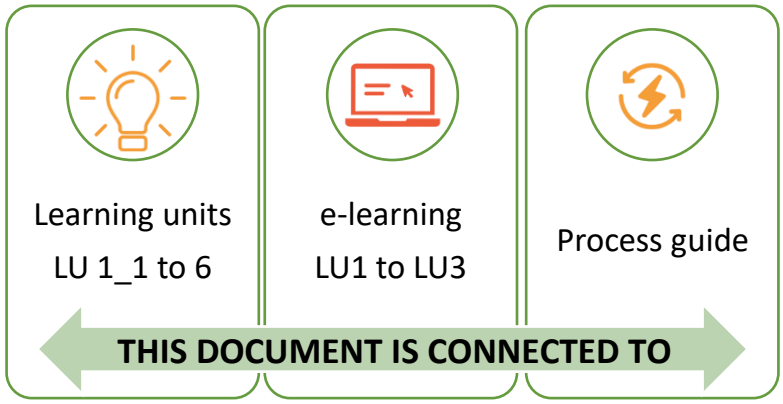
Learning Unit 2

Solar energy technologies



Co-funded by the
Erasmus+ Programme
of the European Union

Learning Unit 2 - Learning Plan

Solar energy technologies

Solar electricity

Photovoltaic systems (PV systems) are made of special materials that convert solar energy (sun's radiation) into an electric current. The most commonly used materials are crystalline silicon, cadmium telluride and copper indium gallium selenide. Photovoltaic systems are generally made of photovoltaic modules which are connected in series (string) and made of photosensitive materials. The installed capacity of solar energy is growing rapidly and therefore the production of photovoltaic systems is still developing and increasing.

Photovoltaic systems represent an ideal solution for household needs including in areas with no access to the electricity network (e.g. isolated mountain huts etc.) to absorb sunlight and convert it into electricity. Just a few photovoltaic modules produce enough kilowatt-hours (kW) of electric energy for the operation of all electrical devices in the house.

A solar power plant consists of a huge number of modules and can produce a few tens of MW of electricity. Produced electricity needs to be transmitted into the grid and it is required to obtain all necessary documentation.

The surface area of the modules needs to be exposed to direct sunlight to increase the efficiency of conversion of solar power. Hence, it is very important to study the position and orientation of the modules or the entire plant.

Concentration photovoltaics (CPV) is a photovoltaic technology that uses lenses or curved mirrors to focus sunlight onto small, highly efficient solar cells. They often use sun trackers to increase their efficiency.

In 2018 18,9 % of electricity was generated from renewable energy sources in Europe. Solar power energy represented 6.4 %.

Co-funded by the
Erasmus+ Programme
of the European Union

Solar heating

Solar-thermal systems operate according to the principle of the dark watering hose which heats up under the sun. The surface of the hose absorbs solar energy and heats water inside. In solar thermal energy systems, the important part is a solar receiver (flat or vacuum). The receiver absorbs solar radiation with its dark surface and transfers energy to a tube (copper or aluminium) containing a circulating liquid (water or antifreeze in colder countries). The pump (in active way) or the temperature difference of the liquid (in passive way) pushes hot liquid into the heat exchanger. The heat exchanger is designed to provide heat exchange wherein the heat of the liquid is transferred to the water sanitary tank.

Solar-thermal systems have three main uses: heating water sanitary tank, heating buildings (space heating) and also district heating. Before installation, the position must be considered with a lot of sun during the whole year, a solid roof structure, and the connection to the boiler (in case of water heaters).

Concentrated solar power systems (CSP) use lenses and mirrors to concentrate a large area of sunlight onto a small area. The concentrated light is then used either for heating or as a heat source for a conventional power plant (solar thermoelectricity) to produce electricity.

Solar-thermal systems can be up to 70% more efficient in collecting heat from the sun, compared to photovoltaic systems.

Co-funded by the
Erasmus+ Programme
of the European Union

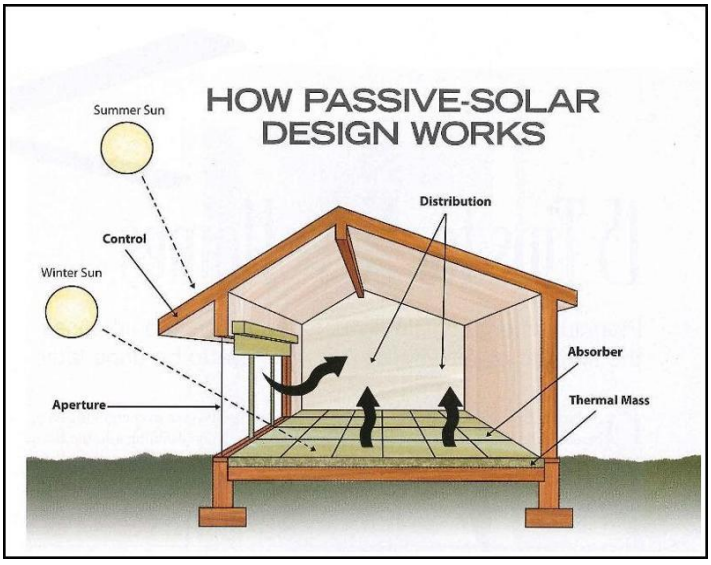
Passive solar heating and daylighting

Passive solar heating or a passive house is built in an energy efficienct way so that the solar energy gain is maximized, and the heat loss is reduced. The annual heating demand is covered by the solar energy heat through glass surfaces and internal heat gains of living inside the house. Additional heating demands should not exceed more than 15 kWh/m^2 of the houses living area per year.

Heat losses are significantly reduced with appropriate construction, thermal insulation materials, controlled ventilation, prevention of air leaks, avoiding of thermal bridges and proper building formation. All principal windows have to be oriented towards the south for efficient solar power gain. The passive heating with a heat exchanger can also base on geothermal energy.

Considering that the domestic energy consumption also tends to be minimal, it is recommended to use energy-saving household appliances.

When planning and constructing a passive house also the exterior part of it should be taken into account. The absorption qualities and therefore energy efficiency of the house also depends on predominant vegetation in the surrounding environment. Especially the shade of near trees can influence the s energy efficacy of the house.



Co-funded by the Erasmus+ Programme of the European Union

SOURCES:

- *http://pv.fe.uni-lj.si/Celice.aspx*
- *fotovoltaika-on.net*
- *https://www.renewableenergyworld.com/solar-energy/tech/solarprocessheat.html*
- *alternative-energy-tutorials.com*
- *https://ec.europa.eu/eurostat/documents/2995521/9571695/8-12022019-AP-EN.pdf/b7d237c1-ccea-4adc-a0ba-45e13602b428*
- *https://ec.europa.eu/eurostat/statistics-explained/index.php/Renewable_energy_statistics#Renewable_energy_produced_in_the_EU_increased_by_two_thirds_in_2007-2017*
- *http://www.klimaterm.si/wp-content/uploads/Toplozra¦Źni-sprejemniki-son¦Źne-energije.pdf*
- *https://news.energysage.com/contentrated-solar-power-overview/*

Co-funded by the
Erasmus+ Programme
of the European Union

LEARNING UNIT 2: TEACHING PLAN

Learning unit 2 – Teaching plan

Solar energy technologies

In this unit pupils realize there are different types of solar energy technologies each with different methodologies and working principles.

TIME: 45 min

CLASS ORGANISATION: group work

METHODOLOGY: discussion, experimental work, demonstration

LESSON GOALS:
Topic of the project: Energy

Students will learn:
- differences of solar thermal and photovoltaic systems
- renewable energy and new technologies
- temperature measurements

INTRODUCTION/MOTIVATION (5 minutes):
Pupils are divided into groups. Each group receives experimental on worksheet with instructions and independently performs the experiment. At the end of the lesson the groups must present the experiment and the findings to the other class mates.

***optional, without experiments:*
Pupils are divided into groups. Using a computer and online search engines, they search for information on different solar energy technologies. Findings are presented in a form of a poster or PowerPoint presentation.

MAIN PART (25 minutes):
1. Group: Solar electricity
2. Group: Solar heating
3. Group: Passive solar heating and daylighting (passive house)

ASSESSMENT (15 minutes):
Presentation of experiments and presentation on how each technology works. The discussion is led by the teacher.

Co-funded by the
Erasmus+ Programme
of the European Union

Learning unit 2 – Experiment 1

Solar electricity

Photovoltaic systems (PV system) are made of special materials that convert solar energy (sun's radiation) into an electric current. The most commonly used materials are crystalline silicon, cadmium telluride and copper indium gallium selenide. Photovoltaic systems are generally made of photovoltaic modules which are connected in series (string) and made of photosensitive materials. The installed capacity of solar energy is growing rapidly and therefore the production of photovoltaic systems is still developing and increasing.

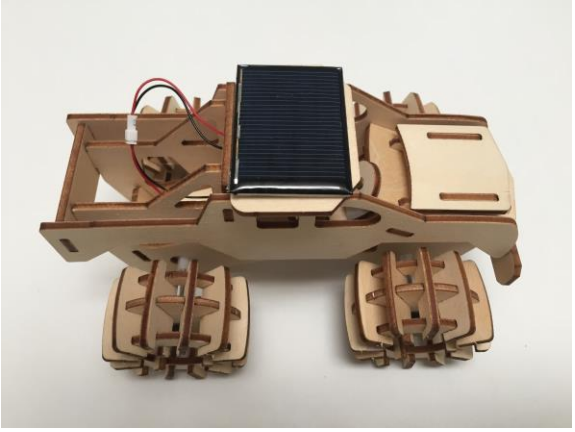
To absorb sunlight and convert it into electricity, photovoltaic systems represent an ideal solution for household needs including in areas with no access to the electricity network (e.g. isolated mountain huts etc.). Just a few photovoltaic modules produce enough kilowatt-hours (kW) of electric energy to have sufficient hot water for heating and sanitary use and even for the operation of all electrical devices in the house.

The solar power plant consists of a huge number of modules and can produce a few tens of MW of electricity. Produced electricity needs to be transmitted into the grid and it is required to obtain all necessary documentation.

The surface area of the modules needs to be exposed to direct sunlight to increase the efficiency of conversion of solar power. Hence, it is very important to study the position and orientation of the modules or the entire plant.

MATERIALS:

- car parts
- wheels and axels
- gears
- Photovoltaic module
- electric motor
- switch
- wires



Assemble a car, correctly connect the wires, photovoltaic module, electric motor and switch. Then test the car.

Test if it moves, in the sun light, in the shadow, on a day light, when shining on it with a lamp, or with mirror.

Co-funded by the Erasmus+ Programme of the European Union

LEARNING UNIT 2: WORKSHEET 1

Learning unit 2 – Worksheet 1

Solar electricity

Fill in the gaps!

A solar cell is a small, most of the times blue plate and it consists of _____. If the sun rays meet the silicon, they produce an electrical voltage which results in the generation of _____.

Many of these small solar cells are interconnected to form a large _____. It is usually mounted on the _____, to catch as much _____ as possible. The electricity generated can be used directly in the house or it can be fed into the _____.

Words to insert:

Photovoltaic system, roof, electricity, public grid, solar energy, silicon

Co-funded by the Erasmus+ Programme of the European Union

Learning unit 2 – Experiment 2

Solar heating

Solar-thermal systems operate according to the principle of the dark watering hose which heats up under the sun. The surface of the hose absorbs solar energy and heats water inside. In solar thermal energy systems, the important part is a solar receiver (flat or vacuum). The receiver absorbs solar radiation with its dark surface and transfers energy to the tube containing a circulating liquid (water or antifreeze) beneath it. The pump (in active way) or the temperature difference of the liquid (in passive way) pushes hot liquid into the heat exchanger. The heat exchanger is designed to provide heat exchange wherein the heat of the liquid is transferred to the water sanitary tank.

Solar-thermal systems are used for heating water sanitary tanks and as support for heating smaller buildings.

MATERIALS:
- Aluminium foil
- tape
- ordinary tabletop lamp
- stopwatch
- plastic glasses
- syringe
- drinking glass
- thermometer
- drinking straws of different colours (black, white, yellow, red, and green)

Tape together two drinking straws of the same colour to form one long straw. Tape all the straws of the five colours onto the aluminium foil close to one another. Place the aluminium foil onto the table so the ends are sticking over the table. Under the end of each straw place a plastic glass.
Above the foil with straws place the tabletop lamp or use sun light. LED lights should not be used. Pour water into the drinking glass and measure the temperature. The values should be written into the table below.
Using a syringe to add water in all straws and shine onto the straws for 1 minute. Pour the water from the straws in the plastic glasses in a way you can collect water from each separately. Measure the temperature of each colour and write down the values. Repeat the experiment with 3 minutes exposure time and 10 minutes exposure time.

RE-SULTS	Starting T (°C)	Through T (°C)	1 min (°C)	3 min (°C)	10 min (°C)
White					
Red					
Yellow					
Green					
Black					

Co-funded by the Erasmus+ Programme of the European Union

Learning unit 2 – Experiment 3

Passive solar heating and daylighting (passive house)

Passive solar heating or a passive house is built in an energy efficient way, so that the solar energy gain is maximized, and the heat loss is reduced. The annual heating demand is covered by the solar energy heat through glass surfaces and internal heat gains of living inside the house. Additional heating demands should not exceed more than 15 kWh/m2 of the houses living area per year.

Heat losses are significantly reduced with appropriate construction, thermal insulation materials, controlled ventilation, prevention of air leaks, avoiding of thermal bridges and proper building formation. All main windows have to be oriented towards the south for efficient solar power gain. The passive heating with a heat exchanger can also base on geothermal energy.

Considering that the domestic energy consumption also tends to be minimal, it is recommended to use energy-saving household appliances.

When planning and constructing a passive house the exterior part of it should also be taken into account. The absorption qualities and therefore energy efficiency of the house depends also on predominant vegetation in surrounding environment. Especially the shade of near trees can influence the energy efficacy of the house.

MATERIALS:

- Styrofoam / wood / Newspaper paper / cardboard / Plexiglas /Aluminium foil
- hair dryer
- tabletop lamp with normal light / IR lamp
- thermometer
- tape / toothpicks

Build a house only using the provided materials to be as much protected from outside as possible. Inside the house the thermometer should be placed after the building is finished. Measure the starting temperature. Then, illuminate the house with the lamp for 10 minutes and after that blow hot wind on it with the hair dryer. Did you find any difference in temperature?

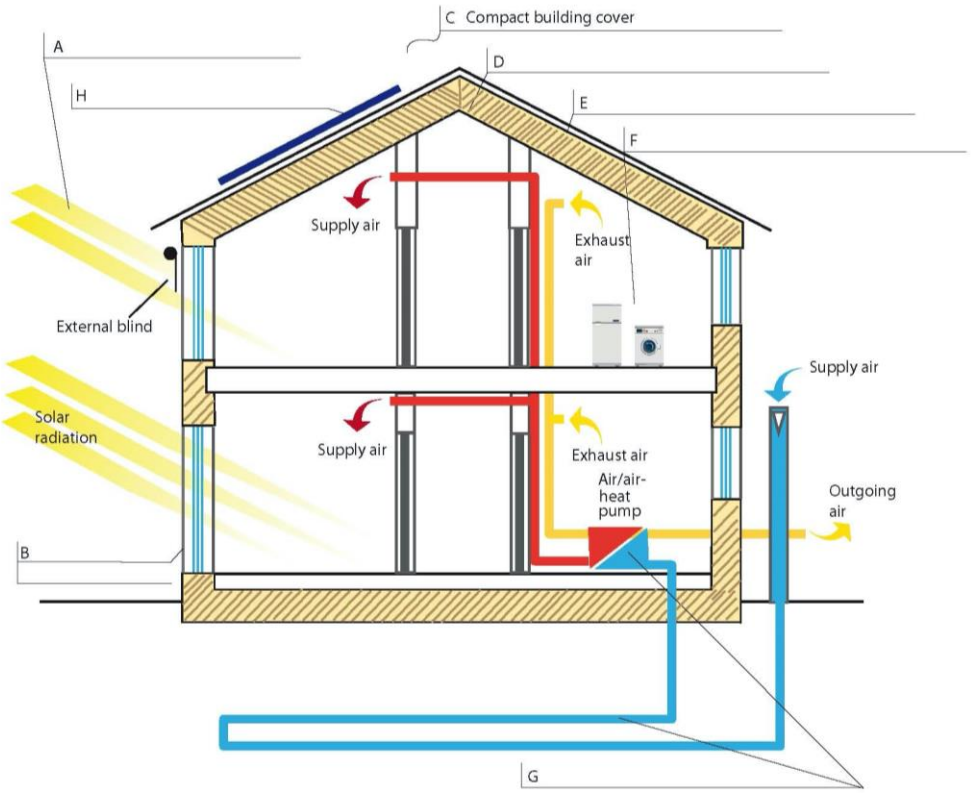
RESULTS:

House	Starting T (°C)	Final T (°C)
Styrofoam		
Paper		
Cardboard		
Plexiglas		

Co-funded by the
Erasmus+ Programme
of the European Union

Learning unit 2 – Worksheet 2

Passive solar heating and daylighting (passive house)



Fill in the characteristics of the passive house on the correct line!

1	Compact building cover
2	Good thermal insulation (thermal insulation with U value below 0.15 W/m²k)
3	Southern orientation
4	High-tech windows (with three panes of glass filled with inert gas)
5	Airtight building
6	Preheating the incoming air
7	Hot water provided by renewable energy
8	Energy-saving electrical devices in the household

Co-funded by the Erasmus+ Programme of the European Union

LEARNING UNIT 2: WORKSHEET 3

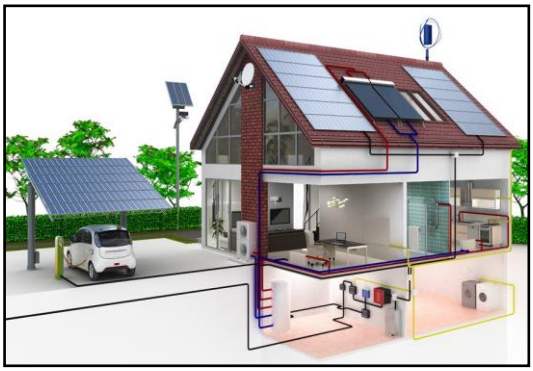
Learning unit 2 – Worksheet 3

Connect pictures with the right sentence about solar energy technologies

I am made of special materials that convert solar energy (sun's radiation) into an electric current.

I use lenses and mirrors to concentrate a large area of sunlight onto a small area.

I am used for heating water sanitary tanks and as support for heating smaller buildings.



I am built in an energy efficient way, so that the solar energy gain is maximized, and heat loss is reduced.

Co-funded by the Erasmus+ Programme of the European Union

Contacts:

WEBSITE: https://solartown.eu/

NATIONAL CONTACTS:

akaryon GmbH, Austria

Website: http://www.akaryon.com/

Climate Alliance Austria

Website: http://www.klimabuendnis.at/

Solar Heat Europe/ESTIF

Website: http://www.solarheateurope.eu/

KPE Pertouliou Trikkeon, Greece

Website: https://blogs.sch.gr/kpepertoul/

VseUK Institute, Slovenia

Website: http://www.vseuk.si

CONTACTS: SOLARTOWN.EU

Co-funded by the Erasmus+ Programme of the European Union