Learning Unit 5.1

Construction of the plant

Learning units
LU 1_1 to 6

Process guide

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Learning Unit 5.1 – Learning Plan

Construction of the plant (solar collector)

Before starting the construction of the solar collector some preparations are necessary.

PREPERATION

PREPERATION FOR THE STUDENTS

Before the students start building the plant, it would be good to get some background information. The learning units 1.1. to 3.3 of "Our Solartown" (Download: materials.solartown.eu) are helpful for this.
Of course, other materials related to solar energy, renewable energies and climate protection can also be used.
It is important that the pupils get to know how solar energy is used and understand the climate protection aspect.

WHERE SHOULD YOU BUILD (ASSEMBLE) THE PLANT?

In the warmer months a covered area of the schoolyard would be ideal. A large room in the school, such as the assembly hall, could also be used. When choosing the room, it is important to consider that the fully installed solar collector must fit through the door so that the collector can be removed! The diagonal of the door should be 5 to 10 cm bigger than the width of the finished collector.

SIZE OF THE PLANT

The size of the system depends on how much hot water is required. The dimensioning of the collector must be clarified and determined in advance. For this purpose, the learning units 3.1 to 3.3 are highly recommended.
For working with young people, it is definitely advantageous to use a construction kit. The dimensions of commercially available kits are 2.05 x 4.00 m, which means that the completed system has 8 m². Often two collectors are built together, so that in total 16 m² of collector surface is created.
If you do, however, not want to use a kit, please remember that the collector must be removed and installed. Do not oversize it!

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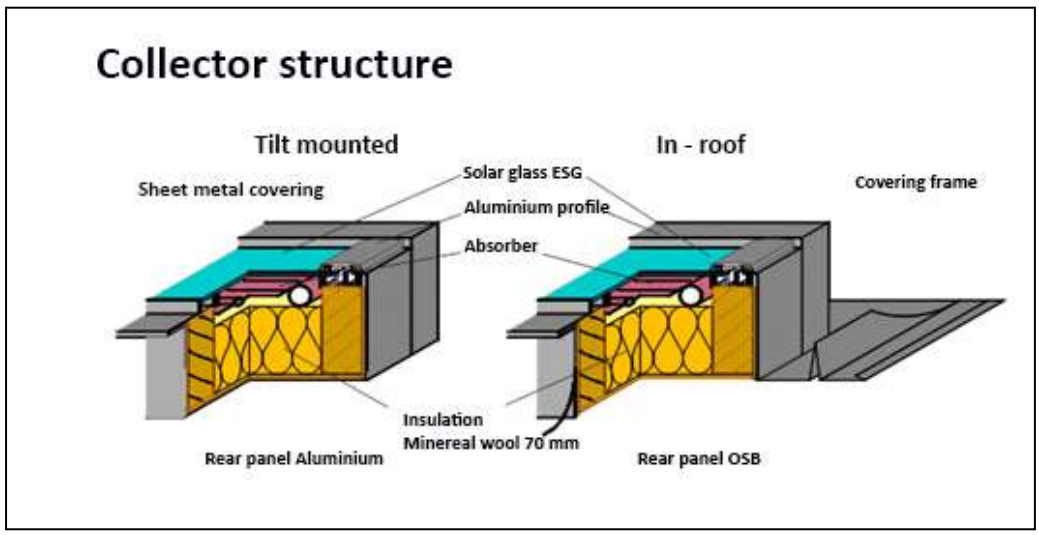
REQUIRED MATERIALS

In general, we recommend the use of a kit, which has proved to be very successful with the systems realised so far. These construction kits can be assembled easier and faster. Most of the materials are already cut and pre-drilled. This is especially advantageous with all metal strips and rails as well as with the glass cover plates.

In Austria, for example, we use the construction kits of the large-area collectors with Sunstrip – strip absorber from the company ÖkoTech, based in Graz (Austria). Depending on whether the collector is installed in-roof or tilt mounted on the roof, the rear wall and the roofing frame of the collector are different.



Components:

Aluminium cover profiles: depending on the collector design (in-roof or tilt-mounted), an additional aluminium cladding is used as weather protection

Solar glass ESG 4 mm: the 4 mm thick single-pane safety glass is highly translucent (>90%) on the one hand, and on the other hand it provides reliable protection of the collector against external weather conditions

Absorber (Sunstrip - strip absorber): with its high degree of absorption (>95%), it ensures an optimal energy efficiency rate of the irradiated solar energy

Mineral wool insulation 70 mm: reduces heat losses from the collector

Collector rear wall: OSB boards (coarse chipboard) or aluminium

Wooden frame construction (square timber mainly spruce/fir): is breathable and provides an optimal microclimate in the collector

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Of course, you can also put together the material yourself. For the construction of your solar collector you need:

Material	**Number per collector**
Squared timber for the frame	7 (2 x length, 5 x width)
Wooden plate for the back (if the collector is integrated into the roof)	preferably 4 separate wooden boards
Sheet metal for the back (if the collector is placed on a stand)	preferably 4 separate sheet metal components
Black varnish	approx. 1 l
Insulation material	4 plates
Absorber strips	Depending on the size of the collector (14 are in the kit)
Copper manifolds	2
Glass plate	preferably 4 separate glass plates
Rubber seal	2 x length, 5 x width plus safeguard
Bars for external frames	2 x length, 2 x width
Bars for glass fixation in the centre	3 x width
Nails, screws, solder, rivets	various
Trestles	6
Window cleaner	1
Cleaning paper	1 role
Cleaning cloth	

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REQUIRED TOOLS

The information about the number of tools in the table is for 10 participating students. For a larger group, the number is correspondingly larger. In general, it is better to provide a few more tools and to have it in reserve.

Tools	**Number for a group of 10 students**
Brushes	5
Handsaw	2
Jigsaw	1
Drilling machine	1
Folding ruler	3
Cordless screwdriver	1
Steel wool, attachments for cordless screwdrivers	1-3
Hammer	5
Pliers	1
Screwdrivers, various sizes	1 each
Riveting pliers	1
Soldering iron	1
Blowtorch	1
Soldering paste with brush	1
Rubber hammer	1
Stanley knife	1
(Hand) vacuum cleaner	1
Pencils	3
Glass lifter	2

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Do not let the students handle the tools without proper supervision. In general, we recommend that you have a technician to assist them in their work.

SOURCES:

- http://www.oekotech.biz/kontakt.asp

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Learning Unit 5.1 – Teaching Plan

Construction of the plant (solar collectors)

The construction of the plant must be well planned and prepared. The pupils can handle a considerable amount themselves, but need guidance and support from a technician and/or the teacher.

TIME: approx. 6-8 hours/collector

CLASS ORGANISATION: Team work (working groups of 10 - 15 students), each group builds a collector **optionally one group works on the collector and the second group deals with theory (Learning units 1, 2 and 3 of "Our Solartown") or public relations (learning unit 4)*

METHODOLOGY: Practical work

LESSON GOALS:
Subject of the project: Solar thermal plants

Students:
- learn how a solar thermal plant works by building it
- learn about different tools and how to use them
- learn to work in a team

MATERIALS: See above

INTRODUCTION/ MOTIVATION (20 minutes):

The students learn about the construction process and the groups are divided into groups.
Each group starts to prepare the workstation with the supervising technician and the teacher, prepare the tools and set up four trestles.
The steps for building a collector are briefly discussed:

1. Construction of the wooden frame
2. Installing the rear panel
3. Insulating the collector
4. Painting the frame
5. Placing the absorber strips
6. Cleaning the copper manifolds and
7. Attaching and soldering the copper manifolds to the absorber strips
8. Fixing of the absorber strips with rivets
9. Absorbers are placed in the wooden frame
10. Metal frame for attaching the safety glass
11. Cleaning and placing the glass on top
12. Mounting of the glass
13. Stress test
14. Transport of the finished collector

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CONSTRUCTION OF THE PLANT (6 to 8 hours):

If possible, all pupils in a working group should be involved in each step of the work. The teacher supervises that the pupils are all cooperating. The technician explains and supervises that the work is done properly.

1. CONSTRUCTION OF THE WOODEN FRAME

The basic structure of the collector consists of a wooden construction made of breathable wood, which ensures an optimal microclimate in the collector. For the frame construction, the squared timbers must be cut to the appropriate length.
The size of the collector is discussed in detail with the students and ideally sketched (during the preparatory work, a scale plan of the collector can be made).

Then the individual tasks are assigned:

Task	Description
Outline a scheme	If there is no construction plan, make a sketch and have dimensions drawn in
Cut square timber to size	The pupils draw the required lengths with a measuring tape and an angle iron, before cutting with the saw, it should be checked once more to be sure that there is no mistake in reasoning.
Screw squared timbers	Then screw squared timbers to an outer frame. The frame is then divided into 4 sections using 3 squared timbers.
Cut a hole for the connection pipe	A hole for the connection pipe to the collector pipe must be cut or milled into the frame.

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2. MOUNTING THE REAR PLATE

Depending on whether the collector is positioned on a stand or integrated into the roof, an aluminum plate or a coarse chipboard (OBS plate) is used as the rear plate. In the kit, the panels are already supplied in the correct size. Otherwise they have to be adapted to the size of the collector. This is the loudest step of the whole collector construction.

Task	Description
Place rear panel on frame	The pupils apply the 4 individual parts of the back wall.
Nail down the rear panel	The pupils now nail the parts of the back wall at approx. 15 to 20 cm intervals with ordinary hammers. It is recommended to mark the distances with a pencil. Different nails are used for coarse chipboards and sheet aluminum parts. ATTENTION, very loud!

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3. INSULATING THE COLLECTOR

To prevent the heat that is transferred to the copper pipes from being wasted through the back wall of the collector, it is insulated by an insulating layer.
In our kit, 7 cm thick mineral wool insulation panels are used, which are also already cut to size.

Task	Description
Inserting the insulation panels	2 pupils each insert the mineral wool plates into the collector. Press gently!
ATTENTION!	Mineral wool has very small fibres which can cause itching! Gloves are recommended!

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4. PAINTING OF THE FRAME AND THE BARS

Since black surfaces have a particularly high degree of absorption (i.e. the incident sun rays are optimally absorbed and not reflected), all surfaces that are not covered are painted with black varnish.
Here it must be noted that in-roof collectors and tilt-mounted collectors must be treated differently.
Several students can carry out this step at the same time.

Task	Description
Painting the frame	Use a brush to paint the remaining areas of the wooden frame.
Painting the bars	Wooden bars are required for an in-roof collector!
ATTENTION!	It is recommended to put on gloves and work clothes during this step!

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5. PLACING THE ABSORBER STRIPS

Since the absorber strips consist of individual parts, they must first be placed and arranged on trestles. First they are held in place by attaching the collector pipes, then by soldering them to the pipes and finally by riveting.

Task	Description
Placing the absorber strips	The absorber strips are placed on at least 6 trestles. To avoid any sagging, wooden battens should additionally be placed underneath.
ATTENTION!	Keep an eye on the final size so that the collector pipes can be attached properly. The width of the wooden frame is a good reference value for this! If necessary, use a prefabricated measuring stick to measure it!

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6. CLEANING THE COPPER MANIFOLDS AND THE ABSORBER TUBE CONNECTIONS

Since the copper manifolds must be soldered to the absorber, it is particularly important that they are cleaned beforehand. The areas to be soldered must be clean and must not have an oxide layer. Steel wool is used for cleaning (manually or with a wire brush attachment for the cordless screwdriver). This work can be carried out in parallel to the frame construction.

Task	Description
Cleaning the copper manifolds	The copper manifolds are cleaned at the soldering point on the outside with steel wool by hand or with an attachment for the cordless screwdriver.
Cleaning the absorber tubes	The tubes of the absorber stripes must be cleaned inside. For this purpose, a correspondingly smaller attachment for the cordless screwdriver must be used.
Applying the soldering paste to the absorber tube	The soldering paste is then carefully and evenly applied with a brush to the outer opening of the absorber tube.

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7. ATTACHING AND SOLDERING THE COPPER MANIFOLDS TO THE ABSORBER STRIPS

After all parts to be connected have been cleaned and the soldering paste has been applied, the collector pipes can be placed on the absorber strips. A rubber hammer helps.
Now the soldering of the two components has to be done. Under expert guidance the students can do this quite well by themselves.

As a pressure and leak test is reed for the installation and connection of the solar system to the existing building technology, this should be carried out by qualified person after soldering or at the latest before the glass is attached. The pipes must be tight and should withstand a pressure of at least 8 bar.

Task	Description
Attaching the manifolds to the absorber strips	The manifolds are now carefully inserted into the openings of the absorber tubes. The rubber hammer can be used to give a gentle tweak.
Soldering of the two components	Here it is absolutely necessary to work in pairs. One person holds the blowtorch and the second person holds the solder. The soldering area is heated first. The soldering tin, which is bent over at the front (approx. diameter of the pipe), is also held over the soldering area and heated. When the soldering paste begins to melt in the correct temperature range, it takes on a silvery colour. Now pull the flame back from the soldering point and pull the solder melting at the same time along the joint. Due to the capillary effect it pulls the solder into the seam all around and fills it.
Wiping the pipes	After soldering, any excess flux should be wiped off with a damp cloth.
Pressure and leak test	A qualified person, ideally an installer, should carry this out. (see the picture below)
ATTENTION!	The soldering should always be carried out under the supervision of qualified technicians. The pressure and leak test should also be carried out by this person!

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8. FIXING OF THE ABSORBER STRIPS BY RIVETING

After the manifolds have been soldered to the pipes of the absorber, the individual strips of the absorber can now be finally fixed by riveting.
For this purpose, it is helpful to have a batten with markings so that you can pre-drill the spots, because riveting itself is quite exhausting.

Task	Description
Mark where to pre-drill	Use a batten with markings to mark the points where pre-drilling is required.
Pre-drilling	The pupils now use a cordless screwdriver to drill the corresponding holes at the marked points. When pre-drilling, it is helpful to press against it from below (not exactly at the point to be drilled, of course).
Riveting	Now the two absorber strips are riveted together at the pre-drilled point. Here too, it is helpful if you press against it from below. ATTENTION, the riveting is very forceful!

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9. ABSORBERS ARE PLACED IN THE WOOD FRAME AND REST OF THE PAINT WORK

After the wooden frame and the absorber have been prepared, the absorber with the collecting pipes can now be inserted into the wooden frame. Afterwards the manifolds are also painted with black varnish.
Several pupils are necessary for this.

Task	Description
Inserting the absorber into the wooden frame	Several pupils take the absorber at the ends close to the manifolds and put it into the wooden frame.
ATTENTION!	Make sure that the absorber is placed in the frame with the correct outlet pipe of the manifold - namely where the corresponding area has been drilled out for this purpose.
Painting the manifolds	Finally, the manifolds and transitions to the absorber are painted.

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10. ATTACHING THE METAL FRAMES FOR FIXING THE GLASS AND INSERTING THE SEALING MATERIAL

After the absorbers have been inserted and the manifolds have been painted, the metal frames for fixing the glass plates can be mounted.
In the construction kit these are delivered again in the corresponding length with predrilled holes.

Task	Description
Screwing on the metal frame	The individual parts of the metal frame (strips) are now screwed to the wooden frame by the pupils with the help of an experienced person. First the outer ones, then the inner ones.
Inserting the sealing rubber	Now the sealing rubber can be pressed into the slot provided. Do not cut off too tightly at the ends (rather add 5 to 10 cm)
Vacuuming the absorber	Now everything is prepared for the insertion of the glass panels. Before the panes are put in place, it is essential that the absorber is vacuum cleaned so that there is no dirt (rubber residues etc.) left in the collector.


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11. CLEANING AND APPLICATION OF THE GLASS

Before inserting the glass panes, any dirt in the collector should be vacuum cleaned. The glass must be cleaned before insertion, too. Observe the safety rules when carrying the glass!

Task	Description
Cleaning of the glass panes	Now the glass panes are cleaned with a conventional glass cleaner. For the time being, only the inside of the collector glass needs to be cleaned. The glass is then turned over with gloves. To ensure that the glass lifters adhere well, it does not hurt to clean the outside.
Inserting the glass panes	With 2 glass lifters each, the individual glass panes are lifted and carefully inserted into the collector.
ATTEMTION!	The glass should always be lifted with a glass lifter! Otherwise, always wear gloves when carrying glass! Due to the sharp edges of glass there is a danger of cuts!

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12. FIXING THE GLASS

Now the collector is almost finished. You only have to fix the panes with fixation strips. These are also included in the kit in the correct length and pre-drilled.

Task	Description
Fixing the glass with strips	The panes are now fixed with a strip. A rubber hammer is used for this .
Cutting the rubber seal	Protruding sealing rubber can now carefully be cut off with a Stanley knife.
Tightening the fixation strips	Finally, the fixation strips must be screwed tight with a cordless screwdriver.

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13. STRESS TEST

We did it! The collector is ready!!!
Now it just has to pass the stress test!
Glass is very resistant. However, production-related internal tensions and small glass defects such as cracks and inclusions reduce the breaking strength. Glass is very resistant to compressive stress, but not to tensile stress. Every deflection of a pane of glass always produces a combination of tensile and compressive stress. Glass always breaks when its tensile strength is exceeded due to strain.

Task	**Description**
Stress test	A pupil climbs onto the collector and checks whether the glass panes are fixed correctly and can withstand the load pressure from her/his weight.
	TEST COMPLETED !!!

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14. TRANSPORT OF THE FINISHED COLLECTOR

The collector is now ready for transport. Either it is brought directly to its destination by a crane truck or it must be stored temporarily. In general, it can be carried and set up by many "strong hands".
Until the collector can be used for its intended purpose, it should be stored properly in any case. If the collector is set up in an upright position, it is advisable to place pieces of wood underneath it or respectively to fix it to the wall and secure it.

Task	**Description**
Carrying the collector	The students gather around the collector and on command it is lifted and carried to the designated place.
ATTENETION!	Lifting, carrying and setting up the collector should always be delegated by a teacher. The collector must be stored properly and safely until it is installed.

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ASSESMENT (5 Minuten):
At the end the pupils should discuss which building steps they found difficult, which problems they encountered and what they enjoyed most.

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Contacts:

CONTACTS: SOLARTOWN.EU

WEBSITE: https://solartown.eu/

NATIONAL CONTACTS:

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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

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