

Solar Power Plants

The Movie:

Concentrated solar energy creates heat to drive steam through a turbine and produce electricity cleanly and efficiently. Featured: Jim Chavez, Mechanical Engineer, U.S. Dept. of Energy Lab; Hank Price, Engineer, Luz Engineering Corporation.

(Movie length: 1:38)



Background:

Much of the electricity produced on Earth is generated by the burning of fuel, in which the energy of the sun has been concentrated and stored for millions of years. Unfortunately, that fuel also stores other things, such as carbon, which turns into the greenhouse gas carbon dioxide when the fuel is burned.

But is it really necessary to wait a million years to use the energy of the sun, when it literally falls from the sky in huge amounts every day? Not according to a new generation of power plant engineers, who have, in the past few decades, built and successfully tested huge solar mirror arrays in the U.S. Mojave desert and elsewhere.

Won't it be nice for our grandchildren to be able to look back and wonder just what the fossil fuel fuss was all about?

Curriculum Connections:

Percent

1

The most efficient solar power plant ever built operated at about 18% efficiency of conversion of solar energy to electricity.

Energy gets "lost" in several different ways:

- 1) Not all of the energy that strikes the mirrors is reflected.
- 2) Not all of the energy that strikes the heat absorber is absorbed.
- 3) Not all of the energy that is absorbed turns water into steam.
- 4) Not all of the energy of the steam is converted by the turbine into electricity.

Suppose the efficiency at step 4 is 62%. What could the efficiencies of the other three steps be, in order to get a total efficiency of 18%?

Measurement (energy, area, time), percent

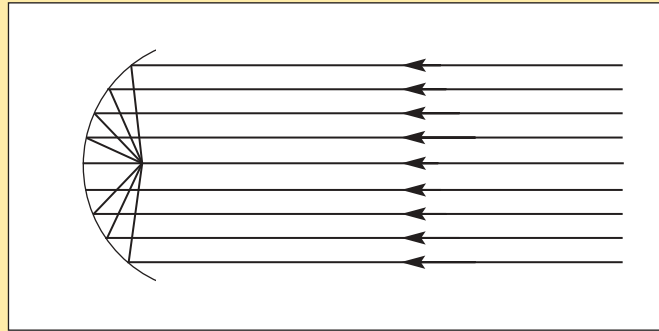
2

The amount of solar energy which falls on an area of earth is measured as kilowatt-hours per square meter per day.

There are areas in the southwest U.S. where an average of as much as 8-9 kilowatt-hours of energy arrive on each square meter of land every day.

- 1) Compute how many kilowatt-hours fall on each square meter during an entire year.
- 2) Suppose you can convert that energy to electricity with an efficiency of 10%. How many square meters of energy would you have to capture to meet the U.S. energy needs for a year (roughly 2.8×10^{10} kilowatt hours)?
- 3) Convert your answer to square miles. How does it compare to the area of the state of Nevada?

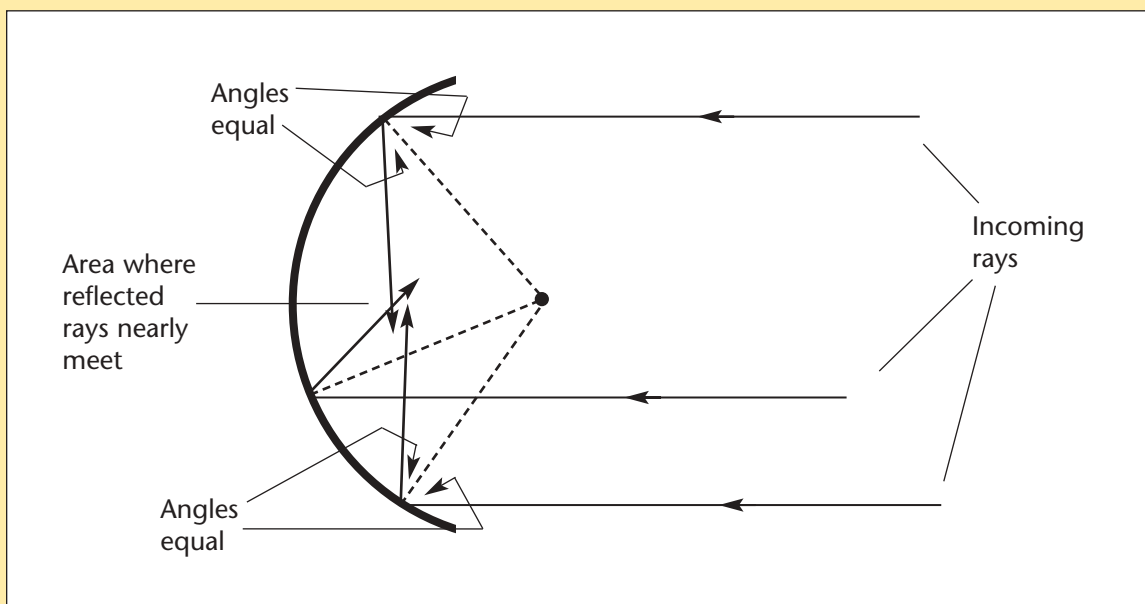
One type of solar power plant uses parabolic troughs to collect solar energy and concentrate it on a tube of fluid that runs through the center of the trough. Since the tube is at the focal point of the parabolic shape of the trough, the concentration of sunlight is very high—up to 70 times.



What if a part of a circle were used instead of a parabola? Circular shapes are easier to make, and therefore the trough would be less expensive. But how well would it concentrate energy? You can get some idea with this procedure:

1. Use a compass to draw an arc of a circle with a radius of about 8 inches. Mark the center of the circle.
2. Draw several radius lines from the center of the circle to the arc.
3. Draw a series of exactly parallel lines which intersect the arc at the same points at which the radius intersects the arc. These represent rays of light.
4. Draw reflecting rays so that the angle between the incoming ray and the radius is equal, in each case, to the angle between the reflected ray and the radius.
5. See how close the reflected rays come to meeting at a point.

Your drawing should look something like this one, but with many more lines:

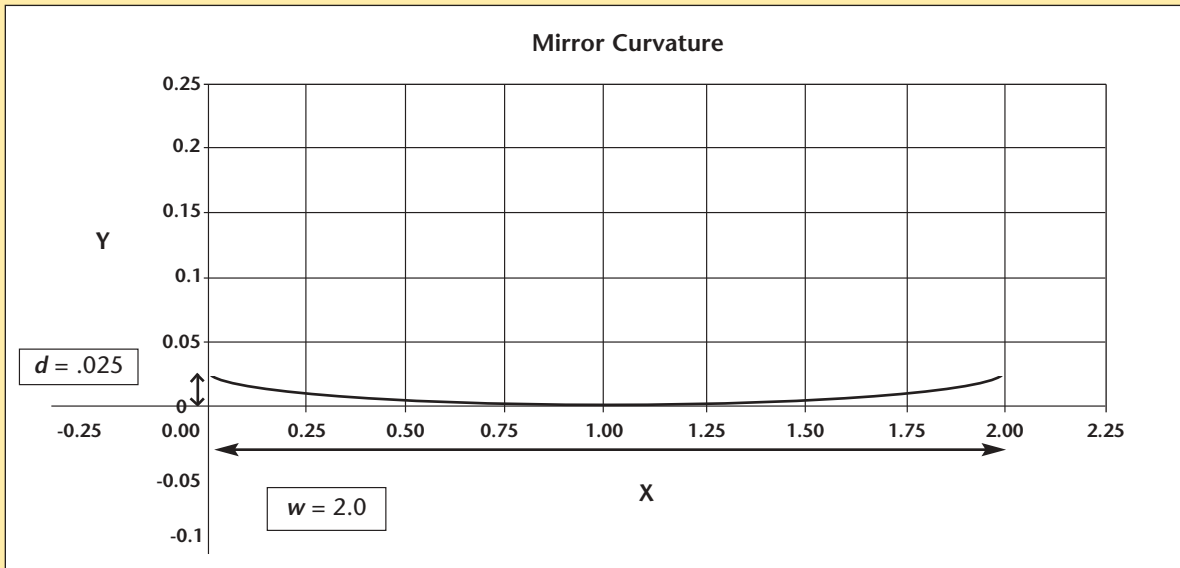


Do you think a circular trough will work for concentration of solar energy? Explain your answer.

Mirror Curvature

4

The graph below represents the curvature of a large solar mirror. In this case the depth of the mirror, d , is .025 meters, and the width of the mirror, w , is 1.0 meters.



- 1) Find the equation for this curve.
- 2) Find the equations for curves with these values of w and d :

w	d
2.4	.025
2.8	.025
3.2	.025
3.6	.025
4.0	.025
2.0	.020
2.0	.022
2.0	.028
2.0	.030
4.0	.030
5.0	.040
6.0	.050



- 3) Create a graph for each of the above curves.

Teaching Guidelines: Mirror Curvature
Math Topic: Quadratic Functions

Answers:

- 1) $y = .025x^2 - .05x + .025$
 2)

<i>w</i>	<i>d</i>	Equation
2.4	.025	$y = .025x^2 - .06x + .036$
2.8	.025	$y = .025x^2 - .07x + .049$
3.2	.025	$y = .025x^2 - .08x + .064$
3.6	.025	$y = .025x^2 - .09x + .081$
4.0	.025	$y = .025x^2 - .1x + 0.1$
2.0	.020	$y = .020x^2 - .04x + .02$
2.0	.022	$y = .022x^2 - .044x + .022$
2.0	.028	$y = .028x^2 - .056x + .028$
2.0	.030	$y = .030x^2 - .06x + .03$
4.0	.030	$y = .030x^2 - .12x + .012$
5.0	.040	$y = .040x^2 - .02x + .025$
6.0	.050	$y = .050x^2 - .035x + .045$



If you enjoyed this Futures Channel Movie, you will probably also like these:

<i>Solar Powered Cars, #1001</i>	Using the energy it takes to run a hair dryer, this solar-powered car travels 200 miles at speeds of 50 to 65 mph.
<i>Off the Grid Series, #1022-1024</i>	Most people in the world don't have access to electricity. Engineers from Sandia Laboratories demonstrate how solar panels can be a solution.