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# Do It Yourself Solar Heater Guide

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## Remember...Safety First!

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# Introduction

There was a time when man's only source of heat was the sun, and when the sun went down at night, so went man's source of heat. Later, man discovered fossil fuels such as coal, oil, and natural gas, and was able to harness these fuels to produce heat, both for warmth as well as for cooking. As electricity was discovered, it too was harnessed to provide a source for heating. But there's a problem with sources, such as coil, oil, natural gas, and even electricity. The problem is that these sources have increased in cost over time as demand has grown and capacity in many cases has remained steady. As well, we're entering a new era, where many are looking to "go green" and where lowering one's footprint is no longer taboo, but is actually fostered among many in society. Today, millions of homes around the world have been built to utilize the sun for heating and electrical needs. Solar heating has been around for a very long period of time and it's not until recently that it's becoming looked at again as a viable, efficient way to heat your home and to save money at the same time!

In the United States alone, heating, ventilation, and air conditioning (HVAC) systems account for over 25% of the energy used in commercial buildings and almost 50% of the energy used in residential homes. This guide will focus on the use of Solar Heating to offset a portion or all of the energy associated with heating a home, building, cabin, RV, or other vented structure requiring heat.

Solar Heating represents a specific use of deriving heat from the sun and falls under the general name of Solar Thermal Collection. We'll note, however, that the same principles apply to the heating of water, also called Solar Water Heaters. The term solar Thermal Collectors or Solar Collectors generally refers to larger and more complex applications, such as those used in commercial power plants. From this point forward, we'll be referring to the heating of air through solar energy as simply Solar Heating.

Solar Heating has been used for a long, long time. In fact, in the period from 100 to 400 AD, the Romans built many of their bath houses with large walls facing the south and windows to allow heat to pass through. They also built large stones that would build up during the day and radiate that heat at night. In 600 AD, sun rooms on homes and public buildings became so common, that laws are passed allowing for "sun rights", so that buildings had access to the sun. In fact, these laws were recorded under the Justinian Code.

In the 1760's, Horace de Saussure, a noted Swiss naturalist observed, "It is a known fact, and a fact that has probably been known for a long time, that a room, a carriage, or any other place is hotter when the rays of the sun pass through glass..." So, de Saussure set out to prove the effectiveness of trapping heat with glass covers. He built a rectangular box out of half-inch pine, insulated the inside, and had the top covered with glass. Upon exposure to the sun, the bottom box heated to 228 degrees! In his day, de Saussure was unsure of how the sun heated the glass boxes. Today, we know that the sun penetrated the glass covers and having no place to go, was converted to heat.

Though clear glass allows the rays of the sun to easily enter through it, it prevents heat from leaving. Its inventor, de Saussure realized that someday the "hot box" would have important practical applications, as "it is quite small, inexpensive and easy to make..." Indeed, the "hot box" has led to the design of solar collectors, which have provided sun-heated water and air to millions ever since.

In the 1970's, hundreds of energy conscious designers, engineers, and handymen experimented with a multitude of solar heater designs, many of which led to thousands of homes and structures around the world being fashioned with cost-cutting and environmentally friendly solar heating units. If you recall, in the 1970's, the U.S. was facing an energy crisis, hence the innovation and use of "green technologies" that took shape. Once in the 1980's, America moved back into a period of excess and soon forgot about the efficiencies learned just a decade earlier.

While there are several different designs that have been created and refined to capture solar energy for heating, we'll be focusing on a couple of different types in this guide series. The first is a very simple 'window box' design and the second is a current modification of the 'Trombe Wall' design. In fact, a Trombe wall is actually a sun-facing wall, built from material that can act as a thermal mass (such as stone, metal, concrete, adobe, or water tanks), combined with an air space, insulated glazing, and vents to form a large solar thermal collector. It is named after the French inventor, Felix Trombe, who popularized the design in 1964 although Edward Morse had patented it back in 1881.

The Trombe wall is comprised of a large air channel that is sandwiched between a window and a sun-facing thermal mass. During the ventilation cycle, sunlight stores heat in the thermal mass and warms the air channel causing circulation through vents at the top and bottom of the wall. During the heating cycle, the Trombe wall then radiates its stored heat. Sunlight passing through the glazing generates heat which conducts through the wall. Warm air between the glazing and the Trombe wall surface can also be channeled by natural convection into the building interior or to the outside, depending on the building's heating or cooling needs.

No matter where you live, or what your living situation may be, solar heating can definitely serve you and lower your fuel costs. Solar heating is easiest in the south where heating needs are less. It's slightly more difficult in the north, where heating needs are greatest. However, the time and cost involved in building simple or complex systems makes solar heating far worth it.

# How Does Solar Heating Actually Work?

During the day, sunlight shines through a clear surface, like glass (called glazing) and hits a surface (called the thermal mass), warming it by absorption. When the sunlight enters the glazing, it can't escape, and while building up, the energy is converted in heat. The air between the glazing and the thermal mass warms, via heat conduction. Hot or even warmed air rises through a process of natural convection. The warmed air moves through vents at the top of the wall and into the living area. This process pulls cooler air from the outside or bottom portion of the living area through vents near the bottom of the wall.

During the day, heat is produced continuously, as long as the sun shines on the thermal mass. When the sun stops shining, the thermal mass begins cooling. As the air temperature comes down, the natural convection process slows, and then stops. At night, a one-way flap located on the bottom vent prevents the movement of warmer air (now inside the structure) from going back outside (called backflow), which would lead to a cooling of the living space. Depending on the type of material used, heat stored in the thermal mass will continue to radiate into the living area throughout the night.

Modern day vents are an addition to the original Trombe wall design, which relied entirely on conduction through the thermal mass to move heat into the living area. In the original design, the majority of the heat collected during the day, radiated back through the glazing at night or on an overcast day. This problem is best addressed by adding insulation between the collector space and the thermal mass, and arranging for the thermal mass to be heated by the air circulating through the collector space via the one-way flaps. This change avoids the massive loss of heat at night or on overcast days. Modern passive solar design emphasizes the separation of collectors and thermal masses. Generally, vents to the interior are closed in summer months when heat gain is not wanted.

Additionally, the design was popularized through an insulated or “glazed” heavy wall. As before, sunlight would shine through the insulated glazing and warm the surface of the thermal mass. However, at night, heat was trapped due to the insulated glazing, keeping the average temperature of the thermal mass significantly above the average outdoor temperature. If the glazing insulates well enough, and outdoor temperatures are not too low, the average temperature of the thermal mass will be significantly higher than room temperature, and heat will continue flowing into the living space.

### *Useful Solar Definitions*

**Thermal Mass** refers to the substance within the solar heater that stores heat. Thermal mass (Cth, also called thermal capacitance or heat capacity) is the capacity of a body to store heat. It is typically measured in units of J/°C or J/K (which are equivalent). If the body consists of a homogeneous material with sufficiently known physical properties, the thermal mass is simply the mass of material present times the specific heat capacity of that material. For bodies made of many materials, the sum of heat capacities for their pure components may be used in the calculation, or in some cases (as for a whole animal, for example) the number may simply be measured for the entire body in question, directly.

Thermal mass materials store solar energy during the day and release this energy during cooler periods. Common thermal mass materials include stone, concrete, and even water. When considering the proportion and placement of thermal mass, one should consider several factors including climate, hours of daylight, and shading conditions. When properly incorporated, thermal mass can passively maintain comfortable temperatures, while reducing energy consumption.

Thermal mass as a concept is most frequently applied in the field of building design. In this context, thermal mass provides "inertia" against temperature fluctuations, sometimes known as the thermal flywheel effect. For example, when outside temperatures are fluctuating throughout the day, a large thermal mass within the insulated portion of a house can serve to "flatten out" the daily temperature fluctuations, since the thermal mass will absorb heat when the surroundings are hotter than the mass, and give heat back when the surroundings are cooler. This is distinct from a material's insulation value, which reduces a building's thermal conductivity, allowing it to be heated or cooled relatively separate from the outside, or even just retain the occupants' body heat longer.

A **Solar Chimney** (or thermal chimney) is a passive solar ventilation system composed of a hollow thermal mass connecting the interior and exterior of a building. As the chimney warms, the air inside is heated causing an updraft that pulls air through the building. These systems have been in use since Roman times and remain common in the Middle East.
Heat is transferred either by conduction or convection. In the case of solar heating of air, natural convection occurs; whereas for water, the process is called conduction.

**Glazing** is the transparent part of a wall, which is commonly made of glass or plastic (acrylic and polycarbonate). Common types of glazing used in architectural applications include clear and tinted float glass, tempered glass, and laminated glass as well as a variety of coated glasses, all of which can be glazed singly or as double, or even triple glazed units. Glazing is commonly recommended in solar thermal collectors, because it results in an increase in the sun's radiosity. In this case, it involves fitting the selected solar collector cover material to the frame to form a weather- resistant seal while providing for expansion and contraction of the different materials being

assembled. Plastics will generally not fracture, but they expand and contract more than glass does over the same temperature range. Remember that if you tilt glass or other flexible materials from the vertical position, their weight causes them to start deflecting or sagging. Therefore, the size of the piece is an important consideration. It is also important to support the glass if your panel is tilted.

**Conduction** is the movement of heat through a solid material from a warmer side of an object to its cooler side. The rate of heat exchange depends upon the temperature difference between the two sides. The resistance that a material presents to conductive heat transfer is called its R-value. Wood, for example, has a higher R-value than metal. If you stir soup with a metal spoon you'll find the heat is transferred rapidly up the spoon whereas with the opposite is true with a wooden spoon.

**Convection** is the transfer of heat by a moving stream of air or water. If air in a room is warm, it expands, becoming wider and rising to the ceiling. And then it dissolves some of the heat to surrounding objects, becomes cooler and heavier and returns to a lower level. This pattern of air movement is also known as the convective loop. The convective loop also takes place inside un- insulated walls. Air moves up the warm interior wall and falls down the exterior wall as it cools. In a poorly insulated house with lots of air leaks, a great deal of energy is wasted in heating the already too hot area near the ceiling to maintain a comfortable air temperature near the floor. In such cases, insulation and weather stripping should be looked at.

**Radiation** is the transfer of heat across an open surface or space without changing the temperature of the air in the space. A warm object will radiate electromagnetic waves to any colder object that it "sees". Radiant heat is the heat that warms your front when your face a hot campfire and warms your back as you turn around. On a clear cold night, the roof of the house radiates heat to the sky and can actually become colder than the outside air. Radiant heat losses are very site specific which means that if the sky is cloudy where you live, your home will heat mostly by convection, but if you live at a high altitude or where the sky is clear at night, your home's radiant heat losses will be increased. Your first priority to keeping warm is to minimize heat losses from your home by first caulking or weather stripping around doors, windows, and other openings where cold air may infiltrate your home.

Up to the 2/3 of a home heat loss can happen through un-insulated walls and ceilings as heat travels through them by conduction, convection and radiation. It is important to note that single pane windows can also lead to major heat loss. In colder climates, double pane glass is definitely recommended.

## Major Forms of Solar Heating

There are two main types of solar heating systems...passive and active. **Passive systems** operate without blowers or dampeners to regulate the movement of heat. They work by the direct absorption of the sun's energy by a thermal mass located in the living space, or by an exterior collector that works through natural convection. Passive systems cost nothing to operate, but can require manual operation of dampeners and vents.

**Active systems** on the other hand use electrical devices to move heat. Usually they are more easily added onto an existing structure, and can be completely automated. Passive style solar heaters are typically used in either external Trombe wall designs, or as window heaters. There is a third type of solar heating system called a hybrid system; however, this type will not be discussed in this guide.

Sunlight is radiant energy which is composed of short and long waves. Most of the sun's energy is in short wave radiation, but it is the sun's long wave radiation that warms us when we sit outside in the sunshine. Glass or any other clear glazing material let's almost all of the short waves solar radiation pass through, but very little of the long wave heat radiation. Lots of short waves pass through the glass and strike a solid non-transparent surface, upon which they turn into long wave heat radiation and cannot escape back through the glass. A good example of this effect is in a car parked in the sunshine for several hours. The interior will most noticeably have an uncomfortably hot interior. The same things happen in greenhouses, hence the term greenhouse effect.

Passive collectors, like passive solar systems, are self-operating, silent and quite efficient. Thermosiphoning air collectors operate by natural flow of warmed air and must therefore be located below or at the same height as their point of use. Sunlight entering the collector becomes heat on the absorber surface. This heat is transferred into the air in the collector which rises and enters the living area, pulling cooler air from the room back into the bottom of the collector. The more intense the sunlight, the hotter the collector becomes and the more forcefully the convective loop moves. At night, a reversal of this loop must be prevented. During the evening hours, warmer air will want to settle back down and then may actually then pull warm air from the building or structure back into the solar heater.

## Solar Heater Designs

Window box solar collectors are one the simplest solar heating devices you can build. They're quite small in relation to the size of the room they're heating. They don't provide a great percentage of the house's total heating needs unless several are used. These heaters provide a slow continuous flow of heated air into the adjoining rooms. They are self-operating and when properly built have an advantage over other solar heating devices in that no dampeners of any kind are needed to prevent night time heat losses. Their best application is on homes with wide south-facing double hung windows that are four feet or more above ground level. They can be installed on other tracts of windows, but the modifications required are more difficult and often expensive and unattractive. If the windows are less than four feet from the ground, the natural convection that moves air through them and into the house will be weak and the collectors won't perform as well as they could. Since window box heaters are fairly small and act as a supplemental heat source, no heat distribution or storage is incorporated into their design. They don't involve any major modifications to the house and don't sacrifice any south-facing exposure, that later may be desired for a larger collector.

Another style is called the Trombe Wall design. For detailed information on this design, see Solar Heater Guide 2 – Trombe Wall Design

***Common Modifications of the Trombe wall***

- Exhaust vent near the top that is opened to vent to the outside during the summer. Such venting makes the Trombe wall act as a solar chimney pumping fresh air through the house during the day, even if there is no breeze
- Windows in the Trombe wall. This lowers the efficiency but may be done for natural lighting or aesthetic reasons. If the outer glazing has high ultraviolet transmittance, and the window in the Trombe wall is normal glass, this allows efficient use of the ultraviolet light for heating. At the same time, it protects people and furnishings from ultraviolet radiation more than do windows with high ultraviolet transmittance

- Electric blowers controlled by thermostats, to improve air and heat flow
- Fixed or movable shades, which can reduce nighttime heat losses
- Trellises to shade the solar collector during summer months
- Insulating covering used at night on the glazing surface
- Fish tanks as thermal mass
- Using a selective surface to increase the absorption of solar radiation by the thermal mass.

***Recommended Design Elements (Temperate Climates)***

- Orienting the building to face the equator (or a few degrees to the East to capture the morning sun
- Extending the building dimension along the east/west axis
- Adequately-sizing windows to face the midday sun in the winter, and be shaded in the summer
- Minimizing windows on other sides, especially western windows
- Erecting correctly-sized, latitude-specific overhangs, or shading elements (shrubbery, trees, trellises, fences, shutters, etc)
- Using the appropriate amount and type of insulation including radiant barriers and bulk insulation to minimize seasonal excessive heat gain or loss
- Using thermal mass to store excess solar energy during the winter day (which is then radiated during the night)
- The precise amount of equator-facing glass and thermal mass should be based on careful consideration of latitude, altitude, climatic conditions, and heating/cooling degree day requirements, and is outside of the scope of this Solar Heating Guide.

*Factors that can Degrade Thermal Performance*

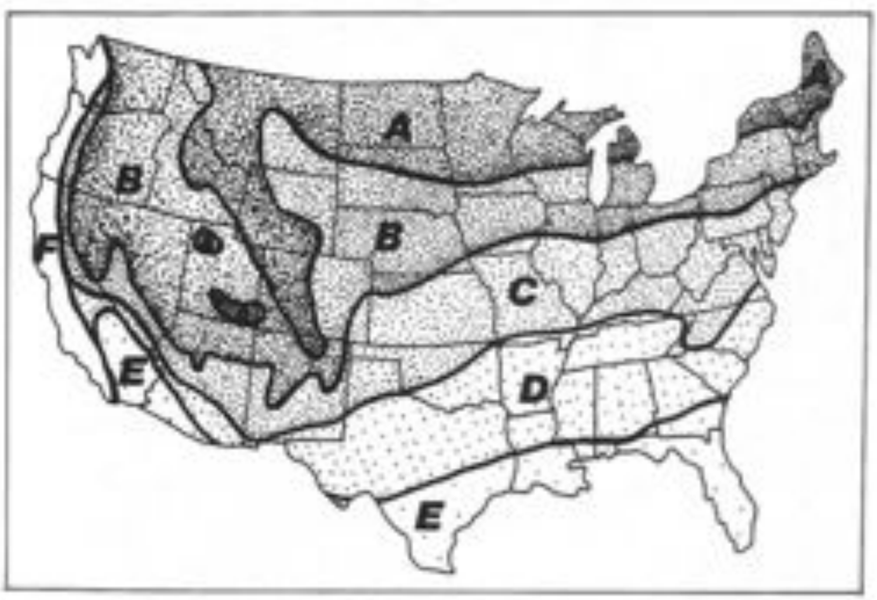
- Deviation from south facing orientation in the northern hemisphere and north facing orientation in the southern hemisphere
- Installing glazing where solar gain during the day and thermal losses during the night cannot be controlled easily (for example, west facing units, skylights)
- Using non-insulated or unprotected glazing
- High building surface area to volume
- Too many corners
- Inadequate weatherization leading to high air infiltration
- Lack of or incorrectly-installed, radiant barriers during the hot season
- Insulation materials that are not matched to the main mode of heat transfer (e.g. undesirable convective/conductive/radiant heat transfer)

# Planning Your Solar Heater Installation

The design instructions within these guides work well for homes and living spaces of most any size. In this section, we'll walk through some simple methods for calculating the size of the solar heater that you'll need.

But first, we feel it's important to offer a special note about efficient heating and cooling of living spaces. Did you know that many homes in colder or windier climates can lose as much as 50% of their heat through leaks around windows, doors and joints? In order to use heat effectively, you'll want to make sure that your home is tightly sealed and insulated.

**Figure 1 - Recommended R-values per Region within the U.S.**




*11. Recommended R values for home insulation (adapted from Owen-Corning):*

| | | | |
|---|---|---|---|
| A) | Ceiling 38 | Wall 19 | Floor 22 |
| B) | Ceiling 33 | Wall 19 | Floor 22 |
| C) | Ceiling 30 | Wall 19 | Floor 19 |
| D) | Ceiling 26 | Wall 19 | Floor 13 |
| E) | Ceiling 26 | Wall 13 | Floor 11 |
| F) | Ceiling 19 | Wall 11 | Floor 11 |

Insulation is KEY to trapping heat. A home that's not well insulated will leak heat, therefore requiring more energy in order to heat the home and keep you comfortable. Leaks should be sealed with caulk or weather-stripping, which is a very easy and inexpensive way to increase efficiency and lower your costs. To locate air leak, simply pass a lighted candle over the surface...perhaps where a window frame meets the wall or where a door frame meets a wall or where a door frame meets the exterior side. If the candle begins to flicker, that's an indication that there's air movement in that location. Once you've spotted a leak, clean the crack completely, and then fill with some beads of caulk or rubber weather-stripping purchased at a local home repair store. You may also do this around your home, taking some masking tape and marking each of the area in which you're finding leaks and then go back in a second pass and seal those areas up. This sounds so simple; however, we can't stress this enough, given the number of homes that are still not adequately sealed against the elements and heat loss.

Selecting the most economical size for your solar heater is not difficult once you know the following factors:

1. The number of BTU's needed to heat your home
2. The climate, which includes the solar radiation and ambient temperature.
3. The operating efficiency of the system
4. The percentage of the heating load that the solar heater(s) will provide

### *Sizing Your Solar Heater*

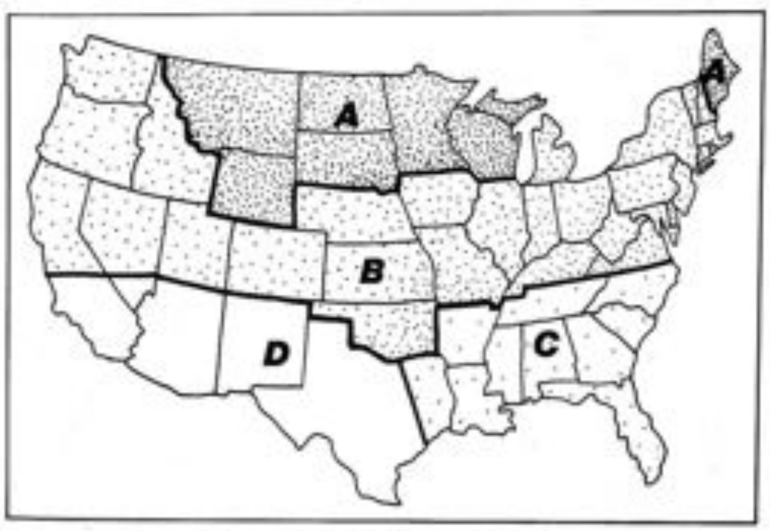
The quality of insulation, otherwise known as solar radiation, which you hope to capture with your solar system, varies substantially throughout the United States. Surprisingly, if you could collect sun light before it enters the earth's atmosphere; we'd find approximately 427

BTU's per square foot per hour available for our needs. But as this radiation passes through the atmosphere, it loses intensity, due to the orientation of the earth and the absorption and scattering of radiation by cloud, vapor, dust, smoke, etc. The influence of these factors is greater in winter months in northern latitudes, where the sun travels lower in the sky and must pass through more of the atmosphere to reach these areas at these times. Also, you would expect increased pollution near large cities or industrial complexes to negatively affect the amount of solar radiation available. In fact, ratings can vary by as much as 20%, even within a few miles.

**Figure 2 - Climate Regions broken out in the U.S.**

## Climatic Regions

The continental United States can be divided into four general climatic regions. Each region is defined by general weather patterns which help to identify the priorities of home energy usage.

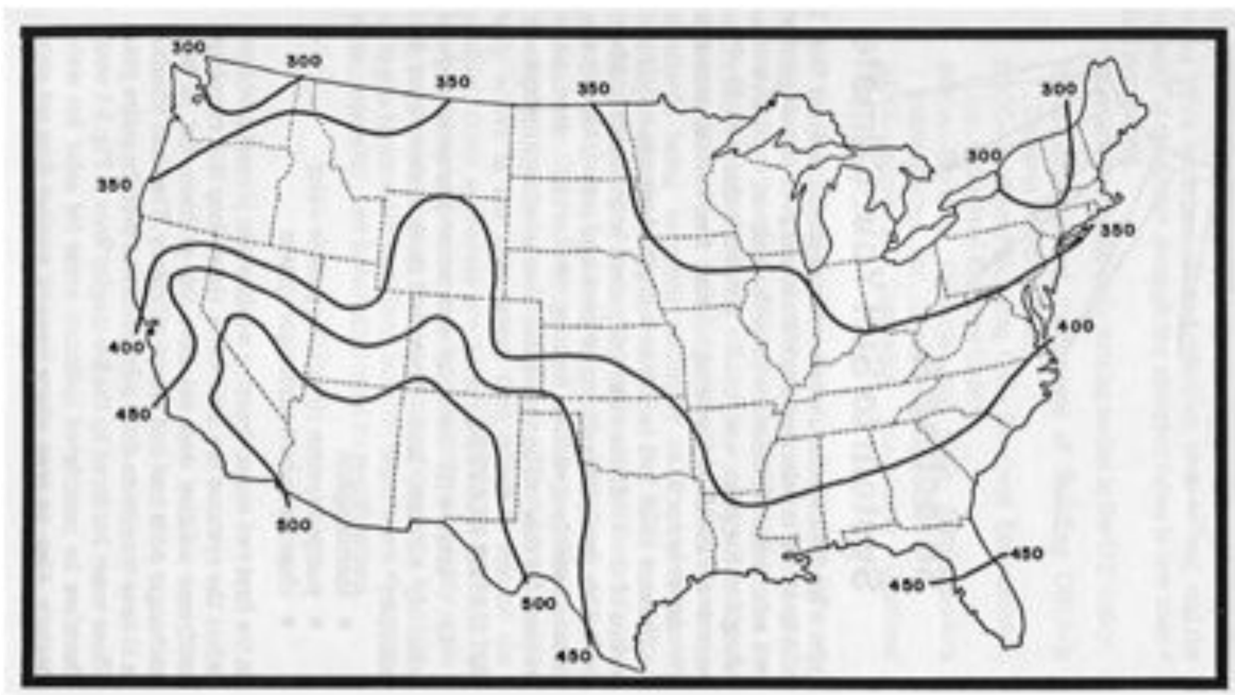



*1. Climatic regions of the United States*
*A) Cool, B) Temperate, C) Hot-Humid, D) Hot-Arid*

| COOL REGION: | TEMPERATE REGION: | HOT-HUMID REGION: | HOT-ARID REGION: |
|---|---|---|---|
| cold winters | cool winters | hot days | hot days |
| mild summers | warm summers | warm nights | cool nights |
| winds from the northwest and southeast | high precipitation | high humidity | winds along the east-west axis |
| | high humidity | variable winds | low humidity |
| | | | clear skies |

Heating needs are calculated for the coldest months of the year, which for most places is November through April. Because of variances in the sun's energy mentioned above, the yearly total solar radiation estimate cannot be used. Instead, solar radiation for the 6 month heating season should be plotted and computed on a map using what's called Langley intervals. This provides a measure of the sunshine or solar fuel that could be expected for each zone across the U.S.

**Figure 3 - Mean Daily Solar Radiation as represented in Langleys**




Because of the amount of cold weather or load varies throughout the country, this load is the next variable that must be calculated. One method commonly used is called the 'Heating Degree Day', which is a unit of measurement representing a 1 degree difference between a base temperature of 65 degrees and the average outside temperature for a 1 day period. If the average outside temperature for 24 hours is 20 degrees, that day will have 45 degree-days (65-20=45). For instance, Duluth, Minnesota averages 9,250 heating degree-days a winter, while Los Angeles averages 2,060.

Sixty Five Degrees was chosen because that is the temperature where home heater use begins to kick in and become needed. The farther below 65 degrees, the temperature falls, the more heat will be required to make a house comfortable. In another example, Boston maintains an average daily temperature is 44.9 degrees during November. This figure (the average daily temperature) is subtracted from 65 degrees to give the daily degree day reading. In this case, 20.1 (65-44.9=20.1) multiplied by 30, which is the number of days in November, provides the total heating degree days for Boston for the entire month of November, a total of 603. Adding the monthly reading for the November through April period totals 5,005.

If you know your heating load or can calculate it by analyzing your actual fuel bills, all the better. If not, an assumption of the load must be made based on historical averages. To do this, we use the heating degree day calculation from above. When home furnaces are installed, they are generally oversized. Design temperatures on based on the rating of 15 degrees above the lowest temperature ever recorded by the meteorological station in that area. This low temperature condition seldom occurs, resulting in unused heating capacity. So let's walk through an example. Assume that you have a 2,500 square foot home in Grand Junction, Colorado, which you determined uses 900,000 BTU's of fuel per day during the month of December, based on an actual fuel bill. Looking at a table, Grand Junction typically has 1,113 heating degree days in the month of December or 36 degree days in a 24 hour period (1113 divided by 31days). You can now calculate the number of BTU's per degree day, per square foot that your home requires. For instance, 900,000 divided by (36x2500) equals 10 BTU's per degree day, per square foot. The average American home is not well insulated and would have a reading in the range of 12 to 20 BTU's per degree day, per square foot. So let's continue our example. Again, with our 2,500 square foot home in Grand Junction, Colorado, with a thermal load of 10 BTU's per degree day per square foot, we calculate a total building load of 25,000 BTU's per degree day (2500x10).

For a table showing heating degree days for the most common cities, see the Tables located at the back of this guide.

If you want your solar heater to produce 50% of the heating for the living space, then you would calculate the amount of collector space needed as follows:

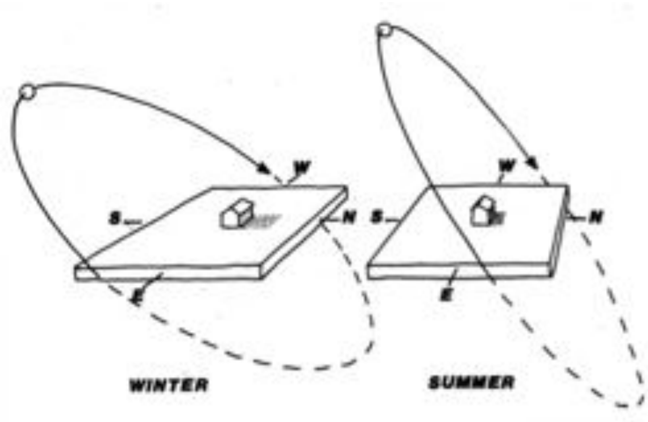
25,000 / 46 = 536 sqft of collector needed (where 46 is the BTU's per degree day per sqft of collector as a percentage of usage...this figure is taken from the Load Ratio table at the back of this guide).

The last consideration is whether you have access to alter the outside of the structure. If so, we would recommend the Trombe wall design. If however, you are living in a condo or apartment, then the window box will be your best choice.

The advantage of building your own solar heater is that you can adjust it any way you want. Nobody knows your home as well as you do and with the ideas presented in this guide, you'll be prepared to build a system to best fit your needs. It's important to know that if you can build a birdhouse...even a simple one, you are well-equipped to build your own window solar heater.

You may wish to incline your solar heater. Ideally, your solar heat collector would remain perpendicular to the sun's rays for maximum efficiency. For those living in northern most areas, the sun will be lower on the horizon. For those living closer to the equator, the sun will be higher in the evening sky. For simple designs simply orient the solar heater to be perpendicular with the suns placement in the winter sky.

**Figure 4 - Seasonal Rotation of the Sun**




Did you know that you can even calculate your solar heater's position based on the moon? Most folks know that a full moon shines in the sky directly opposite the sun. That's what makes it full! The full moon rises as the sun sets during fall harvest because day and night are of equal length during this time of the year. When day and night are of equal length, the full moon rise will be slightly before or after sunset. What few people realize is that the moon also changes it's altitude above the horizon in a pattern identical to that of the sun. The "lunar window" corresponds almost exactly to the "solar window" at a given site and only varies from it by a maximum of four degrees. The moon however completes it's up and down motion throughout the sky every month, whereas it takes the sun a year to complete this cycle. If you use the moon to check for sun angles, do it as close to the solstice or equinoxes as possible, and do it within two or three nights of the full or quarter moon. The transient moon travels the same path throughout the sky for only three or four nights, while the winter sun follows approximately the same path for three months. While you are at looking at moon shadows, locate the Big Dipper and Polaris, the North Star. Since Polaris is located due north of all sight in the northern hemisphere, it becomes very easy to locate true south and you don't have to use a compass and a magnetic variation chart to point your solar collector in the right direction.

# Payback (Short and Long Term)

Once your home is properly weatherized and you've located an appropriate place to install your collector, your next consideration is payback. Payback is an important look at the length of time it will take to recover your investment through a reduction in heating fuel costs. The most straightforward calculation includes factoring the total cost of the construction of your solar heater balanced with the monthly or yearly cost to heat your home. For example, let's say your Solar Heater unit costs $100 to build and was providing 40% of your heating needs. With a final heating bill of $50, it would take a little over two months to recoup the cost of your solar heater installation. There's an even bigger reason for building a solar heater though... A study by some folks at the Small Farm Energy Project in Harrington, Nebraska, looked at a great number of solar installations on both homes and commercial structures. They came to some pretty amazing conclusions. Namely, they found that almost without exception, builders of do-it-yourself solar heaters saved on average 20% of their fuel bills over and above the savings that can be traced to solar heat delivery! Even small systems that couldn't have provided the owners over 10% of their need saved these folks 30% on their fuel bills.

A change in attitude and involvement was undoubtedly the source of this "free heat". Once the homeowners built their own solar heating system, they realized that they weren't helpless in the face of skyrocketing fuel costs and had become even more energy conscious!

They started doing small things like closing the door when going out for the dog, or turning down the thermostat every night or waiting until the solar heater had warmed the shop before starting work in the morning. All these small things added up to dramatic savings. This just goes to show that careful economic analysis certainly isn't the only way to look at the effectiveness of solar heating.

# Other Ideas and Further Enhancements

Below is a list of other tricks, tips, and ideas for enhancing your Solar Heater. Many people decide to modify their solar heaters to better fit their unique needs. We hope this section will provide you with some additional thoughts as you build and install your own solar heater.

***Measuring Internal Temperatures***

You may decide to use a thermometer to determine the inside air temperature of your solar heater. If you do this, make sure you get a thermometer that will handle temp ranges upwards of 220 degrees. Although it sounds very high, solar heaters can produce substantial internal temperatures during the day.

***Using a Blower Fan***

A solar heater that simply collects heat and uses thermosiphoning only to heat a structure is called a Passive Heater. You may decide to install a fan into the output vent and move to an active heater. When you do, you'll actually move more air into the heated space of your home or building, however the temperature will drop slightly from a passive heater. This is not a concern, especially if the solar heater is producing high temperatures in the first place. When installing a fan, consider wiring it to a small battery connected to a small solar panel (if you're not using one already), in order provide ongoing free electricity.

Additionally, you may decide to wire a thermostat to the unit and fan blower, so that the fan does not come on until the internal temperature rises above a threshold, say 110 degrees.

# Appendix - Heating Degree Day Estimates

**Figure 5 - Heating Degree Day (Alabama thru Georgia)**

| States and Stations | JULY | AUG | SEPT | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUNE | ANNUAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ALABAMA | | | | | | | | | | | | | |
| Birmingham | 0 | 0 | 6 | 93 | 363 | 555 | 592 | 462 | 363 | 108 | 9 | 0 | 2551 |
| Huntsville | 0 | 0 | 12 | 127 | 426 | 663 | 694 | 557 | 434 | 138 | 19 | 0 | 3070 |
| Mobile | 0 | 0 | 0 | 22 | 213 | 357 | 415 | 300 | 211 | 42 | 0 | 0 | 1560 |
| Montgomery | 0 | 0 | 0 | 68 | 330 | 527 | 543 | 417 | 316 | 90 | 0 | 0 | 2291 |
| ALASKA | | | | | | | | | | | | | |
| Anchorage | 245 | 291 | 516 | 930 | 1284 | 1572 | 1631 | 1316 | 1293 | 879 | 592 | 315 | 10864 |
| Annette | 242 | 208 | 327 | 567 | 738 | 899 | 949 | 837 | 843 | 648 | 490 | 321 | 7069 |
| Barrow | 803 | 840 | 1035 | 1500 | 1971 | 2362 | 2517 | 2332 | 2468 | 1944 | 1445 | 957 | 20174 |
| Barter Is. | 735 | 775 | 987 | 1482 | 1944 | 2337 | 2536 | 2369 | 2477 | 1923 | 1373 | 924 | 19862 |
| Bethel | 319 | 394 | 612 | 1042 | 1434 | 1866 | 1903 | 1590 | 1655 | 1173 | 806 | 402 | 13196 |
| Cold Bay | 474 | 425 | 525 | 772 | 918 | 1122 | 1153 | 1036 | 1122 | 951 | 791 | 591 | 9880 |
| Cordova | 366 | 391 | 522 | 781 | 1017 | 1221 | 1299 | 1086 | 1113 | 864 | 660 | 444 | 9764 |
| Fairbanks | 171 | 332 | 642 | 1203 | 1833 | 2254 | 2359 | 1901 | 1739 | 1068 | 555 | 222 | 14279 |
| Juneau | 301 | 338 | 483 | 725 | 921 | 1135 | 1237 | 1070 | 1073 | 810 | 601 | 381 | 9075 |
| King Salmon | 313 | 322 | 513 | 908 | 1290 | 1606 | 1600 | 1333 | 1411 | 966 | 673 | 408 | 11343 |
| Kotzebue | 381 | 446 | 723 | 1249 | 1728 | 2127 | 2192 | 1932 | 2080 | 1554 | 1057 | 636 | 16105 |
| McGrath | 208 | 338 | 633 | 1184 | 1791 | 2232 | 2294 | 1817 | 1758 | 1122 | 648 | 258 | 14283 |
| Nome | 481 | 496 | 693 | 1094 | 1455 | 1820 | 1879 | 1666 | 1770 | 1314 | 930 | 573 | 14171 |
| Saint Paul | 605 | 539 | 612 | 862 | 963 | 1197 | 1228 | 1168 | 1265 | 1098 | 936 | 726 | 11199 |
| Shemya | 577 | 475 | 501 | 784 | 876 | 1042 | 1045 | 958 | 1011 | 885 | 837 | 696 | 9687 |
| Yakutat | 338 | 347 | 474 | 716 | 936 | 1144 | 1169 | 1019 | 1042 | 840 | 632 | 435 | 9092 |
| ARIZONA | | | | | | | | | | | | | |
| Flagstaff | 46 | 68 | 201 | 558 | 867 | 1073 | 1169 | 991 | 911 | 651 | 437 | 180 | 7152 |
| Phoenix | 0 | 0 | 0 | 22 | 234 | 415 | 474 | 328 | 217 | 75 | 0 | 0 | 1765 |
| Prescott | 0 | 0 | 27 | 245 | 579 | 797 | 865 | 711 | 605 | 360 | 158 | 15 | 4362 |
| Tucson | 0 | 0 | 0 | 25 | 231 | 406 | 471 | 344 | 242 | 75 | 6 | 0 | 1800 |
| Winslow | 0 | 0 | 6 | 245 | 711 | 1008 | 1054 | 770 | 601 | 291 | 96 | 0 | 4782 |
| Yuma | 0 | 0 | 0 | 0 | 148 | 319 | 363 | 228 | 130 | 29 | 0 | 0 | 1217 |
| ARKANSAS | | | | | | | | | | | | | |
| Fort Smith | 0 | 0 | 12 | 127 | 450 | 704 | 781 | 596 | 456 | 144 | 22 | 0 | 3292 |
| Little Rock | 0 | 0 | 9 | 127 | 465 | 716 | 756 | 577 | 434 | 126 | 9 | 0 | 3219 |
| Texarkana | 0 | 0 | 0 | 78 | 345 | 561 | 626 | 468 | 350 | 105 | 0 | 0 | 2533 |
| CALIFORNIA | | | | | | | | | | | | | |
| Bakersfield | 0 | 0 | 0 | 37 | 282 | 502 | 546 | 364 | 267 | 105 | 19 | 0 | 2122 |
| Bishop | 0 | 0 | 42 | 248 | 576 | 797 | 874 | 666 | 539 | 306 | 143 | 36 | 4227 |
| Blue Canyon | 34 | 50 | 120 | 347 | 579 | 766 | 865 | 781 | 791 | 582 | 397 | 195 | 5507 |
| Burbank | 0 | 0 | 6 | 43 | 177 | 301 | 366 | 277 | 239 | 138 | 81 | 18 | 1646 |
| Eureka | 270 | 257 | 258 | 329 | 414 | 499 | 546 | 470 | 505 | 438 | 372 | 285 | 4643 |
| Fresno | 0 | 0 | 0 | 78 | 339 | 558 | 586 | 406 | 319 | 150 | 56 | 0 | 2492 |
| Long Beach | 0 | 0 | 12 | 40 | 156 | 288 | 375 | 297 | 267 | 168 | 90 | 18 | 1711 |
| Los Angeles | 28 | 22 | 42 | 78 | 180 | 291 | 372 | 302 | 288 | 219 | 158 | 81 | 2061 |
| Mt. Shasta | 25 | 34 | 123 | 406 | 696 | 902 | 983 | 784 | 738 | 525 | 347 | 159 | 5722 |
| Oakland | 53 | 50 | 45 | 127 | 309 | 481 | 527 | 400 | 353 | 255 | 180 | 90 | 2870 |
| Point Arguello | 202 | 186 | 162 | 205 | 291 | 400 | 474 | 392 | 403 | 339 | 298 | 243 | 3595 |
| Red Bluff | 0 | 0 | 0 | 53 | 318 | 555 | 605 | 428 | 341 | 168 | 47 | 0 | 2515 |
| Sacramento | 0 | 0 | 12 | 81 | 363 | 577 | 614 | 442 | 360 | 216 | 102 | 6 | 2773 |
| Sandberg | 0 | 0 | 30 | 202 | 480 | 691 | 778 | 661 | 620 | 426 | 264 | 57 | 4209 |
| San Diego | 6 | 0 | 15 | 37 | 123 | 251 | 313 | 249 | 202 | 123 | 84 | 36 | 1439 |
| San Francisco | 81 | 78 | 60 | 143 | 306 | 462 | 508 | 395 | 363 | 279 | 214 | 126 | 3015 |
| Santa Catalina | 16 | 0 | 9 | 50 | 165 | 279 | 353 | 308 | 326 | 249 | 192 | 105 | 2052 |
| Santa Maria | 99 | 93 | 96 | 146 | 270 | 391 | 459 | 370 | 363 | 282 | 233 | 165 | 2967 |
| COLORADO | | | | | | | | | | | | | |
| Alamosa | 65 | 99 | 279 | 639 | 1065 | 1420 | 1476 | 1162 | 1020 | 696 | 440 | 168 | 8529 |
| Colo. Springs | 9 | 25 | 132 | 456 | 825 | 1032 | 1128 | 938 | 893 | 582 | 319 | 84 | 6423 |
| Denver | 6 | 9 | 117 | 428 | 819 | 1035 | 1132 | 938 | 887 | 558 | 288 | 66 | 6283 |
| Grand Junction | 0 | 0 | 30 | 313 | 786 | 1113 | 1209 | 907 | 729 | 387 | 146 | 21 | 5641 |
| Pueblo | 0 | 0 | 54 | 326 | 750 | 986 | 1085 | 871 | 772 | 429 | 174 | 15 | 5462 |
| CONNECTICUT | | | | | | | | | | | | | |
| Bridgeport | 0 | 0 | 66 | 307 | 615 | 986 | 1079 | 966 | 853 | 510 | 208 | 27 | 5617 |
| Hartford | 0 | 6 | 99 | 372 | 711 | 1119 | 1209 | 1061 | 899 | 495 | 177 | 24 | 6172 |
| New Haven | 0 | 12 | 87 | 347 | 648 | 1011 | 1097 | 991 | 871 | 543 | 245 | 45 | 5897 |
| DELAWARE | | | | | | | | | | | | | |
| Wilmington | 0 | 0 | 51 | 270 | 588 | 927 | 980 | 874 | 735 | 387 | 112 | 6 | 4930 |
| FLORIDA | | | | | | | | | | | | | |
| Apalachicola | 0 | 0 | 0 | 16 | 153 | 319 | 347 | 260 | 180 | 33 | 0 | 0 | 1308 |
| Daytona Beach | 0 | 0 | 0 | 0 | 75 | 211 | 248 | 190 | 140 | 15 | 0 | 0 | 879 |
| Fort Myers | 0 | 0 | 0 | 0 | 24 | 109 | 146 | 101 | 62 | 0 | 0 | 0 | 442 |
| Jacksonville | 0 | 0 | 0 | 12 | 144 | 310 | 332 | 246 | 174 | 21 | 0 | 0 | 1239 |
| Key West | 0 | 0 | 0 | 0 | 0 | 28 | 40 | 31 | 9 | 0 | 0 | 0 | 108 |
| Lakeland | 0 | 0 | 0 | 0 | 57 | 164 | 195 | 146 | 99 | 0 | 0 | 0 | 661 |
| Miami Beach | 0 | 0 | 0 | 0 | 0 | 40 | 56 | 36 | 9 | 0 | 0 | 0 | 141 |
| Orlando | 0 | 0 | 0 | 0 | 72 | 198 | 220 | 165 | 105 | 6 | 0 | 0 | 766 |
| Pensacola | 0 | 0 | 0 | 19 | 195 | 353 | 400 | 277 | 183 | 36 | 0 | 0 | 1463 |
| Tallahassee | 0 | 0 | 0 | 28 | 198 | 360 | 375 | 286 | 202 | 36 | 0 | 0 | 1485 |
| Tampa | 0 | 0 | 0 | 0 | 60 | 171 | 202 | 148 | 102 | 0 | 0 | 0 | 683 |
| West Palm Beach | 0 | 0 | 0 | 0 | 6 | 65 | 87 | 64 | 31 | 0 | 0 | 0 | 253 |
| GEORGIA | | | | | | | | | | | | | |
| Athens | 0 | 0 | 12 | 115 | 405 | 632 | 642 | 529 | 431 | 141 | 22 | 0 | 2929 |
| Atlanta | 0 | 0 | 18 | 127 | 414 | 626 | 639 | 529 | 437 | 168 | 25 | 0 | 2983 |
| Augusta | 0 | 0 | 0 | 78 | 333 | 552 | 549 | 445 | 350 | 90 | 0 | 0 | 2397 |
| Columbus | 0 | 0 | 0 | 87 | 333 | 543 | 552 | 434 | 338 | 96 | 0 | 0 | 2383 |

# Appendix - Heating Degree Day Estimates (cont)

**Figure 6 - Heating Degree Day (Idaho thru Missouri)**

| States and Stations | JULY | AUG | SEPT | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUNE | ANNUAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Macon | 0 | 0 | 0 | 71 | 297 | 502 | 505 | 403 | 295 | 63 | [illegible] | [illegible] | 2136 |
| Rome | 0 | 0 | 24 | 161 | 474 | 701 | 710 | 577 | 468 | 177 | 34 | [illegible] | 3326 |
| Savannah | 0 | 0 | 0 | 47 | 246 | 437 | 437 | 353 | 254 | 45 | [illegible] | [illegible] | 1819 |
| Thomasville | 0 | 0 | 0 | 25 | 198 | 366 | 394 | 305 | 208 | 33 | [illegible] | [illegible] | 1529 |
| IDAHO | | | | | | | | | | | | | |
| Boise | 0 | 0 | 132 | 415 | 792 | 1017 | 1113 | 854 | 722 | 438 | 245 | 81 | 5809 |
| Idaho Falls 46W | 16 | 34 | 270 | 623 | 1056 | 1370 | 1538 | 1249 | 1085 | 651 | 391 | 192 | 8475 |
| Idaho Falls 42 NW | 16 | 40 | 282 | 648 | 1107 | 1432 | 1600 | 1291 | 1107 | 657 | 388 | 192 | 8760 |
| Lewiston | 0 | 0 | 123 | 403 | 756 | 933 | 1063 | 815 | 694 | 426 | 239 | 90 | 5542 |
| Pocatello | 0 | 0 | 172 | 493 | 900 | 1166 | 1324 | 1058 | 905 | 555 | 319 | 141 | 7033 |
| ILLINOIS | | | | | | | | | | | | | |
| Cairo | 0 | 0 | 36 | 164 | 513 | 791 | 856 | 680 | 539 | 195 | 47 | 0 | 3821 |
| Chicago | 0 | 0 | 81 | 326 | 753 | 1113 | 1209 | 1044 | 890 | 480 | 211 | 48 | 6155 |
| Moline | 0 | 9 | 99 | 335 | 774 | 1181 | 1314 | 1100 | 918 | 450 | 189 | 39 | 6408 |
| Peoria | 0 | 6 | 87 | 326 | 759 | 1113 | 1218 | 1025 | 849 | 426 | 183 | 33 | 6025 |
| Rockford | 6 | 9 | 114 | 400 | 837 | 1221 | 1333 | 1137 | 961 | 516 | 236 | 60 | 6830 |
| Springfield | 0 | 0 | 72 | 291 | 696 | 1023 | 1135 | 935 | 769 | 354 | 136 | 18 | 5429 |
| INDIANA | | | | | | | | | | | | | |
| Evansville | 0 | 0 | 66 | 220 | 606 | 896 | 955 | 767 | 620 | 237 | 68 | 0 | 4435 |
| Fort Wayne | 0 | 9 | 105 | 378 | 783 | 1135 | 1178 | 1028 | 890 | 471 | 189 | 39 | 6205 |
| Indianapolis | 0 | 0 | 90 | 316 | 723 | 1051 | 1113 | 949 | 809 | 432 | 177 | 39 | 5699 |
| South Bend | 0 | 6 | 111 | 372 | 777 | 1125 | 1221 | 1070 | 933 | 525 | 239 | 60 | 6439 |
| IOWA | | | | | | | | | | | | | |
| Burlington | 0 | 0 | 93 | 322 | 768 | 1135 | 1259 | 1042 | 859 | 426 | 177 | 33 | 6114 |
| Des Moines | 0 | 9 | 99 | 363 | 837 | 1231 | 1398 | 1165 | 967 | 489 | 211 | 39 | 6808 |
| Dubuque | 12 | 31 | 156 | 450 | 906 | 1287 | 1420 | 1204 | 1026 | 546 | 260 | 78 | 7376 |
| Sioux City | 0 | 9 | 108 | 369 | 867 | 1240 | 1435 | 1198 | 989 | 483 | 214 | 39 | 6951 |
| Waterloo | 12 | 19 | 138 | 428 | 909 | 1296 | 1460 | 1221 | 1023 | 531 | 229 | 54 | 7320 |
| KANSAS | | | | | | | | | | | | | |
| Concordia | 0 | 0 | 57 | 276 | 705 | 1023 | 1163 | 935 | 781 | 372 | 149 | 18 | 5479 |
| Dodge City | 0 | 0 | 33 | 251 | 666 | 939 | 1051 | 840 | 719 | 354 | 124 | 9 | 4986 |
| Goodland | 0 | 6 | 81 | 381 | 810 | 1073 | 1166 | 955 | 884 | 507 | 236 | 42 | 6141 |
| Topeka | 0 | 0 | 57 | 270 | 672 | 980 | 1122 | 893 | 722 | 330 | 124 | 12 | 5182 |
| Wichita | 0 | 0 | 33 | 229 | 618 | 905 | 1023 | 804 | 645 | 270 | 87 | 6 | 4620 |
| KENTUCKY | | | | | | | | | | | | | |
| Covington | 0 | 0 | 75 | 291 | 669 | 983 | 1035 | 893 | 756 | 390 | 149 | 24 | 5265 |
| Lexington | 0 | 0 | 54 | 239 | 609 | 902 | 946 | 818 | 685 | 325 | 105 | 0 | 4683 |
| Louisville | 0 | 0 | 54 | 248 | 609 | 890 | 930 | 818 | 682 | 315 | 105 | 9 | 4660 |
| LOUISIANA | | | | | | | | | | | | | |
| Alexandria | 0 | 0 | 0 | 56 | 273 | 431 | 471 | 361 | 260 | 69 | 0 | 0 | 1921 |
| Baton Rouge | 0 | 0 | 0 | 31 | 216 | 369 | 409 | 294 | 208 | 33 | 0 | 0 | 1560 |
| Burrwood | 0 | 0 | 0 | 0 | 96 | 214 | 298 | 218 | 171 | 27 | 0 | 0 | 1024 |
| Lake Charles | 0 | 0 | 0 | 19 | 210 | 341 | 381 | 274 | 195 | 39 | 0 | 0 | 1459 |
| New Orleans | 0 | 0 | 0 | 19 | 192 | 322 | 363 | 258 | 192 | 39 | 0 | 0 | 1385 |
| Shreveport | 0 | 0 | 0 | 47 | 297 | 477 | 552 | 426 | 304 | 81 | 0 | 0 | 2184 |
| MAINE | | | | | | | | | | | | | |
| Caribou | 78 | 115 | 336 | 682 | 1044 | 1535 | 1690 | 1470 | 1308 | 858 | 468 | 183 | 9767 |
| Portland | 12 | 53 | 195 | 508 | 807 | 1215 | 1339 | 1182 | 1042 | 675 | 372 | 111 | 7511 |
| MARYLAND | | | | | | | | | | | | | |
| Baltimore | 0 | 0 | 48 | 264 | 585 | 905 | 936 | 820 | 679 | 327 | 90 | 0 | 4654 |
| Frederick | 0 | 0 | 66 | 307 | 624 | 955 | 995 | 876 | 741 | 384 | 127 | 12 | 5087 |
| MASSACHUSETTS | | | | | | | | | | | | | |
| Blue Hill Obs. | 0 | 22 | 108 | 381 | 690 | 1085 | 1178 | 1053 | 936 | 579 | 267 | 69 | 6368 |
| Boston | 0 | 9 | 60 | 316 | 603 | 983 | 1088 | 972 | 846 | 513 | 208 | 36 | 5634 |
| Nantucket | 12 | 22 | 93 | 332 | 573 | 896 | 992 | 941 | 896 | 621 | 384 | 129 | 5891 |
| Pittsfield | 25 | 59 | 219 | 524 | 831 | 1231 | 1339 | 1196 | 1063 | 660 | 326 | 105 | 7578 |
| Worcester | 6 | 34 | 147 | 450 | 774 | 1172 | 1271 | 1123 | 998 | 612 | 304 | 78 | 6969 |
| MICHIGAN | | | | | | | | | | | | | |
| Alpena | 68 | 105 | 273 | 580 | 912 | 1268 | 1404 | 1299 | 1218 | 777 | 446 | 156 | 8506 |
| Detroit (city) | 0 | 0 | 87 | 360 | 738 | 1088 | 1181 | 1058 | 936 | 522 | 220 | 42 | 6232 |
| Escanaba | 59 | 87 | 243 | 539 | 924 | 1293 | 1445 | 1296 | 1203 | 777 | 456 | 159 | 8481 |
| Flint | 16 | 40 | 159 | 465 | 843 | 1212 | 1330 | 1198 | 1066 | 639 | 319 | 90 | 7377 |
| Grand Rapids | 9 | 28 | 135 | 434 | 804 | 1147 | 1259 | 1134 | 1011 | 579 | 279 | 75 | 6894 |
| Lansing | 6 | 22 | 138 | 431 | 813 | 1163 | 1262 | 1142 | 1011 | 579 | 273 | 69 | 6909 |
| Marquette | 59 | 81 | 240 | 527 | 936 | 1268 | 1411 | 1268 | 1187 | 771 | 468 | 177 | 8393 |
| Muskegon | 12 | 28 | 120 | 400 | 762 | 1088 | 1209 | 1100 | 995 | 594 | 310 | 78 | 6696 |
| Sault Ste. Marie | 96 | 105 | 279 | 580 | 951 | 1367 | 1525 | 1380 | 1277 | 810 | 477 | 201 | 9048 |
| MINNESOTA | | | | | | | | | | | | | |
| Duluth | 71 | 109 | 330 | 632 | 1131 | 1581 | 1745 | 1518 | 1355 | 840 | 490 | 198 | 10000 |
| International Falls | 71 | 112 | 363 | 701 | 1236 | 1724 | 1919 | 1621 | 1414 | 828 | 443 | 174 | 10606 |
| Minneapolis | 22 | 31 | 189 | 505 | 1014 | 1454 | 1631 | 1380 | 1166 | 621 | 288 | 81 | 8382 |
| Rochester | 25 | 34 | 186 | 474 | 1005 | 1438 | 1593 | 1366 | 1150 | 630 | 301 | 93 | 8295 |
| Saint Cloud | 28 | 47 | 225 | 549 | 1065 | 1500 | 1702 | 1445 | 1221 | 666 | 326 | 105 | 8879 |
| MISSISSIPPI | | | | | | | | | | | | | |
| Jackson | 0 | 0 | 0 | 65 | 315 | 502 | 546 | 414 | 310 | 87 | 0 | 0 | 2239 |
| Meridian | 0 | 0 | 0 | 81 | 339 | 518 | 543 | 417 | 310 | 81 | 0 | 0 | 2289 |
| Vicksburg | 0 | 0 | 0 | 53 | 279 | 462 | 512 | 384 | 282 | 69 | 0 | 0 | 2041 |
| MISSOURI | | | | | | | | | | | | | |
| Columbia | 0 | 0 | 54 | 251 | 651 | 967 | 1076 | 874 | 716 | 324 | 121 | 12 | 5046 |
| Kansas | 0 | 0 | 39 | 220 | 612 | 905 | 1032 | 818 | 682 | 294 | 109 | 0 | 4711 |

# Appendix - Heating Degree Day Estimates (cont)

**Figure 7 - Heating Degree Day (Montana thru Oregon)**

| States and Stations | JULY | AUG. | SEPT | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUNE | ANNUAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| St. Joseph | 0 | 6 | 60 | 285 | 708 | 1039 | 1172 | 949 | 769 | 348 | 133 | 15 | 5484 |
| St. Louis | 0 | 0 | 60 | 251 | 627 | 936 | 1026 | 848 | 704 | 312 | 121 | 15 | 4900 |
| Springfield | 0 | 0 | 45 | 223 | 600 | 877 | 973 | 781 | 660 | 291 | 105 | 6 | 4561 |
| MONTANA | | | | | | | | | | | | | |
| Billings | 6 | 15 | 186 | 487 | 897 | 1135 | 1296 | 1100 | 970 | 570 | 285 | 102 | 7049 |
| Glasgow | 31 | 47 | 270 | 608 | 1104 | 1466 | 1711 | 1439 | 1187 | 648 | 335 | 150 | 8996 |
| Great Falls | 28 | 53 | 258 | 543 | 921 | 1169 | 1349 | 1154 | 1063 | 642 | 384 | 186 | 7750 |
| Havre | 28 | 53 | 306 | 595 | 1065 | 1367 | 1584 | 1364 | 1181 | 657 | 338 | 162 | 8700 |
| Helena | 31 | 59 | 294 | 601 | 1002 | 1265 | 1438 | 1170 | 1042 | 651 | 381 | 195 | 8129 |
| Kalispell | 50 | 99 | 321 | 654 | 1020 | 1240 | 1401 | 1134 | 1029 | 639 | 397 | 207 | 8191 |
| Miles City | 6 | 6 | 174 | 502 | 972 | 1296 | 1504 | 1252 | 1057 | 579 | 276 | 99 | 7723 |
| Missoula | 34 | 74 | 303 | 651 | 1035 | 1287 | 1420 | 1120 | 970 | 621 | 391 | 219 | 8125 |
| NEBRASKA | | | | | | | | | | | | | |
| Grand Island | 0 | 6 | 108 | 381 | 834 | 1172 | 1314 | 1089 | 908 | 462 | 211 | 45 | 6530 |
| Lincoln | 0 | 6 | 75 | 301 | 726 | 1066 | 1237 | 1016 | 834 | 402 | 171 | 30 | 5864 |
| Norfolk | 9 | 0 | 111 | 397 | 873 | 1234 | 1414 | 1179 | 983 | 498 | 233 | 48 | 6979 |
| North Platte | 0 | 6 | 123 | 440 | 885 | 1166 | 1271 | 1039 | 930 | 519 | 248 | 57 | 6684 |
| Omaha | 0 | 12 | 105 | 357 | 828 | 1175 | 1355 | 1126 | 939 | 465 | 208 | 42 | 6612 |
| Scottsbluff | 0 | 0 | 138 | 459 | 876 | 1128 | 1231 | 1008 | 921 | 552 | 285 | 75 | 6673 |
| Valentine | 9 | 12 | 165 | 493 | 942 | 1237 | 1395 | 1176 | 1045 | 579 | 288 | 84 | 7425 |
| NEVADA | | | | | | | | | | | | | |
| Elko | 9 | 34 | 225 | 561 | 924 | 1197 | 1314 | 1036 | 911 | 621 | 409 | 192 | 7433 |
| Ely | 28 | 43 | 234 | 592 | 939 | 1184 | 1308 | 1075 | 977 | 672 | 456 | 225 | 7733 |
| Las Vegas | 0 | 0 | 0 | 78 | 387 | 617 | 688 | 487 | 335 | 111 | 6 | 0 | 2709 |
| Reno | 43 | 87 | 204 | 490 | 801 | 1026 | 1073 | 823 | 729 | 510 | 357 | 189 | 6332 |
| Winnemucca | 0 | 34 | 210 | 536 | 876 | 1091 | 1172 | 916 | 837 | 573 | 363 | 153 | 6761 |
| NEW HAMPSHIRE | | | | | | | | | | | | | |
| Concord | 6 | 50 | 177 | 505 | 822 | 1240 | 1358 | 1184 | 1032 | 636 | 298 | 75 | 7383 |
| Mt. Wash. Obs. | 493 | 536 | 720 | 1057 | 1341 | 1742 | 1820 | 1663 | 1652 | 1260 | 930 | 603 | 13817 |
| NEW JERSEY | | | | | | | | | | | | | |
| Atlantic City | 0 | 0 | 39 | 251 | 549 | 880 | 936 | 848 | 741 | 420 | 133 | 15 | 4812 |
| Newark | 0 | 0 | 30 | 248 | 573 | 921 | 983 | 876 | 729 | 381 | 118 | 0 | 4589 |
| Trenton | 0 | 0 | 57 | 264 | 576 | 924 | 989 | 885 | 753 | 399 | 121 | 12 | 4980 |
| NEW MEXICO | | | | | | | | | | | | | |
| Albuquerque | 0 | 0 | 12 | 229 | 642 | 868 | 930 | 703 | 595 | 288 | 81 | 0 | 4348 |
| Clayton | 0 | 6 | 66 | 310 | 699 | 899 | 986 | 812 | 747 | 429 | 183 | 21 | 5158 |
| Raton | 9 | 28 | 126 | 431 | 825 | 1048 | 1116 | 904 | 834 | 543 | 301 | 63 | 6228 |
| Roswell | 0 | 0 | 18 | 202 | 573 | 806 | 840 | 641 | 481 | 201 | 31 | 0 | 3793 |
| Silver City | 0 | 0 | 6 | 183 | 525 | 729 | 791 | 605 | 518 | 261 | 87 | 0 | 3705 |
| NEW YORK | | | | | | | | | | | | | |
| Albany | 0 | 19 | 138 | 440 | 777 | 1194 | 1311 | 1156 | 992 | 564 | 239 | 45 | 6875 |
| Binghamton (AP) | 22 | 65 | 201 | 471 | 810 | 1184 | 1277 | 1154 | 1045 | 645 | 313 | 99 | 7286 |
| Binghamton (PO) | 0 | 28 | 141 | 406 | 732 | 1107 | 1190 | 1081 | 949 | 543 | 229 | 45 | 6451 |
| Buffalo | 19 | 37 | 141 | 440 | 777 | 1156 | 1256 | 1145 | 1039 | 645 | 329 | 78 | 7062 |
| Central Park | 0 | 0 | 30 | 233 | 540 | 902 | 986 | 885 | 760 | 408 | 118 | 9 | 4871 |
| JFK International | 0 | 0 | 36 | 248 | 564 | 933 | 1029 | 935 | 815 | 480 | 167 | 12 | 5219 |
| La Guardia | 0 | 0 | 27 | 223 | 528 | 887 | 973 | 879 | 750 | 414 | 124 | 6 | 4811 |
| Rochester | 9 | 31 | 126 | 415 | 747 | 1125 | 1234 | 1123 | 1014 | 597 | 279 | 48 | 6748 |
| Schenectady | 0 | 22 | 123 | 422 | 756 | 1159 | 1283 | 1131 | 970 | 543 | 211 | 30 | 6650 |
| Syracuse | 6 | 28 | 132 | 415 | 744 | 1153 | 1271 | 1140 | 1004 | 570 | 248 | 45 | 6756 |
| NORTH CAROLINA | | | | | | | | | | | | | |
| Asheville | 0 | 0 | 48 | 245 | 555 | 775 | 784 | 683 | 592 | 273 | 87 | 0 | 4042 |
| Cape Hatteras | 0 | 0 | 0 | 78 | 273 | 521 | 580 | 518 | 440 | 177 | 25 | 0 | 2612 |
| Charlotte | 0 | 0 | 6 | 124 | 438 | 691 | 691 | 582 | 481 | 156 | 22 | 0 | 3191 |
| Greensboro | 0 | 0 | 33 | 192 | 513 | 778 | 784 | 672 | 552 | 234 | 47 | 0 | 3805 |
| Raleigh | 0 | 0 | 21 | 164 | 450 | 716 | 725 | 616 | 487 | 180 | 34 | 0 | 3393 |
| Wilmington | 0 | 0 | 0 | 74 | 291 | 521 | 546 | 462 | 357 | 96 | 0 | 0 | 2347 |
| Winston Salem | 0 | 0 | 21 | 171 | 483 | 747 | 753 | 652 | 524 | 207 | 37 | 0 | 3595 |
| NORTH DAKOTA | | | | | | | | | | | | | |
| Bismarck | 34 | 28 | 222 | 577 | 1083 | 1463 | 1708 | 1442 | 1203 | 645 | 329 | 117 | 8851 |
| Devils Lake | 40 | 53 | 273 | 642 | 1191 | 1634 | 1872 | 1579 | 1345 | 753 | 381 | 138 | 9901 |
| Fargo | 28 | 37 | 219 | 574 | 1107 | 1569 | 1789 | 1520 | 1262 | 690 | 332 | 99 | 9226 |
| Williston | 31 | 43 | 261 | 601 | 1122 | 1513 | 1758 | 1473 | 1262 | 681 | 357 | 141 | 9243 |
| OHIO | | | | | | | | | | | | | |
| Akron | 0 | 9 | 96 | 381 | 726 | 1070 | 1138 | 1016 | 871 | 489 | 202 | 39 | 6037 |
| Cincinnati | 0 | 0 | 54 | 248 | 612 | 921 | 970 | 837 | 701 | 336 | 118 | 9 | 4806 |
| Cleveland | 9 | 25 | 105 | 384 | 738 | 1088 | 1159 | 1047 | 918 | 552 | 260 | 66 | 6351 |
| Columbus | 0 | 6 | 84 | 347 | 714 | 1039 | 1088 | 949 | 809 | 426 | 171 | 27 | 5660 |
| Dayton | 0 | 6 | 78 | 310 | 696 | 1045 | 1097 | 955 | 809 | 429 | 167 | 30 | 5622 |
| Mansfield | 9 | 22 | 114 | 397 | 768 | 1110 | 1169 | 1042 | 924 | 543 | 245 | 60 | 6403 |
| Sandusky | 0 | 6 | 66 | 313 | 684 | 1032 | 1107 | 991 | 868 | 495 | 198 | 36 | 5796 |
| Toledo | 0 | 16 | 117 | 406 | 792 | 1138 | 1200 | 1056 | 924 | 543 | 242 | 60 | 6494 |
| Youngstown | 0 | 19 | 120 | 412 | 771 | 1104 | 1169 | 1047 | 921 | 540 | 248 | 60 | 6417 |
| OKLAHOMA | | | | | | | | | | | | | |
| Okla. City | 0 | 0 | 15 | 164 | 498 | 766 | 868 | 664 | 527 | 189 | 34 | 0 | 3725 |
| Tulsa | 0 | 0 | 18 | 158 | 522 | 787 | 893 | 683 | 539 | 213 | 47 | 0 | 3860 |
| OREGON | | | | | | | | | | | | | |
| Astoria | 146 | 130 | 210 | 375 | 561 | 679 | 753 | 622 | 636 | 480 | 363 | 231 | 5186 |
| Burns | 12 | 37 | 210 | 515 | 867 | 1113 | 1246 | 988 | 856 | 570 | 366 | 177 | 6957 |
| Eugene | 34 | 34 | 129 | 366 | 585 | 719 | 803 | 627 | 589 | 426 | 279 | 135 | 4726 |
| Meacham | 84 | 124 | 288 | 580 | 918 | 1091 | 1209 | 1005 | 983 | 726 | 527 | 339 | 7874 |
| Medford | 0 | 0 | 78 | 372 | 678 | 871 | 918 | 697 | 642 | 432 | 242 | 78 | 5008 |
| Pendleton | 0 | 0 | 111 | 350 | 711 | 884 | 1017 | 773 | 617 | 396 | 205 | 63 | 5127 |
| Portland | 25 | 28 | 114 | 335 | 597 | 735 | 825 | 644 | 586 | 396 | 245 | 105 | 4635 |

# Appendix - Heating Degree Day Estimates (cont)

## Figure 8 - Heating Degree Day (Pennsylvania thru Wyoming)

| States and Stations | JULY | AUG | SEPT | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUNE | ANNUAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Roseburg | 22 | 16 | 105 | 329 | 567 | 713 | 766 | 608 | 570 | 405 | 267 | 123 | 4491 |
| Salem | 37 | 31 | 111 | 338 | 594 | 729 | 822 | 647 | 611 | 417 | 273 | 144 | 4754 |
| Sexton Summit | 81 | 81 | 171 | 443 | 666 | 874 | 958 | 809 | 818 | 609 | 465 | 279 | 6254 |
| PENNSYLVANIA | | | | | | | | | | | | | |
| Allentown | 0 | 0 | 90 | 353 | 693 | 1045 | 1116 | 1002 | 849 | 471 | 167 | 24 | 5810 |
| Erie | 0 | 25 | 102 | 391 | 714 | 1063 | 1169 | 1081 | 973 | 585 | 288 | 60 | 6451 |
| Harrisburg | 0 | 0 | 63 | 298 | 648 | 992 | 1045 | 907 | 766 | 396 | 124 | 12 | 5251 |
| Philadelphia | 0 | 0 | 60 | 291 | 621 | 964 | 1014 | 890 | 744 | 390 | 115 | 12 | 5101 |
| Pittsburgh | 0 | 9 | 105 | 375 | 726 | 1063 | 1119 | 1002 | 874 | 480 | 195 | 39 | 5987 |
| Reading | 0 | 0 | 54 | 257 | 597 | 939 | 1001 | 885 | 735 | 372 | 105 | 0 | 4945 |
| Scranton | 0 | 19 | 132 | 434 | 762 | 1104 | 1156 | 1028 | 893 | 498 | 195 | 33 | 6254 |
| Williamsport | 0 | 9 | 111 | 375 | 717 | 1073 | 1122 | 1002 | 856 | 468 | 177 | 24 | 5934 |
| RHODE ISLAND | | | | | | | | | | | | | |
| Block Is | 0 | 16 | 78 | 307 | 594 | 902 | 1020 | 955 | 877 | 612 | 344 | 99 | 5804 |
| Providence | 0 | 16 | 96 | 372 | 660 | 1023 | 1110 | 988 | 868 | 534 | 236 | 51 | 5954 |
| SOUTH CAROLINA | | | | | | | | | | | | | |
| Charleston | 0 | 0 | 0 | 59 | 282 | 471 | 487 | 389 | 291 | 54 | 0 | 0 | 2033 |
| Columbia | 0 | 0 | 0 | 84 | 345 | 577 | 570 | 470 | 357 | 81 | 0 | 0 | 2484 |
| Florence | 0 | 0 | 0 | 78 | 315 | 552 | 552 | 459 | 347 | 84 | 0 | 0 | 2387 |
| Greenville | 0 | 0 | 0 | 112 | 387 | 636 | 648 | 535 | 434 | 120 | 12 | 0 | 2884 |
| Spartanburg | 0 | 0 | 15 | 130 | 417 | 667 | 663 | 560 | 453 | 144 | 25 | 0 | 3074 |
| SOUTH DAKOTA | | | | | | | | | | | | | |
| Huron | 9 | 12 | 165 | 508 | 1014 | 1432 | 1628 | 1355 | 1125 | 600 | 288 | 87 | 8223 |
| Rapid City | 22 | 12 | 165 | 481 | 897 | 1172 | 1333 | 1145 | 1051 | 615 | 326 | 126 | 7345 |
| Sioux Falls | 19 | 25 | 168 | 462 | 972 | 1361 | 1544 | 1285 | 1082 | 573 | 270 | 78 | 7839 |
| TENNESSEE | | | | | | | | | | | | | |
| Bristol | 0 | 0 | 51 | 236 | 573 | 828 | 828 | 700 | 598 | 261 | 68 | 0 | 4143 |
| Chattanooga | 0 | 0 | 18 | 143 | 468 | 698 | 722 | 577 | 453 | 150 | 25 | 0 | 3254 |
| Knoxville | 0 | 0 | 30 | 171 | 489 | 725 | 732 | 613 | 493 | 198 | 43 | 0 | 3494 |
| Memphis | 0 | 0 | 18 | 130 | 447 | 698 | 729 | 585 | 456 | 147 | 22 | 0 | 3232 |
| Nashville | 0 | 0 | 30 | 158 | 495 | 732 | 778 | 644 | 512 | 189 | 40 | 0 | 3578 |
| Oak Ridge (CO) | 0 | 0 | 39 | 192 | 531 | 772 | 778 | 669 | 552 | 228 | 56 | 0 | 3817 |
| TEXAS | | | | | | | | | | | | | |
| Abilene | 0 | 0 | 0 | 99 | 366 | 586 | 642 | 470 | 347 | 114 | 0 | 0 | 2624 |
| Amarillo | 0 | 0 | 18 | 205 | 570 | 797 | 877 | 664 | 546 | 252 | 56 | 0 | 3985 |
| Austin | 0 | 0 | 0 | 31 | 225 | 388 | 468 | 325 | 223 | 51 | 0 | 0 | 1711 |
| Brownsville | 0 | 0 | 0 | 0 | 66 | 149 | 205 | 106 | 74 | 0 | 0 | 0 | 600 |
| Corpus Christi | 0 | 0 | 0 | 0 | 120 | 220 | 291 | 174 | 109 | 0 | 0 | 0 | 914 |
| Dallas | 0 | 0 | 0 | 62 | 321 | 524 | 601 | 440 | 319 | 90 | 6 | 0 | 2363 |
| El Paso | 0 | 0 | 0 | 84 | 414 | 648 | 685 | 445 | 319 | 105 | 0 | 0 | 2700 |
| Fort Worth | 0 | 0 | 0 | 65 | 324 | 536 | 614 | 448 | 319 | 99 | 0 | 0 | 2405 |
| Galveston | 0 | 0 | 0 | 0 | 138 | 270 | 350 | 258 | 189 | 30 | 0 | 0 | 1235 |
| Houston | 0 | 0 | 0 | 6 | 183 | 307 | 384 | 288 | 192 | 36 | 0 | 0 | 1396 |
| Laredo | 0 | 0 | 0 | 0 | 105 | 217 | 267 | 134 | 74 | 0 | 0 | 0 | 797 |
| Lubbock | 0 | 0 | 18 | 174 | 513 | 744 | 800 | 613 | 484 | 201 | 31 | 0 | 3578 |
| Midland | 0 | 0 | 0 | 87 | 381 | 592 | 651 | 468 | 322 | 90 | 0 | 0 | 2591 |
| Port Arthur | 0 | 0 | 0 | 22 | 207 | 329 | 384 | 274 | 192 | 39 | 0 | 0 | 1447 |
| San Angelo | 0 | 0 | 0 | 68 | 318 | 536 | 567 | 412 | 288 | 66 | 0 | 0 | 2255 |
| San Antonio | 0 | 0 | 0 | 31 | 207 | 363 | 428 | 286 | 195 | 39 | 0 | 0 | 1549 |
| Victoria | 0 | 0 | 0 | 6 | 150 | 270 | 344 | 230 | 152 | 21 | 0 | 0 | 1173 |
| Waco | 0 | 0 | 0 | 43 | 270 | 456 | 536 | 389 | 270 | 66 | 0 | 0 | 2030 |
| Wichita Falls | 0 | 0 | 0 | 99 | 381 | 632 | 698 | 518 | 378 | 120 | 6 | 0 | 2832 |
| UTAH | | | | | | | | | | | | | |
| Milford | 0 | 0 | 99 | 443 | 867 | 1141 | 1252 | 988 | 822 | 519 | 279 | 87 | 6497 |
| Salt Lake City | 0 | 0 | 81 | 419 | 849 | 1082 | 1172 | 910 | 763 | 459 | 233 | 84 | 6052 |
| Wendover | 0 | 0 | 48 | 372 | 822 | 1091 | 1178 | 902 | 729 | 408 | 177 | 51 | 5778 |
| VERMONT | | | | | | | | | | | | | |
| Burlington | 28 | 65 | 207 | 539 | 891 | 1349 | 1513 | 1333 | 1187 | 714 | 353 | 90 | 8269 |
| VIRGINIA | | | | | | | | | | | | | |
| Cape Henry | 0 | 0 | 0 | 112 | 360 | 645 | 694 | 633 | 536 | 246 | 53 | 0 | 3279 |
| Lynchburg | 0 | 0 | 51 | 223 | 540 | 822 | 849 | 731 | 605 | 267 | 78 | 0 | 4166 |
| Norfolk | 0 | 0 | 0 | 136 | 408 | 698 | 738 | 655 | 533 | 216 | 37 | 0 | 3421 |
| Richmond | 0 | 0 | 36 | 214 | 495 | 784 | 815 | 703 | 546 | 219 | 53 | 0 | 3865 |
| Roanoke | 0 | 0 | 51 | 229 | 549 | 825 | 834 | 722 | 614 | 261 | 65 | 0 | 4150 |
| Wash. Nat'l AP | 0 | 0 | 33 | 217 | 519 | 834 | 871 | 762 | 626 | 288 | 74 | 0 | 4224 |
| WASHINGTON | | | | | | | | | | | | | |
| Olympia | 68 | 71 | 198 | 422 | 636 | 753 | 834 | 675 | 645 | 450 | 307 | 177 | 5236 |
| Seattle | 50 | 47 | 129 | 329 | 543 | 657 | 738 | 599 | 577 | 396 | 242 | 117 | 4424 |
| Seattle Boeing | 34 | 40 | 147 | 384 | 624 | 763 | 831 | 655 | 608 | 411 | 242 | 99 | 4838 |
| Seattle Tacoma | 56 | 62 | 162 | 391 | 633 | 750 | 828 | 678 | 657 | 474 | 295 | 159 | 5145 |
| Spokane | 9 | 25 | 168 | 493 | 879 | 1082 | 1231 | 980 | 834 | 531 | 288 | 135 | 6655 |
| Stampede Pass | 273 | 291 | 393 | 701 | 1008 | 1178 | 1287 | 1075 | 1085 | 855 | 654 | 483 | 9283 |
| Tatoosh Is | 295 | 279 | 306 | 406 | 534 | 639 | 713 | 613 | 645 | 525 | 431 | 333 | 5719 |
| Walla Walla | 0 | 0 | 87 | 310 | 681 | 843 | 986 | 745 | 589 | 342 | 177 | 45 | 4805 |
| Yakima | 0 | 12 | 144 | 450 | 828 | 1039 | 1163 | 868 | 713 | 435 | 220 | 69 | 5941 |
| WEST VIRGINIA | | | | | | | | | | | | | |
| Charleston | 0 | 0 | 63 | 254 | 591 | 865 | 880 | 770 | 648 | 300 | 96 | 9 | 4476 |
| Elkins | 9 | 25 | 135 | 400 | 729 | 992 | 1008 | 896 | 791 | 444 | 198 | 48 | 5675 |
| Huntington | 0 | 0 | 63 | 257 | 585 | 856 | 880 | 764 | 636 | 294 | 99 | 12 | 4446 |
| Parkersburg | 0 | 0 | 60 | 264 | 606 | 905 | 942 | 826 | 691 | 339 | 115 | 6 | 4754 |
| WISCONSIN | | | | | | | | | | | | | |
| Green Bay | 28 | 50 | 174 | 484 | 924 | 1333 | 1494 | 1313 | 1141 | 654 | 335 | 99 | 8029 |
| LaCrosse | 12 | 19 | 153 | 437 | 924 | 1339 | 1504 | 1277 | 1070 | 540 | 245 | 69 | 7589 |
| Madison | 25 | 40 | 174 | 474 | 930 | 1330 | 1473 | 1274 | 1113 | 618 | 310 | 102 | 7863 |
| Milwaukee | 43 | 47 | 174 | 471 | 876 | 1252 | 1376 | 1193 | 1054 | 642 | 372 | 135 | 7635 |
| WYOMING | | | | | | | | | | | | | |
| Casper | 6 | 16 | 192 | 524 | 942 | 1169 | 1290 | 1084 | 1020 | 657 | 381 | 129 | 7410 |
| Cheyenne | 19 | 31 | 210 | 543 | 924 | 1101 | 1228 | 1056 | 1011 | 672 | 381 | 102 | 7278 |
| Lander | 6 | 19 | 204 | 555 | 1020 | 1299 | 1417 | 1145 | 1017 | 654 | 381 | 153 | 7870 |
| Sheridan | 25 | 31 | 219 | 539 | 948 | 1200 | 1355 | 1154 | 1054 | 642 | 366 | 150 | 7683 |

# Appendix - Load to Collector Ratios

**Figure 9 - Load to Collector Ratios**

| City | 25% | 50% | 75% |
|---|---|---|---|
| Albuquerque, NM | 181 | 64 | 31 |
| Apalachicola, FL | 324 | 129 | 65 |
| Astoria, OR | 127 | 45 | 19 |
| Atlanta, GA | 154 | 59 | 29 |
| Bismarck, ND | 78 | 29 | 14 |
| Blue Hill, MA | 82 | 31 | 15 |
| Boise, ID | 106 | 39 | 17 |
| Boston, MA | 86 | 33 | 16 |
| Brownsville, TX | 517 | 218 | 110 |
| Burlington, VT | 63 | 24 | 11 |
| Cape Hatteras, NC | 189 | 74 | 36 |
| Caribou, ME | 68 | 26 | 12 |
| Charleston, SC | 210 | 82 | 41 |
| Cleveland, OH | 71 | 26 | 12 |
| Columbia, MO | 102 | 38 | 18 |
| Columbus, OH | 77 | 29 | 13 |
| Corvallis, OR | 120 | 42 | 18 |
| Davis, CA | 198 | 72 | 33 |
| Dodge City, KA | 126 | 49 | 24 |
| East Lansing, MI | 76 | 28 | 13 |
| East Wareham, MA | 97 | 37 | 18 |
| El Centro, CA | 547 | 206 | 97 |
| El Paso, TX | 228 | 88 | 44 |
| Ely, NV | 119 | 47 | 23 |
| Flaming Gorge, UT | 111 | 43 | 21 |
| Forth Worth, TX | 186 | 73 | 37 |
| Fresno, CA | 195 | 70 | 32 |
| Glasgow, MT | 105 | 41 | 20 |
| Granby, CO | 119 | 47 | 23 |
| Grand Junction CO | 119 | 46 | 22 |
| Great Falls, MT | 93 | 35 | 16 |
| Greensboro, NC | 128 | 50 | 24 |
| Griffin, GA | 217 | 84 | 42 |
| Hatteras, NC | 204 | 79 | 39 |
| Indianapolis, IN | 86 | 32 | 15 |
| Inyokern, CA | 232 | 88 | 42 |
| Ithaca, NY | 68 | 24 | 11 |
| Lake Charles, LA (el. 39 ft) | 261 | 104 | 53 |
| (el. 60 ft) | 244 | 96 | 48 |
| Lander, WY | 108 | 42 | 21 |
| Laramie, WY | 106 | 42 | 21 |
| Las Vegas, NV | 218 | 84 | 42 |
| Lamont, IL | 79 | 30 | 14 |
| Lincoln, NE | 104 | 39 | 19 |
| Little Rock, AR | 126 | 48 | 24 |
| Los Alamos, NM | 107 | 41 | 21 |
| Los Angeles, CA | 416 | 157 | 75 |
| Madison, WI | 76 | 28 | 13 |
| Medford, OR | 107 | 38 | 16 |
| Midland, TX | 202 | 79 | 39 |
| Nashville, TN | 117 | 44 | 21 |
| Newport, RI | 97 | 37 | 18 |
| New York, NY | 88 | 34 | 16 |
| North Omaha, NE | 89 | 34 | 16 |
| Oak Ridge, TN | 111 | 42 | 20 |
| Oklahoma City, OK | 134 | 53 | 26 |
| Page, AR | 128 | 48 | 23 |
| Phoenix, AR | 300 | 118 | 59 |
| Prosser, WA | 117 | 41 | 18 |
| Pullman, WA | 100 | 36 | 16 |
| Put-In-Bay, OH | 68 | 24 | 11 |
| Raleigh, NC | 133 | 52 | 25 |
| Rapid City, SD | 97 | 37 | 18 |
| Reno, NV | 125 | 47 | 22 |
| Richland, WA | 100 | 35 | 15 |
| Riverside, CA | 391 | 152 | 74 |

# Appendix - Load to Collector Ratios (cont)

**Figure 10 - Load to Collector Ratios (cont)**

| City | 25% | 50% | 75% |
|---|---|---|---|
| Saint Cloud, NM | 71 | 27 | 13 |
| Salt Lake City, UT | 107 | 40 | 19 |
| San Antonio, TX | 262 | 103 | 52 |
| Santa Maria, CA | 353 | 142 | 67 |
| Sault Ste. Maria, MI | 74 | 27 | 12 |
| Sayville, NY | 98 | 38 | 18 |
| Seabrook, NJ | 97 | 37 | 18 |
| Seattle, WA | 94 | 33 | 13 |
| Schenectady, NY | 63 | 24 | 11 |
| Shreveport, VA | 179 | 70 | 35 |
| Silver Hill, MD | 111 | 43 | 21 |
| Spokane, WA | 90 | 31 | 14 |
| State College, PA | 78 | 29 | 14 |
| Sterling, VA | 111 | 43 | 21 |
| Stillwater, OK | 132 | 52 | 25 |
| Tallahassee, FL | 283 | 113 | 57 |
| Toronto, Canada | 72 | 27 | 13 |
| Tuscon, AR | 301 | 118 | 59 |
| Winnipeg, Canada | 63 | 23 | 11 |

# Solar Energy Tax Credits

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- For Solar Tax Credit and Rebates, see this website for the latest information at DSIRE, http://www.dsireusa.org/ *DSIRE is a comprehensive source of information on state, local, utility, and federal incentives that promote renewable energy and energy efficiency.
- For specific tax forms involving solar, see Tax Form 5695 at http://www.irs.gov/pub/irs- pdf/f5695.pdf
- The general link to IRS forms and publications can be found here, http://www.irs.gov/formspubs/
- For our friends in Canada, see the Retrofit Grant, by going here, http://oee.nrcan.gc.ca/publications/infosource/pub/ecoenergy-retrofithomes/retrofit-qualify-grant.pdf
- Additional information for our Canadian friends can be found here, http://oee.nrcan.gc.ca/residential/personal/retrofit-homes/retrofit-qualify-grant.cfm
- For those in Latin America, Europe, Asia and Africa, please see the following website, http://www.solarthermalworld.org/