WORKBOOK
FOR SOLAR ENERGY
ACTIVITIES

SOLAFRICA.CH

YUNGA :: WOSM

CONTENTS

INTRODUCTION

Introduction

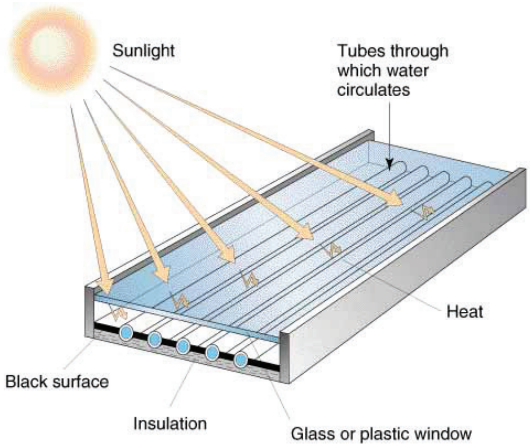
This Workbook is a practical help for Group Leaders.
It is part of the Solar Energy Handbook for Leaders available for download on solafrica.ch/scout-badge
Detailed descriptions for the Activities might be necessary and can be found in the handbook.
If you have developed material which can be useful for other Leaders that you'd like to share, please send it to scoutsgosolar@solafrica.ch

Instruction Sheets for Solar Introduction Workshop

These Instruction sheets help you or the participants to understand the stations of the Introduction Workshop.
You can copy them, so every Station has it's instruction sheet and doesn't need your explanations.
It might be necessary to translate them to your language.

STATION 1 a)

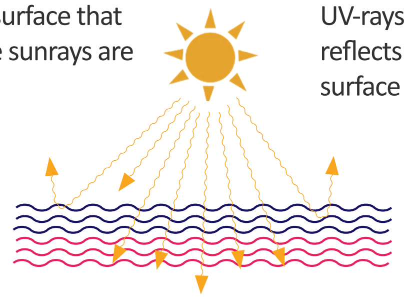
COLOR OF HEAT



Solar collectors absorb solar energy. We can also say they take in or collect energy. Depending on its physical properties, a surface may absorb much or little energy. One important factor in determining this amount is the surface color.

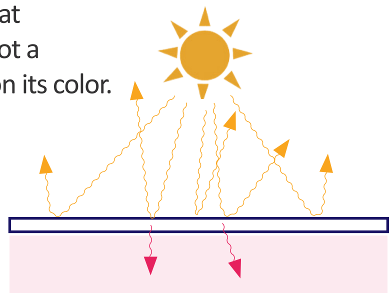
Color

UV-rays from the sun strike a surface that absorbs much of the light. The sunrays are transformed into heat.



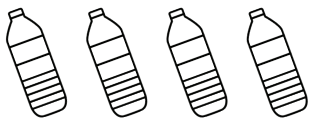
Reflection

UV-rays from the sun strike a surface that reflects most of the light. Whether or not a surface absorbs UV-rays also depends on its color.



STATION 1 a)

ASSIGNMENT



1. Fill four PET bottles of different colour with equal amounts of water until they are almost full. Get water from the bathroom sink.
2. Measure the temperature in each bottle and note under „initial temperature“.
3. Lay the bottles, next to each other in the sun and guess which bottle will heat up the most. Discuss until you agree, then write down your estimate.
4. Wait 30 minutes and repeat the procedure. (You may want to start your next assignment in the meantime)
5. Which bottle contains the warmest water? What do you think is the reason?
6. Empty the bottles at the end of the experiment and put them back.

STATION 1 a)

COLOR OF HEAT

Color				Black
Initial temperature				
Our estimate				
After 30 minutes				
Temperature difference				

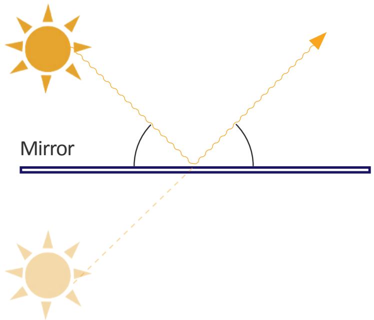
STATION 1 a)

COLOR OF HEAT

Color				Black
Initial temperature				
Our estimate				
After 30 minutes				
Temperature difference				

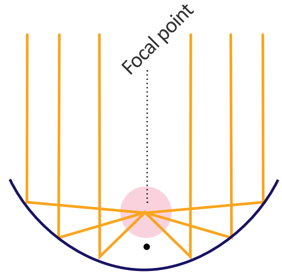
STATION 1 b)

FOCUSING OF SUNLIGHT

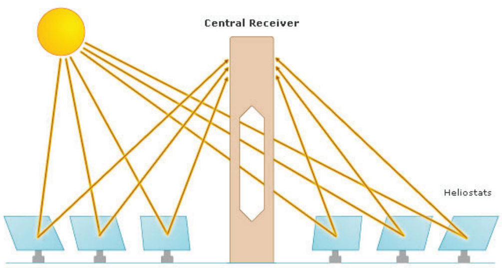


In the diagram on the left a ray of light strikes a reflective surface at an oblique angle. The reflective surface may be a glass mirror or a metal plate or a pane of glass. The ray of light is reflected by the reflective surface.

Parabolic mirrors are curved mirrors that collect rays of light and focus them on a single point. The temperature in this focal point can get very hot; in this way it is even possible to cook with solar energy.



According to legend, Archimedes set Roman ships on fire at a considerable distance by means of an array of mirrors placed along the shore. Even today, the principle of the parabolic reflector continues to be used in a number of technologies: there are solar installations that heat water by means of parabolic reflectors; one can also use a parabolic reflector to cook food; and the so-called power tower uses mirrors to focus sunlight on the tip of a tower to turn water into steam. The steam powers a turbine that generates electricity. In Spain, a power station of this type (the PS10 in Andalusia) generates electricity for 60‘000 households.



STATION 1 b)

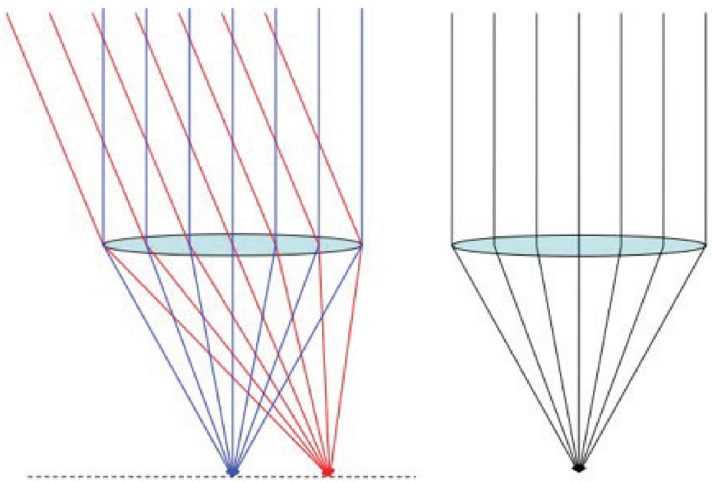
ASSIGNMENT

1. Take a mirror into each hand.
2. Turn the mirrors towards the sun so that the sunlight reflected by the mirrors forms spots of light on the target (thermometer’s tip).
3. Adjust the position of your mirrors so the reflected spots of light come to rest on top of each other.
4. Now position yourselves so that all your light points converge on the tip of the thermometer.

SOLAR ART

Trough a lens, sunlight can be focused to one point, without being reflected (compare the mirror method for focusing sunlight). In the focus point, the power of sunlight can be seen. On a sunny day, you can even light your fire with a lens. In concentrated photovoltaic technique, lenses (or parabolic mirrors) are used to focus sunlight onto small but highly efficient solar cells. According to the technology used, additional solar tracking and cooling might be necessary.

Solar Tracking: Orienting the device in an ideal angle towards the sun to reach maximum efficiency. Usually, electronical devices can do this job. See if you can "solar track" your lens.



STATION 1 c)

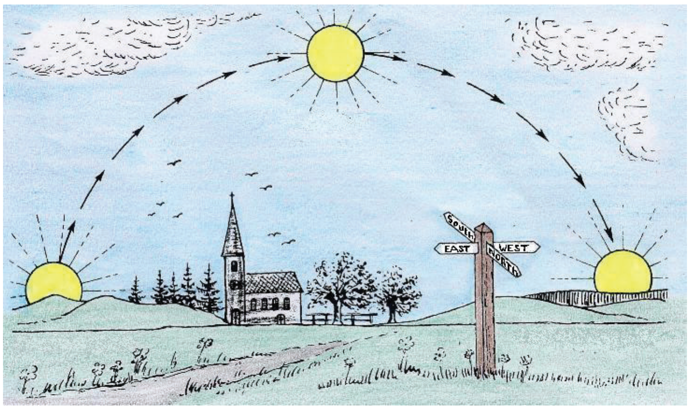
ASSIGNMENT

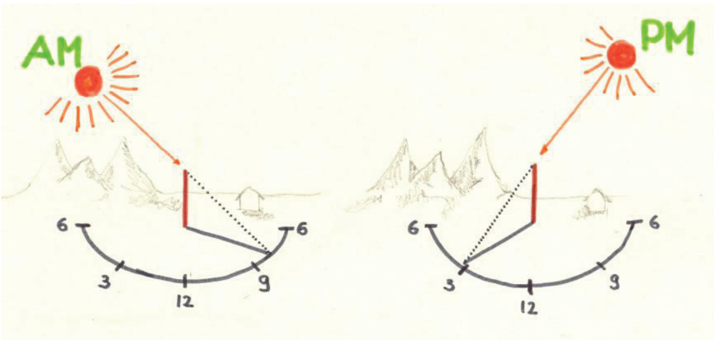
1. Take a small wooden board and draw or write with a pencil your theme.
2. Put on dark sunglasses with UV-protection.
3. Take a big lens and find the point where the sunrays focus.
4. "Draw" along the lines of your sketch on the wooden board by burning a line.
5. When you've done, put the lens in a container where it can not catch sunlight.

   Put back the sunglasses if they are not yours.

STATION 2)
SUNDIAL

The earth rotates once about its own axis within 24 hours. As a result we experience ‚day' when our side of the earth faces the sun and ‚night' when it faces away from it. The day begins with the first rays of sun that appear on the horizon. The sun then seems to traverse the sky on a big arc, reaching the highest point at noon and slowly descending until it disappears below the horizon in the evening. This is the course of the sun. When you are on the northern hemisphere, the sun rises in the east, descending in the west. On the southern hemisphere, it is the opposite.





With the help of a sundial one can use the course of the sun to measure time. Stick a pole into the ground and you can watch its shadow wander in the opposite direction of the sun throughout the day.

STATION 2)
ASSIGNMENT

- In what direction (North, South, West, East) must the arrow of the sundial point so that the sundial indicates the correct time?
- In what direction would one have to hold the sundial in South Africa (southern hemisphere) in order to indicate the correct time ?

SUNDIAL INSTRUCTIONS

For this sundial, you'll need a copy of the template and an (elastic) string.

1. Copy/Print the Sundial template on the next page
2. Glue it evenly on cardboard.
3. Cut at the outer line and the short dashed line in the middle (bottom of the two Flaps only).
4. Find out your latitude (e.g. in an Atlas) and mark a line on the left and right of the base (marked with scales 35°-55°). Draw a line from your required latitude trough the "X" Symbols at the top of the scale. Cut at these lines. You may want to note at the top of the Sundial your location/latitude.
5. Fold on dashed lines to the indicated direction. For sharper folds, score on the opposite side (fold backwards, score on front + vice versa).
6. Score on the back along the horizontal line in the middle (between "noon" and "a.m. p.m.") and fold to the front. The flaps help you bringing it into a right angle.
7. At the top and bottom, where all lines converge, make a small hole. Attach a String trough these holes. The string is the gnomon of your sundial.
8. You're done! You only need to position your sundial in the right direction.

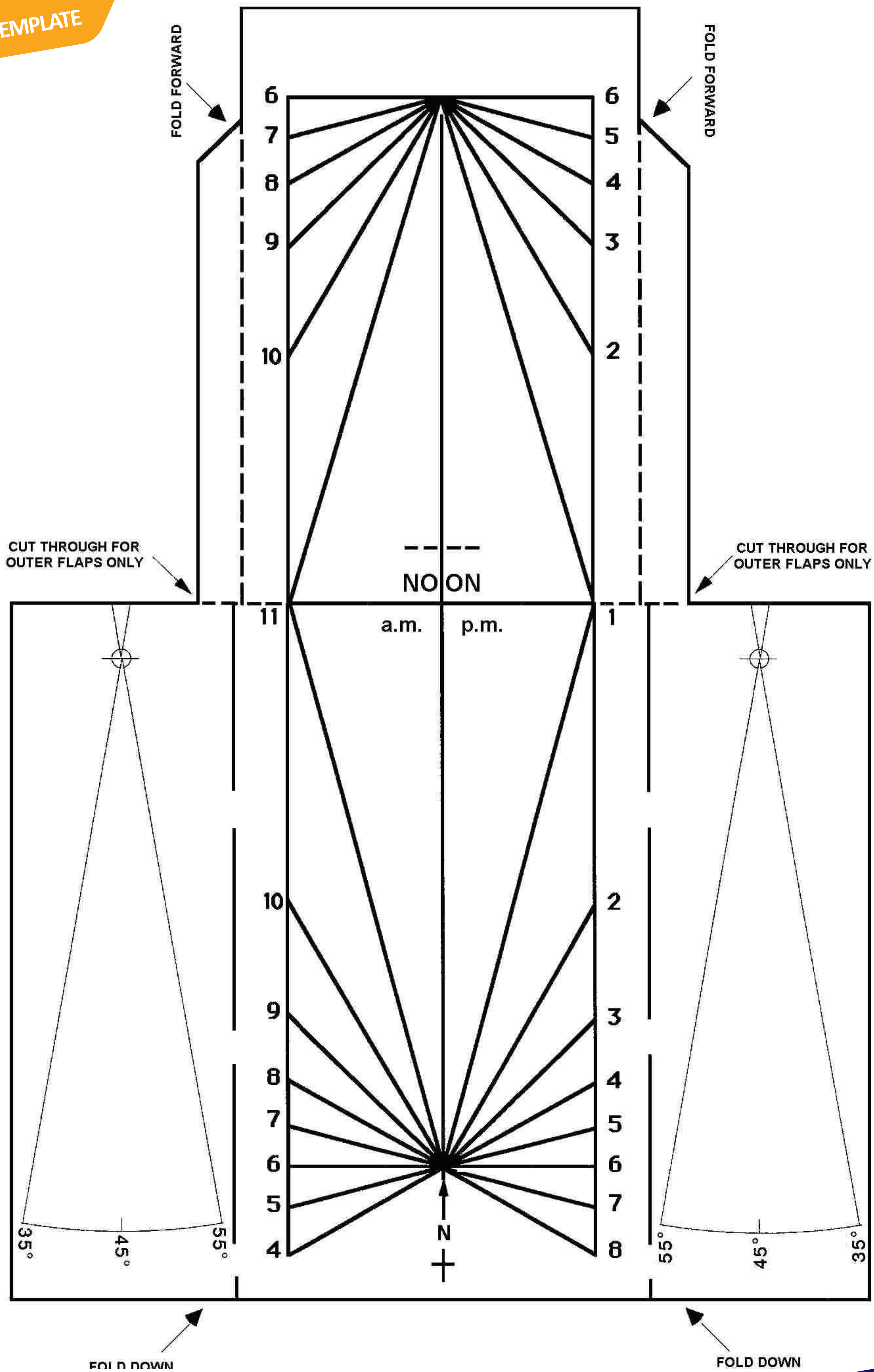
SUNDIAL POSITIONING

The sundial needs to be placed, where the gnomon can cast a shadow.
During the day, as this sundial is portable, you can change place (e.g. inside a building).
It also must be positioned with the gnomon pointing north/south.
Here are described three methods:

Purist Method: North can be found by observing Polaris, the North Star, at night. In orientating the sundial, the gnomon is actually being pointed to the North Celestial Pole which is within 1° of the North Star. Thus, if you can find Polaris at the end of the Little Dipper, line up your dial by pointing the gnomon towards Polaris. You might want to record the orientation for your dial by making light pencil marks on a window sill for future reference. Those in southern latitudes will not be able to use this method as there is no bright star near the South Celestial Pole.

Practical Method: A magnetic compass may be used to determine the north/south line, but, because of the difference between magnetic north and true north, the dial reading could be out by an hour or more depending on the local difference between magnetic and true north (or south if in southern latitudes).

Lazy Person's Method: To a first approximation, the orientation can be found by finding the orientation at any time from a clock or watch and orientating the dial so the shadow shows the correct time. However, if left in this position, there could be an error of up to 30 minutes over the year as a result of what is known as the „equation of time". Because of the Earth's orbital motion around the Sun, the solar day (apx. 24 hours) is not exactly the same length from day to day varying by up to ±16 minutes a day. However, if the orientation is carried out on April 15, June 10, Sept. 1 or Dec. 20, this error will be negligible and any orientation made between April 15 and 1 Sept. will be in error by, at most, a few minutes (but don't forget the effect of daylight savings time).


FOLD FORWARD
FOLD FORWARD
6
7
8
9
10
6
5
4
3
2
CUT THROUGH FOR OUTER FLAPS ONLY
CUT THROUGH FOR OUTER FLAPS ONLY
NOON
11
a.m.
p.m.
1
10
9
8
7
6
5
4
2
3
4
5
6
7
8
N
35°
45°
55°
55°
45°
35°
FOLD DOWN
FOLD DOWN

Eectricity can be generated in different ways. Here are a few examples:

HYDRO POWER
Water flows through a turbine which is attached to a generator. Pulled by gravity of a natural or artificial altitude difference the water powers the turbine and the generator which, not unlike a water wheel or a bicycle dynamo, transforms kinetic energy to electricity.

WIND POWER
The wind drives a turbine much like a windmill, except here, as in the generation of hydro-power, the kinetic energy is converted to electricity.

NUCLEAR POWER
Nuclear fission releases energy that is used to turn water to steam. The rising steam drives a turbine that generates electricity.

SOLAR POWER
Photovoltaics: The rays of the sun are transformed into electricity by means of photovoltaic (solar) cells.
Solar collector: The rays of the sun heat water or an other fluid which can be used for heating or washing.

FOSSIL FUELS
Dead sea organisms, both plants and animals, collect at the bottom of the sea and are covered by layers of sediment over time. Under great pressure and heat, over thousands of years, these layers of organic matter are slowly transformed to petroleum which can be refined into fuels such as gasoline. Vast amounts of CO2 contained in plants and animals is eventually stored in petroleum and released upon combustion.

STATION 3)
ASSIGNMENT

1. Match the different energy sources (cards) with the corresponding energy cubes.

   The size of the cubes reflects the number of GWh (Gigawatt hours)
2. Discuss the following questions:
   - How much energy do the rays of the sun release in a year onto a surface the size of your country?
   - How much electricity from various sources is generated annually in your country?
   - Do you know other electricity sources?

IMPORTANT: Please put the cards back when you're done

STATION 4)

ENERGY USE IN HOUSEHOLDS

Every household around the world consumes energy in different amounts. The differences are due to the climate, availability of electricity and electrical devices, energy efficiency, and the sources of energy.

Assemble the four houses representing four different countries:

USA, Singapore, Switzerland, India.

TIPS:
a) the size of a house is represented by the size of the roof (red)
b) there can not be two pieces of the same colour in one house
c) every colour represents a category of energy use

1. heating – orange
2. lightning – yellow
3. appliances – purple
4. cooling – white
5. water heating – blue
6. cooking – green
7. other – black

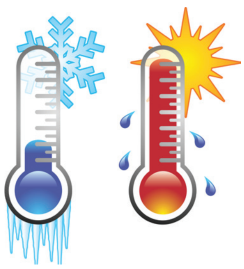
Try to figure out which puzzle belongs to which country and answer the questions on the back side.
Do you know other electricity sources?

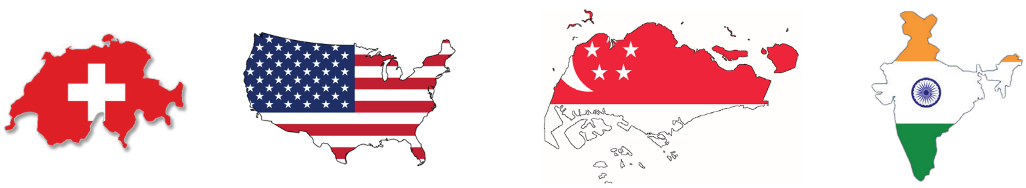
STATION 4)

ASSIGNMENT

Discuss the following questions:

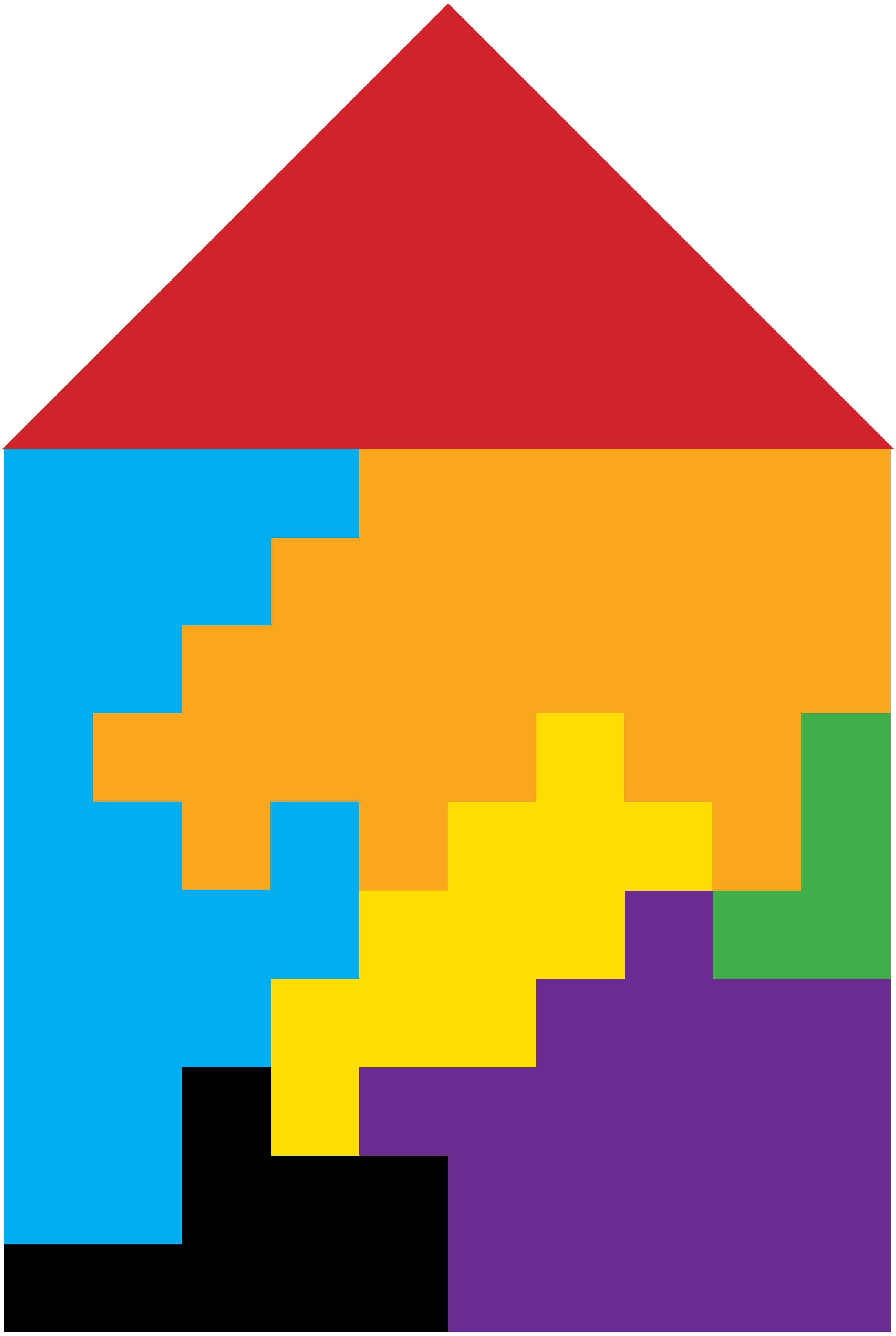
1. Why is the heating percentage different for different countries?
2. Which country uses more energy for heating and why?





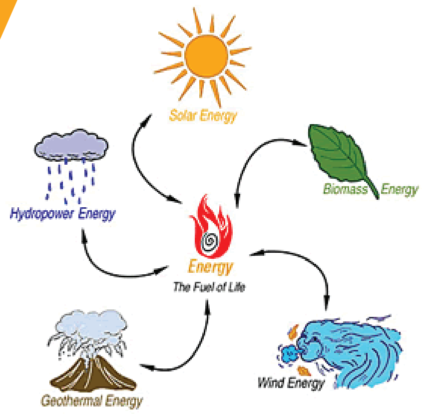
3. Which of these countries is currently considered more energy efficient? (General Knowledge)
4. Why does the USA household use more energy for heating than the Swiss household?

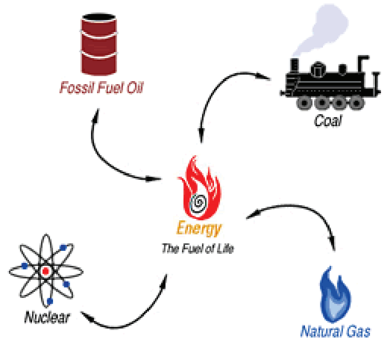
IMPORTANT: Separate the puzzle pieces after you finished this exercise.



STATION 5)

RENEWABLE/ NON-RENEWABLE RESOURCES





Renewable energy is energy generated from natural resources that are naturally replenished within a human lifetime (wood, biomass) or energy that does not deplete the source (solar, wind energy, hydro power) that generates it. Besides hydro power this group includes solar energy, the warmth from the earth's interior (geothermal energy), as well as the tides generated by the gravitational pull of moon and sun (high and low tide).

The supply of fossil fuels such as petroleum, coal, or natural gas is limited and will eventually run out; once the reserves of crude oil are depleted it will take millennia for new supplies to grow. Fossil fuels also increase global warming and pollute the air. However, the overwhelming majority of the world's population today depend on just such fossil fuels for electricity, heat, and transport.Nuclear energy (nuclear fission and nuclear fusion, respectively; the latter is still in development) does not usually count as renewable. The production of electricity in a nuclear power plant requires uranium, a raw material that is not renewable and generates extremely dangerous radioactive waste.

Benefits people obtain from ecosystems are called "ecosystem services". They can be distinguished in four categories: Supporting services, provisioning services, regulating services and cultural services. Ecosystem services is sometimes used synonymous with "ecosystem functions".

STATION 5)

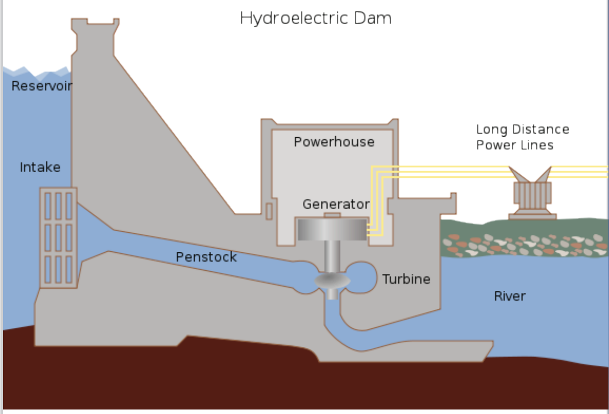
ASSIGNMENT

1. Classify the cards in the three categories
   - "Renewable Resources"
   - "Renewable Ecosystem Services"
   - "Non-renewable resources".
2. Answer the following questions:
   - Which energies are dependent on the sun?
   - Which energies derive from earthly sources – from an element that exists on earth or from a resource can be „planted"?

IMPORTANT: Please put the cards back when you're done

RENEWABLE RESOURCE	**NON-RENEWABLE RESOURCE**
RENEWABLE ECOSYSTEM SERVICE	*A crop of vegetables*
The replenishment of rivers trough the water cycle	*Solar Energy*

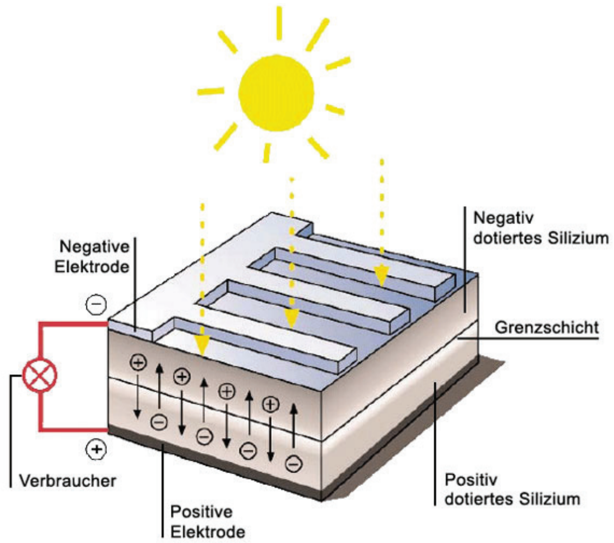
Pollution absorbing ability of a wetland	*Iron Ore*
A herd of cattle	*Crude Oil*
A hardwood forest	*Beauty provided by a mountain*

A school of tropical fish	*Ability of the ocean to trap CO2*
Coal	*Metals*
	

STATION 6)

PHOTOVOLTAICS: SOLAR CELLS

Photovoltaics is the direct transformation of solar energy into electrical energy by means of solar cells. Solar cells have been used on satellites and space craft since 1958. In the meantime arrays of solar cells have become fairly common as electricity generators on earth, e.g. on roofs, on parkingmeters, in calculators, on noise barriers and in large open spaces. The amount of solar energy that radiates to earth in the form of light and heat is roughly 15‘000 thousand times larger than the total energy used by humans. This radiation energy can be captured and partly transformed into electricity without undesirable side effects such as emissions (e.g. carbon dioxide).



The rays of the sun (light) are turned into electricity by means of solar cells. The electricity generated in this way can be used on site, stored in batteries, or fed into the electrical grid.

Individual solar cells are usually deployed in larger units called solar modules/panels. As rays of sunlight hit the solar cell they generate positive and negative charges that migrate to the respective poles. Now you can attach your electronical device, and it begins to turn.

STATION 6)

ASSIGNMENT

1. Have fun with playing with all kind of Gadgets run by Solar Electricity.
2. Which of the items are run directly or indirectly (battery) on solar energy?

STATION 7)

STORING ELECTRICITY

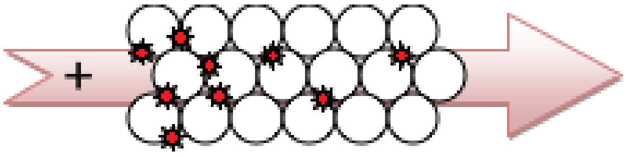
Why does a solar powered flashlight work at night when no rays of sunlight power the solar cells?

Electric current can be stored, in a battery for instance, and released again when needed. We use batteries to operate electronic devices that do not plug into a power outlet. When the battery's current is depleted we discard the battery unless it is rechargeable.

A small container that stores electricity is called a battery. The electric current is stored as chemical energy. Batteries consist of two different metals with opposing charges: one has a positive charge, the other a negative one. In other words, the battery has a positive pole and a negative pole. If the battery is attached to a an electric circuit a current runs through the circuit and lights up a small light, for instance. There are many devices today that run on battery power: flashlights, radios, alarms, telephones, etc.

Electrical current: why does an electrical current flow?

Metals consist of an atomic lattice. Atoms are made up of a nucleus and electrons. Within the atomic lattice the electrons move around freely. At the negative pole of the battery there is a surfeit of electrons and at the positive pole a lack of electrons. The difference between the two charges is called "tension" (and is measured in volts). Tending towards equilibrium the electrons flow from the negative pole to the positive pole until the tension on both sides is the same and the current stops flowing. At that point we say: „the battery is empty".

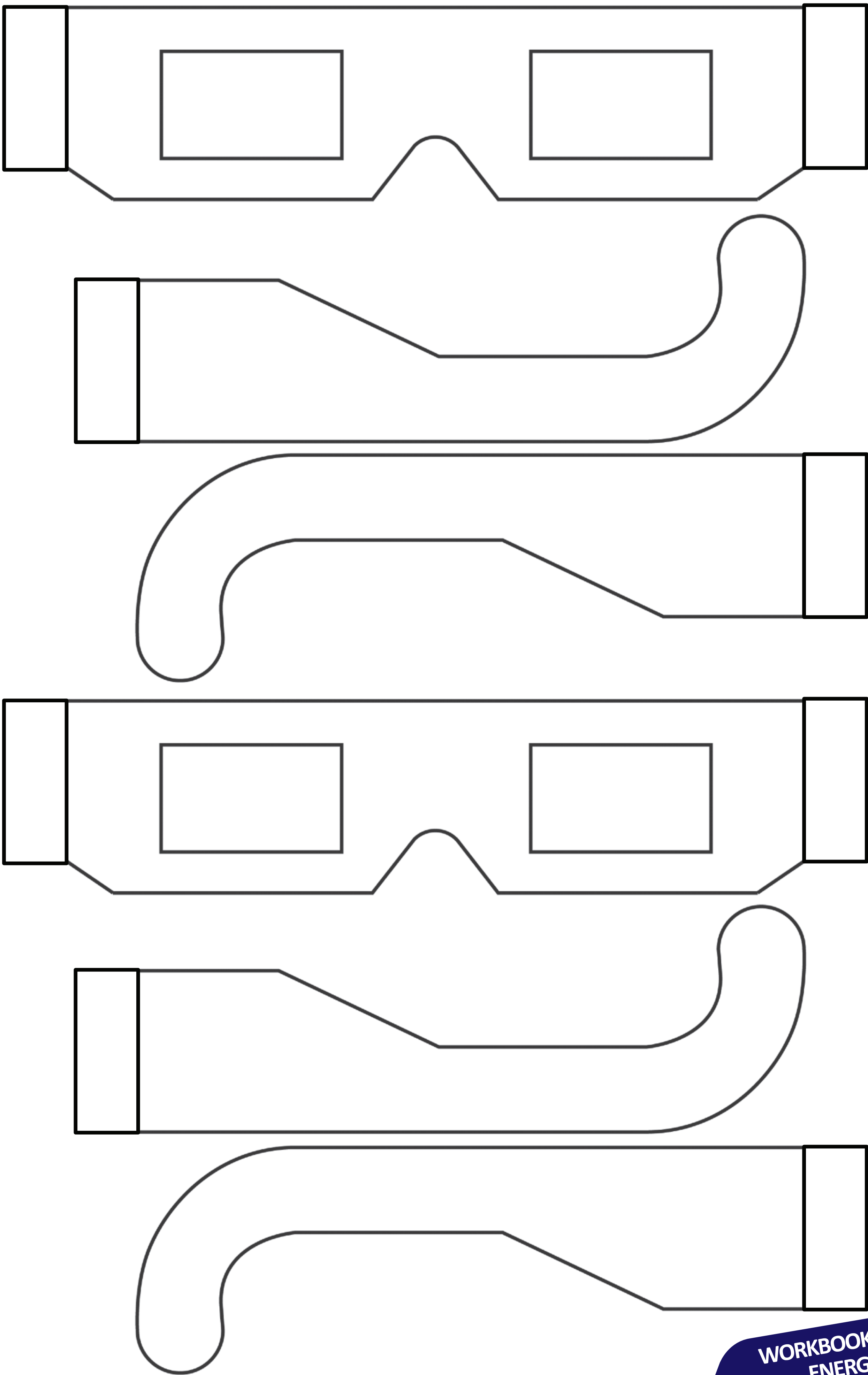


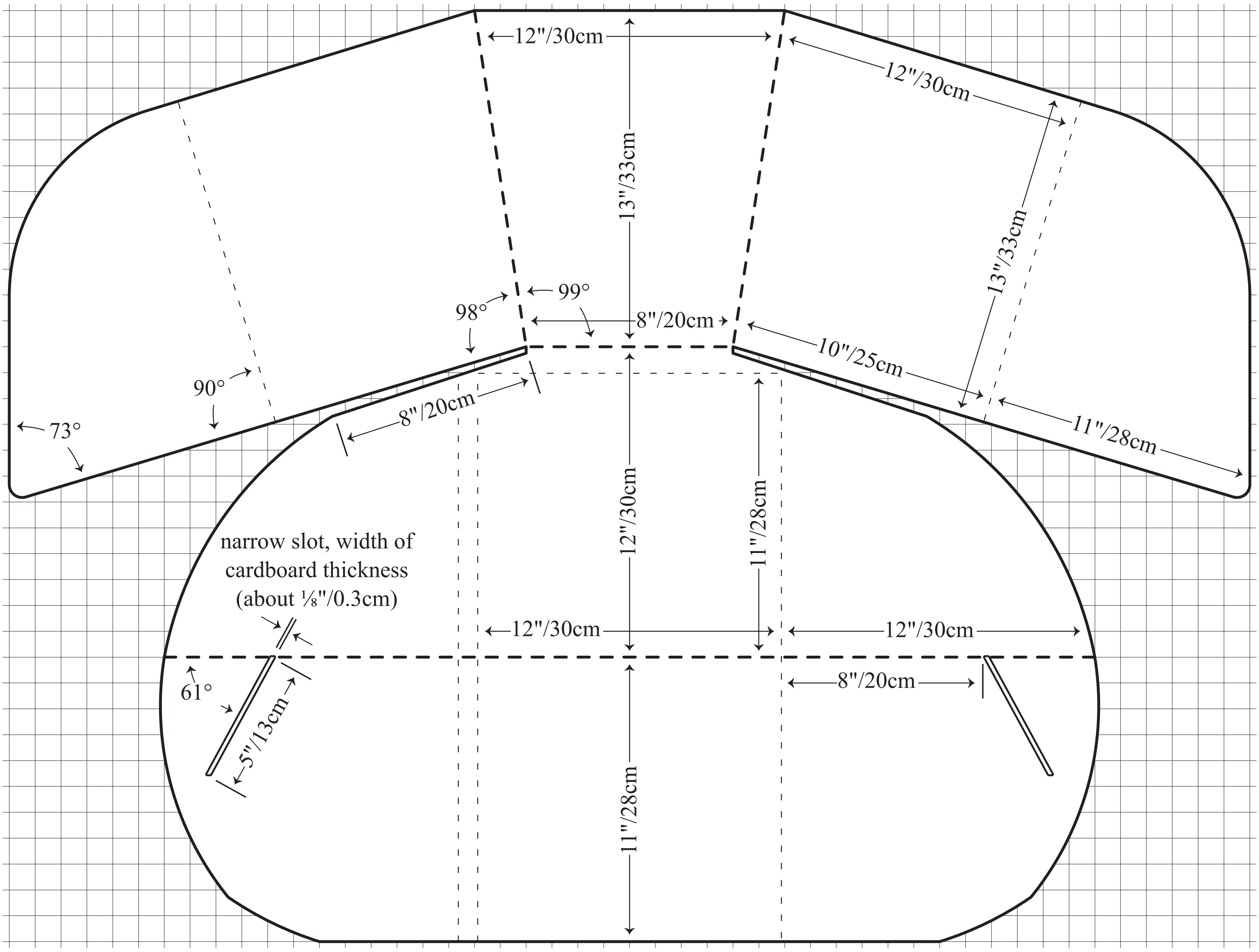
STATION 7)

ASSIGNMENT

1. Connect pieces of zinc, copper and fruit with the plus and minus pole of a beeper.

   This is a simple electrical circuit model. What is the right order of the pieces to make it work?
2. If the beeper does not make a sound, add more pieces.
3. Dismantle the potato battery when you are done and put the different pieces back




12"/30cm
12"/30cm
13"/33cm
13"/33cm
98°
99°
8"/20cm
10"/25cm
90°
73°
8"/20cm
11"/28cm
12"/30cm
11"/28cm
narrow slot, width of
cardboard thickness
(about ⅛"/0.3cm)
12"/30cm
12"/30cm
61°
8"/20cm
5"/13cm
11"/28cm

	Renewable	Non-renewable
Power Density*	Low	High
Power Supply	Less mobile (but can be improved through technological development)	Highly mobile
Dependency	Dependent on weather (sun/wind), natural resources and technology	Independent from weather Dependent on natural resources and technology
Cost	Cheaper in the long term Cheaper regarding all related costs (e.g. impact on environment, health, etc.)	Cheaper in the short term Expensive regarding all related costs
Availability	Infinite No depletion	Finite Depleting
Environment	Little or no pollution Large-dimensioned projects may trigger environmental concerns	High level of pollution

*** Power density:** The amount of power per unit volume (renewable energies use more “space”).

MATERIAL LISTS

These lists can help you to assemble your own "Solar Kit" or a useful Product like the Solar Suitcase or LED Lamp.
These are examples and kept as simple as possible. If you buy and assemble your own material, be sure that safety, especially regarding electricity, is always given. If you are not sure about your material, refer to a professional electrician or order the kit from solafrica.ch/scout-badge

A complete kit to assemble your own solar lamp can be bought from Solafrica: www.solafrica.ch/scout-badge

Material List

1. Solar Panel
2. LED
3. PCB Board with a chip*
4. Switch
5. Diode
6. 100mH induction
7. Battery holer
8. NiM:H rechargeable battery 1,2V
9. Cable

* This piece is specially produced for this self assembling kit.
It can not be bought in ordinary electronic shops.

Tool List

1. wire cutter
2. wire stripper if available
3. knife or cutter
4. pliers
5. soldering iron and tin/lead

Tools are not part of the self-assembling kit.

Find detailed instructions in the construction manual.
www.solafrica.ch/scout-badge

The Solar Starter Kit is composed to help Leaders run activities from the Solar Handbook

Material List

1. Solar water pump/fountain
2. Solar Radio*
3. Solar Torch*
4. Solar grasshopper*
5. Big lens
6. Digital Thermometer
7. Smart lamp self-assembling kit
8. Box

* Combined and other similar gadgets can be found on the market.

The chart below shows you all the different components, which are included in the Solar Center Box.

Material List

1. Solar cooker „Light Oven III“
2. Solar Cooking pan black for Light Oven III
3. Solar water pump/fountain „Palermo“
4. Gadgets with Solar energy
   - Solarradio
   - Solar Torch
   - Solar Grasshopper
   - Solar Car/Helicopter
   - CD-Spinner
5. Mega Power Station
6. Big Lens
7. Digital Thermometer
8. Smart lamp self-assembling kit (10 kits)
9. Energy Saving Card Set
10. Solar Energy Presentation
11. Box/Suitcase

Additionally you'll need more items which can be found in any place:
Cooking accessories, oven glove, cooking ingredients, small mirrors, ...

Here are listed all the different components which are needed for a Solar Suitcase

Material List

1. Suitcase: hard shell with wheels, not too small
2. Solar Panel: 12V, 20-40W
3. Battery: 12V sealed (maintenance free) lead acid, 17-22 Ah
4. Charge Controller: 12V, 6A or more
5. Inverter: 12 V > 115V or 230V (according to power grid), 100-300W
6. 3 or 4 light switches (rated at least 1A)
7. 3 or 4 LED lamps: 12V DC LED lamps and sockets 3-7W each
8. Wires:
   - 2m AWG14 or 2.5mm^2
   - 2 x 0.5m AGW12 or 4mm^2
   - 3-5m/lamp AWG12 or 0.75mm^2
9. Fuse and Fuse Holder: DC Fuse rated 10A (or5A)
10. Female car cigarette lighter (multi-socket)
11. 12V USB adapter for cigarette lighter socket
12. Attachment material: screws, cable ties, tape, etc.
13. Optional: radio, ...

Tool List

1. Different size and type of screw drivers
2. wire cutter
3. wire stripper if available
4. knife or cutter
5. pliers
6. power drill
7. saw
8. multimeter
9. soldering iron and tin/lead

See also the Construction manual for the Solar Suitcase.
www.solafrica.ch/scout-badge