GEOTHERMAL ENERGY

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created by the

Geothermal Education Office

for the

Oregon Department of Energy

with the support of the

Bonneville Power Administration

Distributed with the support of the Geothermal Program at the

Idaho National Engineering Laboratory: (208) 526-9824

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Printed on Recycled Paper

ACKNOWLEDGEMENTS

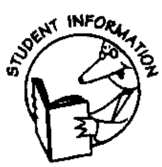
The authors greatly appreciate the expert assistance of the following teachers and geothermal industry professionals:

David Anderson........................ Geothermal Resources Council, Davis, CA
Ron Beaulieu........................ Banks Jr. High, Banks, OR
Jerry Black........................ Dept of Geology & Mineral Industry, Portland, OR
Gordon Bloomquist........................ Washington State Energy Office, WA
Cheryl Butler........................ Sisters Middle/Senior School, Sisters, OR
Anna Carter........................ Vulcan Power Co., Eugene, OR
Gene Culver........................ GeoHeat Center, O.I.T., Klamath Falls, OR
George Darr........................ Bonneville Power Administration, OR
Ken Dragoon........................ Bonneville Power Administration, OR
Domenic Falcone........................ Creston Financial Group, Inc., Oakland, CA
Bob Greider........................ Geologist, Encinitas, CA
Bo Hanson........................ High Desert Middle School, Bend, OR
Rosa Hemphill........................ Oregon Episcopal School, Portland, OR
Susan Hodgson........................ California Dept. of Conservation, Sacramento, CA
Judith Holtzinger........................ Oregon School for the Deaf, Salem, OR
Gladys Hooper........................ U.S. Department of Energy, Washington, DC
Al Hughes........................ Eugene Water and Electric Board, OR
Paul Iverson........................ Nevada Department of Minerals
John Kauffman........................ Idaho Water Resources Research Institute
Joe LaFleur........................ Consulting Geologist, Springfield, OR
Paul Lienau........................ GeoHeat Center, O.I.T., Klamath Falls, OR
Marcelo Lippmann........................ Lawrence Berkeley Laboratory, Berkeley, CA
John Lund........................ GeoHeat Center, O.I.T., Klamath Falls, OR
Roy Mink........................ Idaho Water Resources Research Institute
Nancy Moon........................ Metolius Elementary School, Metolius, OR
Patrick Muffler........................ U.S. Geological Survey, Menlo Park, CA
Ken Neeley........................ Idaho Department of Water Resources
Ken Nemzer........................ Former Chairman, Geothermal Resources Assn.
Martha Northup........................ Cascade Middle School, Bend, OR
Harry Olson........................ University of Hawaii, HI
Lillian Page........................ Retired Elementary Teacher, Claremont, CA
Cindy Phillips........................ Tri City Elementary School, Myrtle Creek, OR
Jerry Quissell........................ Mt. View High School, Bend, OR
Kevin Rafferty........................ GeoHeat Center, O.I.T., Klamath Falls, OR
Leo Ray........................ Fish Breeders of Idaho
Laura Sardis........................ Geothermal Education Office, Tiburon, CA
Alex Sifford........................ Oregon Department of Energy, OR
Lexie Sifford........................ Del Mar Middle School, Tiburon, CA
Barbara Stross........................ Metropolitan Learning School, Portland, OR
Jim Tollen........................ Hood River Middle School, Hood River, OR
Alfred Truesdell........................ Consulting Geochemist, Menlo Park, CA
Phillip (Mike) Wright........................ Earth Sciences and Resources Institute

...with special thanks to George Darr and Alex Sifford for encouraging the development of this curriculum unit.

TEACHER PREFACE

This curriculum unit describes geothermal energy in the context of the world's energy needs. It addresses renewable and nonrenewable energy sources with an in-depth study of geothermal energy – its geology, its history and its many uses. Included are integrated activities involving science, as well as math, social studies and language arts. Whenever possible, high order thinking and problem-solving skills have been suggested or included in the activities. The book is designed for use with grades 4 - 8: you choose which lessons and activities you would like to use, depending on the class knowledge and ability, and the time you have available. You duplicate only those pages you need for your students.



In each section you will find **Student Information** pages. Words in italics on these pages are listed in the Glossary. **Student Activity** pages are also provided along with the student information. These are all identified with a student symbol in the top corner. Duplicate the pages you want for your student packets; perhaps add other materials of your own.

Following the student pages for each section , you'll find a **For the Teacher** section. Here there are some tips and extra directions to help you with the student activity worksheets. In addition, you'll find extra activities and demonstrations you can use to enhance your instruction. All of these are listed in order and labeled according to the subsection in the student background materials that they accompany. Enjoy!

Throughout this unit there are many activities requiring the use of heat. Please stress with your students the importance of the "Safety Precautions" discussed in the Student Preface.

The Oregon Department of Energy, The Geothermal Education Office, and any other parties associated with the development of this curriculum unit assume no responsibility for accidents or injuries which result from performing any of the activities suggested in this book.

STUDENT PREFACE

Meet G. Arthur Mole, a retired professor who knows a lot about geothermal energy. Professor Mole will pop up from time to time throughout this curriculum as you learn about geothermal energy.

AN IMPORTANT MESSAGE FROM PROFESSOR MOLE:
Throughout this unit, you will find some interesting science activities to do. Be sure to read the following safety precautions before performing any of these activities.

SAFETY PRECAUTIONS

Safety and caution are very important when performing science experiments. Most science experiment accidents result from carelessness and impatience. Be sure to review and always use the following safety tips before doing any science laboratory-type experiment, no matter how simple it may seem.

1. Always work with or near other people. Never work alone. Make sure that your teacher or other responsible adult is close at hand. ALWAYS REPORT ACCIDENTS OR HAZARDS TO YOUR TEACHER (OR OTHER ADULT) AT ONCE.

2. Read and understand the directions before you begin. Be sure to study and follow any safety precautions that are included in the directions.

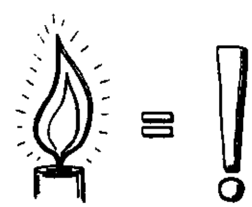
3. Long hair should be tied back and long sleeves rolled up. If aprons are available, wear them.

4. If safety goggles are available, wear them when performing activities involving heat especially when heating chemicals or oil. Use tongs and/or oven mitts as recommended.

5. Handle glassware with care. Once heated, glassware remains hot for a longer time than you might anticipate. Always get adult help if glass breaks.

6. Point test tubes away from yourself and others.

7. Use extra caution when working around flames and hot liquids. Be particularly careful around heated oil. Know the location of safety equipment (such as a fire extinguisher).
If a fire starts, DO NOT RUN and DO NOT PANIC. Always immediately get adult help. A small fire can often be extinguished with baking soda or sand. If a fire blanket is available, cover the fire with it, or douse the fire with a fire extinguisher.



8. Do not taste any materials you are using. Notify your teacher (or other adult) if you spill any chemicals.

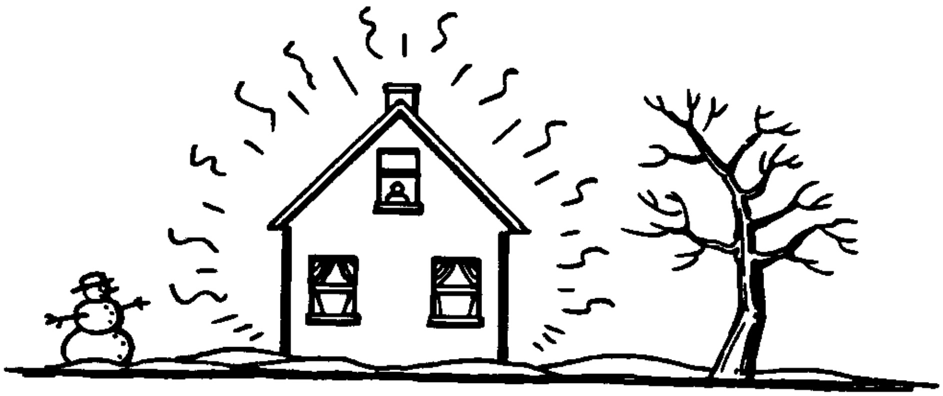
9. Clean and return all materials to their proper places after each activity. Clean your work area carefully. Do not throw harmful chemicals, soil, or sand in the sink.

CONTENTS

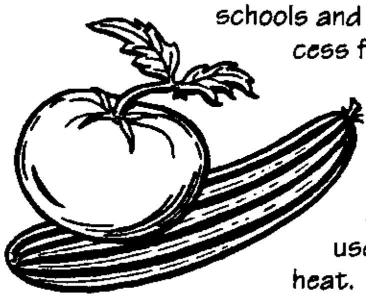
INTRODUCTION

SECTION 1

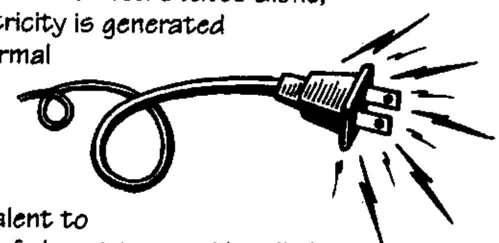
WHY IS GEOTHERMAL ENERGY IMPORTANT?

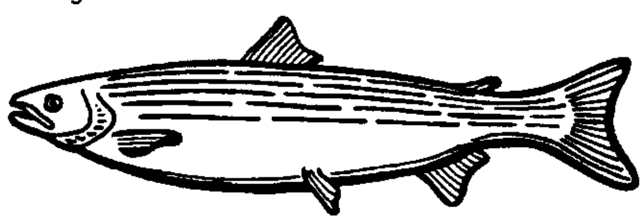


Geothermal resources are an important source of energy for both the United States and the world. Around the globe, people living close to Earth's natural hot spots make "direct use" of geothermal energy to heat homes, schools and businesses, to process food, grow plants, to raise fish and even alligators! In the U.S., the western states are the country's leading users of geothermal heat.



Some geothermal heat can also be used to make electricity. In the United States alone, enough electricity is generated from geothermal energy to supply over 3 million households. That's equivalent to the amount of electricity used by all the families in the states of Oregon and Washington combined!



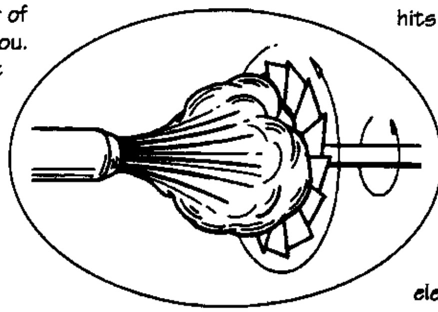


In this unit you will be learning about where geothermal energy comes from, the many ways we can use it, and why it is such an important energy source.

WHAT IS ENERGY?

Energy is the capacity to do work. It is the ability to move something, to heat it up, or change it in some way. Energy can be found in a number of forms, some of which are familiar to you. These include *mechanical energy, heat* (thermal) *energy, and electrical energy.*

You probably have or know about toys that can change from one form to another, called transformers. Well, energy can also transform from one form to another.



This is called *energy conversion.* An example of energy conversion is what happens when forceful steam hits and turns the blades of a machine called a turbine, which is used in the production of electricity. In this case, the forms of energy that are being converted are: heat energy (used to make steam from water) to mechanical energy (the moving turbine blades) to electrical energy (used to power machines, lights, heaters, appliances, and electronic equipment).

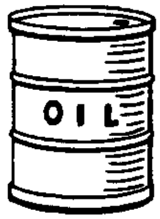
WHAT ARE ENERGY RESOURCES?

Geothermal heat is an energy resource. Other examples of energy resources are fossil fuels, nuclear fuel, moving water, the wind, and the sun. Energy resources help us do work. Our lives would be a lot different without them.

When we talk about energy resources, we call them either.....

NONRENEWABLE ***OR*** **RENEWABLE**

Nonrenewable energy resources are resources that get used up before more can be made. Nature has been providing us with some resources for *fuel* which take hundreds of thousands and even sometimes millions of years to make. These include fossil fuels (coal, oil, natural gas) and some minerals (such as uranium). Even though the earth is always creating more of these, it will be a LONG wait - maybe millions of years - before more are available. Therefore fossil fuels and uranium are considered nonrenewable because they aren't replaced within a reasonable amount of time.

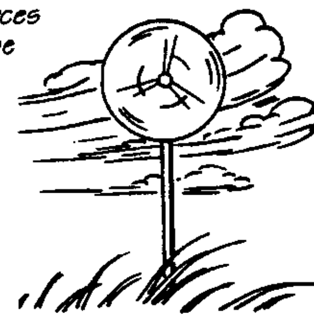


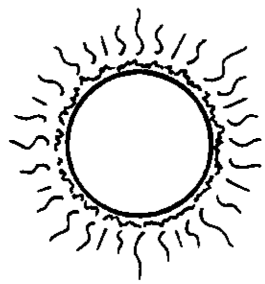
USING FOSSIL FUELS

The most widely used nonrenewable resource group, fossil fuels, must be burned in order to be useful. This burning is called *combustion*. Combustion usually creates heat energy which assists us in heating our homes, for cooking and for bathing. Heat is also useful for making steam to produce electricity.

One result of burning fossil fuels is air pollution. Compounds such as carbon dioxide, nitrous oxide, and sulfur dioxide are produced during combustion. These compounds may contribute to environmental problems.

Renewable energy resources are resources that can be used over and over again without being used up. This is because nature is always replacing them. Examples of renewable resources are the sun, earth's heat, wind, wood and water.

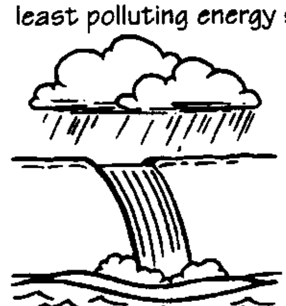




Outside the surface of the planet, a constant supply of wind and water is available for use as energy. The sun's rays themselves can be used directly for electrical energy and heat. And deep inside the planet natural forces are constantly creating more heat - so, in a way, we are riding around on a giant heat engine, full of energy available to do work for us.

USING RENEWABLE RESOURCES

One of the best things about many renewable resources is that most of them – like geothermal – don't rely on burning, so there is very little pollution. Today, people concerned about our environment look to renewable resources as the least polluting energy sources. People are also concerned about "using up" the earth's resources, because these resources will also be needed by future generations. This is why many people today encourage the use of renewable resources. With proper management, renewable resources can be sustained for humankind indefinitely.

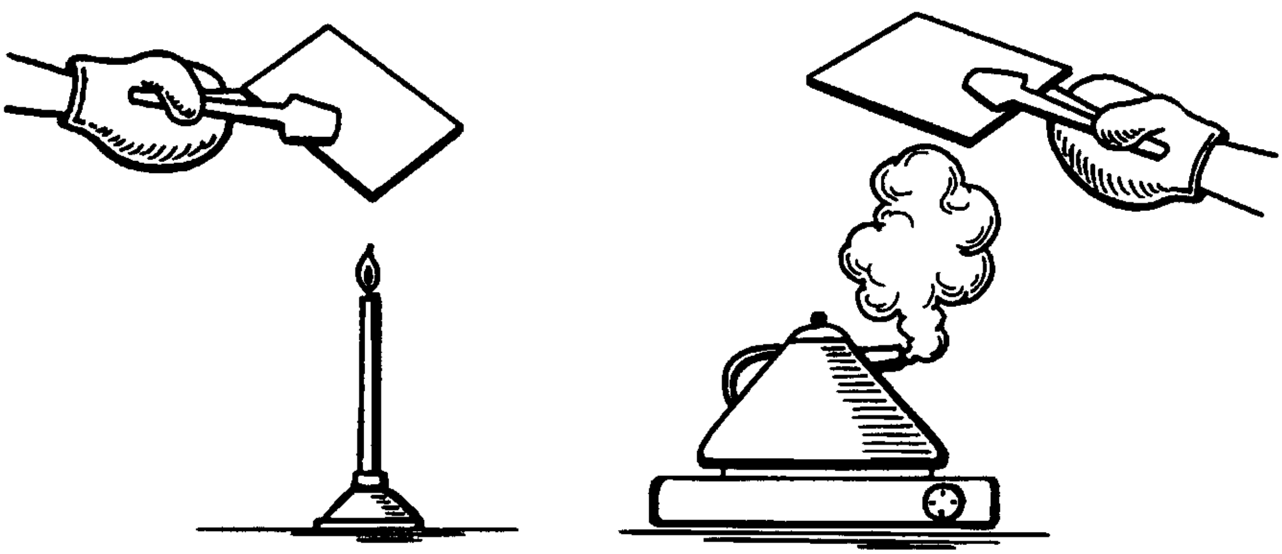


DO IT WITH MIRRORS: A DEMONSTRATION OF THE EFFECTS OF BURNING FUELS

Remember that when we burn something, a chemical reaction called "combustion" happens. As a result of this reaction some new materials are created which usually go into the air. Soot, for example, is a byproduct of combustion. Combustion of fuel is one of the main causes of air pollution.

We burn fuels to get them to do work for us, such as making engines run in cars. We also burn fuels to heat water to make steam. The steam, as you will learn later, is used to help generate electricity. In certain places we can use steam directly from the earth – geothermal steam – to make electricity (see Section IV).

In this demonstration you will **1.)** see the results of combustion and **2.)** compare the use of combustion to the use of a clean energy source such as geothermal steam.



Materials:

- candle
- candle holder
- matches or lighter
- small mirror
- kitchen tongs
- hot mitt
- tea kettle
- heat source such as a hot plate
- a source for cleaning the mirror such as soap
- water and towels
- goggles, if possible

Directions:

1.) With adult supervision, light the candle (standing in its holder).

2.) Wearing the mitt, hold the mirror in the flame using the kitchen tongs. Do this for about 5 seconds or so.

3.) Take the mirror away and look at the results. Be ready to describe what you see and where you think it came from.

4.) Now try a different version of the experiment . First wash and dry the mirror well.

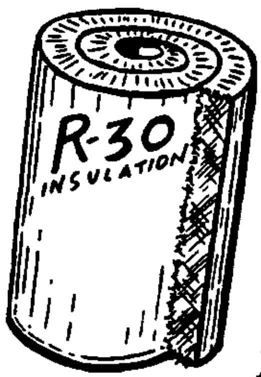
5.) Get the tea kettle actively boiling with water.

6.) Wearing the hot mitt, use the kitchen tongs to hold the mirror over the steam coming from the tea kettle. Don't hold it too long – just a few seconds – or the mirror might slip due to the moisture.

7.) Look at the mirror to see the result of using hot water as your energy source. Be ready to discuss the results of both demonstrations and how they relate to energy and pollution.

ENERGY CONSERVATION

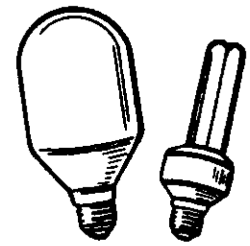
No matter what energy resources we use (renewable or not), we need to pay close attention to how we use them. When we manage our resources with care, then we are practicing energy conservation – a way of life that benefits our country and all the earth.



At present, we are still very dependent on fossil fuels for most of our energy needs. Because over half of the fossil fuel we use comes from other countries, we are dependent on those countries for some of our energy. Conserving fossil fuels means we have to import less and so are not as dependent on other countries. And, when we reduce our use of fossil fuel, we produce less pollution at the same time, which protects our environment. For example, alternative fuel cars, such as electric cars – which don't burn fossil fuels – are one way to cut down on air pollution.

We can all take responsible steps to reduce the amount of energy we use – and this does not mean having a cold house or school. We can add insulation and weather stripping to our homes and other buildings, turn off unneeded lights and turn down the heater when we really don't need it or are not home. We can use sources such as geothermal or solar energy, for heating and making electricity.

Another way to practice conservation is to use machines, appliances, and cars that use less electricity or fuel. These devices do their jobs without wasting a lot of energy, and therefore use less energy in the process. So energy conservation also means using energy efficiently.


Energy-Saving Compact Fluorescent Light Bulbs

Over time, some people have recognized the wisdom of using renewable resources such as earth's heat carefully and imaginatively. On the following page, you'll read about some of the creative uses of earth's heat - geothermal energy - that have been practiced over the years.

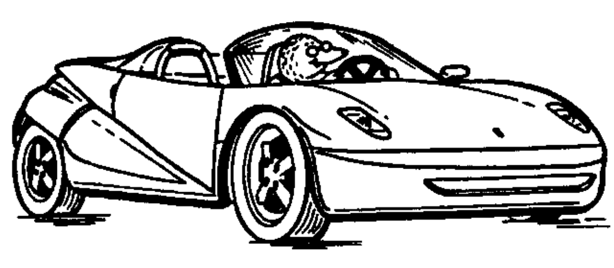
COGENERATION: "TWO FOR THE PRICE OF ONE"

Some manufacturing and power plants use a special system called cogeneration that is a great way to save energy. In many of these plants, a lot of heat or steam is often given off as "waste" in the process of making electricity, or refining oil or oil products. Instead of just "blowing off" the heat or steam, this energy is captured for another use. For example, in some places where oil is made easier to use (called oil refineries), waste heat from the oil refining process is used to turn turbines that generate electricity. In Oregon, some forest products mills also use their waste heat for electricity generation. Another method is found in Hawaii, where some sugar companies burn shredded, processed sugar cane to produce steam for their electricity generators. The steam that has gone through the turbine still has enough energy to process the sugar. Talk about energy efficient!

FORMULA FOR A CLEANER ENVIRONMENT

– Decrease Fossil Fuel Use
\+ Increase Renewable Energy Use
– Decrease Energy Use (Conserve)

= A Safer, Cleaner Sustainable Energy Future



This Australian car gets 135 miles per gallon of gasoline !

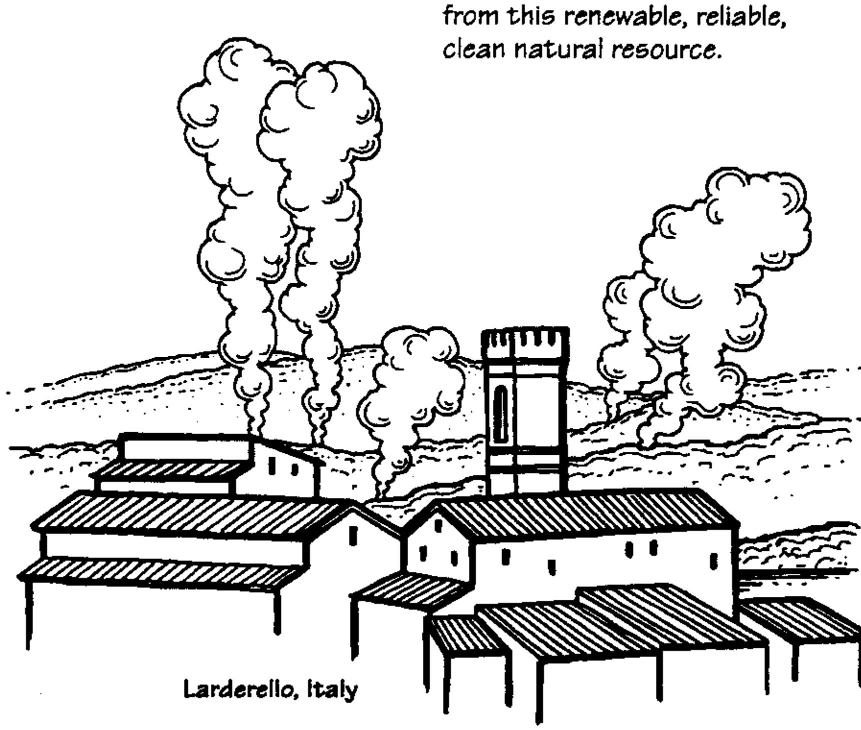
GEOTHERMAL THROUGH THE AGES

Since the beginning of the earth, geothermal resources have been generating inside our globe. Humans have been "tapping" into geothermal resources for thousands of years. Some scientists think that Stone Age people must have used geothermal heat. There is evidence in Europe that as early as 3,500 years ago, the Etruscans bathed in geothermal hot springs. The Romans swam in geothermally heated pools, treated eye and skin disease with the waters from mineral hot springs, and heated buildings in Pompeii with geothermal waters. During the Middle Ages people even fought over who would get to use the land on which hot springs were located. In France certain towns began heating their homes using hot geothermal water. Before Columbus sailed to the Americas, the Maoris of New Zealand were cooking their food using geothermal resources.

In the 1800's and 1900's, the many uses of geothermal energy increased. In the late 1800's production of boric acid, an antiseptic still used today, and borax, a cleansing and water softening agent, began in Italy. These were made from byproducts of geothermal hot springs.

The first time geothermal steam generated electricity was in Larderello, Italy, in 1904. By 1913, electricity was being sold to the nearby community, and by 1943 there was enough electricity being produced from geothermal energy to power about 132,000 households. Tragically, all the Italian power plants were destroyed in World War II. But the geothermal reservoir was not damaged, and today this same geothermal area again produces lots of clean electricity.

Geothermal energy is used all over the world. It brings heat and helps generate electricity for those of us who are lucky enough to be able to benefit from this renewable, reliable, clean natural resource.



Larderello, Italy

HOW DOES IT COMPARE?

Metric and Customary Measurements

As you've learned, geothermal energy is used all over the world. When talking about and using geothermal energy, scientists and other people in the geothermal industry need some common languages when they refer to measuring amounts of energy and quantities of resources. As students of energy resources, we need to also understand these measurement languages, or systems.

The two most widely used measurement systems are *Customary Measures* and the *Metric System.*

In the United States, we measure things using Customary Measures. However, in many places around the world people use the Metric System. Once you get the hang of it, the Metric System is much easier and more precise to use.

Scientists everywhere use the Metric system. For example, when measuring temperature, people in the United States usually use the *Fahrenheit System.* However, scientists in the United States use *Celsius temperatures,* which are based on the Metric System. So, it's a good thing to know about the Metric System and how to change things from Customary to Metric and back again.

Here are some things to know about the Metric System:

Some Basic Metric Units:

length:	**meter** (millimeter, centimeter, kilometer)
volume:	**liter/cubic meter** (milliliter, cubic centimeter)
mass/weight:	**gram** (milligram, centigram)
temperature:	**degrees Celsius**
area:	**square meter** (square kilometer)

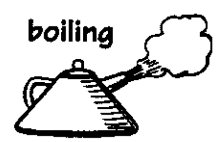
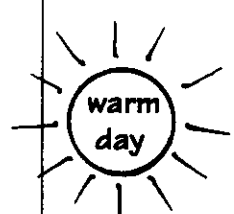
The metric system is based on tens:
The prefixes tell you what fraction or multiple of the unit you are using. Here are some of them:

kilo	**1000 times**
centi	**1/100 of (0.1)**
milli	**1/1000 of (.001)**

For example, one kilometer is 1000 meters. There are 1000 meters in one kilometer. A millimeter is 1/1000 of a meter. That is, there are 1000 millimeters in a meter.

For your reference:
1 meter is a little less than a yard.
1 kilogram is a little more than 2 pounds.
1 kilometer is less than a mile.

Some common temperatures:

	Fahrenheit	**Celsius**
boiling 	**212°**	**100°**
body temperature 	**98.6°**	**37°**
 **warm day**	**86°**	**30°**
room temperature 	**68°**	**20°**
freezing 	**32°**	**0°**

Metric and Customary Measurements Continued

Here are some formulas to help you convert back and forth with Metric and Customary:

Inches to Centimeters: Multiply inches times 2.54
Centimeters to Inches: Multiply centimeters by 0.394

Feet to Meters: Multiply feet by 0.305
Meters to Feet: Multiply meters by 3.281

Square Feet to Square Meters: Multiply sq. feet by 0.305
Square Meters to Square Feet: Multiply sq. meters by 10.764

Miles to Kilometers: Multiply miles by 1.61
Kilometers to Miles: Multiply kilometers by 0.621

Quarts to Liters: Multiply quarts by 0.946
Liters to Quarts: Multiply by 1.057

Ounces to Grams: Multiply by 28.35
Grams to Ounces: Multiply by 0.035
Pounds to Grams: Multiply by 453.592
Pounds to Kilograms: Multiply by 0.454
Kilograms to Pounds: Multiply by 2.205

Cubic Yards to Cubic Meters: Multiply cubic yards by 0.765

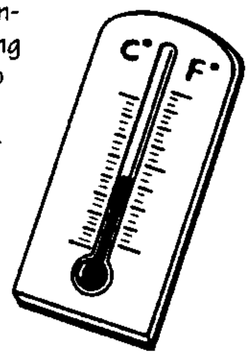
Fahrenheit to Celsius: Subtract 32 from Fahrenheit temperature, multiply the difference by 5, then divide the product by 9. [F = (C)(9/5) + 32]

Celsius to Fahrenheit: Multiply Celsius temperature by 1.8, then add 32 [9/5C+32 or 1.8C+32]

HOW DOES IT COMPARE?

Using Formulas to Convert Metric and Customary Measurements

1. For this problem you will need:
- two thermometers: 1 Celsius, 1 Fahrenheit or one thermometer that will give a Celsius and a Fahrenheit temperature reading with masking tape over the Celsius side so you can't read it
- containers of water of different temperatures ranging from icy cold to hot



   a. Estimate, then find, the Fahrenheit reading of various temperatures of water: icy cold, cool, warm, hot. Record the temperatures.

   b. Convert the Fahrenheit temperatures to Celsius.

   c. Check your Celsius conversions by using your thermometer to find the Celsius temperatures of the various waters you tested.

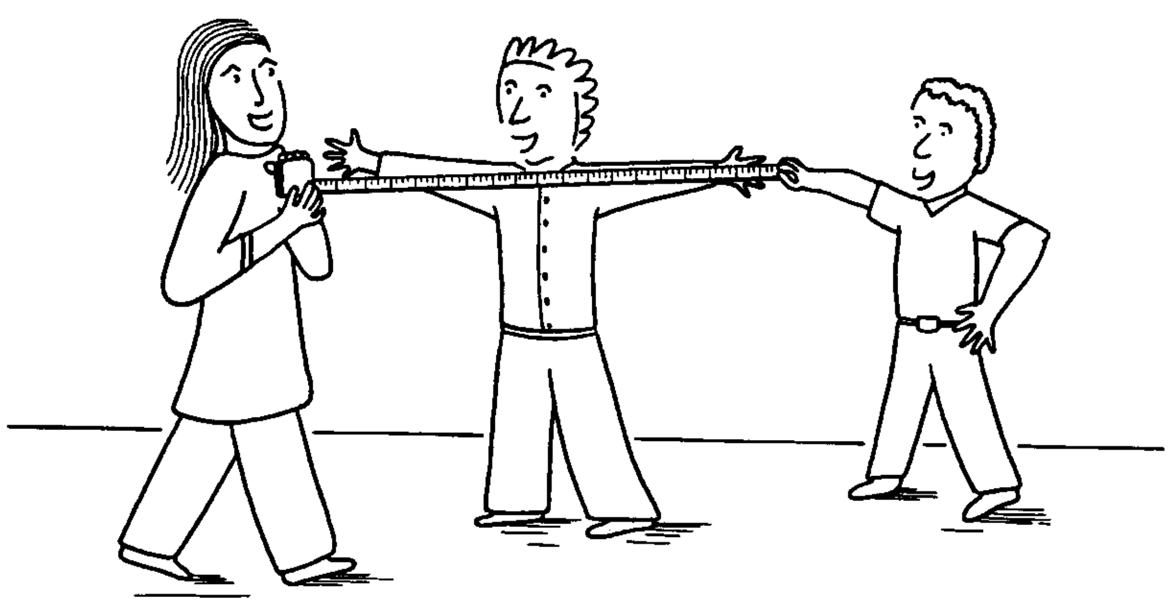
2. Magma is hot molten or partially molten rock the temperature of which can exceed 1000° Fahrenheit! Convert this temperature to Celsius.

3. Geothermal reservoirs are found from 200 to 14,000 feet below the earth's surface. What would these depths be using the Metric system? Would you convert to meters or kilometers?

4. Sam's geothermally-heated greenhouse is 60 cubic yards in size. Convert this to Metric units.

5. One of the most famous areas in the U.S. where there are geothermal power plants is The Geysers, located near Santa Rosa, California. Using an atlas, find the approximate distance in miles from Santa Rosa, CA, to your home town. Convert this distance to kilometers.

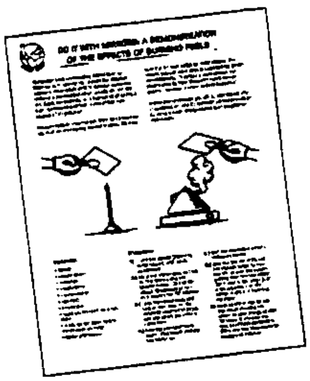
6. Bonus: Using a measuring tape (or string and a measuring stick), measure a partner. Measure things like height, circumference around the head, the length of an arm from shoulder to middle fingertip, and so forth. Decide before you begin whether you will use Customary or Metric measurements. Record all your findings. Switch partners and measure again. Then convert all your findings to the other measurement system. Check your answers if you can by measuring.



FOR THE TEACHER

1.) Show Videotape, "Geothermal Energy - A Down to Earth Adventure," featuring G. Arthur Mole. Professor Mole is the mascot of this unit and in the video gives an excellent overview of the concepts covered in more depth in this unit. (Videotape available from Geothermal Education Office. See Resources, Section VII)

2.) Science Activity: Do it with Mirrors: A Demonstration of the Effects of Burning Fuels" (Student Worksheet Provided)



Materials: (per student group)
- candle
- candle holder
- matches
- small mirror
- kitchen tongs
- hot mitt
- tea kettle
- heat source such as a hot plate
- a source for cleaning the mirror such as soap
- water
- towels

Directions: Found on Student Worksheet.

Management Suggestions: You may want to use this activity as a teacher demonstration or divide your class into groups for more hands-on experience. Remember to warn students about working around open flames and steam. Have plenty of hot mitts available, have long hair pulled back, and sleeves rolled up. Remind students to use these safety techniques for any science activity using heat or chemicals.

3.) Social Studies Activity: Ask students to list as many current uses and locations of renewable energy sources as they can. Answers can range from small devices such as solar-powered calculators to large scale production of electricity from hydroelectric dams to occasional uses like wood for cooking on camping trips and wind for sailboats.

4.) Language Arts/ Art Activity: (follow-up to Activity 3.) Tell the class to take a mental trip into the future. It is 50 years from now. Half of all the energy we use in the United States comes from renewables - wind, sun, water (hydro power), biomass, earth heat (geothermal). Ask students to think of some inventions that have made this possible. How are houses, offices, and schools heated and lighted? Where does the energy used to run factories come from? What do people use for transportation? Have students write down their ideas or draw pictures. Collect these pictures and ideas. At the end of the unit, review with them what they did and have them revise their ideas.

5.) Social Studies/Geography / Current Events Activity: Locate a world map which you won't mind getting marked up and post it in the classroom. If you're going to have an "Energy", "Geology", or "Geothermal Energy" bulletin board, this would be a great place to put the map. Ask your students to keep on eye on the newspaper and other sources such as magazines for anything about geothermal energy, volcanoes, earthquakes, geysers, and hot springs. Have them clip or copy the article to bring in to class. Have them locate where on the map their article's subject occurs. Have the students devise a method to mark the place on the map. Keep this as an ongoing activity for a good period of time - an entire quarter, semester or even longer. As marks are made on the map of all the geologic occurences, certain areas will stand out as being especially active. In Section II, students will read about the Ring of Fire. Later on, after the map is marked up, you may encourage students to compare their classroom map and the Ring of Fire.

6.) Other materials are available from the Geothermal Education Office and other sources. For example, a world map with highlights of geothermal activities occurring around the globe is available from the Geothermal Education Office. (See Resources, Appendix, Section VII)

7.) Answers to: How Does It Compare?

1. Answers will vary
2. 1000° F = 538° C
3. 200 feet = 61 meters
   14,000 feet = 4,270 meters
4. 60 cubic yards = 45.9 cubic meters
5. Answers will vary
6. Answers will vary