Experiential Workshop

Course: *Multidisciplinary*	
Workshop: *Potential Social Impact of Solar Cooking*	
Area: *Math, Physics and Design Technology (DT)*	
Grade Level: *Secondary*	Timeframe: 2+ hours

Workshop Overview:

- A more detailed look at the concept of solar ovens and the potential impacts on the global population and energy usage. Groups will build a more advanced version of a solar oven to heat water. This is to replicate the possible way in which water sources can be made safer for consumption in areas where energy sources are scarce or how to conserve energy for warming water for hygienic purposes.

Objectives:

Upon completion of this workshop students will;

- Understand that there are nearly a billion people (13% of the global population) that do not have access to a stable source of electricity and 3 billion (40% of global population) who do not have access to clean fuels for cooking. Understand there are more than 3 million premature deaths each year due to cooking pollution
- Research the activities undertaken by people to find fuels sources and the dangers associated with this process and the use of such fuels
- Consider the impact of the human activities on the environment and society
- Build a basic solar oven using limited resources
- Attempt to use the solar oven to heat water for either safe consumption or for use for hygiene purposes
- Complete various calculations and extrapolate data values
- Apply critical thinking to solving the cooking and heating related problems in the world
- Experience team building and real-world problem solving.

Material / resources:

1. Medium sized cardboard boxes or shoe boxes
2. Rolls of aluminium foil
3. Sheets of black paper / card or black oven tray that will fit within the boxes
4. Sticky tape and / or glue
5. Scissors
6. Digital thermometers (one for measuring ambient and one for water temperatures)
7. Water source

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8. Measuring cylinders
9. Black liquid container or small cooking pan
10. Insulated gloves for handling containers carrying hot liquids
11. Graph paper, timer / stopwatch and a pencil
12. *If possible, sheets of polystyrene of the same size as the size of the sides of the box to increase insulation and help to keep more heat inside the oven**
13. **Sheets of Perspex, Plexiglas, actual glass and mirrors if working with older students or making a more advanced solar oven**
14 **If attempting to undertake this activity on a day where there is little or no sun light then you may need to use halogen lamps to recreate the light and heat necessary to warm the solar ovens**

This activity works best on a sunny or partially sunny day

Workshop Activities:

1. ***Introduction and context***

The problem (Teacher delivery):

- More than 3 billion people in the world do not have sufficient energy for cooking and heating and they often have to cut down and burn trees to cook or to pasteurize water to make it safe for drinking - https://ourworldindata.org/energy-access
- There are more than 3 million premature deaths each year due to open-fire cooking pollution - https://www.who.int/news-room/fact-sheets/detail/household-air-pollution-and-health
- Cutting down trees for cooking and heating accelerates deforestation. Burning fuels indoor for cooking and heating represents a significant health problem. Spending time looking for trees or spending money for buying cooking and heating fuels also limits the resources for social development.
- For some context to these problems please watch: https://www.youtube.com/watch?v=x6AGXne27kY and / or https://www.youtube.com/watch?v=EoAfXfparNY

Workshop discussion (small group breakout activity):

- Participants to work in small groups (3-4 people per group)
- Ask the groups to spend some time thinking about the different types of alternative cooking fuels used where electricity is unavailable (e.g. Wood, Kerosene, Charcoal, Coal and Dung)
- Next, the groups should discuss what activities and problems could be associated with sourcing these different types of energy sources (e.g. mining, deforestation, risk of fire, diseases, risk of injury or even death)
- Finally, the groups should brainstorm some ideas on how this problem could be addressed and identify some potential solutions for safer sustainable energy sources.

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One potential solution (Teacher delivery):

- Introduce the concept of community-oriented solar cooking technology and how developing user-friendly solar ovens can help to solve the environmental, health, and social development issues linked to this problem. Please watch the following for more context - https://www.youtube.com/watch?v=Ofn7jqPDTeY&t=45s

Important information (Teacher delivery):

- ****Contrary to what many people believe, it is not necessary to boil water to make it safe to drink. Heating water to 65° C (149° F) for 6 minutes, or to a higher temperature for a shorter time, will kill all germs, viruses, and parasites. This process is called pasteurization*.***

2. *Building a simple solar oven (practical workshop activity with Teacher guidance):*

- The groups will now engineer and produce a simple DIY solar oven.
- Keep the participants in the groups assigned earlier and provide them with all the necessary materials mentioned in materials / resources section above.
- The groups start by lining all the inner areas of their cardboard boxes (including the folding over flaps or lid) with aluminium foil. This can be done using either glue or sticky tape (see example images below).

- ****If using polystyrene sheets for added insulation within the box, then groups should cover the polystyrene with the aluminium foil first and then place them inside the box to cover all four internal sides*.***

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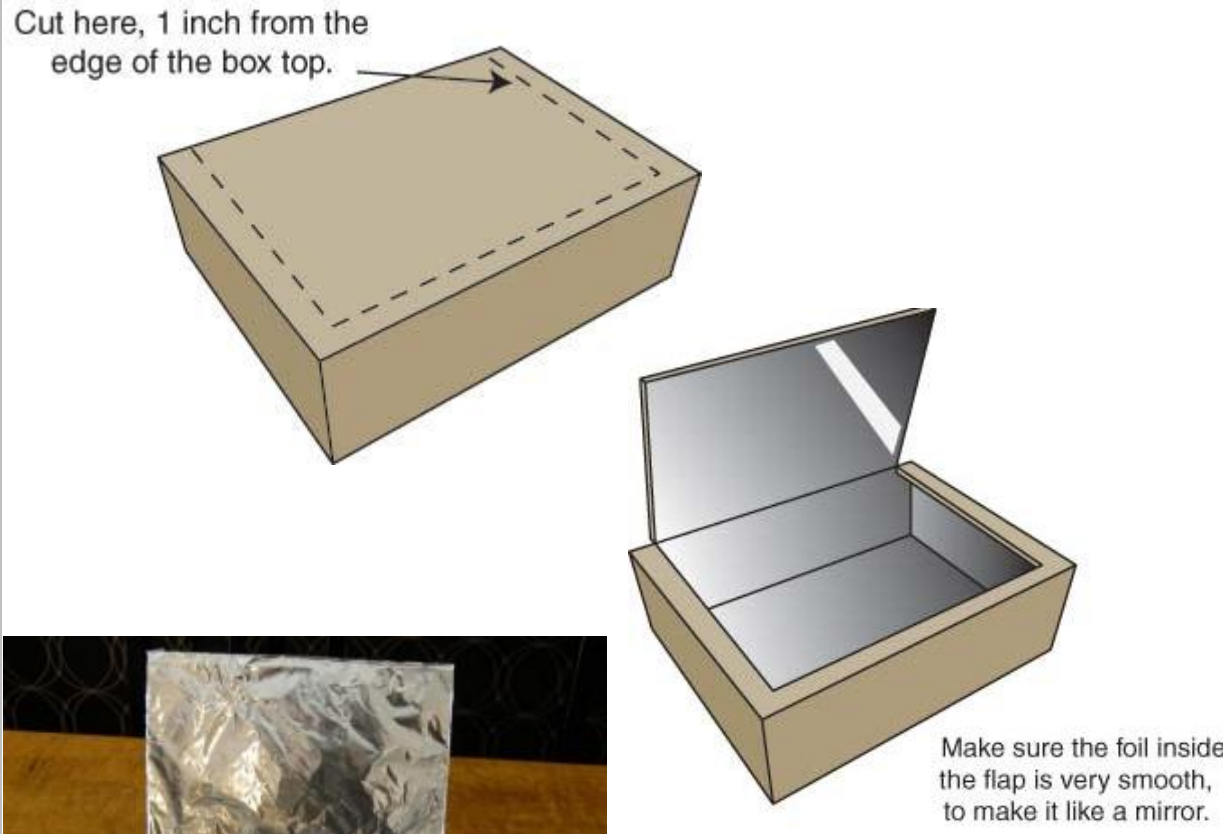
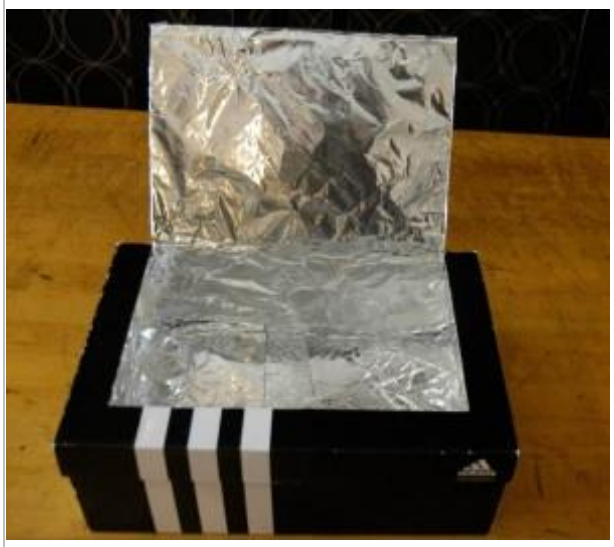
- ***If using shoe boxes, then the groups will have to cut into the lid to create an opening flap as in the images below*.**





- The groups should then cover the inside base of the box with either the black paper / card or by placing a black oven tray within the box to increase the radiating effect within the oven.

- ***If the groups have access to Perspex, Plexiglas or glass sheets then these can be added as a covering over the box to help to keep the heat within the box and improve the heating process (see diagrams below)*.**

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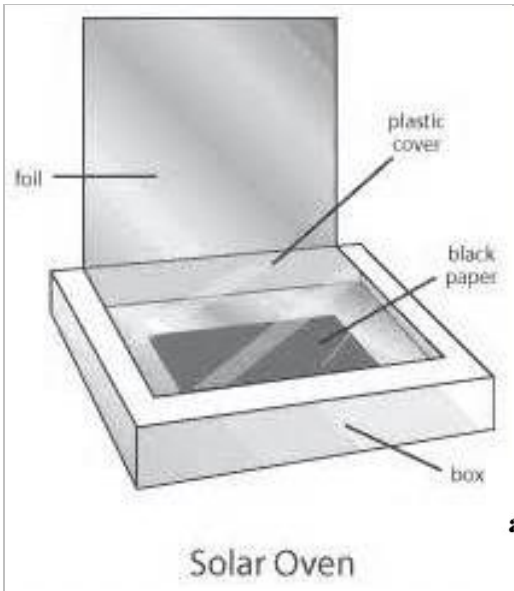
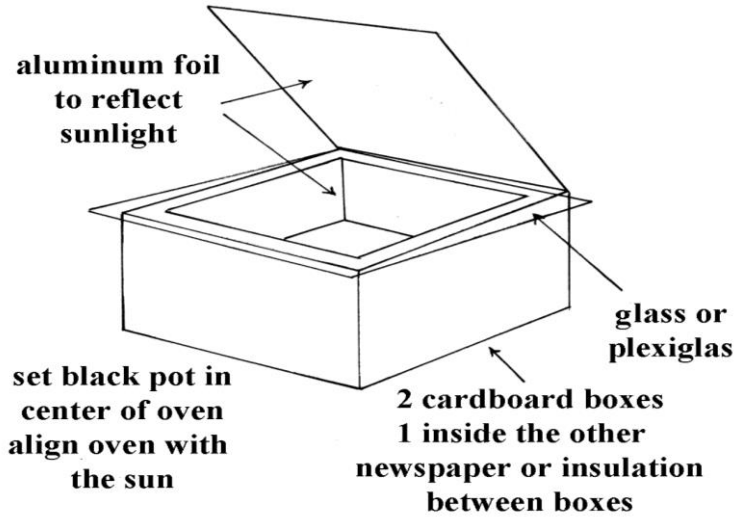


Solar Oven



There are several ways in which the groups could make a solar oven, the above is just one of these ways, here are some additional resources to guide the production process;

1. https://www.greenmatch.co.uk/blog/2016/08/build-your-own-solar-oven-in-5-steps
2. https://www.fix.com/blog/solar-cooking/
3. https://sciencing.com/make-shoebox-solar-oven-5240773.html
4. https://www.dummies.com/home-garden/green-living/energy-sources/how-to-make-a-solar-oven/
5. https://www.wikihow.com/Make-and-Use-a-Solar-Oven

Video guides to making basic solar ovens;

1. https://www.youtube.com/watch?v=v5CdNH3sQT0
2. https://www.youtube.com/watch?v=qofh1vy2XzI
3. https://www.youtube.com/watch?v=xXxrX0JvKa8
4. https://www.youtube.com/watch?v=wGfgjXJ__rE (aimed at a younger student cohort)
5. https://www.youtube.com/watch?v=tDB3zP9MEZc (more advance solar ovens using wooden box, glass and mirrors)

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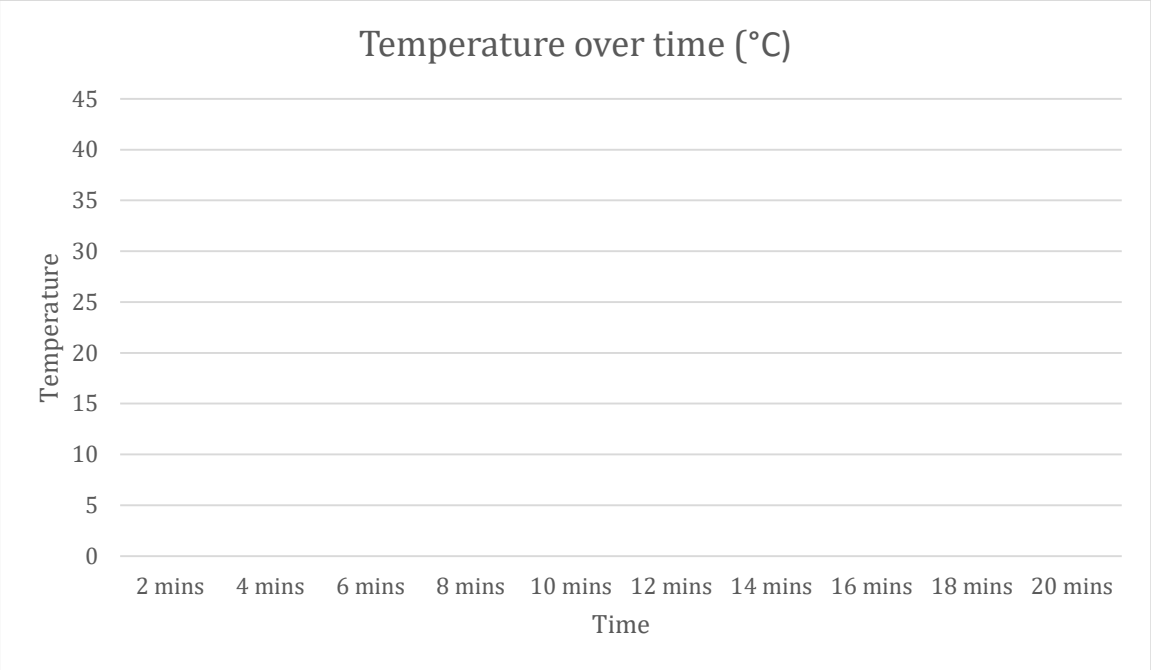
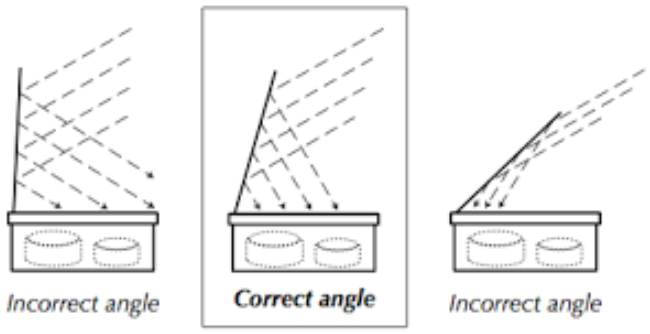
3. ***<u>Use your solar oven to heat water</u> (group activity with Teacher guidance)***

- The groups will now try to use the DIY solar ovens to heat a container of water.
- Ideally, the groups will allow the solar ovens to heat up first, they should place a thermometer into the ovens to monitor the ambient temperature within.
- Place the ovens in direct sunlight with the reflective surfaces facing the sun, this could be done outside or inside next to a window facing the sun.
- ****If you are attempting to undertake this workshop on an overcast day or during the winter where temperatures will not reach sufficient levels, then halogen lamps can be used to recreate the light and heat generated by sunlight*.***
- The groups should begin to monitor and record the ambient temperature within the ovens at regular 2 minute intervals. They should record their figures on the graph paper provided *(with the horizontal axis recording time and the vertical axis recording temperature as shown below).*



- Once the ambient temperature within the solar oven reaches 30°C / 86°F then groups should add their liquid containers / cooking pans containing 300ml of water.
- The groups should place their ovens in the optimal position to absorb the most amount of light and heat possible to ensure efficiency (please see the diagrams provided).



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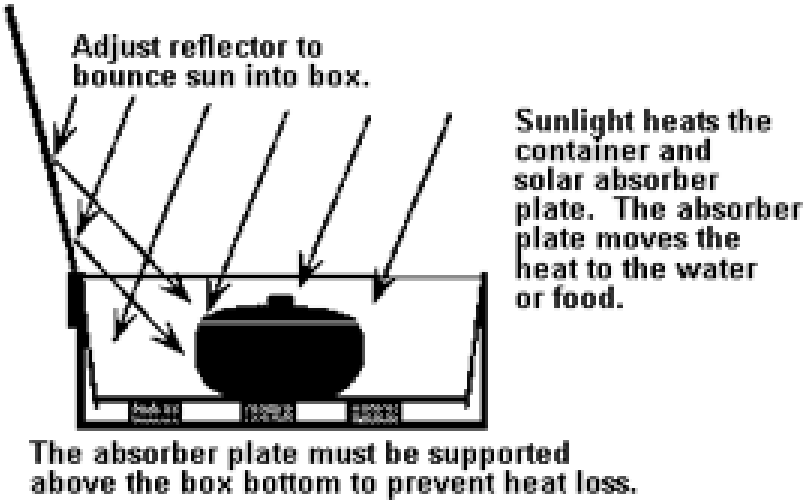
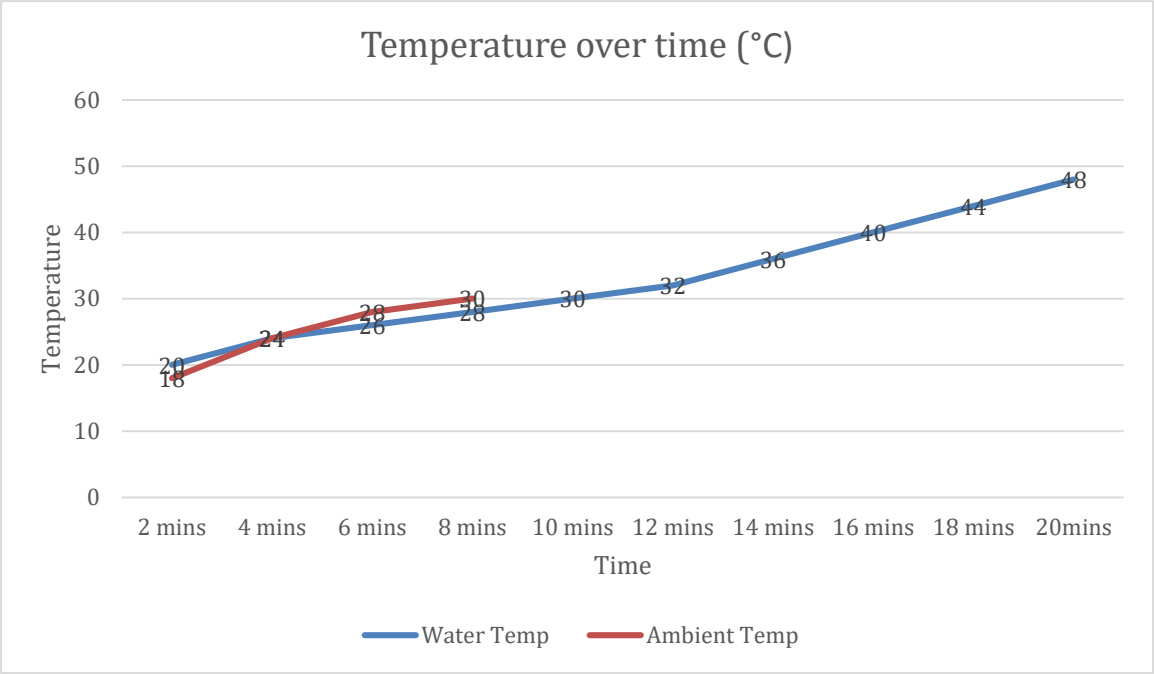


- Groups should now place a liquid thermometer into the container of water and again begin to monitor the temperature reading at regular 2 minute intervals as they did with the ambient temperature within the ovens.
- These figures can be recorded on the same graph as used for the previous records, however it will likely take longer to heat the water to the sufficient temperature than it took to heat the solar ovens to 30°C (please see the diagram below for an example).



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- If the aim of the activity is to pasteurize water for safer consumption, then groups are aiming to heat the water to a temperature of 65°C for a 6 minute period. If the aim is to show how water can be heated using solar energy for hygiene purposes then a temperature of 45 – 50°C will be sufficient (this is around the temperature of warm water from a standard household tap).

- ***It is worth noting that the rate in which the solar ovens will heat the water will vary dramatically depending on the temperatures achieved within the ovens. If the experiment is taking place on a hot sunny day in a country with a warm climate then the process will be far more effective and quicker than if taking place on a day with limited sunlight in a more temperate climate. The use of Halogen lamps will help to speed up the heating process if required and available*.***

- ***it is also important to consider that if the conditions are extremely warm then the process of heating the water will also cause evaporation of the water, if this is the case then the groups may have to start with a larger volume of water (e.g. 500ml instead of 300ml) in order to factor in the effect of evaporation. This issue could also be addressed by covering the water container with a lid to reduce water loss through evaporation*.***

There is a lot of information available regarding the pasteurization of water;
1. http://www.solarcooking.org/pasteurization/metcalf.htm (information about solar water pasteurization)
2.https://sswm.info/sites/default/files/reference_attachments/ANDREATTA%202007%20A%20Summary%20of%20Water%20Pasteurization%20Techniques.pdf (detailed research on the pasteurization of water)
3. https://solarcooking.fandom.com/wiki/Water_pasteurization (more information regarding water pasteurization)
4. https://www.youtube.com/watch?v=9KVhjnp40ck (more specifics behind the idea of pasteurizing water using solar ovens)

4. ***Do the Math….potential scalability (group activity with Teacher guidance)***

- So, the groups have made their solar ovens and demonstrated how it is possible to warm water using the power of solar energy. Now, they will investigate how this process could work on a larger scale to help address some of the issues outlined at the beginning of the workshop.

- From the graphs each group created when recording the ambient and water temperatures within their solar ovens, there should be some useful data that can be extrapolated.

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- Each group should now use their graphs to identify the following data;
  1. Calculate the time needed to pasteurize a cup of water (300ml)
  2. Calculate the volume of water that could be pasteurized in 1 hour
  3. Calculate the volume of water that could be pasteurized if there were 12 hours of sunlight in a day
  4. Finally, calculate the volume of water that could be pasteurized in a month if there were 20 sunny days.

Different Measures of Volume

10 millilitres (ml)	=	1 centilitre (cl)
100 millilitres	=	10 centilitres / 1 decilitre (dl)
1000 millilitres	=	1 litre (L)
10 litres	=	1 dekalitre (dal)
100 litres	=	10 dekalitres
1000 litres	=	1 kilolitre (kl)

- ***Each group should have slightly different figures as they will be extrapolated via the data gained from their own individual solar ovens*.**

5. ***In conclusion……..what have we learned? (whole class discussion and debrief)***
   - Hopefully, this workshop has been fun and informative for the participants and it has opened their eyes to a real global issue.
   - They should now be able to reflect on the following;
     1. How a large percentage of the global population have no access to a stable source of energy
     2. How millions of unnecessary premature deaths could be avoided if alternative, safer and more sustainable forms of cooking / heating water could be implemented
     3. How, using limited resources, you can sometimes overcome complex problems
     4. How they can utilise Science, Design Technology and Math in everyday situations
     5. How they can extrapolate data values from a data source.

Additional information for workshop delivery:

- There are other types of solar ovens that can be used for different purposes. This workshop has focused on using a solar oven to heat water, however they can be, and are used all over the world to cook food without using any energy source other than sunlight.
- The potential positive impacts of using solar ovens for providing a sustainable source of energy and reducing the negative impact of deforestation and pollution from using other cooking methods is yet to be fully explored.

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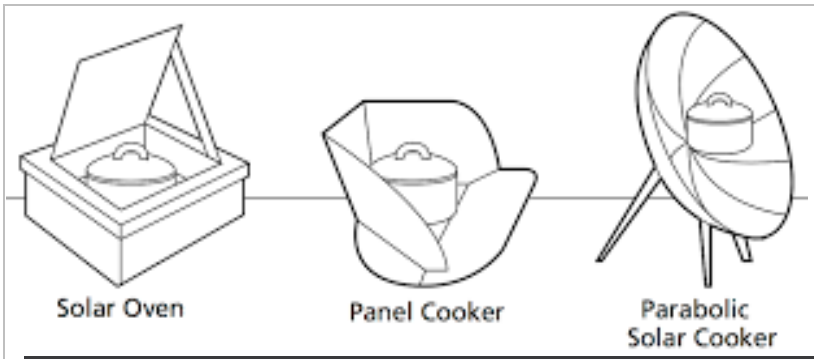
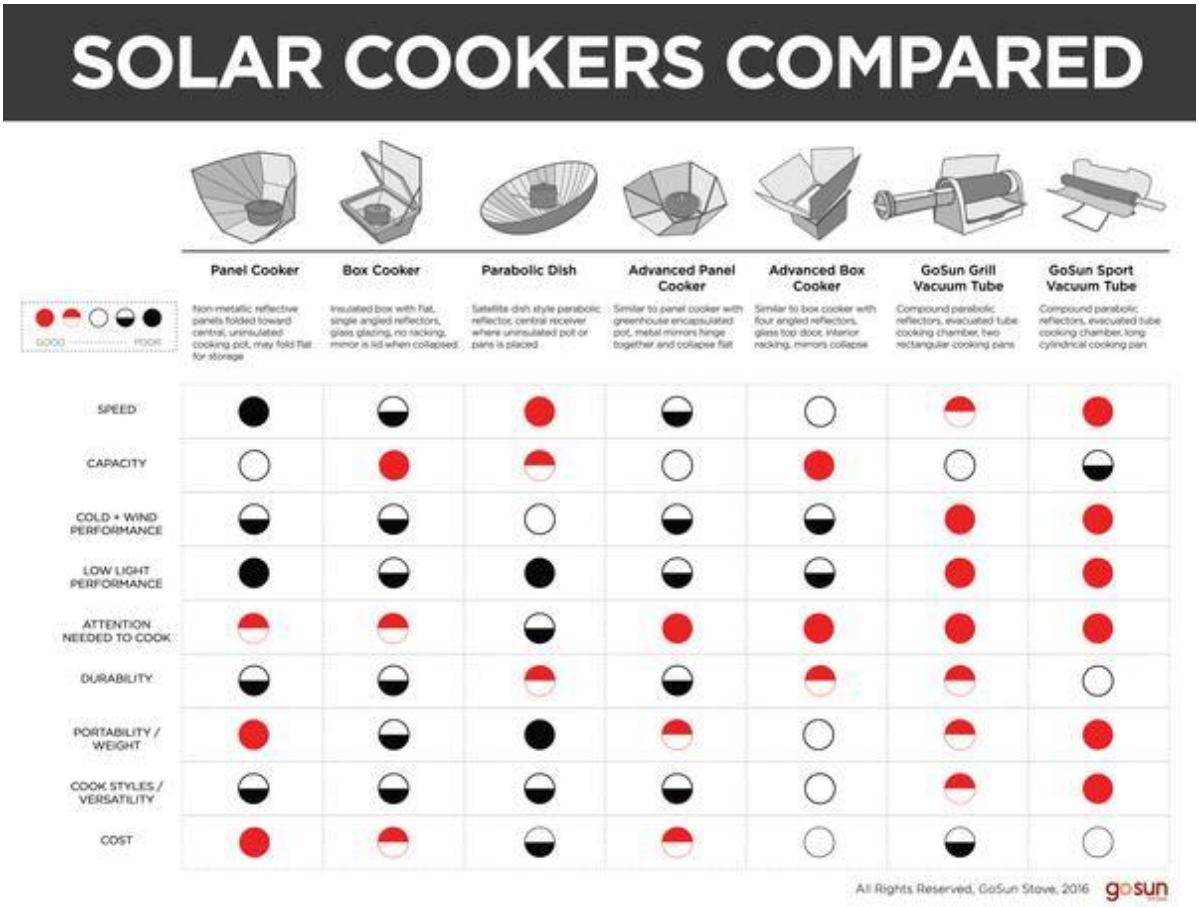


- Different types of solar ovens have different attributes that make them suitable for different purposes, the chart below gives an overview.



Other useful references:

1. https://ourworldindata.org/energy-access (information regarding access to energy sources globally)
2. https://www.who.int/news-room/fact-sheets/detail/household-air-pollution-and-health (World Health Organisation Data on air pollution caused by cooking)
3. https://gosun.co/blogs/news/top-solar-cookers-compared (more information about different types of solar ovens)
4. https://www.thecalculatorsite.com/conversions/liquidvolume.php (liquid volume conversions)

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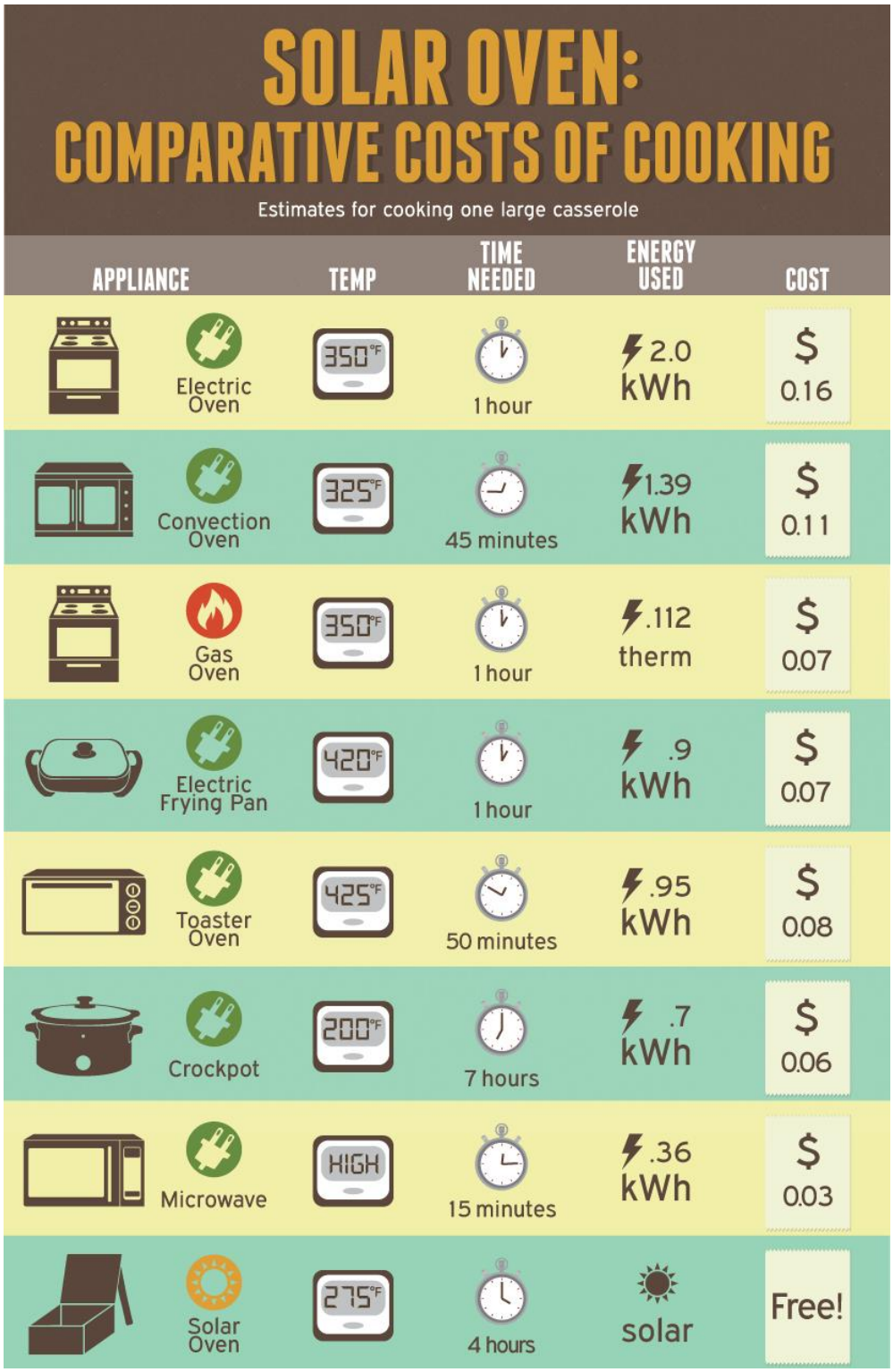

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