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PROJECT "VIRTUAL REALITY BASED EDUCATIONAL APPROACH IN TACKLING OF CLIMATE CHANGE"

AGREEMENT № 2021-1-SI01-KA220-SCH-000027860

INTELECTUAL OUTPUT O1

INTRODUCING OF CLIMATE CHANGE RELATED TOPICS IN STEM ORIENTATED SCHOOL SUBJECTS

HANDBOOK

FOR SCHOOL TEACHERS

Contents

Chapter I

THEORETICAL APPROACH ON THE CLIMATE CHANGE ISSUES (FORESEEN SCENARIOS AND BEST MITIGATION AND ADAPTATION MEASURES)

https://climate.nasa.gov/solutions/adaptation-mitigation/

Climate change is one of the most complex issues facing us today. It involves many dimensions – science, economics, society, politics, and moral and ethical questions – and is a global problem, felt on local scales, that will be around for thousands of years. Carbon dioxide, the heat-trapping greenhouse gas that is the primary driver of recent global warming, lingers in the atmosphere for many thousands of years, and the planet (especially the ocean) takes a while to respond to warming. So even if we stopped emitting all greenhouse gases today, global warming and climate change will continue to affect future generations. In this way, humanity is "committed" to some level of climate change.

How much climate change? That will be determined by how our emissions continue and exactly how our climate responds to those emissions. Despite increasing awareness of climate change, our emissions of greenhouse gases continue on a relentless rise. In 2013, the daily level of carbon dioxide in the atmosphere surpassed 400 parts per million for the first time in human history. The last time levels were that high was about three to five million years ago, during the Pliocene Epoch.

Because we are already committed to some level of climate change, responding to climate change involves a two-pronged approach:

1. Reducing emissions of and stabilizing the levels of heat-trapping greenhouse gases in the atmosphere **("mitigation")**;
2. Adapting to the climate change already in the pipeline **("adaptation")**.

Mitigation and Adaptation

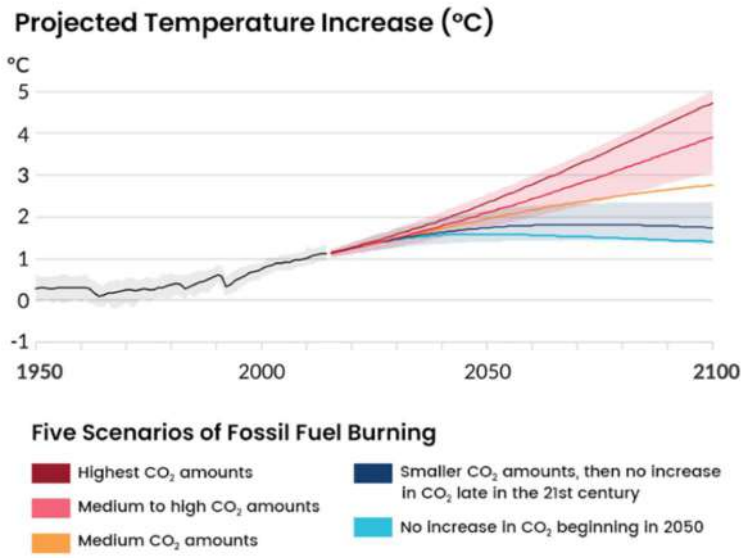
Mitigation – reducing climate change – involves reducing the flow of heat-trapping greenhouse gases into the atmosphere, either by reducing sources of these gases (for example, the burning of fossil fuels for electricity, heat, or transport) or enhancing the "sinks" that accumulate and store these gases (such as the oceans, forests, and soil). The goal of mitigation is to avoid significant human interference with Earth's climate, "stabilize greenhouse gas levels in a timeframe sufficient to allow ecosystems to adapt naturally to climate change, ensure that food production is not threatened, and to enable economic development to proceed in a sustainable manner" (from the 2014 report on Mitigation of Climate Change from the United Nations Intergovernmental Panel on Climate Change, pg. 4).

Adaptation – adapting to life in a changing climate – involves adjusting to actual or expected future climate. The goal is to reduce our risks from the harmful effects of climate change (like sea-level rise, more intense extreme weather events, or food insecurity). It also includes making the most of any potential beneficial opportunities associated with climate change (for example, longer growing seasons or increased yields in some regions).

Throughout history, people and societies have adjusted to and coped with changes in climate and extremes with varying degrees of success. Climate change (drought in particular) has been at least partly responsible for the rise and fall of civilizations. Earth's climate has been relatively stable for the past 10,000 years, and this stability has allowed for the development of our modern civilization and agriculture. Our modern life is tailored to that stable climate and not the much warmer climate of the next thousand-plus years. As our climate changes, we will need to adapt. The faster the climate changes, the more difficult it will be.

While climate change is a global issue, it is felt on a local scale. Local governments are therefore at the frontline of adaptation. Cities and local communities around the world have been focusing on solving their own climate problems. They are working to build flood defences, plan for heat waves and higher temperatures, install better-draining pavements to deal with floods and stormwater, and improve water storage and use.

According to the 2014 report on Climate Change Impacts, Adaptation and Vulnerability (page 8) from the United Nations Intergovernmental Panel on Climate Change, governments at various levels are also getting better at adaptation. Climate change is being included into development plans: how to manage the increasingly extreme disasters we are seeing, how to protect coastlines and deal with sea-level rise, how to best manage land and forests, how to deal with and plan for drought, how to develop new crop varieties, and how to protect energy and public infrastructure.



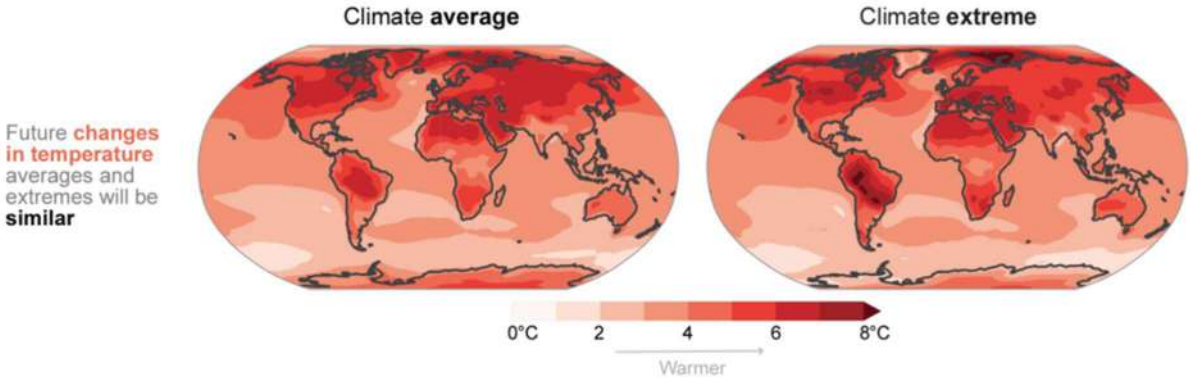
The amount of climate change by the end of the century depends on decisions we make today. If we reduce CO_2 amounts to stop increasing after 2050, global average temperature will increase from 1-1.5°C, and this is considered a best-case scenario (blue line in graph). If we don't reduce CO_2 and the amounts continue to increase, the worst-case scenario warming will be 4.5-5°C (red line in graph).
IPCC Working Group I, 2021

Predictions of Future Global Climate

Scientists from around the world serve as part of the Intergovernmental Panel on Climate Change (IPCC). These scientists have found that from 1900-2020, the world's surface air temperature increased an average of 1.1°C due to burning fossil fuels that releases carbon dioxide and other greenhouse gases into the atmosphere. This may not sound like very much change, but this warming is unprecedented in over 2000 years of records. Even one degree can impact the planet in many ways. Climate models predict that Earth's global average temperature will rise an additional 4°C during the 21st Century if greenhouse gas levels continue to rise at present levels. Without swift action to reduce greenhouse gas emissions, models project that holding global average temperatures to within a 1.5-2.0°C increase may no longer be possible.

Predicted Impacts of Climate Change

Climate change is predicted to impact regions differently. For example, temperature increases are expected to be greater on land than over oceans and greater at high latitudes than in the tropics and mid-latitudes.

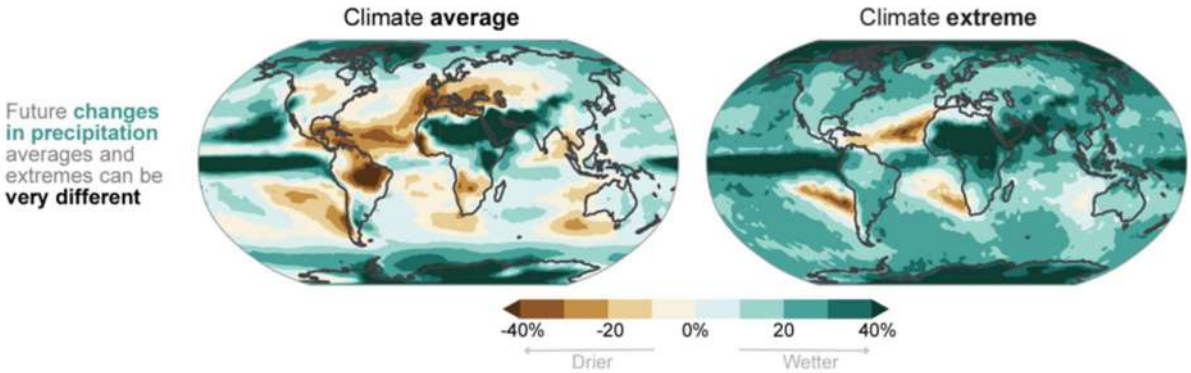


Warming is already occurring in all areas of the globe, but models of future temperatures show that the changes will not be distributed equally. Polar regions and land areas are expected to see the largest temperature changes. *IPCC Working Group I, 2021*

Warmer temperatures will cause (and are causing) changes to other aspects of climate - such as rain, snow, and clouds. They are also causing changes to the ocean, life, ice, and all other parts of the Earth system.

Changing Precipitation

A warmer average global temperature will cause the water cycle to "speed up" due to a higher rate of evaporation. More water vapor in the atmosphere will lead to more precipitation. Global average precipitation can increase by 7% for each degree of warming, which means we are looking at a future with much more rain and snow, and a higher risk of flooding to some regions. With a 2°C temperature increase, heavy rain events are expected to become 1.7 times more likely, and 14% more intense. However, changes in precipitation will not be evenly distributed. Some locations will get more, and others will see less.



Future changes in precipitation will vary regionally, with some parts of the globe likely to become wetter and other areas projected to become drier. *IPCC Working Group I, 2021*

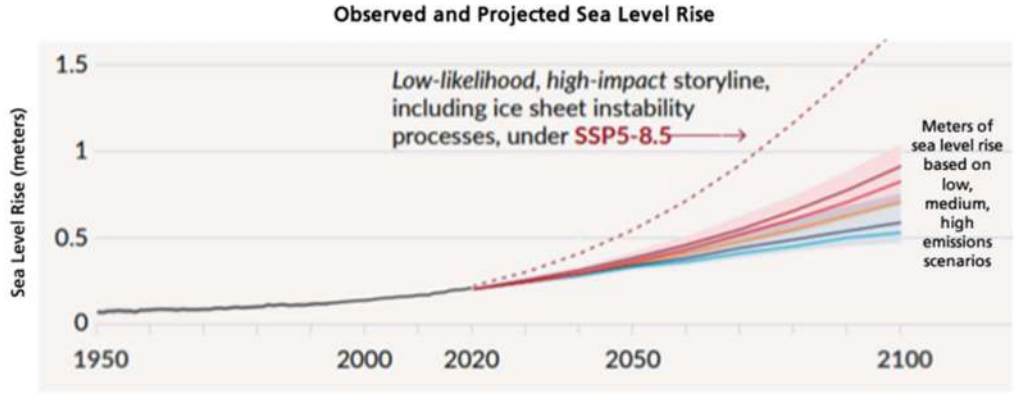
Melting Snow and Ice

As the climate warms, snow and ice melt. It is predicted that the melting of glaciers, ice sheets, and other snow and ice on land in the summer will continue to be greater than the

amount of precipitation that falls in the winter, which means a decrease in the total amount of snow and ice on the planet. Over the past 100 years, mountain glaciers in all areas of the world have decreased in size and so has the amount of permafrost in the Arctic. Greenland's ice sheet is melting faster, too. The amount of sea ice (frozen seawater) floating in the Arctic Ocean and around Antarctica is expected to decrease. Already the summer thickness of sea ice in the Arctic is about half of what it was in 1950. Arctic sea ice is melting more rapidly than the Antarctic Sea ice. Melting ice may lead to changes in ocean circulation, too. Although there is some uncertainty about the amount of melt, summer in the Arctic Ocean will likely be ice-free by the end of the century.

Rising Sea Level

A warmer climate causes sea level to rise via two mechanisms: (1) melting glaciers and ice sheets (ice on land) add water to the oceans, raising the sea level, and (2) ocean water expands as it warms, increasing its volume and thus also raising sea level. Since 1880, sea levels have risen about 0.10 to 0.20 meters depending on region and location. Thermal expansion and melting ice each contributed about half of the rise, though there is some uncertainty in the exact magnitude of the contribution from each source. By the year 2050, models predict sea level will rise an additional 0.25 to 0.30 meters, and by 2100, without immediate reductions in greenhouse gas emissions, global sea level rise is expected to be on the order of 1.1 meters. Some low-lying areas could experience even higher levels, threatening coastal communities, wetlands, and global trade. Even if swift emission reductions occur, the greenhouse gases levels currently present will still likely result in about 0.6 meters of sea level rise by the end of the century.



Observed (black line) and projected sea level rise through 2100, where the coloured curves indicate sea level rise for different emissions scenarios. *IPCC Sixth Assessment Report*

Acidic Ocean Water

Earth’s oceans are predicted to act as a buffer against climate change by taking up some of the excess heat and carbon dioxide from the atmosphere. This is good news in the short run, but more problematic in the long run. Carbon dioxide combined with seawater forms weak carbonic acid. Scientists believe this process has reduced the pH of the oceans by about 0.1 pH since pre-industrial times. Further acidification of 0.14 to 0.35 pH is expected by the year 2100. Higher acidity in the ocean causes problems for coral reefs and other marine organisms.

Changes to Ocean Currents

Large-scale ocean currents called thermohaline circulation, driven by differences in salinity and temperature, may also be disrupted as the climate warms. Changes in precipitation patterns and the influx of fresh water into the oceans from melting ice can alter salinity. Changing salinity, along with rising water temperature, may disrupt the currents. In an extreme case, thermohaline circulation could be disrupted or even shut down in some parts of the ocean, which could have large effects on climate.

Changing Severe Weather

Some climate scientists believe that hurricanes, typhoons, and other tropical cyclones will change as a result of global warming. Warm ocean surface waters provide the energy that drives these immense storms. Warmer oceans in the future are expected to cause the intensification of such storms. Although there may not be more tropical cyclones worldwide in the future, some scientists believe there will be a higher proportion of the most powerful and destructive storms. Some scientists believe we already see evidence for an upswing in the numbers of the most powerful storms. Others are less convinced.

Changing Clouds

Clouds are a bit of a wild card in global climate models. Warmer global temperatures produce faster overall evaporation rates, resulting in more water vapor in the atmosphere...and more clouds. Different types of clouds at different locations have different effects on climate. Some shade the Earth, cooling the climate. Others enhance the greenhouse effect with their heat-trapping water vapor and droplets. Scientists expect a warmer world to be a cloudier one, but are not yet certain how the increased cloudiness will feed back into the climate system. Modelling the influence of clouds in the climate system is an area of active scientific research.

Risks to Marine Life

Ocean ecosystems will change as sea-surface temperatures continues to warm. Animals like fish are able to move to other ecosystems with cooler water at higher latitudes. But many marine organisms – like kelp and corals – that aren’t able to swim elsewhere are at high risk. Warmer waters in the shallow oceans have contributed to the death of about a quarter of the world's coral reefs in the last few decades. Many of the coral animals died after being weakened by bleaching, a process tied to warmed waters.

Risks to Life on Land

Changes in temperature, precipitation, and seasonal timing will alter the geographic ranges of many types of plants and animals. Since species can only survive if they are in a habitat that suits their needs, many species will face extinction if the geographic range where they can survive shrinks. If warming is kept to 2°C, 18% of insects, 16% of plants, and 8% of vertebrate animals are projected to lose over half of their geographic range. However, if we can keep the amount of warming to 1.5°C, the habitat loss to insects, plants, and vertebrates decreases by about a half. On the other hand, the range of some species, such as mosquitos which carry different types of diseases, may increase due to climate warming. Warming surface temperatures are also predicted to increase the frequency of heat waves and droughts, which can affect crop production, increase the risk of wildfires, and even impact human health.

Climate change is causing many other aspects of Earth to change. Using models, scientists can project how these aspects of Earth are likely to change in the future as the climate continues to warm.

Abrupt changes are also possible as the climate warms

Some changes to the climate are gradual and predictable, while others are more sudden and difficult to foresee. The latter is often referred to as “tipping points.” A tipping point is a large, abrupt change that cannot readily be stopped at the last minute, even by employing drastic measures. Possible tipping points include:

The collapse of major ice sheets in Greenland and Antarctica

Melting of these ice sheets is an ongoing process. However, there are signs that moderate melting may accelerate into a runaway situation that leads to a relatively sudden loss of large amounts of ice. Such a collapse could lead to dramatic changes in sea level and could also impact ocean circulation.

Disruption of thermohaline circulation

If the ocean’s circulation changed dramatically or even shut down altogether, the transfer of heat in the climate system would be altered in a huge way.

A sudden release of methane

If the potent greenhouse gas methane were released rapidly from its stores in Arctic permafrost and special ices beneath the seafloor (called methane hydrates or clathrates), the rate of warming would increase. Methane releases would generate a feedback loop of increased greenhouse warming by methane, driving further methane emissions. Some scientists suspect that sudden increases in methane may have played a role in major extinction events in the past.

Ocean uptake of carbon

Today, the ocean is absorbing CO_2 that would otherwise stay in the atmosphere. At some point, seawater will become saturated with CO_2 and unable to absorb any more. At that point, anthropogenic emissions of CO_2 would all land in the atmosphere, increasing the rate of greenhouse warming. Acidification of the oceans could also disrupt marine life, causing photosynthesizing plankton to succumb, preventing them from removing CO_2 from the air. Shells of many types of marine organisms might begin to dissolve in the presence of the acidic oceans, releasing the carbon stored within the shells back into the environment.

None of these tipping points are considered very likely to occur over the next several decades. Still, the consequences of any of them are so severe, and the fact that we cannot retreat from them once they’ve been set in motion is so problematic, that we must keep them in mind when evaluating the overall risks associated with climate change.

I.1 RENEWABLE ENERGY SOURCES

Today's world is faced with the greatest challenge – how to preserve the environment which gives suitable living conditions on the planet Earth. The greatest promoters of the civilization development – the available energy and transport, today are the worst enemy of the living environment. Renewable energy sources (RES) provide sustainable solution, not only in provision of energy, but also vision of the future.

On global level the RES use is increasing. Almost everywhere in the world the renewable energy is gathering greater role followed by increased industry for manufacture and maintenance of the RES technology. The guarantee for a greater future use is seen in the awareness rising, increasing the capacity of industry supporting the technologies for transformation and use of renewable energy, and the growing concern of the governments of all countries to protect the environment from pollution.

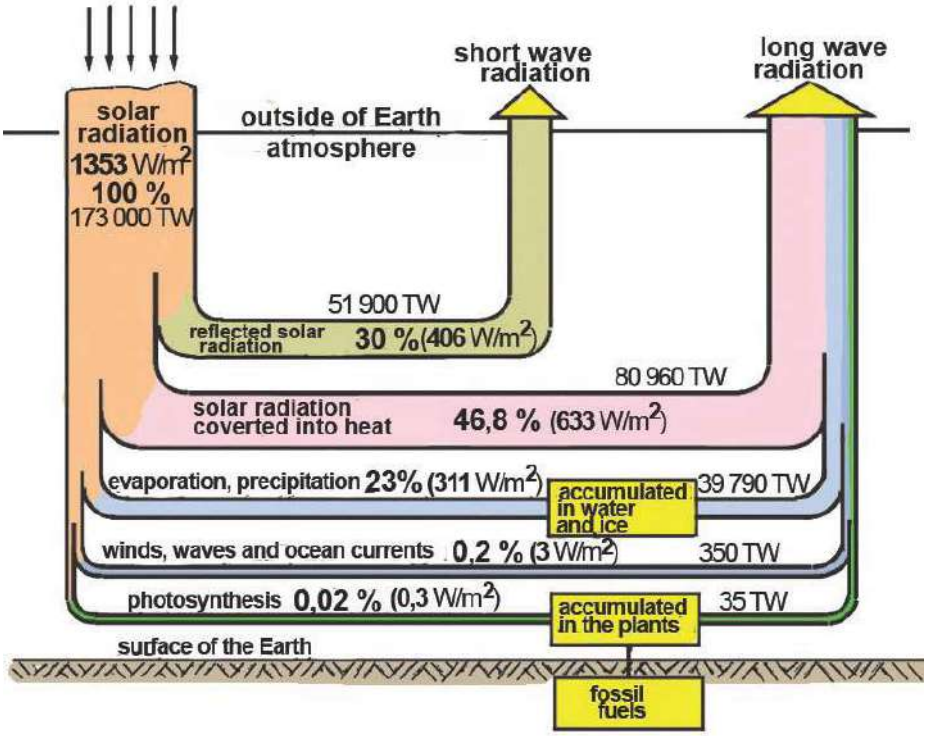
What are RESs? Energy that is exploited, but it is replenished with the same rate.
RES use offers environmentally friendly and sustainable solution.

SOLAR ENERGY

The sun and solar radiation

Energy that arrives on the Earth by electro-magnetic (solar) radiation is called electro-magnetic energy. This type of energy is the most abundant, free and renewable energy source available which does not pollute the environment.

To harness this energy, new solutions are constantly being investigated that would concentrate the flow of solar radiation and maximize its accumulation. This is a very important task because solar radiation is characterized by a low density of energy flux and instability.



Distribution of solar energy on the Earth

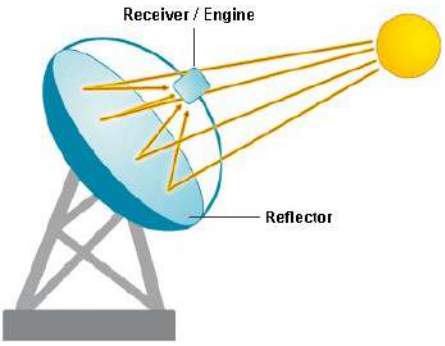
Transformation of solar radiation energy

The Sun releases two types of energy, *light* and *heat*. For many years, man used the energy from the Sun for lighting and space heating in buildings through special architectural features and other special equipment.

Solar collectors are special kinds of heat exchangers which transform energy from solar radiation into internal energy of the transport medium. These devices absorb incoming solar radiation, convert it into heat, and then transfer the heat into a fluid flowing through the collector. Solar collectors are the most important and expensive parts of a solar plant.

According to construction and function, solar collectors can be either **non-concentrating** or **concentrating collectors**. Non-concentrating or flat plate solar collectors collect global solar radiation, both direct and diffuse, and transform it into heat with temperatures of up to 100°C. While concentrating through an optical system, can only collect direct solar radiation and can achieve temperatures up to 3000°C.

Non-concentrating (flat plate) collectors

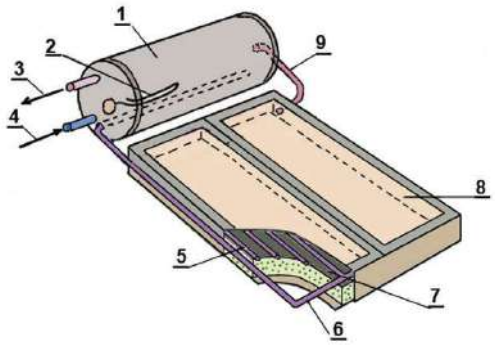


Concentrating collector

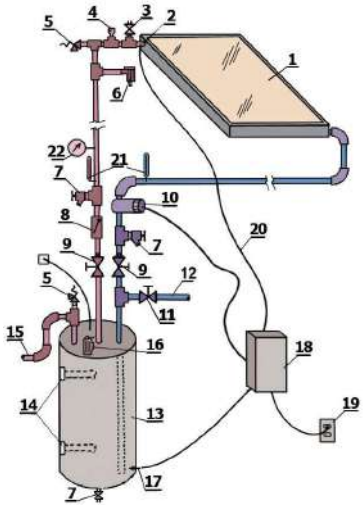
Direct application of solar energy

Systems intended for direct use of solar energy can be: *active*, *passive* or *combined*. Solar systems for water heating are composed of collectors, a circulation system, a reservoir, an additional system for water heating and systems for automatic control.

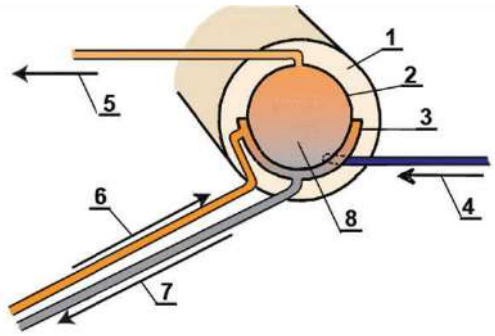
Solar systems for heating water typically use flat plate collectors with natural or forced circulation of the fluid for the transfer of energy. Water collectors can be heated to low (up to 32°C), medium (up to 70°C) and high (up to 180°C) temperatures.



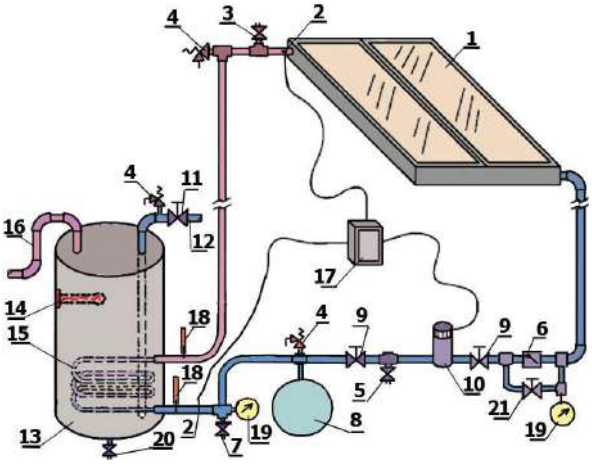
Direct thermosiphon solar system for hot water



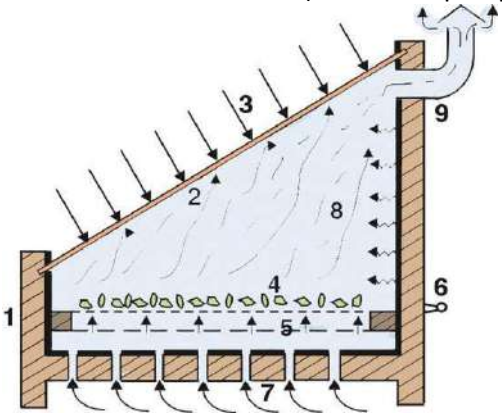
Direct solar system for sanitary hot water with forced water circulation



Indirect solar system for hot water with natural circulation of antifreeze-thermosiphon



Indirect solar system for sanitary hot water with forced circulation of water (circulation pump)



Solar dryer for drying agricultural products

Solar Power Generation

One way to improve the quality of the resulting energy from solar radiation is to transform thermal energy into mechanical or electrical energy.

The transformation of the thermal energy into mechanical or electrical is done directly or indirectly by means of a thermodynamic cycle (Rankine, Brayton, Stirling, etc.).

The temperature of the heat source determines which thermodynamic cycle to be applied. Depending on the temperature of the working fluid the concentrators may:

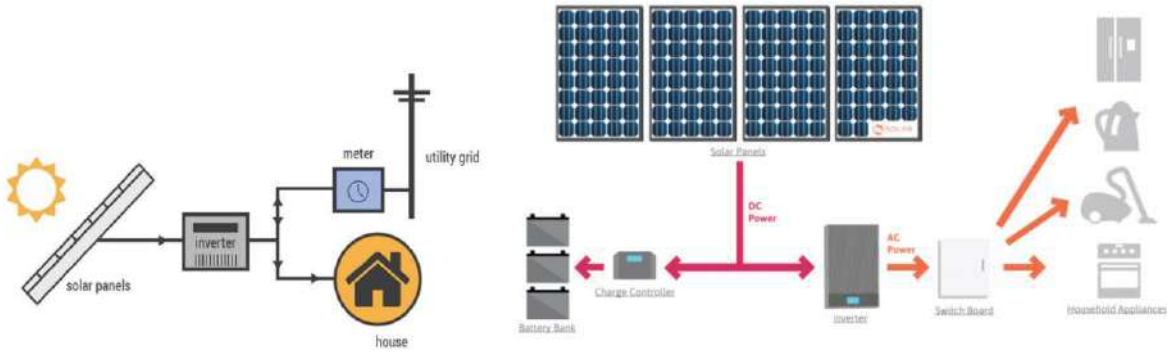
- concentrate the solar radiation to medium temperatures of the working fluid (125°C to 450°C); or
- concentrate the solar radiation to a high temperature of the working fluid (> 450°C).

Basic composition of a solar system with solar radiation concentration comprises:

- *field* of solar concentrators;
- *receiver;* and
- system for *energy transformation.*

Solar plants for direct power generation

Solar energy can be directly converted into electricity through solar cells called photovoltaic (PV) cells. The name PV derives from the process of converting light (photons) to electricity (voltage).



Small photovoltaic systems connected to the grid (right) and stand-alone (left)

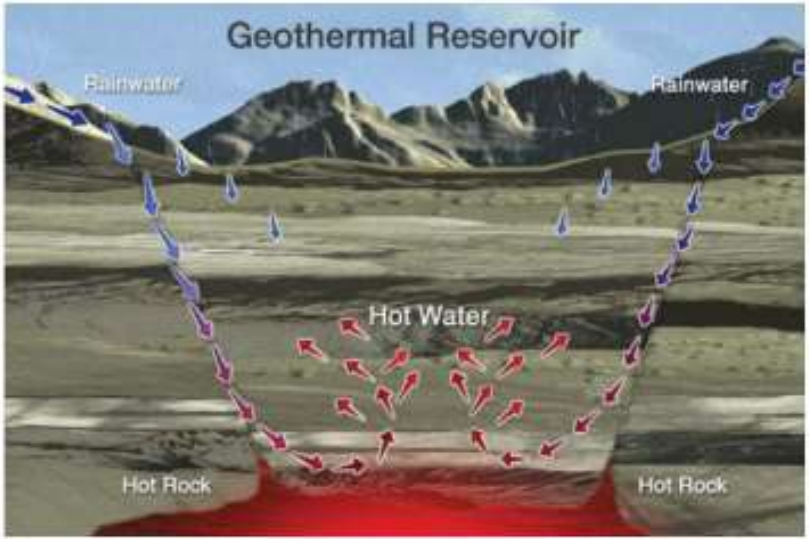
GEOTHERMAL ENERGY

The Earth is a great reservoir of thermal energy, however most of that energy is hidden deep inside the crust and mantle. This type of energy, known as *geothermal energy,* can reach very high temperatures as demonstrated by many natural phenomena. For example, volcanic eruptions spew molten material with temperatures reaching beyond 800°C, vapor springs release vapor with high temperatures into the atmosphere, vapor mix with water springs to form geysers and the occurrence of natural hot springs all confirm that serious heat lies beneath the surface of the Earth.

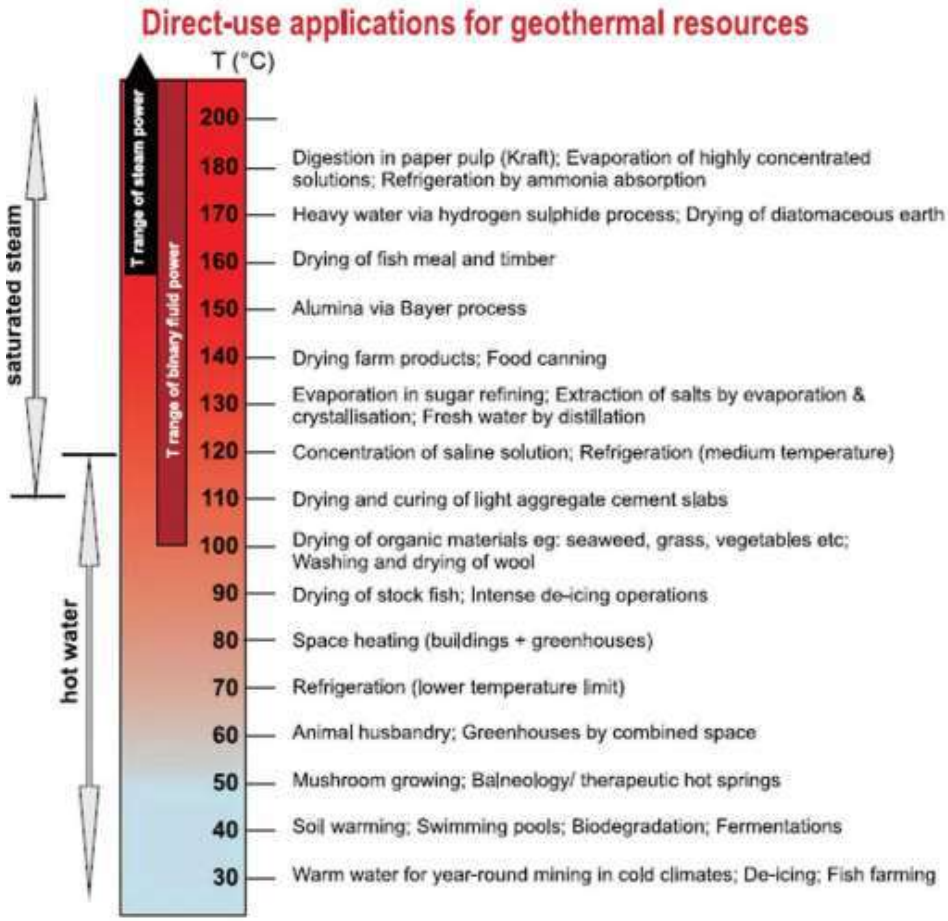
Geothermal sources can be classified based on several criteria: geothermal source type, fluid temperature, and the fluid circulation mode.

According to geological characteristics and the manner in which heat is transferred to the Earth's surface, geothermal sources belong to one of the three following categories:

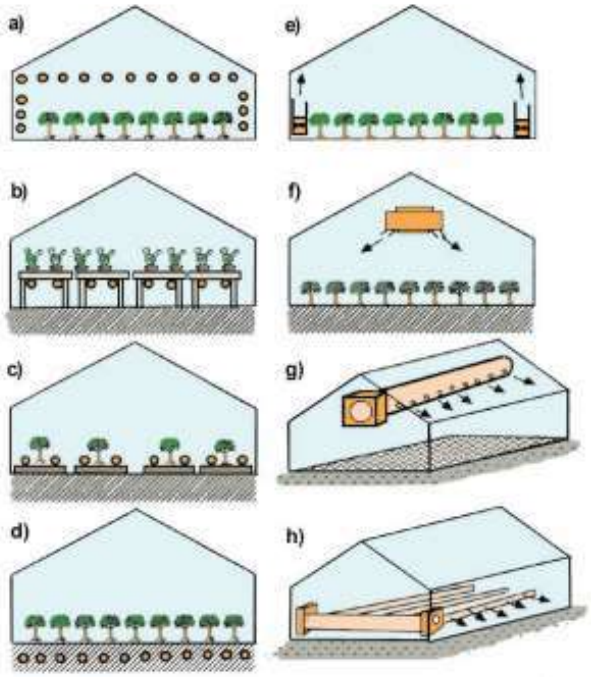
- hydrothermal sources with either *normal* or *increased* pressure;
- hot dry rocks; and
- magma.



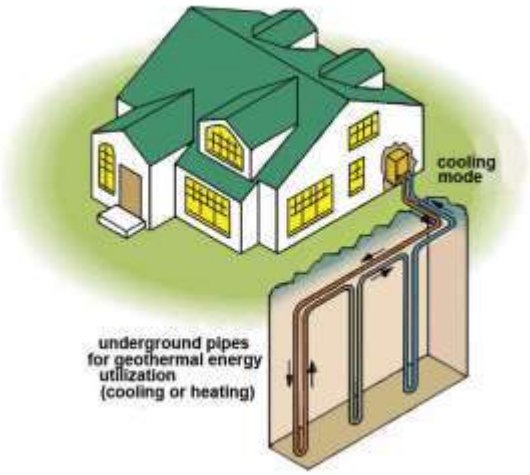
Penetration of heat (convection and conduction) from the interior to the Earth surface



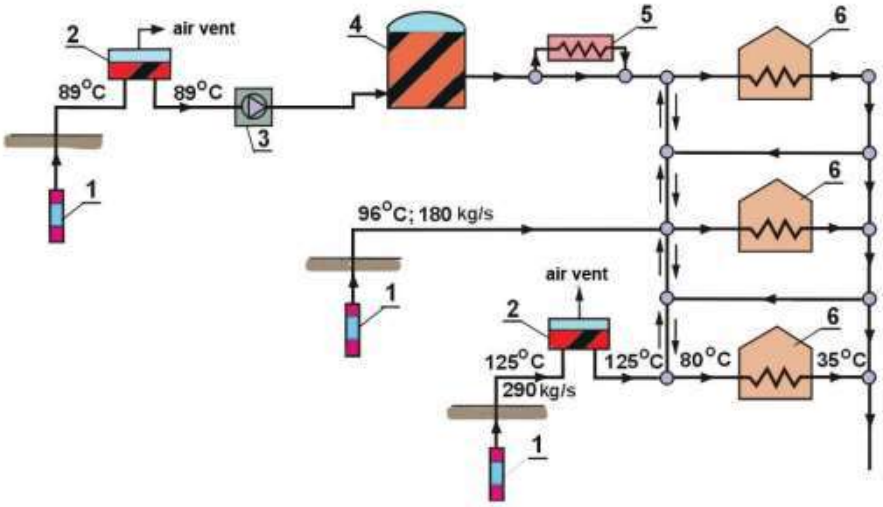
Recommendations for direct use of geothermal resources according the geothermal fluid temperature (modified from Lindal, 1973)



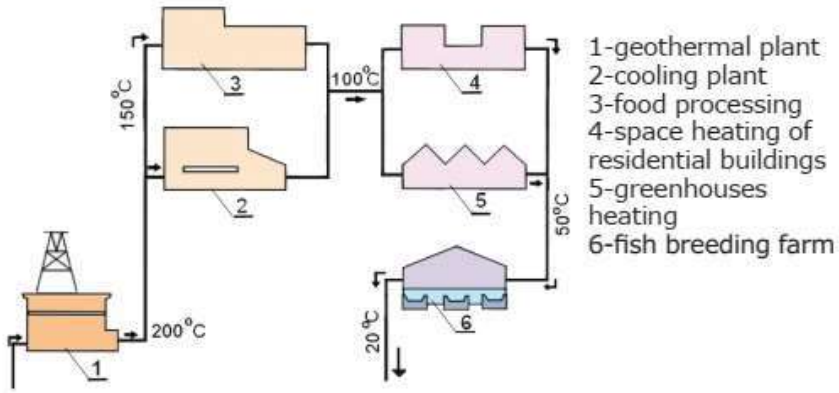
Greenhouse heating



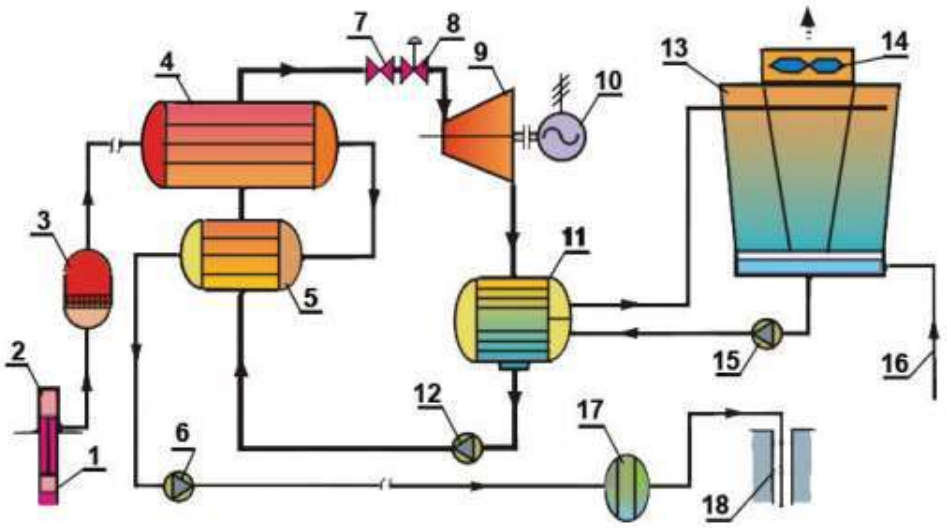
Geothermal Heat Pump - Closed vertical loop system, for storage or extracting heat from the ground in the season of cooling or heating



Reykjavik (Iceland) geothermal district heating system



Example of cascade use of geothermal energy



Simplified schematic diagram of a binary cycle power plant

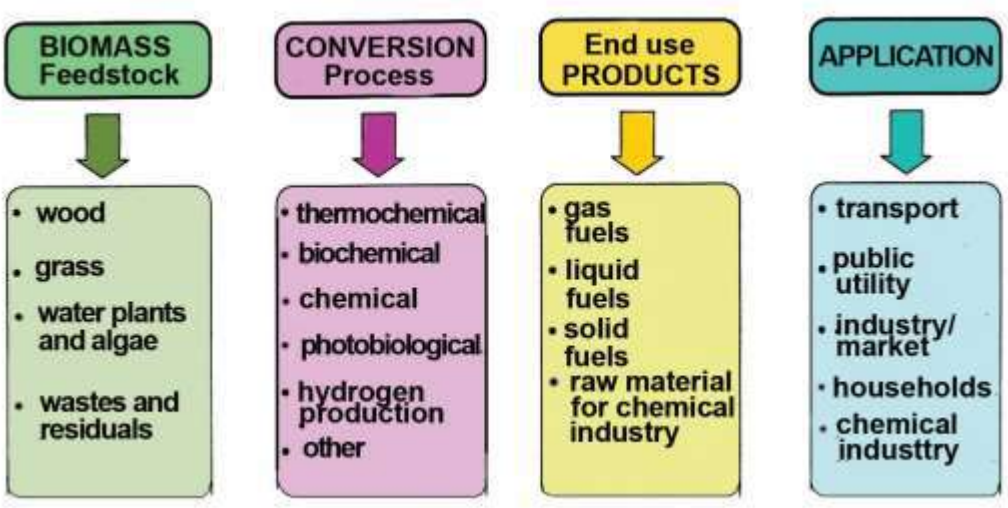
BIOMASS ENERGY

The term *biomass* refers to any biodegradable organic matter derived from biological sources (fauna and entire flora of the Earth) by transformation through the process of photosynthesis using the visible part of the solar radiation spectrum.

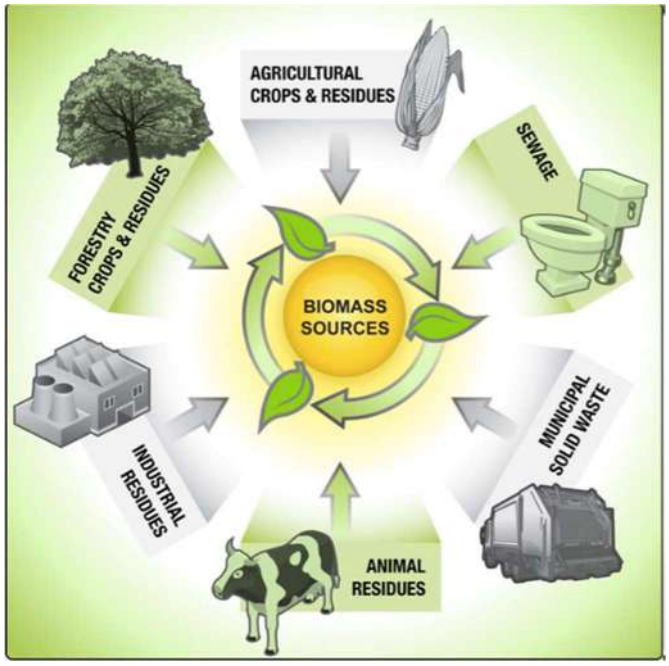
Biomass is the oldest known source of renewable energy. It has been used by humans for thousands of years, beginning with the invention of fire up until today. It is called a renewable energy source because its creation is continuous and unlimited, therefore it is also sustainable. Biomass can be grown in unlimited quantities and produced in a relatively short time. It has a heterogeneous and complex chemical composition.

Biomass as an energy source can include: plants in form of grass and trees, agricultural food and fodder plants, waste residues from agricultural crops, industrial plants, waste and tree residues, water plants and other waste materials, as well as some materials from municipal waste. Bioenergy can be obtained from human and animal waste products as well. The energy stored in plants and in waste produced by animals is called *bioenergy*. During the conversion process of combustion, energy is released from biomass, often in the form of heat. The carbon re-oxidizes to carbon dioxide and replaces the carbon which was absorbed while the plants were growing. Essentially, the transformation of biomass into energy is the reverse process of photosynthesis.

Biomass can be used directly through combustion or indirectly through other processes. In indirect use, biomass is transformed into a liquid (ethanol, methanol and biodiesel) or fuel gas (biogas).



Biomass conversion processes into end use products and possibilities for their application



Sources of biomass

Biomass is any organic material obtained through the process of photosynthesis in flora species on the Earth. According to its origin, the following classification of biomass can be established:

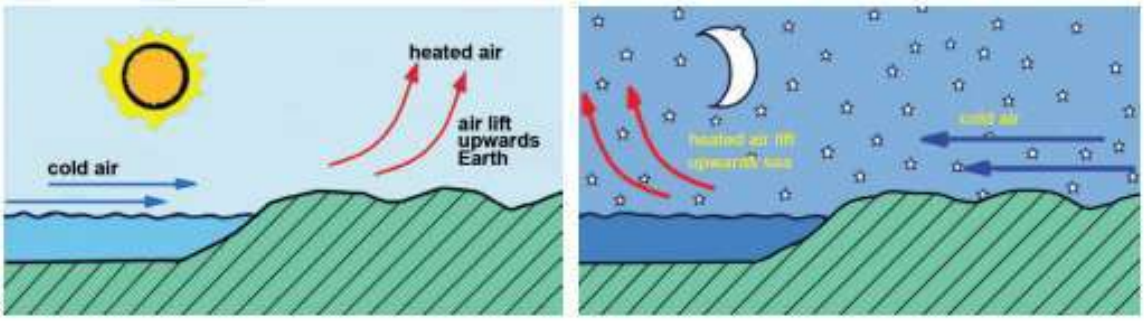
- forest waste
- agriculture wastes
- livestock residues
- energy crops (forest, agricultural, industrial)
- algae
- industrial waste, and
- municipal waste.

WIND ENERGY

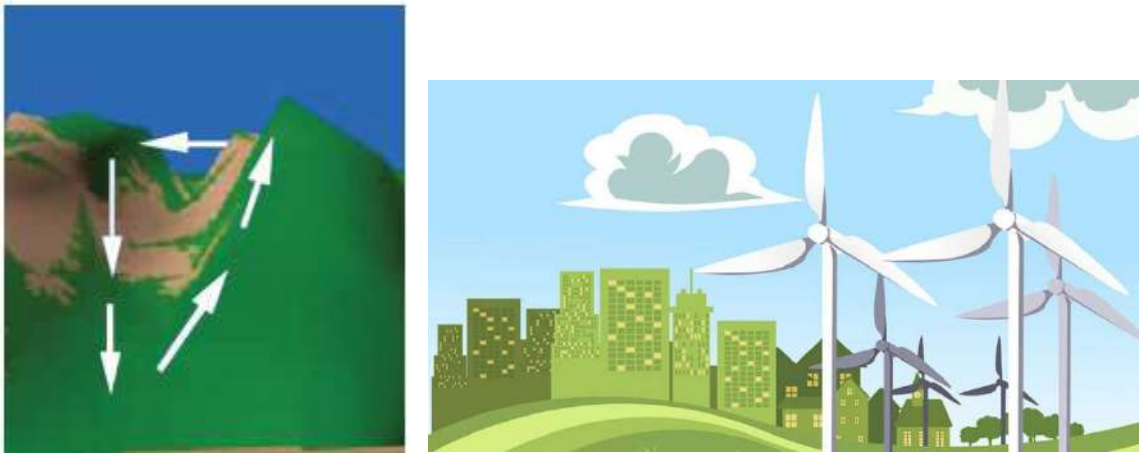
The term "wind energy" refers to the process of transformation of kinetic wind energy into mechanical or electric energy. Wind turbines convert the kinetic energy of wind into mechanical energy which may be used directly or converted into electrical energy.

Winds are caused by unequal heating in the atmosphere, which is influenced by the solar radiation and Earth's rotation.

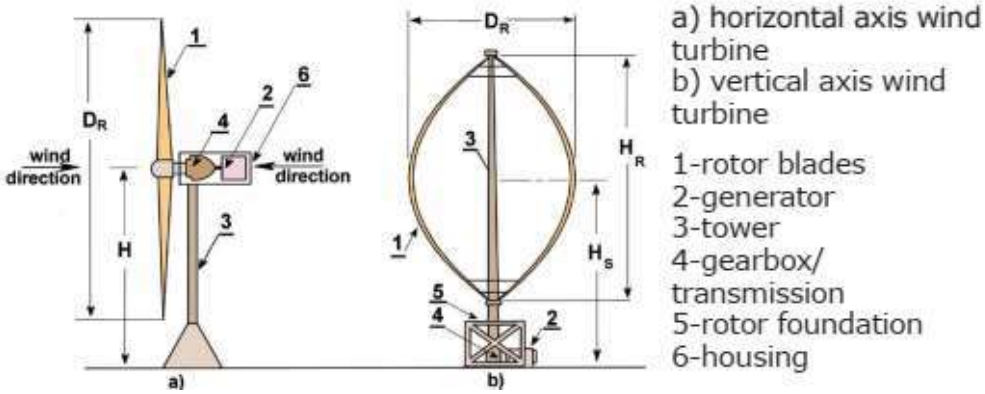
The wind blowing accommodates to the land configuration (water or ground surfaces) and vegetation. Modern wind turbines can use this air movement, or this kinetic energy to generate electricity.



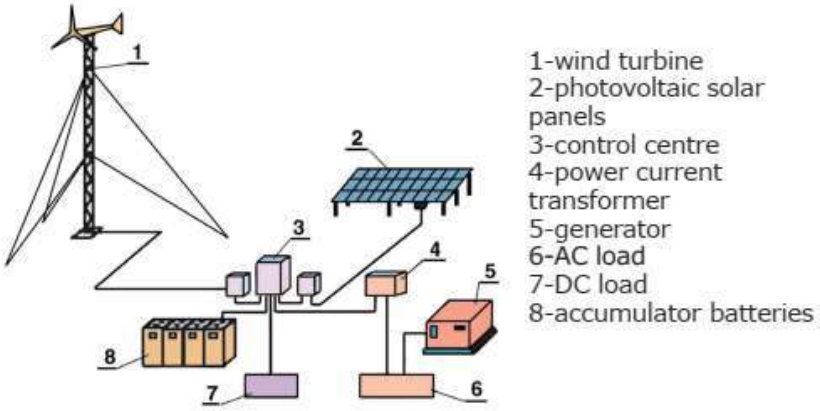
Winds caused by local warming and cooling



Direction of mountain winds during the day



Types of wind turbines



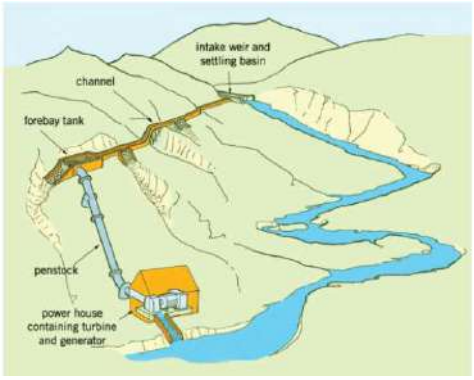
A combined system of photovoltaic solar panels and a wind turbine

HYDRO ENERGY

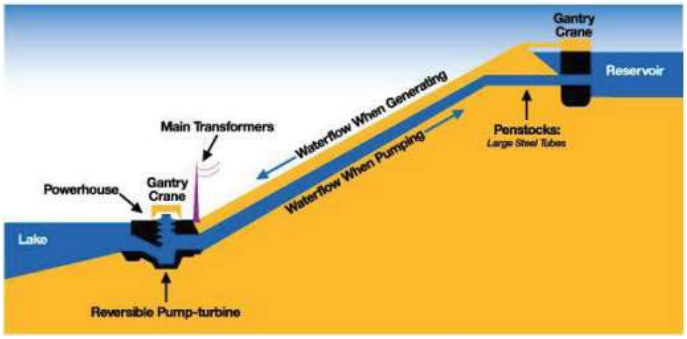
Water flows on the mainland of the Earth's surface is derived from the circulation of water in nature and therefore its energy is derived from solar radiation.

The first application of *hydro energy* was in transport, then, through the creation of mechanical energy in driving mills, presses, forges, sawmills and other similar machinery became possible. The first *hydropower plant* in the world was built in Bavaria in 1876 and was used to supply a palace located nearby with electricity.

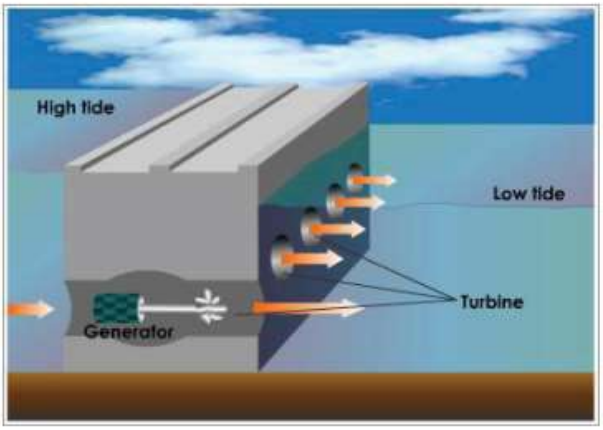
When talking about hydropower plants in terms of renewable energy sources, it is thought of plants with low capacity (up to 5, i.e., 10 MW), although the largest hydropower plants can generate power up to several GW. The main reason for this "discrimination" is due to the sustainability of the use and its environmental impact.

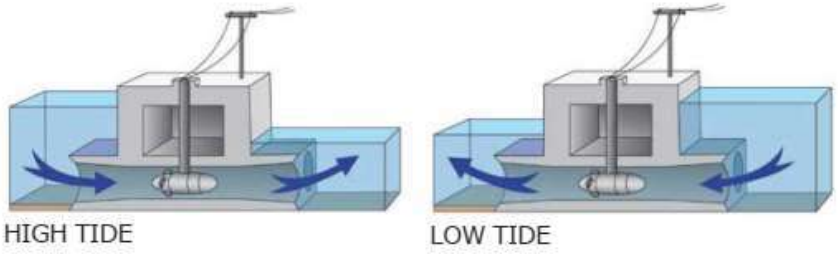


Scheme of run-off the river SHPP



Small pumped- storage hydropower plant





Tidal hydropower plant

I.2 ENERGY EFFICIENCY

Energy efficiency means using the minimum amount of energy for heating, cooling, equipment or lighting that is required to maintain comfort conditions in a building. The most important factor that impact energy efficiency is the building envelope. This includes all the building elements between the interior and the exterior of the building such as: walls, windows, doors, roof and foundation. Efficient energy use is crucial in the fight against climate change and in the development of a sustainable and low carbon society.

End use energy also called total final consumption or baseline energy consumption is the energy directly consumed by the user.

Kilowatt – kW is a measure of demand for power. The rate at which electricity is used during a defined period (usually metered over 15-minute intervals). Utility customers generally are billed on a monthly basis; therefore, the kW demand for a given month would be the 15-minute period in which the most power is consumed. Customers may be charged a fee (demand charge) based on the peak amount of electricity used during the billing cycle. (Residential customers are generally not levied a demand charge.)

Kilowatt-hour – kWh is a measure of consumption. It is the amount of electricity that is used over some period, typically a one-month period for billing purposes. Customers are charged a rate per kWh of electricity used.

Temperature deficit/surplus is defined as total of differences in temperature between the interior of the building (by agreement in country) and outside air, of all heating days. The duration of heating is limited to the time when the outdoor temperature is lower than agreed temperature in country. Therefore, for the certain place, we take the average outdoor temperature during the heating season and subtract it from the agreed interior temperature and multiply it by number of heating days.

Thermal transmittance, also known as U-value, is the rate of heat transfer (in watts) through one square metre of a structure, divided by the difference in temperature across the structure. It is expressed in watts per square metre kelvin, or W/m^2K. Well-insulated parts of a building have a low thermal transmittance whereas poorly insulated parts of a building have a high thermal transmittance. Losses due to thermal radiation, thermal convection and conduction are taken into account in the U-value.

The transmission **heat loss** occurs, because of heat transfer through the building envelope, depending of surface and thermal transmittance of each element and climatic conditions described by temperature deficit. Based on known surfaces of individual elements like floor, walls, ceilings, windows, doors and their thermal transmittance we can therefore determine the required annual energy for heating for individual places in country. It is expressed in kilowatt hour - kWh.

Determining the quality of devices for converting energy base on the **energy conversion efficiency** of the device. The energy conversion efficiency of the device is determined by measurement in laboratories or test facilities. The values obtained are expressed in % and are referring to the conditions obtained during the test. The energy conversion efficiency of the device tells us how much of the input of primary energy in the form of a fuel is converted into

final energy (under the standard conditions of the test). Values are always less than 100%, because fuel cannot be fully utilized, as part of the energy is lost through flue gases and moisture in it and other part by surface radiating of the boiler to the surrounding area, and the remainder remains in incomplete burning residues.

For orientation, you can see the energy conversion efficiency of combustion plants according to the construction and type of energy carrier in table below:

Energy carrier	Construction	Energy conversion efficiency
Solid fuels	Old versions	65 do 72 %
	Combined boilers for liquid fuel	70 do 75 %
	Modern special boilers	80 do 90%
	Wood biomass boilers - pellets - chips	 up to 93% 85 do 90%
Liquid fuels	Combined boilers for solid fuels Special boilers	68 do 75 % 90 do 95%
Gasoline	Special boilers Condensing boilers	do 98% over 100%

Table 1: Energy conversion efficiency

The **heating value** is the amount of heat produced by combustion a unit quantity of a fuel. The difference between energy carriers is shown in table below and it is based on amount of heat that they contain:

Energy carrier	Density kg/m^3	Heating value-Hi
Light heating oil	830	10,0 kWh/l
Natural gas	0,7	9,44 kWh/m^3
Liquified natural gas	2,02	12,8 kWh/kg
Lignite	550	3,1 kWh/kg
Wood	570	4,2 kWh/kg

Table 2: Heating values

Emission factors is a representative value that attempts to relate the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. These factors are usually expressed as the weight of pollutant divided by a unit weight, volume, distance, or duration of the activity emitting the pollutant (kilograms of particulate emitted per megawatt of used gas). Such factors facilitate estimation of emissions from various sources of air pollution. In most cases, these factors are simply averages of all available data of acceptable quality, and are generally assumed to be representative of long-term averages for all facilities in the source category.
Emission factors are summarized in table 3, 4 and 5.

Energy carriers	tCO_2/MWh
Natural Gas	0,202
Natural Gas Liquid	0,231
Heating Oil	0,267
Lignite	0,364

Table 3: Emission factors for fossil fuel combustion

Energy carriers	tCO_2/MWh
Wind Power	0
Hydroelectric Power	0
Photovoltaics	0
Biogas	0,197
Wood	0,007
Geothermal	0
Solar thermal	0

Table 4: Emission factors for local electricity or thermal production renewable energy sources

	IPCC tCO_2/MWh					
Country	2005	2006	2007	2008	2009	2010
Austria	0,226	0,212	0,202	0,206	0,200	0,204
Germany	0,619	0,621	0,645	0,626	0,609	0,616
Hungary	0,563	0,551	0,606	0,593	0,516	0,539
Italy	0,491	0,494	0,493	0,484	0,453	0,467
Poland	1,262	1,243	1,188	1,123	1,141	1,165
Slovenia	0,536	0,536	0,539	0,561	0,613	0,582

Table 5: Emission factors for electricity by country (examples)

Principles of heat transfer - Heat is energy in transit. Spontaneously, heat flows from a hotter body to a colder one. Heat transfer tells us:

- how heat is transferred,
- at what rate heat is transferred and
- the temperature distribution inside the body.

There are several modes of heat transfer: conduction is an energy transfer across a system boundary due to a temperature difference by the mechanism of inter-molecular interactions. Furthermore, convection is an energy transfer across a system boundary due to a temperature difference by the combined mechanisms of intermolecular interactions and bulk transport. Convection can be natural (induced by natural forces: wind etc.), forced (induced by external means) or it changes phases (boiled/condensed). Besides conduction and convection, radiation heat transfer involves the transfer of heat by electromagnetic radiation that arises due to the temperature of the body. While conduction needs matter, but does not require any bulk motion of matter, convection needs fluid matter and bulk motion of matter. However, radiation does not need matter.

Energy Use Intensity (EUI) indicator provides the means to equalize the way that energy use is compared between various types of buildings and evaluate the means of reducing overall energy consumption. It is calculated by dividing the total gross energy (expressed in kWh) consumed in a one-year period by the total gross square conditioned floor area of the building.

EUI can vary significantly depending on building type. Its measurement unit is kWh/m^2a. Hospitals usually have high EUI, due to high energy demand of interior lighting and hospital equipment. Food service facilities also tend to have very high energy usage. In contrast, a school may have smaller EUI's due to smaller amount of time average spent in the building. Climate can have a significant effect on EUI, due to the variations in heating and cooling costs

between different areas of the country. For this reason, EUI values may be broken up into region to provide a more accurate comparison of selected structures. By adjusting the EUI, there is a possible comparison between buildings in a different type of climate.

Ventilation requirements

Within a building, all enclosed spaces that are normally used by human must be continuously ventilated during occupied hours with outdoor air, using either natural or mechanical ventilation. Natural ventilation may be provided for spaces which are all normally occupied and are within a specific distance from an operable wall or roof opening through which outdoor air can flow. Airflow through the openings must come directly from the outdoor. Air may not flow through any intermediate spaces such as other occupied spaces, unconditioned spaces, corridors or atriums. High windows need to have a control mechanism accessible from the floor.

Mechanical outdoor ventilation must be provided for all spaces normally occupied that are not naturally ventilated. Buildings usually require that a space conditioning system provides outdoor air equal to or exceeding the ventilation rates required for each of the spaces that it serves. In the space, the required ventilation can be provided either directly through supply air or indirectly through transfer of air from an adjacent space. The designer may specify higher outside air ventilation rates based on the owner's preference or specific ventilation needs associated with the space. However, specifying more ventilation air than the minimum allowable ventilation rates increases energy consumption and electrical peak demand and increases the costs of operating the HVAC equipment. Therefore, the designer should have a compelling reason to specify higher ventilation air rates than the calculated minimum outside air requirements.

Thermal comfort of building users

Adopting a revised model of thermal comfort puts us one step further toward increasing energy-efficiency in building. Thermal comfort is a condition of mind that expresses satisfaction with the thermal environment. Due to its subjectivity, thermal comfort is different for every individual. It is maintained when the heat generated by the human metabolism is allowed to dissipate at a rate that maintains thermal equilibrium in the body. Any heat gain or loss beyond this generates substantial discomfort. Essentially, to maintain thermal comfort, all heating losses (transmission and ventilation losses) must be equal to temperature gains (heating demand, solar and internal gains) which is also known as heat balance of a building (figure 3).

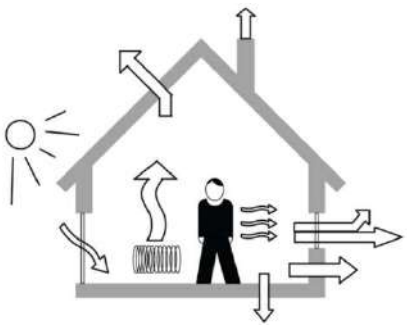


Figure 1: heat balance of a building[1]

[1] http://www.slideserve.com/lawrencia/izobra-evanje-svetovalcev-za-energetsko-izrabo-lesne-biomase

There are six primary thermal comfort variables:

- ambient temperature (air temperature),
- radiant temperature (the temperature of the surfaces around us),
- relative humidity (measurement of the water vapor in an air-water mixture),
- air motion (the rate at which air moves around and touches skin),
- metabolic rate (amount of energy expended) and
- clothing insulation (materials used to retain or remove body heat).

Knowing these six variables is essential to making informed decisions when planning and designing a building air conditioning system.

Understanding thermal comfort is important to architecture, since it not only lays the foundation for building design, but also affects the field of sustainable design. Contemporary models of thermal comfort recommend that a narrow temperature range be applied equally across all building types, climatic zones, and populations. This method casts the building occupants as passive recipients of thermal applications, leading to thermal comfort standards that require energy-intensive environmental control strategies.

HVAC systems

HVAC stands for heating, ventilation, and air conditioning. HVAC equipment perform heating and/or cooling for residential, commercial or industrial buildings. The HVAC system may also be responsible for providing fresh outdoor air to dilute interior airborne contaminants such as odours from occupants, volatile organic compounds (VOC's) emitted from interior furnishings, chemicals used for cleaning, etc. A properly designed system will provide a comfortable indoor environment year-round when properly maintained.

In computing and especially in enterprise data centres, HVAC systems control the ambient environment (temperature, humidity, air flow, and air filtering) and must be planned for and operated along with other data centre components.

External factors influencing energy use

Degree days are measures of how cold or warm a location is. The more extreme the outside temperature, the higher the number of degree days. A high number of degree days generally results in higher levels of energy use for space heating or cooling. They are a specialist type of weather data, calculated from readings of outside air temperature. Heating degree days and cooling degree days are used extensively in calculations relating to building energy consumption.

People study degree day patterns to assess the climate and the heating and cooling needs for different regions of the country during the seasons of the year. There are three main types of degree days: heating degree days, cooling degree days, and growing degree days.

- Heating degree days are a measure of how much (in degrees), and for how long (in days), the outside air temperature was below a certain level. They are commonly used in calculations relating to the energy consumption required to heat buildings.
- Cooling degree days are a measure of how much (in degrees), and for how long (in days), the outside air temperature was above a certain level. They are commonly used in calculations relating to the energy consumption required to cool buildings.

> Growing degree days are calculated in the same way as cooling degree days, but the base temperatures used are based upon the temperatures above which certain plant or insect growth occurs. Different plants have a different base temperature above which they will start to grow, and their growth will typically be roughly proportional to the amount by which that base temperature is exceeded. This is very similar to the way in which building cooling is proportional to the amount by which the building base temperature is exceeded.

Solar irradiance

Solar radiation is radiant energy emitted by the sun, particularly electromagnetic energy. About half of the radiation is in the visible short-wave part of the electromagnetic spectrum. The other half is mostly in the near-infrared part, with some in the ultraviolet part of the spectrum. Solar irradiance is the power per unit area (W/m^2) received from the Sun in the form of electromagnetic radiation in the wavelength range of the measuring instrument. Irradiance is measured perpendicular to the incoming sunlight. Insolation is the power received on Earth per unit area on a horizontal surface (W/m^2). In construction, insolation is an important consideration when designing a building for a particular site.

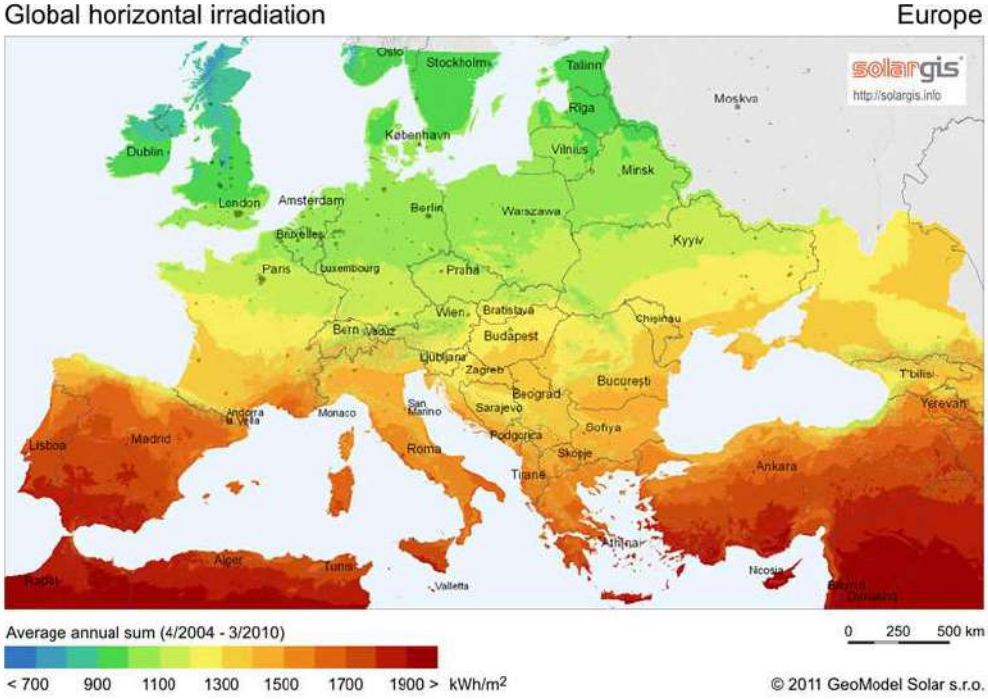


Figure 2: Global annual horizontal irradiation in Europe[2]

Figure presents global average annual horizontal irradiation in Europe in kWh/m^2. As seen, countries in southern Europe receive more solar irradiance than countries in northern Europe. You can use the link below to determine the potential of solar radiation for your country or place.

http://re.jrc.ec.europa.eu/pvgis/index.htm

[2] Source: (http://re.jrc.ec.europa.eu/pvgis/index.htm)

I.3 SUSTAINABLE TRANSPORT

We often hear that modern lifestyles are not sustainable. The term means that we meet our needs in ways that literally threaten our future and the future of our descendants. This is particularly true of transport, which is one of the main sources of air pollution and climate change. Changing our travel habits is therefore of great importance. Sustainable mobility is about meeting the mobility needs of all people and reducing traffic. Sustainable mobility is that which is both environmentally acceptable, socially just and promotes economic development. Transport policy measures must ensure that everyone's needed to move is met, but at lower cost and with fewer side effects, risks and consumption of natural resources. We are concerned about the growing awareness of the negative impacts of transport on the environment, health and overall quality of life in recent decades. On the one hand, traffic serves us and on the other it harms us. To address this development dilemma, as in other development areas, sustainable development approaches have become a top priority. This meets the economic, social and environmental needs of society while reducing the negative economic, social and environmental impacts of transport. In practice, this means in particular the possibility for people to live well without private cars, by improving accessibility by public transport and creating adequate conditions for walking and cycling. Residents feel safe in such a traffic-managed environment, with a high level of traffic culture, fewer accidents and injuries, streets and other public open spaces in settlements becoming again places of meeting, play and enjoyment, and less spaces of transport and parking.

Organised transport also helps to clean the air, reduce noise and reduce the use of fossil energy sources. Organised transport also helps to clean the air, reduce noise and reduce fossil energy consumption. Therefore, a sustainable approach to transport problems is one of the major development opportunities of modern society. Efficient public passenger transport can carry large numbers of passengers in a short time and at low cost. It provides quality access to major destinations for all groups of people, reduces traffic problems and improves the functionality of settlements. It has an important role to play, especially over longer distances.

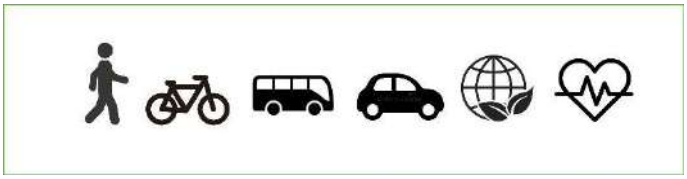
A bus, which takes up about as much space on the road as three cars, in can carry as many as 50 passengers. Thanks to increasingly efficient vehicles and the use of alternative fuels, the environmental impact of public passenger transport, especially when calculated per passenger, are significantly lower than for the private car. From the passenger's point of view, it is also preferable because the lower costs and stress associated with driving and finding a free parking space. Last but not least it allows passengers to spend quality and active travel time reading or working instead of rather than being engaged in the driving itself.

WHY TRAVEL SUSTAINABLY?

By doing so, we contribute to:

- Reducing transport costs
- Better personal well-being and health
- Reducing stress
- Better air quality and quality of life in the city

Options for travelling sustainably



Walking is the most natural, democratic, healthy and socially just form of mobility. It produces no emissions or other environmental impacts and has low infrastructure requirements compared to other modes of transport. It is suitable for shorter distances (up to 2 km), which corresponds to the characteristic of the structure of most settlements in Slovenia and the average length of journeys made there. Walking is essential as all journeys by car and public transport start and end with walking. It is the second most common mode of mode of transport in Slovenian settlements, although its share has been declining for decades. In the context of integrated transport in holistic transport planning, walking is the one for which we need to ensure good conditions as a priority.

A bicycle is the preferred means of transport for distances up to 5 km, while electric bicycles are suitable for longer distances. The bicycle is an accessible means of transport for all social groups, is environmentally friendly and does not take up much space. On most routes in large or small settlements, the bicycle is the fastest form of transport. Daily cycling also has a positive impact on health. Due to its positive impact on quality of life, cycling has become an equal and efficient way to get around every day in many European cities. Favourable climatic conditions make it possible to use a bicycle most days of the year. Electric bikes are increasingly in use. They enable longer distances and sustainable mobility even for the less physically fit and on more rugged terrain. We might encourage locals and visitors to pedal a considerably larger percentage of their routes throughout the year by promoting cycling culture, enhancing cycling infrastructure, and increasing awareness.

Public passenger transport includes different forms of transport. If efficient, the system can transport large numbers of people at low cost and in a short time. It provides quality accessibility for all and solves many transport problems. A quality offer is based on an efficient network, priority treatment in the road network, new, comfortable, efficient and environmentally friendly vehicles, optimisation of timetables, and information support for the system and awareness-raising among the population.

It consists of:

- Bus transport (urban and intercity)
- Train transport
- Ship transport
- Transport by taxi

A private car can also be a sensible choice and its use without negative consequences, for example in the case of a family returning from an afternoon of activities and a week's shopping in the evening fully loaded with an electric car. But there are also meaningless choices and its use is costly for the user and society. Experience shows that it is pointless to keep up with the growth in car traffic by building more and more roads and car parks. New roads and car parks attract additional car traffic and new areas are soon filled. Advanced cities and countries have therefore long been able to manage congestion and other problems caused by private cars not by constantly adapting infrastructure, but by adapting the volume and distribution of car traffic to the space available.

In recent years, motor traffic has been growing rapidly, putting increasing pressure on the environment. Noise, the burning of fossil fuels in transport and transport infrastructure increase the concentrations of greenhouse gases released into the atmosphere. All of this has negative impacts on ecosystems, degrading quality agricultural land that could grow food, while air pollution has negative impacts on human, plant and animal health and destroys the exterior of buildings. Integrated transport management plays an important role by supporting the development of transport modes that use less energy and have fewer negative impacts on the environment. Such regulation promotes action to improve air quality, reduce noise and mitigate climate change, while accelerating the transition to a low-carbon society.

Motor traffic emits various gases, the main ones being nitrogen oxides and ozone, but it also emits smaller particulate matter. All these emissions cause respiratory and cardiovascular diseases, as well as diseases of the brain and other tissues and organs. Statistics for Europe tell us that 400,000 people still die prematurely each year from air pollution, more than 1100 in Slovenia. The consequence of excessive car use is insufficient physical activity Active mobility, such as walking, cycling or using public transport to get to nursery, school, work and everyday errands, can help meet the daily exercise recommendations of the health profession. They say that as little as half an hour of moderate physical activity most days of the week significantly reduces the risk of chronic non-communicable diseases.

Integrated transport planning is strategic and targeted transport planning that promotes sustainable transport, treats all modes of travel equally and involves the public. It is based on the results of analysis and monitoring of the situation, evaluation of measures and integration of other planning areas.

Soil degradation means the reduction of soil quality, its degradation in terms of fertility and ecosystem resilience.

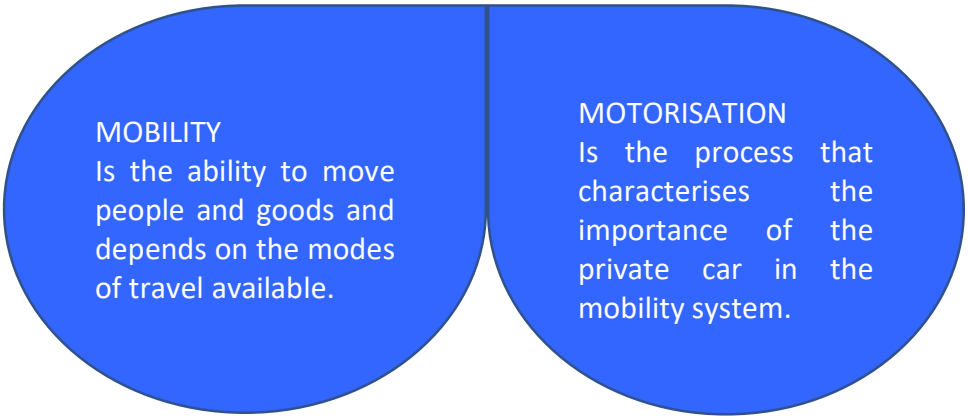
(TRANSPORT) ACCESSIBILITY means, in the case of public passenger transport, the spatial or temporal distance from a selected starting point to a public passenger transport stop,

measured in metres, kilometres or minutes. The starting point may be a settlement or a residence, a school, a health facility or a workplace. Accessibility is the fact that the stop can be reached from/to within a reasonably short time, that the connection is adequately designed for particular, especially sustainable, modes of access (e.g., walking and cycling) and for particular population groups (e.g., people with physical and sensory barriers, children, the elderly, mothers with pushchairs).

Fossil fuels are fuels that were formed in the distant past in geological deposits from deposited organic matter. These are most commonly coal, petroleum and its derivatives, and natural gas. They are important because their exploitation means introducing carbon that has been stored in the depths of the earth into the carbon cycle at the surface, which increases the concentration of carbon dioxide in the air and leads to an increased greenhouse effect or global warming. Today's transport system is based almost entirely on the use of fossil fuels.

Nitrogen oxides (NOx) include the terms nitrogen monoxide and nitrogen dioxide. In Slovenia, transport is the main source of NOx, but energy is also an important source. Nitrogen oxides are so-called primary pollutants, which means that they are a source of photochemical smog, which has many negative effects on the environment and on humans. Exposure to concentrations of 0.1 ppm of nitrogen dioxide over one or more years causes an increase in the incidence of bronchitis and has a negative impact on lung function in children.

PUBLIC PASSENGER TRANSPORT means organised and publicly accessible collective transport of people on predetermined routes, on a regular timetable, with a fixed price and serving the satisfaction of daily mobility needs. It is a system comprising passenger transport, the overall organisation of the service and the infrastructure on which it is operated. The most known means of public passenger transport are buses and trains, but it also includes boats, ferries, trams, subways, taxis and others.



The degree of motorisation is usually indicated by the number of private cars per 1000 inhabitants. CARBON DIOXIDE (CO_2) is a key greenhouse gas released into the atmosphere by natural processes in the plant and animal kingdoms and by the burning of fossil fuels. CO_2 is partly removed from the atmosphere by photosynthesis and partly absorbed by the oceans. Increased atmospheric concentrations of CO_2 are the main contributor to the current warming of the climate. OZON (O_3) is a molecule of three oxygen atoms. The ozone layer is the Earth's 11 vital protective mantle, formed between 10 and 50 km above the Earth's surface. In the air layer near the ground, ozone is a pollutant produced by photochemical reactions of vehicle and industrial exhaust gases. Ozone is harmful to health because it affects the respiratory systems of humans and animals.

PASSENGER KILOMETERS (pkm) are an indicator of the volume and composition of passenger traffic. A passenger kilometre is the sum of the products of the number of passengers and the distances they travelled.

TRAVEL ADVANTAGES are the usual ways people travel on their daily journeys, e.g., to work, school or other errands. They depend on various factors - spatial, socio-economic, administrative-political, etc.

The mode of travel is the way people move depending on the means used, e.g., walking, cycling, public passenger transport, private motor transport.

TRANSPORT is the movement of people, vehicles and goods along transport routes and by different modes of transport.

TRANSPORT PLANNING is the field of planning concerned with the operation, provision and spatial location of transport infrastructure and services to ensure the accessibility and mobility of people and freight.

Spatial planning is an interdisciplinary activity which plans spatial interventions based on development guidelines and taking into account public benefits. SUSTAINABLE MOBILITY is moving around in a sustainable way, including walking, cycling, using public transport, etc. It means ensuring efficient and equitable accessibility for all, with an emphasis on limiting private motorised transport and energy consumption and on promoting sustainable travel modes.

SUSTAINABLE TRANSPORT is transport with travel modes that have a low negative impact on the environment, such as walking, cycling, public passenger transport, responsible car use, environmentally friendly vehicles, etc.

SUSTAINABLE DEVELOPMENT is development that meets the needs of the present human generation without compromising the ability of future generations to meet their own needs. It is characterised by its aim to balance the social, economic and environmental components of development.

PM are fine particles in the air, which may be of natural origin (e.g., pollen, dust, sea salt, forest fire smoke, meteoric dust, volcanic ash) or of anthropogenic origin (generated by vehicle parts - tyres, brakes, etc., or by emissions from transport, energy installations, industry, agriculture, individual combustion plants), or may also be produced as secondary pollutants, i.e., by the reaction of different substances in the air. The smaller they are, the further they can penetrate our bodies and the more dangerous they are. PM 2.5 and smaller particles pose the greatest health risk.

SUSTAINABLE MOBILITY MANAGEMENT is a concept that promotes sustainable transport and manages transport demand by changing people's attitudes and travel habits, which today are based on unsustainable (car-based) mobility. The aim of sustainable mobility management is to provide the conditions for increasing the proportion of journeys made in a sustainable way, such as encouraging children and employees to walk, cycle, take the bus or train instead of the car to school, kindergarten or work.

Chapter II

EDUCATIONAL APPROACHES FOR IMPLEMENTATION OF THE CLIMATE CHANGE-RELATED ISSUES IN SCHOOLS' CLASSES

Implementation of CC in School Subjects

WHY IS IT IMPORTANT TO TEACH CLIMATE CHANGE IN PRIMARY EDUCATION?
So many of the world's biggest challenges, from poverty to wildlife extinction, are made more difficult by climate change. Things will get worse if we do nothing, but if we act now, we can limit the amount of damage we do to our planet, people and wildlife. By learning more about climate change that affects our world through school subjects, young people can understand what needs to be done, recognise what matters most to them, and take action to help protect people, places, wildlife and things they love.
(INTRODUCTION TO CLIMATE CHANGE, Teacher activity guide for ages 7-11)

THEACHERS'S CLIMATE GUIDE is an education package for subject teachers. It explains climate change in the context of each school subject, and provides exercises and visual material. It also contains tips for multidisciplinary climate education, tips for integrating climate change in education and activities at the primary level, and basic information about climate change and climate education.

Biology
Climate change is the most pressing challenge humankind has ever faced. It has a complex impact on humans and natural environments both today and particularly in the future. Climate change can be attributed to human activity, but it can be decelerated enough that harmful impacts are not insurmountable. it is therefore crucial to teach about the impact of a changing climate and provide ideas on how biological approaches can be applied to climate change mitigation. Biology plays an important role in understanding the complexity of climate change and in building a climate-friendly world. Some topics to be covered:

- Climate change is due to the human acceleration of the greenhouse effect (Carbon cycle in nature, Climate change affects the carbon cycle)
- The climate has always changed
- Species are struggling to adapt to climate change
- Climate change causes biodiversity loss (Climate change may bring substantial ecosystem changes)
- Climate change is linked to other environmental issues
- The role of biology in climate change mitigation and adaptation (Nature reserves play an important role; Forests and fields – the carbon storage experts; How bio-economy and circular economy help to fight climate change; The great climate change adaptation has already begun)

Chemistry
Climate change affects humans and natural environments today and particularly in the future. In chemistry class, climate change can be looked at in relation to the structure of the atmosphere, composition and role of greenhouse gases, and energy production systems. Therefore, chemistry plays an important role in understanding climate change in-depth and building a climate-friendly world. Some topics to be covered:

- Chemistry of the atmosphere
- Increase in greenhouse gases causes climate change (Climate change is caused by human expansion of the greenhouse effect, Greenhouse gases absorb heat radiation, Carbon dioxide is the most important greenhouse gas, Carbon cycle in nature, Carbon dioxide is not the only greenhouse gas in the climate system)
- Ocean Acidification is linked to Climate Change
- Tackling Climate Change requires Chemistry **(**Our Energy System is based on burning Fossil Fuels, The Petrochemical Industry produces Fuels and Durable Materials, Climate Benefits of Biofuels vary, Future Solar Cells are powered by Electrochemical Reactions)

Foreign Languages

Climate change is the most serious threat humankind has ever faced. It has a number of impacts on humans and natural environments today and particularly in the future. Climate change is due to human activities but a severe catastrophe can still be avoided. Mitigation requires global cooperation and sharing knowledge, skills and strategies. In this, fluency in foreign languages is a valuable asset. Also, media literacy plays an important role in becoming an active citizen, and stories about climate change provide excellent material for practicing a critical approach.

Geography

Climate change is at the heart of geography in many ways, and vice versa. As a holistic phenomenon, its causes, consequences and implications are closely related to natural and social sciences, culture, technology and economics. Furthermore, it is a regional phenomenon, meaning although climate change and its impacts are seen around the world, they vary from place to place. The geographical concept of scale plays an important role in understanding climate change in-depth. Impacts of global warming and methods of climate change mitigation are different in different communities, counties, countries and continents around the world, and processes at different levels impact on each other.

In the context of most school subjects, it is relatively easy to define their take on climate change clearly and compactly, but this does not apply to geography. Therefore, it is highly recommended that geography teachers read the entire guidebook.

This text highlights three geography topics particularly relevant in understanding and fighting climate change: regional variation of climate change impacts; regional planning for climate change; and Geographic Information Systems (GIS) as a tool of understanding and solving climate change. Some topics to be covered:

- Regional Impacts of Climate Change (Climate Change changes Biomes, Climate Change in the Global South and North)
- Regional Planning for Climate Change (Climate Factors create Framework Conditions for Regional Planning, Climate Change poses Challenges to Cities, Meticulous Regional Planning helps to tackle Climate Change, Climate Change Adaptation has already begun, Climate Change Considerations in Urban Planning)

History

Climate change has an impact on humans and natural environments today and particularly in the future. The history of man-made climate change is relatively short and closely linked to the Industrial Revolution, the rise of consumerism and the history of energy politics. Understanding the past helps us to make more sense of the present and to figure out what kind of decisions should be made for a better future. Therefore, history as a school subject plays an important role in understanding climate change in-depth and building a climate-friendly world. Some topics to be covered:

- We are living in the Anthropocene Epoch
- Climate Change affects Nature and People (The Climate has always changed, Climate Changes have had an Influence on Human Civilizations)
- Climate Politics are in their Early Stages (Scientific Knowledge in the Background of Climate Politics, Intergovernmental Sustainability Targets are negotiated at International Climate Conferences, Environmental Issues gave Birth to the Environmental Movement, Civil Society brings unaddressed Issues to Public Attention)
- The History of Climate Change is the History of the Industrial Revolution, the Rise of Consumerism and Energy Politics (Exploitation of Fossil Fuels began with the Industrial Revolution, Our Energy System is based on Fossil Fuels, Climate Politics is about Energy Politics and Foreign Policy)

Home Economics

Climate change affects human activities and natural environments now and particularly in the future. Most of the emissions caused by individuals come from housing, transport and food. Home economics class is an excellent place to practice knowledge and skills essential to fight climate change. Therefore, home economics plays an important role in understanding climate change in-depth and building a climate-friendly world. Some topics to be covered:

- New Ways of Consumption and Economic Systems to tackle Climate Change (-I, Consumer; The Sharing Economy, Circular Economy and Bio-Economy)
- Food has many sorts of Effects on the Climate (From Field to Table and Compost; Seasonal, Local and Organic Food; More Vegetables, Less Meat; Tackling Food Waste Climate Change Impacts on Housing; Home Economics Teachers as Climate Educators)

Mathematics

Climate change affects humans and natural environments today and particularly in the future. Mathematical knowhow is necessary in producing knowledge about climate change, understanding it as a phenomenon and contributing to the climate debate. Therefore, learning mathematics plays an important role in building a climate-friendly world by raising critical thinkers, active citizens and young scientists.

Climatology needs Mathematics - Scientists discovered the first signs of climate change already over 100 years ago, and ever since then knowledge of climate issues has increased and become more accurate. However, there has been a great deal of procrastination over developing mitigation strategies. This indicates that scientists alone can't fix the problem, but solving it requires participants from all walks of life.

Learning mathematics boosts abstract thinking, which is an essential tool for anyone interested in climate issues. The senses are not the only authoritative source of knowledge and it is not possible for any individual to perceive planetary climate change. Weather and climate form a complex system affected by ever-changing conditions of the atmosphere, oceans, glaciers and land. The climate of a specific place is determined by the average weather conditions over a long period of time. In other words, climate is about weather statistics and therefore climate change is a statistical phenomenon, the effects of which are seen in the world around us. Thus, climate science requires large-scale application of mathematics.

Mathematics is needed for describing and projecting changing climate and communicating those findings. In order to describe the changing climate, we need to know first of all what is “normal”. For this, we have to calculate environmental measurements concerning temperature, rainfall, snow cover, sea level, amount of carbon dioxide in the atmosphere etc.

By calculating averages, analysing variance and making diagrams, we can find out whether the climate has changed and how.

Predicting future climate requires mathematical modelling with differential equations and stochastic methods. Climate models are complex entities and they require, inter alia, different types of atmospheric, oceanic and cloud modelling as well as modelling of their interconnectedness. As a result, we can get many different projections of future changes in the climate. These models are useful for decision-makers, businesses and active citizens pondering action over climate change mitigation.

Climate knowledge is embodied in texts, diagrams and charts. Communicating this complex information within the scientific community and among decision-makers, planners and the public requires an audience with mathematical literacy. Thus, communicating climate knowledge requires mathematical skills within both the producers as well as the consumers of this knowledge.

How Mathematics can make a Difference - Mathematics is a powerful tool for effective problem solving as well as exercising power – including political power. Therefore, mathematics is linked to human-made value assessments benefitting some more than others. Hence, mathematics is not neutral. This concerns the boundary conditions in models, algorithm design and choice of parameters. However, decision-making based on sheer mathematics excludes a number of factors that cannot be mathematized, such as human values, friendship and empathy.

To participate efficiently in a democratic society, students need a critical understanding of mathematics, its possibilities and limitations as a tool of producing knowledge. This should also apply to finding solutions for climate change, as well as playing a role as an active citizen.

<u>Mother Language and Literature</u>

Climate change affects human activities and natural environments now and particularly in the future. Our own mother tongue is a tool to express our views on climate change in fresh and creative ways through different channels. Media education, reading, writing, speaking, argumentation and skills of expressing one’s own emotions clearly and effectively play an

important role in environmental education, understanding climate change in-depth and building a climate-friendly world.

Music

Climate change affects humans and natural environments today and particularly in the future. Like any art form, music can change our approach to the changing world, communicate insight on climate change and help to process emotions. Therefore, music plays an important part in understanding climate change in-depth and building a climate-friendly world.

Physics

Climate change affects humans and natural environments today and particularly in the future. Physics play a central role in understanding climate change in-depth and building a climate-friendly world. Important sectors are thermodynamics and electricity. In addition to these, this guide introduces knowledge related to climate change through units and figures. Some topics to be covered:

- Climate Change is a Human Expansion of the Greenhouse Effect (Greenhouse Gases absorb Heat Radiation; Thermodynamic Equilibrium of the Earth can be observed through Blackbody Radiation)
- The physical Impacts of Climate Change (Global Temperatures, Precipitation and the Composition of the Atmosphere are changing; Climate Change Feedbacks amplify the Effects of the Consequences)
- Humans change Climate (Climate Feedback illustrates the Energy Imbalance in the Earth's Climate System; Climate Engineering has a major Risk of Side Effects)
- Climate Change and the Energy System (Our Energy System is based on the burning of Fossil Fuels, Energy Technology can make our Planet more sustainable)

Visual Arts

Climate change affects humans and natural environments today and particularly in the future. Visual arts provide tools to spur social change and process and overcome emotions that come with climate change. Instead of a passive approach, arts encourage us to engage and take action. Therefore, visual arts play a key role in understanding climate change in-depth and creating a climate-friendly world. Some topics to covered:

- Visual Arts as a Tool for Social Change (Communication Changes the World; Observations and New Ideas; Friendly Handprints)
- Art and Emotions
- Artists and Climate Change

(https://teachers-climate-guide.fi/)

II.1 RENEWABLE ENERGY SOURCES

Renewable energy is a core issue in the world today. It affects jobs, homes, food production and climate change. The world would not function without energy – and the importance of clean, affordable energy has never been more relevant.
From its effects on global warming to the natural disasters across the globe, clean energy has a huge impact on our lives. This is an important context for many academic subjects and classroom discussions today.

Why is teaching renewable energy important?
Energy surrounds us. Energy powers homes and classrooms. It provides heat, light and electricity. It fuels our vehicles, powers our computers and prepares our food. It's at the core of students' daily lives across the world and is a subject that we should encourage them to engage with on an academic level.

However, it's not just the existence and importance of energy that could form part of lesson plans. The value of renewable energy sources should also be at the forefront of students' minds. Even with humanity's progress in clean energy producers like solar and wind power, energy still contributes to around 60% of global greenhouse gas emissions – one of the main causes of climate change.

Finally, it can be easy to take access to energy for granted. Across the world, huge amounts of the global population do not have access to modern electricity or other energy sources. Today's students can be the ones to drive change and strive for clean, affordable energy for all.

How can renewable energy be part of a teaching program?
The subject of energy crosses over into a wide array of scientific and engineering topics in the classroom. For example, teachers could explore:

- The different types of renewable energy: solar, wind, water, geothermal.
- How that energy is converted from one form into another, e.g., solar power to electricity.
- Our sun as a source of energy across the globe.
- Engineering challenges and achievements such as hybrid cars or biodegradable materials.
- Causes and effects of global warming.

As energy is generally an invisible force behind our lives, it can be easy to overlook its importance. In reality, it's not an abstract subject, but one that is highly-relevant and with which we should all engage.

Renewable energy sources can be studied in many subjects, like: mathematics, physics, biology, chemistry, geography, innovations, etc.; even in: mother or foreign language and literature, arts, etc.

https://www.participatelearning.com/blog/teaching-the-importance-of-renewable-energy/

II.2 ENERGY EFFICIENCY

The road to energy efficiency is, in theory, a sustainability sweepstake. More efficiency means that less fuel is required to generate a given amount of energy, which in turn means lower costs for the provider and cheaper prices for the customers.
Jens Martin Skibsted

Energy efficiency is defined as using less energy to provide the same product or service, such as lighting, heating and transportation. Together with the move to renewable energy sources, increasing energy efficiency is considered to be one of the twin pillars of sustainable energy policy.

As energy efficiency is a cheap and abundant resource, possessed by all countries, rich and poor alike, it is key to ensuring a safe and reliable reduction in energy consumption and greenhouse gas emissions. In addition, energy efficiency improvements are by far the quickest and least costly solution to the climate crisis.

Energy-efficiency experts worldwide have identified several areas where the greatest savings in the use of energy can be made, including industry, transport, homes and buildings, and recycling.

The International Energy Agency (IEA) has stated that improved energy efficiency in industrial processes, transportation, and buildings could lead to a 30% reduction in the world's energy needs by 2050 and help control global emissions of greenhouse gases.

Energy efficiency can be studied in many subjects, like: mathematics, physics, biology, chemistry, geography, innovations, etc.; even in: mother or foreign language and literature, arts, etc.
https://humanjourney.us/energy-efficiency/?gclid=CjwKCAiAwc-dBhA7EiwAxPRylHi_NF6R_6NY-4E0By6tYya3cTtWrZYn_QcMi8kcy8p2CJ48HMcDEBoC3zQQAvD_BwE

II.3 SUSTAINABLE TRANSPORT

Transport was responsible for 28% of global final energy consumption in 2016 and is one of the biggest sources of greenhouse gas emissions, with road-based modes of transport such as trucks, buses and cars emitting the most greenhouse gases. The use of modern computer-aided design and computer-aided manufacturing (CAD/CAM) methods, together with the employment of new lightweight materials, mandated improvements in mileage efficiency, improved engine technologies, hybrid cars, and plug-in electric vehicles have already produced gains in savings and reductions in emissions. Global sales of electric vehicles grew by 40% in 2016, mainly in China and Europe, and there are now more than 2 million electric vehicles worldwide, but this still represents less than 0.2% of the 1.2 billion light-duty vehicles (LDVs) on the road. Electric vehicles are much more efficient than diesel or gasoline alternatives but are not yet at a scale to have a significant influence on global LDV fuel economy. Moreover, sales of less efficient large passenger vehicles such as trucks and SUVs

have increased, especially in the U.S., due to falling gasoline prices, leading to a reduction in the global rate of improvement in fuel efficiency.

Mass transit systems such as bus and light rail networks in urban areas, along with complementary walking and cycling infrastructures, can sharply reduce both CO_2 emissions and energy used, and also improve air quality with subsequent health benefits for local inhabitants.

According to the World Health Organization, “*Safe, equitable, and energy-efficient urban transport can help achieve multiple health and sustainability goals. Shifting urban design and infrastructure investments into public transport networks that prioritize rapid bus transit or light rail over private vehicles can reduce the long-term trajectory of both air pollution and climate emissions generated by private transport – and improve health equity by providing those lacking cars with better mobility.*”

A number of companies in the aviation industry have developed much lighter and stronger materials which, together with more efficient fuel use and aircraft design, have achieved gains in energy efficiency. Yet, despite these advances, the environmental impact of aviation continues to be of great concern. Lower fares and the consequent growth in the number of air passengers, along with the lack of taxes on aviation fuel worldwide mean that CO_2 emissions from air travel and air freight are such that, unless market constraints are implemented, this growth will result in aviation emissions amounting to almost all of the annual global CO_2 emissions budget by the year 2050.

Sustainable transport can be studied in many subjects, like: mathematics, physics, biology, chemistry, geography, innovations, etc.; even in: mother or foreign language and literature, arts, etc.

https://humanjourney.us/energy-efficiency/?gclid=CjwKCAiAwc-dBhA7EiwAxPRylHi_NF6R_6NY-4E0By6tYya3cTtWrZYn_QcMi8kcy8p2CJ48HMcDEBoC3zQQAvD_BwE

Chapter III

USING THE OER AND THE FREE ONLINE AVAILABLE VR EDUCATIONAL SOFTWARE IN SCHOOL SUBJECTS ON THE CLIMATE CHANGE RELATED TOPICS

USING OF WEB 2.0 TOOLS

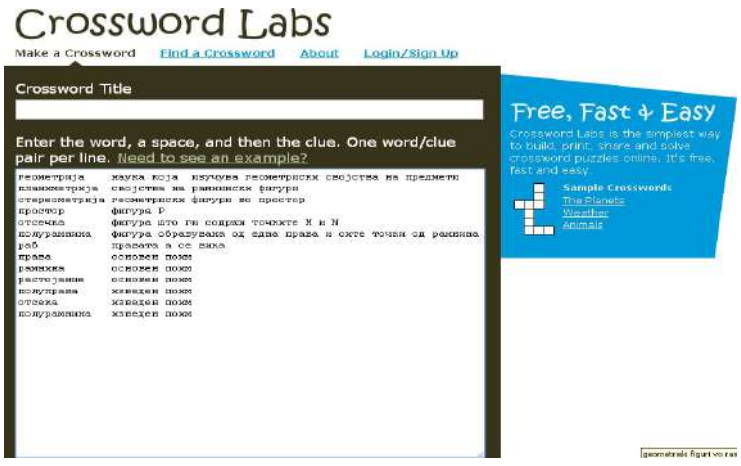
Open Educational Resources (OER) are educational tools and content that are free to use. These are educational tools that are free and can be used without any compensation for educational and research purposes.

WEB 2.0 in teaching:

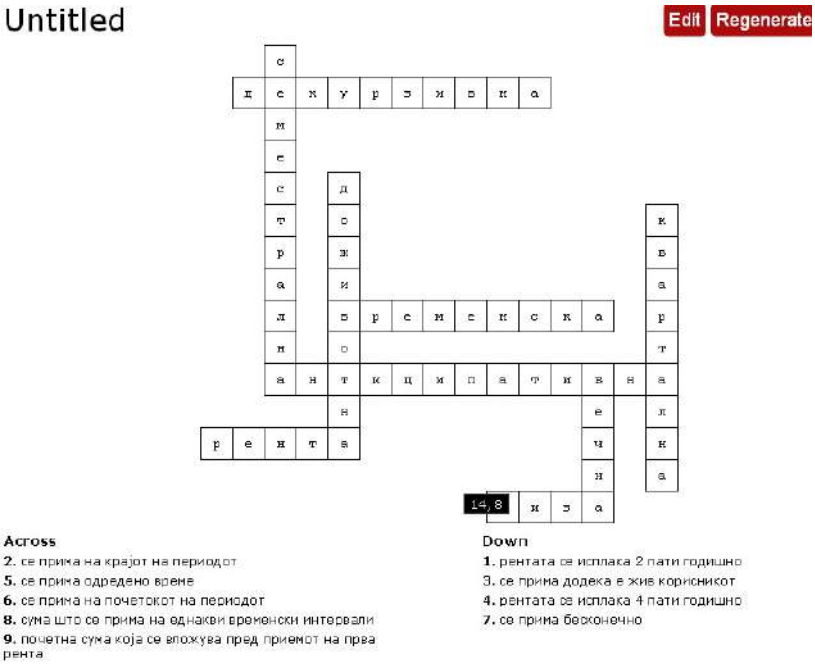
- Innovative approach
- Greater motivation
- Develops critical thinking
- Encourages collaboration and teamwork
- Stimulates creativity
- Own educational content

CrosswordLabs https://crosswordlabs.com/
is a tool that creates classical crosswords. This Web 2.0 tool supports the use of a vendor, and registration is not required for its use.

When using it, the title of the crossword is entered, and then insert one below the other terms that are required (solutions) and their explanations. Between the term and the text with which it is explained, a space is left. Finally click on the Generate button and the crossword is generated.



If we want a different layout of the crossword fields, it's enough to click on Regenerate, if we want to edit the crossword (for example with new terms), click on Edit, and to save the crossword click on Save. As options this web 2.0 tool allows us to save crosswords as a pdf or Word document, and it can be solved on-line.



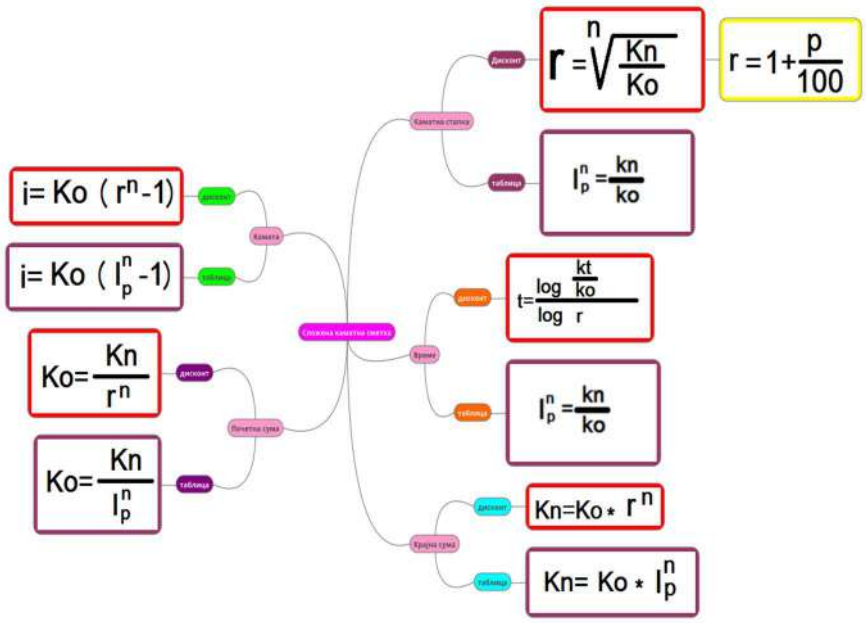
Theteacherscorner (http://worksheets.theteacherscorner.net)

is a tool for creating crosswords, smudges, calendars, sudoku, labyrinths, graphs, materials for mathematics ... The smudges (shown in the picture below) are very easy to create. It is enough to add words and it will be updated with every new word. If we want to be the terms shown on the icilic, then we need to write a letter with capital letters and then we will copy the entire smudge into Word and change all Cyrillic letters using Macedonian fonts (Mac C Times for example).

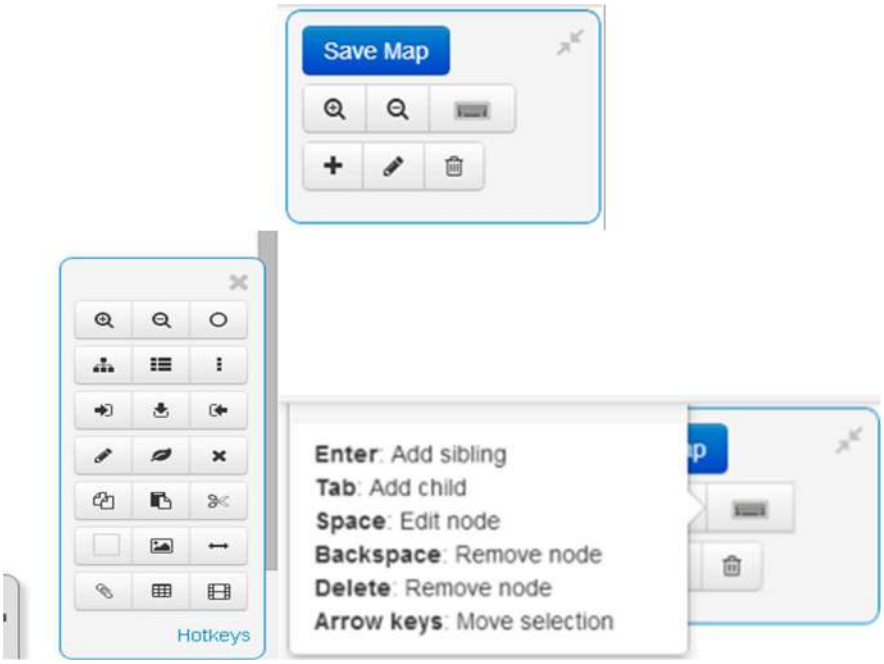
As a suggestion for the use of this web tool, it is recommended to organize a teaching lesson in which students will make smudges and crosswords in groups on climate change issues and then exchange and solve them.

MindMup www.mindmup.com

is a free online tool that can creates mental maps in a fast, easy and simple way. In fact, the map is already created, it is only necessary to change the text, to add new ideas or to delete unnecessary ones. No need of online registration. When we first visit the site, we will see an already created job map. We can change this map or start creating a new map through the Create a Map (top left).

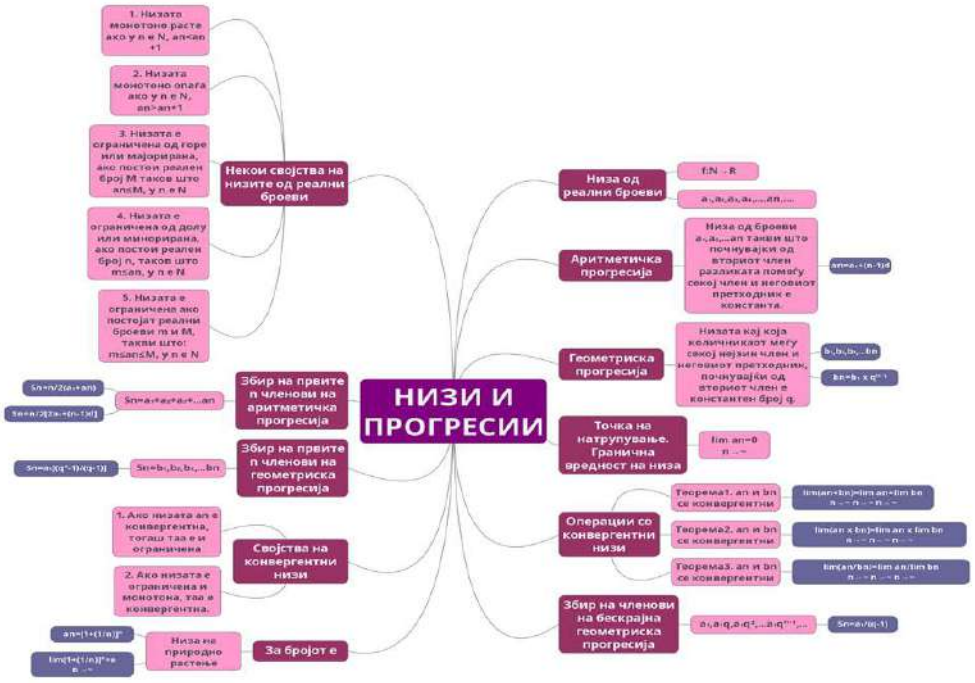


The bar in the upper left corner contains the necessary tools: the plus sign to add new nodes to the selected node, a pencil for writing text in the selected node, and a delete node for the selected node.



There are also zooming tools, as well as a keyboard through which we can edit the map. With the help of a computer mouse, each node can be moved to another position.

After the map is created, click on the Save button. After that, our map will receive a unique URL. We can copy the address and share it with students or colleagues. After saving, there will be buttons for sharing the map over social networks.
When we visit the page the next time, the map we last edited will appear.



Glogster www.edu.glogster.com

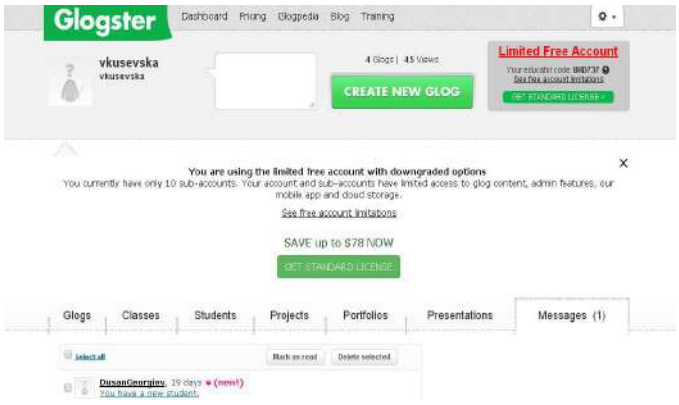
is a program for making interactive digital posters and posters in a simple and interactive way. During the production of digital posters, text, images, links, audio and video recordings are used.

With Glogster, the classic posters that were formerly made on humerus paper are replaced with multimedia posters that can be shared via social networks or embedded in a web site.

For application in teaching, it is recommended Edu.Glogster with which the production of posters takes place in a safe environment with teacher’s control. This web tool enables us to include up to 10 students through a free user account.

When we register as a teacher, we receive a code by which our students will register. The teacher has a record and full control over their work.

Teacher Registration:



Student Registration:

Example:

Postermywall https://postermywall.com

is one of the best sites for creating and organizing posters, photo collages, calendars and postcards. You have a great selection of ready-made templates, wallpapers and fonts, and you can also insert your own images or find a suitable image online. You can share your creations with other teachers, save them and print them. You sign up via email or facebook account. You can always view the posters and create new ones through the My Stuff link.

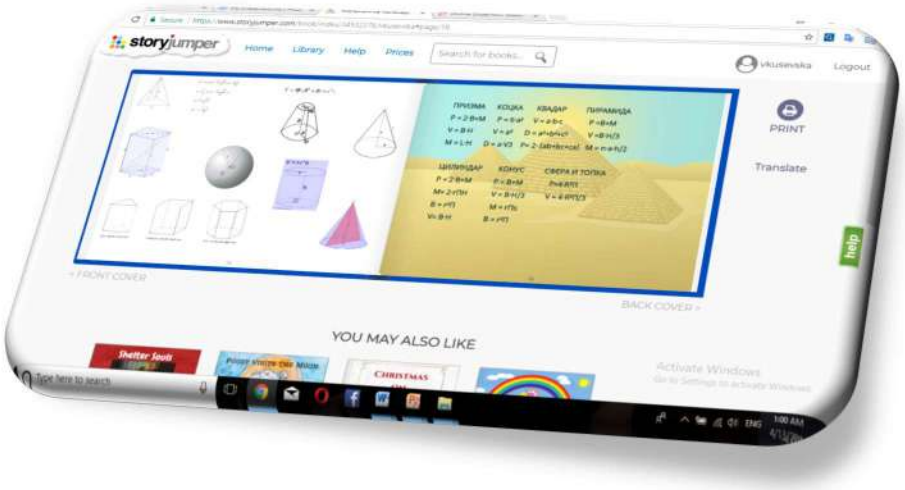
To create a new poster, click on Start Project -> Poster. The design itself is simple - you choose wallpaper, you add pictures, you write text.

Example:

STORYJUMPER www.storyjumper.com is a tool for creating interactive books.

- The finished book can be shared by using a link and a code.
- For making a book you can use photographs, student artwork, ready-made texts, own creations ...
- Register
- Click Create a book
- Select wallpaper (Mostly Blank)
- Create a book (write text or copy text, place photos from the offerings or from your computer ...

Example:



PADLET (https://padlet.com)

On the cover Padlet, select the link "Sign up", and create your own profile.

Open the Padlet Blank page in which it is enough to click the mouse twice and start creating notes. At the place where you clicked, you can upload images, documents, links, or simply enter text by creating your own note. All changes made to the inside of the wall are automatically saved.

By selecting the "Modify this padlet" icon located in the vertical toolbar on the right side, you can:

- define the name and description of the wall and select or upload your own image to indicate the wall ("Basic info")
- select one of the wallpapers offered or send your own picture as wallpaper on the wall ("Wallpaper")
- choose a wall view, or a way to insert notes and files. Select free forms (FreeForm), the notes will be uploaded as you wish.
- only those users to whom you have sent a link (Hidden link) can access and make notes on your wall.
- select a link name to the wall in order for other users to have access to it more easily. Otherwise, the link to the document will consist of a long series of randomly selected alphanumeric characters ("Address").
- copy or delete the created wall
- after you define all these elements and create your own Padlet, you can share or integrate it in different ways.
- You can share it through different social networks or converted to a JPEG / PDF / CSV file.

Example:

VR EDUCATIONAL SOFTWARE

One of the greatest challenges faced by humanity is climate change, which has already led to dramatic consequences for the environment (e.g., sea ice and mountain glaciers are melting, wildlife populations and habitats are changing, extreme weather conditions are becoming more frequent). Climate change is caused by increased emissions of greenhouse gases. In order to counteract climate change, it is therefore important to make people aware of the origins of climate change and to alter their attitudes and behaviour. However, this endeavour has turned out to be challenging, and people’s level of concern does not appropriately reflect the scope of the problem.

The main problem that needs to be addressed is that climate change is abstract. Its meaning only unfolds in 10, 15, or 100 years. It is very hard for people to understand and plan and make decisions.

Virtual reality could transport you to a potential future where the Earth’s climate has drastically changed and over time, VR experiences will develop climate empathy.

VR technology can also be used to promote sustainable energy practices. For example, VR simulations can be used to demonstrate the benefits of renewable energy sources such as wind, solar, and geothermal energy. By providing an immersive experience that allows people to see the impact of renewable energy in action, VR can help promote the adoption of sustainable energy practices and reduce the reliance on fossil fuels, which are the primary drivers of climate change.

Another way VR can help mitigate the effects of climate change is through the development of virtual simulations for environmental protection and conservation efforts.
Here are some examples:

Eco Boat
The main aim is to produce an effective and attractive educational tool through which students will learn about the "real" Climate Change factors - the "greenhouse" gases emission as well as renewable energy resources as measures to reduce it.

By using solar energy, biofuel and integrating various filters the goal of the game is to reduce air pollution.

There is also competitive element in the game because at the end there is a score which could be compared with the results of other players.

Main target are children of the age 14 – 18.

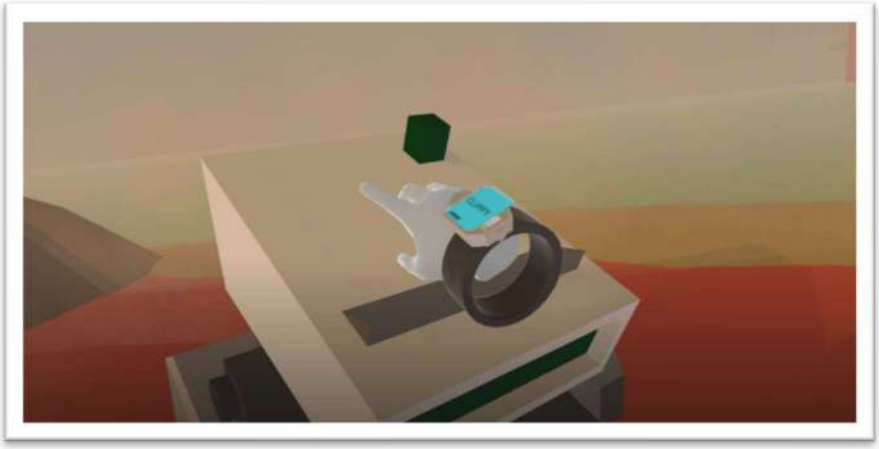
The scene of open educational resources for VR application in a segment of climate change is very limited. Therefore, the value of such an application developed under Erasmus programs has bigger value.

WEBSITE URL

Future Earth
Set in a dystopian future, you are the first human to walk planet earth in a long time.

Your mission objective is to plant and sustain 100 trees. Whether or not humanity will attempt to return to earth hinges upon your success.

But that isn't an easy feat. Climate change and unsustainable human habits have created a toxic wasteland. And to make things worse, robots left behind to clean up, have fried in the sun and turned dangerous over time. Fight these bots, collect technical components, build sustainable technology and become the one to save the world!



https://sidequestvr.com/app/2597/future-earth

Climate Change Pinball

Climate Pinball is a pinball game about climate adaptation and resilience. You play the game to save the planet, and the goal of the experience is to encourage behavior change and climate education in a fun and interactive manner. The overall message of the experience is that positive change and to help remind us that climate change is not a lost cause. This is not the first crisis humans have encountered, and it won't be the last. If everyone does their part to push for good habits, reduce consumption, and demand policy change we can turn this around. And remember, don't drop the ball on Climate Change!

https://sidequestvr.com/app/5888

Aftermath Climate Change VR Experience

Aftermath is an interactive VR experience which showcases the effect of rapid rising sea levels on coastal areas. The environment illustrates the impact of marine plastics as well as the mitigation and adaptation techniques used against rising sea levels, such as seawalls. Remnants of coastal communities, following their displacement and ultimate evacuation of their homes, are also portrayed. The premise is to make people aware of issues small island nations and coastal areas face as a consequence of climate change. This experience is an attempt at making viewers question their present behaviour and the impact it has on the future.

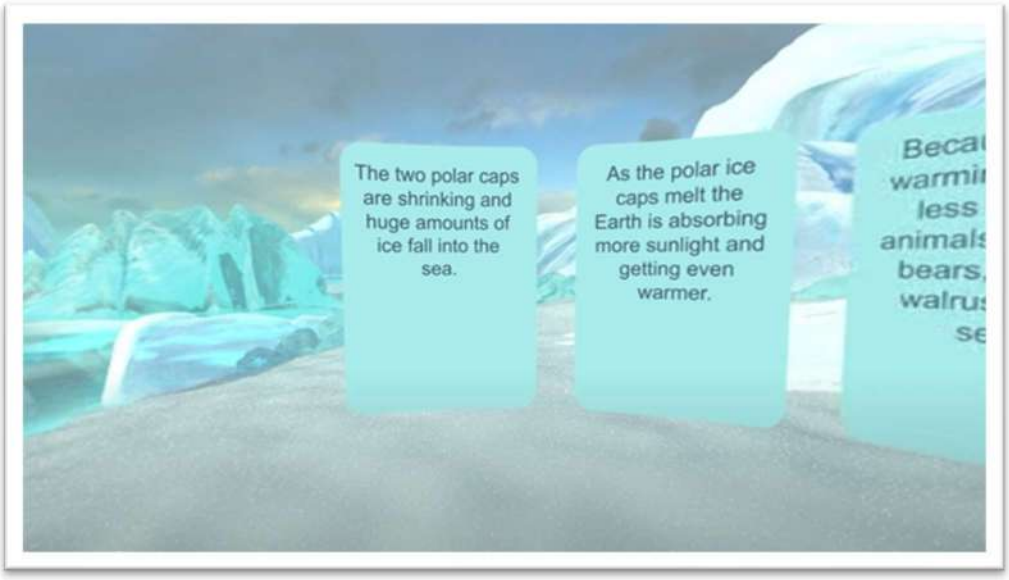
https://sidequestvr.com/app/6058/aftermath-climate-change-vr-experience

VR-Boat-Sea-Rise-Experience

A climate-change experience, exploring the melting icebergs and the effects of sea-level rise. Navigating a boat around the areas effected by sea level rise: icebergs, costal nature and costal urban areas. The app allows to experience before and after sea rise the impact on these scenarios.

What Climate Change Will Look Like on Earth | 360 | VR

Massive flooding, huge forest fires, droughts and thunderstorms are all becoming more frequent and powerful and putting a strain on our way of life! What would it look like if a familiar environment was flooded, dried out or set on fire? Global warming will affect everyone, so it is important to know what some of the outcomes could look like so we can plan more effectively. Increases in temperature will both increase the number of droughts that will hit countries and melt the ice caps giving rise to the sea levels and permanently flooding low level coastal villages and towns. Climate change refers to long-term shifts in temperatures and weather patterns. These shifts may be natural, but since the 1800s, human activities have been the main driver of climate change, primarily due to the burning of fossil fuels (like coal, oil and gas), which produces heat-trapping gases.



Climate Change VR

The player is submerged in a surreal underwater landscape and tasked with removing pollutants to improve the climate.

https://www.youtube.com/watch?v=aQom1yczKsk

Meet your carbon footprint

What we eat, how we get around, our energy use at home and the stuff we buy – it all links us to climate change. Your carbon footprint is the amount of greenhouse gases released to the atmosphere as a result of your consumption choices. In this video, you will confront your carbon footprint in real size. You will also experience sea level rise, smog, and wildfires – some of the impacts we are responsible for. But you will also discover how easy – and delicious – it is to live a climate friendly lifestyle.

https://www.youtube.com/watch?v=aCu9rZvXRLg

BIOSPHERE VR

BiosphereVR is a pioneering project using 360-degree, immersive film, also known as virtual reality (VR). Through this experience, you are taken on a ’virtual field trip’ to an array of distant places around the world where Climate Change is already showing its opposing face. This experience enables you to connect with distant crises as if they are close enough to touch.

https://www.biospherevr.com/

ANNEX

PREPARATION NOTES FOR 45 MINUTE SCHOOL CLASSES FOR IMPLEMENTATION OF CLIMATE CHANGE ISSUE IN STEM ORIENTATED SCHOOL SUBJECTS (WITH USING OF FREE ONLINE OER AND VR EDUCATIONAL SOFTWARE)

1. TEACHING SUBJECT: **Biology**
Scope of learning: Greenhouse effect
Success criteria: to connect using of fossil fuels with higher concentration of CO_2
Description of activity: Introduction (5 min.) To think about the number of vehicles and the frequency of daily activities in vehicles which use derivatives of oil and produce CO_2 Main part (35 min.) Divide students in groups; 2 groups – research of literature and the Internet about the data regarding the quality of air (production of CO_2 and SO_2) before a specific time, interval (50 years ago when there were fewer vehicles), 2 groups- research of alternative energy sources (el. cars, vehicles that go on hydrogen, vehicles that go on ethanol) for vehicles, organised transportation (buses, trains…) and planting of plants (bushes, trees, photosynthesis) Conclusion (5 min.): brief report of all groups
Methods & techniques: conversation, brain storming, working with data base
Resources: Internet, encyclopaedia
Proof of activity: analysis of research results

2. TEACHING SUBJECT: **English**
Scope of learning: Pollution of land
Success criteria: vocabulary, awareness of the problem, cooperation of students
Description of activity: reading comprehension
Methods and techniques: texts on pollution, teaching new vocabulary, gap filling texts
Resources: handbook, handout
Proof of achievement: a questionnaire

3. TEACHING SUBJECT: **English**
Scope of learning: Environmental pollution
Success criteria: vocabulary, awareness of the problem, survey results presentation
Description of activity: The teacher divides the pupils into 4 groups and gives instructions for group work. Students explore material on environmental pollution (internet, books in school library, magazines, newspaper), then each group has to formulate at least 5 questions on the subject. The first group does the research about waste sorting, the second group does the research about recycling, the third group about the use of plastics in households and in general and the fourth group about the use of alternative sources of transportation. The teacher can offer different subject for research, for example: electricity and water saving or something of his or her choice. Each group creates a survey with these questions in Google or Microsoft Forms. Students in other classes are asked to fill out these surveys. When all selected classes complete surveys, each group prepares a data analysis and presentation – they have to write short paragraph on padlet and prepare a power point presentation with tables and graphs. The representative of each group presents the results of their analysis to their classmates.
Methods and techniques: research work, collaborative learning, group work, presentation
Resources: books, internet, magazines, newspapers
Proof of achievement: survey results presentation on padlet

4. TEACHING SUBJECT: **Language** Team: Greek language teachers (Charalampos Konstatellias, Nikolaos Pappas, Chrysoula Kolitsa)
Target group: Secondary school (Gymnasium)
Scope of learning Students will be able: • to clarify what is climate change • to list the causes of climate change • to explain what is climate change, using relevant vocabullary • to gather information for climate change from a variety of sources as part of the research
Success criteria: cooperation, activation of creativity, positive atmosphere, responsibility
Description of activity: Introduction (5 minutes) • Use a picture for activating prior knowledge (brainstorming) Source: https://www.arabnews.com/node/2025461/world Explicit Instruction (10 minutes) • Collect the students' answers and make a mindmap explaining clmate change and the main causes of it Guided Practice (10 minutes) • Show a video (source: https://www.youtube.com/watch?v=aU6pxSNDPhs) for listening comprehension. Ask students to complete a 'True or False' worksheet in groups. The teacher provides feedback whenever it is necessary. Independent Group Working Time • (10 minutes) Read a text from United Nations for reading comprehension (source: https://www.un.org/en/climatechange/what-is-climate-change) and then complete a 'Fill the gap' worksheet in groups. Students can use internet, dictonaries etc to search for 'unknown' words. • (10 minutes) Write a brief article in order to be published at the school newspaper. Students with learning diffiulties can draw a relevant sketch.
Methods and techniques: Brainstorming, group work
Resources: You Tube, pictures, internet, computer
Prove of achievement: Role playing (In a radio show one is the interviewer and one is a scientist explaining about climate change)

5. TEACHING SUBJECT: English Language by Sophia Basmatzi
Target group: Secondary students (Gymnasium)

Scope of learning: Renewable energy resources
Students will be able:

- to gather information about renewable energy from a variety of sources and improve their reading skills by prioritising and selecting relevant material, thus promoting student autonomy
- to revise what they have written, re-focus, rearrange and polish their ideas and language to come up with their final version of their writing project
- to engage in process- writing about renewable energy sources and uploading their work on the following padlet https://padlet.com/basmasoph/4holtz3ybnf0g6ls
- to explain and present the different types of renewable energy resources and their benefits and drawbacks in class , using relevant vocabulary

Success criteria: vocabulary assimilation regarding alternative energy resources, cooperation of students in the peer evaluation stage, posts on the padlet, presentation of Students' work in class, positive atmosphere

Description of activity: (The suggested time for the different stages can vary depending on the level of students and their response to the tasks)

Warm-Up Stage (15 minutes)

The Teacher (T) writes 'alternative energy resources' on the board to activate prior knowledge (schemata) through brainstorming, and, in the form of a mindmap, notes down the Students' (Ss) ideas. T explains any new vocabulary on the topic.

Ss find information about the meaning and types of alternative or renewable energy using different sources on the internet such as: Renewable energy - Wikipedia
https://www.un.org/en/climatechange/what-is-renewable-energy
https://www.twi-global.com/technical-knowledge/faqs/renewable-energy
T writes down on the board the different types of renewable energy resources and invites different Ss to choose one form to research including advantages and disadvantages (during the lesson), write a post about on the padlet (at home) and present in class (for the follow-up lesson)

Main Activity (20 minutes)

Ss write on the computer (Word document) their first draft about the form of alternative or renewable energy source they chose to delve into by selecting and rephrasing (not copying exact paragraphs or sentences)
Then, Ss email their answer to a pre-selected student to read and provide any corrections on.
T circulates around the classroom helping Ss with any vocabulary they need or with problems that may arise.

Peer evaluation stage (10 minutes)

Ss read their classmate's first draft and send back their suggestions for corrections.
Ss look at the corrected version of their first draft and try to improve their original version.
Connection with the following lesson
Ss will upload their research findings on the padlet at home, print a copy of their work and present it in class. (Alternatively, they could prepare a PowerPoint presentation and present it to their classmates)

Methods and techniques: brainstorming, internet research in the computer lab, peer correction of first draft based on the following criteria: content, spelling, punctuation, word order, word forms, verb tenses, syntax, (Optional – PowerPoint presentation)

Resources: computers, internet access, padlet

Proof of achievement: posts on padlet https://padlet.com/basmasoph/4holtz3ybnf0g6lsl Oral Presentation of individual work in class (with an optional PowerPoint Presentation)

6. TEACHING SUBJECT: **Physics**

St. Cyril and Methodius" – Kochani

Date: Teacher: Elizabeta Gjorgjieva Class no. IX

Unit: Measurement and Problem Solving

Solving problems using units of measurement W, kW, kWh

Learning objectives: To know the measurement units for power (W, kW) and energy kWh, to apply them in tasks

Success criteria: Can solve tasks using power W, kW and energy measures kWh

Description of activity:

10 min.

Introductory activity

The teacher explains to the students about:

- Power and energy measures - W, kW, kWh
- How electricity consumption is calculated.
- What are photovoltaics and how is the number of photovoltaics calculated according to the energy consumption in a family (house).

Forms and techniques

- Data editing,
- Solve tasks using power and energy measures W, kW, kWh,
- Individual work,
- Project work

Resources:

Textbook, computer, Internet - Google, Word, Excel, GeoGebra, Calculator

Evidence of achievement: Research, Observation, Questions Answer, Discussion

15 min.

Research

The teacher first gives the students an example of how to calculate the number of photovoltaics for a home according to energy consumption, and then assigns tasks to the students to research and calculate how many photovoltaics are needed for their home.

The teacher explains:

Independent photovoltaic system

When you install a stand-alone photovoltaic system, it means that you are not dependent on the grid and that you can only consume the electricity that you produce yourself.

The calculation is as follows: the power of each device is multiplied by the number of working hours during the day and finally all the obtained values are added. This gives how many kilowatt hours (kWh) a household uses per day.

- Boiler: 2000 W x 3h = 6000 Wh
- Electric hob: 1000 W x 1 h = 1000 Wh
- Electric oven: 2000 W x 0.5 h = 1000 Wh
- Refrigerator: 300 W x 7 h = 2100 Wh
- Washing machine: 2000 W X 0.5 h = 1000 Wh
- TV: 100 W x 6h = 600 Wh
- Computer: 150 W x 5 h = 750 Wh
- Bulbs: 15 W x 10 pieces x 2 h = 300 Wh

When all this is added up, you get 6000 Wh + 1000 Wh + 1000 Wh + 2100 Wh + 1000 Wh + 600 Wh + 750 Wh + 300 Wh = 12750 Wh or 12.75 kWh

One solar panel works efficiently for 4-5 hours per day on average, if we consider that the solar panel has a power of 250 W by multiplying by 4.5 hours, we get that one solar panel produces 1125 Wh or 1.125 kWh per day.
If we divide our daily electricity demand of 12.75 kWh by the 1.125 kWh produced by one solar panel - we get that we need 12 solar panels.
A 250 W solar panel usually has 2 solar cells of 100 Ah each and you also need an inverter of say 5 kW, which proves to be quite a satisfactory choice for the average household and leaves room for a possible upgrade of the solar system.
From the attachment we see that half of the electricity consumption (6000 Wh out of 12450 Wh) goes to the water heater. If, for example, you install a solar thermal water heating system, you will use half the electricity and need half the solar panels, so 6.
Each student researches about his family (house) how much energy he consumes and then calculates how many photovoltaics he will need to use solar energy.
The teacher observes, compares, asks, helps.
Evidence of achievement: Worksheet, Observation, Questions Answer, Discussion
10 min.
Discussion
- Students decide, discuss, ask questions
- the teacher follows, explains
Evidence of achievement: Posters, Presentation, Discussion
5 min.
Application
- The teacher gives homework assignments to the students to research how many photovoltaics the school will require to be installed
Evidence of achievement: Posters, Presentation, Discussion
5 min.
Application
- The teacher gives homework assignments to the students to research how many photovoltaics the school will need to use completely solar energy
- Students notice
Evidence of achievement: Posters, Presentation, Discussion

7. TEACHING SUBJECT:	**Physics**
Scope of learning:	Climate Change: What it is, causes, effects, response
Success criteria:	Students learn, become aware through knowledge and look for actions and attitudes to deal with the problem
Description of activity:	Introduction with pictures related to the effects – Discussion (15 min): From the results, the students understand the problem, describe it and reflect on the causes that create it. Main activity (60 min): Students work in groups. A) They learn about the causes that create Climate Change. Link to anthropogenic activity. B) They look for the effects now and in the future. C) Collective and individual actions to deal with. Final activity (10 min): Each group presents its work.
Methods & Techniques:	- DATA BASE WORK, discussion, BRAIN STORMING - Group work, reading
Resources:	- Internet https://climate-pact.europa.eu/about/climate-change_el and others - Images, videos
Prove of achievement:	- Knowledge, awareness, action

8. TEACHING SUBJECT: **Mathematics**
Scope of learning: Statistics
Success criteria: statistical analysis and display of the data
Description of activity: - searching for the data (on the Internet) about the temperatures in 6 different countries of the 6 different continents - data editing and various displays (table, graph …), - calculation of the mean values (arithmetic mean, modus, the median), - interpretation of the mean values (arithmetic mean, modus, the median).
Methods and techniques: data editing, graphs drawing, individual work, project work
RESOURCES: Internet, calculator, Excel, dynamic geometry program (GeoGebra)
PROOF OF ACHIEVEMENT: posters, presentation

9. TEACHING SUBJECT: **Biology**
Scope of learning: Ozone layer holes
Success criteria: to connect the increase of UV radiation with ozone depletion
Description of activity: Introduction (5 min.) - to remember the UV factors which are presented in weather forecast in summer months together with other factors of weather report Main part (35 min.) Divide students in groups; 2 groups – 1st group of students researches the influence of certain factors of UV radiation on health of people (skin, eyes) and ways of protection (creams, clothes, sunglasses); they also research on the Internet for protective sunbathing creams and marking of UV factors on the bottles of the creams 2nd group searches for information about the movement and growth of ozone layer holes throughout all the years it has been measured Conclusion (5 min.): brief report of all groups
Methods & techniques: conversation, working with data base
Resources: Internet, encyclopaedia
Proof of activity: analysis of research results

10. TEACHING SUBJECT: **Biology**
Scope of learning: Greenhouse effect and forests
Success criteria: to determine the importance of forests as consumers of CO_2 which is a result of burning of fossil fuels
Description of activity: Introduction (5 min.) - to repeat the process of photosynthesis, to think about a saying "Parks are lungs of a town" Main part (35 min.) Divide students in groups; 1st group does an experiment with Elodea Canadensis (water plague) (leaves are in the water under a funnel – monitoring of release of bubbles (oxygen) which will gather at the top of the test tube) 2nd group searches on the Internet to find out which percentage of our planet (and Croatia) was covered with forests in the past and which percentage is covered today (comparison – 70 years ago and today) – they will realize how big of a problem is deforestation 3rd group searches and compares ecological footprint in different countries in the world; they compare the level of development of individual countries (ecological awareness) and the value of ecological footprint Conclusion (5 min.): brief report of all groups
Methods & techniques: conversation, experiment, working with data base
Resources: Internet, encyclopaedia
Proof of activity: analysis of research results

11. Teaching subject: **English**
Scope of learning: Pollution
Success criteria: vocabulary about pollution, awareness of the problem, cooperation of students (pair work)
Description of activity: In the previous classes students would have learnt about different kinds of pollution around the world. Now their task is to choose two immediate problems connected with pollution in their surroundings (around the house, neighborhood, village). They are going to film a video in pair (first one pupil talks and the other films, and then the other way around). Each student will introduce the problems, show the proof of the problem (it has to be visible in the video) and say what type of pollution they are going to talk about. Then they have to choose one of those two problems, explain why they chose that one and how they are going to solve it. Both pupils work at solving the problem together – ex. picking up the rubbish, making warning signs, removing branches and other rubbish from the creak etc. In the video has to be visible area before and after dealing with the problem. Students will present their video in pair in front of the class. Other students are going to watch and listen and write 2-3 questions about the video they saw. Presenters will answer most of the questions in the end.
Methods and techniques: pair work, speaking, editing a video, Q and A
Resources: Youtube, personal computer, projector
Proof of achievement: a video

12. TEACHING SUBJECT:
Scope of learning:
Success criteria: