

Simple Solar Power

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1 Introduction

Solar concentration is the technique of using mirrors, reflective material, or lenses to focus large amounts of sunlight on to a smaller area. Using this process allows for potentially enormous amounts of heat to be produced. This process would be necessary in a situation without a means to provide power, healthy consumption of food, and hot or clean water. It is a perfect alternative to creating a basic fire because adequate fire wood is not always available but sunlight is an unlimited resource. Construction of a device using this system will help in providing the community with a sustainable long term heating or cooking method that does not require electricity or fire. The device that this manual will be discussing is a Parabolic Dish Solar Concentrator (PDSC) focused on the application for cooking food and boiling water. The PDSC is a concentrator that is in the shape of a satellite dish that provides a central point for the sunlight to heat.

1.1 Background

Solar concentration was first used for cooking as early as 1767. Parabolic Dish Solar Collectors were first developed as a source of power generation in the early part of the industrial revolution, born from fears that Europe would run out of coal. Through the use of curved mirrors, sunlight can be concentrated into a point, generating intense heat. This heat can then be used to boil water, produce steam, cook food, and generate power. The P.D.S.C described in this manual can generate temperatures of close to 200 degrees F, and can be used anywhere a direct source of sunlight is available, including high altitudes.

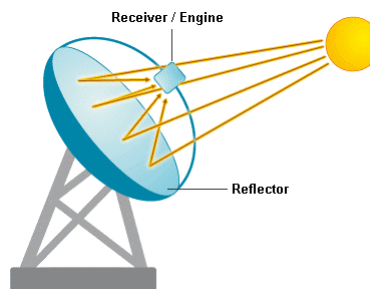


Figure 1: Reflection of sunlight to the focal point[1]

2 Materials, Tools and Skills

2.1 Materials Required

Item	Amount	Notes
1/2-inch plywood	Varies	For the Panel Template. If Jigsaw not available for cutting, heavy duty cardboard may be substituted.
1x4 boards		For the Panel Template.
Square Sheet of paper	1	Used to measure the angle for the Panel Template. Alternatively, a protractor may be used
Heavy duty cardboard		Corrugated cardboard is ideal.
Adhesive		Spray adhesive works the best. Alternatively, glue can be used instead.
Aluminum foil	Enough to cover dish.	Must be reflective. Heavy duty works best.
Metal strip		Reinforces the Dish, and attaches it to the Frame. Drywall corner strips work well, if available.
1-inch 8-32 screws with flat washers and nuts		
6-inch 1/4-20 carriage bolt with flat washers and wing nuts		Holds the center of the Dish, and serves as the guide for alignment with the Sun. Threaded rod may be used instead.
2x4s		Used for the base
3-inch deck screws		
1/2-inch electrical conduit		If not available, metal rods can be used instead.
Grill grate	1	Holds the cooking pot.
Binding wire		Holds the grate

2.2 Tools Required

Tool	Notes
T Square	For drawing the parabola required for the dish template. See appendix A
550 Cord	For drawing the parabola required for the dish template. See appendix A
Pencil	
Clamps	
Measuring Tape	
Duct Tape	Must be heavy duty
Utility Knife	
Scissors	
Jigsaw	Jigsaw is ideal for cutting template panels. In case power not available, different materials may be required.
Drill and Drill Bits	Used for building frame. Heavy duty adhesive or other fastening methods may be substituted.
Hammer	

3 P.D.S.C. Safety Guidelines

To minimize the risk of injury when using the P.D.S.C., please follow the safety guidelines listed below, and throughout the manual.

1. Do not use the P.D.S.C. on cloudy or very cold days, to minimize the risk of foodborne illnesses.
2. Always use a thermometer to check the internal temperature of food before eating it, if possible.
3. Wear protective eyewear, and avoid looking directly into the dish during use, to prevent eye damage.
4. The P.D.S.C. may become very hot, especially near the cooking area. Always wear protective gloves to prevent burns.
5. Keep children and pets away from the P.D.S.C. when in use.

4 Preparing the Location

4.1 Environmental Specifications

The P.D.S.C. is well suited to cooking at high altitudes and only requires a direct view of the sun to function.

Do not try to use the P.D.S.C. to cook food on overcast days, at risk of not heating the food to a safe temperature. Make sure to clear the area of any obstruction and make sure that the P.D.S.C. Frame is on a stable, level surface.

5 Building the P.D.S.C.

While following this guide, keep in mind that this design can be built larger or smaller depending on how much material is available. The measurements listed in diagrams and in the instructions are one possible size of reflector.

5.1 Building the P.D.S.C. Dish Template

In order to easily make the panels for the P.D.S.C., a template is required. See appendix A for instructions on drawing a parabola using string and a ruler or T-square. The more sections the dish has, the more efficiently the P.D.S.C. will function. The instructions below are designed for 16 sections, but the angle can be adjusted to allow for more or less sections.

1. For the template, take a piece of plywood slightly longer than the desired panel length, and about 2/3rds as long
2. Measure 8 in. from one end on the long side of the plywood piece. This is the focal point of the parabola. Mark the focal point clearly.

3. See Appendix A for steps to use the focal point, rope, pencil, and T-square to draw a parabolic arc on the plywood.
4. Once the parabola has been marked, measure from the focal point to the arc of the parabola. This is the focal length. Make a note of this measurement.
5. Draw a line along the focal length, and then cut out the marked area. Use this piece to cut a second, matching piece. These parts will make up the sides of the template.
6. The angle required for 16 sections is 22.5° . To measure this angle, fold the square piece of paper corner to corner to get a 45° angle. Then, fold in half again for a 22.5° angle.
7. Use the paper reference to form the correct angle at the apex of the plywood form, then measure the wide end.
8. Cut a piece of 1x4 board to match the measured length of the wide end. Secure the boards to the wide end with tape to reinforce the plywood.

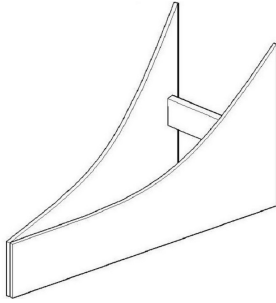


Figure 2: Isometric Diagram of completed template form

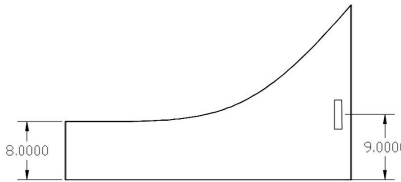


Figure 3: Side view of template form with sample measurements.

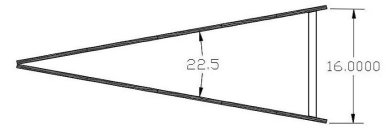


Figure 4: Top view of template form with sample measurements

9. Clamp a piece of cardboard the the plywood form and mark along the edges of the form, against the cardboard.
10. Cut out the cardboard along the lines drawn. The cardboard section is the template for all the sections of the dish.

5.2 Building the P.D.S.C. Dish

The P.D.S.C. Dish is made from 16 sections of aluminum foil coated cardboard made into a dish shape. The template made in the previous section is used to make the individual parts, which are then assembled.

1. Use the P.D.S.C. template made in the previous step to cut 15 more sections, for a total of 16 identical sections.
2. Crease each section every 2 inches starting from the wide end.
3. Once all the sections have been creased, the aluminum foil needs to be applied. Make sure the shiny side of the aluminum is facing out when covering the sections. Spray adhesive is recommended, but if that is not available, a thin layer of liquid glue will work. The panels need to be as smooth and shiny as possible.
4. Leave enough foil to fold over the edges and glue to the back of the panels.
5. Tape the panels together using heavy duty duct tape. Use something to support the center of the dish when assembling the sections.
6. If using a drywall corner strip to support the dish, hammer it flat.
7. Drill holes in the ends of the metal strip and tape the strip to the back of the dish. The holes are used to attach the P.D.S.C. dish to the frame.
8. Screw the edge of the dish to the edge of the metal strip using the 1-inch 8-32 screws with flat washers and nuts.
9. Cut a 12 inch circle of cardboard and cover with aluminum foil.
10. Drill or cut a hole in the center of the cardboard circle and bolt a 6-inch 1/4-20 carriage bolt with flat washers and wing nuts to the center of the circle. The long end should point towards the focal point of the P.D.S.C. Dish Assembly.

11. Attach the cardboard circle to the center of the Dish assembly. The long part of the center screw will serve as a guide for aligning the dish with the Sun.
12. The P.D.S.C. Dish Assembly is now complete.

5.3 Building the P.D.S.C. Frame

The P.D.S.C. Frame is a simple structure built from 2x4 boards. The P.D.S.C. Dish Assembly attaches to the Frame using the metal support strip and 2 6-inch 1/4-20 carriage bolts with flat washers and wing nuts. Measurements in the following diagrams are suggestions, and can be easily adjusted to fit the diameter of the completed P.D.S.C Dish Assembly.

1. Measure the diameter of the P.D.S.C. Dish assembly. The frame consists of 2 T-shaped reinforced end pieces and a 2x4 board holding them together.
2. The T-shaped end pieces need to be nearly as tall as the diameter of the dish, and the board holding the 2 ends together must be as long as the diameter of the dish.

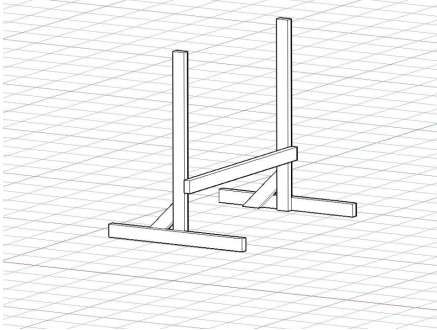


Figure 5: Isometric Diagram of completed base

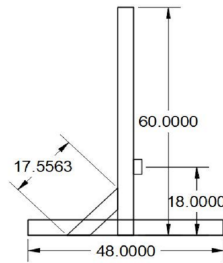


Figure 6: Side view of base with sample measurements

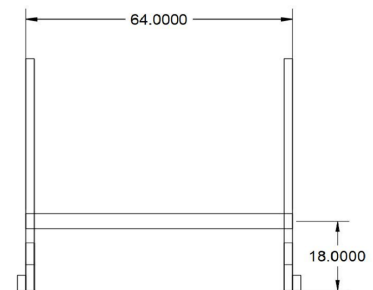


Figure 7: Rear view of base with sample measurements

5.4 Assembling the P.D.S.C.

Assembly and usage of the P.D.S.C. is fairly simple. A wooden dowel or section of metal rod can be used to hold the

1. Drill a hole in each upright part of the frame, a distance half the diameter of the P.D.S.C. Dish from the bottom.
2. Use 2 6-inch 1/4-20 carriage bolt with flat washers and wing nuts to attach the metal strip on the dish to the stand using the holes drilled in the previous step.
3. Make sure the dish is firmly bolted to the stand, but is still able to be rotated.
4. Measure from the ground to the previously noted focal point of the dish. This is the height at which the grill grate needs to be mounted for optimal heat production.
5. Mount 2 lengths of the 1/2 inch electrical conduit using clamps to the Frame at the same height as the focal point.
6. Attach the grill grate to the conduit using binding wire. This is where the pan will go when the P.D.S.C. is in use.
7. Adjust the P.D.S.C. Dish assembly to the correct angle, and use a wooden dowel and clamp to hold the dish in position.

The P.D.S.C. is now complete and ready for use.

6 P.D.S.C. Operation

The P.D.S.C. has a variety of uses, due to its ability to produce heat without combustion. For best results, use a dark colored pot or pan to cook with. Follow the steps below to safely use the P.D.S.C. for food safety purposes.

6.1 Cooking food

When cooking food, especially meat or fish, with the P.D.S.C. it is extremely important that the food reach an internal temperature of 165°F. Failure to reach these temperatures may result in the contraction of food borne illnesses.

1. Make sure the area is clear of obstructions, that the sky is clear of clouds, and that there are at least 2 hours of direct sunlight available.
2. Position the P.D.S.C. Dish assembly facing the sun, using the large screw at the center of the dish as a guide. If the shadow is not visible, then the dish is properly aligned with the Sun.
3. Place the food to be cooked in a dark colored pan (cast iron should be fine), and place on the rack.
4. Depending on the food type, it may help to wrap the pan in a clear plastic bag to seal in some of the heat and moisture.
5. The P.D.S.C. Dish Assembly will need to be rotated every 5-10 minutes to ensure optimal heating.
6. Use a thermometer, if available, to check the internal temperature has reached 165°. If a thermometer is not available, make sure the food is thoroughly cooked.
7. Average cooking time depends on what kind of meal is getting prepared.

6.2 Pasturizing water

The steps to pasturize water to make it safe for drinking are very similar to the steps above, with some minor differences. The major differences are listed below.

1. The temperature required to pasturize water is 149°F.
2. The water must be brought to at least this temperature for 6-8 minutes.
3. After that time, the water will be safe to drink.

7 Maintenance and Troubleshooting

Compared to heating systems reliant on combustible fuel, the P.D.S.C. requires very little maintenance. For optimal performance, however, some level of care should be taken.

7.1 Maintenance

Follow the steps below to ensure the P.D.S.C. is not damaged during use.

1. If any spills occur on the reflective material be sure to clean it up immediately after cooking, as staining the reflective material may reduce the solar cooker's effectiveness.
2. Make sure to clean the reflective material every so often with a dry or wet cloth so as to keep the solar cooker at maximum efficiency (If using a wet cloth make sure to dry it with a dry cloth afterwards).
3. Bring in the solar cooker if you are expecting rain or it starts raining. The water can damage the cardboard/wood as well as the reflective material of your solar cooker.
4. Beware of strong winds as they might knock the solar cooker over and damage it. Make sure that the P.D.S.C. is secured outside.

7.2 Troubleshooting

If the P.D.S.C. does not seem to be working properly, follow the steps below to fix the issue.

1. Check to make sure the P.D.S.C. has an unobstructed view of the sun.

2. Check the alignment of the P.D.S.C. Dish assembly. If the guide rod has a shadow visible, adjust the angle as necessary.
3. Make sure that the reflective surface is clean and free of debris.
4. Check that the cooking surface is at the correct height. If a piece of paper is placed on the cooking surface, the light should be concentrated in a single spot.

8 Additional Use Cases

The P.D.S.C. can be adapted for large scale useage including the folowing examples.

8.1 Heating Water

The larger the P.D.S.C. Dish is, the higher the possible temperature generated is. With a sufficiently large dish, or a parabolic trough system, water can be heated on a large scale, allowing for use for bathing and cleaning of laundry.

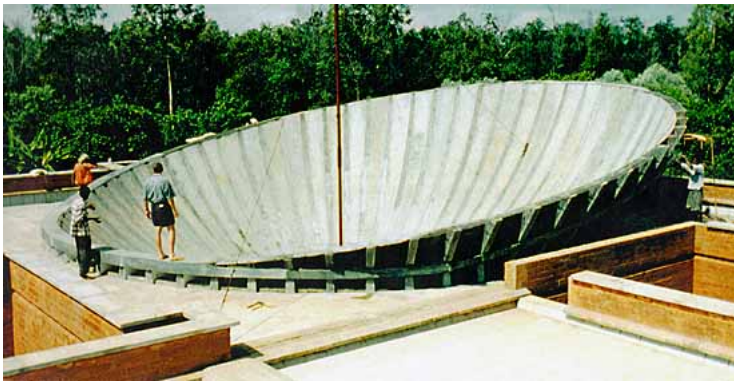


Figure 8: Large scale parabolic dish collector

8.2 Steam Generation

On a large enough scale, the P.D.S.C. should be able to produce steam from water. This would allow for the production of electricity via a steam turbine generator, or a stirling engine placed at the focal point of the dish assembly.

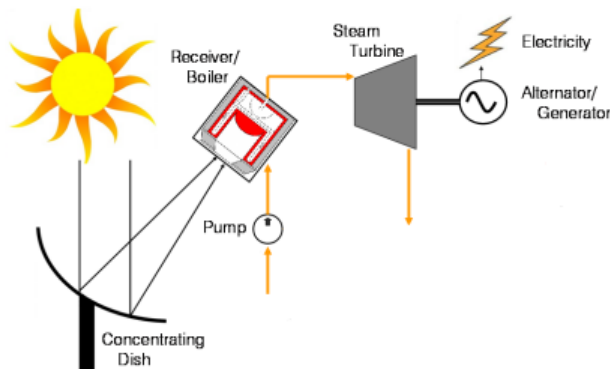


Figure 9: System diagram for steam turbine setup.[2]

8.3 Under-floor Heating

If heated water was produced in larger amounts, with some degree of storage, then hot water could be run through pipes underneath the floor. This would provide heating for the floor, and by extension, the room.

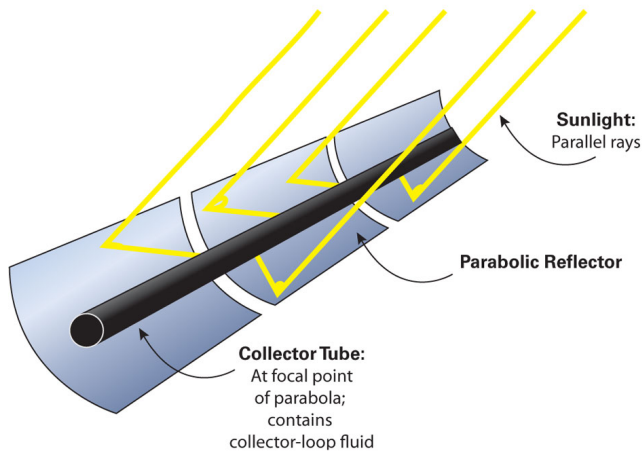


Figure 10: Example layout for trough collector system.[3]

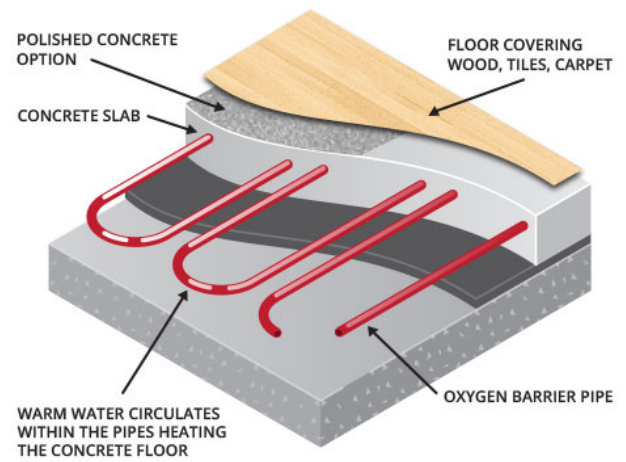
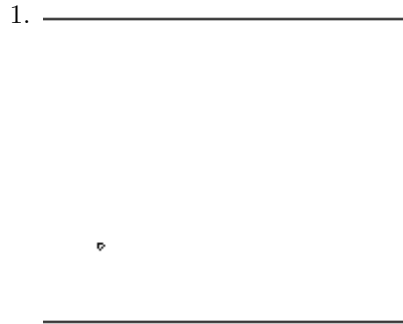


Figure 11: Cross-section of flooring setup with radiant heating pipes.

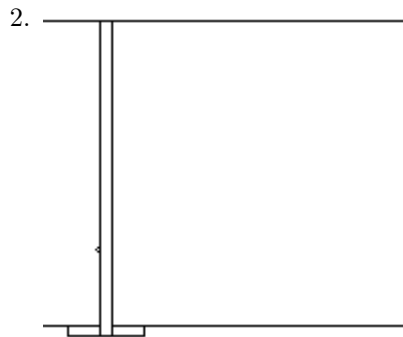
Appendices

A Drawing a Parabola

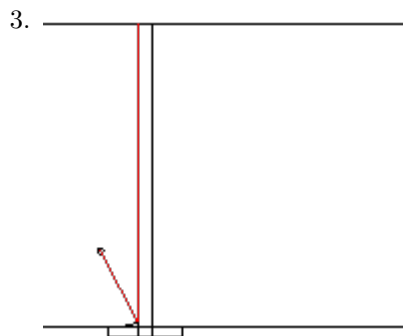
In order to efficiently concentrate solar energy, a parabolic dish or trough is required. The following instructions describe a simple method of drawing a parabolic curve.[4]



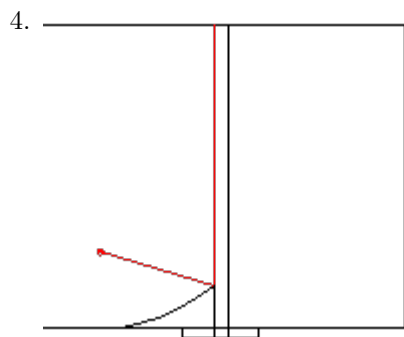
Mark the focal point on the surface the parabola is to be drawn on.



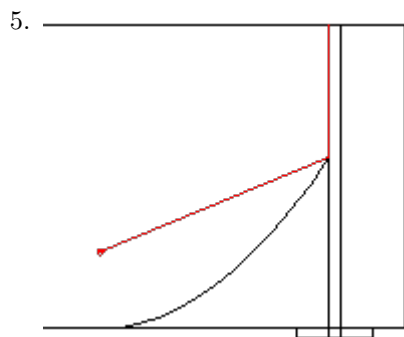
Align a T-square or straight edge with the marked focal point.



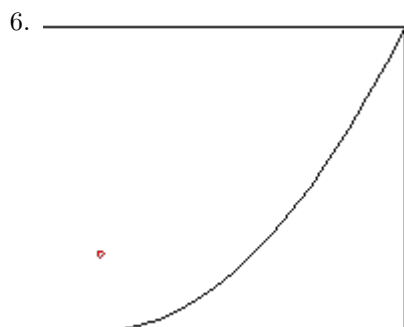
Attach a rope or string to the focal point and the top of the t-square using tacks or nails, as shown above.



Place a pen or pencil at the bottom of the t-square in the rope, and slowly slide the t-square away from the focal point, holding the pen against the t-square.



Continue sliding the t-square, forming a smooth curve. The resulting curve is half of a parabola.



The completed curve.

References

- [1] S. Mohasin. (Aug. 2012). World of energy, [Online]. Available: <https://shaikmohasin.wordpress.com/2012/08/25/parabolic-dish-system/>.
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- [3] C. Marken. (2009). Solar collectors ...behind the glass, [Online]. Available: <https://www.homepower.com/articles/solar-water-heating/equipment-products/solar-collectors-behind-glass>.
- [4] W. E. Johns. (2003). Notes on laying out a parabola, [Online]. Available: <http://www.gizmology.net/parabola.htm>.