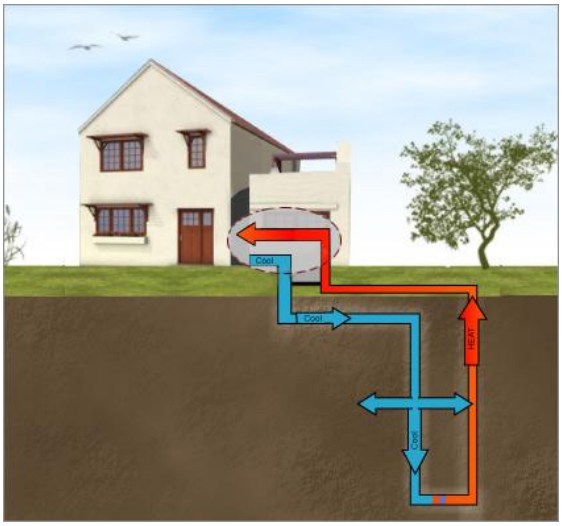
A HOME-OWNERS GUIDE TO GEOTHERMAL

Introduction

Geothermal heat pump (also known as ground source heat pumps) is a central heating and cooling system that pumps to or from the ground, depending on the season; it uses the earth as a heat source in the winter and a heat sink in the summer. Geothermal heat pumps (GHPs) use the constant temperature of the earth as the exchange medium instead of the outside air temperature. This allows the system to reach fairly high efficiencies (300%-600%) on the coldest of winter nights, meaning the system is able to extract 3-6 times as much energy as it put in to deliver the energy!

The best way to conceptualize how geothermal heat pumps work is to compare it to your refrigerator running backwards. Your fridge uses heat from electricity and compresses a refrigerant (which causes the temperature to rise and the fluid to evaporate) and moves the fluid until it condenses again which causes the fluid to cool and pull heat from inside of your refrigerator. This process is the same whether it is your fridge's compressor using heat to pull heat from its inside, the Earth using heat to pull heat from your home (cooling mode during summer) or your home using heat to pull heat from the Earth (heating mode during winter).



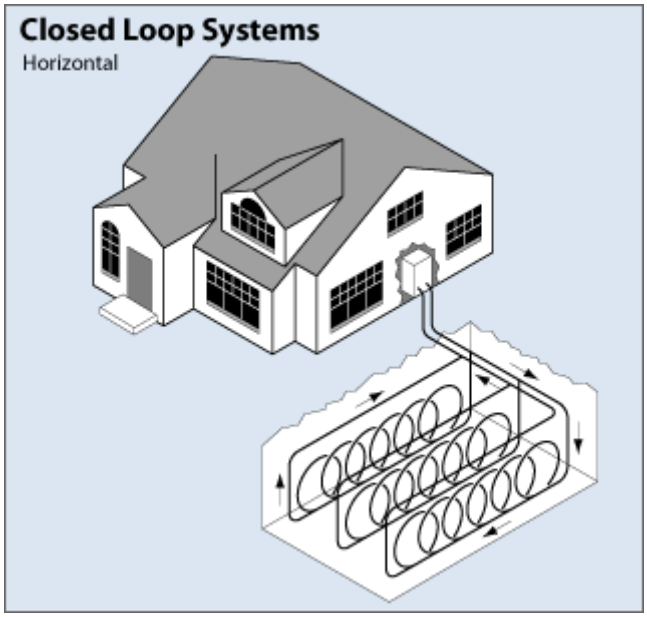
New Hampshire experiences dramatic seasonal temperature extremes—from scorching heat in the summer to sub-zero cold in the winter—just a few feet below the earth's surface the ground remains at a relatively constant temperature – approximately 55°F.

The geothermal heat pump takes advantage of this difference in temperature through exchanging heat with the earth through a ground heat exchanger.

There are two main types of Geothermal Heat Pumps, Closed Loop and Open Loop Systems and many variations on how to install them. They are all presented here in order of their relative prevalence in the State of New Hampshire.

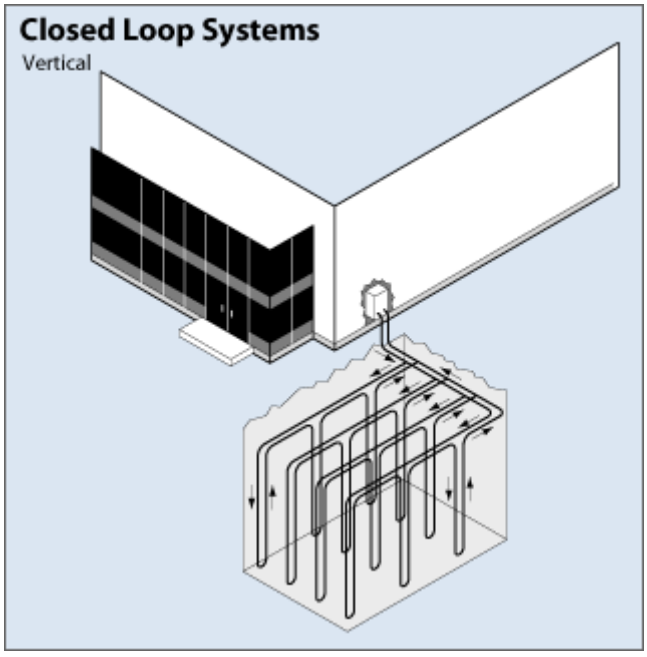
Closed-Loop Systems

Horizontal

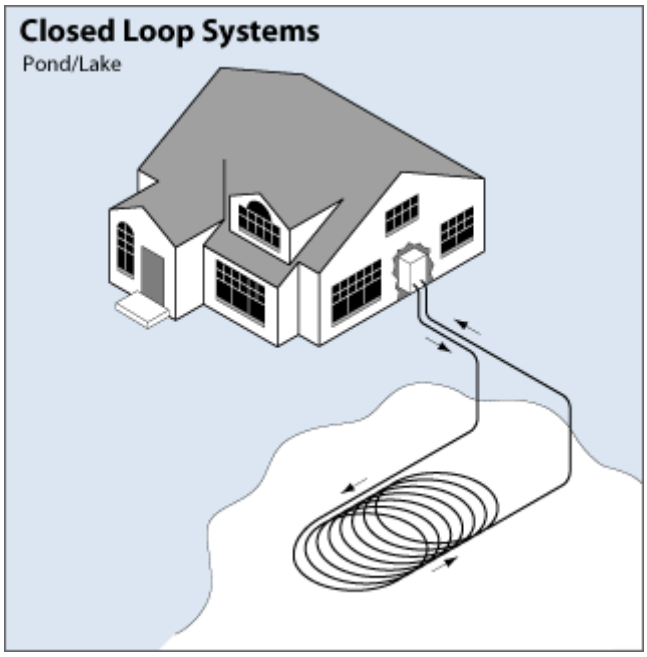


This type of installation is generally most cost-effective for residential installations, particularly for new construction where sufficient land is available. It requires trenches at least four feet deep. The most common layouts either use two pipes, one buried at six feet, and the other at four feet, or two pipes placed side-by-side at five feet in the ground in a two-foot wide trench. The Slinky™ method of looping pipe allows more pipe in a shorter trench, which cuts down on installation costs and makes horizontal installation possible in areas it would not be with conventional horizontal applications.

Vertical



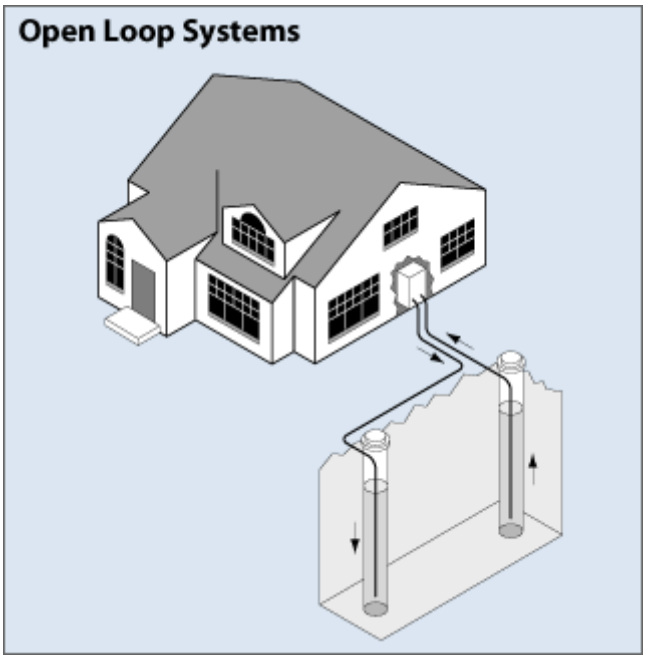
Large commercial buildings and schools often use vertical systems because the land area required for horizontal loops would be prohibitive. Vertical loops are also used where the soil is too shallow for trenching, and they minimize the disturbance to existing landscaping. For a vertical system, holes (approximately four inches in diameter) are drilled about 20 feet apart and 100–400 feet deep. Into these holes go two pipes that are connected at the bottom with a U-bend to form a loop. The vertical loops are connected with horizontal pipe (i.e., manifold), placed in trenches, and connected to the heat pump in the building.



Pond/Lake

If the site has an adequate water body, this may be the lowest cost option. A supply line pipe is run underground from the building to the water and coiled into circles at least eight feet under the surface to prevent freezing. The coils should only be placed in a water source that meets minimum volume, depth, and quality criteria. Typically, these systems are only allowed in man-made ponds and impoundments and it is illegal in New Hampshire to connect a heat exchanger to an existing water body or waterway.

Open-Loop System



This type of system uses well or surface body water as the heat exchange fluid that circulates directly through the GHP system. Once it has circulated through the system, the water returns to the ground through the well, a recharge well, or surface discharge. This option is obviously practical only where there is an adequate supply of relatively clean water, and all local codes and regulations regarding groundwater discharge are met. Currently, open loop systems are not permitted in New Hampshire

Incentives

Currently, the Federal government will provide 10% of the system cost for geothermal heat pumps in the form of a Department of Treasury Grant program until the end of 2011. After 2011, geothermal heat pump systems will be eligible for 10% of the system costs in a dollar-for-dollar tax credit.

For more information on the program, visit the Department of Treasury's Grant program website.

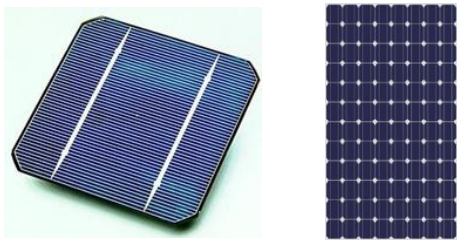
A HOME-OWNERS GUIDE TO SOLAR PHOTOVOLTAIC

What is Solar Photovoltaic?

The term photovoltaic can be interpreted by breaking the word down into its components; "photo" means related to light and "voltaic" pertains to electricity or electric currents, producing a literal meaning of light that produces electricity, which is exactly what photovoltaic panels do. When the sun's radiation hits the solar panel, an excited electron is given off and clean, renewable electricity is created! Solar power has tremendous potential to power the globe; the amount of energy that strikes the Earth in one hour would supply the world's energy needs for an entire year!

Solar Panels

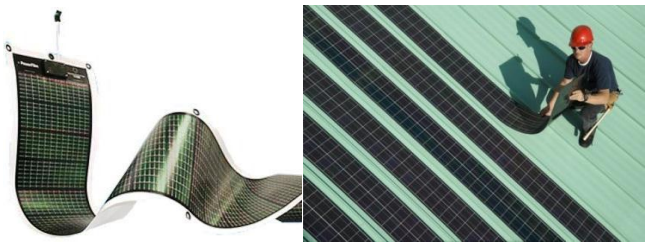
Each solar panel consist of several dozen silicon semiconductor "wafers" that are connected in series and emit an electrical charge. Those panels are strung together to create an "array" which can be as small as a few panels for a residential home or as large several thousand panels in commercial scale solar farms. Typically speaking, a single solar panel is 3' x 5' and produces about 200 watts of power. When wired together in series the solar panels produce a larger amount of electricity. For instance, a 3 kW (kilowatt)solar array will produce half of the needed electricity for an average household in New Hampshire and will consist of fifteen 200 watt solar panels.



An enlarged view of a solar wafer (left) and solar panel (right).

Thin Film Solar Panels

Thin film solar panels are a new way to construct solar panels where instead of producing expensive crystalline wafers, very thin layers of various semiconductor materials and placed on a clear sheet of flexible plastic or glass. Circuits are laid between the layers of semiconductor materials to allow for the electricity to be drawn from the thin film solar panels. A major appeal of thin film solar technology is that it can be integrated seamlessly and simply into building facades and roofs. Currently, thin film technology is more expensive than traditional wafer photovoltaic technology but production techniques are rapidly being improved and may eventually provide a high-efficiency and low cost solar panel.



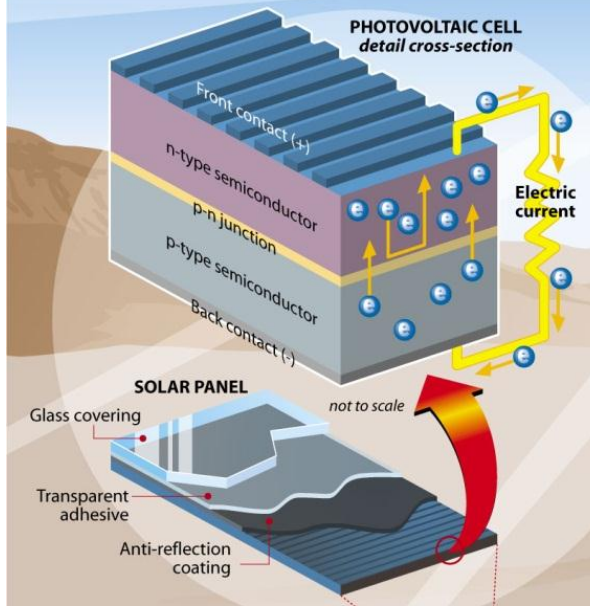
Thin film solar panel demonstrating its flexibility (left) and how easily it can be integrated onto a metal seam roof (right).

Tapping the Sun's Energy

Solar panels, or photovoltaic cells, harness energy from the sun. The cells are made of a semiconductive material that is specially treated so that the sun's rays help create a flow of electrons, which can be used to power your home.

The sun gives off about 400 trillion trillion watts of power

A lot of the sun's energy is reflected back into space or absorbed by the Earth's atmosphere. An average of 1,000 watts hits each square meter of the Earth's surface during peak times, more energy per hour than the global population uses in a year.



PV cell at a glance

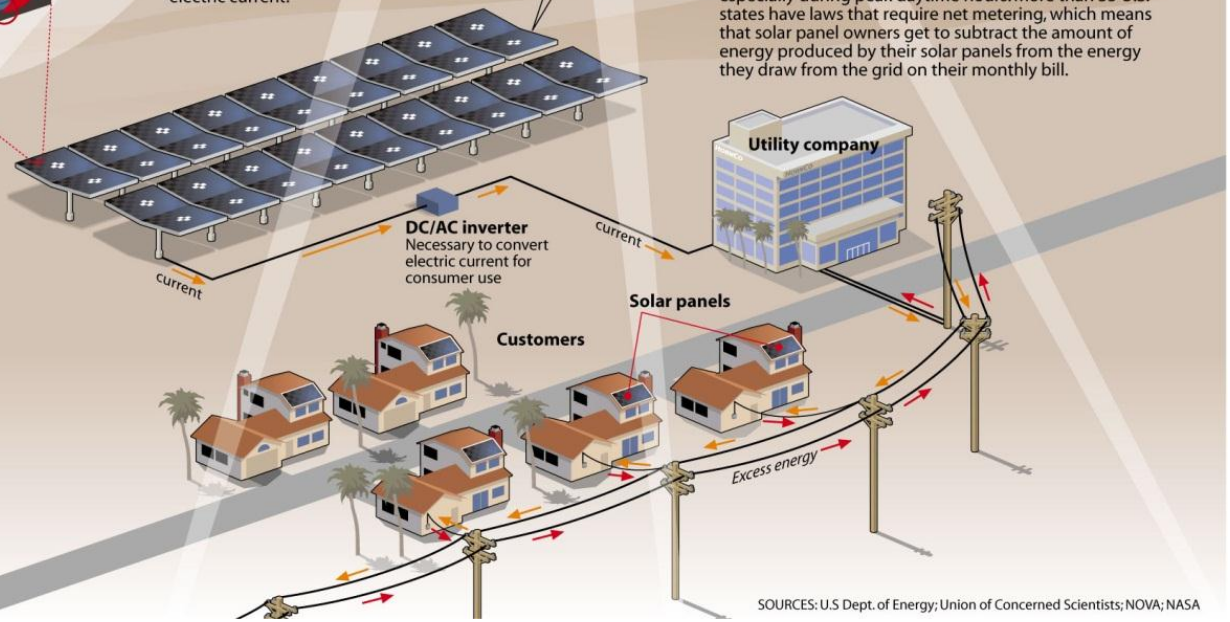
A photovoltaic (or PV) cell is a specially treated wafer of silicon, sandwiched between two thin contact plates. The top contact is positively charged and the back contact is negatively charged, making it a semiconductor.

- The **n-type semiconductor** has an abundance of electrons, giving it a negative charge, while the **p-type semiconductor** is positively charged.
- Electron movement at the **p-n junction** produces an electric field that allows only electrons to flow from the p-type layer to the n-type layer.
- When sunlight hits the solar cell, its energy knocks electrons loose from the atoms in the semiconductor.
- When the electrons hit the electrical field, they're shuttled to the top contact plate and become a usuable electric current.

Solar panel farm
How much energy a solar panel can make depends on how efficiently it converts the sun's energy. An average solar panel around a square meter in size can generate about 100 watts. Commercial panels are up to 17% efficient, and are getting better every day.

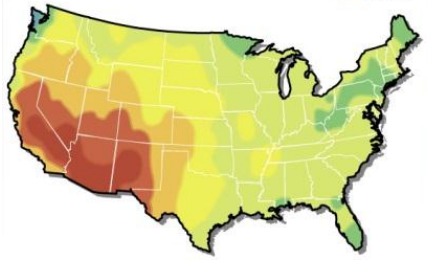
Feeding the grid

Excess energy from the solar array is fed into the power grid. It helps provide extra electricity to the community, especially during peak daytime hours. More than 35 U.S. states have laws that require net metering, which means that solar panel owners get to subtract the amount of energy produced by their solar panels from the energy they draw from the grid on their monthly bill.



Solar potential in the U.S.

The amount of energy striking almost any part of the Earth is vast, regardless of region, season, time of day, climate and air pollution. Shown is the average radiation received on a horizontal surface across the continental United States in the month of June.



SOURCES: U.S Dept. of Energy; Union of Concerned Scientists; NOVA; NASA

History of Solar Power

Photovoltaic technology was born in 1954 when Daryl Chapin, Calvin Fuller and Gerald Pearson developed the first silicon photovoltaic cell at Bell Laboratories. In the 1970's, production techniques reduced the cost per watt for a solar panel from $100 to $20 and industry began to commercialize. Over the last decade, the solar market has seen explosive growth in areas with competitive incentives including Germany, California, New Jersey. Currently, the United States hosts a total of 1.7 gigawatts of installed solar capacity and the solar industry has been the fast growing market for the last 3 years.

How much will it cost me?
Typically speaking, a solar array will cost between $5,000-$7,000 per kilowatt fully installed for residential scale arrays, depending on size, installation complexity, mounting type and equipment used. To estimate roughly what size system you would need for home and a reasonable price range use the following calculation:

((Average monthly kWh use x 12 months) x % of desired solar electricity) / 1,200
= kW size for your home

kW size of solar array x $5,000/kW = lower estimate of solar array cost
kW size of solar array x $7,000/kW = upper estimate of solar array cost

For example:
A house that uses an average of 600 kWh per month and wants 50% of electricity needs to come from solar.

600kWh x 12 months = 7,200 kWh annually
7,200 kWh x 50% desired solar = 3,600 kWh
3,600 kWh / 1,200 = 3 kW solar array for your home

3 kW solar array x $5,000 = $15,000 – lower estimate of solar array cost
3 kW solar array x $7,000 = $21,000 – upper estimate of solar array cost
$18,000 – average estimate of solar array cost

Are there incentives?
Yes, there are both state and federal incentives available for solar energy. For the remainder of 2011, the US Treasury grant program will issue a check for 30% of the installed system cost system upon completion of the installation. After 2011, 30% of the installed system cost will be given to the owner of the solar array in the form of a dollar-for-dollar federal tax credit; in short, the solar array will reduce your tax obligation by 30% of the installed system cost. To estimate, how much you will receive from the federal incentive, use the following calculation:

Total System cost x 30% = Federal incentive

For example:
A 3 kW solar array that costs $18,000.

$18,000 x 30% = $6,000 – Available federal incentive

Currently, a rebate offered by the State of New Hampshire will provide the lesser of 50% of the system cost or $1.25/watt up to $4,500 for each array. To calculate how much you would receive from the state rebate program use this following calculation:

Choose the lesser of the two:
Total System size (kW) x $1,250 = $ amount of state incentive
Total System Cost $ x 50% = $ of state incentive

For example:
A 3kW solar array that costs $18,000.

3kW x $1,250 = $3,750
$18,000 x 50% = $9,000
$3,750 = Available NH State Rebate

As you can see by the examples provided, the currently available incentives will provide over 50% of the system costs to homeowners and are well worth the time and effort required to file for the available incentives.

For further information on the current status of available incentives visit the New Hampshire page of the Database of State Incentives for Renewables and Efficiency (DSIRE) website.

Environmental Considerations
There are numerous hazardous emissions that are avoided when electricity is produced from solar panels:

- Carbon dioxide: A major greenhouse gas that is produced by any combustion-based power plant.
- Sulfur dioxide: Produced most commonly by coal-fired power plant, sulfur dioxide if the major cause of acid rain worldwide.
- Nitrous dioxide: Formed in high-temperature combustion, nitrous dioxide causes smog that plagues most of the world's city centers.

For additional information…
Consult the Department of Energy's
Get Your Power from the Sun: A Consumer's Guide

Frequently Asked Questions:

Q: Where should I mount my solar array?

A: If your roof pitch runs East to West, often the best place to locate your array is on the South side of your roof. If your roof is shady or not oriented well, a ground mounted array on the edge of your lawn may be your best option.

Q: What kind of maintenance is associated with my solar array?

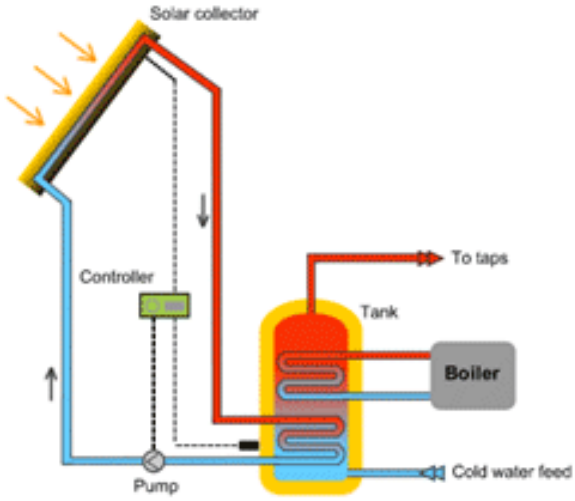
A: In truth, not much. Solar arrays can collect dust that can reduce its output and often a quick rinse with a hose will remove the dirt. Solar arrays have no moving parts and warranties of over 20 years of worry-free operation.

Q: Will my solar array provide electricity when the power is out?

A: In most cases, no. Most solar arrays are "net metered" that allows the array to feed any surplus electricity generated back to the grid and receive a credit for the power produced. An expensive battery bank is required to supply electricity when the grid is down.

A HOME-OWNER'S GUIDE TO SOLAR THERMAL

Technology:
Solar thermal technology converts the sun's energy into usable heat. This heat is most often used for domestic hot water but can also be used for heating. Since space heating is a specialized adaptation, this introduction only covers domestic hot water projects.



Typical layout of a solar thermal system

Some rules of thumb:

- Electric, oil and propane hot water systems have a better payback period than natural gas, in that order.
- For most domestic hot water applications, having a secondary solar hot water tank that your existing hot water tank draws from is the best option.

Determining the size of a system:

- For an average home, a well installed and appropriately sized thermal system can displace between 275 to 325 gallons of oil a year.
- Most experts recommend sizing the system to 75% of the summer load and 25-45% of the winter load – any higher, will result in overheating.
- Storage is usually necessary at the rate of about .75 gallons for each square foot of collector. A single solar thermal collector is approximately 15 square feet. Typically, a 2 collector system is appropriate for households with 2-3 people and a 3 collector is appropriate for households with 3-5 people.

Flat Plate vs. the Evacuated Tube

The evacuated tube collector is considered more efficient in low light and windy conditions.

Evacuated tube collectors only require flow through the header at the top. This can be helpful when installing drainback designs, which are the most efficient freeze-proof designs.

Flat plate panels melt the snow due to their high heat losses through the un-insulated glass.

Evacuated tube collectors are so well insulated they do not melt the snow but may collect less snow. The evacuated tubes seem to work well under light-to-medium frost. And they will collect energy when half covered with snow (about half as much as when fully exposed).

Flat panels have a more consistent output over the year.

Appearance is purely subjective.

System Cost and Financing:

-Solar thermal is eligible for a 30% federal income tax *credit* until 2016.

-State rebates are available but changing due to fluctuations in federal and state funds.

-Installations are more unique than Solar PV so pricing is not always consistent, but expect anywhere from $7,000 - $15,000

-The installation cost will depend on the equipment, the complexity and any additional expertise needed. Getting a couple quotes can help, word of mouth for a reliable installer and our tear out on Choosing an Energy Service Provider can help

How much will it save me?
There incentives are several ways to consider this question. First off, solar thermal arrays save money from fuel. Given the very simple calculation of 300 gallons of fuel oil saved by the average system, we can see the following annual savings based on oil prices:

Annual Savings Calculation

Price	Gallons	Annual Savings
$2.50	300	$750.00
$3.00	300	$900.00
$3.50	300	$1,050.00
$4.00	300	$1,200.00

Installing and maintaining a system:

- A clear Southern exposure is best with an unobstructed view in the winter is especially important.
- The solar thermal systems circulate glycol through the collectors and transfer the heat into the water tank for use and storage.
- Roof mounts, wall mounts and even ground mounts can be done.
- There are two kinds of technologies flat panels and evacuated tubes, see the sidebar about these different systems.
- All systems require some maintenance and regular inspection to insure long-term operation and function.
- The existing hot water tank is typically left in place to allow redundancy of hot water systems. The solar hot water system extends the existing hot water systems and their heat elements.

How much does it cost?

Solar thermal systems require equipment and installation. Anyone can search the internet to get an idea for how much a solar thermal package costs. Although a professional system installer/designer is highly recommended to insure you have the correct system, here are two excellent sources for packaged systems that can give you an idea about costs and can help you be an informed energy user:

- Alt-E Store – Packaged Thermal Systems.
- AAA Solar – Packaged Thermal Systems are shown on page 30 of the catalog.

What incentives are available?

The next set of cost impacts are state rebates. The current rebate is performance based and ranges from $1,500 - $1,900 per system in a two-step filing process that most installers can help you fill out. Access the PUC's rebate page.

The final cost impact relates to the federal tax credit. This is a credit, not a deduction, and is applied to your taxes dollar for dollar. This can represent a significant savings with some effective planning and you can maximize your credit if you have a year with high tax liability. Although it is not refundable, it can be carried forward for a number of years to offset future tax liability.
The important things to know about the federal tax credit:

- The credit is in place until 2016 and has no limit.
- It is 30% of the system cost - equipment and installation.

- The system must be certified by the SRCC – something your installer can provide – to be eligible for the credit.
- Principal and second homes qualify but NOT rental units (these may be eligible for business tax credits).
- The credit is entered into your 1040 on like 52 from Form 5695.

Hypothetical System	3 Person Home System
Installed Cost	$10,000.00
Tax Credit	$3,000.00
State Rebate	$1,500.00
Final Cost	$5,500.00
Annual Savings	$1,000.00
Simple Payback in years	5.5

calculation with current incentives

Where do I need to install solar thermal?
In general, thermal systems need a southern exposure with an unobstructed view. Roof and wall mounts are both utilized and in some cases a ground mount may be employed. Piping is one major concern for installation and must be considered during the system layout.

Who can install these systems?
Many contractors can install solar thermal systems. Specialized contractors are present in the region and HVAC contractors have started expanding into the solar field. See the document on Choosing and Energy Service Provider for more information about how to pick an installer.

What will it look like?
We offer the pictures to the right for a simple illustration, but there are several images on the internet. For an up close and personal inspection, we recommend you consider participating in the national Green Buildings Open House offered every year by the New Hampshire Sustainable Energy Association.

Example of the payback

A roof mounted evacuated tube solar thermal collector

A roof mounted flat-plate solar thermal collector

What is the maintenance like?

Advances in the technology make most systems trouble-free. A high-quality pump station is the best way to avoid technical maintenance on the system. Visual inspections for leaks and corrosion are recommended at least annually. Depending on installation some snow removal may be warranted if the system is covered but most systems shed snow quickly. Fluids should be changed every few years. Your installer will have a recommendation for this and it is good idea to follow it. If I have to replace your roof/wall, the system can be moved and replaced at a reasonable cost.

What if I move? Does it lower my house value?

Since the installation requires some changes to your home, it may be best to leave the system in place, in light of recent research, solar systems appear to be raising house values since these systems lower utility costs and are consistent with growing concern about the energy and the environment. Having a system in place when a new home owner moves in may be an attractive way for some people to enter the renewable energy world.

For more information visit:

A homebuilder's guide to going solar – shows the benefit from homebuilders perspective and how a home can be prepared for solar and the benefits.

- http://www1.eere.energy.gov/solar/pdfs/43076.pdf

Financial Information – borrow's guide to financing solar:

- http://www.nrel.gov/docs/fy99osti/26242.pdf

A very thorough "Quickguide" to solar thermal:

- http://www.rurdev.usda.gov/or/biz/QuickGuide2SolarThermal.pdf

A HOME-OWNERS GUIDE TO WOOD PELLET STOVES AND BOILERS

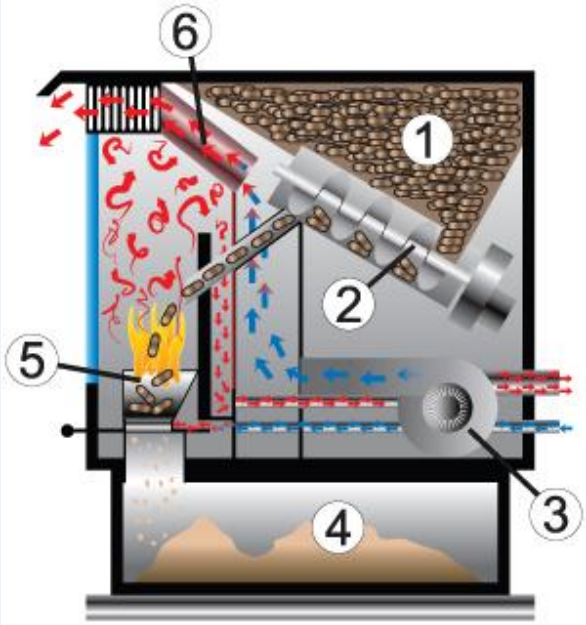
Introduction

Humankind has used woody biomass for heating and cooking needs since the dawn of time and now wood pellet stoves and boilers can provide the ease of use and automation that we have grown to expect from our heating systems. Wood pellets are formed when very fine wood chips and saw dust are extruded through a dye under high pressure, forcing natural components in the wood to bind the pellet like glue as it cools, forming a dense and homogenous fuel source. Wood pellets are often produced from wood shavings and saw mill waste and are a great reuse of valuable biomass that would have otherwise been left to decompose. Wood pellets are often package in 40 pound bags and stacked on a pallet and sold in 1 ton increments.

Two tons of wood pellets has the same energy content of one cord of dried hardwood, and is much easier and cleaner to handle. Typically, wood pellets are bundled into easy-to-carry 40lb bags which are stackedSimilarly, one ton of wood pellets displaces 2.8 barrels of #2 heating oil, the most common home heating fuel in New England. Wood pellets provide one of the best solutions for carbon neutral home heating in cold climates.

The most common way to burn wood pellets is in a pellet stove, a convenient alternative to traditional wood stoves.

The pellet stove's hopper (1) is filled with wood pellets and an electric auger (2) feeds pellets into the burn grate (5) at a rate determined by the temperature control. The fire heats the air in heat exchange tubes (6) and a convection fan (3) blows heated, uncontaminated air into the room. An ash pan (4) below the burn grate collects all ash and residue. Typically speaking, a pellet stove only needs to be filled once a day and the ash pan only needs to emptied once or twice a year. Wood pellet stoves are most typically used a supplemental heat source.



All wood pellets are not created equal.

As you can imagine, different kinds of wood have different energy densities; the harder the wood, the more energy it contains. Since wood pellets are often made of sawmill waste, there is variety of wood that goes into the pellets themselves. The Pellet Fuels Institute was created to evaluate and standardize fuel quality within the pellet industry and reports important fuel characteristic for each pellet manufacturer including energy content, moisture content, fines (amount of wood dust in the bottom of the bag) and bulk density (how well formed the pellet is) and then places each pellet into one of three categories; PFI Premium, PFI Standard and PFI Utility. Understanding the quality of the pellet itself is an important characteristics when evaluating which brand of wood pellets to purchase; the quality of pellet fuel is more variable than traditional fossil fuels that consumers are accustomed to and the better quality pellet you use, the less you will have to empty the ash bin.

More information of pellet fuel quality is available at Pellet Fuel Institute's website

Pellet Fuels Institute

Wood Pellet Boilers

In the last few years, major advancements in wood chip and wood pellet boilers has made it a more viable technology and increased its prevalence in the United States. Wood pellet boilers operate with many of the same components as wood pellet stoves but offer a much greater control and can be directly integrated into existing hot water tanks, hydronic heating loops and forced hot air heating system. Many models of wood pellet boilers have efficiencies as high as 90%, making them cost competitive to most fuel sources.

Unlike pellet stoves, pellet boilers are capable of running 24 hours a day, can provided domestic hot water and forced hot air and are usually designed to provide the entire heat load for the building. Like traditional boilers, the modern wood pellet boiler is governed by a thermostat, is able to modulate (reduce or increase its heat output based on demand) to increase its overall efficiency and can be even be controlled by a computer or smart phone. Wood pellet boilers often have substantial storage bins that receive bulk delivery of wood pellets brought by truck and are blown in by strong fans. Below is a cross-section of a typical wood pellet boiler

Pellet stoves and air quality

A chimney emitting wood smoke has become synonymous with winter-time New England, but the grey smoke is actually evidence of high-particulate matter and unbalanced air to fuel mixture! Fireplaces are actually among the most inefficient ways to heat your home; a majority of the combusted energy is exhausted out the chimney. Since the pellet fuel is gradually fed into the combustion chamber, the stove or boiler is able to increase the air to fuel ratio, reducing the amount of uncombusted particulate matter in the smoke. Some models of pellet stoves actually route a portion of the exhausted smoke back into the combustion chamber to burn off remaining particulates.

The Environmental Protection Agency has developed a program called Burn Wise that assists consumers in making informed decisions around how to heat their home and identifying wood stoves, pellet stoves and pellet boilers that have the cleanest and most efficient burn characteristics.

Visit www.epa.gov/burnwise/ for more information on air quality and best burn practices.

What incentives are available for pellet stoves and boilers?

Currently, there is a both a state and federal rebate available for pellet stoves and boilers. There is a $300 federal rebate available for boilers and stoves with a thermal efficiency of 75% or better. This rebate may seem like a small amount, but it actually constitutes about 25% of system cost for some mid-range pellet stoves. Pellet boilers are much more costly and the $300 federal incentive hardly makes an impact on a consumer's decision to buy pellet boiler.

The New Hampshire Public Utilities Commission offers a rebate for 30% of system cost up $6,000 for pellet boilers installed on the primary residence of the applicant. Additionally, the system must be installed by an authorized installer and it must provide at least 75% of home's heating needs.

Frequently Asked Questions:

Q: Why should I buy pellets when cordwood is less expensive?

A: Pellets are created most often from sawmill waste and are a fantastic reuse of biomass that has already been cut and transported. Pellets are also easier, less messy and prevent trips to the wood pile during the frigid months.

Q: What kind of maintenance does my pellet stove require?

A: The combustion chamber itself should be checked everyday to ensure air inlets are clear and open. The ash drawer should be emptied before starting a new fire and will need to be dumped anywhere from once a week to once a month depending on fuel quality and the stove model. The hopper should be periodically checked and the glass should be cleaned as needed.

Did you know….

One ton of wood pellets is the equivalent of:

- 120 gallons of heating oil
- 170 gallons of propane
- 4,755 kWh of electricity
- 16,000 cubic feet of natural gas