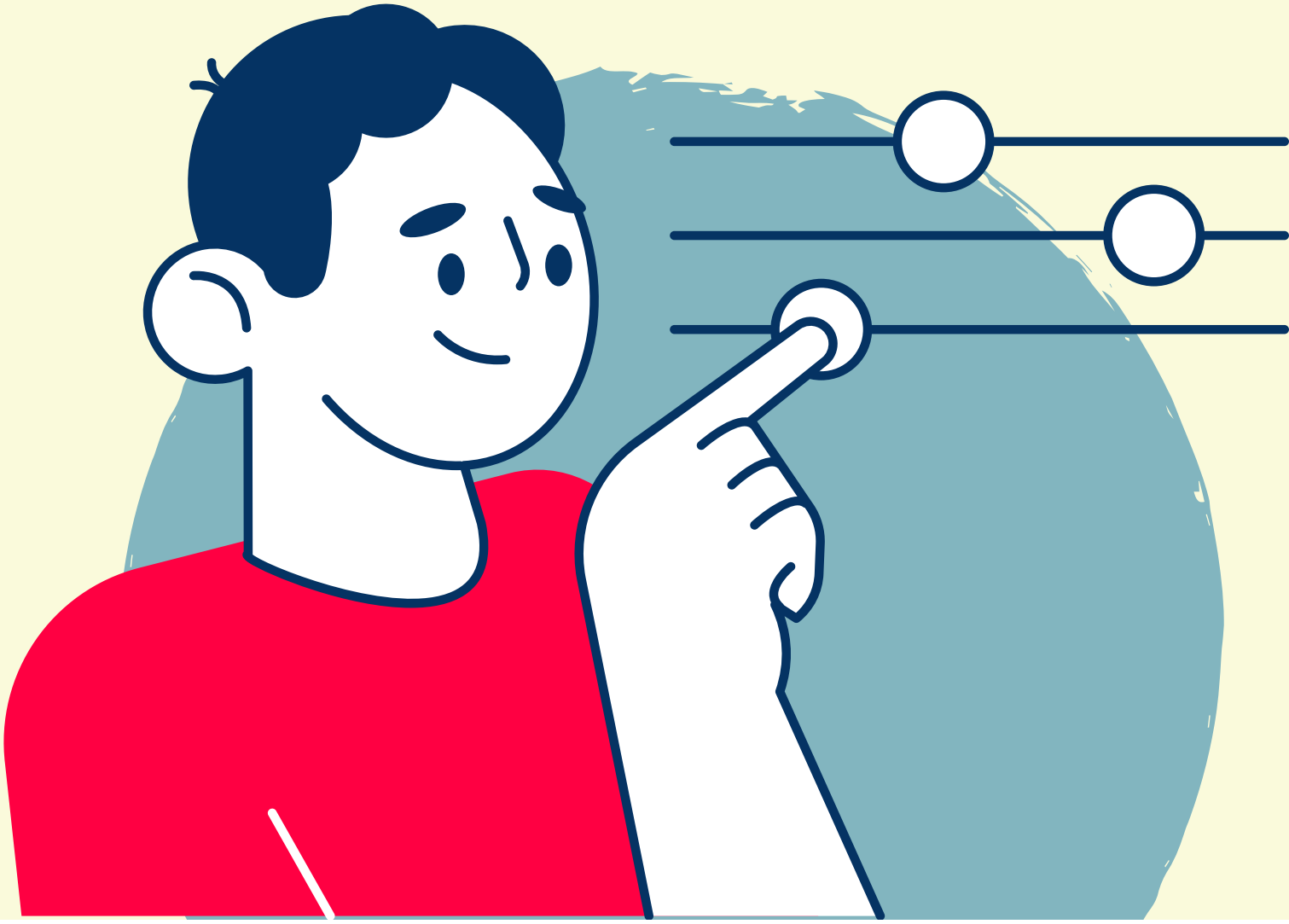
Mexico City, Mexico

The city has one of the largest networks in the world for fast transit bus lines and one of the biggest shared bikes systems. Mexico implemented a climate action program between 2008 and 2012, which has reduced transport emissions by 62%. The network comprises 6 such lines, with a total length of 125 km.

Energy and its production

LESSON 1

WHAT IMPACT DOES ENERGY HAVE ON CLIMATE CHANGE?



European Climate Foundation

With the financial aid of the European Climate Foundation.

Teach For Bulgaria

OBJECTIVES AND KEY POINTS

Globally, energy use is the largest source of greenhouse gas emissions from human activity. Around three quarters of global greenhouse gas emissions are related to the burning of fossil fuels for energy to be used for heating, electricity, transport and industry.

Objective and key points

1. Students will be made familiar with the energy sector and its carbon footprint.

2. Students will understand that:

» Energy use and production have a huge impact on climate.
» Climate change is already changing our energy production potential and our energy needs.

3. Pupils will consider alternative methods of energy production.

Materials and time required

» Printed worksheets/ Google doc
» Multimedia
» Internet-enabled mobile devices

The lesson lasts 40-60 minutes.

LESSON PLAN

Engagement

The aim of this activity is to check pupils' initial knowledge of the subject and to highlight existing unclarities.

Activity flow:

1. Write the following three questions in three columns on the board:

What are the energy s ources most used at the moment?	What is this energy used for?	What impact do different energy sources have on the climate?
Fossil fuels such as coal, oil and natural gas.	For electricity, heat and transport, while the rest is used in industry.	From the extraction of fossil fuels from the bowels of the earth, through their processing, to the final process of burning and energy production – every stage generates huge amounts of carbon emissions.

2. Allow pupils two or three minutes to work independently.
3. Then ask them to compare their answers with those of a class-mate.
4. In the large group, using questions, get the answers of the pupils and write the main points on the board.
5. Summarize key points:

The main sources of energy currently – more than 80% – are still fossil fuels: coal, oil and natural gas, but using renewable sources such as the sun, wind, and water is a more environmentally friendly solution in the long term.

From Section 1: "Climate change – an introduction" – we remember that the energy sector generates 74% of greenhouse gas emissions. Part of this sector concerns electricity generation, which we will look at in this lesson.

This subsector includes the following sources from which we generate electricity:

- Coal (36%)
- Oil (3%)
- Natural gas (22%)
- Biomass (2%)
- Hydropower (12%)
- Wind (7%a
- Solar energy (4%)
- Nuclear energy (10%).

Source: Ourworldindata.org

Study

Wind, solar energy and hydropower are a renewable energy alternative that has the potential to drastically reduce the carbon footprint of the energy sector. This is why we will examine in greater detail the way they work.

Activity flow:

1. Divide pupils into four groups. Each group will be tasked with getting familiarized with the text about one of the alternative energy sources. After reading the text on their own, pupils will be given the task to summarize the main advantages and disadvantages of the type of energy and to indicate how it can become a major energy source in the region concerned.

- Group 1 - Wind energy
- Group 2 - Hydroelectric power
- Group 3 - Solar energy
- Group 4 - Nuclear energy

2. Each group will present for 5 minutes. The others will take notes and ask clarifying questions.

3. You will write the carbon emissions per 1 GWh for the different energies.

4. Once all the groups have shared their main conclusions, discuss the lessons learned from each group.

5. If the information in point 3 has been skipped, pupils now add information about carbon emissions per 1 GWh of electricity from different energy sources and vote for two alternative energy sources they would invest in. *1 gigawatt hour (GWh) is the average electricity consumed by 150 EU citizens.*

6. To conclude, sum up that switching to renewable energy sources, albeit logical, is not an easy step. However, there are also opportunities and they lie in energy independent communities, the use of local renewable energy sources, technological advances:

From the various renewable energy sources (RES) and nuclear energy worksheets, we have seen that their share in the global energy mix for electricity generation is not small, 33%. But let us not forget that this is the energy produced for the needs of electricity. The share of RES and nuclear energy in the total energy consumption is only 17%. Moreover, although these capacities are constantly increasing, at the current pace, this growth will not be sufficient for us to reach the zero emissions target by 2050.

Why is this so? On the one hand, all RES share the same major challenge, and it is that none of them can independently deliver the energy needs of the modern world. Each of them faces a set of challenges, a common one being their volatility, and as for nuclear energy – the associated dangers. On the other hand, although the technology has been around for a lot of time – since the XVIII century regarding water, the XIX century regarding wind, the middle of the XX century regarding solar and nuclear power, its development has been left behind. There are numerous reasons for this, and most of them have been valid for a very long period of time in the XX century, and some continue to be valid even today:

- Easily accessible and cheap oil, coal and gas;
- Lack of intergovernmental control on the pollution caused by their extraction and use (burning);
- Lack of shared responsibility of all countries for the greenhouse gas emissions that this extraction and use (burning) cause;
- Economic and strategic interests of the industry and the lobbies it creates;
- Economic and strategic interests of the stronger countries exploiting these fossil fuels more.

But we have seen the potential for **decarbonization** of the energy sector. Between 96% and almost 100% fewer emissions, according to different solutions. Several steps are necessary to integrate them to a larger degree into the global energy mix:

- Priority government policies and investments for development of the RES sector;
- Technological developments, and such are ongoing, in each RES sector, making them more efficient;
- Accessibility and affordability of RES for more consumers, and it is ongoing as their market is also developing;
- Combining different renewable energy sources in the same energy system;
- Using them, where available, to supply energy to small communities and businesses;
- Consumers creating a lot of small independent energy clusters (groups, communities);
- The needs of people to be separated from those of the industry;
- Of course, changing (consumer) habits will always remain a key solution. Although seemingly far from the scale needed to change the energy sector, it is an obligatory example of upbringing and education.

Wrap-Up

This is the time to close the first more detailed presentation of the subject of energy and to hear more about what the pupils have understood.

Activity flow:

1. Summarize the main ideas of the lesson

It is important to look for alternatives to the ways in which energy is produced, because globally the generation and use of energy, the so-called energy sector, is the biggest contributor to greenhouse gas emissions. The use of fossil fuels to generate energy is a process that generates extremely high amounts of carbon emissions from the very beginning to the moment of energy use. In order to reduce the rate of climate change, we need to reduce the carbon emissions generated by human activity, so we need to consider the possibilities of producing energy by other means, using renewable sources like the sun, wind and water.

2. Ask pupils the following questions and let each one of them think and write their answers on their own.

» 1 thing that struck me the most from what was read and discussed? Why?
» 2 things which have changed in my way of thinking on this subject?
» 3 things I would like to learn further?

Read the text and answer the following questions:

- What are the main advantages of wind energy?
- What are the current shortcomings?
- What do you think is a possible solution for more use of wind energy, eliminating the associated challenges?
- How can wind energy be used more in your community?

Wind – a natural source of energy

We have been using the power of wind in the sails of our ships for millennia. But it was only in the XIX century that we began to use wind for electricity purposes. In 1887, the first wind turbine for electricity production was manufactured. This happened in Scotland, and the structure was created by Professor James Blyth in the small town of Marykirk. His 10-meter-long wind turbine with blades made of sails was erected in the garden of his holiday cottage and was used to power accumulators, developed by the Frenchman Camille Alphonse Faure, and thence to provide the lighting of the house. This made it the first house in history, to use wind energy. Prof. Blyth offered the people of Merykirk to use his invention to light the main street, but they refused, seeing "the work of The Devil" in the thing.

Use of wind energy today

Logically, we can use it where there is wind. These areas are most often mountain crests as coastal areas (both on-shore and off-shore). Today we use only 7% wind energy in the world to produce electricity[1]. The largest share of wind in **its energy mix** in Europe belongs to Denmark with 48%, followed by Ireland and Lithuania with 33% each. Bulgaria has a share of only 3%.

Despite its small share in the global energy mix, it is striking that 2020 saw a double increase in installed **Gagawatts** produced by wind energy compared to 2019. However, even this growth is not enough to reach the zero emission target by 2050. It is estimated that by the end of the decade, we will have less than 2/3 of our required wind power.

[1] In this lesson, we are talking only about the energy produced for electricity. The share of wind in all of mankind's energy use is only 3%.

The advantages of wind

Bulgarian households have varying electricity consumption, between 100 and 1000 kWh of electricity per month. We will choose consumption of 500 kWh for our story. A 15-kilowatt wind turbine will be sufficient to satisfy the electricity needs of four households with this type of consumption. Of course, there must be enough wind at the place of installation. To get an idea about it, the diameter of such a turbine is 9 meters and it is as tall as a four-story building.

The annual electricity consumption of 150 EU citizens is 1 GWh. The carbon footprint for producing this electricity by wind is 11 tons of carbon dioxide. By contrast, the same amount of electricity produced by coal-fired power plants has a footprint of 1,000 tons of carbon dioxide. This would mean a 99% reduction in the carbon footprint of electricity, if we replace coal with wind!

Challenges to wind

Let us list three main challenges to wind. Firstly, its variability. In fact, a turbine operates only around 40% of the time of the year. Secondly, this is the distance of the place of consumption to the suitable places with enough wind, which can be far away. Thirdly, this is the impact on birds which stand no chance if they run into the rotor blades. Studies suggest up to 1 million birds die every year in the United States. For comparison, communication towers claim the lives of over 6 million birds, the electricity grid – 25 million, window clashes – up to 1 billion, and cats are responsible for up to 4 billion bird deaths per year (the Sierra Club).

Read the text and answer the following questions:

- What are the main advantages of water energy?
- What are the current shortcomings?
- What do you think is a possible solution for more use of water energy, eliminating the associated challenges?
- How can water energy be used more in your community?

Water – a natural source of energy

The history of water and its use by humans as energy dates back two millennia. Even then, our neighbors, the Greeks, used water mills to produce flour. The development of the water **turbine** began in the middle of the XVIII century when French hydraulic engineer Bernard Forest de Bélidor wrote his book Hydraulic architecture [L'architecture hydraulique].

All we need to use its energy is to have a source of water and to use its natural flow from a higher to a lower point. Then we add the turbine which catches this movement and turns it into electricity. The situation described here concerns both water sources on land (our rivers and dams) and the water in the oceans. In the latter case, we use the water movement created by marine currents and tides.

Use of water energy today

Today we use only 12% water energy in the world to produce electricity[1]. The largest share of water in its energy mix in Europe belongs to Norway with 92%, followed by Iceland (69%) and Austria (63%). Bulgaria has a share of 8%.

Water energy has traditionally occupied the largest share in renewable energy sources. Despite the addition of new capacities in the sector, the expected growth will not be sufficient to reach the zero emission target by 2050.

[1] In this lesson we are talking only about the energy produced for electricity. The share of water in all of mankind's energy use is only 7%.

Advantages of water

Bulgarian households have varying electricity consumption, between 100 and 1,000 kWh of electricity per month. We will choose consumption of 500 kWh for our story. A micro system for generating electricity from the **kinetic** energy of water, such as a **1-kilowatt** water turbine, will be sufficient to meet the energy needs of a household with such consumption. We would need about 10 square meters to install this system.

The annual electricity consumption of 150 EU citizens is 1 GWh. The carbon footprint for producing this electricity by water is 24 tons of carbon dioxide. By contrast, the same amount of electricity produced by coal-fired power plants has a footprint of 1,000 tons of carbon dioxide. This would mean close to 98% reduction in the carbon footprint of electricity, if we replace coal with water!

Challenges to water

We will list a number of major challenges for the use of water for energy. They concern the situation in which we are not using water to meet the needs of a household or a small business. When it comes to larger-scale energy production, we build dams, which means controlling the water flow. This creates a number of problems. The migration of fish and, hence, its population, changes. The temperature of the water and its natural flow change. This often has a negative impact on plants and animals in the river and on land. A changed natural flow also means less soil-forming minerals downstream – a factor for fertile soil in the plains. Natural forest areas and land suitable for agriculture and food can be lost for the construction of dams. This may also be accompanied by the need to resettle people. Rivers often cross different countries. A dam in one country can deprive people downstream of access to water, which in turn can lead to conflict between peoples.

Read the text and answer the following questions:

- What are the main advantages of solar energy?
- What are the current shortcomings?
- What do you think is a possible solution for more use of solar energy, eliminating the associated challenges?
- How can solar energy be used more in your community?

The sun – an inexhaustible source of energy

The solar energy, which falls on the ground for 15 minutes, is equal to the energy consumption of mankind for 1 year. There are various ways to capture this energy, the most frequent being with **solar collectors** (for water heating) and **photovoltaic panels** (for electricity generation). With the help of photovoltaic panels, every person can make his or her own power plant. The technology was created in Bell Labs (USA) in 1954.

Use of solar energy today

Today we use only 4% solar energy in the world to produce electricity[1]. The largest share of solar energy in **its energy mix** in Europe belongs to Malta with 11%, followed by Greece, Italy and Germany with 9% each. Bulgaria has a share of almost 4%.

The pace at which the sector is developing today is not sufficient to achieve the zero emission target by 2050. To this end, we should install new capacity as large as the biggest solar park today, every day, until the end of the decade. In other words, 10 million panels a day.

Advantages of the sun

Bulgarian households have varying electricity consumption, between 100 and 1,000 kWh of electricity per month. We will choose consumption of 500 kWh for our story. How much solar energy will we need to ensure this amount of electricity? The answer to this question depends on many factors. On the one hand, what matters is the amount of solar energy that we get every day where we live. On the other hand, the power of our photovoltaic panels is important. A very rough estimate shows that we can produce the electricity we need with 10 panels, which means having a roof or other area of about 20 square meters.

[1] In this lesson, we are talking only about the energy produced for electricity. The share of the solar energy in all of mankind's energy use is only 1.7%.

The annual electricity consumption of 150 EU citizens is **1 GWh.** The carbon footprint for producing this electricity by solar energy is 50 tons of carbon dioxide. By contrast, the same amount of electricity produced by coal-fired power plants has a footprint of 1,000 tons of carbon dioxide. This would mean a 95% reduction in the carbon footprint of electricity, if we replace coal with wind!

Challenges to solar power

We will list three major challenges for the use of the energy of the sun. Firstly, the amount of solar energy reaching the earth varies according to the place where we live and depending on the season. Quite simply, this is due to the Earth's axial tilt, as well as to its movement around the sun. While the equator has a relatively constant amount of solar energy during the year, at the North Pole, for half of the time, it is equal to... zero. In Bulgaria, during the summer months we receive 3 to 4 times more solar energy than during the winter. Secondly, further development of technology is needed. The efficiency of photovoltaic panels today is only 20%. This is not that low, given that Bell Labs' panels had an efficiency of 6%. Thirdly, space is needed. If for one household enjoying good conditions for producing and consuming solar electricity, the decision to install roof panels appears to be a manageable task, large areas for panels are needed for more serious energy quantities. It is not logical to use land that might have other uses, such as for food production.

Read the text and answer the following questions:

- What are the main advantages of nuclear energy?
- What are the current shortcomings?
- On the basis of the two, what would you recommend concerning the use of nuclear power in your area?

Nuclear energy – a controversial source of energy

Nuclear energy is obtained by splitting atoms resulting in the release of energy contained in the nuclei. It is released in the form of heat which is then cooled down, often via water, and the steam produced is used in **electricity-producing turbines.**

In the nuclear energy sector, we divide the atoms of uranium, which is a metal spread across many parts of the world. Nuclear reactors use an enriched version, the atoms of which are more easily divided. It is known as U-235.

Nuclear energy does not count as a renewable source, as it depends on finite resources such as uranium. Although we have stocks for another 200 years, they will still be exhausted. In this sense, nuclear energy, as we know it today, is only a temporary solution for reducing greenhouse gas emissions.

Use of nuclear energy today

Today we use only 10% nuclear energy in the world to produce electricity[1]. The largest share of nuclear energy in **its energy mix** in Europe belongs to France with 67%, followed by Slovakia (54%) and Hungary (46%). Bulgaria has a share of 41%.

According to the International Atomic Energy Agency, in order to achieve the zero emission target by 2050, nuclear energy production should triple during that period. Even with the 50 reactors currently under construction and the planned new 100, this objective will not be achieved. The reason for this is the decommissioning of the reactors existing today due to their obsolescence.

[1] In this lesson we are talking only about the energy produced for electricity. The share of the nuclear energy in all of mankind's energy use is only 4%.

Advantages of nuclear energy

The annual electricity consumption of 150 EU citizens is **1 GWh.** The carbon footprint for producing this electricity by nuclear energy is 12 tons of carbon dioxide. By contrast the same amount of electricity produced by coal-fired power plants has a footprint of 1,000 tons of carbon dioxide. This would mean close to 99% reduction in the carbon footprint of electricity, if we replace coal with nuclear energy!

Challenges facing nuclear energy

The major risks of nuclear power are not so much related to the finite nature of the resource as to the rare but devastating accidents associated with nuclear power plants, and to the problems of waste nuclear fuel.

One of the most infamous cases was the one with the Chernobyl Power Plant in the not-so-distant 1986, as well as the one from the more recent past, in 2011 – the Fukushima I Plant.

The cause of the Chernobyl disaster seems to have been a human error leading to an explosion in one of the reactors. A huge amount of radioactive material ended up in the air, leaving hundreds of thousands of people homeless and worse – losing their lives instantly and in the coming decades. The Fukushima I accident was caused by a tsunami caused by the Tohoku earthquake. This accident raises the issue of the safety of reactors built in seismic activity areas such as the Armenian Nuclear Power Plant.

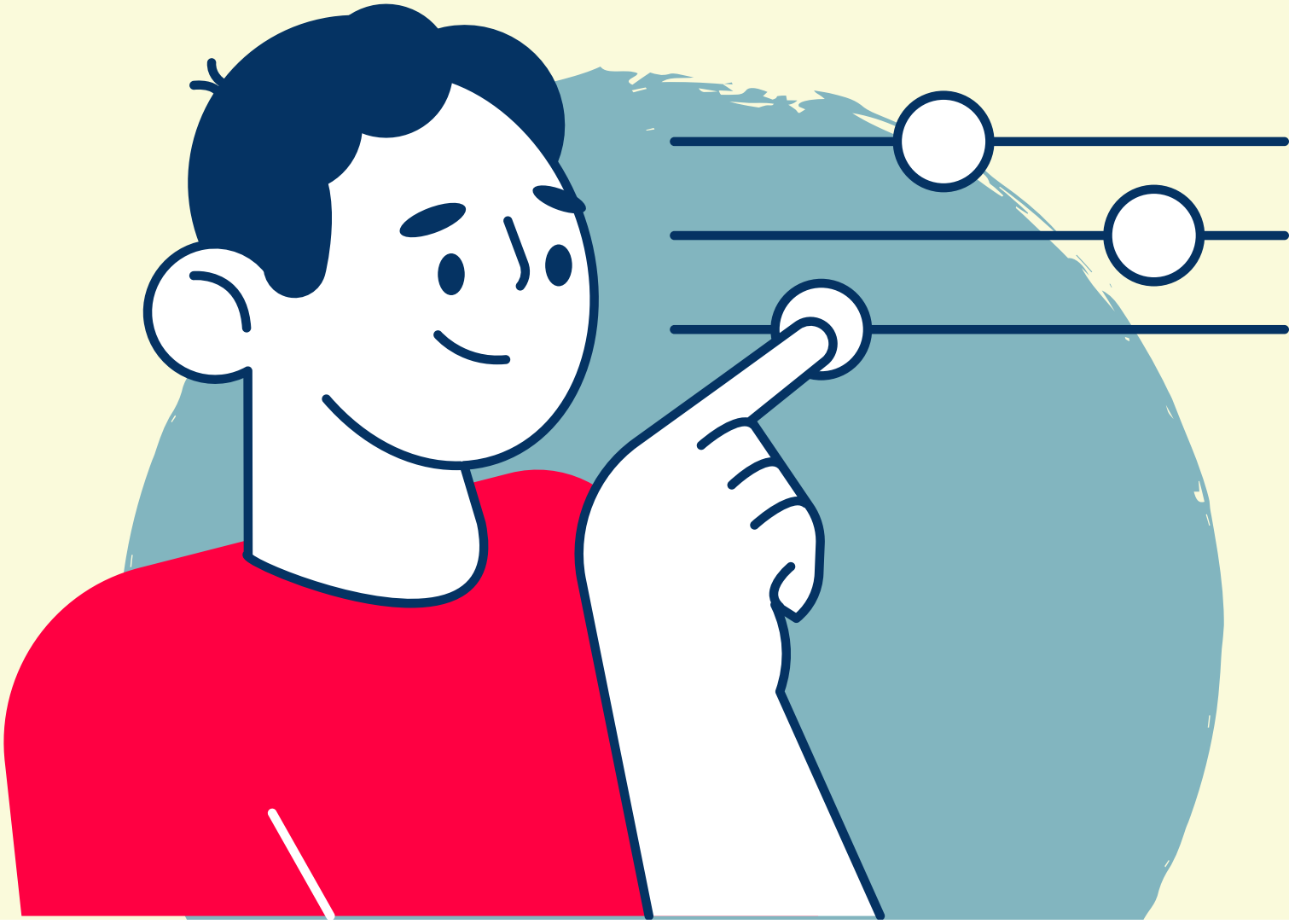
In addition, the risks associated with the storage of waste nuclear fuel are not lower. It remains radioactive for thousands of years. There are concerns that an insufficient level of protection of this waste could lead to terrorist attacks on spent fuel storage facilities. There are also concerns about its illegal dumping at the seabed and about the closed pits being insufficiently rendered safe.

photo: Catalania Catalino (Pixabay)

Energy and its production

LESSON 2

WHAT CAN WE DO TO REDUCE THE CARBON FOOTPRINT OF OUR BUILDINGS?



European Climate Foundation

With the financial aid of the European Climate Foundation.

Teach For Bulgaria

*The materials in this publication reflect the opinion of the author

OBJECTIVES AND KEY POINTS

Buildings are a major contributor to energy consumption, accounting for 18% of the total emissions. Furthermore, building emissions are also related to the production of the materials used in their construction and to the construction process itself. This means that up to 40% of the total emission are due to the buildings we use in much of our daily lives.

Objective and key points

1. Students will learn about buildings as a source of 18% of the total carbon emissions associated with energy use.

2. Students will learn that through our choice of materials and equipment and through design and architectural solutions, we can reduce the carbon footprint of buildings.

3. Pupils will calculate how much their school footprint can be reduced by using alternative energy sources – they will learn about heat pumps.

Materials and time required

- Printed worksheets/ Google doc
- Internet-enabled mobile devices
- Multimedia

The lesson lasts 40-60 minutes.

LESSON PLAN

Engagement

Students understand buildings as spaces consuming a lot of energy, learn about the associated emissions and about possible solutions to reduce them.

Activity flow:

1. Students are tasked to describe the causes of greenhouse gas emissions associated with buildings and what solutions they know about reducing these emissions. If necessary, you can refer them to the discussion and topic of the previous lesson.

2. After making their assumptions, they read the following text in the Energy, emissions and buildings worksheet, and complement and broaden their knowledge in order to answer the following question: How can we, as consumers, reduce our own contribution to the footprint of buildings?

3. Students guess the answer to the task in the worksheet.

4. The teacher sums up:

Main recommendations for personal consumption in buildings:

- Do not heat water too much. Set the temperature of your water heaters to a maximum of 60°C, so that it operates efficiently and hygienically;
- Use the thermostat wisely. Did you know that your home will not get warm faster, if you increase the temperature of the thermostat? This only affects the maximum temperature in your home;
- During hot days, draw the curtains or close the window shutters to limit the sunlight that gets into the house.

- Cool with a fan. Fans use much less energy than air conditioners.
- Replace ordinary windows with double-glazed windows. Double-glazed windows provide between 50 and 70% lower heat loss.
- You cannot install double-glazed windows? Thick curtains or movable window insulation panels will help you limit the cold air flow to your home.
- Draughts may be a source of significant heat loss. You can save energy by sealing joints around windows or gaps below doors. You will feel the difference even if you only cover the keyholes and the openings of mailboxes!
- Isolate your water tanks, central heating pipes and walls. If you cannot install insulation on the walls, have reflective insulation between the radiator and the wall behind it.
- Buy energy efficient appliances. In the EU, most household appliances for everyday use, such as refrigerators, dishwashers and cookers, have an energy label. Each appliance is ranked from A+++ (most efficient) to G (least efficient). An A+++ dishwasher, for example, uses half the energy of a class D appliance.
- Avoid washing plates by hand if you have a dishwashing machine. Today's dishwashers use less water and energy and most of them have an Eco mode, but only run them when they are full.
- Fill the washing machine. Do not run it half-empty. Wait until it is full, but do not exceed the maximum allowed weight.
- Select the lowest suitable temperature. Nowadays, detergents are so efficient that they clean clothes even at low temperatures.
- Skip the pre-washing cycle if your clothes are not very dirty.
- If possible, avoid using a drier. A drying program can spend twice as much energy as an average washing program.
- Turn off your devices. Connected devices such as smart TVs, printers and game consoles manufactured in 2016 or earlier can use up to 80 watts of electricity in standby mode. You can use a single extension cord so as to easily disconnect them all together.

Research

Familiarize pupils with an alternative source of energy for use in buildings. Students will determine the carbon footprint according to the sources of energy used.

Activity flow:

1. Students are given the worksheet Our school's footprint, and tasked with calculating the school's carbon footprint from the use of heat in the building (produced by burning coal).
2. Students calculate the carbon footprint of the same amount of energy, but this time produced by photovoltaic panels and heat pumps.
3. Students calculate how much they can reduce the footprint, if they change the energy source.
4. The teacher assists with the calculation, if difficulties arise.

The teacher prepares information on the amount of heating energy used by the school for one calendar year (in kilowatt hours). If this information is not available, a value of 1 kilowatt (kW) is used for each 10 sq. m.

Example of solving the problems:

If one floor of our school is 250 sq. m there are 4 floors, the total area is 1,000 sq. m. This means 100 kW of energy for heating purposes. Assuming the heating season is 3,000 hours, this means 300,000 kWh. Coal accounts for 28% of this energy, which means 84,000 kWh. The carbon footprint of coal is 1 kg of carbon dioxide per 1 kWh, meaning 84,000 kg of carbon dioxide, or 84 tons.

The PV panel produces 1.2 kWh of electricity per day (300 Watts * 4 hours = 1,200 Watt). A year this means 438 kWh per annum. Approximately 400 panels (700 sq. m. /1.7 sq. m per panel equals 411, but a distance between the panels is also necessary for corridors for maintenance). This means that the school roof can produce 175,200 kWh of electricity.

Thanks to heat pumps, we have 4 times more heating energy given off than electricity used to produce it. This means that only 75,000 kWh of the 175,200 kWh of our panels will be enough to heat the school.

The carbon footprint of solar panels is 0,05 kg CO2/kWh, meaning 3,750 kg of carbon dioxide, or nearly 4 tons, for our heating needs, instead of 84 tons, generated by burning coal.

We even have an additional 100,200 kWh that we could use for the school's electricity needs or even sell this surplus.

Wrap-Up

This is the time to close the first more detailed presentation of the subject of energy and buildings and to hear more about what the pupils have understood.

Activity flow:

1. Summary of the topic:

The way we design buildings, materials, and the equipment we use in them, as well as our energy consumption, can change their future carbon footprint.

2. Ask pupils the following questions and let each one of them think and write their answers on their own.

» 1 thing that struck me the most from what was read and discussed? Why?
» 2 things which have changed in my way of thinking on this subject?
» 3 things I would like to learn further?

Read the text and answer the following question:

» How can we, as consumers, reduce our own contribution to the footprint of buildings?

Emissions from our buildings

Today, most people spend 70% of their time indoors. Buildings have become our natural environment and largely determine our everyday lives. Apart from having an impact on us, they also affect the climate. Energy use in buildings accounts for 18% of greenhouse gas emissions. Energy is needed for heating and cooling, water heating, lighting, electric and other appliances such as the gas cookers in restaurants. The carbon footprint of buildings becomes even greater when we add the emissions associated with the production of construction materials to the energy used. Cement production generates 3% of the total CO2 emissions. Iron and steel – more than 7% of total emissions.

Potential of the sector

What is curious is that there is probably no other sector with such a great potential to reduce CO2 emissions. According to the International Energy Agency, by 2050 we could reduce emissions by as much as 87%. This can be done through energy efficiency and renewable energy sources. The energy efficiency of buildings is mainly linked to their design and materials input, which determine heating/cooling needs, and by improving the energy class of the equipment used in buildings. We know that appliances have a label indicating the level of energy they use. We also know about LED lighting technology, which is 75% more efficient than old (incandescent) bulbs. Energy saving bulbs (compact fluorescent) are only about 30% more efficient than an old bulb.

Lagging behind the needs

Nevertheless, only 1% of the buildings nowadays are carbon neutral. At the same time, only 3% of the investments in construction are associated with low-carbon solutions (Global Economic Forum, 2021).

The solutions for lower emissions will be particularly necessary in the light of the expectation for them to double by 2050. The International Energy Agency's forecast for electricity demand for the cooling of buildings alone is that between 2018 and 2050 it will increase by 37%.

Natural cooling

Speaking of cooling, let us get to know the termites. They, like many other inhabitants on the planet, build homes. At the end of the last century, science supposed that the above-ground construction of their homes, the spires getting narrower with height, provided the necessary ventilation for a suitable climate in the underground part of the mound. This inspired architect Mick Pearce in the design of the Eastgate Center, a shopping center and an office building in Harare, Zimbabwe.


photo: David Brazier

Albeit in the tropics, Harare is at such an altitude that the average temperature difference between day and night is about 12 degrees. The building is designed so as to use this difference as an air-conditioning system. At night, cold air enters into the building through holes in its base which is evenly distributed. During the day the temperatures gradually rise and special elements lead the heat to the chimneys of the building. The plants on the façade reduce the warming by the sun and the elongated eaves create the shade on the last floor. Thanks to its architecture and materials, the building uses only 10% of the energy needed to control the temperature of buildings of the same size.

Read the text and the steps to calculate your school's carbon footprint.

1. What energy does your school use for heating?
2. How much did it spend last year? What is the carbon footprint that this has left?
3. How much can it be reduced, if the school switches to another source of energy?

There are specific guidelines and steps in the text to be able to make such calculations.

The energy of the bowels of the earth

Today we are going to learn about heat pumps. These are devices through which the warmth of the bowels of the earth can be used to heat our living space. One example of a heat pump is the following. We **drill** at a depth of 100 meters. The temperature of the ground at this depth is about 16 oC all year round. A plastic tube is placed in the well, filled with carbon dioxide. At this temperature the gas starts boiling and the heat rises in the upper part of the tube where a **heat exchanger** is located. The pumps are connected to the mains supply, i.e. they operate on electricity, but the ratio of the input electric power to the output heating energy is 1:4.

Calculation

Now let us calculate the carbon footprint of our school from the energy currently used for heating. To this end, we need to find information about the amount of energy that the school has used over a period of one year. You will get this information from your teacher. If you cannot obtain it, assume the school's consumption to equal 1 kilowatt (kW) for heating 10 sq. m and estimate the approximate floorage of your school.

The next question is how much of this energy has been produced by coal-fired power plants? In Bulgaria, 28% of the energy is produced from coal. The carbon footprint of this energy is 1 kg CO2/ kWh. Multiply the total consumption by 28%. You already know what the carbon footprint of your school is from burning coal.

One more calculation

Another problem you can solve is how much your school's carbon footprint can be reduced. In other words, we will calculate how much electricity we can generate, if we install photovoltaic panels on the roof of our school, and power heat pumps with the electricity produced to provide the necessary heat ourselves.

To do this, you need to learn what the roof surface of your school is. If you do not have this information, assume that the area on which we can install the panels is 700 sq. m. The size of a panel is 1.70/1.00 m, its power is 300 **Watts** and the sun shines on the roof for 4 hours a day. The carbon footprint of placing photovoltaic panels on the roof is 0.05 kg CO2/kWh.

Calculate:

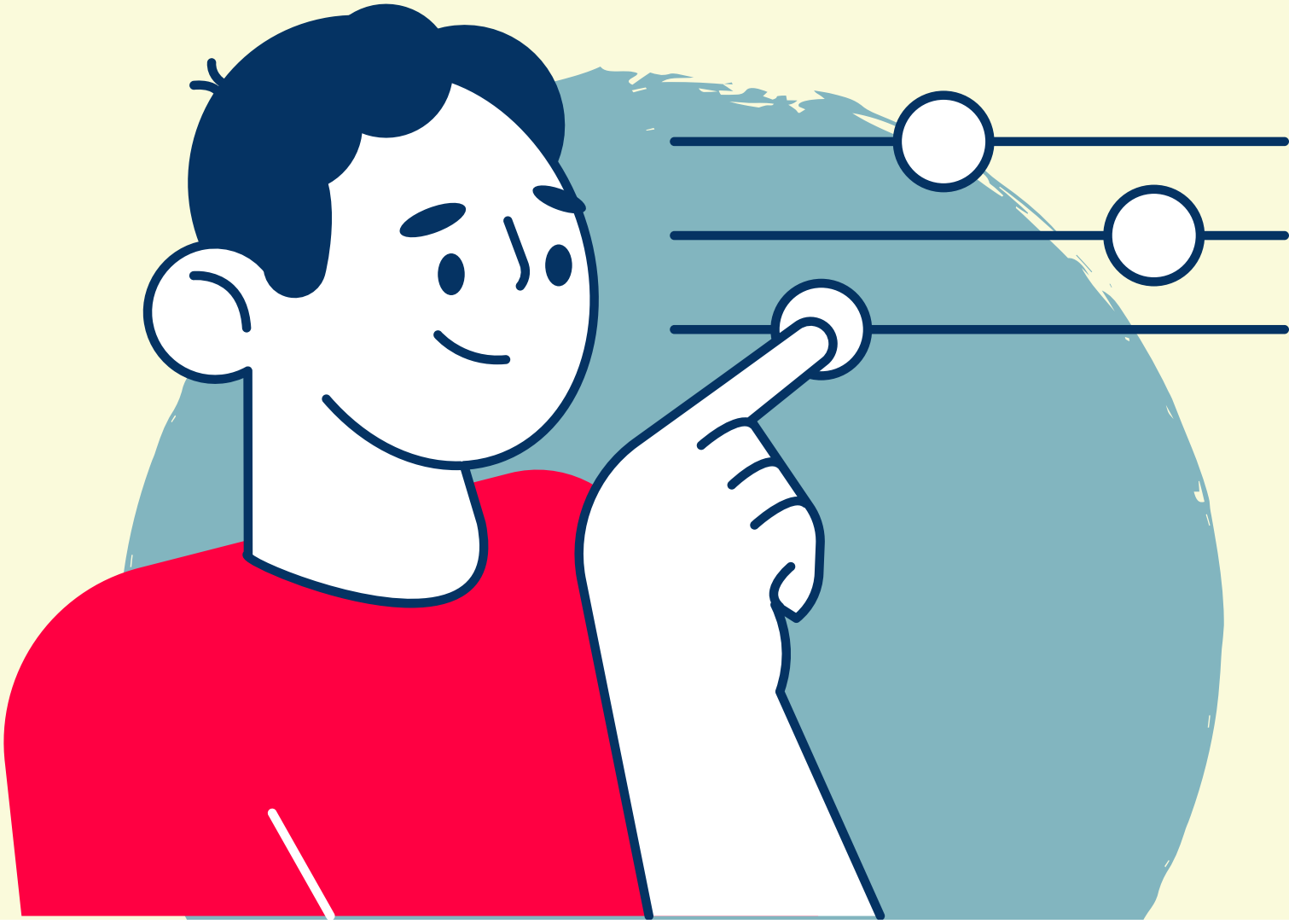
- How much electricity does 1 panel produce?
- How much electricity over a period of 1 year?
- How many panels can be installed on the roof?
- How much electricity can a school roof covered by panels produce?
- What is the carbon footprint of this electricity?

Given that in heat pumps using the earth's heat the input electricity energy is four times less than the heat produced, calculate how much of the electricity produced by the roof panels will be sufficient to provide the necessary heat output. Compare also the carbon footprint of coal-fired heat generation versus the electricity produced by PV panels and used by heat pumps. You already know how much you would reduce your school's carbon footprint, if you use the energy of the sun and the bowels of the earth for heating.

Energy and its production

LESSON 3

WHAT IS THE IMPACT OF THE FASHION INDUSTRY ON CLIMATE CHANGE?



European Climate Foundation

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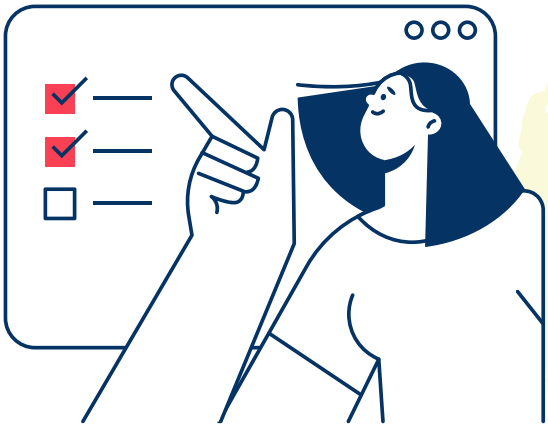
OBJECTIVES AND KEY POINTS

The topic of manufacturing may not be of great interest to some students, so in this lesson our aim is to involve them and present to them something that has a significant impact on climate and nature, and to which they can relate to on a daily basis: clothes.

1. Students will understand what the impact of the fashion industry on climate change is.

2. Students will understand how they can limit their own contribution to this impact.



Materials and time required

- Printed worksheets/ Google doc
- Internet-enabled mobile devices
- Multimedia

The lesson lasts 40-60 minutes.

LESSON PLAN

Engagement

We involve the students with this subject by presenting three characters with clothes and habits described – the task is to make a hypothesis about who has the greatest carbon footprint and to share the reasons for this.

Activity flow:

1. Present the three characters to students: Georgi, Maria and Simeon.

Georgi	Maria	Simeon
Almost every month buys new jeans and T-shirts.	She wears cotton clothes and buys new clothes once every 3-4 months.	Known for wearing his favorite polyester sweat-shirt for years.

2. Ask students to rank the characters according to the carbon footprint of the clothes they wear. Ask several students to explain their choice.

3. Once pupils share and substantiate their assumptions, summarize their conclusions and guide them to the conclusion that the information provided is not sufficient to reach a decision.

4. Then distribute the worksheet Carbon footprint of the textile industry.

5. Having become familiar with the text, they will have 5 minutes to think about one issue they are given as a task.

6. Students answer the question posed, and the teacher summarizes:

We have seen that if we only know the material our clothes are made of we can hardly determine their carbon footprint. A large proportion of it is due to the energy used, and we cannot learn anything about it from just reading the garment's label. The carbon footprint of the energy type used in the country or factory for raw material extraction and processing and production of our clothes is more important than that of the fiber itself.

Even if we know the kind of energy used for manufacturing the piece of clothing, this is something that we cannot change. What we can change, however, is how much and in what way we use the products of the textile industry. How much we buy, how long we use what we have bought. We have also seen that we, as consumers, are actively involved in CO2 emissions from fashion.

So... What can we do as consumers? Here are a few pieces of advice that can help us minimize our footprint.

- Buy clothes whose materials and design presuppose long use.
- Buy them less often – quality before quantity.
- Buy clothes from recycled materials.
- Wear the clothes until they are worn out or donate them.
- Buy second hand – from the brands we love.
- Look for a new application of worn our clothes. One such solution is to turn them into packaging for the foods we store in our refrigerator. This is not hard at all. We take a piece of fabric, cover it with beeswax, put it in the oven and after a short while we have the ready packaging.

But, above all, only buy as much as we will be able to actually use. Quantity does not make us more beautiful. And lastly, only buy to fulfill a need.

Research

Familiarize the class with the concept of circular economy, presenting them an example from the textile industry and the world of fashion. Then challenge students to find other examples of circular economy and to shape them in a PowerPoint presentation or another (artistic) presentation either during the class or at home.

Activity flow:

1. Distribute the text Worksheet – circular economy and the textile industry.
2. Give students 5 minutes to read the text and think about what in the text has provoked them or made the greatest impression on them.
3. Complete their responses with the information in the box. Note other curious conclusions from what the students share.

Circular economy

In the worksheet, we have very superficially presented a huge subject. For those of you who are curious, there is a lot of information on the Internet, which we encourage you to read. Taking action to shift from the current linear economy to a circular economy is extremely important; it will save a lot of resources, many emissions from the production of new resources, a lot of waste. The circular economy makes use of existing resources while reducing dependence on new raw materials and minimizing waste. These are three valuable steps toward reducing the global carbon footprint. Prolonging the lives of existing resources will not only limit emissions, but will also reduce existing social inequalities.

MUD Jeans

We saw in the text that MUD jeans are using several curious things. On the one hand, this is renting rather than selling jeans. On the other hand, this is the use of organic cotton.

In the previous part of the lesson, we have seen that this kind of cotton has a smaller carbon footprint than the other, so-called conventional cotton. But it also has many other environmental and health benefits that we will mention. They are not part of the main subject of our lessons, namely climate change, and that is why we have not addressed them earlier, in the textile topic.

Environmental benefits
The use of water on part of industry is crucial. According to the WWF, 2,700 liters of water are used for the production of one T-shirt from conventional cotton. By comparison, the same T-shirt, made of organic cotton, has a water footprint of 243 liters. In the case of MUD, one pair of their jeans uses 477 liters, against 7,000 liters for conventional production.

Heath
As regards health benefits, organic cotton does not use harmful pesticides and herbicides, which are otherwise a necessity for conventional cotton and are associated with many and serious health problems for workers.

Finally, we have seen that MUD jeans also use recycled cotton. 40%, against textile industry average of 1%. In fact, textile recycling has significant carbon benefits. To imagine them, let us say that: 1 ton of cotton T-shirts submitted for recycling saves 13 tons of carbon dioxide and 3,100 cubic meters of water.

4. Then you can let each of the groups share their ideas on the use of the circular principle in clothes used with the rest of their peers.

5. In the end, allow time and hear other areas where the circular principle can be applied.

Wrap-Up

This is the time to close the first more detailed presentation of the subject of the carbon footprint of fashion and its decrease though an example from the circular economy and to hear more about what the pupils have understood.

Activity flow:

1. Summary of the topic

The fashion industry creates an extremely high amount of carbon emissions and waste. It is therefore important that we, as consumers, change our habits and attitude toward clothes.

2. Ask pupils the following questions and let each one of them think and write their answers on their own.

» 1 thing that struck me the most from what was read and discussed? Why?
» 2 things which have changed in my way of thinking on this subject?
» 3 things I would like to learn further?

Прочетете текста и след това отговорете на следния въпрос:

Как можем като потребители да намалим собствения си принос във въглеродния отпечатък на модата?

Clothes and emissions

The carbon footprint of the fashion industry[1] is 4% of total CO2 emissions[2]. This is not insignificant at all – as much as the aggregate emissions of Germany, France and the UK altogether. Seventy percent of the sector's emissions are due to the energy used. The remaining 30% – to transport, packaging, sales, use and disposal.

Textile industry uses both electricity and heat. The former concerns mainly the processing of natural fibers (such as cotton) and is used in the spinning and weaving processes. The latter is mainly used in chemical processes in the manufacture of synthetic fibers (such as polyester).

In the case of cotton, in addition to processing, energy is also used for growing the crop (for irrigation, fuel for processing machines, fertilizer production and plant protection products). Part of the energy-related emissions are fewer for **organic cotton** production, for which no fertilizers and plant protection products are used.

In the case of polyester, in addition to processing, energy is also used to extract crude oil, to produce a **primary polymer** and to obtain fiber from it. Very often, the primary polymer of polyester is PET – the same as used for mineral water bottles. The polyester fiber is also the most used in the textile industry.

[1] The textile industry has a greater footprint; in this case, we are talking only about fashion.
[2] McKinsey & Company (2020).

The eco-friendly choice of fiber and clothing

There is a lot and contradictory evidence in scientific literature about which carbon footprint is higher – that of cotton or polyester. This is not even important. What is more important is to reduce emissions from the extraction, processing and manufacture of fibers and clothing, respectively. And this can happen by thinking about how and how much we use textile products. How much we buy, how long we use what we have bought.

It is our consumption that has made fashion a significant contributor in global emissions. Today, we buy 60% more clothes than in 2000. Consumption is expected to grow more and more and this growth means not meeting the objective of limiting global warming to 1.5°C.

Furthermore, we use clothes for half the time. The fact that we turn them into something expendable so quickly is reflected in its carbon footprint – 4 kg of emissions per kilogram of clothing dumped (the reason is the loss of resource and the need to produce a new primary one). Fashion in the recent past meant two collections: spring-summer and autumn-winter. Today we can see up to 24 collections per year (Zara). Production has become cheap and fast, but what we can see has its carbon price.

Read the text on the circular economy and textile industry as a group:

- Generate other possible ideas for circular use of clothes that can be promoted among your peers
- Give examples of other goods and industries where circular economy principles can be used.
- Shape your ideas in a short presentation/poster.

Circular economy

Even if you have not heard this term, you will certainly hear it in the years to come, as you grow and start studying for your future profession. The concept of a circular economy means designing our systems following nature's principles. And we know that there is no waste in nature. Instead, there are constant cycles the planet's resources are going through, recovering.

Unlike this cyclic natural model, many of our systems are **linear**. We take natural resources, produce something from them, use it and throw it away, quite fast. You can already guess that this process is mainly powered by fossil fuels, which means carbon dioxide in the atmosphere.

A key task for the present, looking to the future, is to apply nature's model to process, product, and service design. Just as nature cycles organic (biodegradable) resources, the economy should also cycle technical resources. What does this mean? Think of a washing machine. And now let us imagine it has been designed so as to be easily disassemblable into its components. When one of them breaks, we could repair or replace it. Only the broken part, not the whole washing machine, will go to the rubbish. Now let us imagine that we have not even bought this washing machine at all. It has remained the property of the manufacturer. We have only rented it. When we no longer want it, we would return it, and the producer would give us a new one. Rented again. The resources of the old, thanks to its design, can be reused in production. This is circular economy in a few words.

It is based on three principles:

- No waste and no pollution
- Recycling products and materials, without losing their value
- Restoration of nature.

MUD jeans

Speaking of renting. Let us meet the Dutch MUD Jeans. Most jeans produced today follow the principle of the linear economy. Less than 1% of the materials used worldwide to produce clothing are recycled.

This is not the case in MUD jeans. They produce their geans using 40% recycled and 60% organic cotton. Then they would rent them for a monthly fee. If your monthly salary is BGN 1200, your fee, according to the MUD's tariff, would be BGN 4 for the same period.

During the period of rent, any amendments are free of charge. In one year's time, you are given the following options:

- Replace your jeans for a new pair and the rent will continue.
- Continue to wear them for free being able to return them for recycling at any time.

In addition, MUD's jeans are carbon neutral. The production of one pair emits just over 6 kg of carbon dioxide into the atmosphere. This is 74% less than the industry standard. They succeed thanks to low energy production and use of recycled cotton. They compensate these 6 kg by paying another organization which saves these emissions through its activity. For example, by financing renewable energy installations or afforestation activities.

How can we contribute to addressing climate challenges?

GUIDELINES FOR ORGANISING AND CONDUCTING YOUR OWN PROJECT, FOLLOWING THE PRINCIPLES OF DESIGN THINKING.

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Teach For Bulgaria

Dear teacher,

Thank you for choosing to work with your students on climate change. Having worked on the separate sections, the time has come to embark with your students on the adventure of generating a solution. For this purpose, we will use the method of design thinking. The power of design thinking allows students and adults alike to transform the world into a more responsible, empathetic, and "green" world. It is your important role to guide students to see that a change in the living environment can be meaningful and fun, and that through this process they can also be "changed".

What is design thinking?

» An approach to finding solutions to complex problems based on empathy, collaboration, analytics, and creativity.
» A mindset and a way of thinking and working.

Design thinking requires:

» Showing empathy and understanding the needs of the people for whom we design solutions;
» Defining problems and looking for possible solutions;
» Generating and visualizing our creative ideas;
» Developing prototypes;
» Testing solutions and looking for feedback;
» Presenting the process and results achieved before an audience;
» Reflecting on the path trodden and the lessons learned.

Example:
If you give students the task of designing a car that is eco-friendly, they are likely to invent the coolest cars, but what if you ask them to design an eco-friendly way for people to move from one place to another? This way the possible solutions become much more. When your students start thinking about solutions to the actual problem, instead of redesigning an existing solution, it is already an innovation in action.

Why is design thinking important for students in the 21st century?

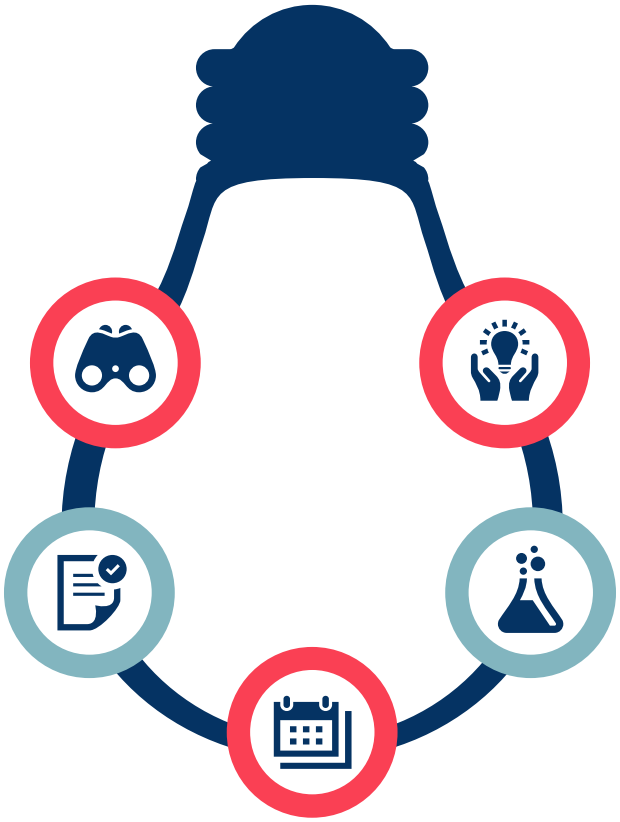
Think about the rapidly changing world we live in. In order to be able to thrive in the future, students will need to be adaptable and flexible. They should be prepared to face situations they have never seen before. Design thinking is one of the best tools we can give our students to ensure that they:

» Develop confidence in their ability to adapt and respond to the new challenges of the 21st century;
» Are able to develop innovative, creative solutions to the problems they and others face;
» Learn to accept failures, take risks, and develop perseverance.
» Develop as optimistic, empathetic and active members of society who can contribute to solving the complex challenges the world is facing.

How can we and our students use design thinking in our work on an eco-project addressing climate change?

Design thinking is an approach that consists of several specific steps and stages. Each of them offers a set of strategies to achieve the expected results listed. It is hard to determine how best to fit these into a 40-minute class, because it may take more time, to be distributed between classwork and extracurricular work.

The pages to come present the different stages that students should go through. Familiarize yourself with them before you start work. All the steps are written as instructions to the students, and in addition you will find clearer guidelines to hold the respective classes. It is up to you and your students how long it will take. Students take the leading role in the process, so dare to have fun and learn along with them. This is one of the adventures in which there is no single right path to achieve to the desired result.



Step One
Understanding

Whom are we trying to help?

Step Two
Defining

What specific problem are we solving?

Step Three Planning

What is the best solution?

Step Four
Testing

How are we going to make it, and test whether it is working?

Step Five
Sharing

How are we going to present and assess the efforts and results?

STEP 1

Researching the problem selected

This is the first and most important step in your project. You are about to explore the surrounding environment to learn more about the perceptions and opinions of the people around you, so as to get to a specific topic of the project you are going to work on.

In the process of work, you will develop many skills. Read them before you start. You can discuss with your classmate which one you feel most confident about and which one rather worries you.

Active listening Looking for ways to understand someone else's point of view, not to prove my own.	» Asking questions to fully understand what the person next to me is talking about. » Avoiding reprehensible reactions to the other person. » Paraphrasing to be sure I understand the other side correctly.
Empathy Empathy increases when I observe more.	» Acknowledging my feelings. » Taking into account the emotions and feelings of those around me. » Seeing opportunities for change in my surroundings.
Critical thinking Offering a solution requires a thorough knowledge of the issue.	» Taking into account the thinking and views of the people involved in an issue. » Trying to understand the reasons that affect the existence of the problem. » Looking at the problem from different perspectives before reaching a solution.

Guidance for the teacher

Teachers: use this activity to check students' understanding of individual skills and clear any ambiguities surrounding the meanings of specific terms and actions. This can be a valuable benchmark to help you choose specific skills to focus on in your work with students.

Have a brief discussion with students about their understanding and mastery of specific skills.

Click **here** for more information and ideas on developing social and emotional competences.

1. How do other students around the world work to protect the climate?

With all the knowledge and experience you have already gained, as well as with those you are about to develop, you can realize many different ideas. Before diving into this adventure, it would be valuable to pay attention to projects that other students have already implemented. This will help you come up with new ideas, see what is possible and how much you can achieve. To do this, follow the steps:

» Look online for examples of school initiatives aimed at protecting the environment and reducing the process and consequences of climate change, or look at **some of the projects** presented by participants in the first "Understanding Climate Change" event. Present them to your classmates by sharing the answers to the following questions:

- What is the idea of the students?
- What is their age?
- What makes the idea impressive?
- How can the idea be built on?
- What inspires me from this story?

Discuss the impressions of the stories told and the projects.

Guidance for the teacher

You can conduct this activity to set the scene, to engage students, or alternatively to assign it as homework to be presented at the beginning of the class. The main goals are two – for students to be inspired by different examples and to have a critical look at what they could build on them.

2. What do people around us do? Why?

To make sure the project is successful, it is important to have a good understanding of how people live and use the different resources around us. It means knowing the choices they make and the reasons behind them. Only in this way can we offer solutions that simultaneously improve the environment around us and are acknowledged by people as such. Otherwise, we will offer a solution that may be liked, but not used. This means that we will not achieve a change the environment.

Acquaint yourself with the steps below and divide the tasks among you. Perform them in the sequence in which they are specified.

Your goal is to explore all the behaviours of people in your community who are directly or indirectly related to the problem you are trying to solve.

Observations What types of behaviour do you see in the people around you?	**Opinions** What do you hear from the people around you?	**Sensations** What do you feel on their part, when it comes to the subject?

» Based on the information collected, you can create a map describing the situation. Enrich it with photos, drawings, quotes so as to illustrate the diversity of people's choices, behaviours and thoughts.

» Once you have collected and aggregated this information, start with your analysis. The first step is to determine what things are bothering you and what are the things you think can serve as a foundation to build on and improve.

Example: Many people use cars to get to work, even though they want to do so by bicycle. Using cars as the most common choice can be a concern, but the attitude toward the bicycle is a positive thing.

Fill these in here:

I am concerned that: **Because:**	**The fact that...** **gives me hope,** **Because...**
What opportunities for development do you see on this basis?	

Guidance for the teacher

The goal of this step is for students to gather information about how people in the community perceive the problem. In order to find a solution that is acknowledged by people as such, it is important that it does not require too drastic a change in people's habits, but offers a real alternative. Therefore, whether you have chosen to work toward changing transport, food or consumption habits, it is key to understand what people use most often and how, why they prefer it and what it gives or saves them.

Once you have chosen the topic and the problem you want to solve, ask students to describe in a table everything that is observed as behaviours in people, everything that can be heard from them as causes, perceptions, and all the attitudes and moods that can be felt.

Discussion

Discuss in small groups what the similarities and differences between problems and opportunities you see are. To what do you attribute this?

Similarities	Differences

Choose as a class the main conclusions, on the basis of which you will develop your project idea.

»

»

»

Then consider what the main reasons that have led to it are.

Remember, these are just hypotheses and assumptions. At the moment, you have no direct evidence that any of them is true.

Guidance for the teacher

In this part, be sure to remind students that they should choose "something" they find worrying, which sounds important to them and worries them in some way. Get to the heart of these concerns by provoking them with the question "why". Even if they have already indirectly explained their thoughts, provoke them again with the question "why", not hesitating to refer to the critical thinking skills that develop through such exercises.

3. What do people think and know?

Now is the time to conduct interviews with different people to find out more about the real attitudes and causes of people's behaviours in the community. In the same groups, you should conduct short interviews with people from the community who are directly involved in the problem and topic of choice.

For example: If you have chosen the topic of transport, you can talk to car owners and cyclists.

For the interview, use the following questions:

» ***Factual questions*** *– they help you understand more about the picture that interviewees see. For example: How often do you use...? What do you prefer? What kind of...?*

» ***Research questions*** *– they help you understand the reasons and get to the deeper preferences of the interviewees. For example: Why? How is this better than...? How did you choose it? And so on.*

» ***Paraphrasing questions*** *– they help you check if you have correctly understood the person you are interviewing. For example: You said that... Is that what you mean? Does this mean that...?*

Fill in the information in pairs in the following format:

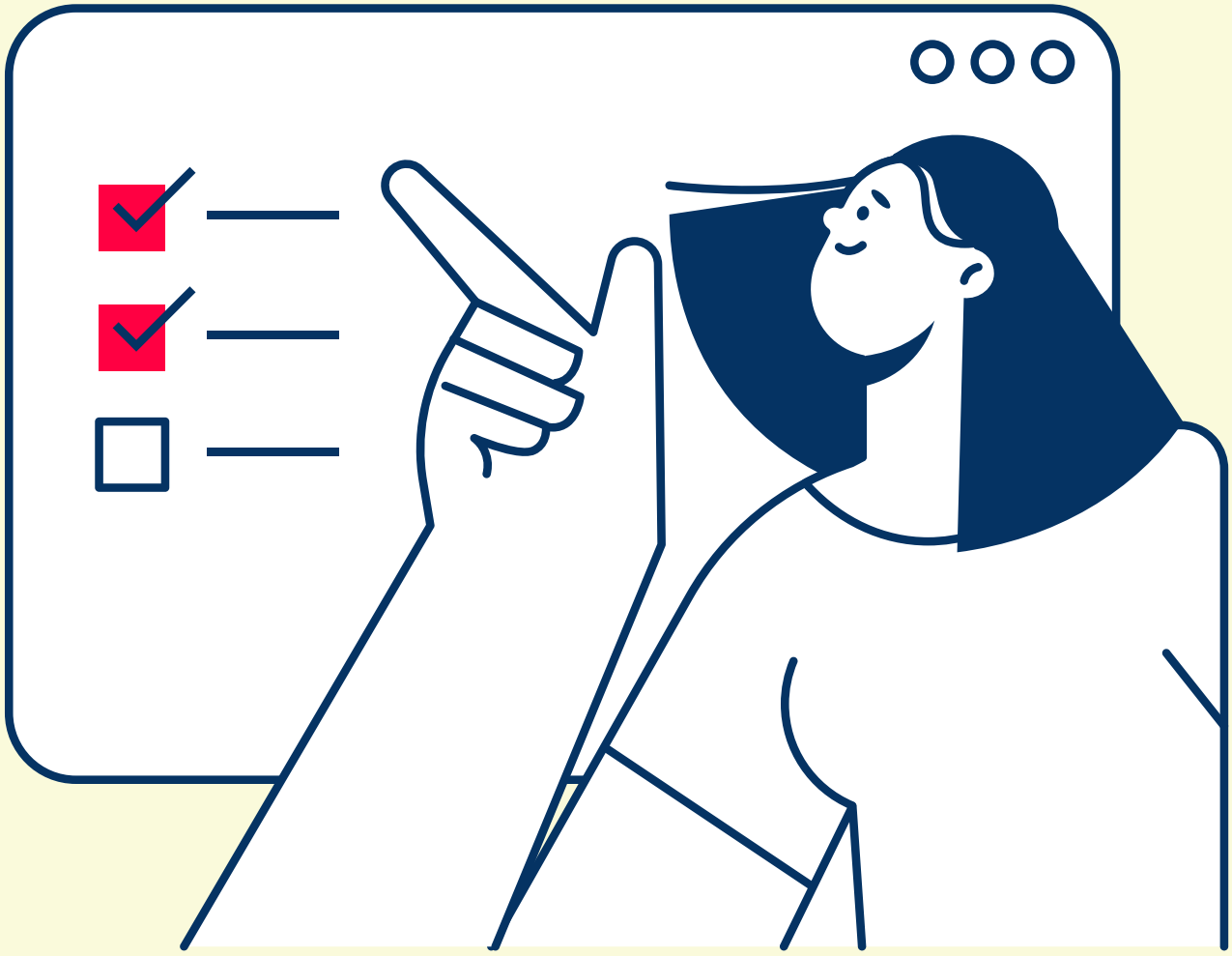
Who is the interviewee?
Why did you choose him or her?
What new information did the interview give you?

Guidance for the teacher:

Let each pair briefly present the information from their study or exchange it in groups so that they become familiar with the preferences and habits of different people. At the end of the presentations hold a short discussion with students on the general and different trends that can be inferred from the interviews to arrive at a more comprehensive understanding of the issue and the behaviours of the people.

STEP 2

Defining the topic of the project



1. What is possible to achieve?

On the basis of all the information, consider and summarize the main issue you would like to address as a challenge. Give the project a name.

Let each pair share theirs and then move on to finding the common element in your ideas to come up with a shared understanding of the challenge you will take on.

Write them here:

The challenge: How can we...

Project name: ....

Guidance for the teacher

Let each pair define a challenge for the project and propose a name.
Let each pair then share their ideas and thoughts, and finally, as a class, choose a common one if you have all decided to work on the same project.
In order for this to happen, you can:

- Vote;
- Point out the shared features among all ideas and create a common one.

Congratulations on the idea you have come to! More congratulations and for all efforts to apply and develop new skills in the process of work.

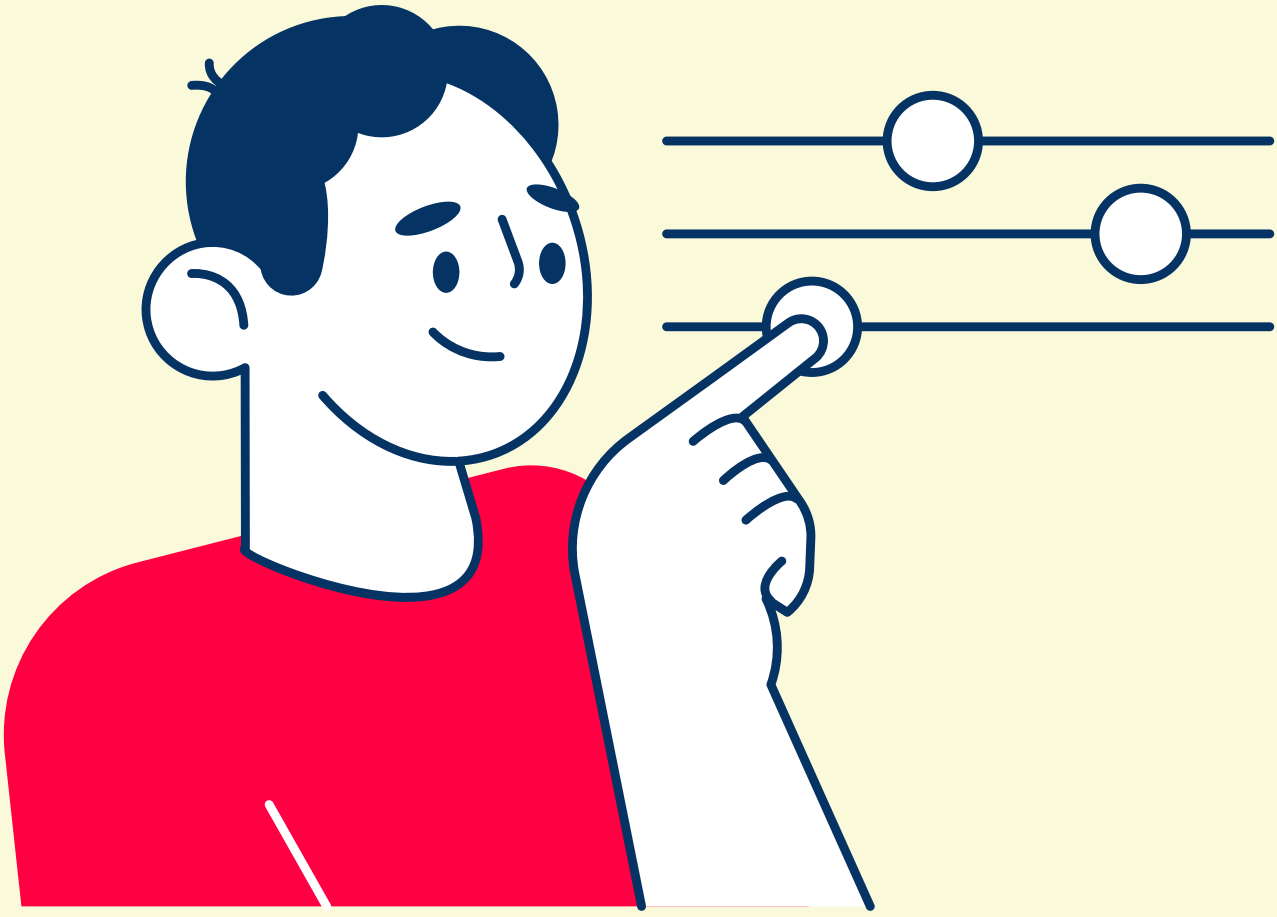
In the coming hours you will begin the actual work on the project by generating ideas for possible solutions!

Guidance for the teacher

You can have a brief discussion with the students about their impressions of working on the project. What was useful, challenging, exciting? Explain that the next step is to reach ways for proposing solutions to the situation.

STEP 3

Planning



The purpose of this step is to create a plan for the implementation of all upcoming project activities. A good organization of all activities is a key ingredient in the recipe for a successful project. You will list all the tasks and distribute them to each other, set deadlines and think about all the resources you will need for this.

Objectives:

- Creating an action plan
- Presenting your own idea and collecting feedback
- Giving feedback in a respectful and constructive way

These are the skills you will develop through these activities. Familiarise yourself with them and discuss with your classmate how confident you feel with each of them at this stage.

Persistence, perseverance and creative thinking	» Creation of a detailed plan to solve a problem. » Preparing for the challenges that await me. » Looking for feedback to improve my ideas and actions.
Cooperation	» Helping in things I am good at.
Giving feedback	» Giving concrete and constructive feedback.

1. What could go wrong?

- List all the ways your decision can go wrong or fail.
- Share your ideas with others in the group.
- Take note if there are concerns that overlap.

Guidance for the teacher

Let students list and discuss all their assumptions about what could potentially go wrong in the realization of their idea. Let everyone share their concerns and ideas.

Provoke students with the question ***what will help them avoid their concerns coming true or to react calmly and effectively in case they do become real?***

Summarize the answers and focus on the planning process, such as preparation for the realization of their idea and selecting the most important steps for this to happen.

This activity aims to provoke students to consider the importance of planning. Explain that much of the process of realising ideas depends on them, and in particular on how much time they have invested in preparation before they begin to act.

2. How to prepare best?

Work in pairs or small groups to create your preparation plan. Before moving on placing tasks along a timeline, discuss the following questions:

- How are we going to implement the idea?
- List all the activities that need to be done to get your idea to fruition?
- Discuss who could do them and who could be useful in the process?
- Distribute them in time using tables like this one for each of the weeks

	Week 1		
Objective:			
Activities			
Who will do it?			
Who will help with opinions and guidance?			

Make similar tables for the entire period of your project.

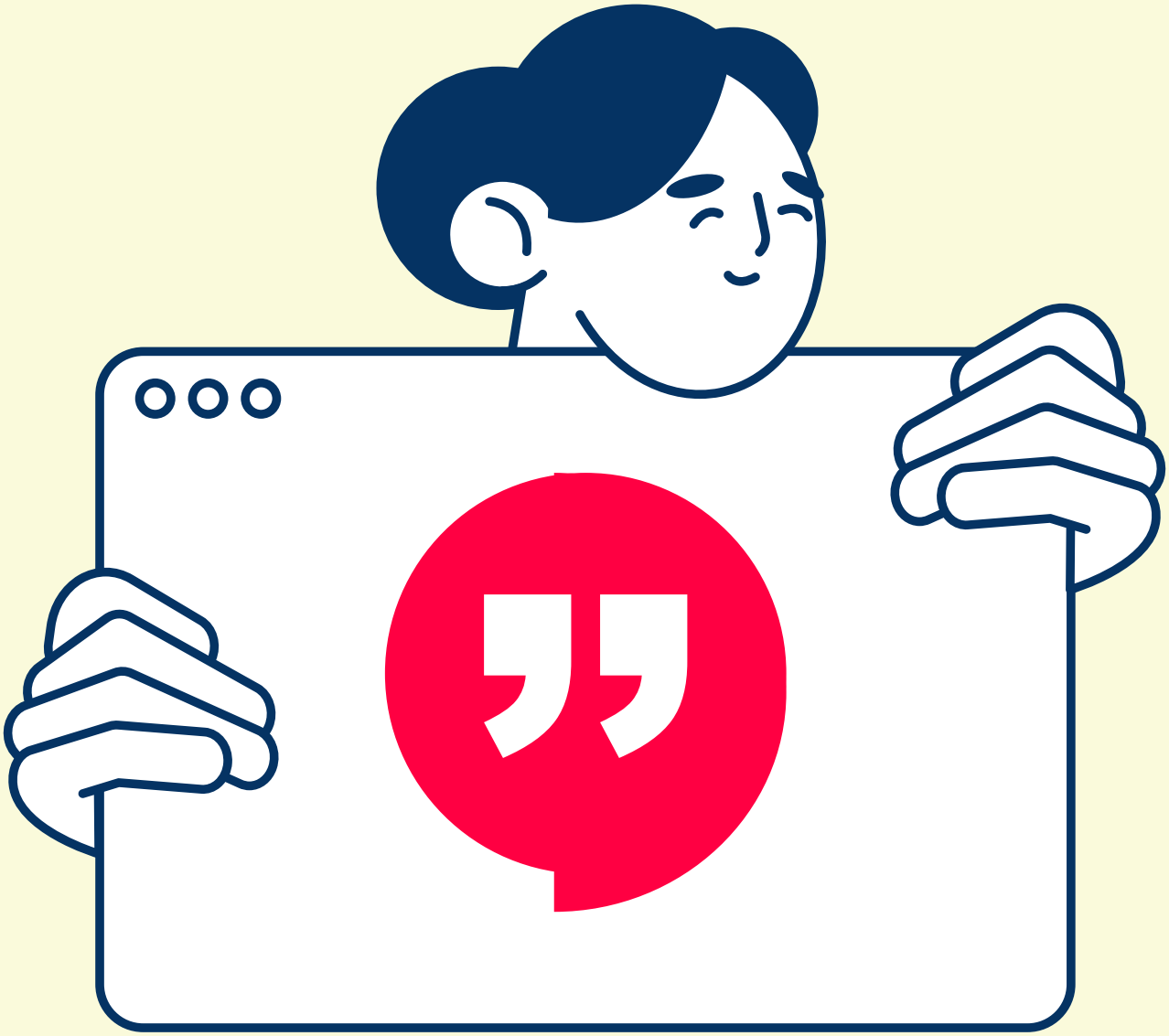
Guidance for the teacher

Distribute the table with questions to think about to students before they start implementing their plan. Assign specific tasks to individual students/groups.

If necessary, create more such tables so as to cover a longer period of time.

STEP 4

Testing



1. How will we know if our idea is good?

When we come up with a solution to a challenge, there is a danger that it will only remain in our "closed" circle, thus risking not to achieve the results we want. So the next most important step is to tell, test and check the reactions and attitude of the other people to the problem and its possible solution. To do this, add "testing" as a step in your plan and be guided by the following:

- Find at least 5 different people to tell your ideas to – they may be of different ages, gender, interests, abilities and attitudes. This will give you a more complete picture of people's perceptions.
- Ask them what they think, whether they would get involved, what is bothering them.
- As you listen to them, take notes and ask additional questions.
- Do not convince them why the idea is good, and do not excuse yourself, but learn as much as possible about the reasons for their attitude, as well as the things that would make the idea appealing to them.
- Take notes carefully and then share them with the others.
- Summarize your notes and divide them into two main categories to present to the rest of the class.

Advantages of the idea	Opportunities for improvement
»	»
»	»
»	»

- Based on the information collected, take time to discuss what you can improve in your idea.
- Add these as activities in the plan and distribute them among you.

Guidance for the teacher

In this part, it is very important to pay attention to the added value of carrying out such a test of the idea. You can return students to the initial plan and add "idea testing" as a first step in implementing the solutions to the problem.

When preparing for testing, you can pay attention to their reactions when they encounter disapproval of the idea. Remind them that the goal is not to convince others of the added value of the solution, but to obtain valuable information to improve the initial idea. You can enact it so that they can imagine it.

After presenting the information they have collected, take the time to discuss the results and the need to change the plan.

2. Lastly, what else can we do? :)

On the final stretch, the time has come for the task to try to check our action plans once again and make sure they will take us in the right direction. We will use the Compass Protocol for the purpose. Each of you will present their plan to the others, who will share their thoughts and ideas using the four directions:

- East – Excitement: what you are finding exciting in the action plan
- West – Concern: what is bothering you about the plan
- North – Need of further information: what else you need to learn about this plan
- South – suggestions for improvement: what would build on the idea and the plan

Let everyone summarize the answers and ideas, return to the plan and consider the suggestions received.

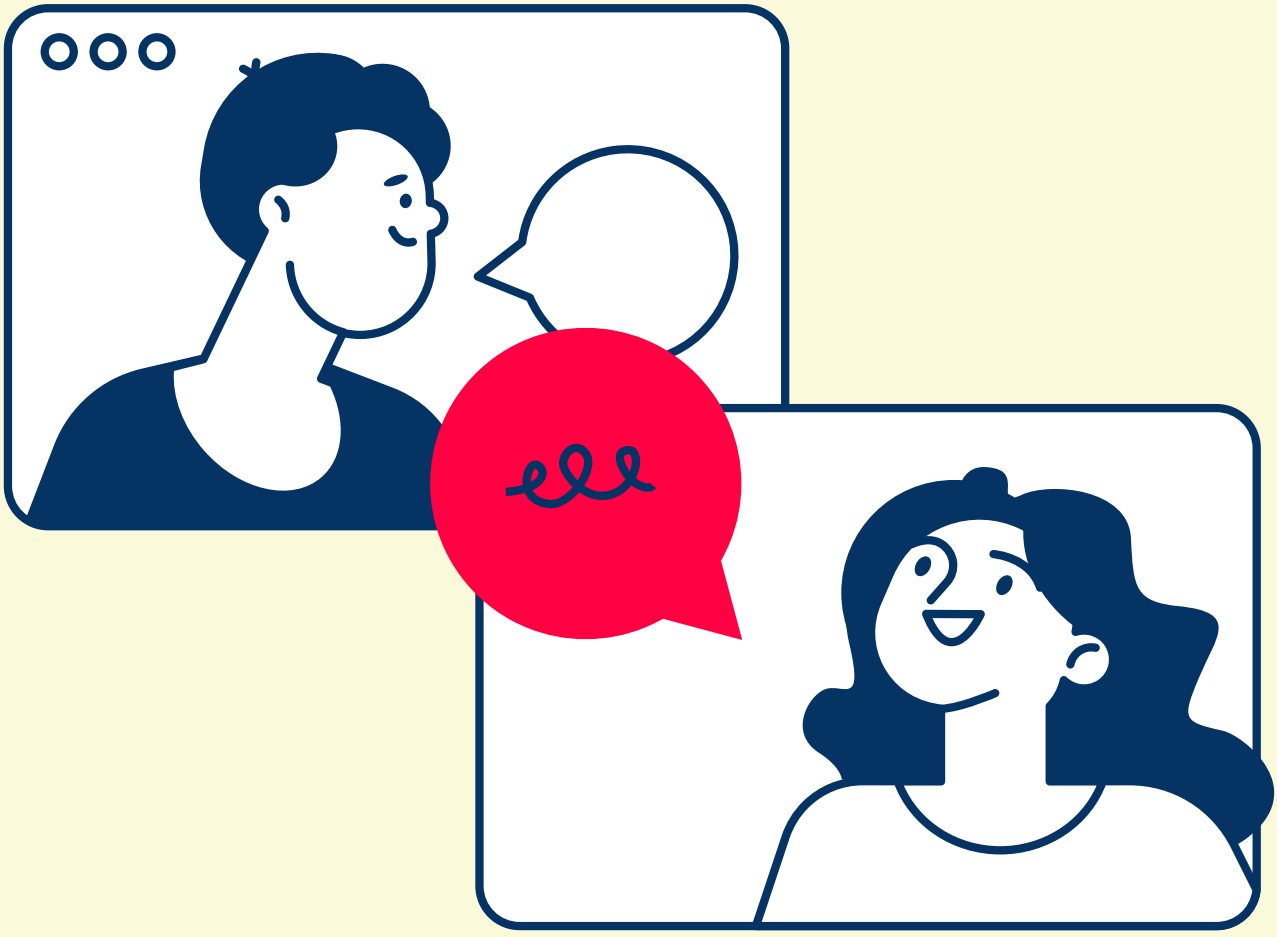
Guidance for the teacher

Explain to students the need for the final test and shaping of action plans as a step that will ensure the exchange of ideas and experience and make them much more prepared for work.
You can go through the questions together to make sure that students understand what is expected of them in this activity.

Then explain to the students that they will begin working independently on the realization of their ideas. The last step will be to understand the experience they have gained.

STEP 5

Reflecting on our experience



The goal of this final step in the whole process is to make sense of the experience you have gained and the results you have achieved. Regardless of everything you have managed to do and not do, your overall work on the project is one of the most significant ways to learn and develop.

Objectives:

- Understanding your own experience and development during the project
- Self-assessment skills
- Presentation of results

These are the skills that you will develop through these activities. Acquaint yourself with them and discuss with your classmate how confident you feel about them.

Metacognition	» Analysing the results achieved in the process of work. » Outlining the next steps that I should develop to improve myself.
Presentation skills	» Presenting my ideas clearly and fascinatingly.

1. What did I experience during the project?

- Think about and choose one word that best describes your overall experience during the project.
- Explain to others what your word is and why you have chosen it.
- Listen to the others and write down similar and different ideas you hear from them.

Guidance for the teacher

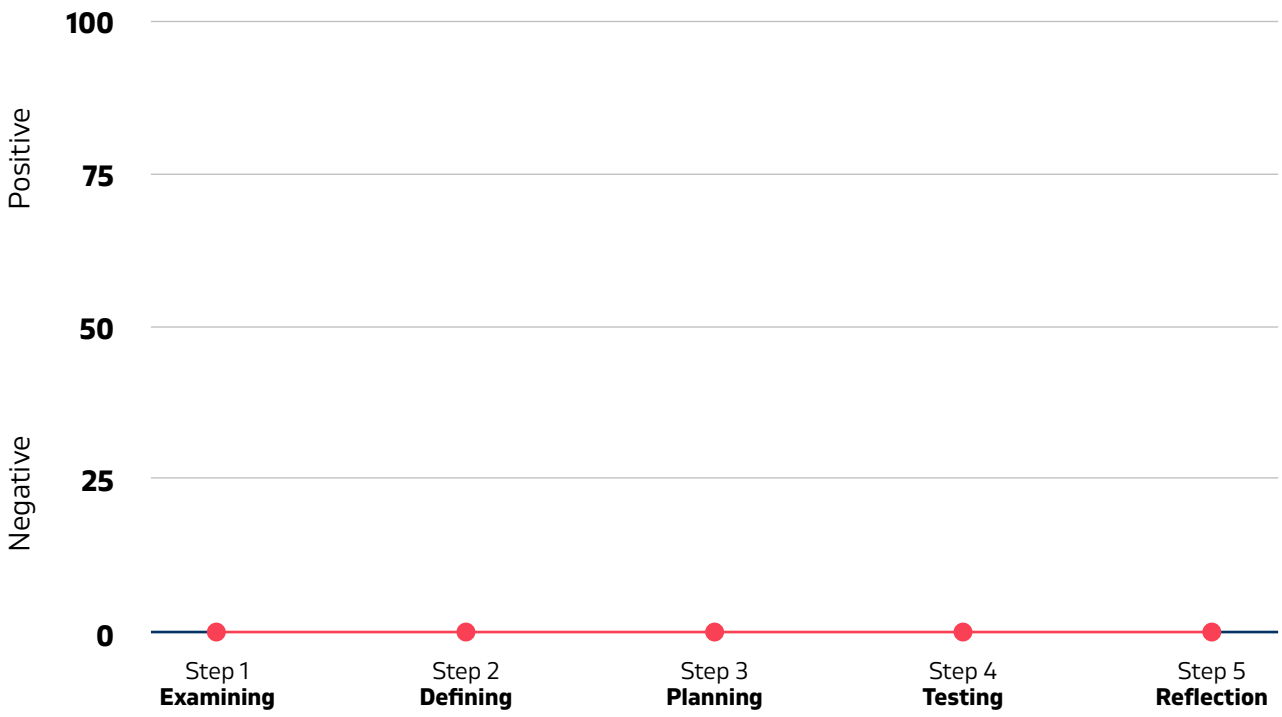
- Challenge students to choose a word that describes their experience of the project.
- Let everyone write it down and discuss it with a classmate.
- Ask them what they have found in common and what was different during the sharing process.
- Write down keywords and try with students to select one word that best describes the group experience.

2. What is our story?

To understand your overall experience on the subject, it is important to reflect on the individual stages of the process. You are about to have a reflection that will allow you to understand the whole experience more fully, to see what you have managed to develop and achieve and what more you want to do in the future.

» Think and write the answers to the following questions:
- What have we achieved? Re-examine the reason for change, and review whether the desired impact has been achieved – for the people involved and affected by the problem.
- What have we learned about this topic? Has a better understanding of the cause/ situation/behaviour been developed??
- What have we learned about ourselves? What about our community?
- What new skills have we developed? You can remind them of the skills at each step.

» Draw a map of your experience in which you can share the individual specific moments in which you felt challenged/inspired, etc.



» Summary and presentation of what has been learned
- Tell your story through photos and/or videos that visualise your journey.
- Share your story with your school, parents and friends to inspire them.

Guidance for the teacher

During the reflection, it is important to try to lead the process so that students can reflect both on their strengths and the areas they have identified for development based on their work.

Do not rate students' answers – it is a personal experience.

Share with your students your own answers along with everything else you have been able to learn in the process. This way you will model a development mindset and desire for improvement.
Send your experiences to **prepodavame@zaednovchas.bg**. We will be happy to learn more about your stories and share them with the community.

Lesson 1 – Introduction to the topic of climate change	Carbon dioxide	A chemical compound of the elements carbon and oxygen.
	Methane	A chemical compound of the elements carbon and hydrogen.
	Water vapor	A chemical compound of the elements hydrogen and oxygen.
	Absorption	The capacity of liquids or, less commonly, solids, to take in gases or liquids.
	Average surface temperature	The average temperature on the surface of the sea and on land.
	Greenhouse gas	A chemical compound capable of absorbing heat.
	Climate change	A long-term change in global or regional temperature and time.
	Fossil fuel	Hydrocarbon-containing materials that can be burned to produce energy.
	Industrial revolution	A period of transition from an agrarian economy to industrial production.
	Ice samples	Cylindrical ice profile.
	Empirical data	Data based on previous experience.
Lesson 2 – Section 1	Carbon reservoir	Ecosystems that store carbon.
	Carbon source	Something that releases carbon.
	Anthropogenic impact	Impact caused by man.
	Lignin	An organic substance that determines the hardening of plant tissues.

Lesson 2 – Section 1	Cellulose	A substance that is the main constituent of the plant cell wall.
	Phytoplankton	Microscopic organisms that live in seas, rivers, lakes and are buoyant or float, are involved in the cycle of substances and are important food for a number of aquatic organisms.
	Shellfish	Invertebrate animals with a soft body, covered with a hard shell.
Lesson 1 – Food and nature	Intensive farming	A type of farming known for the higher levels of resources input and extracted from a unit of arable land.
Lesson 2 – Soils and forests	Primary (old-growth) forest	Forests with insignificant traces of human impact.
	Mechanical soil structure	Characteristics of the soil, which determine its mineral composition.
	Acid-base balance	The ratio between positively charged hydrogen ions and negatively charged ions in one solution.
	Herbicides	Plant protection products.
	Pesticides	Plant protection products.
	Erosion	Gradual caving, destruction and removal of soil, rocks and other objects, caused by water, ice, atmospheric impacts and other natural factors and phenomena, which change the shapes of the earth's surface and relief.

Lesson 2 – Soils and forests	Biomass	In this case: What remains of crops, not used by the food industry. Otherwise: The total mass of living organisms existing in equilibrium on a given area or in a given volume of sea (ocean) or freshwater.
	Compost	Organic fertilizer obtained from the mixing of animal or plant waste with peat, earth enriched with phosphorus flour and other minerals.
Lesson 3 – Water	Solar collector	A device for capturing solar energy to heat water.
	Intensive fishing	A type of fishing known for the higher levels of resources input and extracted from an area unit.
	Trawling	A method of industrial fishing, consisting of active pulling of a special fishing net – trawlnet – from one or several boats called trawlers.
Lesson 2 – Transport	Gross world product	A macroeconomic indicator defined as the final output of the annual production of tangible goods and services in monetary terms in the world economy.
	Globalisation	A process of convergence and unification of the economy, political relations, culture, etc. of countries worldwide, possible thanks to modern technical means of communication, reducing the importance of individual sovereign states.
Lesson 3 – Transport	Fast transit bus lines	A system that includes roads which are designed for buses, giving them priority at intersections and places where they can interact with other traffic.

Lesson 1 – Energy	Energy mix	The combination of different energy sources.
	Gigawatt hour (GWh)	Unit of measurement for the amount of energy consumed.
	Turbine	A rotary mechanical device that extracts energy from water, steam or gas flow.
	Kinetic energy	Measure of mechanical movement of a body.
	Photovoltaic panel	A device for capturing solar energy for the production of electrical energy.
	Lobby	Banking agents and capitalists, who have a strong influence on lawmakers to adopt a law.
	Decarbonisation	The process of reducing, eliminating the carbon footprint
	RES sector	The sector of renewable energy sources.
Lesson 2	Drilling	Exploration of the earth's layers. Attempts are being made to reach the oil fields through drilling.
	Heat exchanger	A device that serves to transfer heat from one heat carrier to another.
	Watt	Unit of measurement of electrical or mechanical power (equal to one Joule per second).
Lesson 3	Linear system	A system where there is no cycling of resources.

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