## Introduction to Use of Energy Corps Learning Modules and Knowledge Based Questions

Welcome to the Renewable Energy unit! This document will provide you with a guide for educating a variety of age groups on the subject of Renewable Energy. The following pages will outline the most important concepts to cover in any presentation related to a specific topic. It will also supply you with a set of appropriate questions you must ask for each age group as part of any presentation/workshop/other questionnaire you conduct related to Renewable Energy. In addition to providing you with a starting point for your presentation, these questions provide change-in-knowledge data that fulfills your performance measurement requirements. Finally, you will find some tips on how to work with different age groups. These are, however, just a starting point. Including this information in your presentation should be considered a minimum requirement. There are sources included to help you find images and other material for your presentation. We hope this teaching module will help you give effective presentations throughout your term of service. This is a work in progress, and your feedback will help us improve our efforts to deliver information and evaluate the effectiveness of that delivery.

By the end of your presentation, you should have touched on each of the concepts listed below. Student knowledge of each concept will be tested by the questions found in this unit. Each age bracket will contain at least one question relating to each concept. Feel free to go beyond what is listed here and explore concepts in greater depth or detail. These questions and concepts are deliberately broad to allow you to tailor your presentation to a specific audience, region, or topic. Be creative! Contact your site supervisor or state coordinator with any questions.

## Learning Objective

This unit teaches the different types of, and applications for, renewable energy in the United States. Students should also learn the basic incentives available for specific types of renewable energy at the federal, state, and local level.

## Core Concepts

The following are the key concepts that any presentation on Renewable Energy should include.

1. **Renewable Energy Use in the US**
    a. **Power Generation**
    b. **Transportation**
2. **Types**
    a. **Biofuels and Biomass**
    b. **Ground Source Heat Pumps**
    c. **Hydro**

d. **Solar**
    i. **PV**
    ii. **Solar Water Heating/Solar Thermal**
e. **Wind**

3. **Economics and Funding**
    a. **Types of Funding Available**
    b. **State – State Variations and Frequent Changes**

## Explanation of Concepts

### Renewable energy use in the US

Because of all the rhetoric surrounding renewable energy in recent years, it is important to present students with an accurate assessment of the breakdown of energy production in the United States and just how much (or how little) is coming from renewable sources. This information is important and easy to present. There are two main applications for renewable energy in the United States: power generation and transportation fuel.

**Power Generation**

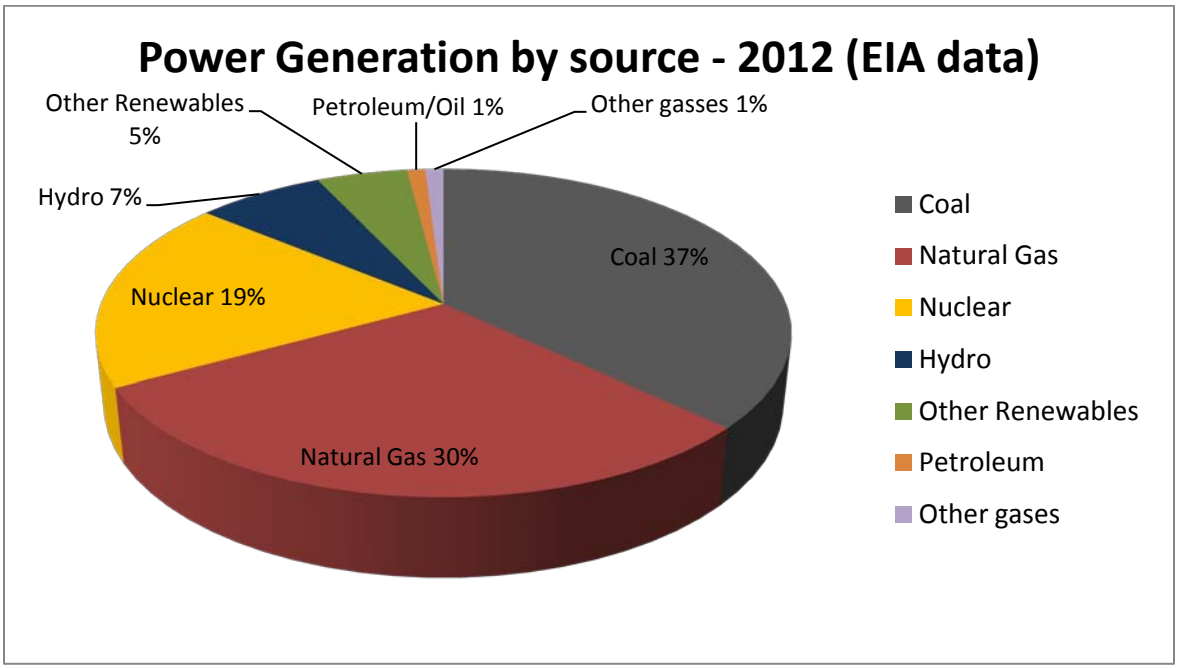


**Figure 1**

**2012 Electricity Generation by power source**

*(Courtesy, US Energy Information Administration, www.eia.gov)*

As can be seen from the charts above and on the following page, renewable sources (including hydro) account for about 12% of US electricity generation, while coal and natural gas combine for 67% and

nuclear sits at a steady 19%. These figures will vary from state to state. Resources like the Energy Information Agency (www.eia.gov) and the American Council for an Energy Efficient Economy (ACEEE – www.aceee.org) offer statistics on states' renewable electricity production and overall efficiency, respectively. Presentations should include data specific to individual states. Each age group also includes a question about where different states rank in terms of renewable energy use. No diagram is included because these statistics can change quickly. Again, ACEEE and EIA are good places to find this information. Always try to use the most up-to-date information possible.

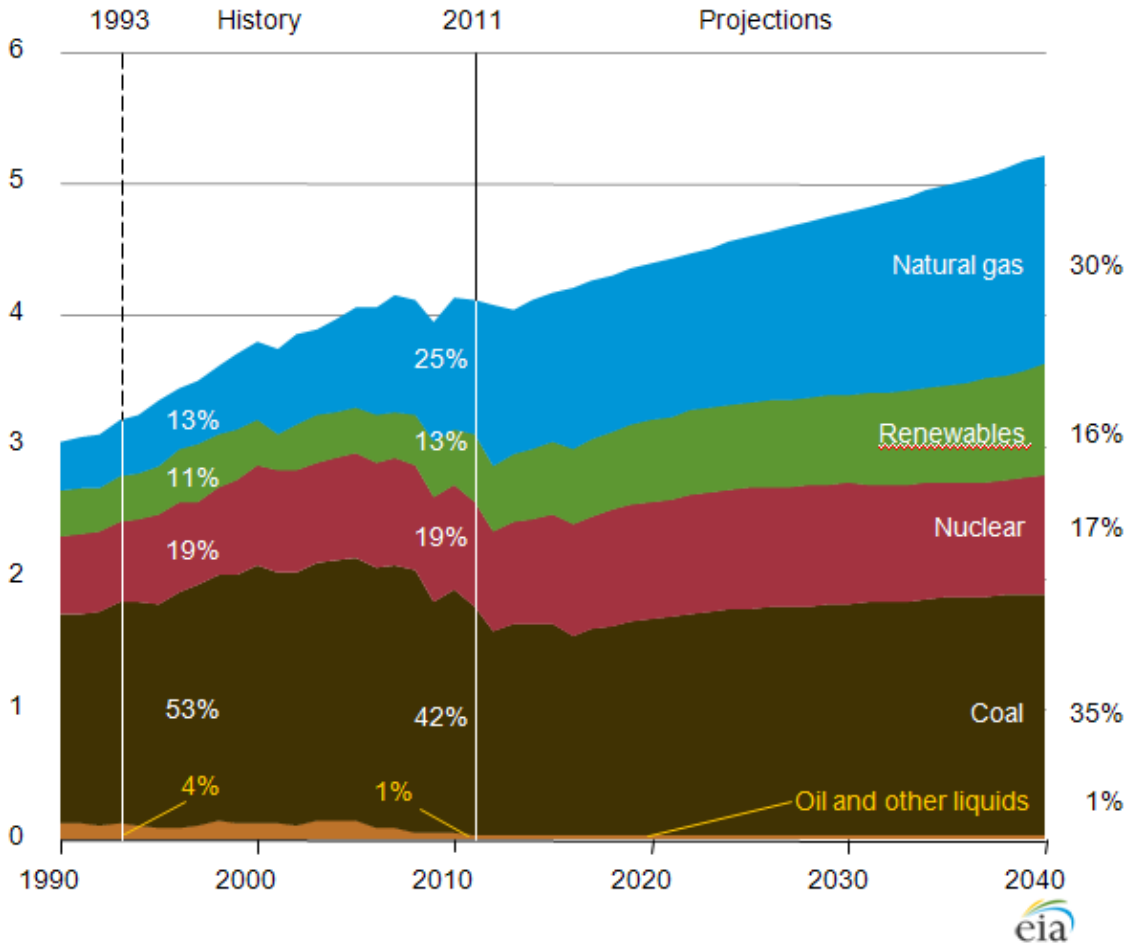


**Figure 2**

**Electricity Generation by fuel 1990 - 2040**

(*Images courtesy of US Energy Information Agency, http://www.eia.gov/forecasts/aeo/er/early_elecgen.cfm*)

**Transportation**

Renewable energy for transportation consists primarily of alternative fuels used in internal combustion engines and falls under the "Biomass" category in this unit. These fuels include ethanol, biodiesel, and a variety of other fuel products derived from natural sources.

## Types of Renewable Energy

**Biomass**: Biomass can be refined to produce Syngas or other alternative fuels. Syngas is a catchall term for gases made up of combinations of hydrogen, methane, carbon monoxide, and carbon dioxide. Syngas and other biomass products can be used as fuel for transportation or electricity generation. Ethanol, a clean burning form of alcohol (the same type of alcohol found in beer, wine, and spirits) can be derived from a wide variety of grains and waste materials and used as fuel in gasoline engines. Biofuels are consistent with the idea of varied, small scale, and local solutions to world energy problems because they can be derived from one or more of any number of different feedstocks. Thus, unlike fossil fuels, different locations can use whatever feedstock is most readily available, be it wood chips, corn stover, baggase, fruit skins, or waste vegetable oil. It is critical to note that, while the end product is essentially the same, biofuels derived from crops grown *specifically for fuel production* raise a host of issues that are not yet fully understood and about which many have grave reservations. Most notable amongst these are water usage, food prices, and land use.

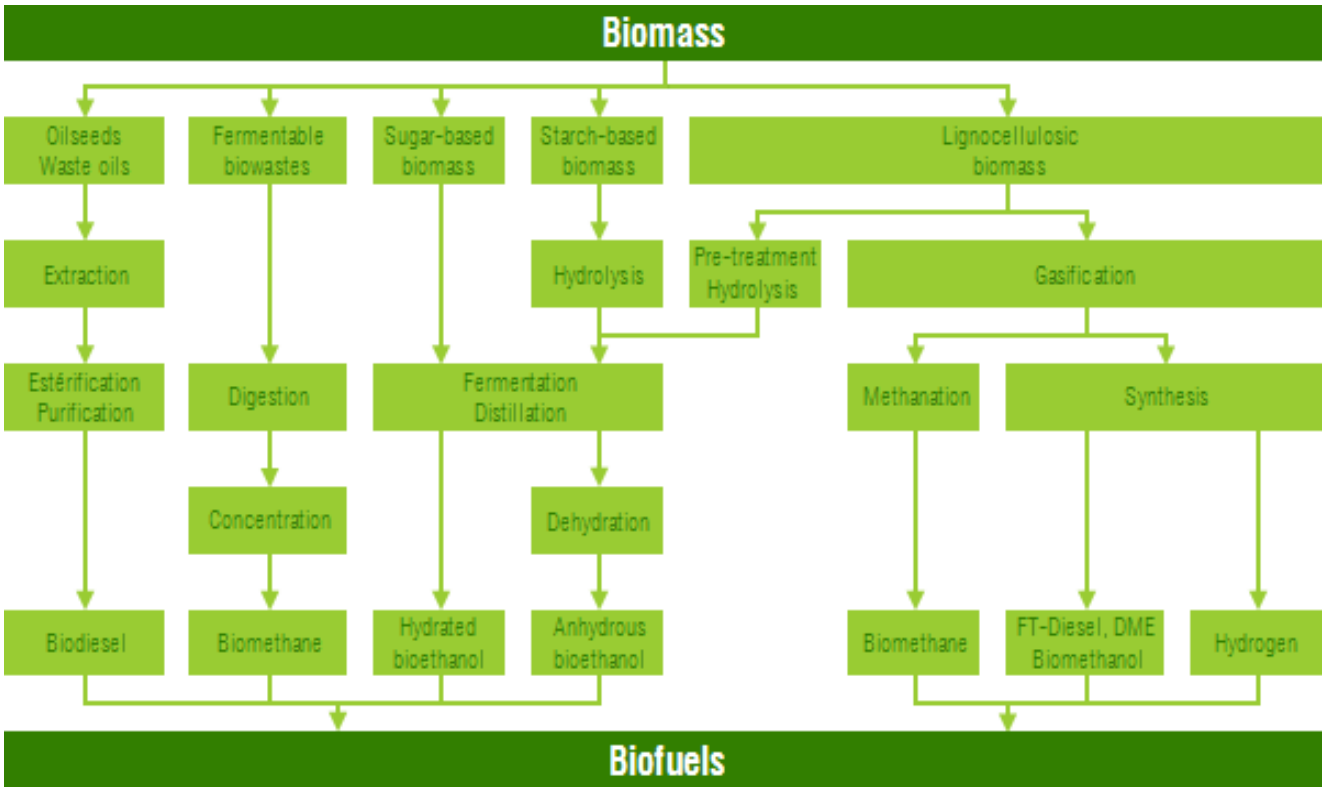


Figure 3

*(Courtesy [www.biofuels-platform.ch](www.biofuels-platform.ch))*

**Ground Source Heat Pumps:** The Earth's inner heat can be exploited to provide heating and cooling in a home. Ground source heat pumps (GSHPs) use the principles of heat transfer along with the relatively

constant heat of the Earth to regulate temperature within a home. (See US Dept. of Energy "Geothermal Heat Pumps" www.energy.gov.) According to the DOE, temperatures in the ground vary by latitude but generally range from 45°F - 75°F. GSHPs (and related water-source heat pumps) are able to heat and cool the house as well as heat water. They work by passing a fluid, usually a mix of water and food-grade antifreeze, through a system of tubing in the ground (or in a body of water). The fluid heats up or cools off in relation to its temperature upon leaving the house, before returning to a heat exchanger in the building. There the heat is exchanged with the refrigerant in the heat pump to be sent throughout the house. In a heating situation, the home's standard heater may further boost the warmer air to a more comfortable level.

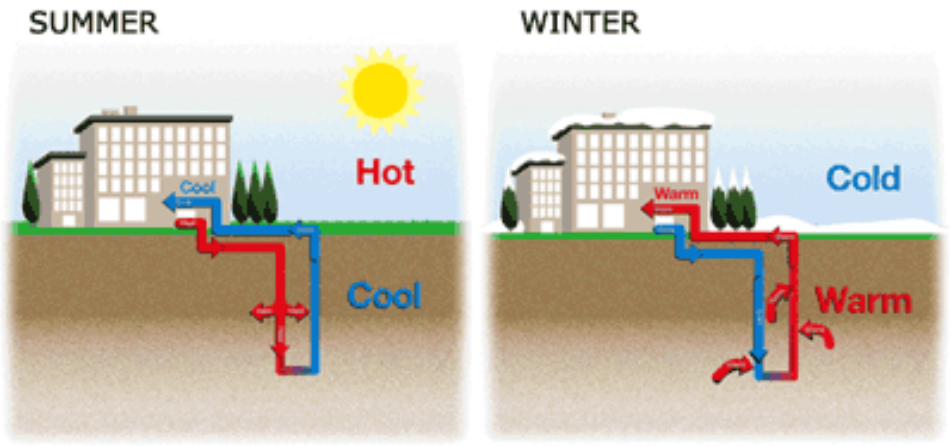


Figure 4

(*Courtesy, US Dept. of Energy www.energy.gov*)

There are a variety of different layouts for the tubing, but generally they are of either the open or closed loop varieties (see figure 5). "Most closed-loop geothermal heat pumps circulate an antifreeze solution through a closed loop – usually made of plastic tubing – that is buried in the ground or submerged in water." (See "Geothermal Heat Pumps" US Dept. of Energy (2012), www.energy.gov.) Open Loop systems use ground or surface water that circulates directly through the pipe system to the heat exchanger. (See "Geothermal Heat Pumps" US Dept. of Energy (2012), www.energy.gov.) The loop can be in a horizontal, vertical, or pond/lake configuration. Pipe is installed at 4 to 8 feet for a horizontal system, or 100 to 400 feet for a vertical system. Just as with any space heating and cooling system, proper sealing of ductwork inside the home is critical to efficient performance. Benefits of a GSHP system include 25 to 50% reductions in electricity compared to conventional heating or cooling systems and substantial associated emissions reductions.

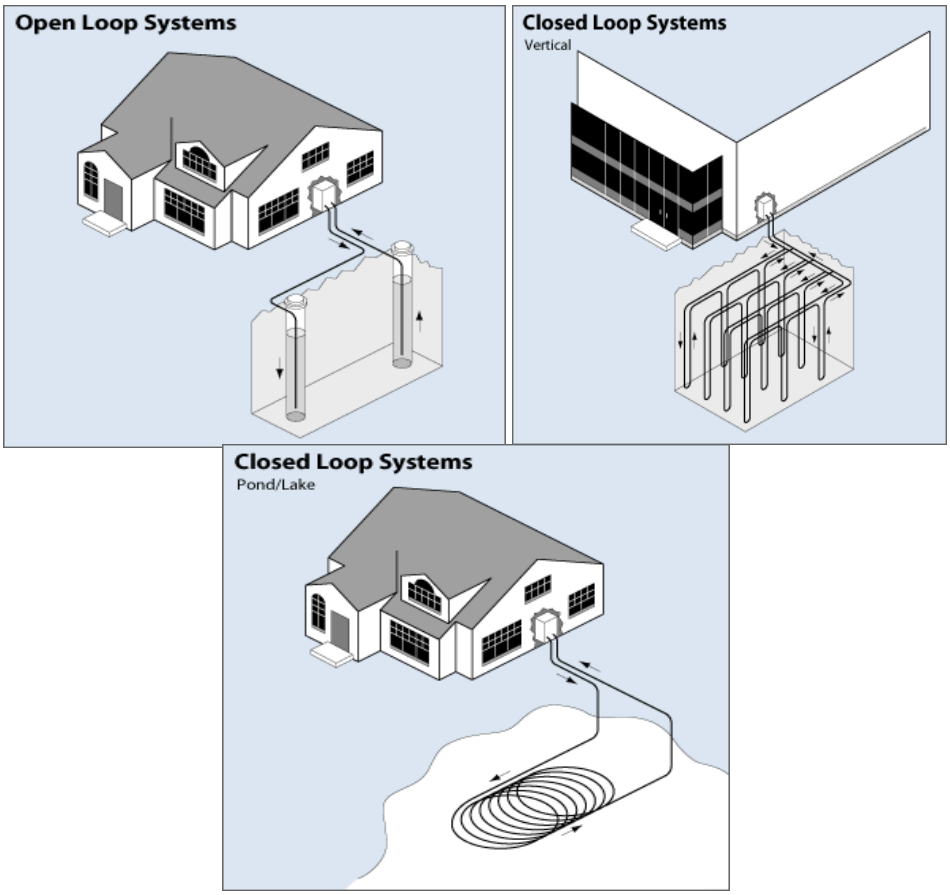


Figure 5 (3 images)

*(Courtesy US DOE www.energy.gov*

**PV Solar:** The sun is our largest and most powerful resource, with approximately 173,000 terawatts of solar energy hitting the Earth at any one moment. According the US Department of Energy, that is "10,000 times the world's total energy use." (US DOE "Top 6 Things You Didn't Know about Solar Energy" www.energy.gov.) As a result, PV solar will function during daylight hours, whether it is sunny or cloudy. This unit focuses primarily on "distributed solar." (See the Key Relevant Definitions section below.) Over the past few years, demand for distributed PV solar in the US has increased, nearly doubling from 2011 to 2012. (See "Solar in Demand" (2012) www.energy.gov.) The distributed-solar marketplace is led by dealer/installers who work directly with customers.

Modern photovoltaic panels achieve an efficiency rate of about 10 to 15%, with the very best in the world hitting 20% or 21%. ("Solar Panel Comparison (2013) www.energyinformative.org.) Weather and total solar potential are concerns and will differ from one location to another. Use NREL and other resources to determine your state's solar potential. Of greater importance is panel orientation and time of year; panels should be facing south or west, and winter months see less solar energy reaching the Northern Hemisphere.

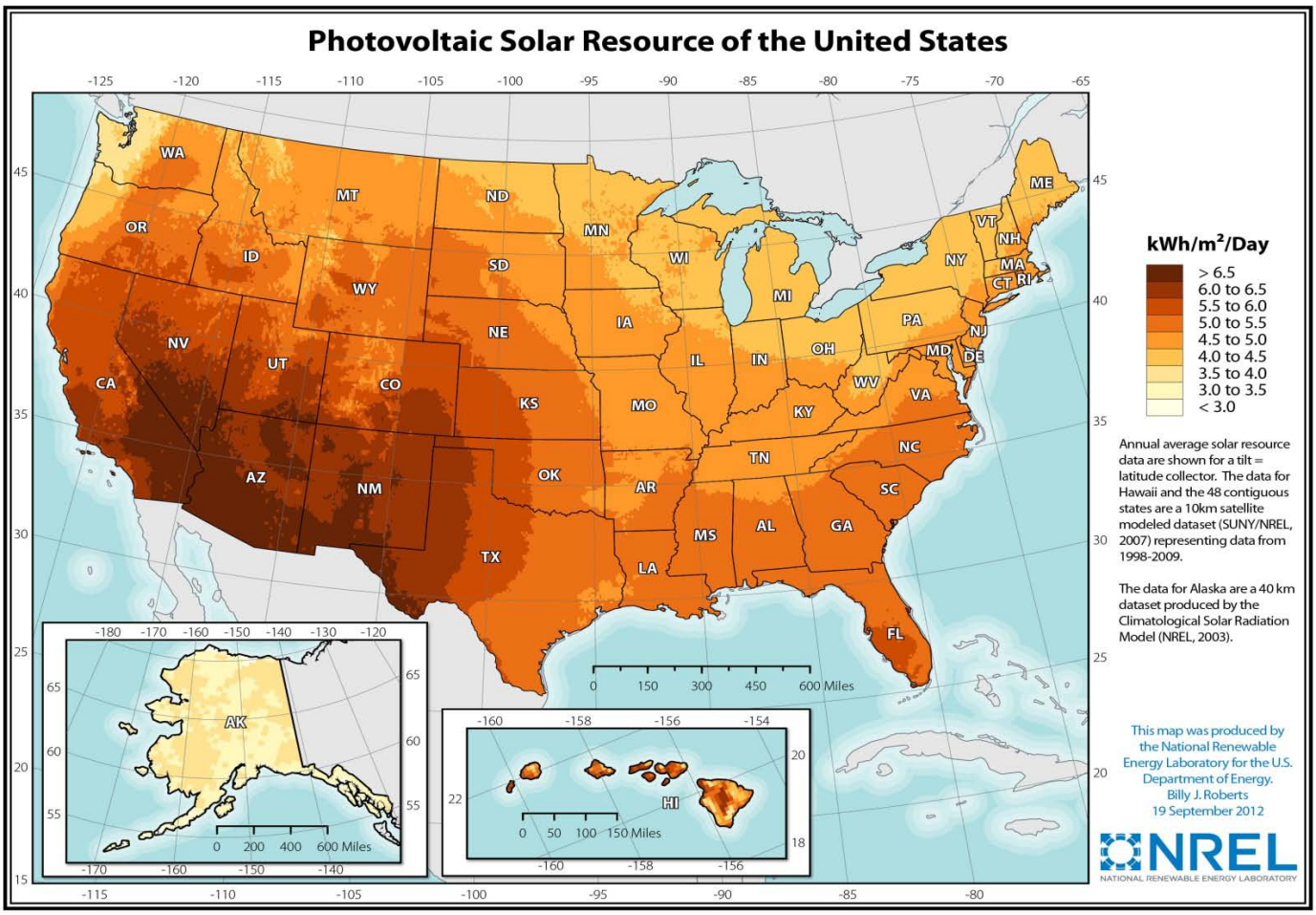


**Figure 6**

(*Courtesy, National Renewable Energy Laboratory, [www.nrel.gov](http://www.nrel.gov)*)

Solar arrays can be grid-tied or off-grid. Almost all electric companies will credit or pay residents for power put into the grid (grid-tied systems). These payments or credits vary from one utility company to the next and are subject to change. They are also critical to the financial feasibility of grid-tied solar. Check with the utility provider(s) in your area to determine what these payments or credits are.

**Solar Thermal**: Solar Thermal, also known as solar water heating, is another application of the sun's energy. The simplest iteration of this technology is a black-colored tank with water in it. Solar energy can be used to heat water for potable or non-potable hot-water uses or for space heating. There are a variety of configurations and several different components. The two broadest categories are active, which uses pumps to circulate the water, and passive, which does not use pumps.

Active solar water heating systems work by pumping water or another heat transfer fluid, (HTF) such as antifreeze, through a solar collector where the energy from the sun heats it. In the case of direct water heating, that water goes back to the tank(s). In the case of an HTF, it is routed through a heat exchanger that then heats the water in the tanks. Passive systems can either be combined storage and collector units, in which the tanks themselves are heated, or they use a "thermo-siphon" system that

uses the movement of warm and cool water to cause circulation. See Figure 9 below for a passive, batch heating system and an active closed loop system using an HTF. Solar water heating is most often used as a way to pre-heat the water before it goes into a standard water heater. Doing so can save a significant amount of money compared to using only a standard water heater – up to 50%.

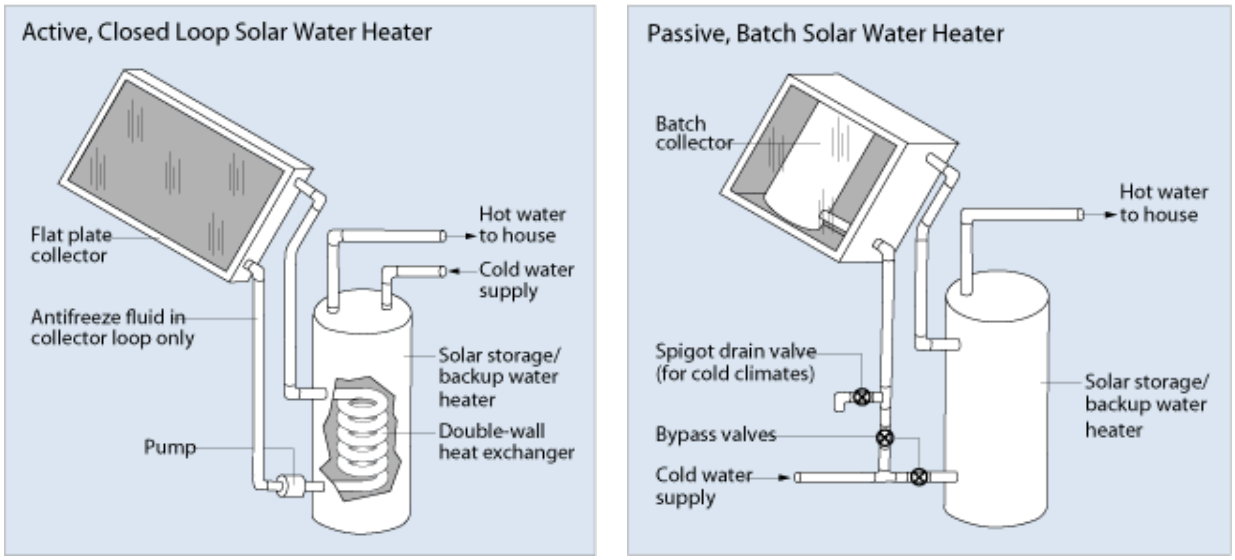


Figure 7

*(Courtesy, US Dept. of Energy)*

**Wind:** This unit covers wind energy in a similar scope as solar (i.e. homes or other small buildings,). The principles of electricity production are roughly the same no matter what the scale. Wind drives a turbine that then drives a generator, which in turn produces electricity. Like PV solar systems, wind power can be off-grid or grid-tied. Batteries, an inverter, and a charge controller are also required, again similar to PV solar.

Wind resources vary across the US (see Figure 10), and measuring the wind speed at a site is a key step to installing a small wind turbine. A minimum wind speed of 4 to 6 mph is generally required for a system to reliably produce electricity. Furthermore, wind increases with height, so a wind turbine at 30 meters might see speeds 30 to 40% less than one at 60 meters. However, according to DOE, code and zoning regulations frequently make installations of greater than 30 meters impossible. Code and zoning are in fact critical considerations with wind, since many turbines cannot be mounted on roofs, and all need to be away from structures or trees that could block them. A further drawback is that residential wind turbines, like all wind power developments, pose a threat to local and migratory bird and bat populations. All of these factors make wind energy highly site specific. Below is a map for wind resources nation-wide at heights of 30 meters. Maps for 60 meters and higher are available at www.nrel.gov.

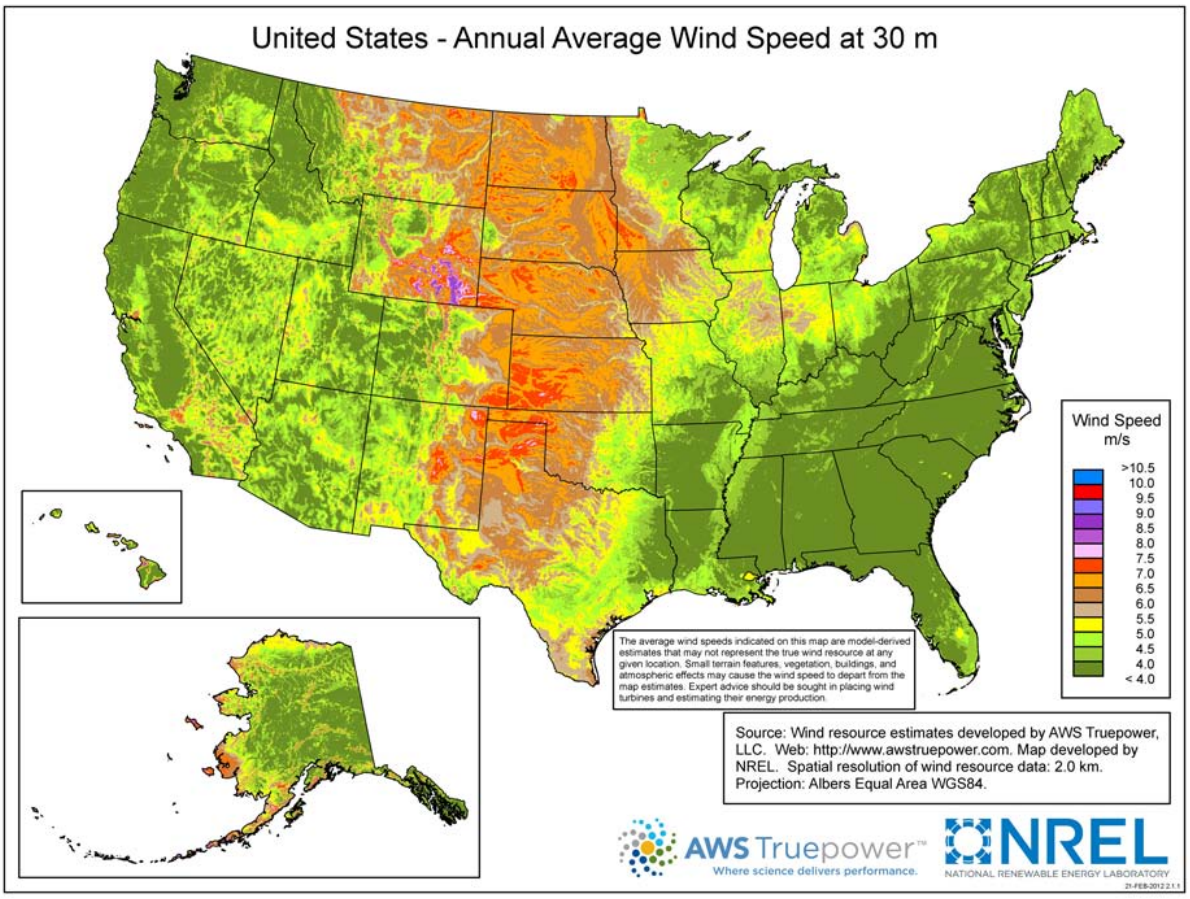


**Figure 8**

(*Courtesy NREL, www.nrel.gov)*

## Economics and Funding

Economics and funding primarily deals with costs and rebates associated with installing or developing alternative energy sources on an individual basis. There are no specific questions included on this concept because costs of systems vary depending on the technology (solar vs. wind vs. biodiesel) and the company. There are many different financial aids available, but they change periodically. For example, there is a 30% Federal tax credit for residential PV solar installations, but this tax credit will expire at the end of 2016, according to current law. On top of that, every state and many cities and towns, utility companies, and even some counties may have some other rebates that are available, but again these change frequently. For businesses, particularly agricultural businesses, grants may be available as well. It is important that your presentation include relevant and up-to-date information on these topics. For the most up-to-date information visit the DSIRE database maintained by North Carolina State University. (www.dsireusa.org) Information about alternative fuel incentives can be found at the Alternative Fuels Data Center Incentives page. (http://www.afdc.energy.gov/laws/)

## Key Relevant Definitions

**Biodiesel:** Biodiesel is a form of diesel fuel manufactured from vegetable oils, animal fats, or recycled restaurant greases. It is safe, biodegradable, and produces less air pollutants than petroleum-based diesel.
(http://www.fueleconomy.gov/feg/biodiesel.shtml)

**Biomass**: Biomass is a clean renewable energy resource derived from the waste of various human and natural activities. It excludes organic material that has been transformed by geological processes into substances such as coal or petroleum.
(http://library.thinkquest.org/06aug/01335/biomass.htm)

**Distributed Solar/Distributed Energy Generation:** Distributed generation (DG) refers to electricity that is produced at or near the point where it is used. Distributed solar energy can be located on rooftops or ground-mounted and is typically connected to the local utility distribution grid.
(http://www.seia.org/policy/distributed-solar)

**Ethanol:** Ethanol (or Bioethanol) is an alcohol-based fuel made by fermenting and distilling starch crops, such as corn. It can also be made from "cellulosic biomass," such as trees and grasses.
(http://www.fueleconomy.gov/feg/ethanol.shtml)

**Fuel Cells:** Polymer Electrolyte Membrane (PEM) fuel cells used in automobiles — also called Proton Exchange Membrane fuel cells — use hydrogen fuel and oxygen from the air to produce electricity.

**Ground Source Heat Pump**: GSHPs are similar to ordinary heat pumps, but instead of using heat found in outside air, they rely on the stable, even heat of the Earth to provide heating, air conditioning, and, in most cases, hot water.
(http://www.consumerenergycenter.org/home/heating_cooling/geothermal.html)

**Inverter:** An inverter is an electric power converter that changes direct current (DC) to alternating current (AC).

**Photovoltaic Effect:** Photovoltaic effect is a process in which two dissimilar materials in close contact produce an electrical voltage when struck by light or other radiant energy. Light striking crystals such as silicon or germanium provides the energy needed to free some electrons from their bound condition. Free electrons cross the junction between two dissimilar crystals more easily in one direction than in the other, giving one side of the junction a negative charge and, therefore, a negative voltage with respect to the other side, just as one electrode of a battery has a negative voltage with respect to the other.

**Semiconductor:** A semiconductor is any of various solid crystalline substances, such as germanium or silicon, having electrical conductivity greater than insulators but less than good conductors.

**Turbine:** A turbine is a rotary engine actuated by the reaction or impulse or both of a current of fluid (such as water, steam, or air) subject to pressure and usually made with a series of curved vanes on a central rotating spindle.
(http://www.merriam-webster.com/dictionary/turbine)

## Some Pointers on Different Age Groups

Part of your job as an Energy Corps member is to be able to work with a variety of age groups. To that end, this unit provides you with questions deemed by NCAT to be appropriate for a given age group. There are three main age groups: grades 3 –5, grades 7 – 9, and upper-high school/ adult. Each set of questions has been designed to shoot for the middle of each age group, with the ability to step up or down one grade level. The upper-high school/adult age group is targeted at a high school junior or senior, assuming most adults have at least that degree of education. Here are a few things to keep in mind when crafting any presentation.

- Some students, particularly younger students, will not have the same concept of "energy" that you do. For example, they may think of energy as the sugar rush they get from candy, or they may not yet have been taught what electricity is. This doesn't mean you can't present to them, but you must account for their level of learning.
- No matter what age, try to assess the educational level of your audience, and don't assume they know what you know.
- If you can coordinate with a teacher/group leader in advance of a classroom visit, do so.
- Have fun and be creative, especially with younger groups. They don't have long attention spans, but they will get excited if something is fun and different.
- If you have an age group not covered by these categories, contact your site supervisor or state coordinator to help you determine which set of questions to use or to make your own set of questions.

### The Questions

We have provided you with the following questions, approximately five for each of the three age groups. They can be found in the following pages.

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### Grades 3 – 5

1. Renewable energy sources account for what percentage of US energy production?
    a. Less than 1%
    b. 5 - 10%
    **c. 10 - 15%**
    a. 20 - 25%

2. A solar cell can produce electricity….
    a. Only when its sunny
    b. When it is sunny or there are just a few clouds
    **c. Any time there is daylight**
    d. A solar cell makes electricity 24 hours per day

3. Which of these uses heat from inside the earth to heat and cool homes?
    a. Coal

**b. Ground source heat pumps**
c. Natural gas
d. Solar

4. Which of these generates more electricity in the United States?
   **a. Coal power plants**
   b. Hydroelectric power plants
   c. Nuclear power plants
   d. Wind farms

5. Which energy source provides most of our transportation needs?
   a. Solar
   **b. Petroleum**
   c. Biomass
   d. Coal

## 7 – 9

1. Renewable energy sources account for what percentage of US energy production?
   a. Less than 1%
   b. 5 - 10%
   **c. 10 - 15%**
   e. 20 - 25%

2. What minimum wind speed is recommended in order to produce electricity from a residential wind turbine?
   a. 1 - 3 mph
   **b. 4 – 6 mph**
   c. 7 – 9 mph
   d. 10 – 12 mph

3. Which of these is a component of **both** Grid-tied and Off-grid solar systems?
   a. Batteries
   **b. Inverter**
   c. Charge controller
   d. All of the above

4. Which of the following is true of biofuels produced from locally available waste biomass?
   **a. Biofuel production from waste uses locally available resources.**
   b. Biofuel production from waste results in more wastes to dispose of.
   c. The use of biofuel produced from waste emits more CO2 than fossil fuels.
   d. Locally available waste biomass is more expensive to access and transport than crude oil.

5. Ground Source Heating systems take advantage of the relatively constant temperature found between 6 and 400 feet below the surface of the Earth, in the Crust layer. What is that temperature?
    a. 0 - 30$^{o}$ F
    **b. 45 - 75$^{o}$ F**
    c. 80 – 110 $^{o}$ F
    d. 120 – 150 $^{o}$ F

## High School – College/Adult

1. Renewable energy sources account for what percentage of US energy production?
    a. Less than 1%
    b. 5 - 10%
    **c. 10 - 15%**
    d. 20 - 25%

2. What is the current approximate maximum efficiency reached by a solar panel?
    **a. 10 – 15%**
    b. 25 – 35%
    c. 45 – 55%
    d. 90 – 100%

3. For a horizontal Geothermal Heat Pump System in a residential application, how deep do you have to dig to install the piping
    **a. 4 – 8 feet**
    b. 10 – 15 feet
    c. 50 – 65 feet
    d. Over 100 feet

4. How much can a solar thermal water heating system reduce your water heater's energy use?
    a. 10%
    b. 25%
    **c. 50%**
    d. 75%

5. Ethanol for use as fuel can be derived from waste products. Which of the following can be used to make ethanol fuel?
        I. Wood Chips
        II. Bagasse (waste from sugar cane processing)
        III. Fruit rinds and stems
        IV. Spoiled crops

a. None of these
b. IV only
c. II, III, and IV
**d. All of these**

That ends the questions part of this unit. We encourage you add your own questions to these.

## Some Sources to Get You Started

Except where noted, all the questions above were developed from information from these sources.

**American Council for an Energy-Efficient** Economy – www.aceee.org

One of the most comprehensive national resources available. Can be tricky to navigate, but it is full of information on any a wide range of topics.

**DSIRE Database** http://www.dsireusa.org/

A database maintained by North Carolina State University, the US Department of Energy, and the Interstate Renewable Energy Council. It contains information on rebates available at the utility, local, state, and federal level for all 50 states and the District of Columbia. It also has a wide range of other information on various topics related to renewable energy.

**National Center for Appropriate Technology** – www.ncat.org

Your own organization! ATTRA, Energy Corps, and NCAT have a wealth of resources available, including the experiences of staff and other Energy Corps members.

**National Energy Education Development Project** – www.need.org

An organization with a set of teaching manuals and "infobooks" covering all age groups.

**National Renewable Energy Laboratory (NREL)** http://www.nrel.gov/

A national resource that includes nation-wide energy resource maps

**United States Dept of Energy** - www.energy.gov

Federal energy organization has many resources available and can also link you to many other government websites, including the EPA's Energy Star program.

**U.S. Energy Information Administration** – www.eia.gov

Similar to DOE.

**Feel free to find your own sources to supplement these! Have fun and good luck!**