Energy On a Sphere: Renewable Energy Resources

Paul Phongsavan, Minority Educational Institution Student Partnership Program
Department of Energy
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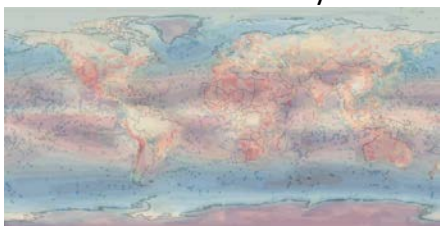
Dataset/Sources	Key Points	Visual
Science on a Sphere: Blue Marble and Nighttime Lights Key points Source: EIA EIA Kids	Introduction *Blue Marble and Nighttime Lights* Energy is defined as the ability to do work. It is involved in every activity that we do. We use energy to power our homes, drive our cars, and charge our phones. We get this power through the use of various resources such as nuclear power plants, coal burning, or hydroelectric dams. Resources such as these can be defined as renewable and non-renewable. Renewable resources can be easily replenished while non-renewable resources cannot. The most common resources used today are non-renewable, which account for nearly 80% of all energy use in the world. However non-renewable resources are abundant and can be found all over the world. Renewable energy has many benefits including reducing emissions and water consumption related to energy needs.	Blue Marble and Nighttime Lights 
Renewable Resources Combined: Solar, Wind, and Geothermal Energy	These renewable resources come in a wide range from geothermal to tidal energy and can provide a large amount of energy to everyone. These resources can be tapped to provide a clean energy future that is sustainable and can be an important tool to combat climate change. Featured here are solar, wind and geothermal.	Combined Resources Layer 

Heat Conductivity

Key Points Source: THE GLOBAL HEAT FLOW DATABASE OF The INTERNATIONAL HEAT FLOW COMMISSION

Site Provided by the University of North Dakota
Database Site Metadata

Data Used: Column 12: Conductivity of Boreholes. Conductivity indicates the ability of the site to transfer heat. Higher values indicate a greater ability to transfer heat to the circulating fluid or material used.

Key points Sources:
EIA Kids
Energy.gov

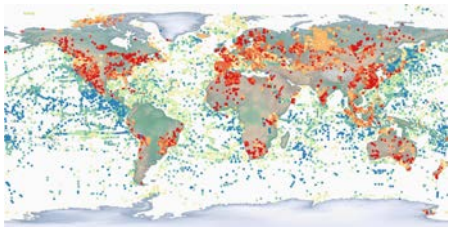
Geothermal Energy

- Geothermal energy is generated in the earth's core. Temperatures hotter than the sun's surface are continuously produced inside the earth by the slow decay of radioactive particles. Note: The temperature at a given depth can vary a lot. Therefore, it is hotter close to the surface.

Turn on Geothermal Power Plant Layer

- We use the heat by drilling wells into the earth and then piping steam or hot water to the surface. The hot water or steam is used to operate a turbine that generates electricity.
- Geothermal energy is renewable and has very little impact on the environment.
- Geothermal power plants produce electricity 24 hours per day / 7 days per week.
- Geothermal power plants do not burn fuel to generate electricity, so the levels of air pollutants they emit are low. They release less than 1% of the carbon dioxide emissions released by a fossil fuel plant.
- Some geothermal wells may be as deep as two miles!

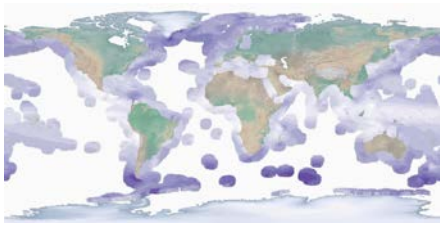
Global Heat Conductivity



Geothermal Power Plant Layer

Wind Speeds at 50m above the Earth's Surface – Monthly and Annual Average 1983 - 1993 Source: NASA Surface meteorology and Solar Energy (SSE) Release 5 Data Set 10-year Monthly & Annual Average (July 1983 - June 1993) Wind Speed At 50 m Above The Surface of the Earth (m/s) Openei Data Used: Average Wind speed at 50m above the surface over a ten year period from July 1983- June 1993 Key points Sources: EIA Kids Energy.gov EPA's Clean Power Plan Report	*Wind Energy* ● What is it? ○ Wind is caused by the uneven heating of the earth's surface by the sun. As the air in different locations is heated differently, it causes the air to circulate in complex patterns. We experience this moving air as wind. ***Turn on Turbines Layer*** ● Wind Turbines ○ Wind turbines use blades to collect the wind's kinetic energy. Wind flows over the blades creating lift (similar to the effect on airplane wings), which causes the blades to turn. The blades are connected to a drive shaft that turns an electric generator, which produces electricity. ○ Wind turbines are big. A wind turbine blade can be up to 260 feet long, and a turbine tower can be over 328 feet tall -- taller than the Statue of Liberty. ● Wind power could help America combat climate change by avoiding more than 12.3 billion metric tons of carbon pollution cumulatively by 2050, the equivalent to avoiding one-third of global annual carbon emissions.	Global Wind Speeds  Turbines Layer  http://www.eia.gov/kids/energy.cfm?page=wind_home#top-container

	• Windmill Technological Developments
	  ○ Lower Cost
	  ○ Bigger Windmills which give higher altitude where there is stronger, more consistent wind	

Wind Speeds Offshore at 10m – 90m above the Earth's Surface
 	
Source:
Wind resource based on NOAA blended sea winds and monthly wind speed at 30km resolution, using a 0.11 wind shear to extrapolate 10m - 90m. Annual average >= 10 months of data, no nulls.
Openei
 	
Data Used:
Annual average wind speed of heights 10m - 90m above the surface of global offshore areas
 	
Keypoints Sources:
Wind Vision
BOEM.gov
	Offshore Wind
	• Potential Capacity
	  ○ Worldwide there are 4.45 GW of offshore wind energy installed.
	  ○ Offshore winds tend to blow harder and more uniformly than on land.
	  ○ The potential energy produced from wind is directly proportional to the cube of the wind speed. As a result, increased wind speeds of only a few miles per hour can produce a significantly larger amount of electricity.
	
	Turn on Offshore Turbines Layer
	• For instance, a turbine at a site with an average wind speed of 16 mph would produce 50% more electricity than at a site with the same turbine and average wind speeds of 14 mph. This is one reason that developers are interested in pursuing offshore wind energy resources.
		Offshore Wind
		 
		
		Offshore Turbines Layer
		 

Solar Irradiance

Source:
NASA Surface meteorology and Solar Energy (SSE) Release 6.0 Data Set
22-year Monthly & Annual Average (July 1983 - June 2005)
Direct Normal Irradiance (kWh/m^2/day)
One Degree Resolution
Openei

Data Used:
Direct Normal Irradiance: The normal amount of sunlight from the direction of the sun at its current point in the sky. The annual average in kWh/m^2/day taken from July 1983 - June 2005

Keypoints Sources:
Energy.gov
EIA Kids

Solar Energy

- Solar energy is sunlight.
- Solar energy is the most abundant energy resource on earth – 173,000 terawatts of solar energy strike the Earth continuously. That's more than 10,000 times the world's total energy use.
- A variety of technologies convert sunlight. The most commonly used solar technology is solar photovoltaics for electricity.

Turn on Photovoltaic Layer

- Solar Energy can be used in two ways
  - Photovoltaic (PV devices) or solar cells change sunlight directly into electricity.

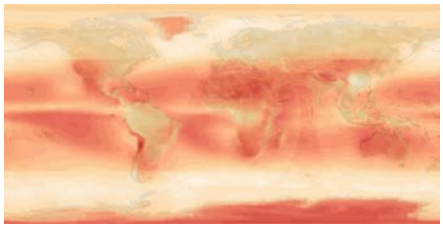
***Turn on Solar Thermal/Electric Plant Layer ***

  - Solar thermal/electric power plants generate electricity by concentrating solar energy to heat a fluid and produce steam that is then used to power a generator.

Turn on Solar Dish Layer

- There are 3 types of Solar thermal plant designs
  - Parabolic Troughs use a curved mirrored trough which reflects the sun onto a glass tube containing a fluid.
  - Solar Dish is the cheapest and one of the most efficient ways to capture solar energy. It is a reflective dish that focuses sunlight onto a single

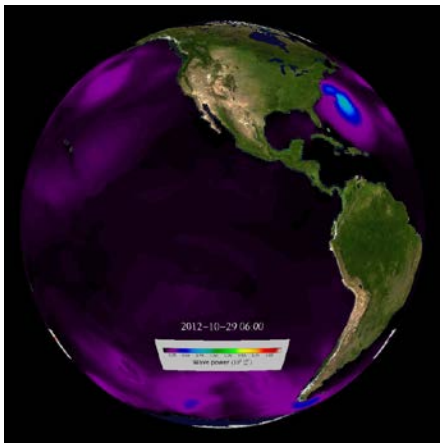
Solar Energy

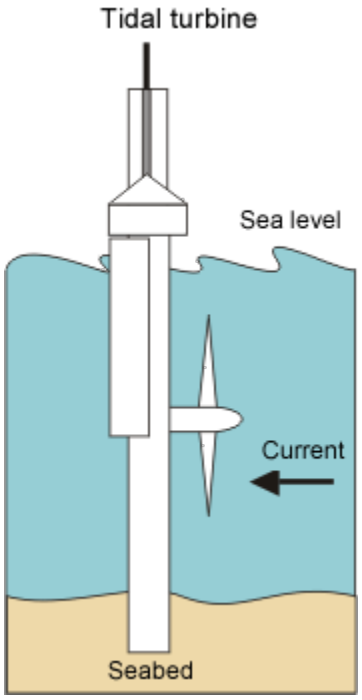


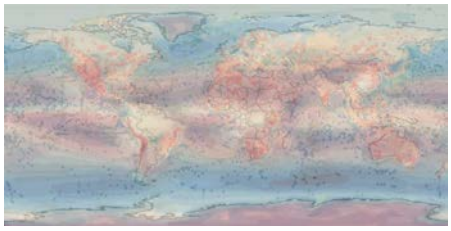
Photovoltaic Layer

Solar Thermal/Electric Plant Layer

Solar Dish Layer

	point above the dish, where a receiver captures the heat and transforms it into a useful form. ○ Solar Power Tower use tracking mirrors to capture and focus the sunlight.	
Wave Power 2012 Data Used: Wave Power Calculations taken from WAVEWATCH III® model that estimates wind driven waves every 3 hours. Source: EIA Kids Energy.gov Energy.gov	*Tidal Energy* The ocean provides incredible opportunities for renewable energy. We can generate clean energy from waves, tides, coastal currents, and thermal gradients. Waves are caused by wind blowing over the surface of the ocean. Wave power works to capture the variety activity of waves as a means of producing electricity. Wave power varies depending on location around the globe. There are several areas that have an abundance of wave energy including the west coast of the U.S., Scotland, Northern Canada, South Africa, and Australia. ● This map of wave calculations uses global and regional wind data to calculate wind-driven wave height every three hours. ● Recoverable resource for electric generation from waves is approximately 1,170 terawatt-hours per year (TWh/year), which is almost one third of the 4,000 TWh of electricity used in the United States each year ● All coastal areas experience two high tides and two low tides over a period of	Wave Power 2012 

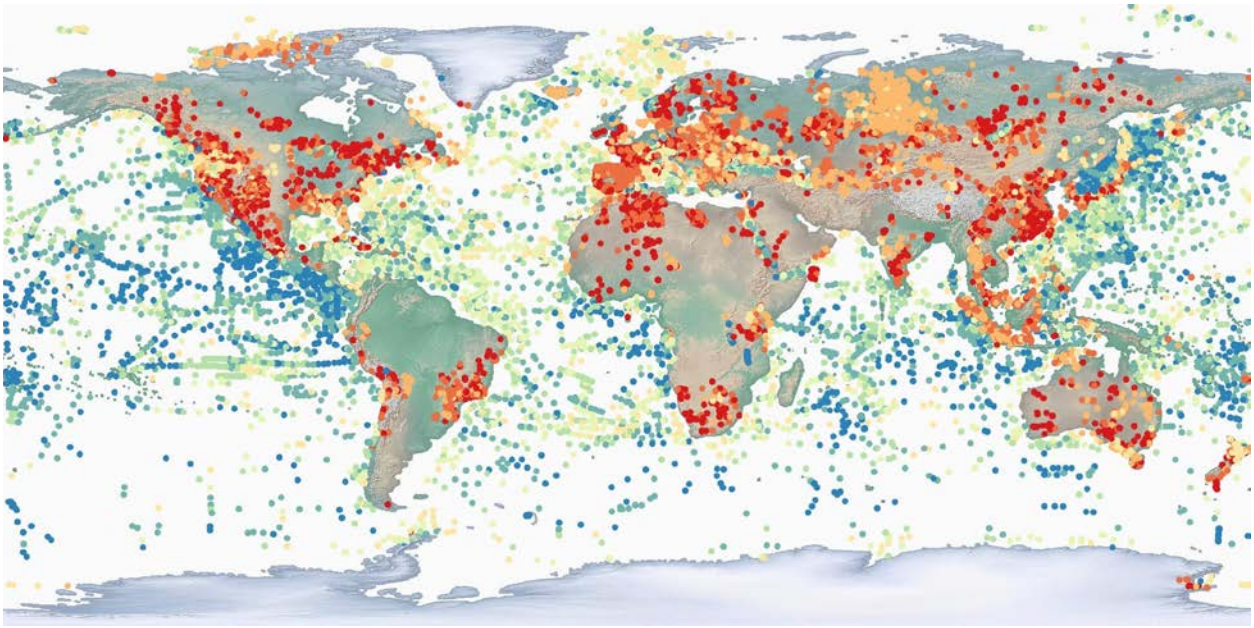
	slightly more than 24 hours. For those tidal differences to be harnessed into electricity, the difference between high and low tides must be more than 16 feet (or at least 5 meters). However, there are only about 40 sites on Earth with tidal ranges of this magnitude. ***Turn on Barrage Layer*** ● A barrage or dam is typically used to convert tidal energy into electricity by forcing water through turbines, which activate a generator. ● They can reach across channels between small islands or across straits between the mainland and an island. The turnstiles spin via tidal currents typical of coastal waters. Some of these currents run at 5–8 knots (5.6–9 miles per hour) and generate as much energy as winds of much higher velocity. ***Turn on Tidal Turbine Layer*** ● They are arrayed underwater in rows, as in some wind farms. The turbines function best where coastal currents run between 3.6 and 4.9 knots (4 and 5.5 mph). In currents of that speed, a 49.2-foot (15-meter) diameter tidal turbine can generate as much energy as a 197-foot (60-meter) diameter wind turbine.	Barrage Layer  Tidal Turbine Layer 

	Turn on Power Plant Layer ● There is another kind of energy from the ocean as well. Energy from the sun heats the surface water of the ocean. In tropical regions, surface water can be much warmer than deep water. This temperature difference can be used to produce electricity. The Ocean Thermal Energy Conversion (OTEC) system uses a temperature difference (of at least 77°F) to operate a turbine to produce electricity.	Power Planet Layer 
Renewable Resources Combined: Solar, Wind, and Geothermal Energy	Conclusion ***Combined Resources Layer*** ● Renewable energy currently provides about 10% of worldwide energy. ● Renewable energy is abundant, has a lower environmental impact and has a great deal of potential to be harnessed. ● Renewable energy technologies are currently being developed to increase efficiency and to expand their use. ● Renewable energies such as wind and solar are some of the fastest growing industries currently.	

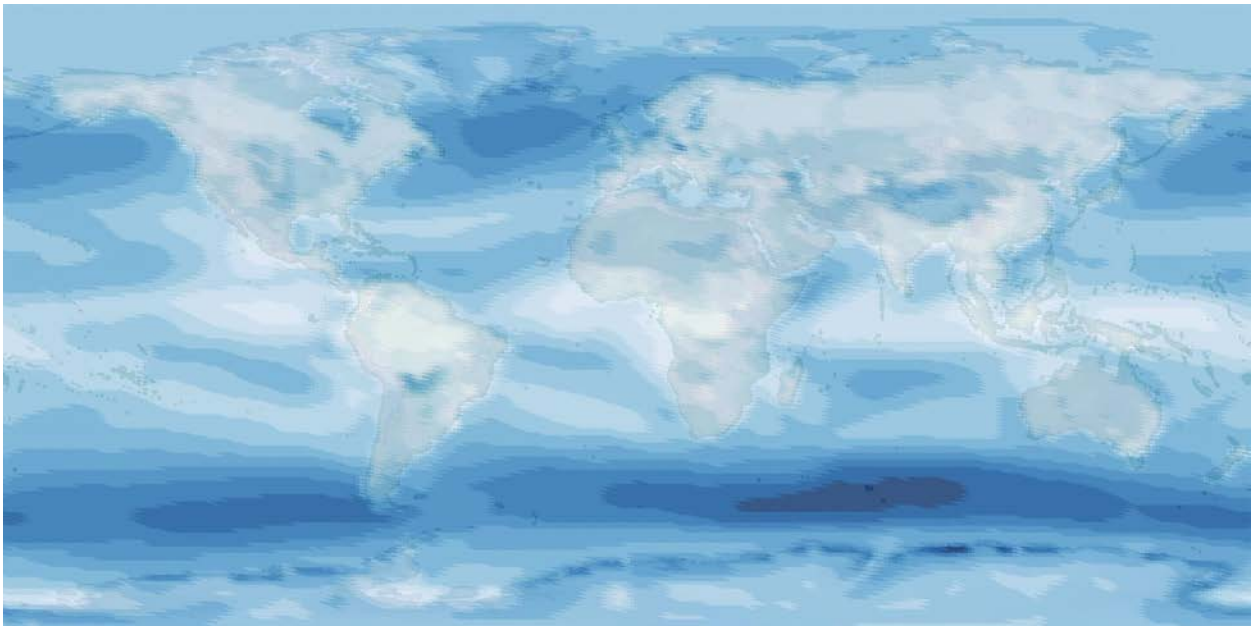
(* *) Indicates an action to be taken or layer to display

Maps

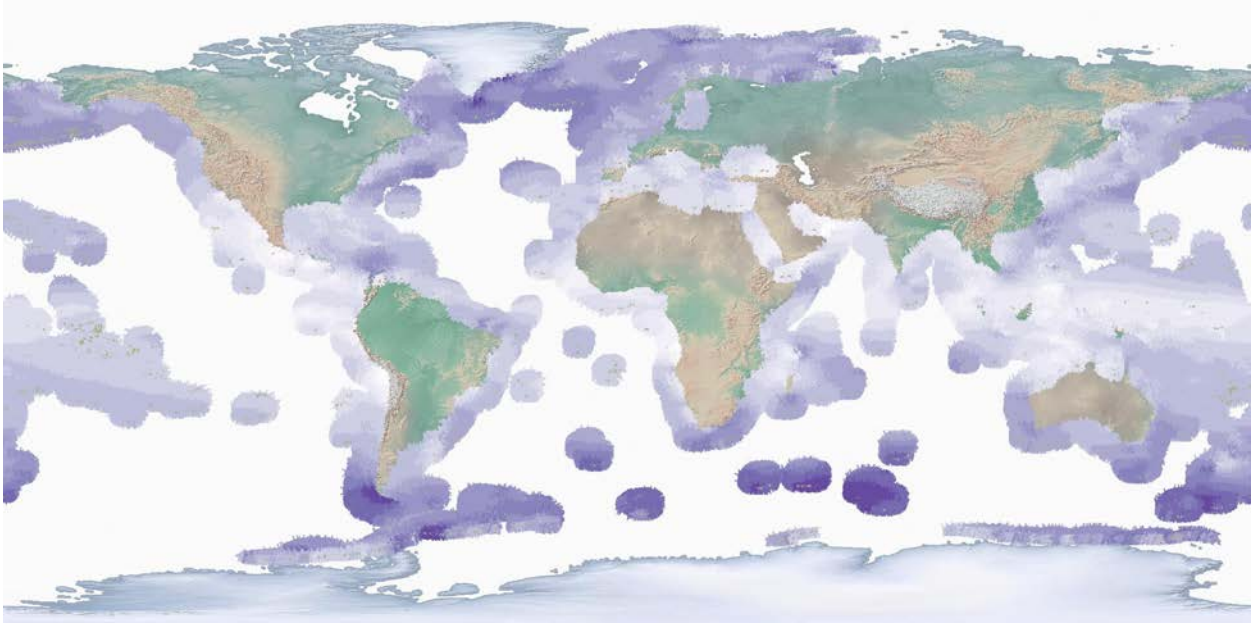
Global Heat Conductivity



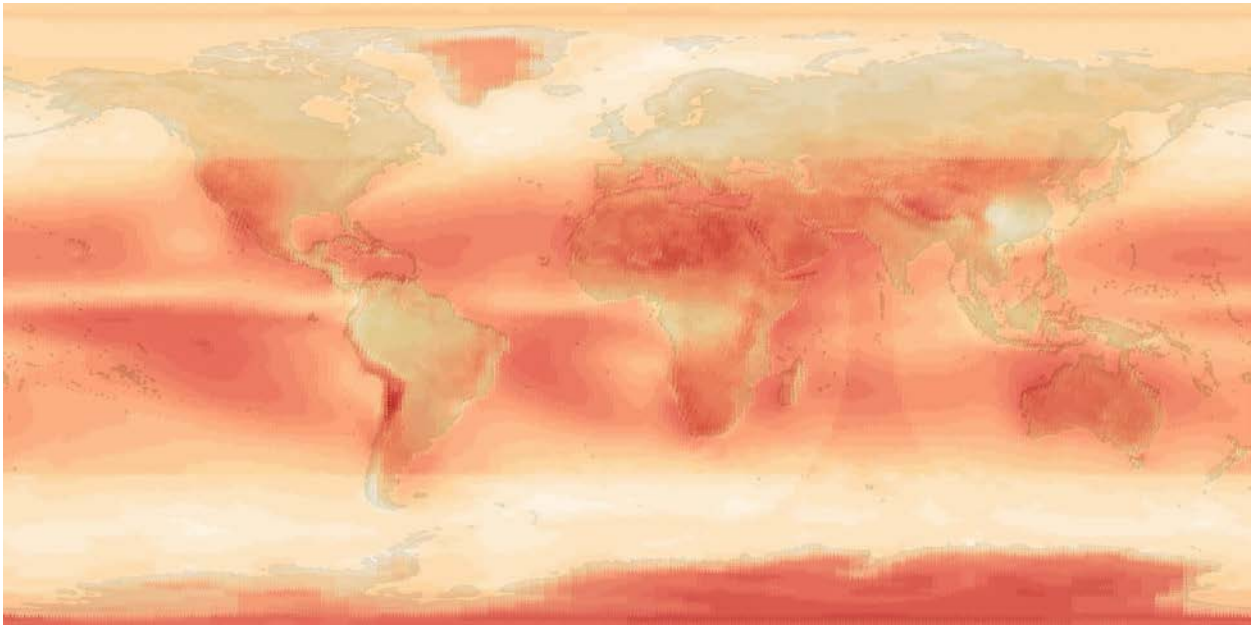
Global Wind



Offshore Wind



Global Solar DNI



Combined Resources (Geothermal, Solar, Wind) Map