

## Smart Solar? Worksheet Example Answers

### Engage:

Many people assume that building solar panels is always a smart idea. But is it?

Your engineering task is to analyze solar energy data from the Renewable Energy Living Lab to determine if solar panels are always a smart choice.

In the space below, explain what you know about solar energy.

Solar energy is light and heat from the sun's radiation. We are able to use solar energy by capturing it with technology such as photovoltaic solar panels that convert solar energy to useable electrical energy.

Why do you think it is good/bad to build solar panels?

It is good to build solar panels because once built, they enable us to capture renewable solar energy, which decreases the amount of non-renewable energy we need. On the other hand, it is bad to build solar panels because it takes energy, money and materials to build the solar panels.

### Explore:

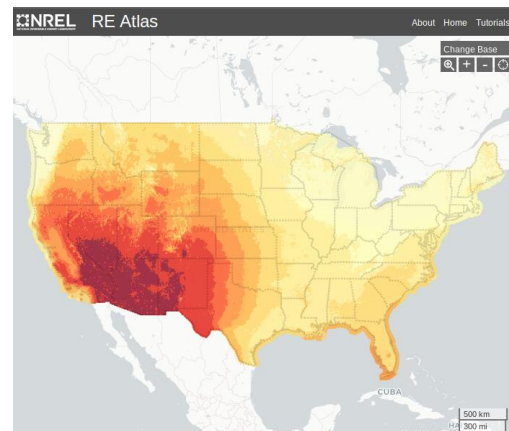
1. Go to the Renewable Energy Living Lab at <http://www.teachengineering.org/livinglabs/index.php>.
2. Enter the Renewable Energy Living Lab and choose age group K-12.
3. Check the boxes under the Resources folder (located on the left under the Data Layers tab) to switch between the maps depicting the potential for the five different forms of renewable hydropower, biomass, geothermal, wind and solar. Use the icons in the lower left corner to read more information about each form of energy.

4. Use the "Zoom to a location" icon in the upper right corner of the map to zoom in and find your home town. What is the solar potential in your town? (Include units!)

5.3 kWh/m<sup>2</sup> /day

Explain:

I found my solar potential by zooming in to Boulder, Colorado, which is where I live. I compared the color of Boulder on the Renewable Energy Living Lab map with the solar potential layer to the legend scale. Based on the color of the Boulder area and the color it matched on the scale, I determined that the solar potential is 5.3 kWh/m<sup>2</sup> /day.



Name: \_\_\_\_\_ Date: \_\_\_\_\_ Class: \_\_\_\_\_

### Part 1: Solar Potential

Zoom in on the following locations and determine their potential for solar power.

Location	Potential for Solar Power
Minneapolis, Minnesota	4.4 kWh/m <sup>2</sup> /day
Las Vegas, Nevada	6.6 kWh/m <sup>2</sup> /day
Portland, Oregon	4.0 kWh/m <sup>2</sup> /day
San Antonio, Texas	5.0 kWh/m <sup>2</sup> /day

#### Stop and think!

Of the cities listed above, which is the most likely candidate for solar? Why do you predict that one?

The most likely candidate for solar power is Las Vegas, Nevada, because it has the highest solar power potential value.

What criteria do you think you need to consider in order to determine if each of these cities is a good candidate for solar panels? Explain your thinking.

The first criteria to consider would be the value of the solar power potential. If the potential value is very low, it could cost too much to install solar panels based on how much energy would be produced by the solar panels. Another criterion to consider is the potential area to place the solar panels. If there is nowhere or very little feasible room to place the solar panels, then very little solar energy could be harnessed. Seasonal variation in each area is also important to investigate. Some areas may have consistently high solar power potential, while other areas may have a short season with high potential and the rest of the year has much lower potential.

#### Elaborate:

##### Part 2: Energy Generation

For each of the locations above, calculate the amount of energy that will be produced in one month.

Base your calculations on the following design parameters:

- You have room on the roof of your building to install 200 m<sup>2</sup> of solar panels.
- Average solar panels on the market today are able to convert 12% of the potential energy into electricity.

Location	Amount of electricity generated per month
Minneapolis, Minnesota	3,200 kWh/month
Las Vegas, Nevada	4,800 kWh/month

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Class: \_\_\_\_\_

<b>Portland, Oregon</b>	2,900 kWh/month
<b>San Antonio, Texas</b>	3,600 kWh/month

Calculations:

Minneapolis:  $4.4 \text{ kWh/m}^2 \text{ /day} \times 30 \text{ days/month} \times 200 \text{ m}^2 \times 0.12 = 3168 \text{ kWh/month}$

Las Vegas:  $6.6 \text{ kWh/m}^2 \text{ /day} \times 30 \text{ days/month} \times 200 \text{ m}^2 \times 0.12 = 4752 \text{ kWh/month}$

Portland:  $4.0 \text{ kWh/m}^2 \text{ /day} \times 30 \text{ days/month} \times 200 \text{ m}^2 \times 0.12 = 2880 \text{ kWh/month}$

San Antonio:  $5.0 \text{ kWh/m}^2 \text{ /day} \times 30 \text{ days/month} \times 200 \text{ m}^2 \times 0.12 = 3600 \text{ kWh/month}$

### Stop and Think!

Explain how you calculated the amount of energy generated per month.

For each location, I multiplied the solar power potential data I found on the Renewable Energy Living Lab map (in units kWh/m<sup>2</sup> /day) by 30 days per month, which converted this data to energy per day per square meter to energy per month per square meter, and multiplied by 200 m<sup>2</sup>, which is the available space for solar panels, and then multiplied by 0.12, to find 12%, which is the typical amount of potential solar energy that is converted to electricity.

### Part 3: Energy Offset

Now it is time to think about the money needed to install the solar panels. The cost of installation per square meter of solar panels is \$1,075.

How much would it cost to install 200m<sup>2</sup> of solar panels?

\$215,000 ( $200 \text{ m}^2 \times \$1075/\text{m}^2 = \$215,000$ )

The government in each of the states above helps to subsidize the cost of installing the solar panels. Assume that the government subsidizes 60% of your initial investment.

How much of the cost will the government subsidize?

\$129,000 ( $\$215,000 \times 0.60 = \$129,000$ )

How much of the cost will you have to cover?

\$86,000 ( $\$215,000 - \$129,000 = \$86,000$ )

The average cost for energy in your area is \$0.15/kWh. How much savings will solar panels in each of the cities above save per year?

City	Amount Saved
<b>Minneapolis, Minnesota</b>	\$5781.60/year
<b>Las Vegas, Nevada</b>	\$8672.40/year
<b>Portland, Oregon</b>	\$5256/year
<b>San Antonio, Texas</b>	\$6570/year

Calculations:

Minneapolis:  $4.4 \text{ kWh/m}^2 \text{ /day} \times 365 \text{ days/year} \times 200 \text{ m}^2 \times 0.12 \times \$0.15/\text{kWh} = \$5781.60/\text{year}$

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Class: \_\_\_\_\_

Las Vegas:  $6.6 \text{ kWh/m}^2 \text{ /day} \times 365 \text{ days/year} \times 200 \text{ m}^2 \times 0.12 \times \$0.15/\text{kWh} = \$8672.40/\text{year}$

Portland:  $4.0 \text{ kWh/m}^2 \text{ /day} \times 365 \text{ days/year} \times 200 \text{ m}^2 \times 0.12 \times \$0.15/\text{kWh} = \$5256/\text{year}$

San Antonio:  $5.0 \text{ kWh/m}^2 \text{ /day} \times 365 \text{ days/month} \times 200 \text{ m}^2 \times 0.12 \times \$0.15/\text{kWh} = \$6570/\text{year}$

How many years will it take for you to “save” back the portion of your costs you had to pay to install the solar panels?

City	Years
Minneapolis, Minnesota	15 years
Las Vegas, Nevada	10 years
Portland, Oregon	16 ½ years
San Antonio, Texas	13 years

Calculations:

Minneapolis:  $\$86,000 / \$5781.60/\text{year} = 14.9 \text{ years} \approx 15 \text{ years}$

Las Vegas:  $\$86,000 / \$8672.40/\text{year} = 9.9 \text{ years} \approx 10 \text{ years}$

Portland:  $\$86,000 / \$5256/\text{year} = 16.4 \text{ years} \approx 16 \frac{1}{2} \text{ years}$

San Antonio:  $\$86,000 / \$6570/\text{year} = 13.1 \text{ years} \approx 13 \text{ years}$

Looking at your cost analysis, do you think that solar is a smart solution everywhere? Why or why not?

Based on my cost analysis, solar energy is not necessarily a smart solution everywhere, or in every person’s case. The lesser the potential solar energy in an area, the longer it would take to pay off the price of the solar panels. The difference between areas is not a few weeks or months, but years. Also, based on this cost analysis, it would only make sense to install solar panels if you plan to stay in the same building for multiple decades. Even in Las Vegas, which has some of the high solar energy potential in the entire country, it would take 10 years to pay off the cost of solar panels.

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Class: \_\_\_\_\_

## Evaluate:

### Part 4: Alternatives

Return to the Renewable Energy Living Lab. For each city, determine if an alternative form of energy might be a better choice to pursue. Explain your reasoning.

City	Is there an alternative form of energy that is a better choice? Which one(s)? Why or why not?
Minneapolis, Minnesota	Solar energy may be the best here, because the other forms of renewable energy are not very high. The only other energy form I would recommend pursuing would be biomass, because some areas around the city have relatively high (>500 thousand tonnes/year) energy potential from biomass.
Las Vegas, Nevada	Las Vegas has very high solar energy potential compared to the rest of the country so this may be its best renewable energy choice. But, there is also very high potential for geothermal energy, and just south of Las Vegas is an area with extremely high potential for hydro power. It may be worth investigating multiple options.
Portland, Oregon	Portland has the lowest potential for solar energy, so other alternative energy may be better choices. It has about 750 MW of potential hydropower, which converts to approximately 180,000 kWh/day of energy potential. Just south of the city of Portland is also an area with very high potential for energy derived from biomass.
San Antonio, Texas	San Antonio has relatively high potential for solar energy, so this may be the best option. Other forms of energy that could be investigated include biomass, because there is high potential for this, and geothermal energy, because the potential has a ~class 3 ranking.