



# Lee – Energy Handbook

A Resource for Residents

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## Introduction.

This handbook provides Lee residents with an introduction on how to help mitigate climate change within their community. Community-scale activities such as energy benchmarking and efficiency upgrades will not only reduce Lee's fossil fuel emission and fuel-related costs; they will also make an important public statement about your values and priorities.

This guide presents very little new information on climate change science or technology. Instead it focuses on specific actions, technologies and resources that are locally available for Lee.

We can all effect change in our communities if we choose to. This document is for those who decide to become those agents of change.

## Getting Started: The Lee Energy Committee Roadmap.

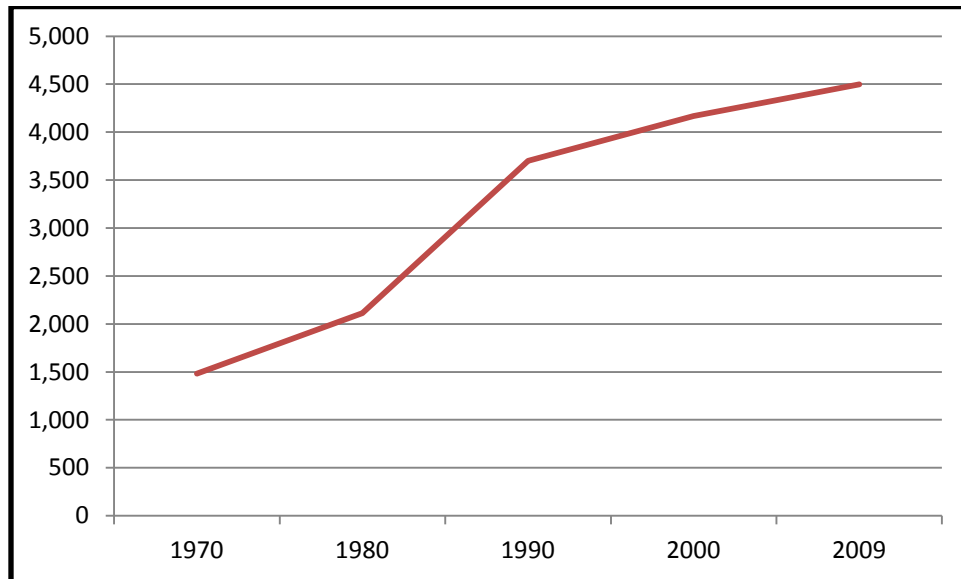
The Lee Energy Committee was formed in 2009 and has been tasked by the Board of Selectman to investigate the town's energy use, create a town-scale greenhouse gas inventory, and engage, educate, and enthuse local residents around energy efficiency and renewable energy. In April of 2011, the Lee Energy Committee hosted a tremendously successful energy fair with over 150 people in attendance, 20 vendors and 11 presentations from renewable industry leaders from across the state. The Lee Energy Committee used survey data from residents to create a comprehensive energy plan and provide ongoing guidance and support to the community.

This handbook is meant to serve as a quick reference for residents to develop the necessary background to understand energy efficiency and renewable energy, and provide resources to locate consultants and contractors. It is intended to be a resource that residents can return to time and time again as their interests, goals, and understanding evolves to learn something new and learn how to apply the information into their own lives and homes.

## Understanding Lee and its Energy Needs

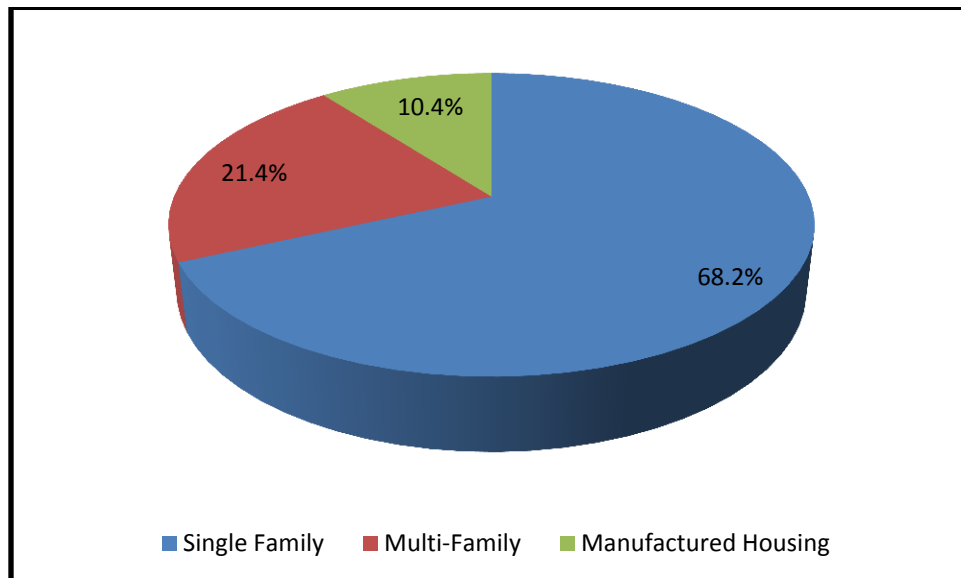
Lee is a rural and largely agrarian community of about 4,330 residents situated in Strafford County in the seacoast region of New Hampshire. Lee's close proximity to the University of New Hampshire has resulted in an engaged community that has a deep appreciation and sense of stewardship for the land. Lee is also a well-educated community, with 95% of the residents having a high school degree, and 49% receiving a bachelor's degree or higher.

When the census was first taken in 1790 Lee had 1,029 residents. Lee has seen extensive growth in the last fifty years, from only 575 residents (less than a third than when census was first gathered) in 1950 to 4,169 in 2000. Coincidentally, it can be inferred that the majority of the housing stock in Lee was constructed after 1950, which experienced 40% growth between 1950-1980. Lee experienced the greatest increase in population of 75% between 1980-1990, so it is a reasonable assumption that a large portion of the housing stock was constructed during that time.



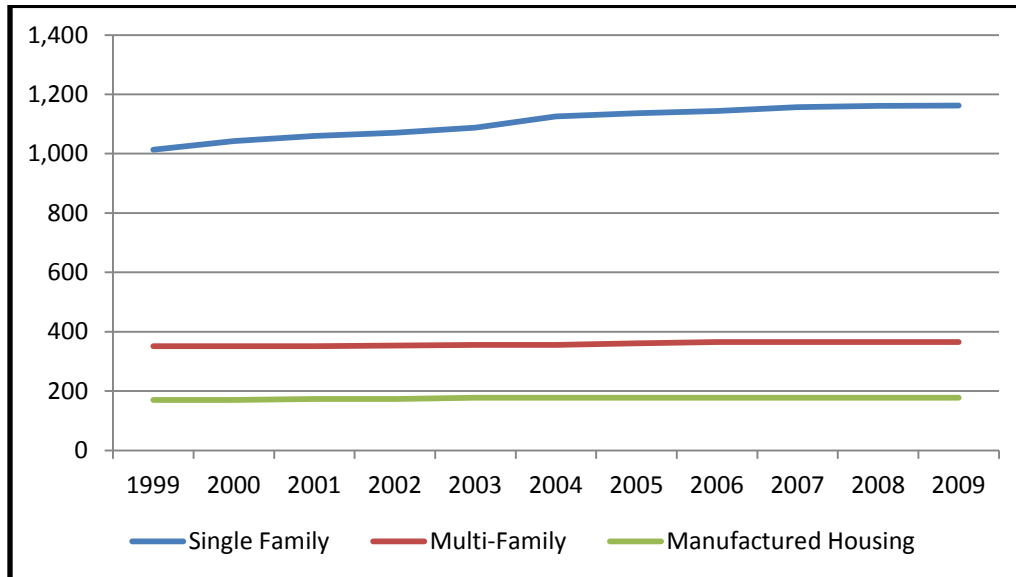
*Population of Lee, NH 1970-2009*

The predominance of homes in Lee are single-family residences, of which multi-family residences and manufactured housing constitute about 30% of the housing stock.



*Lee's housing stock by type, 2009*

Lee continues to see growth in its housing stock, albeit slower than the last 30 years and predominantly in the single family home sector.

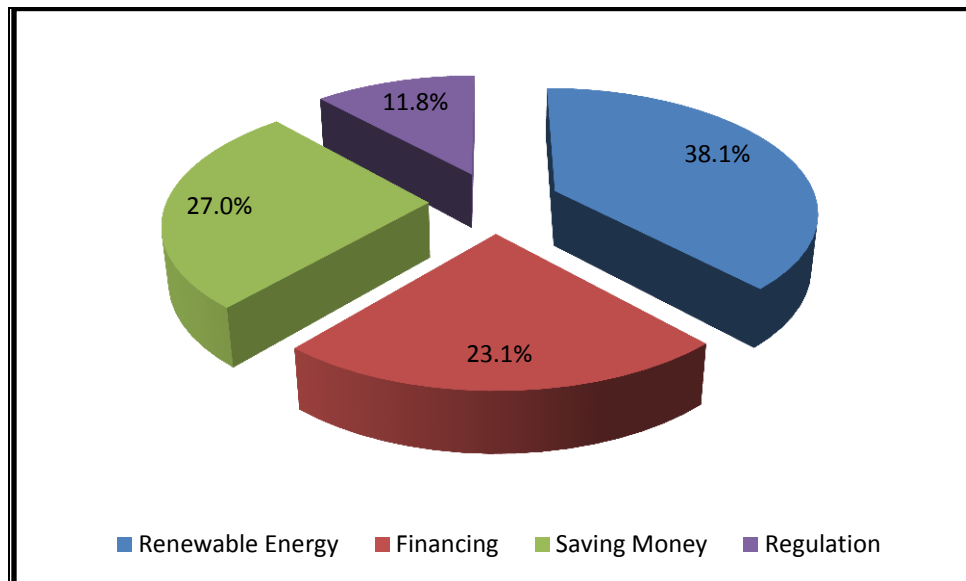


*Lee housing stock by sector, 1999-2009*

The Lee Energy Committee was formed in 2009 with a goal to interact with local citizens, to determine their energy goals and needs for their community and to inform, educate and enthuse the local population around energy security, energy efficiency and renewable energy. The Lee Energy Committee is an all-inclusive group that encourages local residents to become active in determining Lee's Energy future. The Lee Energy Committee hosted the first annual Lee Energy Fair in April 2011, inviting local residents to meet with local sustainable contractors and businesses, attend lectures from leaders of green industry and to talk about their energy goals, both for themselves and the community. The fair was a resounding success, with over 20 local businesses represented, over a hundred residents in attendance and several dozen door prizes given out including energy audits, electricity monitoring equipment and many more. To be entered into the drawing for door prizes, each resident was asked to fill out a short survey about energy, their primary concerns and their goals for the community. The survey itself provides excellent insight and will serve as guidance for the Lee Energy Committee and community moving forward. The following is a discussion of the results of the Energy Survey and its broader implications.

**1) In order of importance, what local energy issues are most important to you?**

Renewable Energy - 38.1%, Saving Money - 27.0%, Financing - 23.1%, Regulation - 11.8%

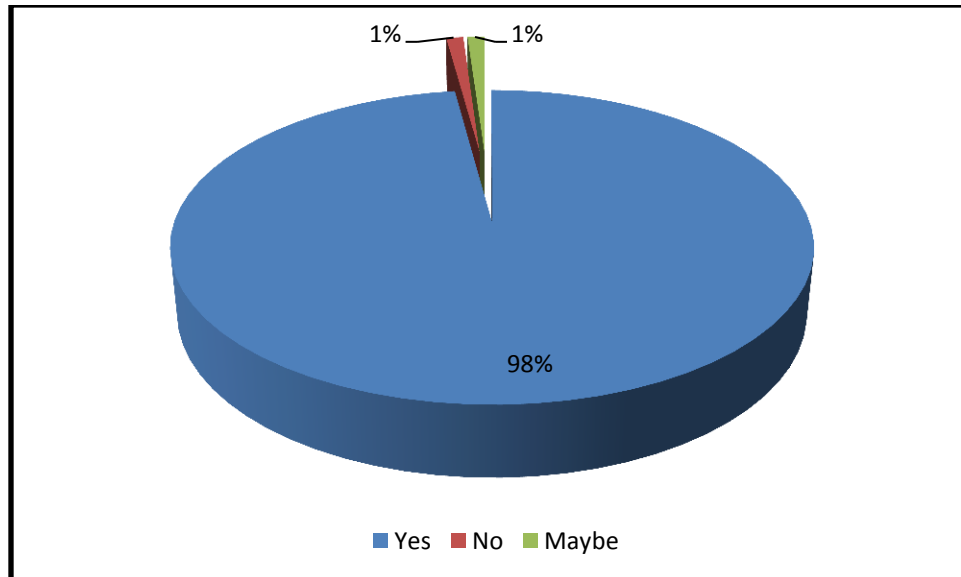


One of the most surprising results of the survey was the Lee community's prioritization of renewable energy over saving money on energy expenses. This demonstrates the progressive nature of the community in regards to its' outlook for future energy projects, especially in a time where energy costs are at all an all-time high. The ideal situation for Lee residents is to identify renewable energy systems that reduce annual operating expenses immediately, which can often be achieved through third-party power purchase agreements and performance contracts. In a close third to saving money is financing, which may suggest that Lee would be agreeable to a municipal alternative energy financing program like the Property Assessed Clean Energy (PACE) program already adopted by neighboring Durham and many other communities in the United States. One of the clearest results from this question is that regulation around energy is the lowest priority and not favorable to Lee Residents.

**2) Should energy saving measures be an investment priority for Town and School owned buildings?**

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Yes- 98%, No - 1%, Maybe - 1%



The clearest result of the survey was making town-owned and school buildings an investment priority, with 98% of those surveys agreeing with such an initiative. There is a multiplicity of benefits investing in energy saving measures in school and town building, including the reduction of operating costs and tax burden on residents, investment into a project that has a true payback, and educating townspeople and children about the significance of energy reduction through leading by example. Town buildings in particular have not been winterized for many years despite the need and clear benefit to all residents. There are energy audits now completed on town buildings, and this survey provides a clear indication that townspeople support proceeding with energy saving measures outlined in the energy audit report.

**3) Has your home or business had an energy audit?**

No - 80.6%, Yes - 19.4%

**Understanding Your Energy.**

The most recent major study of energy usage in New Hampshire was undertaken in 2006. This data represents the general state of how energy is consumed, its source, and its economic impact to the state and our residents. In order to properly consider decisions about energy, we should understand the full ramifications of our decisions with respect to these impacts. This broad view into energy, provides the basis for decision makers (in government, business, and most

importantly – at home) to formulate their own goals and objectives. The goal of this document is to provide enough information to make an informed decision. Respecting the right of an individual or group to pursue particular objectives, the most help comes from presenting information and alternative options for the informed decision. There are several points where we may add analysis, which will be identified and acknowledged as such. In most cases we attempt to provide alternative viewpoints.

We evaluate on the micro-level how a typical household uses energy, how the money is spent and where the money goes. This document has a strong emphasis on keeping energy expenses local and allowing that money to be reinvested in the locally to create a multiplier effect that provides real and quantifiable economic stimulus while strengthening the regional as a whole.

## Understanding Your Energy Use

The most important step in reducing overall energy consumption is to take some time to understand the ways in which a household uses energy.

- Home types.
- Heating system age
- Fuel types.
- Historical data on costs and usage.
- Economic predictions and trends about fuels.
- Household's desired temperature level



## Reading your bills

Energy bills provide significant insight into the overall efficiency of a building. At least one year's worth of bills allows you to view the total amount of energy required to heat and power the building and most bills provide a summary of this information. Our homes and businesses receive a monthly set of energy bills from their utilities. These bills typically include a monthly electric bill, along with a monthly heating fuel bill (in the case of propane, oil, or another form of delivered fuel, the bill can be more sporadic and is received at the time of delivery).

### Electric Bills

When evaluating your electric bills there are several important points of information to look for. Electric bills can be somewhat confusing at first glance, but are simple to understand with a little practice. Your electric bills typically contain two over-arching areas of information – actual energy usage and the cost for that usage. First, let us focus on obtaining how much energy was used in a month. [NHEC's website](http://www.nhec.com/memberservices_understandingyourbill.php) has a great online description of your electricity bill and how to read it. By accounting for each month's electric use for one to three years you can gain an understanding of how much total energy is being consumed and when the highest rate of use is. Understanding this allows you to manage your home more efficiently and possibly reduce electric use during peak demand periods. This leads to the next area you want to evaluate – cost.

- [http://www.nhec.com/memberservices\\_understandingyourbill.php](http://www.nhec.com/memberservices_understandingyourbill.php)

The cost of electricity depends on more than just your usage charge. Your bill includes additional costs such as transmission and distribution costs, demand charges, and applicable taxes. To guarantee you are always factoring in the full costs, be sure to use the total cost figure.

### Heating Fuel Bills

The type of fuel the building consumes will determine how the building receives a heating fuel bill. For example, if a building uses natural gas for a fuel there will likely be a monthly bill describing the amount of fuel consumed (propane and oil are reported in gallons) and the cost (per gallon) of that fuel. If the building consumes a fuel that has to be delivered, which is the case for almost all of Lee, then there will be an invoice for each time that fuel is delivered (usually in \$/gal.). In either scenario, the bill will provide a total amount of fuel consumed/purchased and the cost of that fuel.

Unlike electricity, this schedule can make it difficult to account for the time of use and quantity of fuel used in a given period. As such, most auditors and homeowners have to use modeling or engineering methods to make assumptions about fuel use. In almost all cases, these methods produce results that are reliable and can still be used to plan for efficiency upgrades and alternative sources.

## Determine Your Goals

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There are three top categories of goals; economic, environmental, and personal. Although these three issues are easy to define and quantify, the lens and weight given to each is a personal matter and the point of this section is to identify these topics.

- Economic – Quantify efficiency expenses and resultant energy reduction benefits in terms of the cost of the measures and the savings to energy expenses. Beyond this, economic issues can be considered to the extent they relate to regional health. Although this is a more indirect impact, it is important and reasonable to consider these benefits in the context of today's economic crisis and the need for jobs. Regional economic development is generally accepted as a positive goal for an individual's decision about purchases.
- Environmental – the impact of energy choices have a direct and indirect result on the environment. Although climate change is a major topic, there are a myriad of other issues that relate to environmental impact including harvesting, transportation, combustion, production and refining of fuels.
- Personal – this is a means to describe all other issues beyond the above. Additionally, personal choices and decisions will assign a relative value to all other choices.

The most important piece of guidance we can provide, is to make sure your goals are supported by the right information. Your goals are your own and we strongly support exercising individual choice in these matters since these decisions are an important way to feel right about what you do.

## Seeking and Finding Help.

Self – In an age where anyone can publish a website, the internet is equal parts confusion and information. There are many government sites that can provide well-reviewed information. As with anything, we recommend that you recognize the source of the information and let that guide the weight you give the information. We support the careful use of Wikipedia as a source, it is reviewed and developed by many users and represents a unique crowd-based consensus result for information. An underutilized section in many articles, is the reference section which can take a user to many sources of information that are both helpful and supportive.

Top four gateways to start your research:

- Energy Star: <http://www.energystar.gov/index.cfm?c=home.index>  
This site has something about everything.
- Home Energy Saver: <http://hes.lbl.gov/consumer/>  
Like Energy Star but more user-friendly – very consumer oriented.
- My energy plan.net - <http://myenergyplan.net/>  
This is a NH focused web portal produced and supported by Clean Air Cool Planet has information, calculators and is best because it is for NH by NH.

- New Hampshire Office of Energy and Planning:
  - [http://www.nh.gov/oep/programs/energy/cover\\_resources.htm](http://www.nh.gov/oep/programs/energy/cover_resources.htm)
  - This site has all research and information for OEP sponsored programs and other general information – beneficial because of its ties to NH.

Friends. Many of your friends have likely done a renewable energy or energy efficiency project—we support direct experience and sharing for the best source of information. Our community is small and contractors and professionals live by word-of-mouth recommendations. We honor that tradition by listing this tool as one of the best ways to find help.

Utility. NHEC offers a wealth of information for the resident and business customer. In addition to financial assistance, the small steps website is a great resource for all NHEC customers.

[Conservation starts with you...Small Steps – NHEC's Energy Conservation Resources](#)

[NH Saves Catalog - Energy Efficient Products from PSNH](#)

Professionals. Always a source of great information, but requires an informed consumer if you are dealing with a provider seeking business. My Energy Plan.net, above, has many links to providers and professionals. Word of mouth for references, just like any other industry is an effective way to learn about who to call and when.

## **Tools for the Resident.**

The general intent of this handbook is to provide sufficient support, information and education so that the Lee Resident can become an informed consumer of energy as well as solutions for a more efficient use of that energy. To do this, we have included some self-help solutions, such as by performing your own walk-through.

## **Energy Audits**

The single most important factor in looking at energy use and investment starts with the audit. Although a professional audit is recommended, we also recommend you conduct your own audit which will help you learn about your own home or business, identify some potential easy fixes and prepare you to be an informed consumer of energy services. When you get to the point of investing in a professional audit, understanding the different forms of audits is critical when choosing both the type of audit necessary to achieve your objectives and in comparing an auditor's proposals.

One way to get an audit is to participate in the [New Hampshire Electric Coop's Home Performance with Energy Star Program](#). This is a rebate/loan program with a small fee for an audit - \$100.00. The details can be accessed at the NHEC website at the link above.

## **Conducting your own Walkthrough Audit.**

This is the simplest and quickest type of audit you can complete. It involves no cost and gives you the ability to become familiar with your own building and how its systems operate and can even help to identify some of the obvious areas of energy waste or inefficiency.

### *Think like a British Thermal Unit (BTU)*

When you begin your walk-through, get into the right frame of mind. When a carpenter is roofing a house, they need to think like a drop of water. That drop of water will enter the home wherever it can. So, the carpenter takes the utmost care in making sure that water cannot enter. In that same vein, you need to think like a BTU (British Thermal Unit). A BTU is a unit of measurement commonly used to explain how much thermal energy is used/needed to heat a particular area. Because of the laws of thermodynamics, the BTU, as compared to the droplet of water, really wants to leave the building when it is cold out (or enter - when it is hot outside) – and it will, wherever it can! We try to slow that process by increased insulation

- Put simply: A Wasted BTU = A Wasted \$

### *Conducting your own walk-through*

For the rest of this description, we use the term home to describe the building for simplicity but it can obviously be any building. The City of Seattle has the best online resource for a self-help DIY home audit. Access this guide at this address:

- [http://www.seattle.gov/dpd/static/DIYweb\\_LatestReleased\\_DPDP016083.pdf](http://www.seattle.gov/dpd/static/DIYweb_LatestReleased_DPDP016083.pdf)

You should proceed through your house by fully examining one room at a time, and attempt to observe and include in your report the following items:

- **Exterior Doors** - From the inside, examine all the exterior doors. Look for gaps around the edges of the door, the doorframe and between double doors. If it is cold outside you may be able to feel the draft with your hand. In some cases, you will be able to see light through these cracks as well. These cracks can add up.
- **Windows** - Examine all the windows in the home. Note if they are single or double pane. If they are double pane, and installed at least fairly well, replacing them may not be a source of savings. Single pane windows, however, should certainly be considered for replacement. While some single pane windows might be historic and appealing, they are extremely inefficient and costly. If the historic value of the windows means a lot, consider a more efficient model or an additional layer of glass to slow that BTU.
- **Thermostats** - Keep track of every thermostat and its setting. Be aware of any small space heaters in your home, these are very costly and indicate a system problem and an opportunity for savings. If there are many areas of different temperature, this is a clear issue of improper zoning or problems with dampers or the duct work in the heating system, or, improperly located thermostat(s). The results of a properly conditioned home are energy savings and greater comfort.

Programmable thermostats are a quick and easy way to save heating and air conditioning costs by setting back the temperature when the home is not occupied or when areas are not in use (such as a downstairs floor during the night when bedrooms are upstairs).

- **Lighting** – The obvious task is to look for any incandescent light bulbs. Be aware, however, that just because a room already has florescent lights, doesn't mean that they are the most efficient option. Be sure to document where lights can be changed to compact fluorescent bulbs or even LEDs as the technology becomes more affordable. This is an immediate action that can begin saving money immediately.
  - **For lighting that is already priced to include rebates from PSNH, visit the [NHsaves catalog](#).**
- **Insulation** – This is a tough one, but for some homeowners it may possible to estimate the level of insulation in the building envelope.<sup>1</sup> Today's International Building Code dictates that walls must be insulated to R-19, and ceilings to R-30. Many older buildings may not be insulated to such standards. When evaluating the insulation, be sure to check not only how much insulation is in the attic, but also in various crawl spaces, the walls (if possible) and the basement. In most cases, about 10% of a heating bill goes out the basement walls because they are un-insulated. Most of the time, in our climate, basements walls should be considered part of the thermal boundary.
- **Pipe Insulation** – Examine all hot water pipes you find and check them for insulation. Some may be associated with the heating distribution system, others for domestic use. Be sure to examine these pipes, when visible, throughout the home.
  - Most people only seem to be concerned that pipes are insulated in the boiler room. Just because a hot water pipe, heating or domestic hot water, is within the thermal boundary does not necessarily mean it should be un-insulated. A domestic hot water pipe should not be used to help heat a room if the radiators are properly sized. It only needs to efficiently transport hot water to the faucet. Furthermore, these pipes often travel along the perimeter of the building. Much of the heat from these pipes will radiate and conduct through the building shell to the exterior while on the way to its final destination.
- **Duct Air-seal/Insulation** – Where possible, try to examine the duct system. Unfortunately, most duct systems are inadequately air-sealed and insulated. "Duct tape" is not effective for sealing ducts.
  - The principal purpose for sealing ducts is the same for insulating pipes. You want to get the heat traveling through the ducts to where it needs to go without losing temperature. As with pipes, just because a run of ducts is within the thermal boundary of the building that does not mean that it should be unsealed and/or un-

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<sup>1</sup> The term "building envelope" is simply a term of art used to describe the buildings separation between the interior and exterior environments. We try and minimize the impact of the exterior environment through the installation of insulation. Appendix V provides a short list of cost-effective R-values for existing homes. Consult with a trained professional when determining the appropriate R-value and material for your building.

insulated. Greater comfort and energy savings are realized from properly sealed and insulated duct system. Document all the location that should be sealed/insulated.

- **Ventilation** – When looking at a building’s ventilation system, you will likely find one or two scenarios.
  1. The building may have an inadequate or non-existent ventilation system: in this case, there are probably going to be a number of natural air exchanges per hour related to the tightness of the building envelope. Unfortunately, you will not be able determine if there is too much or too little ventilation from your walk through. That would have to be determined by a trained professional. You should, however, note the lack of a ventilation system.
  2. You may find a ventilation system as part of a forced hot air/cooling system if there is a connection to the outside. What you will likely find is that the system pulls air directly from the exterior of the building, which needs to be heated or cooled before it enters the conditioned areas of the building. This is very inefficient and somewhat rare. A more likely possibility is that there is a mechanical ventilation system (like a bathroom fan) or a whole house fan. These fans can work great in the summer in lowering temperatures where air conditioning is not used. If air sealing and insulation is completed it is important to insure that enough fresh air is brought into the building. If ventilation is needed, an Energy Recovery Ventilation System (ERV) may be considered. The ERV exhausts stale air from the interior. The stale air heats up the incoming air with its heat through an exchange system and reduce needed energy to bring that air up to the desired temperature.
- **Attic Spaces** – Take note if there is a mechanized ventilation system in the attic space. This usually takes the form of fans which blow hot air out of the attic space during warmer months. Mechanically venting these spaces is a great idea. It keeps the building cooler, allowing the cooling system to run more efficiently. These fans do use quite a bit of electricity, however, and could be replaced with inexpensive solar powered units.
- **Kitchen Equipment** – Note the equipment being used. Are there an old electric range or refrigerator that could be replaced with a much more efficient model? Is there a refrigerator running, empty, and not being used in the basement? Look for a yellow sticker displaying the energy efficiency of the unit. Inefficient kitchen equipment are a huge load on electricity costs. Replacing an old unit, only to move it to the basement, is not advised given the progress in efficiency over the last few years.
- **Computers, Games, DVRs TVs** – The dreaded vampires of a home; they drain electricity without us knowing! Many of these systems stay on all the time but don’t need to be – computers can be set to shut off after sitting idle for a period of time, DVR units need some upgrade from the manufactures since they can lose channel information

on shut downs, but smart strips can control most other appliances without damaging their internal electronics.

## Sealing Leaks - Inside

Air leakage is a very important factor in the performance of your home. Not only does it translate directly to the amount of air leaving the building as the temperature and pressure try to balance, but with the traveling BTU, you may experience increased costs in heating and cooling your building. With respect to air transfer, common fiberglass insulation has little resistance to air movement. Air sealing can be an easy and quick way to increase the efficiency of your home.

Air sealing is also important to have in mind during your walk-through. Finally, professional air sealing can be warranted in some extreme cases – which can be determined with a blower door test. Before that however, let's see what we can do.

Many air leaks and drafts are easy to find because they are easy to feel — like those around poorly installed windows and doors, attic hatchways, unused chimneys, and broken or damaged portions of the home. But holes hidden in attics, basements, and crawlspaces are usually bigger problems and harder to find. Sealing these leaks with caulk, spray foam, or weather stripping will have a great impact on improving your comfort and reducing utility bills.

After you have addressed the obvious air leaks (drafts) it is time to move on to the more hidden locations. Remember that the potential energy savings from reducing drafts in a home can range from 5% to 30% per year, and the home is generally much more comfortable afterward. Even with your own efforts you can make a difference.

For the hidden leaks, check for gaps along the baseboard or edge of the flooring and at junctures of the walls and ceiling – it may be hard to tell, but during a windy day, you may feel a draft. Other places to check to see if air can flow through are the following:

- Electrical outlets
- Switch plates
- Window frames
- Window gaskets
- Weather stripping around doors
- Fireplace dampers
- Attic hatches
- Basement windows
- Wall- or window-mounted air conditioners.

Also look for gaps around pipes and wires, electrical outlets, foundation seals, and mail slots. Check to see if the caulking and weather stripping are applied properly, leaving no gaps or cracks, and are in good condition.



If you are still having difficulty locating leaks, you can conduct your own basic building pressurization test:

1. Close all exterior doors, windows, and fireplace flues.
2. Turn off all combustion appliances such as gas burning furnaces and water heaters.
3. Turn on all exhaust fans (generally located in the kitchen and bathrooms) or use a large window fan to suck the air out of the rooms.

Once you complete these steps, the test increases infiltration through cracks and leaks, making them easier to detect. You can use incense sticks or even a damp hand to locate these leaks. If you use incense sticks, moving air will cause the smoke to waver, and if you use your damp hand, any drafts will feel cool to your hand.

Homeowners are sometimes concerned about sealing their residence too tightly, but this is not a serious concern. In actuality, the lower the amount of uncontrolled air entering and exiting the building the better. While a certain amount of fresh air is needed for good indoor air quality and there are specifications that set the minimum amount of fresh air needed for a building it is better to have mechanical ventilation to control the amount of fresh air entering the building and will lead to lower energy bills and greater comfort for the inhabitants.

If you are truly concerned about how tight your building is, it is time to hire a professional, such as a “Home Energy Rater”, who can use diagnostic tools to measure your building's actual leakage.

If your building is actually too tight, a fresh air ventilation system may be recommended. Such a system can be an energy recovery system and provide fresh air that has been conditioned by the exiting air – providing the best of both worlds – fresh air a temperature closer to the target temperature.

Despite everything we have stated to this point, after any extensive building sealing project, it is important to have a heating and cooling technician check to make sure that your combustion appliances (gas- or oil-fired furnace, water heater, and dryer) are venting properly and that a carbon monoxide monitor is present (with batteries).

### *Sealing Leaks - Outside*

On the outside of your house, inspect all areas where different building materials meet, including:

- All exterior corners
- Where siding and chimneys meet
- Areas where the foundation and the bottom of exterior brick or siding meet.

You should plug and caulk holes or penetrations for faucets, pipes, electric outlets, and wiring. Look for cracks and holes in the mortar, foundation, and siding, and seal them with the



appropriate material. Check the exterior caulking around doors and windows, and see whether exterior storm doors and primary doors seal tightly.

Here are some common leakage points in a home:



### Anatomy of an Energy-Efficient Window, Door and Skylight<sup>2</sup>

When you look at your windows – or consider replacement windows, here are the components of an efficient window.

<sup>2</sup> [http://www.energystar.gov/index.cfm?c=windows\\_doors.pr\\_anat\\_window](http://www.energystar.gov/index.cfm?c=windows_doors.pr_anat_window)

## WHAT MAKES A WINDOW ENERGY EFFICIENT?



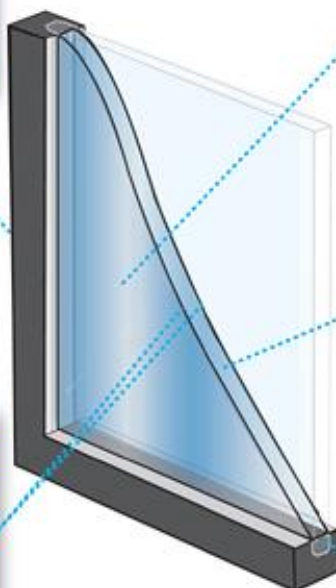
Today, manufacturers use an array of **advanced technologies** to make ENERGY STAR-qualified windows.

### IMPROVED FRAME MATERIALS

Wood composites, vinyl, and fiberglass frames reduce heat transfer and help insulate better.

### MULTIPLE PANES

Two panes of glass, with an air or gas-filled space in the middle, insulate much better than a single pane of glass. Some ENERGY STAR-qualified windows include three or more panes for even greater energy efficiency, increased impact resistance, and sound insulation.



### LOW-E GLASS

Special coatings reflect infrared light, keeping heat inside in winter and outside in summer. They also reflect damaging ultraviolet light, which helps protect interior furnishings from fading.

### GAS FILLS

Some energy-efficient windows have argon, krypton, or other gases between the panes. These odorless, colorless, non-toxic gases insulate better than regular air.

### WARM EDGE SPACERS

A spacer keeps a window's glass panes the correct distance apart. Today's warm edge spacers—made of steel, foam, fiberglass, or vinyl—reduce heat flow and prevent condensation.

## WHAT MAKES A DOOR ENERGY EFFICIENT?

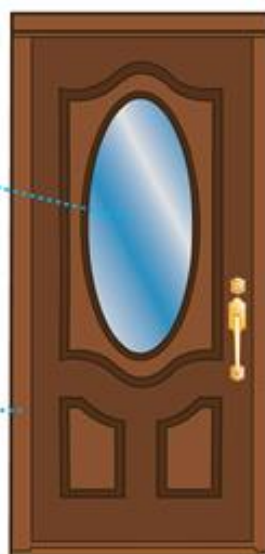


### MULTIPLE GLASS PANES

Double or triple-paned insulating glass is used to reduce heat flow.

### IMPROVED CORE MATERIALS

Fiberglass, wood cladding, and steel with polyurethane foam core are among the most energy-efficient door materials available today.



### TIGHTER FIT AND IMPROVED WEATHER STRIPPING

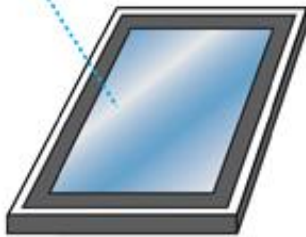
New frames may include a magnetic strip to create a tighter seal that reduces air leakage around the edges.

## WHAT MAKES A SKYLIGHT ENERGY EFFICIENT?



### TRADITIONAL SKYLIGHTS

Skylights use the same technologies as windows. But these technologies are even more valuable for skylights, which receive direct sun in summer and greater outside/inside temperature differentials in winter.



### TUBULAR DAYLIGHTING DEVICES INCREASES DAYLIGHT

Tubular daylighting devices (TDD) gather sunlight at the roof and transmit it down to a diffusing lens mounted in an interior surface, usually a ceiling. The natural light from a TDD can illuminate closets, bathrooms, hallways, or other spaces that typically would not have access to sunlight, decreasing the need for electric lighting.



## *Mechanical Systems*

This is the most technical part of your walk-through. Although heating and cooling equipment should be inspected and tuned annually, or as recommended by the manufacturer, now is as good a time as any to start. This not only insures safely operated equipment, but also that your systems are operating as efficiently as possible. If your system requires filters, it is important to change them, since a clogged filter requires more energy to work effectively. Likewise, vents and returns should be open and accessible to insure the proper flow of air in your home.

If a heating unit is more than 10 or 15 years old, you should consider replacing your system since newer units are more energy-efficient and can be eligible for tax incentives. Replacements can be a significant expense for a family, but a newer, more-efficient and properly sized unit can greatly reduce your energy consumption, especially if the existing equipment is in poor condition. If you are able to combine the federal tax credit with the PSNH or NHEC program, you can get a rebate and a low-interest loan, the payments for which may be offset by the energy savings.

### *Sealing Ducts*

In buildings with forced-air heating and cooling systems, ducts are used to distribute conditioned air throughout the building. In a typical building, however, about 20 percent of the air that moves through the duct system is lost due to leaks and poorly sealed connections. The result is higher utility bills and difficulty keeping comfortable, no matter how the thermostat is set.

If you can, check your ductwork for dirt streaks, especially near seams. These indicate air leaks, and they should be sealed with a duct mastic. Insulate any ducts or pipes that travel through unheated spaces. An insulation R-Value of 6 is the recommended minimum. These labels can be found on the insulation product.

Because some ducts are concealed in walls and between floors, repairing them can be difficult. However, exposed ducts in attics, basements, crawlspaces, and garages can be repaired by sealing the leaks with duct sealant (also called duct mastic). In addition, insulating ducts that run through spaces that get hot in summer or cold in winter (like attics, garages, or crawlspaces) can save significant energy.

In radiant, steam and domestic hot water systems, insulating the piping with at least R-6 pipe insulation will reduce losses in delivery. This is especially important if the piping is outside the insulated area of the building.

## Hiring an Auditor

21

After you have conducted your walk-through audit and generated a baseline amount of information, you are now ready to decide if a professional energy auditor can be helpful to carry out a more precise energy evaluation. The auditor will utilize the information already obtained by you and apply those findings to specific recommendations to improve the buildings performance and lower energy consumption. There are two types of audits that are available to you at this stage – a “Decision-Grade Audit” (DGA) or an “Investment-Grade Audit” (IGA). The energy auditor industry is an emerging industry, and as such, there will be several types of certification that an auditor may possess. The State of NH does not require energy auditors to be certified to conduct audits. The most common national audit certifications, however, are the [Home Energy Rater System](#) (HERS) certification and the [Building Performance Institute](#) (BPI) certification. Some auditors may be new to the business as well. This is not necessarily a bad thing, but you want to make sure you are getting your money’s worth. Ask your auditor to provide an example audit that he or she has provided to another customer. At a bare minimum, certified auditors are required to carry out a certain number of audits that are reviewed and approved by an entity established to train new auditors. Your auditor should at a minimum be able to provide you with one of these audit examples, this will allow you to see what you will get for your money. Taking information from the HERS source, RESNET, they describe 3 levels of audits:

### Home Energy Survey

A Home Energy Survey is a visual inspection and does not include the use of diagnostic testing equipment. Its purpose is to assess the general energy performance of an existing home including:

- Building envelope features (windows, doors, insulation, ducts) and ages
- Heating, cooling and ventilation equipment types, characteristics and ages
- Appliance and lighting characteristics
- Comfort complaints
- Visible moisture issues
- Visible health and safety issues

The Home Energy Survey Professional (HESP) will request a review of utility use and billing history to better understand potential opportunities for savings. A report of the complete assessment is provided, including basic recommendations for improving the home's energy efficiency, as well as low-cost do-it yourself tasks. It also includes information on relevant utility-based programs that may incentivize the homeowner to take action. A Home Energy Survey takes approximately one hour to complete.



## Building Performance Audit

A Building Performance Audit includes all of the inspections provided in the Home Energy Survey and also includes diagnostic testing using specialized equipment such as a blower door, duct leakage tester, combustion analyzer and infrared camera to determine:

- The amount and location of air leaks in the building envelope
- The amount of leakage from HVAC distribution ducts
- The effectiveness of insulation inside walls and ceilings
- Any existing or potential combustion safety issues

A Building Performance Auditor (BPA) conducts a whole-house evaluation and performs computer software analysis to identify and prioritize proposed treatments for improvement. The detailed report will provide suitable retrofit recommendations and specifications and guide the homeowner to the appropriate RESNET Qualified Energy Smart Contractors who can perform the work. A Building Performance Audit takes 3-4 hours depending on the size of your home.

## Comprehensive HERS Rating

A Comprehensive HERS Rating is the most in-depth performance audit of an existing home. It consists of the evaluation, diagnostic testing, cost-effective recommendations and work specifications contained in a Building Performance Audit.

**In addition**, a Comprehensive HERS Rating includes a computerized simulation analysis utilizing RESNET Accredited Rating Software to calculate a rating score on the HERS Index. The report will also contain a cost/benefit analysis for the recommended improvements and expected return on investment. Comprehensive HERS Ratings of existing homes will be required to qualify loan applicants for certain federally sponsored mortgage products.

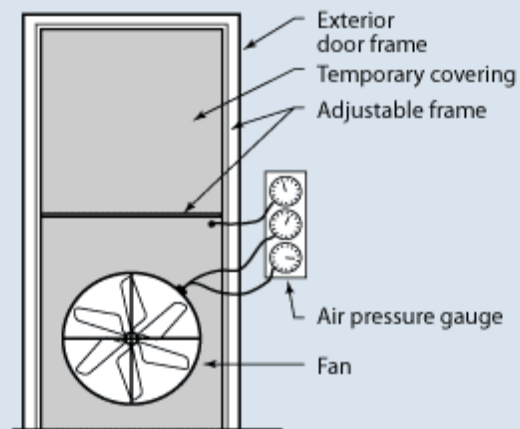
For more information on energy ratings, see [What is an Energy Rating?](#)

## The Blower Door Test:

A blower door test is considered one of the most important energy audit tools. The test provides a professional auditor with the buildings air-tightness. The tightness of the building directly relates to how much air exchange occurs, therefore providing an understanding of how much heat and air conditioning escapes. The illustration and information on the next page was obtained through the [Department of Energy's Consumer Guide to Energy Efficiency and Renewable](#)

### Diagnostic Tools

Testing the airtightness of a home using a special fan called a blower door can help to ensure that air sealing work is effective. Often, energy efficiency incentive programs, such as the DOE/ EPA ENERGY STAR Program, require a blower door test (usually performed in less than an hour) to confirm the tightness of the house.



*Energy.* While the example illustrates a home test, a professional auditor can still conduct a blower door test on many types of larger buildings. Be sure to ask the auditor if they have the equipment to test within a larger doorway. 23

Professional energy auditors use blower door tests to help determine a home's air-tightness. These are some reasons for establishing the proper building tightness:

- Reducing energy consumption due to air leakage
- Avoiding moisture condensation problems
- Avoiding uncomfortable drafts caused by cold air leaking in from the outdoors
- Making sure that the home's air quality is not too contaminated by indoor air pollution.

### *How a Blower Door test works:*

A blower door is a powerful fan that mounts into the frame of an exterior door. The fan pulls air out of the house, lowering the air pressure inside. The higher outside air pressure then flows in through all unsealed cracks and openings. The auditors may use a smoke pencil to detect air leaks. These tests determine the air infiltration rate of a building.

Blower doors consist of a frame and flexible panel that fit in a doorway, a variable-speed fan, a pressure gauge to measure the pressure differences inside and outside the home, and an airflow manometer and hoses for measuring airflow.

There are two types of blower doors: calibrated and uncalibrated. It is important that auditors use a calibrated door. This type of blower door has several gauges that measure the amount of air pulled out of the house by the fan. Uncalibrated blower door can only locate leaks in homes. They provide no method for determining the overall tightness of a building. The calibrated blower door's data allow the auditor to quantify the amount of air leakage and the effectiveness of any air-sealing job.

### *Preparing for a Blower Door Test*

Take the following steps to prepare your home for a blower door test:

- Close windows and open interior doors
- Turn down the thermostats on heaters and water heaters
- Cover ashes in wood stoves and fireplaces with damp newspapers
- Shut fireplace dampers, fireplace doors, and wood stove air intakes.

### **Defining Success.**

It is important for you to remember to monitor your energy consumption after making improvements in order to determine the success of your efforts. Many projects may have a relatively long return on investment, but do not let this discourage you. You can see your savings

right away if you just look for it. You can use your electric bill to show the annual consumption of electricity and month to month comparisons. [NHEC has a great place on its website](#) that teaches you how to read your bill. And remember, you will only realize limited energy efficiency gains without working with your family. An airtight envelope quickly loses its efficiency when you leave a window open.

## Introduction to Technologies and Projects that can Save Money and Reduce Pollution.

### Universal Projects.

#### Weatherization

The process of weatherizing a building is typically the starting block to efficiency. Many buildings are similar to a leaky bucket – there are holes that need to be plugged before you try and fill it with water. A building is the same way. You want to fix the leaks (inefficiencies) in your building while at the same time try to incorporate new energy sources.

These are discussed more fully in the section above on the walk-through audit.

Weatherization typically includes:

- Sealing/repairing/replacing windows and exterior doors
- Improving insulation R-Values
- Insulating heating pipes and/or air ducts
- Cleaning air ducts and radiator units to allow for better heat transfer

### Specific Energy Generation Projects and Technologies.



#### Wood Pellet Stoves and Boilers<sup>3</sup>

##### *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

<sup>3</sup> The Massachusetts Division of Energy Resources released a guidebook titled *Wood Pellet Heating: A Reference on Wood Pellet Fuels and Technology for Small Commercial & Institutional Systems* in June 2007 that discusses wood pellets as a fuel source and a some common consideration when evaluating wood pellets for your application. You can download this guidebook at [http://www.mass.gov/Eoca/docs/doer/pub\\_info/doer\\_pellet\\_guidebook.pdf](http://www.mass.gov/Eoca/docs/doer/pub_info/doer_pellet_guidebook.pdf).

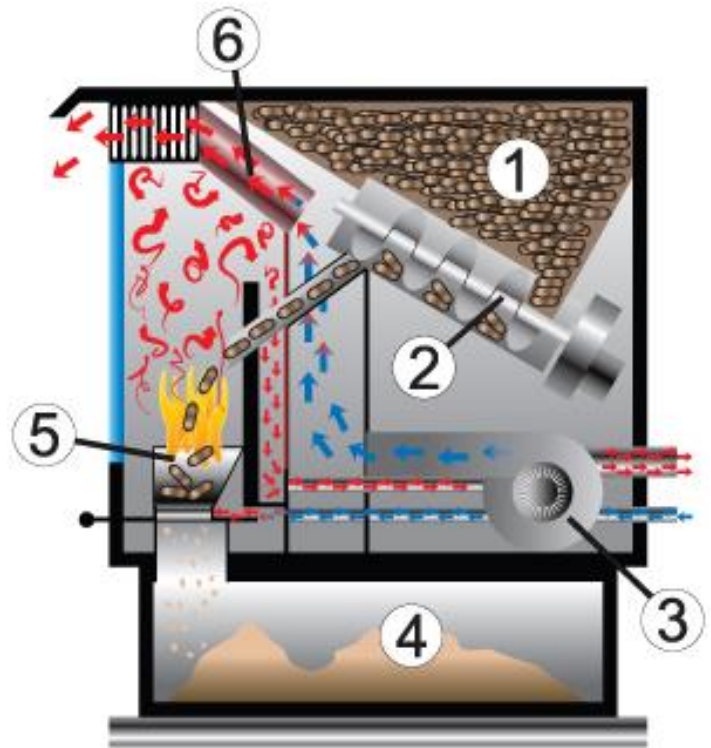


components in the wood to bind the pellet like glue as it cools, forming a dense and homogenous fuel source. Wood pellets are often produced from wood shavings and saw mill waste and are a great reuse of valuable biomass that would have otherwise been left to decompose. Wood pellets are often package 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. Similarly, 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. Wood pellet stoves do require electricity, they will require a generate in the event of a power outage.

#### *Wood Pellet Stove*

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 be emptied once or twice a year. Wood pellet stoves are most typically used a supplemental heat source.



#### 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 provide 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.

*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 characteristics 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 characteristic 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](#).

*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

*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/](http://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 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 to \$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.

[State rebates are available for central pellet boilers](#) and the program has over 75% of its original funding available for rebates. There [US Department of Energy has a very helpful website](#) to help you make a decision about these boilers.

For more information, see our Tear Out on Wood Pellet Stoves and Boilers.

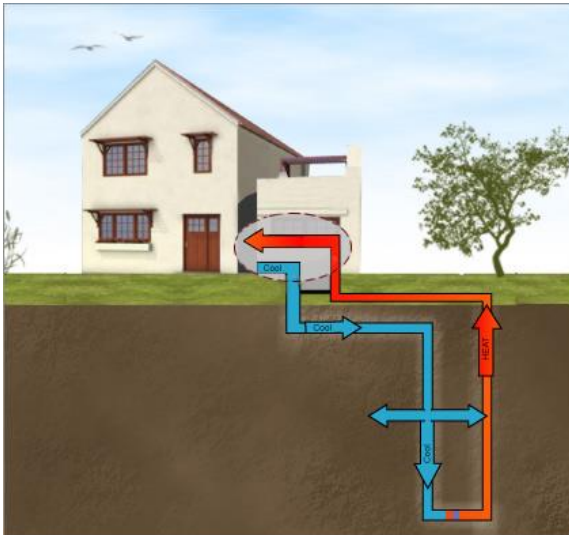
## Geothermal

Geothermal energy is the capture and use of the earth's relatively constant temperature for heating and cooling within a building. A geothermal heat pump (GHP) (also known as ground-source pumps) transfers thermal energy between the building and the ground through a series of pipes that are installed on the property. Pumps are then used to circulate the medium fluid through the ground loop that absorbs the heat during the summer to provide cooling, or provides BTU's for heating in the winter. The entire process simply moves heat back-and-forth from the ground into your building.

According to the US Department of Energy:

“The biggest benefit of GHPs is that they use 25%–50% less electricity than conventional heating or cooling systems. This translates into a GHP using one unit of electricity to move three units of heat from the earth. According to the EPA, geothermal heat pumps can reduce energy consumption—and corresponding emissions—up to 44% compared to air-source heat pumps and up to 72% compared to electric resistance heating with standard air-conditioning equipment.”<sup>4</sup>

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

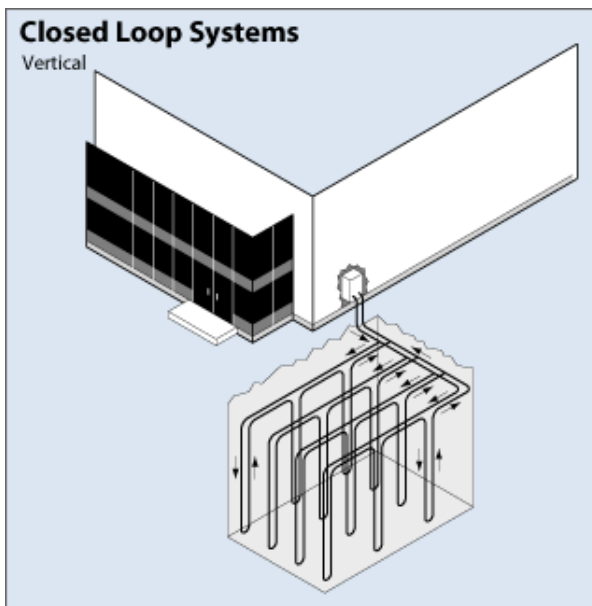
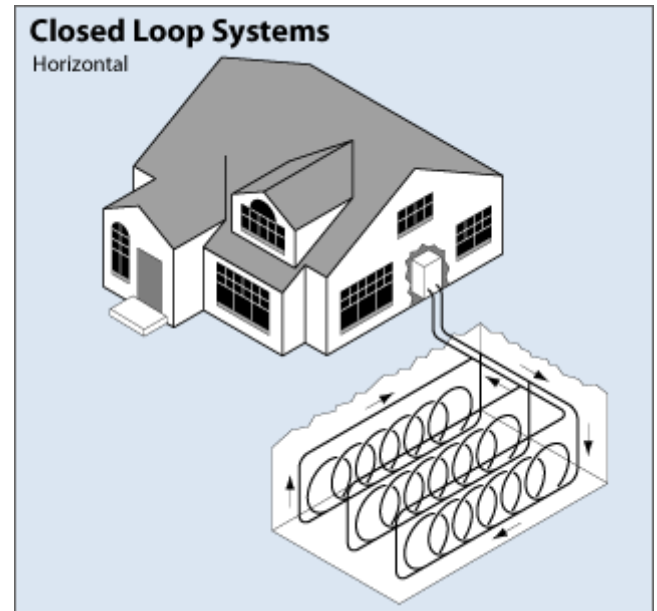
There are two main types of Geothermal Heat Pumps, Closed Loop and Open Loop Systems and many variations on how to install them.

<sup>4</sup> US Department of Energy. Energy Efficiency and Renewable Energy: *Benefits of Geothermal Heat Pump Systems*. [http://www.energysavers.gov/your\\_home/space\\_heating\\_cooling/index.cfm/mytopic=12660](http://www.energysavers.gov/your_home/space_heating_cooling/index.cfm/mytopic=12660)

## Closed-Loop Systems

### *Horizontal:*

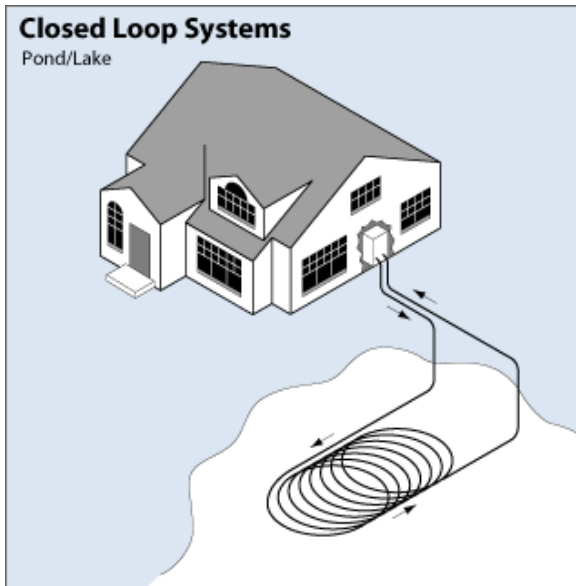
This type of installation is generally most cost-effective for residential installations, particularly for new construction where sufficient land is available. It requires trenches at least four feet deep. The most common layouts either use two pipes, one buried at six feet, and the other at four feet, 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.

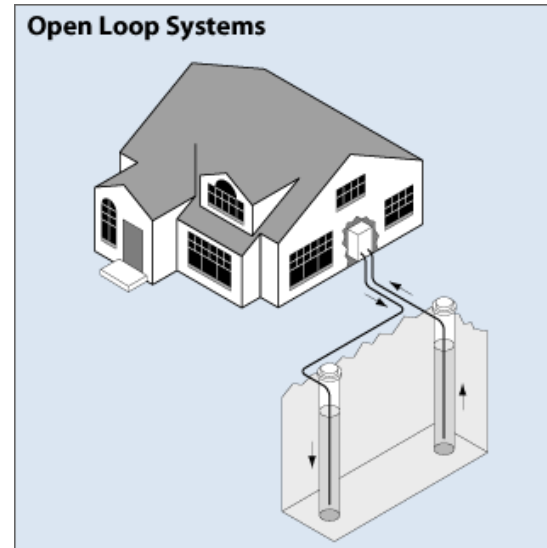


*Pond/Lake:*

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.

### 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



For your municipality, typical applications can include coupling a geothermal heat pump with a radiant floor within the building to provide space heating, or for use in a garage bay at a municipal garage. These applications provide even, comfortable heat and are able to significantly lower the buildings heat loss (especially when compared to forced air systems).

The New Hampshire Department of Environmental Services require a registration process for the development of the wells associated with a geothermal installation, so be sure that your installer is aware of the necessary state requirements and codes before carrying out the installation.<sup>5</sup>

<sup>5</sup>NH Department of Environmental Services: Requirements for Geothermal Systems in New Hampshire.  
<http://des.nh.gov/organization/commissioner/pip/factsheets/dwgb/documents/dwgb-22-23.pdf>

The Town of Strafford recently opened their new geothermal Town Hall. The system was integrated into the new construction project. This included a 3,600 square foot building that was built with state-of-the art environmentally friendly materials including: cellulose insulation, raised heel trusses, insulated concrete floor slab, insulated slab edge, and a Geothermal heating, ventilating and air conditioning system. The use of these “green” materials will assist in saving the Town money in operating costs and do so in a way which ensures a healthy environment for years to come.

### **Combined Heat and Power (CHP)**

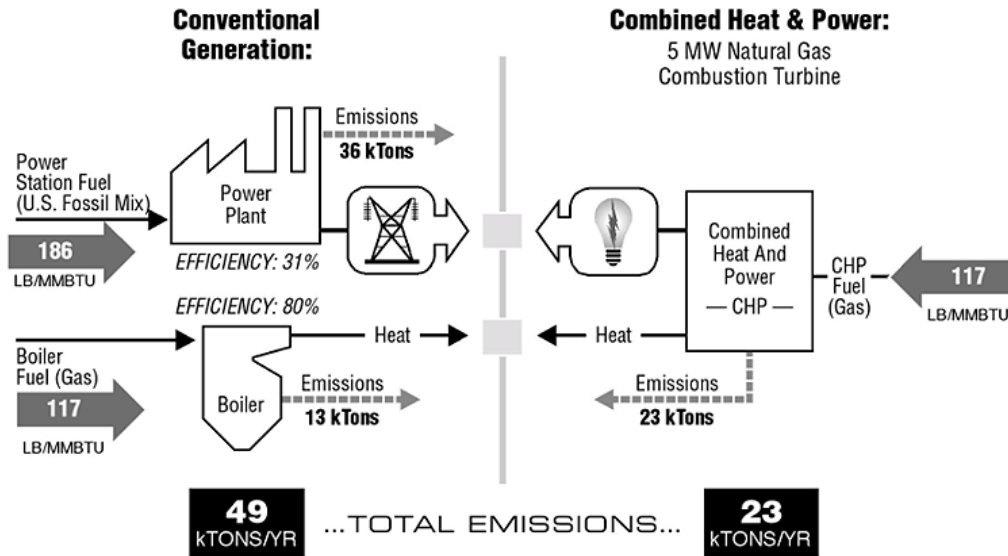
Combined heat and power, also known as CHP or co-generation, is “an efficient, clean, and reliable approach to generating power and thermal energy from a single fuel source.”<sup>6</sup> A CHP system utilizes that single fuel, be it a fossil fuel based or renewable in nature, and ties into a buildings heat distribution system in the same way a traditional boiler does. The additional process is the connection of the system to the electrical panel to also provide electricity to the facility.

CHP is a form of distributive generation (meaning more, smaller, dispersed generating systems as compared to centralized power plants) that is now gaining significant traction in the United States. The image below provides an example of the increased efficiencies found with a large scale distributed CHP system.<sup>7</sup> The avoided electrical losses seen when transporting electricity through outdated transmission systems provide for a more stabilized, less polluting power generation scenario.

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<sup>6</sup> EPA Combine Heat and Power Partnership. <http://www.epa.gov/chp/>

<sup>7</sup> EPA Combined Heat and Power Partnership: Environmental Benefits. <http://www.epa.gov/chp/basic/environmental.html>. The illustration above was found on the EPA website and represents a larger, 5 megawatt CHP plant, but the efficiencies seen on a smaller scale are equal to or greater than that seen from a larger scale CHP plant.



Technological advances in the field of micro-CHP and micro-turbine technology have come a long way and now allow for individual building-sized applications. Typically seen in large scale industrial sites, university campuses, and district heating systems, CHP is now scaled for individual residential, commercial, and municipal uses. While the typical installation still uses a fossil fuel for its fuel source, CHP units possess the added benefit of increased efficiency through the production of two forms of energy. These efficiencies, coupled with proven technologies make CHP a wise option when evaluating a project that will require both heat and electricity.

In the fall of 2007, the [Town of Epping, NH](#), through the leadership of the Epping Planning Board and Planner, installed a 4.5 kw micro-CHP system in the Town's 125 year old Town Hall. The system runs on propane and provides the majority of the buildings heat for the entire year. To date, the Town has seen a 50% reduction in the buildings electric bills and a 50-60% reduction in the heating bills. This technology was the first of its kind installed in New Hampshire and provides a replicable example of the use of micro-CHP within existing municipal buildings.<sup>8</sup>

Smaller residential systems are being developed and can be uniquely applied where heating needs are high. The [freewatt system](#) is currently expanding its installed base.

## Renewables.

### Solar Energy

<sup>8</sup> To find out more information about the Epping, NH, micro-CHP installation visit [www.nhenergy.org](http://www.nhenergy.org).



Solar energy in New Hampshire has previously been regarded as a difficult investment because of the perception that there is an extended payback period due to upfront costs and lower solar radiance at this latitude. With reduced costs now seen with solar equipment, and a greater understanding of the actual output and benefits of solar power, these investments are proving more feasible and appropriate. Coupled with innovative financing options, further discussed in the solar tear outs, solar power is now a completely viable option. When you consider the fact that energy costs in NH are higher than other parts of the country, these investments are very cost-effective.

Two primary forms of solar energy are widely available – photovoltaic (PV) and solar thermal. Photovoltaic solar panels produce electrical power for use in a building, while solar thermal energy uses that same energy but transfers the energy into a fluid medium that is heated and used for either space heating or domestic hot water use within the building.<sup>9</sup>

For a flat-plate collector, New Hampshire averages about 4-5 kw per square meter per day.<sup>10</sup>

If you are considering solar, be aware of locations that provide a large, flat, south-facing, non-shaded area where solar energy could be installed. Typical locations ideal for solar arrays include roof lines and ground areas.

Furthermore, solar energy can also be used to provide increased heat during the winter by utilizing passive heating, or preventing that passive solar gain during the summer to keep buildings cooler. Utilizing or preventing this passive solar gain can be as simple as opening or closing blinds or placing furniture in a way to expose thermal mass in the room to the sun.

The [Seacoast Area Renewable Energy Initiative](#) (SEAREI) has put together a terrific program called “Energy Raisers” that brings local volunteer community members together to help install solar thermal and PV arrays on local resident’s homes. Local citizens can learn about renewable energy system first hand while connecting with people in their community who share their interest. SEAREI is able to get competitive rates for its members by bulk purchasing equipment, resulting in a low installed cost through the use of skilled volunteers.

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<sup>9</sup> A terrific resources for all things solar is the Solar Energy Industries Association (SEIA). <http://www.seia.org/>

<sup>10</sup> US Department of Energy. Alternative Energy Resources in New Hampshire. [http://apps1.eere.energy.gov/states/alternatives/resources\\_nh.cfm](http://apps1.eere.energy.gov/states/alternatives/resources_nh.cfm)

## Solar Photovoltaic (PV)

### *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!

A good diagram and explanation from a residential solar leasing company, Solar City – (which does not offer systems in NH):

#### **A - Solar Panels**

Solar panels, or solar modules as they are sometimes called, are typically installed on the roof. These panels are made up of photovoltaic (PV) cells, which convert sunlight into direct current (DC) power.

#### **B- Inverter**

The DC power from the solar panels is sent to an inverter, where it is converted into alternating current (AC) power, or standard electrical current used your home.

#### **C - Electrical Panel**

AC power travels from the inverter to the electrical panel, often called a breaker box. This power is now ready to use in your home.

#### **D- Utility Meter**

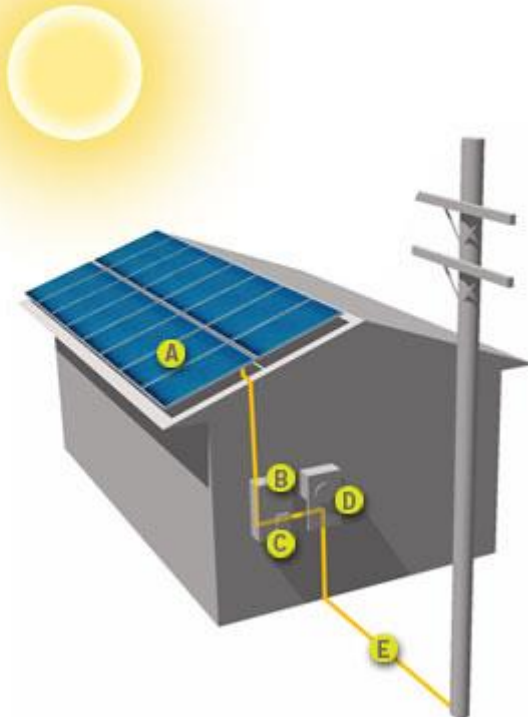
The utility meter continually measures your electrical supply; when your solar system produces more power than you need, the meter literally spins backwards, accumulating credits with the utility company that will offset your next bill.

#### **E -Utility Grid**

Your home remains connected to the utility grid to supply you with electricity when you need more power than your system has produced, such as at night.

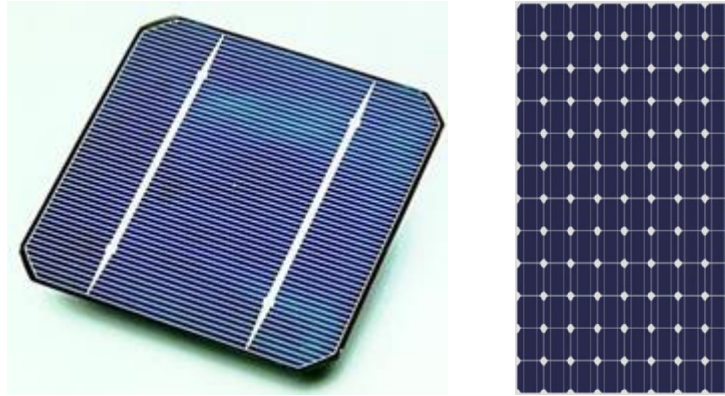
#### **B -Solar Production Monitoring**

SolarGuard allows you and SolarCity to continuously monitor energy production and make sure your system is running smoothly. If production levels drop below normal, SolarCity will alert you and help remedy the situation.



*Solar Panels:*

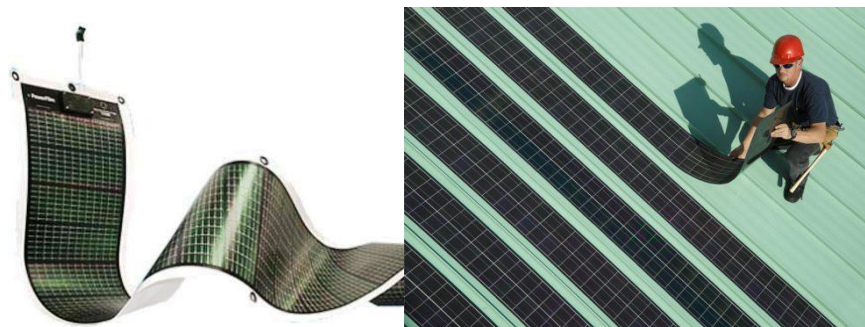
Each solar panel consists of several dozen silicon semiconductor “wafers” that are connected in series and emit an electrical charge. Those panels are strung together to create an “array” which can be as small as a few panels for a residential home or as large as several thousand panels in a commercial 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 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 are 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).*



### 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 \$6,000-\$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 your home and a reasonable price range, use the following calculation:

$((\text{Average monthly kWh use} \times 12 \text{ months}) \times \% \text{ of desired solar electricity}) / 1,200 = \text{kW size for your home}$

- kW size of solar array x \$6,000/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 \$6,000 = \$18,000 – lower estimate of solar array cost
- 3 kW solar array x \$7,000 = \$21,000 – upper estimate of solar array cost
- \$19,500 – 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:

$\text{Total System cost} \times 30\% = \text{Federal incentive}$

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.

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

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

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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.*

1.  $3\text{kW} \times \$1,250 = \$3,750$
2.  $\$18,000 \times 50\% = \$9,000$
3.  $\$3,750 = \text{Available NH State Rebate}$

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 is 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 Solar Thermal](#)



*What is Solar Thermal –*

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.

*Some rules of thumb:***Systems - Size:**

- 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.

**Systems – Installation:**

- Southern exposure is best with an unobstructed view in the winter is especially important.
- 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 to insure long-term operation and function.
- A back-up will be needed.

**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 depending on installation, equipment and size.

**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.

Your installer can guide you best based on your use and goals.

Financial Considerations:*How much does it cost?*

Solar thermal systems, as with PV 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.

The installation cost will depend on the equipment, the complexity of the installation, 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 also help.

*How much will it cost me?*

There are several ways to consider this question. First off, solar thermal arrays save money on fuel costs. 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

The next set of cost impacts to consider are state rebates. The current NH rebate is a performance based approach with rebates ranging 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 personal taxes dollar for dollar. This can represent a significant savings with some effective planning, especially 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 liabilities. The important things about the federal credit for Lee residents are:

- 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).

	3 Person Home System
Hypothetical 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

- The credit is entered into your 1040 on line 52 from [Form 5695](#).
- The previous chart is a simple payback analysis.

### Installation:

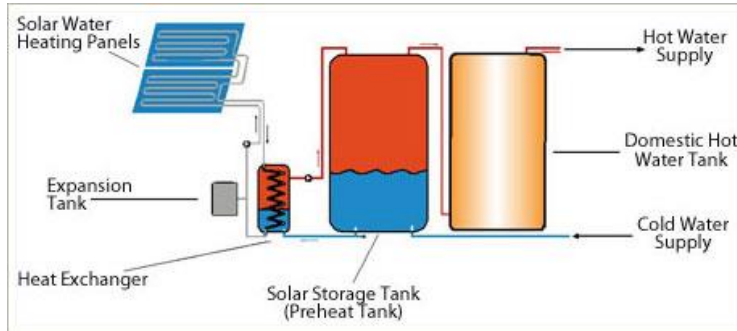


Image above from NH Electric Co-op:

[http://www.smallsteps.coop/coop\\_programs/solar\\_hotwater.php](http://www.smallsteps.coop/coop_programs/solar_hotwater.php)

### *Where do I need to install solar thermal?*

In general, thermal systems need a southern exposure with an unobstructed view. Roof and wall installations are both utilized and in some cases a ground installation may be employed. Piping is one major concern for installations 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](#).

### *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 needed if the system is covered during the winter, 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 you 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 concerns about 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.

More information:

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>

## Wind Power

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Wind power is another clean form of energy generation that does not produce any emissions during electrical generation. The development of wind turbine technologies has also come a long way in their design and scale. The most critical component to wind power installations is first understanding what type of wind resource is available at a specific location. Just because it appears to always be windy in certain areas of your town does not necessarily mean those areas are appropriate for a wind turbine installation. Wind resources can be very site specific to a building/property. Not all locations have a steady/predictable amount of wind to harvest, as compared to solar which is relatively predictable over a year time frame. The most effective way to determine whether the installation of a wind turbine is appropriate at a facility is by erecting and operating (for a minimum of 6 months) a wind “anemometer”. An anemometer is a device that attaches to the top of a pole and collects valuable wind speed data over a gain period of time. This allows you to evaluate whether there is a consistent amount of wind at that location to warrant the installation of a turbine, as well as what size turbine is appropriate.

Wind turbines also vary greatly in size and shape. Turbines now range anywhere from tiny 400 watt systems all the way through multiple megawatt systems (1,000,000 watts equals 1 megawatt).

The objective for any wind turbine installation is to have the turbine in operation as much as possible. If the turbine installed requires too high of a cut in speed than is present on a consistent basis for the site (meaning the speed required for the system to initially begin operating), then the turbine will only operate during those times of high gusts and not produce the desired energy generation. Therefore, it is important for you to first evaluate potential sites you could erect a turbine(s) and then work with a professional installer to determine the weather that site has enough of a wind resource to warrant a project.

To find out more information on wind energy, visit the following sites:

- American Wind Energy Association - <http://www.awea.org>
- US Department of Energy: Wind Powering America - [http://www.windpoweringamerica.gov/astate\\_template.asp?stateab=nh](http://www.windpoweringamerica.gov/astate_template.asp?stateab=nh)
- New Hampshire Office of Energy and Planning – <http://www.nh.gov/oep/resourcelibrary/swes/index.htm>

## Financial Considerations.

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Once you have an understanding of your energy use and impact and you have engaged in the preliminary analysis of project selection, it is time to consider financing. Analyzing the wide range of options available for financing insures that projects receive the support they deserve. The only option we do not cover is the possibility of private donations. It is quite likely that such funds can be secured and should be considered, but the wide-range of possible outcomes is beyond the scope of this effort.

Acquiring financial resources to conduct energy audits, educational programs, and energy efficiency and generation projects can be challenging. There are many organizations throughout the state that are working together to ramp up these resources and provide assistance to communities that are interested in exploring projects. This chapter is organized so that it follows financing structures for consideration. Different projects are discussed in the context of each structure along with the pros and cons of each implementation. Further research tips are provided as well as next steps to insure that your consideration is complete.

Since this is the heart of many implementation efforts we start with some basic concepts, many of which are repeated several times in this document but must be clear in the exploration of energy project financing.

## Introduction.

This section boldly states concerns that are relevant to energy issues in our municipal building stock. We have taken a more aggressive stance in the position toward completing projects and combating the myths associated with energy projects due to the recent price fluctuations, dramatic economic downturn and stunning development of new incentives for action. If New Hampshire municipalities miss this opportunity to invest in a domestic and sustainable energy future that results in a vibrant local economy and cost-stabilization, there is no one else to blame but ourselves. The time for action has not been more focused.

In this context, it is important as we consider the economics of these efforts that we confront facially the misperceptions and omissions in our dialogue about energy.

## Life Cycle Costing

The National Institute of Standards and Technology (NIST) Handbook 135, 1995 edition, defines Life Cycle Cost as “the total discounted dollar cost of owning, operating, maintaining, and disposing of a building or a building system” over a period of time. Life Cycle Cost Analysis is an economic evaluation technique that determines the total cost of owning and operating a facility over period of time.

As we consider our own personal budgets, we sometimes fall victim to an inordinate focus on the bottom line cost of construction instead of the lifetime cost to operate our homes. This is potentially critical misstep with energy concerns for homes because they represent a significant investment in our lives and even though the most energy-efficient choice may be a little more

expensive, the savings could pay the costs of initial investments several times over, especially with some upfront research on incentives and financing options.

### How much do projects save? – Modeling for the homeowner

Energy projects that save money and reduce emissions are often researched and presented in terms of the cost, the projected savings, the projected emission reductions and with transparency with respect to assumptions. There are several easy software programs that allow users to model the effectiveness of most upgrades. These modeling software programs provide the most assistance in their ability to provide the base data necessary to fully explain and understand these projects.

As previously discussed, the fundamental data needed to understand the footprints of our buildings relates to the size and use of the structure, a year's worth of energy use (bills will do) and a general understanding of the current conditions of the facility (this list's items are the essential elements of a building's "benchmark"). This data can be plugged into most models to produce a variety of decision tools for consideration using available weather data, energy rates and emission profiles for the fuel. The benefit of trying to do it yourself is that multiple options can be explored without great expense and will generally lead to a more fully-formed understanding of the entire field.

Some funding mechanisms that may be new to the reader are also worth defining and describing. In some cases, these incentives have limiting factors that must be understood before assuming that they will be present in the financial picture. In other cases, these incentives may go unnoticed.

### Financial Support for Projects.

#### Tax Incentives

Normally, in the context of municipal investments in New Hampshire the concept of tax incentives is never raised. However, recent developments in the market and the law have led to creative approaches to project financing that allows for governments to indirectly benefit from these benefits. Each of the financial vehicles that invoke these benefits on behalf of the municipality is discussed below.

The issue here is to realize that municipalities are no longer constrained by the budget approach – appropriation and expense. The changes are prolific in their benefits and limited in their costs, but require learning on the part of the government to insure that the right vehicle is selected for the right project.

#### State Incentives.

Currently, the state of New Hampshire offers numerous incentives for renewable energy installations on residencies and commercial buildings.

*Residential*

The New Hampshire Public Utilities Commission offers three renewable energy incentive programs for homeowners; a solar hot water rebate program, a wood pellet central boiler and furnace rebate program and a renewable energy rebate program.

The second program offered by the NH PUC is a residential wood pellet central boiler and furnace rebate program. Only bulk-fuel fed, indoor, high-efficiency wood pellet boilers and furnaces are eligible and have to provide at least 75% of the home heating load needs.

The Renewable Energy Rebate Program contributes \$1.00 watt DC capacity for wind and solar systems up to 5 kW and the maximum incentive is \$4,500 or 50% of system costs, whichever is less. However, the program is currently fully subscribed with a waiting list.

*Commercial and Industrial*

The NH Public Utilities Commission also offers rebate program for commercial, industrial, non-profit, schools, local governments, state governments, tribal governments, multi-family residential, agricultural and institutional entities seeking solar PV and solar thermal systems. Systems up to 100kW DC capacity are eligible for a \$1.00/watt rebate for new systems and \$0.50/watt for expansion of existing systems. For solar thermal systems are eligible, for \$0.07/kBTU/year for new systems and \$0.04/kBTU/year for additions to existing systems. The maximum incentive amount is the lesser of \$50,000 per project or 25% of total cost. The program opened in November 2010 with a budget of \$1,000,000 and is set to expire at the end of June 2011.

The State of New Hampshire also offers a rebate program for commercial, industrial, non-profit, schools, local governments, state governments, tribal governments, agricultural and institutional entities seeking to make energy efficiency improvements to their facility. Many efficiency measures are applicable pending prior approval. The program requires an energy audit, a financing plan and a construction schedule to be approved, which the program administrators can assist in the development of the documentation. There are several levels of incentives from \$40,000 to \$200,000 depending on the scale of the project. For information on the program, contact program administrators through their website, [www.nhp4p.com](http://www.nhp4p.com).

## Bank Loan Programs

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Obviously traditional lending vehicles such as home equity loans can provide funds for home improvement projects – there is no direct link between these programs and their use other than the improvement being part of the home. An interesting way to measure the success of these loans is to gauge whether the savings from the project is greater than the loan payment – in such a case, the loan is actually cash positive to the borrower.

Local banks in NH are also beginning to offer “green” loans. Usually, these loan programs offer a reduced rate, in part because the investments are seen as secure since the improvement will lower costs to the borrower. Other factors can contribute to a banks’ participation, including the mission of the loans as well as the benefit to the greater community – many of these programs are coming out of smaller, regional banks for exactly the same reason you may be making your investment. In other words, it is beyond the dollars and cents.

## PACE – In Limbo.

*What is PACE?*

PACE was created by the passage of New Hampshire House Bill 1554 and allows municipalities within the state of New Hampshire to create clean energy districts, allowing loans for energy retrofits and efficiency improvements for residents to be provided by the town based on the assessed value of the property. A PACE bond is a land-secured municipal bond where the proceeds are loaned to commercial and residential property owners to finance clean energy projects. The loans are paid back by the residents based on special annual assessment on their tax bill. In effect, the town makes the initial investment for energy improvements and is paid back over time through an added annual tax fee. The project must be “cash positive” demonstrating annual savings that are greater than the annual tax fee. The PACE loan is comparable to other forms of financing and is maintained at the property during the agreement and will transfer ownership to the buyer if the property is sold. The bond is secured with a lien on the property. If sold, both the energy improvements and annual payments stay with the property, ensuring that an owner only pays for the improvements while benefiting from them.

Additionally, many towns in New Hampshire have adopted a property tax exemption for renewable energy systems, removing the increased assessed property value from the available taxable base. This means you can install a renewable energy system on your home without having to pay taxes on the increased assessed value of your home. The exemption is available through your local tax assessor and a complete list of the 84 cities and towns that have adopted the exemption can be found [here](#). Lee has adopted an exemption for solar energy resources.

*How do I help establish a PACE program for my town?*

First of all, your town must establish a clean energy district through adoption of the PACE program. Providing information about PACE to your local government will assist in the passage of the program.

*How will PACE benefit me?*

The PACE program is a way for local governments to support clean and alternative energy resources with a safe and secure financing mechanism. It provides property owners an opportunity to retrofit their residential and commercial buildings with clean energy installations. PACE helps alleviate many of the financial hurdles facing property owners who want to install clean energy systems. In addition to a decreased utility bill due to energy savings from the retrofit, property owners wishing to participate in the program will also benefit from the flexibility to install a clean energy project without the need to provide an upfront cost of installation. Instead of a large, upfront cost, incremental property tax payments are available. These are low and fixed cost payments for a set period of time.

*Once the program is adopted, how much money am I eligible for?*

PACE loans are between \$5,000 and \$35,000 for single family residential properties and up to \$60,000 for commercial, industrial and multifamily property and cannot exceed 15% of the property's equalized assessed valuation. Combination with existing mortgages cannot exceed 85% of the value of the property. The loan repayment term is not to exceed 85% of the projected useful life of all improvements, weighted by cost. For a calculation for your annual payment under the PACE program, there is a payment calculator [here](https://www.renewfund.com/pace/property-owners) (<https://www.renewfund.com/pace/property-owners>).



## Completing a Project

- Project process:
  - Goals and Objectives (incorporating all of the above).
    - Do your own research.
    - Do your own walk-through.
    - Decide what you want.
    - Decide what you can afford.
      - Incentives.
      - Financing.
  - Finding a contractor:
    - Check out friends or [myenergyplan.net](http://myenergyplan.net).
  - Get a contract and understand your roles and responsibilities.
  - Inspect the work, seek help and insure any systems are commissioned.
  - Rebates and Incentives.
    - Forms and examples.

## Public, Private, Commercial, and Residential.

### Transportation.

- Tough to implement public transportation.
- Tips for personal behavior.
- Show generic information on savings/costs and impacts of choices.
- School locations and Safe Routes to School implementation.

### Safe Routes to School

The goal of the Safe Routes to School program is to encourage a greater number of children to either walk or ride their bikes to school. The program encourages children to walk or ride their bike through education and incentives that remind them how much fun it can be. Parents' safety concerns are also addressed by encouraging greater enforcement of traffic laws, exploring ways to create safer streets and educating the public about safe walking, biking and driving habits.

In the Fall of 2004, the [Nashua Regional Planning Commission](#) (NRPC) conducted the Safe Routes to School Pilot Study at Ledge Street Elementary School in Nashua. The purpose of the study was to identify current attitudes about biking and walking to school and issues and concerns that are deterring these modes of travel. The process involved gathering information from students and their parents regarding the trip to and from the school.



A sample survey and map are available for download, as well as the complete study from the Nashua Regional Planning Office website.

Process:

To implement a Safe Routes to Schools Program in your community, the Marin County Bicycle Coalition, creators of Safe Routes to Schools, offers many resources on their [website](#), including links for training and technical assistance to aid in the development of your unique plan, model press releases and letters of support, and the [Safe Routes to Schools Toolkit](#)! For potential funding, look to the federal government's [SAFETEA program](#). Additional information can also be found by visiting the [National Center for Safe Routes to Schools](#).

Implementing a safe routes to school initiative in your community can help with outreach into the school and residential communities while improving your towns air quality, addressing other health issues and reducing emissions and money spent on gasoline from parents driving students to school when they live walking distance away.

- Lee Pathways Committee.

The Lee Pathways Committee is expanding alternative transportation options beyond the school focus. The Committee's work will result in greater options for travel in Town and will expand tourism benefits and have a direct impact to energy use.

The side benefits are beyond the scope of this document, including, healthy living, public spaces and interaction and so on.

## Utility Grant Program

### New Hampshire Electric Co-Op – Home Energy Assistance

**Applicable Sectors:** Income-Qualified for Residential

**Max. Limit:** Up to \$5,000

**Terms:** To qualify, the customer must be a co-op member and meet the income guidelines provided on the website

**Website:** [http://www.nhec.com/residential\\_energyassistance\\_home.php](http://www.nhec.com/residential_energyassistance_home.php)

### **Summary:**

The Energy Assistance Program is designed to help NHEC's income-qualified members manage their energy use with the goal of lowering their energy costs. Qualified members living in an apartment or house, either rented or owned, can receive up to \$5,000 in products and services, including a free customized audit report which will help members better understand their home and the factors affecting their energy use. Based on the Home Energy Analysis, NHEC will make recommendations for improving energy efficiency in the customer's home that may help reduce the heating portion of their electric bill. Measures identified in the audit are then installed by Community Action Program (CAP) agencies, contractors managed by the Co-op, or Co-op energy specialists. Eligible improvements include:

- Sealing air leaks with caulking and installing weatherstripping
- Upgrading insulation in attics, walls and basement ceilings
- Improving windows with energy-saving storm windows
- Installing thermal covers on windows, sliding glass doors and whole house fans
- Replacing old thermostats on heating systems
- Upgrades to Energy Star appliances
- Upgrades to Energy Star lighting

### Contact:

Member Solutions

New Hampshire Electric Co-Op

579 Tenney Mountain Highway

Plymouth, NH 03264-3154

Phone: (800) 698-2007

Web site: <http://www.nhec.com/>

**Utility Loan Program***New Hampshire Electric Co-Op - SmartSTART Energy Efficiency Loan Program<sup>11</sup>*

Review: 12/08/2011

**Incentive Type:** Utility Loan Program**Eligible Efficiency Technologies:** Lighting, Duct/Air sealing, Building Insulation, Custom/Others pending approval**Applicable Sectors:** Commercial**Terms:** Loan payments equal to two-thirds of the monthly savings realized through the energy efficiency measure will be applied to the customer's utility bill.**Website:** [http://www.nhec.com/business\\_energysolutions\\_smartstart.php](http://www.nhec.com/business_energysolutions_smartstart.php)**Summary:**

New Hampshire Electric Co-Op's SmartSTART (Savings Through Affordable Retrofit Technologies) Program is a no money down option to have energy efficient products installed in a home or business. The cost of the improvements is repaid over time, using the savings generated by the products themselves. For instance, if a customer installs energy efficient products worth \$500 and those products save the customer \$50 per month, the customer will pay for the product in monthly payments on their electric bill equal to two-thirds of the savings, or \$34 per month. Customers still realize overall savings on their electric bills while paying for energy efficient improvements that will save money for years to come. If the customer moves and the installed products stay, their obligation to pay for them ends. The next occupant will "pay as they save."

**Contact:**

Member Solutions

New Hampshire Electric Co-Op

579 Tenney Mountain Highway

Plymouth, NH 03264-3154

Phone: (800) 698-2007

Fax: (603) 536-8687

Web site: <http://www.nhec.com/>*New Hampshire Electric Co-Op:**Large Business Energy Solutions<sup>12</sup>*

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11[http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive\\_Code=NH20F&state=NH&CurrentPageID=1&RE=1&EE=1](http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=NH20F&state=NH&CurrentPageID=1&RE=1&EE=1)

Last DSIRE Review: 12/05/2011

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**Incentive Type:** Utility Rebate Program**Eligible Efficiency Technologies:** Lighting, Lighting Controls/Sensors, Furnaces, Heat pumps, Air conditioners, Compressed air, Energy Mgmt. Systems/Building Controls, Motors, Motor-ASDs/VSDs, Custom/Others pending approval, LED Traffic Lights**Applicable Sectors:** Commercial, Industrial**Incentive Amount:** Up to 35% of the installed cost or a buy-down to a one-year payback, whichever is less.**Website:** [http://www.nhec.com/business\\_energysolutions\\_largebusiness.php](http://www.nhec.com/business_energysolutions_largebusiness.php)**Summary:**

New Hampshire Electric Co-Op offers incentives for its large business customers (using 100 kW or more) to increase the energy efficiency of their facilities through their Large Business Energy Solutions Program. This program offers prescriptive and custom rebates designed to pay up to 35% of the installed cost or a buy-down to a one-year payback, whichever is less. To qualify for rebates, the business must be a non-residential property, an NHEC member, and the proposed measures will save electricity and pass a benefits/cost test. Eligible projects include: lighting conversions and controls, energy-efficient motors, variable frequency drives (VFDs), HVAC and compressed air equipment and controls, LED traffic lights, and approved custom projects.

**Contact:**

Member Solutions  
New Hampshire Electric Co-Op  
579 Tenney Mountain Highway  
Plymouth, NH 03264-3154  
Phone: (800) 698-2007  
Fax: (603) 536-8687  
Web site: <http://www.nhec.com/>

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*New Hampshire Electric Co-Op:*

*New Equipment and Construction Program*<sup>13</sup>

Review: 12/08/2011

53

**Incentive Type:** Utility Rebate Program**Eligible Efficiency Technologies:** Lighting, Lighting Controls/Sensors, Chillers, Furnaces, Boilers, Heat pumps, Air conditioners, Motors, Motor-ASDs/VSDs, Custom/Others pending approval, Energy Efficient Transformers**Applicable Sectors:** Commercial, Industrial**Incentive Amount:** The lesser of 12-month payback or 75% of incremental costs up to the member's incentive cap.Website: [http://www.nhec.com/business\\_energysolutions\\_newbusiness.php](http://www.nhec.com/business_energysolutions_newbusiness.php)**Summary:**

New Hampshire Electric Co-Op offers incentives to its commercial and industrial customers to encourage energy efficiency. The program targets any commercial/industrial member building a new facility, undergoing a major renovation, or replacing failed (end-of-life) equipment. The program offers prescriptive and custom rebates designed to cover the lesser of a one year payback or 75% of incremental costs up to the member's incentive cap. Rebates are available for: energy-efficient lighting and controls; energy-efficient motors, variable frequency drives (VFDs), HVAC equipment and controls, energy-efficient transformers, chillers, and approved custom projects.

**Contact:**

Member Solutions

New Hampshire Electric Co-Op

579 Tenney Mountain Highway

Plymouth, NH 03264-3154

Phone: (800) 698-2007

Fax: (603) 536-8687

Web site: <http://www.nhec.com/>

*Residential Energy Efficiency Rebate Programs*<sup>14</sup>

Review: 12/08/2011

**Incentive Type:** Utility Rebate Program**Eligible Efficiency Technologies:** Clothes Washers/Dryers, Refrigerators/Freezers, Equipment Insulation, Lighting, Heat pumps, Air conditioners, Programmable Thermostats, Duct/Air sealing, Building Insulation, Comprehensive Measures/Whole Building, Room Air Conditioners**Eligible Renewable/Other Technologies:** Geothermal Heat Pumps**Applicable Sectors:** Residential**Incentive Amount:** Insulation, air sealing, refrigerators, equipment thermostats and lighting upgrades: 50% - 100% of project cost**Energy Star Room A/C:** \$20**Energy Star Clothes Washer:** \$50**Energy Star Lighting:** \$2-\$15 per fixture**Energy Star Home:** Up to \$2,500**Air Source Heat Pump:** \$1,000-\$2,000**Geothermal Heat Pump:** \$800 per ton, up to 5 tons; plus \$500 for all ductwork**Maximum Incentive:** Insulation, air sealing, refrigerators, thermostats, and lighting upgrades: \$4,000 max

Geothermal Heat Pump: \$4,500 max

**Website:** [http://www.nhec.com/residential\\_homeenergysolutions.php](http://www.nhec.com/residential_homeenergysolutions.php)**Summary:**

New Hampshire Electric Co-Op provides incentives for its residential members to increase the efficiency of their homes through several rebate programs. First, members can receive a free Home Energy Analysis through their Home Energy Solutions Program. The analysis will examine the home's air sealing, insulation, equipment thermostats and insulation, as well as the energy consumption of the home's refrigerator. The NHEC representative will recommend certain improvements during the evaluation and offer 50% - 100% off the cost of the improvements up to a total of \$4,000.

NHEC also offers rebates on Energy Star rated Homes, lighting, room air conditioners and washing machines. To qualify for the Energy Star Home rebate, the home must be a new or completely renovated existing single-family or multi-family home, located in the Co-op's service territory, which meets certain design specifications. Some restrictions apply to individual rebate offers.

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14

[http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive\\_Code=NH19F&state=NH&CurrentPageID=1&RE=1&EE=1](http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=NH19F&state=NH&CurrentPageID=1&RE=1&EE=1)



NHEC also provides rebates to customers who install new or upgraded air source or geothermal heat pumps. The rebate is worth \$1,000-\$2,000 for a new energy efficient air source heat pump and \$800 per ton, up to a maximum of \$4,500, for geothermal heat pumps. In order to receive the maximum rebate, the house in which the heat pump is installed must achieve a HERS (Home Energy Rating System) of 86 or higher. A \$350 fee may be deducted from the rebate for plan evaluations and site inspections for new construction. The completed application and plans must be submitted prior to construction. The website contains a list of qualified HVAC vendors and installers, as well as further program details.

**Contact:**

Member Solutions  
 New Hampshire Electric Co-Op  
 579 Tenney Mountain Highway  
 Plymouth, NH 03264-3154  
 Phone: (800) 698-2007  
 Fax: (603) 536-8687  
 Web site: <http://www.nhec.com/>

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*New Hampshire Electric Co-Op:*

*Small Business Energy Solutions*<sup>15</sup>

Last DSIRE Review: 11/10/2008

**Incentive Type:** Utility Rebate Program

**Eligible Efficiency Technologies:** Refrigerators/Freezers, Equipment Insulation, Lighting, Lighting Controls/Sensors, Heat pumps, Air conditioners, Custom/Others pending approval

**Applicable Sectors:** Commercial

**Incentive Amount:** Up to 50% of the cost

**Website:** [http://www.nhec.com/business\\_energy\\_solutions\\_smallbusiness.php](http://www.nhec.com/business_energy_solutions_smallbusiness.php)

**Summary:**

New Hampshire Electric Co-Op offers incentives for its small commercial customers (those using less than 100 kW) through their Small Business Energy Solutions Program. The Co-op will conduct a free assessment of a company's energy consumption, recommend efficiency improvements to reduce consumption, and provide rebates of up to 50% toward the cost of implementing the recommendations. Eligible improvements include: lighting technologies,

<sup>15</sup>

[http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive\\_Code=NH23F&state=NH&CurrentPageID=1&RE=1&EE=1](http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=NH23F&state=NH&CurrentPageID=1&RE=1&EE=1)

occupancy sensors, hot water tank insulation wraps, refrigeration, and HVAC systems.

**Contact:**

Member Solutions  
New Hampshire Electric Co-Op  
579 Tenney Mountain Highway  
Plymouth, NH 03264-3154  
Phone: (800) 698-2007  
Fax: (603) 536-8687  
Web site: <http://www.nhec.com/>

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*New Hampshire Electric Co-Op:*

*Solar and Wind Energy Rebate Program*<sup>16</sup>

Review: 01/15/2009

**Incentive Type:** Utility Rebate Program

**Eligible Renewable/Other Technologies:** Solar Water Heat

**Applicable Sectors:** Commercial, Residential, Nonprofit, Schools, Agricultural, Institutional

**Incentive Amount:** PV: \$3.00 per installed watt (DC);

**Solar Hot Water:** 25% of installed project cost;

**Wind:** 25% of installed project cost

**Maximum Incentive:** PV: \$3,500; Solar Hot Water: \$1,500; Wind: \$5,000

**Installation Requirements:** System must be installed by a qualified installer

**Ownership of Renewable Energy Credits:** Remains with system owner

**Expiration Date:** 2009: TBD

**Project Review/Certification:** A monitoring and evaluation follow-up visit may be conducted by a NHEC engineer. System owner must also submit a project completion form.

**Website:** [http://www.smallsteps.coop/coop\\_programs](http://www.smallsteps.coop/coop_programs)

**Summary:**

New Hampshire Electric Co-Op (NHEC) will offer the following rebates again in 2009, although program guidelines and applications are not yet posted on their website. NHEC encourages those who plan to request a rebate in 2009, to call Co-op Member Solutions at 1-800-698-2007 to hold your place in the queue. Rebates will be awarded on a first-come first-served basis to members who install

<sup>16</sup>

[http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive\\_Code=NH29F&state=NH&CurrentPageID=1&RE=1&EE=1](http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=NH29F&state=NH&CurrentPageID=1&RE=1&EE=1)

qualified systems and submit required paperwork. Check their website for updates.

New Hampshire Electric Co-Op (NHEC) offers rebates to customers who install qualified renewable energy systems in its service territory. Members that install a solar hot water systems may receive a rebate of 25% of the installed system cost, up to \$1,500. Members that install a photovoltaic (PV) system may qualify for a rebate of up to \$3,500. NHEC is also providing incentives for the qualified installation of small and medium-sized wind generators of up to \$5,000.

All projects must be installed by qualified installers, and systems must be installed in NHEC's service territory. See the program web site listed above for more information, applications and FAQs.

**Contacts:**

Thomas Palma (for PV and Wind)  
Project Development Executive  
New Hampshire Electric Co-op  
579 Tenney Mountain Highway  
Plymouth, NH 03264  
Phone: (603) 536-8650  
Web site: [www.nhec.coop](http://www.nhec.coop)

Mike Reynolds (for Solar Hot Water)  
New Hampshire Electric Co-op  
579 Tenney Mountain Highway  
Plymouth, NH 03264  
Phone: (800) 698-2007  
Web site: [www.nhec.coop](http://www.nhec.coop)

**Tear – Outs.**

Page 59 – 62: A Citizen’s Guide to Solar Electric

Page 63 – 65: A Citizen’s Guide to Geothermal

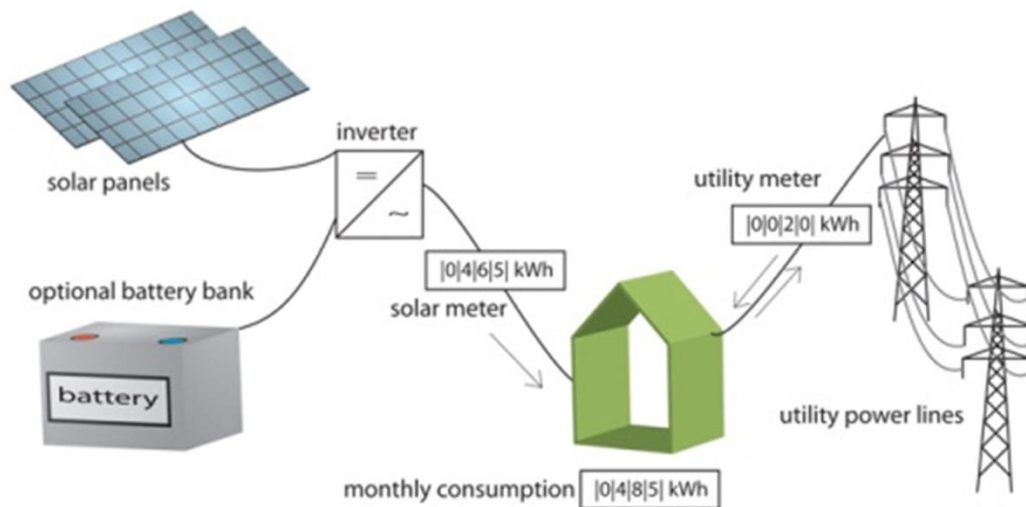
Page 66 – 68: A Citizen’s Guide to Biomass

Page 69 – 72: A Citizen’s Guide to Solar Thermal

# A CITIZEN'S GUIDE TO SOLAR ELECTRIC POWER

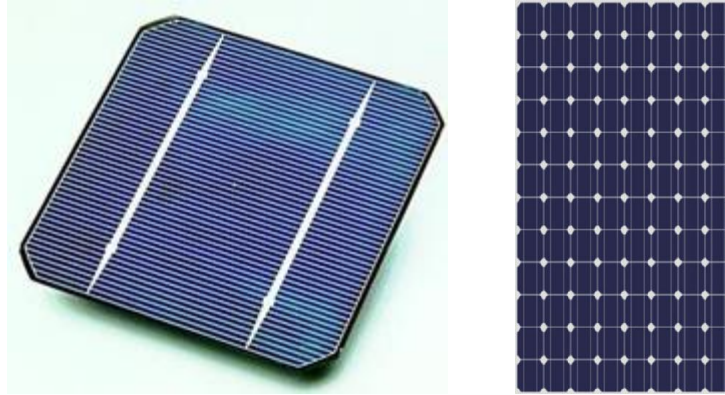
## Introduction

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 consists 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 as 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 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.

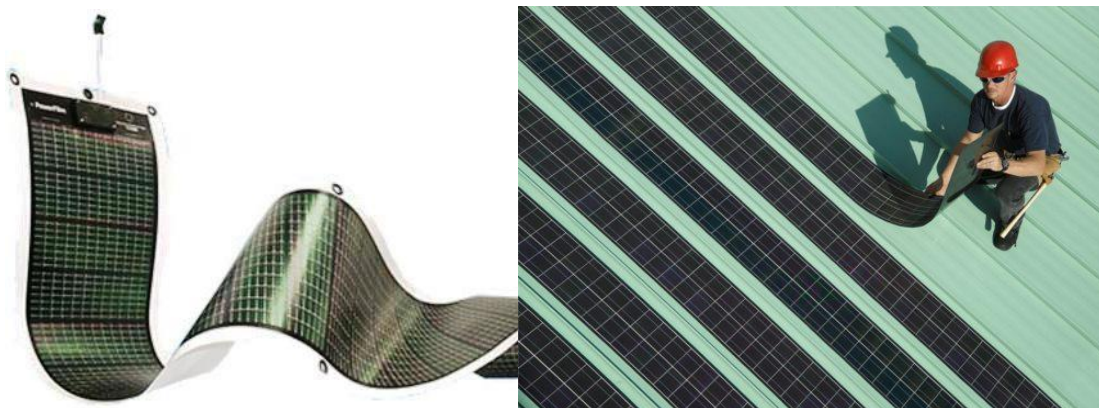


*An enlarged view of a solar wafer (left) and solar panel (right).*

### *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 are 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 has a high potential for being installed, as seen in the picture below, on a metal standing seam roof. The installation would be lower cost and have much less weight than a traditional solar panel installation.



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





## 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 solar 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 a site in Meredith, including costs (this calculation takes into account the average installation location, some shading, snow cover, sunlight, and costs):

$$\frac{((\text{Average monthly kWh} \times 12) \times \% \text{ of solar desired})}{(\text{Size in watts of solar needed.})} = \text{Size}$$

- Size x \$5.00/W = lower estimate of solar array cost
- Size x \$7.00/W = 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. These costs reflect the cost BEFORE incentives.

$$((600\text{kWh} \times 12 \text{ months}) \times 50\% \text{ desired solar}) = 3,600 \text{ watts}$$

- 3,600 watt solar array x \$5.00 = \$18,000  
– lower cost range
- 3,600 watt solar array x \$7.00 = \$25,200  
– upper cost range

### *Are there incentives?*

Yes, there are both state and federal incentives available for solar energy. Until 2016, 30% of the installed system cost will be issued to a tax-paying owner of a qualifying 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. See [Dsite.com](http://Dsite.com) to learn more. To estimate, how much you will receive from the federal incentive, use the following calculation:

*Using our above example, a solar array that costs \$18,000:*

$$\$18,000 \times 30\% = \$6,000 \text{ tax credit incentive}$$

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, our solar array that costs \$18,000.*

- $3.600 \times \$1,250 = \$3,750$
- $\$18,000 \times 50\% = \$9,000$
- $\$3,750 = \text{Available NH State Rebate}$

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.

$\$18,000 - (\$6,000 \text{ credit}) - (\$3,750 \text{ rebate}) = \$8,250.00 \text{ final cost}$

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 is 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\*](#)

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 CITIZEN'S GUIDE TO GEOTHERMAL

## Introduction

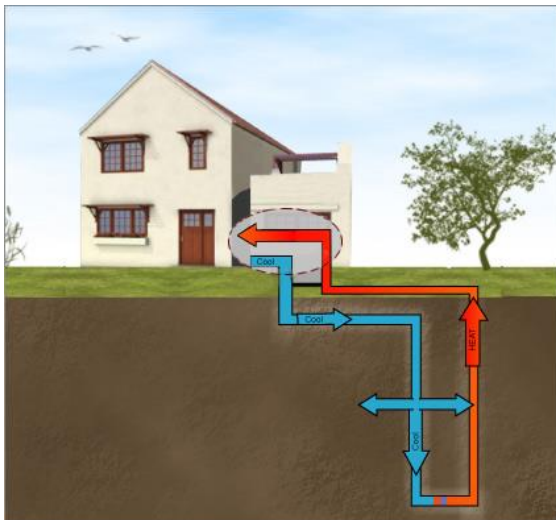
Geothermal heat pump (also known as ground source heat pumps) is a central heating and cooling system that pumps to or from the ground, depending on the season; it uses the earth as a heat source in the winter and a heat sink in the summer. Geothermal heat pumps (GHPs) use the constant temperature of 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!

Geothermal systems are highly customized projects. Rather than provide misleading examples, we are describing how the technology works and where to go for some more information. There are several local installers for geothermal and we recommend you do your own research to learn if such a system can be beneficial.

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).

*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.*



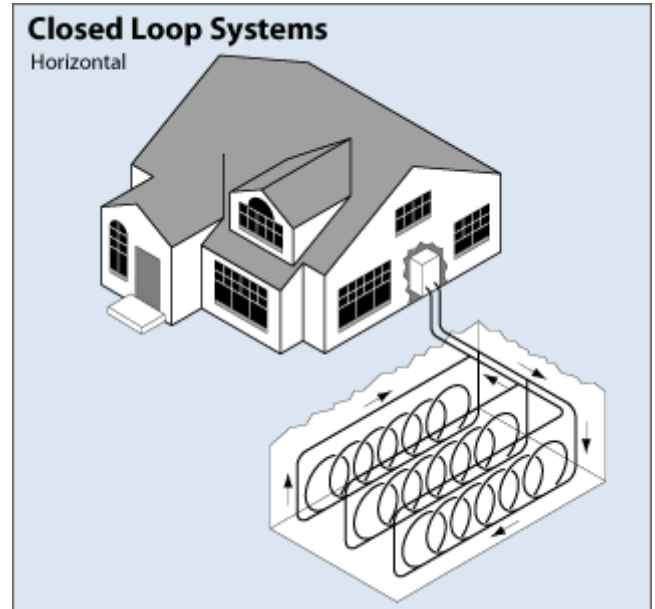
New Hampshire experiences dramatic seasonal temperature extremes—from scorching heat in the summer to sub-zero cold in the winter—just a few feet below the earth's surface the ground remains at a relatively constant temperature – approximately 55°F.

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

## Closed-Loop Systems

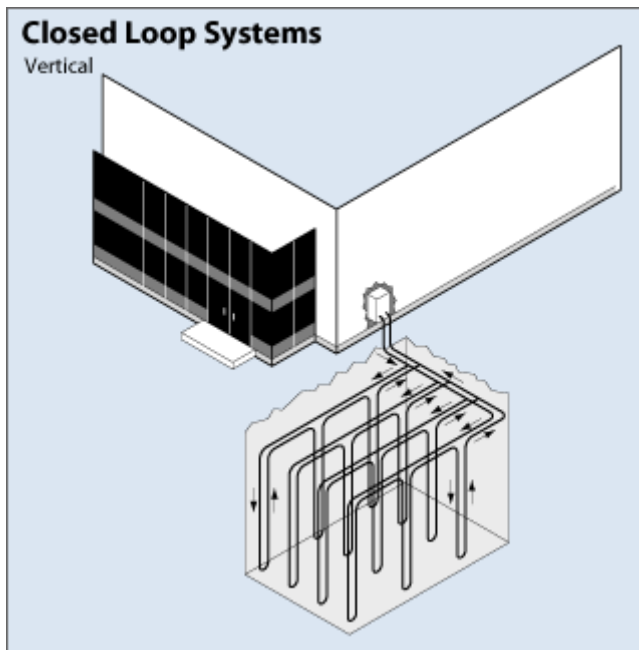
### *Horizontal*

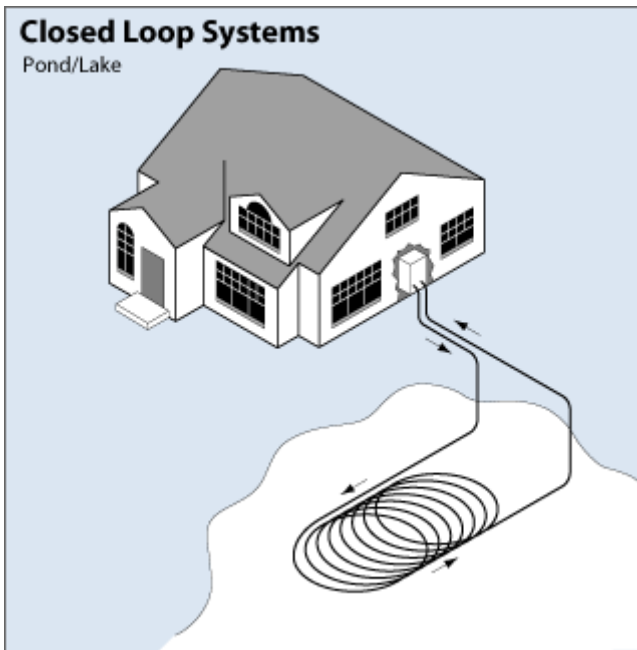
This type of installation is generally most cost-effective for residential installations, particularly for new construction where sufficient land is available. It requires trenches at least four feet deep. The most common layouts either use two pipes, one buried at six feet, and the other at four feet, 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.





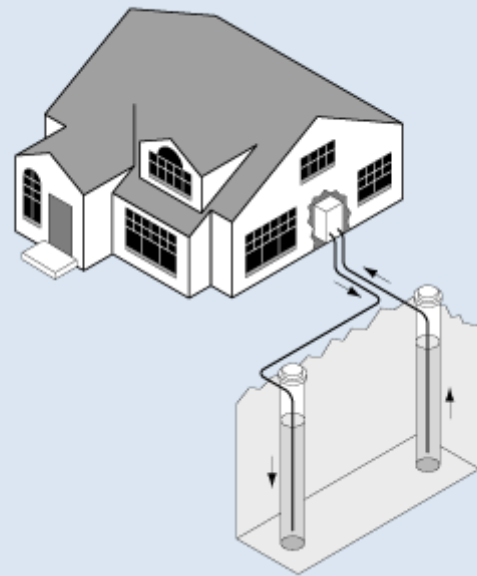
### *Pond/Lake*

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

### **Open Loop Systems**



### *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 CITIZEN'S GUIDE TO BIOMASS HEATING

## 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 die 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

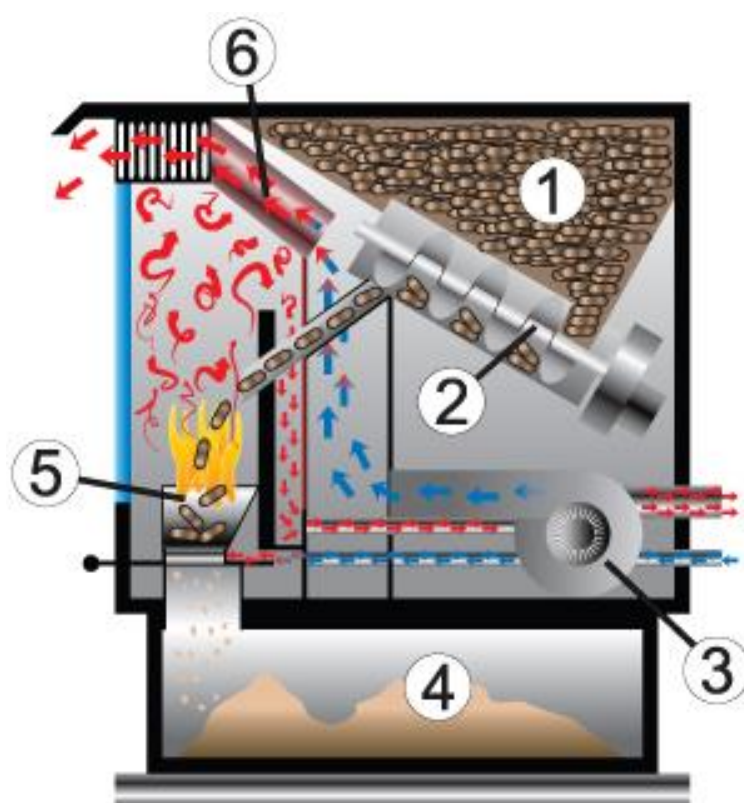
reuse of valuable biomass that would have otherwise been left to decompose. Wood pellets are often package in 40 pound bags and stacked on a pallet and sold in 1 ton increments.

Two tons of wood pellets has the same energy content of one cord of dried hardwood, and is much easier and cleaner to handle. Similarly, 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.



## Wood Pellet Stove

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 be emptied once or twice a year. Wood pellet stoves are most typically used as a supplemental heat source.





### 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 provide 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.

### *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 characteristics 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 characteristic 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](http://www.pelletfuelinstitute.org).

*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/](http://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 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 to \$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....**

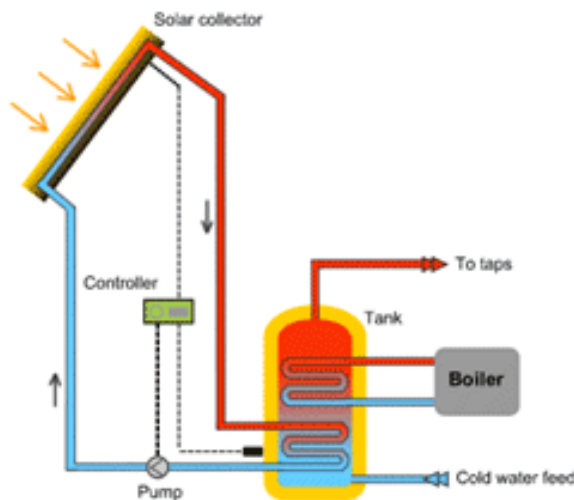
One ton of wood pellets is the equivalent of:

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

# A CITIZEN'S GUIDE TO SOLAR THERMAL

## Introduction

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

### 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

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.

### *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 line 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

*Example of the payback 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](#).



*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>

## Appendix A: What to look for during a Walk Through Energy Audit

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**What to Look for During a Walk Through\***

- How old is the heating and distribution system?
  - What year was the boiler installed?
  - What type of fuel does the system use?
  - These questions directly relate to the systems overall efficiency.
- What is the total square footage of the building?
  - How much of the space is conditioned (heated or cooled)?
- How many electric meters are there and where are they located?
- What do the windows look like/how old are they? Are the seams sealed with caulking?
- What types of light fixtures are present throughout the building?
- Where are the thermostats and are they programmable?
- Are there air leaks in the doors, or areas of the building that should be better insulated (i.e. the attic, basement, or exterior walls)?
- Are heating pipes or ducts insulated? Check crawl spaces and dropped ceilings for pipe/duct runs.
- What type of electronic equipment (computers, soda machines, etc.) is there throughout the building? How many of each? Are power strips utilized to shut down computers/equipment at night?

**Items to Bring With You on a Walk Through**

- ✓ Pen / pencil
- ✓ Notebook to write findings
- ✓ Digital camera
- ✓ Tape recorder
- ✓ Flashlight
- ✓ Compass
- ✓ A phone to call the paramedics once you faint after seeing inefficiencies



\* Appendix IV provides a simple walk through audit worksheet that your committee can use and expand upon when touring a facility



**To Seal and Insulate with ENERGY STAR:**

- Seal air leaks throughout the building to stop drafts,
- Add insulation to block heat loss in winter and heat gain in summer,
- Choose ENERGY STAR qualified windows when replacing windows.

If your attic is accessible you can Do-It-Yourself with help from our [Guide to ENERGY STAR Home Sealing](#). The Guide offers step-by-step instructions for sealing common air leaks and adding insulation to the attic.

Insulation helps your building maintain a constant temperature. There are several common types of insulation — fiberglass (in both batt and blown forms), cellulose, rigid foam board, and spray foam. [Reflective insulation \(or radiant barrier\)](#) is another insulating product which can help save energy in hot, sunny climates.

When correctly installed with air sealing, each type of insulation can deliver comfort and lower energy bills during the hottest and coldest times of the year.

Insulation performance is measured by R-value — its ability to resist heat flow. Higher R-values mean more insulating power. Different R-values are recommended for walls, attics, basements and crawlspaces, depending on your area of the country. Insulation works best when air is not moving through or around it. So it is very important to seal air leaks before installing insulation to ensure that you get the best performance from the insulation.

- See [Recommended Levels of Insulation](#) to determine what is most cost-effective for your building. ( See Appendix C)

To get the biggest savings, the easiest place to add insulation is usually in the attic. A quick way to see if you need more insulation is to look across your uncovered attic floor. If your insulation is level with or below the attic floor joists, you probably need to add more insulation. The recommended insulation level for most attics is R-38 (or about 12–15 inches, depending on the insulation type). In the coldest climates, insulating up to R-49 is recommended.

**Why Insulate Your Building?**

Heating and cooling account for about a quarter of a typical building..<sup>17</sup> Inadequate insulation and air leakage are leading causes of energy waste in most buildings. Insulation:

- saves money and our nation's limited energy resources
- makes your building more comfortable by helping to maintain a uniform temperature throughout the building, and
- makes walls, ceilings, and floors warmer in the winter and cooler in the summer.

The amount of energy you conserve will depend on several factors: your local climate; the size, shape, and construction of your building; the living habits of your family; the type and efficiency of the heating

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<sup>17</sup> <http://www.energystar.gov/index.cfm?c=business.EPA BUM CH9 HVAC>

and cooling systems; and the fuel you use. Once the energy savings have paid for the installation cost, energy conserved is money saved - and saving energy will be even more important as utility rates go up.

This fact sheet will help you to understand how insulation works, what different types of insulation are available, and how much insulation makes sense for your climate. There are many other things you can do to conserve energy in your building as well. The Department of Energy offers many [web sites](#) to help you save energy by sealing air leaks, selecting more energy-efficient appliances, etc.

It is always more economical to install the recommended levels of insulation during initial construction rather than adding insulation later. Many insulation locations are enclosed during the construction process and it is very difficult to add insulation to these locations at a later time.

### How Insulation Works

Heat flows naturally from a warmer to a cooler space. In winter, the heat moves directly from all heated living spaces to the outdoors and to adjacent unheated attics, garages, and basements - wherever there is a difference in temperature. During the summer, heat moves from outdoors to the building interior. To maintain comfort, the heat lost in winter must be replaced by your heating system and the heat gained in summer must be removed by your air conditioner. Insulating [ceilings, walls, and floors](#) decreases the heating or cooling needed by providing an effective resistance to the flow of heat.

Batts, blankets, loose fill, and low-density foams all work by limiting air movement. (These products may be more familiarly called fiberglass, cellulose, polyisocyanurate, and expanded polystyrene.) The still air is an effective insulator because it eliminates convection and has low conduction. Some foams, such as polyisocyanurate, polyurethane, and extruded polystyrene, are filled with special gases that provide additional resistance to heat flow.

Reflective insulation works by reducing the amount of energy that travels in the form of radiation. Some forms of reflective insulation also divide a space up into small regions to reduce air movement, or convection, but not to the same extent as batts, blankets, loose-fill, and foam.

#### *Which Kind Of Insulation Is Best?*

- ***Answer is that the 'best' type of insulation depends on:***
  - how much insulation is needed,
  - the accessibility of the insulation location,
  - the space available for the insulation,
  - local availability and price of insulation, and
  - other considerations unique to each purchaser.

Whenever you compare insulation products, it is critical that you base your comparison on equal R-values.

### What Is an R-Value?

Insulation is rated in terms of thermal resistance, called R-value, which indicates the resistance to heat flow. The higher the R-value, the greater the insulating effectiveness. The R-value of thermal insulation depends on the type of material, its thickness, and its density. In calculating the R-value of a multi-layered installation, the R-values of the individual layers are added.

The effectiveness of an insulated ceiling, wall or floor depends on how and where the insulation is installed.

- Insulation which is compressed will not give you its full rated R-value. This can happen if you add denser insulation on top of lighter insulation in an attic. It also happens if you place batts rated for one thickness into a thinner cavity, such as placing R-19 insulation rated for 6 1/4 inches into a 5 1/2 inch wall cavity.
- Insulation placed between joists, rafters, and studs does not retard heat flow through those joists or studs. This heat flow is called thermal bridging. So, the overall R-value of a wall or ceiling will be somewhat different from the R-value of the insulation itself. That is why it is important that attic insulation cover the tops of the joists and that is also why we often recommend the use of insulative sheathing on walls. The short-circuiting through metal framing is much greater than that through wood-framed walls; sometimes the insulated metal wall's overall R-value can be as low as half the insulation's R-value.

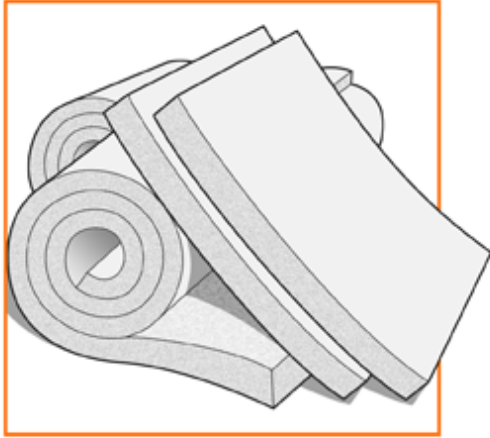
### Reading the Label

No matter what kind of insulation you buy, check the information on the product label to make sure that the product is suitable for the intended application. To protect consumers, the Federal Trade Commission has very clear rules about the R-value label that must be placed on all residential insulation products, whether they are installed by professionals, or whether they are purchased at a local supply store. These labels include a clearly stated R-value and information about health, safety, and fire-hazard issues. Take time to read the label BEFORE installing the insulation. Insist that any contractor installing insulation provide the product labels from EACH package (which will also tell you how many packages were used). Many special products have been developed to give higher R-values with less thickness. On the other hand, some materials require a greater initial thickness to offset eventual settling or to ensure that you get the rated R-value under a range of temperature conditions.

### Insulation Product Types

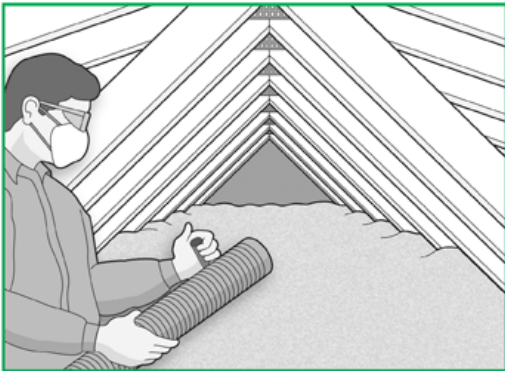
Some types of insulation require professional installation, and others you can install yourself. You should consider the several forms of insulation available, their R-values, and the thickness needed. The type of insulation you use will be determined by the nature of the spaces in the building that you plan to insulate. For example, since you cannot conveniently "pour" insulation into an overhead space, blankets, spray-foam, board products, or reflective systems are used between the joists of an unfinished basement ceiling. The most economical way to fill closed cavities in finished walls is with blown-in insulation applied with pneumatic equipment or with sprayed-in-place foam insulation.

The different forms of insulation can be used together. For example, you can add batt or roll insulation over loose-fill insulation, or vice-versa. Usually, material of higher density (weight per unit volume) should not be placed on top of lower density insulation that is easily compressed. Doing so will reduce the thickness of the material underneath and thereby lower its R-value. There is one exception to this general rule: When attic temperatures drop below 0°F, some low-density, fiberglass, loose-fill insulation installations may allow air to circulate between the top of your ceiling and the attic, decreasing the effectiveness of the insulation. You can eliminate this air circulation by covering the low-density, loose-fill insulation with a blanket insulation product or with a higher density loose-fill insulation.



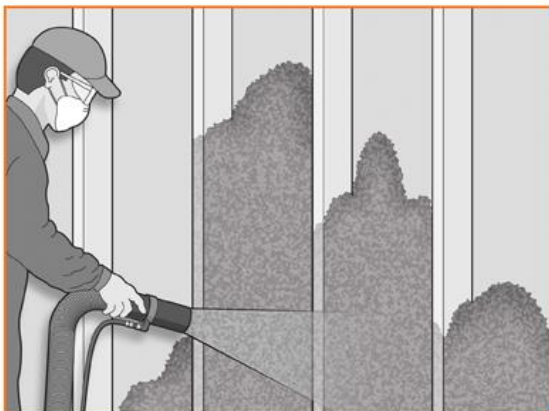
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Blankets, in the form of batts or rolls, are flexible products made from mineral fibers, including fiberglass or rock wool. They are available in widths suited to standard spacings of wall studs and attic or floor joists. They must be hand-cut and trimmed to fit wherever the joist spacing is non-standard (such as near windows, doors, or corners), or where there are obstructions in the walls (such as wires, electrical outlet boxes, or pipes). Batts can be installed by you or a professional. They are available with or without vapor-retarder facings. Batts with a special flame-resistant facing are available in various widths for basement walls where the insulation will be left exposed.



ORNL 07-G01657/abn

Blown-in loose-fill insulation includes cellulose, fiberglass, or rock wool in the form of loose fibers or fiber pellets that are blown using pneumatic equipment, usually by professional installers. This form of insulation can be used in wall cavities. It is also appropriate for unfinished attic floors, for irregularly shaped areas, and for filling in around obstructions.

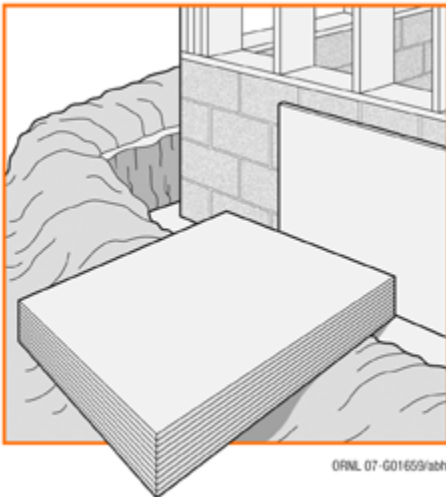


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In the open wall cavities of a new building, cellulose and fiberglass fibers can also be sprayed after mixing the fibers with an adhesive or foam to make them resistant to settling.



Foam insulation can be applied by a professional using special equipment to meter, mix, and spray the foam into place. Polyisocyanurate is an open-celled foam. Polyisocyanurate and polyurethane are closed-cell foams. In general, open-celled foam allows water vapor to move through the material more easily than closed-cell foam. However, open-celled foams usually have a lower R-value for a given thickness compared to closed-cell foams. So, some of the closed-cell foams are able to provide a greater R-value where space is limited.



Rigid insulation is made from fibrous materials or plastic foams and is produced in board-like forms and molded pipe coverings. These provide full coverage with few heat loss paths and are often able to provide a greater R-value where space is limited. Such boards may be faced with a reflective foil that reduces heat flow when next to an air space. Rigid insulation is often used for foundations and as an insulative wall sheathing.

Reflective insulation systems are fabricated from aluminum foils with a variety of backings such as kraft paper, plastic film, polyethylene bubbles, or cardboard. The resistance to heat flow depends on the heat flow direction, and this type of insulation is most effective in reducing downward heat flow. Reflective systems are typically located between roof rafters, floor joists, or wall studs. If a single reflective surface is used alone and faces an open space, such as an attic, it is called a [radiant barrier](#).

Radiant barriers are installed in buildings to reduce summer heat gain and winter heat loss. In new buildings, you can select foil-faced wood products for your roof sheathing (installed with the foil facing down into the attic) or other locations to provide the radiant barrier as an integral part of the structure. For existing