

Solar Energy and Its Use Today

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Introduction

Solar energy is referred to as the energy that comes from the sun's rays. There are many ways to use this power including heating a house, providing electricity, or desalination of seawater.

Energy is a form of power that is used to do many different things. Energy is used to light our houses, run our vehicles, trains, planes, ships, rockets, and others. Energy also warms our homes, cooks our food, plays our music, and allows us to see images on the TV screen. Energy is what makes the world go around. It is what makes this world of ours work.

Energy is not always outside. When we eat food, our bodies convert food to energy. This energy we burn is in the form of work or exercise. Energy comes in many forms one of which is solar energy. Solar energy is being used widely today and this is what will be discussed in this book.

During the 1970s, there appeared to be oil shortfalls after the 1973 oil embargo struck. Because of the shortfall in oil, an alternative method had to be produced that would allow other types of energy sources to be used as a replacement for oil. Therefore, the federal government stepped in to resolve this

problem. They knew that if something wasn't done soon, the world would eventually run out of oil reserves. This is why they allocated \$400 million per year for solar energy research.

The reason solar energy was the most likely source of new energy was because it was clean and renewable. When we wash our clothes and hang them up to dry, we are in fact using the sun's rays to dry them. Plants use the sun's rays to make food. Even the human skin uses the sun's rays to produce vitamin D.

Solar energy is widely available today, because the sun will always shine on the Earth. We only need the right instruments to capture the sun's rays and convert those rays into energy. Also a need must exist for solar energy to be stored for future use.

The only problem with solar energy is that if a day happens to be overcast or it is night, you don't have power. A means of storing the energy has to be implemented. Solar energy has the ability to provide us with a much needed energy source, if we can only know how to tap into it during times when the sun is not shining.

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Solar energy is here to stay and will become the primary source of energy when scientists develop a way to harness it and store it for later use.

Chapter One – Solar Water Heating

Solar water heaters can be a cost-effective way to provide hot water in your homes. Instead of relying on gas that is more expensive and could cause death if inhaled, you can save money with free power that only the sun can provide.

Solar water heaters come complete with storage tanks and solar collectors. In order to use a solar water heater you must have a well-insulated storage tank. These storage tanks have an outlet and inlet connected to and from the collector. If you happen to have a two-tank storage system, the solar water heater will preheat the water before it goes into the regular water heater.

As for the collector, there are three types that are used including:

- **Flat-plate collector:** There are two types of flat-plate collectors. One is a glazed flat-plate collector that is insulated and waterproof. It also contains a dark absorber plate under a glass cover. The other type is an unglazed flat-pate collector. This has a dark absorber that is made of metal or polymer, but without a cover.

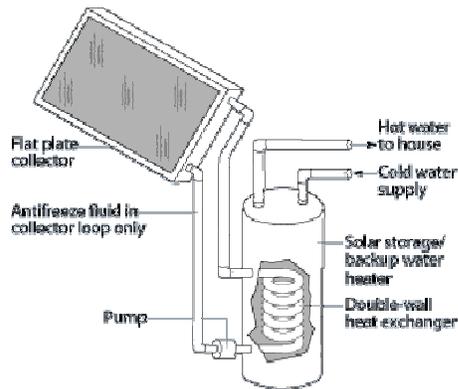
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- **Integral collector-storage system (ICS):** This system contains one or more black tanks or tubes in an insulated and glazed box. It works by cold water going through the solar collector first, where it is preheated. Then to a storage tank where it is used.
- **Evacuated-tube solar collector:** This collector features parallel rows of transparent glass tubes, with a glass outer tube, and a metal absorber tube that is attached to a fin.

There are two types of solar water heater systems available: active and passive. As for the active system, there are two that are available:

- **Direct circulation systems:** The pumps circulate household water through the collectors and into the home.
- **Indirect circulation systems:** The pumps circulate non-freezing, heat-transfer fluid through collectors and

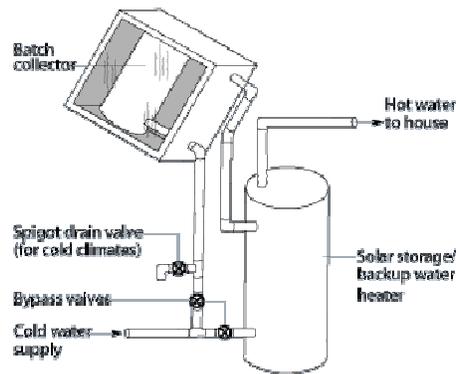
a heat exchanger. This allows the water to get heated then it flows into the home. Look at the figure below:



Just as there are two active solar water heating systems, there are also two passive water heating systems:

- **Integral collector-storage passive system:** This system works best in areas where the temperature rarely hits the freezing point.
- **Thermosyphon system:** This system works by water flowing through when warm water rises as cooler water sinks. A collector must be installed below the storage tank, so the warm water will rise into the tank. Look at the picture below:

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No matter what solar water heating system you use, there will always be a backup system you will need to deal with. This is to provide hot water on cloudy days and when demand for hot water rises.

Heat Exchangers

Each solar water heating system carries certain parts that make it do its job. These parts include the heat exchanger and heat-transfer fluid.

The heat exchanger takes the solar energy that was absorbed by the solar collectors, and transfers it to whatever is

used to heat the water. Heat exchangers are usually made of steel. But they can also be made of copper, bronze, stainless steel, aluminum, or cast iron.

There are three designs of heat exchangers available. These include:

- **Coil-in-tank:** This heat exchanger uses a coil of tubing that is inside the storage tank.
- **Shell-and-tube:** This heat exchanger is separate from the storage tank. it contains two fluid loops that are separate from each other, but are contained in a case or shell. When the fluid flows, the tubes are directly opposite each other when it goes through the heat exchanger. This way the most heat possible gets transferred.
- **Tube-in-tube:** This type of heat exchanger is actually very efficient, for the tubes of water and heat-transfer fluid are in direct thermal contact with each other.

Heat-Transfer Fluid

Heat-transfer fluids work by carrying heat through solar collectors and a heat exchanger to heat storage tanks. The types of heat-transfer fluids are:

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- **Air:** This is the most obvious one and is also common. Air is used because it will not freeze or boil, plus it is not corrosive. The only negative to it is that it can leak out of pipes, ducts, or whatever a little hole may be.
- **Water:** Water is also another form that is used being it is nontoxic and inexpensive. Water is very easy to pump. The only problem with water is that it can boil and freeze. Plus, it can corrode pipes and ducts.
- **Glycol/water mixtures:** Glycol and other water mixtures are sometimes used. You may find such mixtures as 50 or 60/40. You may even find ethylene and propylene glycol being used. This is antifreeze. Ethylene glycol is very toxic and should only be used in a double-walled, closed-loop system. Because if it leaked out into the water supply, it could cause major problems.
- **Hydrocarbon oils:** These oils have a high viscosity and lower specific heat than water. A downside to using this fluid is it requires more energy to pump. But on the plus side the fluid is cheap.

- **Freon:** Freon is used in refrigerators, air conditioners, and heat pumps. They do have a low boiling point and a high heat capacity. Because of this, only a small amount of refrigerant is needed to transfer a large amount of heat efficiently. These units work by heat being absorbed when the Freon boils in the solar collector. Heat is released when the gas condenses to a liquid in the heat exchanger.
- **Silicone:** Silicone is good to use in solar water heating systems because it has a low freezing point and very high boiling point. The downside to silicone is it requires more energy to pump, and can leak easily.

If you are looking for a solar water heating system, there are many things to consider including the costs, location, and legal issues. Solar water heating systems cost much more to purchase and install than regular water heating systems. However, if you are in it for the long-term, you will save a good deal of money. You could end up saving a bundle, depending on how much water you use, how your system performs, your geographic location, the cost of fuels you use for the solar system, and the cost of any fuel you use for your backup water heating system.

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If you decide to go this route, expect to see a drop in your water bill by as much as 50%-80%. Plus, you won't have to pay anymore gas bills, for as long as you have the solar system in your house. If you are having your house built for the first time, and you install a solar water heating system, you will luck out because of tax savings and government grants that will be available to you.

When you consider a solar water heating system, consider your location. If you don't have much sunshine aimed at your home, you are wasting your money. However, if you get a lot of sunshine or enough, you may luck out. Have your site checked by a solar energy expert or get a solar site analysis to determine how your site stands up.

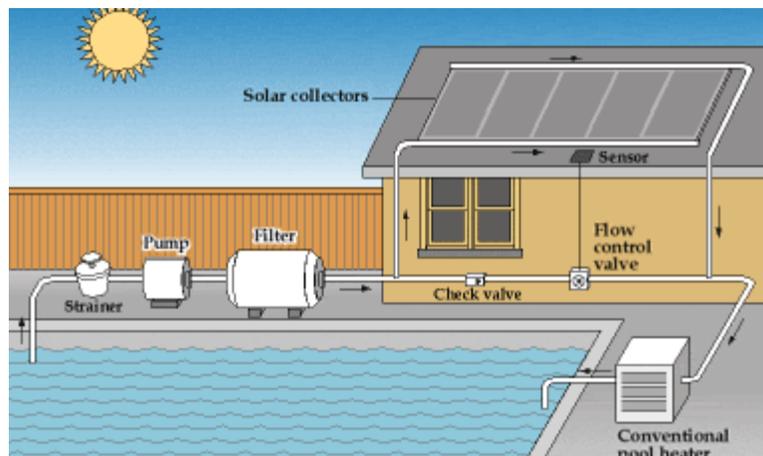
Size is also of importance. You will have to know the total collector area and the storage volume you'll need to meet at least 90%-100% of your hot water needs. Talk to your solar system contractor. They usually have some kind of worksheet or computer printout to show you what type of system would be good for your home.

Before you buy your solar water heating system, check with your local building codes, zoning ordinances, and any other rules or regulations (if you own a condo), to see if you have the right to install a solar water heating system. You will definitely need a building permit to do the work.

After your solar water heating system is installed, you normally don't have to worry about maintenance on it for at least 10 years, unless your system uses some electrical components. If that is the case, your system will need maintenance every 3-5 years.

Chapter Two – Solar Pool Heating

If you have a solar swimming pool heater, you can reduce swimming pool heating costs dramatically, by simply installing a solar pool heater. It makes sense because you are able to enjoy your pool longer throughout the year. Solar swimming pool heaters are cost competitive with gas and heat pump pool heaters. And they don't take a lot of money to operate. Look at picture below:



Courtesy of the U.S. Department of Energy

When you purchase a solar swimming pool heater, they usually come with a solar collector, filter, pump, and flow control valve.

A solar swimming pool heater works by the pool water being pumped through a filter. Here debris is trapped and removed from the water. The water is then sent through the solar collectors, where the water is heated by the sun's rays before the water is returned to the pool.

Some systems include sensors and an automatic or manual valve that is used to divert water through the collector when the collector temperature reaches a level that is higher than the pool temperature. If the collector temperature was the same as the pool temperature, the water would not stop at the collector. It would merely proceed back to the pool.

When you go shopping for a solar swimming pool heater, you have many things to consider including costs, location, and the legal aspects of having one. Typical solar swimming pool heaters can cost as much as \$3,000 to \$4,000 to purchase and install. But the time it will pay for itself can be anywhere from 1.5 to 7 years. This all depends on the type of fuel used, your site location, the size of your pool, legal, and other factors.

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When you consider the legal aspects of it, you have to look at any legal requirements in your city, town, or county. You're your solar swimming pool heater be allowed? You also have to be concerned about building codes, zoning ordinances, and other rules and regulations (like if you live in a condo). A building permit will also be needed.

Solar swimming pool heaters are the most cost effective systems you can have. They can help you save on water, electric, and gas, depending on your energy source.

Chapter Three – Solar Electricity

If you are tired of high electric bills there is a way out, and it doesn't involve switching electric companies. Instead, what you can do is get electricity from a different source.

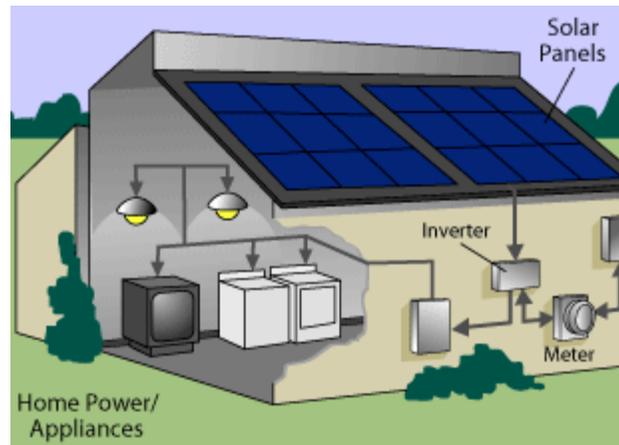
Once you start tapping into another way of getting electricity without using the electric company's power lines, you'll wonder why you didn't do it sooner.

If you currently use electricity from a known supplier, you are using a grid-connected system. A grid-connected system allows you to have power to your home using outside lines from the pole.

If, however, you do not use the electric company's power source, but you use your own, you are using what is referred to as a stand-alone (off-grid) system. This kind of system makes sense to many people because it is cost effective and helps save the environment.

If you use a stand-alone system, you can take advantage of many techniques and technologies that are available for your use including the ability to generate your own power, reduce costs, and give you more convenience. Here is an example of a stand-alone system:

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Courtesy of the U.S. Department of Energy

If you go in this direction you will need photovoltaic panels and a balance-of-system conditioner, to safely transmit the power to your home or other load.

Of course the amount of equipment you will need to purchase will depend entirely on what you want your system to accomplish. If you want only a small area to be provided electricity for, you won't need much in equipment. But if you want to provide a large source of power you will need the necessary equipment to do so.

Solar Electricity

Solar electricity is a wonder of science that can really help you in many ways. It is cost effective and lean you away from the big guns who try to monopolize the industry. To have solar electricity, you really need a small solar electric or photovoltaic (PV) system. This kind of system is not only reliable but is also pollution-free. Not only that but because of the increasing demand for this type of system, the costs of purchasing and installing one is cheaper.

PV technology uses both direct and scattered sunlight to produce electricity. This means that a lot of the sunlight is absorbed by the system, while other sunlight is reflected. This reflected or scattered sunlight is the result of air molecules that interact with the sun's rays, causing the rays to go into different directions. Water vapor is also a culprit. It can reflect the sun's rays pretty easily. Clouds are another factor. The sun's rays cannot penetrate clouds unless the clouds are very dense. Otherwise they won't be able to penetrate the thickness of the clouds. Dust can also affect sunlight. Pollutants are like dust. They can divert some if not all the sunlight.

The good thing about using solar power to create electricity is its available pretty much wherever you go in the world. As long as you have sunshine and the right equipment, you will always have electricity.

Of course, on the other side of the coin, if there really is a limited amount of sunshine in your neck of the woods, you will find having electrical power hard to come by. So the site of the solar power is very important to consider when you want to convert to solar power for your electricity.

How Solar Electricity Works

The basic premise behind solar energy conversion of electricity is in the use of photovoltaic (PV) systems. These systems convert the sunlight into electricity.

Basically, solar cells, the heart of the PV system, are made of semiconductor material. At the time that sunlight hits the materials, the rays are absorbed.



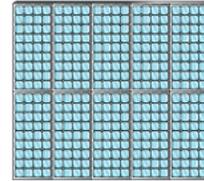
These rays are converted into electricity by the solar cells, and a conditioner works to make sure the electricity is clean and at the right level before it is sent into the home.

If you evaluate the PV system, you will find it can only produce a small amount of power. In order to produce a large amount of power, several solar cells would have to be

connected to from panels or modules, as they are also called. In most cases, several PV modules are connected together and installed in a rack to form an array. It takes on average about 10-20 PV modules to provide enough power for a house.



Module



Array

PV arrays can be mounted in two different ways: a fixed angle facing south, or they can be mounted on a tracking device which follows the sun.

What to Buy

Before you go out and buy the equipment to convert your home to solar power, you must consider location, size of your house and equipment needed, cost, and legal issue.

If your house is not getting enough sunlight, you will be serious trouble if you want to switch over to solar electricity. You must have sunlight to work. You also need to know how much power you will need (this will determine the amount of equipment to purchase), and how large a roof your house has (to install the solar panels).

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You also have to be concerned about costs. Will you be able to afford the cost of the equipment you will need to install? Plus, look at your past year's electric bill and get a cost estimate for how much electricity you used last year and compare that with what you may spend for the next year with solar electricity. If your findings show using electricity from your supplier is cheaper, stay with that. However, if you find you can save money with solar electricity, go make the change. It depends on your preference and what you wish to achieve.

One other factor to consider is any legal issues that you may have to get involved in. Is having solar electricity allowed where you live? You have to be concerned with building codes, zoning ordinances, and other rules and regulations (like if you live in a condo). A building permit will also be needed.

Electrical Components Needed

A solar electric system comprises certain components including solar cells, modules or panels, arrays, and balance-of-system parts. Your system will not work unless you have all these parts in working order.

Chapter Four – Water Purification

In some parts of the country sun is not a commodity but safe water is, while in other areas sunshine is in great supply but the water is unsafe. Because of this, a need must be filled to provide safe water to drink. Why use electricity to filter it when you can use solar energy to do it.

Think about this: unsafe water causes many deaths or illnesses per year. Why let this happen. The sun has been used for years to cook food outside and for other purposes, why not use it to purify water in order to make it safe to drink.

The simplest solar water purification system around is the solar box and solar still. Solar boxes have been used for a long time in cooking food and can also be used to purify water.

In order to kill bacteria, boiling water is not the only method that needs to be used. This method only kills pathogens. The water needs to be pasteurized in order to kill off disease causing bacteria. A method was developed to handle this problem. This was the Water Pasteurization Indicator (WAPI). It was developed by Dr. Fred Barrett, of the US Department of Agriculture in 1988. The WAPI is a polycarbonate tube that is sealed at both ends. Before the tube is sealed, it is partially

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filled with a blue soybean fat that can melt at 156 degrees. To use it, the WAPI is placed inside a water container with the fat end up. As soon as the fat melts, the person performing the experiments knows the temperature has reached 156 degrees. This way pasteurization can be obtained at a lower temperature than boiling.

Sun Utility Network produced their own version of the solar box called SunThermos Bottle. They state it will kill bacteria, protozoa, and viruses as it reaches pasteurization temperature.

Another part of this pasteurization process besides the box is the solar still. If you have ever been inside a steamy greenhouse, you will have an understanding of how a solar still works. A solar still consists of a large flat surface (about 3 by 5 feet). Often a short wall will be placed around the top of the table and is lined with some kind of impermeable material to make a small pool on the top of the table.

A pane of glass, or Plexiglas may be used, and is mounted at a slight angle above the table. When the water is heated, it turns into water vapor, which you will see on the pane. Gravity

goes to work here by pulling the water vapor down till it gets to the lower edge of the pane, which as you know overhangs the pool. Because of this overhang, the water vapor drips into a trough and then through a hose or tube, depending on what you use, which in turn goes into a collection jug. Once the solar box and solar still are installed, they treat the water and make it safe to drink.

Some companies have even taken those solar device and providing improvements to it by adding a heat exchanger. By adding a heat exchanger it can increase efficiency. This is because heat exchangers can preheat the untreated water with heat from the treat water. This increases output and provides more filtered drinking water in a faster time span.

When installing a solar water purification system, there are certain requirements that must be met. These include providing users with instruction on sanitary waste disposal, proper containers for water storage, transport, dispensing, and maintenance of the system.

Chapter Five – Solar Cooking

Have you ever cooked food outdoors on an open grill or seen someone do it and wonder how you can do it without the use of electricity or gas, as many food cookers require to work?

Well, with technology the way it is today, cooking food by use of the sun's rays is not all that strange, for there are solar cookers around today.

Some of you may have never seen a solar cooker so you may wonder what it is. A solar cooker is a device that allows you to cook food using the sun's energy as fuel.

Up till now, people have used a certain type of fuel to ignite a flame so as to cook the food they wanted on a cooker. The problem with these cookers is that often they would cook the food unevenly, or would burn the food. Cooking food using the sun's rays makes cooking easier. You are not required to use fuel to ignite a flame. Instead, the sun's rays are converted to heat so as to cook the food that is placed on a rack or grill. Take a look at this picture as an example of a solar cooker:



There are different types of solar cookers. Some of them are slow cookers while others reach higher temperatures so as to fry the foods. Slow cooking is better because slow cooking retains flavor, moisture, nutrients, and makes meats tenderer.

If you decide to go with a slow solar cooker, you will just have to add an extra hour of cooking time, so prepare accordingly. The advantage to solar cooking is that you just put the food in and take the food out. You do not have to stay with the food for any length of time.

Some of the advantages to using a solar cooker include:

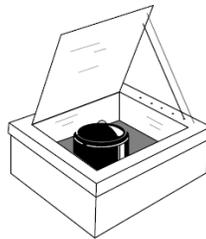
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- Using a free source. Sunshine is free and always will be free. By using a solar cooker, you are saving fuel as well.
- You don't have to watch the food. Just put it in and take it out. This frees you up for other things while the food is cooking.
- You have no pots to clean since you did not use them. And if you did place a pot on a solar cooker, you won't have to worry about pots getting messed up from the foods being cooked.
- Solar cookers are safe being there is no fire to start.
- There is no smoke to get into your eyes and no chance of developing lung problems from the smoke.
- The average cooking temperature of a solar cooker is between 180-250 degrees Fahrenheit. This is why food does not get burnt or overcooks like they would in conventional ovens, which reach temperatures of over 500 degrees Fahrenheit.

- Solar cookers even use solar water pasteurization when cooking. This can help reduce Cholera and other waterborne diseases.
- Solar cookers save trees. This is important for our environment.

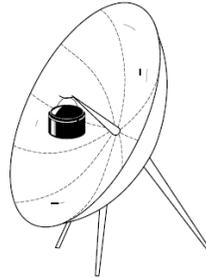
There are different solar cookers available on the market. These include heat-trap boxes, curved concentrators, and a combination of both.

Box cookers are the most used types of solar cookers around. See image below:

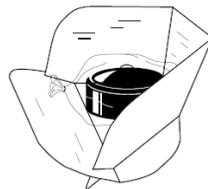


Curved concentrator cookers cook fast and at very high temperatures. The only problem with this type of solar cooker is you have to adjust it frequently and supervisor the cooking for a safe operation. See image below for sample:

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Combination cookers are also used. These consist of certain elements of a box and curved concentrator cooker. SCI's CookKit is one of these. Here is what a combination cooker looks like:



There are several advantages to using a combination cooker. These include:

- Combination cookers do not need to be moved to track the sun while cooking food.

- Temperatures when cooking is better because it is more even.
- The combination cooker does not require any insulation.
- You can only cook one pot at a time, but the price of this unit is cheaper than a box cooker.

In order for a solar cooker to work it needs sunlight. This sunlight gets absorbed and turns into energy. The sun's rays hit the solar cooker, where it is redirected and focused on the pot. This pot must be dark, because dark holds heat. It also must be thin and have a tight-fitting lid. This holds in heat and moisture better.

When the sun's rays come down and hit the solar cooker, a transparent heat trap around the dark pot lets in sunlight. It also keeps the heat. This could be a heat-resistant plastic bag or a large inverted glass bowl. It could also be an insulated box with a glass or plastic window. It doesn't matter the material as long as it holds and absorbs the sun's rays.

Chapter Six – Solar Cooling and Heating

Most houses are built with conventional heating and cooling systems. These systems usually burn oil or gas, depending on system. Cooling systems, if they are central, are typically a large compressor in the backyard leading into the basement into a distribution network of ducts to various parts of the house.

This system is incorporated in most any home, especially new homes built today. Everyone that owns a home knows what type of system this proves to be. They have to pay large electric, oil, or gas bills, or a combination thereof.

But what if there was a system installed in homes that allowed the homeowner to use alternative energy sources that is free. This would really save the homeowner a lot of money, not to mention he won't have to depend on the utility company that supplies him the power the previous heater. Not to mention it would clean the air since oil can produce dust and gas is lethal if a gas leak should occur.

Solar heating systems are more efficient and reliable than any other kind of system. The US Government realizes this so they instituted the US Energy Policy Act that will provide 30% tax credit to consumers who install solar heating systems.

Since 1970, solar heating systems and the collectors they use have been improved dramatically. This has forced the cost of the systems to drop. With this drop in prices, people have used solar energy for both heating and cooling of their home or business. Take a look at the following image to see an example of solar collectors that are used in a solar heating system:



Passive Solar Heating System

When solar energy is used for heating purposes, it will have a certain type of system. This system can be passive, or active, or both. The difference between the two is that the passive system is least costly and less complex. But when it comes to

installing the system in a building, and getting the piping to fit, the active system is more practical.

The passive solar space heating system uses large south-facing windows, and special materials that absorb warmth during the day, then release that warmth at night. A greenhouse can be considered an example of a passive system.

If you are considering a passive solar space heating system, you will find three types will be available for purchase:

- **Direct gain:** This happens to be the easiest and simplest system around. It takes energy from the sun's rays that was shining directly into the building, converts it to heat, and then stores the heat, after which it releases the heat slowly.
- **Indirect gain:** This works nearly the same as direct gain, except it uses materials that hold, store, and release heat. Such materials could be installed on something that is between the sun and the living

space. More than likely this could be a wall or glass window.

- **Isolated gain:** This system collects solar energy from a remote location and feeds the energy into another space that is connected to it.

Obviously passive solar space heating systems do have advantages and disadvantages.

Active Solar Space Heating System

An active solar space heating system contains a bunch of collectors that absorb the sun's rays. The collectors also have electric fans or pumps that distribute the heat to where it has to go. The medium the collectors use to absorb and transfer heat from the sun's rays are liquid and air.

Liquid-based systems can contain antifreeze in a hydronic collector. This is because antifreeze will not boil or freeze easily. Air-based systems heat the air in an air collector. The air-based system usually uses air-to-water heat exchangers to provide heat to the hot water heater.

Both the liquid and air-based systems have one purpose: to collect and absorb solar energy, after which it transfers the heat to the inside of the house. If a storage system is employed, the means to transfer the heat is usually by means of liquid.

In an active solar space-heating system, the collector that is used will more than likely be a medium-temperature solar collector. In a solar space heating systems, the collector is large, large storage units, and complex control systems. Active solar heating systems are generally designed to provide from 30% to 70% heating for the house and supply hot water as well. This is why active systems are more complex.

Cooling System

A home can have cooling and refrigeration without the usual electricity or other methods to deliver the power to operate the cooling system. This process can be handled by using thermally activated cooling system (TACS) that is driven by solar energy.

Typical cooling and refrigeration systems can deliver up to 30% to 60% of the required cooling for the building, while the rest is provided by the TACS, which is fueled by natural gas.

Solar cooling systems work by using thermal energy that is collected from the solar collector, and uses this to separate a mixture of the energy and the refrigerant fluid. The refrigerant is condensed, throttled, and evaporated to produce a cooling effect, after which it is re-absorbed back into the system to complete the work the system had intended.

Solar heating and cooling is possible today with the right equipment, proper usage, and correct installation. It is possible also to cut costs on your utility bill if your heating or cooling system is dependant on that utility to function.

Summary

Solar energy is here and will stay around for years to come. The price of solar equipment has and will continue to drop as more and more people get involved and install the many different systems, in the homes, that are in use today.

Think about a house that is solar ready. Think about it as a place that runs on solar power as the primary source for everything in the home. This would be great as long as the home continues to receive sunshine to provide the energy. If not, the solar system better have some kind of storage unit available to provide back up power, water, or heat, in the event that the sun does not shine for a day and for night use.

The cost of solar systems as was stated previously is cheap and getting cheaper. This trend will continue as long as people continue to buy solar equipment and have it installed in their homes.

Even the US Government is getting involved by offering incentives in the form of tax breaks and grants to those who

make solar power a part of their new home. This provides the necessary backing that you would need to invest in solar energy, particularly for the long haul.

If you want to know more about solar energy and how you can use it to your advantage, just look it up on Google or go to your local library and research alternative energy resources. There is a lot of information online, in the library, and in encyclopedias about solar energy. The US Government also has websites dedicated to this subject.

The information is there you just need to know where to go and how to look.