# [earth,globe,planet,world](http://findicons.com/icon/17735/earth)

**Demonstration**

**Science on a Sphere**

# **Solar Energy**

*Visitors learn about global energy use and the potential of solar energy to provide power in Oregon and globally.*

#### SCIENCE TOPICS PROCESS SKILLS GRADE LEVEL

|  |  |  |
| --- | --- | --- |
| Energy sources | Look for patterns | 3rd - adult |
| Global energy use | Make comparisons |  |
| Renewable energy |  |  |
| LESSON OBJECTIVES |  |  |

Visitors will learn that:

* Humans use **15 terawatts** (TW) to power today’s world (1 TW = **1012** watts = 1 trillion watts).
* Fossil fuels are stored chemical energy originally generated from solar energy.
* Fossil fuels are not renewable but there are many renewable forms of energy, including solar energy.
* Oregon gets more sun than Germany, the world’s solar electricity leader.

#### TIME REQUIRED

## Advance Preparation Set Up Demonstration Clean Up

**0 minutes 10 minutes 20-30 minutes 5 minutes**

#### SUPPLIES

* SOS, remote, and green laser pointer
* Wireless headset microphone
* 15 watt compact fluorescent light bulb
* Solar toys and hand held utility light
* Cart on wheels

#### SAFETY ISSUES

* When using the microphone, turn volume up from “normal\_demo” playlist for the demonstration. Lower volume to original volume after demonstration.
* The laser pointer is only to be used by an OMSI employee or volunteer, not by visitors. Never shine the laser beam at anyone. Point it at the sphere only.

#### SET UP

* Arrange the benches. If using solar toys, move several benches to one side of SOS so visitors can see SOS and props at the same time.
* Place solar toys, utility lamp, and 15 watt light bulb on rolling cart. Plug in lamp.
* Load “Demo\_Solar\_Energy” playlist on SOS.
* Test the Wii remotes. Synch the remotes if they are not already on.
* Test the wireless microphone and adjust the volume.
* Get the laser pointer.

#### DEMONSTRATION

**NOTE:** **Major themes are outlined first. An example script is included to help give ideas on ways to present. Do not present the example script line for line, but come up with what is comfortable for you and the audience in front of you. Tailor your presentation to your audience. You don’t need to use all the datasets.**

1. **Earth at Night** 
   * **globe shows electricity use**
   * **it takes 15 terrawatts to power everything**
   * **of these 15 terrawatts, around 2 TW are used as electricity**

* Hi! Welcome to OMSI. My name is\_\_\_\_\_\_\_. Today, we’re going to talk about the energy we use to power our world.
* **Take a look at the globe - can anyone tell what we’re looking at?** (Pause and take answers. Repeat audience answers so everyone can hear).
* This is an image of the Earth at night. **Where do you see more electricity being used?** (Pause and repeat answers.)
* We use many forms of energy, including electricity.
* Today, humans use about **15 Terawatts** of power to run everything in our world. To get an idea of how big a number that is, 1 Terrawatt = 1 trillion watts. 1 trillion is a 1 followed by 12 zeroes.
* **This light bulb uses 15 watts**. Humans use the equivalent of 1 trillion of these lightbulbs at any given moment.
* Of the 15 terrawatts that people use across the world, about 2 Terrawatts is used as electricity.

1. **Air Traffic with Day/Night Terminator** 
   * **globe shows commercial air flights for a 24 hour period**
   * **about 3 – 4 TW are used for transportation**

* We also use a lot of energy to move people and things around the world.
* **Any guesses what those moving yellow dots represent?** (Pause for answers). Each of these yellow dots represents one plane. The researcher who made this image plotted all the GPS records for commercial airplanes on one day. This is only about 1/3 of all flights. It doesn’t include military, cargo, or private planes.
* Planes aren’t the only way to move things around. **What else do we use to move people and things around?** (Pause for answers – cars, trucks, trains, ships, etc.)
* Imagine adding on the paths of all those things over the planes.
* Of the 15 terrawatts that we use world-wide to power everything, about 3 to 4 watts is used just for transportation.
* Where does the rest go? Industry, powering homes and commercial buildings, and changing fuel to an energy form we can use.

1. **Earth At Night (PIP: Terrawatt Challenge)**

* Next, I have a matching challenge for you. Can you match how much power the following things need?
  + a toaster
  + a laptop computer in sleep mode
  + a plane
  + a power plant
  + the world
* Explain the following units to visitors:
  + MW = megawatt, which is 1 million watts
  + GW = gigawatt, which is 1 billion watts
  + TW = terawatt, which is 1 trillion watts

1. **Earth At Night (PIP: Terrawatt Answers)**

* Here are the answers:
  + A laptop in sleep mode 1 watt
  + A toaster 1000 watts
  + A plane 1 megawatt (MW)
  + A power plant 1 gigawatt (GW)
  + The world 15 terrawatts (TW)

1. **X-Ray Sun (PIP: Photosynthesis):**
   * **fossil fuels come from ancient plants and are sources of stored solar energy**
   * **fossil fuels are not renewable**
   * **solar energy is renewable**
   * **enough solar energy strikes Earth every hour to power human activities for over a year**

* All those things computers, planes, toasters need energy to run.
* Currently, the majority of the energy we use comes from burning fossil fuels, such as coal, oil, petroleum, and natural gas.
* **Does anyone know why they are called fossil fuels?** (Pause for answers). Because they are fossils. They are the remains of ancient plants, and phytoplankton and zooplankton, tiny organisms that live in oceans and lakes.
* Plants and phytoplankton use photosynthesis to convert sun light into chemical energy, stored as carbohydrates and sugars.
* Fossil fuels are nature’s way of storing converted sunlight from long dead plants and phytoplankton, buried and compressed over millions of years.
* Today, with the world’s heavy dependence on fossil fuels, we are using this energy source much quicker than it can be replaced. This is why fossil fuels are considered nonrenewable.
* There are many energy sources that are renewable – they are replaced quicker than we can use them.
* Solar energy is renewable – it’s replaced much faster than we can use it.
* If we could harness it, enough solar energy strikes the Earth every hour to power human activities for over a year.

1. **X-Ray Sun (PIP: Solar Techonologies)**

* There are different technologies that use solar energy.
* Slide #1 Passive solar - these include various techniques that can be used in homes to keep houses at a comfortable temperature year round, such as putting windows on the south side for more sunlight and insulation to prevent heat loss during the winter.
* Slide #2 Solar water heating – this device uses solar energy to directly heat water.
* Slide #3 Solar concentrators – dish shaped mirrors concentrate sunlight onto one area.
* Slide #4 Photovoltaic – solar cells convert solar energy to electricity. They can be put on houses and commercial buildings.
* Have volunteers try shining the utility light on the solar toys and see what happens.
* These toys use photovoltaic cells, also called solar cells. Solar cells take light energy and turn it into electricity. We use much larger solar cells to convert sunlight into electricity for our homes and our power grids.

1. **Photovoltaic (PV) Land Requirements** 
   * **6 areas (250 miles x 250 miles) filled with photovoltaics could power all human energy requirements**
     + - The United States uses about 3 TW of power.
       - A scientist from Caltech University figured out that we can power everything in the US by covering an area 250 miles by 250 miles with solar cells.
       - 6 such areas could power everything in the world.

(Source: Nate Lewis, Caltech, <http://nsl.caltech.edu/energy>)

* + - * **What are some of the challenges with solar energy?**
      * Solar energy with current technology is still 2 to 10 times more expensive than oil or coal.
      * What happens when the sun isn’t shining? We need a cheap, efficient way to store energy.

1. **Solar Insolation (quarter view)**
   * **Germany is the current leader in solar electricity**
   * **even cloudy Portland gets more sun than Berlin**

* Solar insolation measures the amount of solar energy reaching a given area at the Earth’s surface in a given time.
* Germany is the current world leader in solar energy. In 2006, Germany generated over 2200 gigawatt-hrs of electricity from solar power, which was about 4 times the electricity generated in the United States.
* If you’ve lived in Portland, you know that Portland is often cloudy. **Is there enough sun in Portland to justify putting solar cells on your roof if you live in Portland?**
* Look at and compare the solar insolation values for Oregon (about 3.5 kWh/m2 – kilowatt-hour/meter2 in Portland), Arizona (about 5.5 KWh/m2 for Phoenix), and Germany (about 2.7 kWh/m2 for Berlin).
* Germany has installed more solar energy systems per capita than any other country even though it gets less sun than we do in Portland.
* Many homeowners and businesses in Germany and Spain installed solar panels on their homes because it was heavily subsidized by the government.

**Conclusion**

* Solar power isn’t the only answer. A cleaner energy future will require a mix of using more energy efficient equipment, and a mix of different renewable energies depending on what makes the most sense for the area.
* Does anyone have any questions?
* Thank you all for coming. Have a great visit to OMSI

#### BACKGROUND INFORMATION

1. **Earth at Night** 
   * The current world population is around 6 billion. By the year 2050, the population is projected to be 9 – 10 billion.
   * The world now uses about 15 Terawatts, and this amount is expected to triple by 2050 if we continue at the current rate of power use, and assuming a future population of 10 billion.
   * If we incorporate energy conservation and efficiency measures, then energy use is expected to double instead of triple by 2050.

<http://ncbase.wordpress.com/2008/06/21/the-economist-on-alternative-energy/>

1. **Air Traffic with Day/Night Terminator** 
   * Where does the 15 Terrawatts go?

- Electricity 2 TW

- Transportation 3-4 TW

- Changing fuel to energy we can use 4 TW

- Industry 5-6 TW

- Building: commercial and residential 2 -3 TW

These numbers total over 15 since there is overlap between the different areas.

<http://www.scientificamerican.com/article.cfm?id=a-path-to-sustainable-energy-by-2030>

<http://www.scientificamerican.com/article.cfm?id=powering-a-green-planet>, Powering a Green Planet: Sustainable Energy, Made Interactive

1. **X-Ray Sun (PIP: Photosynthesis):**

Many renewable energy sources also ultimately get their energy from the sun. These include: geoexchange (using heat from the surface of the Earth), biofuels, wind, wave, and tidal.

1. **X-Ray Sun (PIP: Solar Technologies)**

Slide #1- passive house design

* Highest energy standard can reduce heating energy consumption by 90%.
* Heating by **passive solar gain** and internal gains from people, pets, electrical equipment, etc.
* Super insulation and “air-tight” building shell to minimize energy losses.
* Ventilation system with high efficiency heat recovery system for fresh air and excellent indoor air quality.

<http://www.passivehouse.us/passiveHouse/PassiveHouseInfo.html>

Slide #2- solar water heater in Cirque de Mafate, Réunion- French island in Indian Ocean

Slide #3- photovoltaics

Slide #4- solar concentrators (dish/Stirling engine units): parabolic dish of mirrors concentrates sunlight onto central engine/power conversion unit to produce electricity

<http://www1.eere.energy.gov/solar/dish_engines.html>

<http://www1.eere.energy.gov/solar/csp_basics.html>

1. **Photovoltaic (PV) Land Requirements**

* The US uses about 3 TW (red box). “The nation’s entire energy needs could be met by tiling a 400 x 400 km (250 miles x 250 miles) parcel of land with solar panels”.
* The amount of new energy generating capacity these 6 squares represent is like building 50 new Exxon Mobil industries.
* Coal and natural gas cost about 5 cents or less per kilowatt.
* Photovoltaic systems (solar panels) cost about 24 to 50 cents per kilowatt-hour.
* Solar thermal systems costs about 10 to 15 cents per kilowatt-hour.

Source: Nate Lewis, Caltech, <http://nsl.caltech.edu/energy>

1. **Solar Insolation (quarter view)**

The boom in solar electricity generation in European countries like Germany and Spain has been spurred by “feed-in tariff” systems, where the government requires utilities to pay premium rates to homeowners and businesses that produce green electricity. Utilities pay homeowners for electricity that they generate and don’t use.

Data source: NASA Surface meteorology and Solar Energy (SSE) Release 6.0 Data Set (Jan 2008), 22-year Monthly & Annual Average (July 1983 - June 2005), <http://eosweb.larc.nasa.gov/sse/>

#### RESOURCES

**Global Energy Challenge**

1. Caltech (Nate Lewis)- Powering the Planet references at <http://nsl.caltech.edu/energy>
2. Stanford/UC Davis (Jacobson and Delucchi)- <http://www.scientificamerican.com/article.cfm?id=a-path-to-sustainable-energy-by-2030>, <http://www.scientificamerican.com/article.cfm?id=powering-a-green-planet>, Powering a Green Planet: Sustainable Energy, Made Interactive)
3. Economist (Geoffrey Carr, science editor)- <http://ncbase.wordpress.com/2008/06/21/the-economist-on-alternative-energy/>

**General Renewable Energy**

1. NREL (<http://www.nrel.gov/learning/>)
2. <http://en.openei.org/wiki/Main_Page>
3. EIA (<http://www.eia.doe.gov/>)
4. EIA Energy Kids (<http://www.eia.doe.gov/kids/energy.cfm?page=renewable_home-basics>)
5. <http://www.oregon.gov/ENERGY/RENEW/index.shtml>
6. <http://www.portlandonline.com/bps/index.cfm?c=41462>

**Renewable Energy Data and Maps**

1. <http://en.openei.org/wiki/Gateway:U.S._OpenLabs/Exploring_Resources>
2. <http://www.nrel.gov/gis/mapstore/>
3. <http://www.nrel.gov/rredc/>
4. <http://www.geni.org/globalenergy/library/renewable-energy-resources/index.shtml>

#### GLOSSARY

**Energy** = capacity to do work; measured in units of kilowatt-hour (kWh)

**Power** = rate of using energy; measured in units of watt

**1 watt** = 1 Joule/ second

**Insolation** = the solar radiation that reaches the Earth’s surface