

Solar Heating Basics

The SolarWall® system heats ventilation air, fresh air and make-up air. It heats fresh air directly to achieve as high an efficiency as possible and to improve indoor air quality. The SolarWall systems are unglazed, and are all designed to heat or preheat outside air as it enters a building.

Early Solar Heating Systems

Solar liquid collectors have been used for pool, water and space heating as an alternative energy source to fossil fuels. Heating air with solar energy is more popular in colder countries requiring space heating. Many of the early solar buildings were experimental projects emphasizing the engineering needs to harness the sun's energy. Unfortunately, many of these left much to be desired regarding architectural design. Now, much more attention is being given to the aesthetic aspects of solar system design. There are many options for both existing and new buildings. Conserval Engineering was one of the first companies in the 1970's to become actively involved in air solar heating and is now considered a world leader in building integrated solar heating systems.

Solar Radiation

For a workable solar energy system, you should understand how the sun's energy reaches the earth and how this energy varies according to the time of day. Solar collectors must catch the sun's energy through an imaginary "window" in the sky above your building.

The optimum climatic conditions for solar heating are based on bright sunshine on the coldest days of the year. A solar collector is then able to gather plenty of energy when it's needed most.

What is surprising is the amount of energy available even on cloudy days, which also tend to be not as cold. Clouds act as a blanket over the earth preventing some of it's energy from radiating away. Solar radiation reaches solar panels in three ways: as direct, diffuse, and reflected radiation. The three types of radiation are illustrated in fig 1.

Direct radiation consists of parallel rays coming straight from the sun. This type of radiation casts shadows on clear days.

Diffuse radiation is scattered, nonparallel energy rays. This type of radiation makes the sky blue on clear days and grey on hazy days.

Reflected radiation is solar energy received by collectors from adjacent surfaces of the building or ground. It de-

pends a lot on the shape, colour, and texture of the surrounding surfaces.

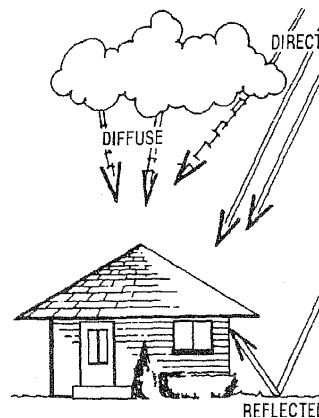


Figure 1. Three types of solar radiation: direct, diffuse & reflected

A nearly constant amount of solar radiation strikes the exterior of the earth's atmosphere 1,350 W/m² (429 Btu/h.ft²) However, a large amount of this energy is lost in the earth's atmosphere by absorption and reflection as it travels towards the earth's surface. The purity of the atmosphere, vapor, dust, and smoke content all have an effect on radiation, as does the angle of the sun. The relative amount of radiation received on earth is diminished when the sun is lower in the sky.

Clouds and particles in the atmosphere not only reflect and absorb solar energy, but they also scatter it in many directions. Thus, part of the solar radiation may be diffused. Diffuse radiation, as opposed to direct radiation, is greater on hazy days than clear ones. Diffuse radiation can account for 50 percent of the total annual radiation for a wall facing south.

Reflected radiation from adjacent surfaces amounts to about 20 percent of the direct and diffuse solar radiation. However, with a bright snow-covered surface in front of a solar collector, the reflected radiation can increase to over 50 percent. Reflected radiation from adjacent surfaces, can be a very important factor in collector sizing and placement.

Typical Solar Radiation for South Walls		
Radiation	Amount Received Each Day	
	Btu/ft ²	MJ/m ²
Direct	485	5.5
Diffuse	245	2.8
Reflected	150	1.7
Total	880	10

Solar Window

Imagine the sky as a transparent dome as shown in figure 2. The centre of the dome would be the SolarWall collector on a building. The path of sun can be drawn on the dome to outline a "solar window". This imaginary window would outline the area through which a maximum amount of solar energy could reach the collectors throughout the days of the year.

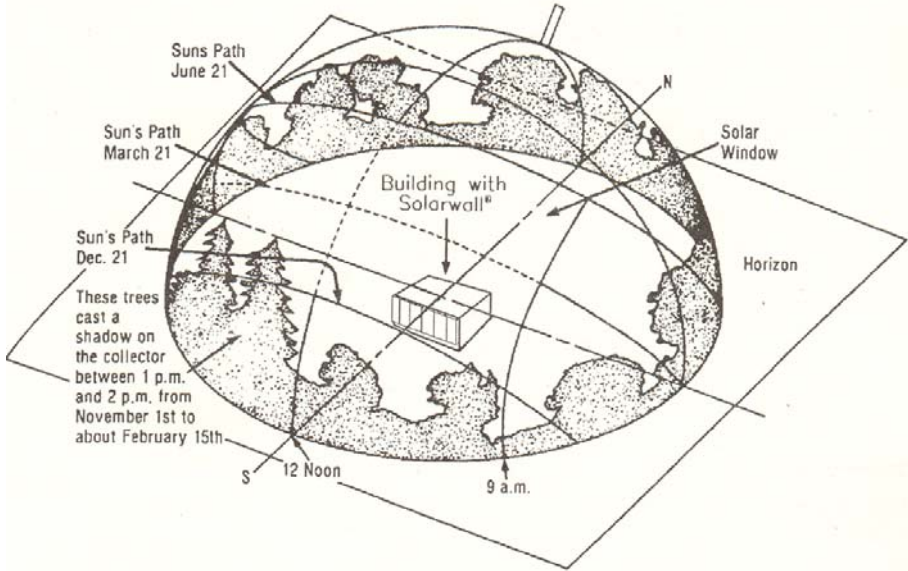


Figure 2. Solar Window

across the sky. The sides of the window would be drawn by the sun's position at four hours before and after solar noon: These positions might be found at 8 a.m. and 4 p.m. depending on the particular time zone.

Most of the useful solar energy for a solar collector must come through the window. The window will show you which objects such as trees or other buildings might interfere with energy collection. Such objects will cast a shadow on the collector during certain hours of the day, at certain times of the year. With the sun lower in the sky during the winter, when the greatest amount of solar energy is needed, shade becomes an important consideration in locating solar collectors.

The solar window changes with geographical area. The top and bottom of the window are dependent on latitude.

Figure 3 is a side view of a solar window for a latitude of 40°N. The diagram illustrates that solar energy can reach the collector during all days of the year

Collector Angle

Solar designers have traditionally recommended that collectors used for space heating applications be sloped at the degree of latitude, plus 10° to 15°. By having the collectors at this slope, the incident radiation is maxi-mized during the months in which there is a space heating requirement, however, there are other factors to consider. Unless the collectors can be supported on a sloped roof of this angle, a collector support rack must be built.

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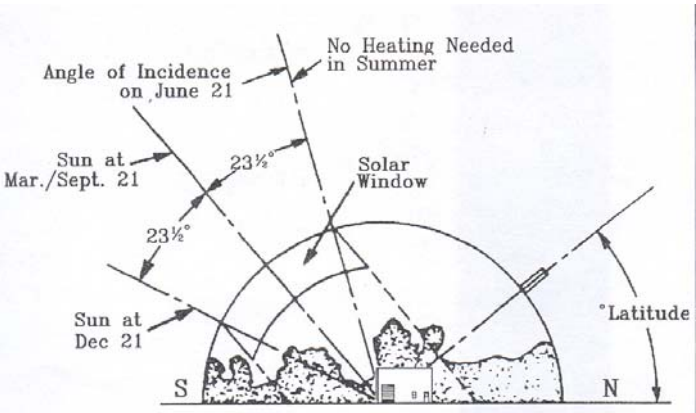
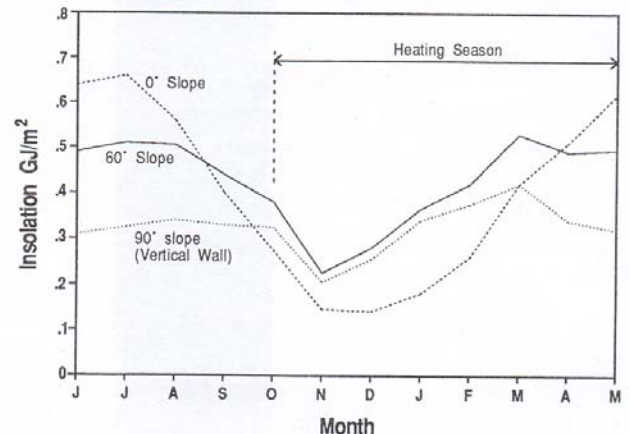


Figure 3. Solar Window for latitude of 40° N.

The top of the window would be drawn by the sun's path at the start of summer (June 21ST) when the sun travels its highest path across the sky. The bottom of the window would be drawn by the sun's path at the start of winter (December 21ST) when the sun travels its lowest path



Note: 30 Year Average, No Ground Reflectance

Figure 4. Solar Radiation comparison for collector slopes

Figure 4 graphs the incident radiation on a horizontal, vertical and a 60° sloped surface in Ottawa and illustrates that a vertical collector performs close to that of a sloped collector without any ground reflectance. When ground reflectance is included, a vertical wall will produce from 15% to 30% more heat than a collector at a 60 degree angle. For heating of buildings in northern latitudes, a vertical wall is therefore the preferred surface for mounting solar collectors.

There are other advantages to vertically mounted collectors versus sloped collectors.

- Incident radiation during the summer months is greatly reduced on a vertical surface, thus reducing heat gain during these no-load periods.
- The structural costs for wall-mounted systems are low.
- Duct losses for wall-mounted fans are non-existent.
- Snow build-up is not a problem
- Vertical panels rarely add wind loads to the building.
- Installation costs are lower

If the south wall is not suitable, consider either or both east and west walls. If a large volume of air is to be heated, all three walls can be utilized. Remember, only the solar contribution is affected by collector orientation, the wall insulation benefit remains the same at R55 (RSI-1.0).

Solar Heating Efficiency

The efficiency of a solar collector is highest when the temperature of the air entering the solar panel equals ambient temperature. This occurs with the SolarWall heater since outside air always enters the system.

In space heating designs, building return air enters a solar panel to be heated above room temperature. On cold, overcast days, there may be insufficient energy to achieve this, whereas, with the SolarWall any heat gain, whether it be a rise of two degrees or twenty degrees, is useful energy.

Performance Example

Using the solar efficiency curve in figure 5, the solar performance of heating fresh air can be compared to conventional solar heating systems. Assume:

Plant air temperature: 20°C Outside temperature: -10°C
Solar radiation: 1000 W/m².

Recirculating plant air through solar panels: X-axis intercept $(20 - (-10)) / 1000 = 0.03$ therefore, efficiency is 30% from graph

Drawing ventilation (outside) air through solar panels: X-axis intercept $(-10 - (-10)) / 1000 = 0$ therefore, efficiency is

60% from graph

Performance of the SolarWall system can be double that of other solar heating designs

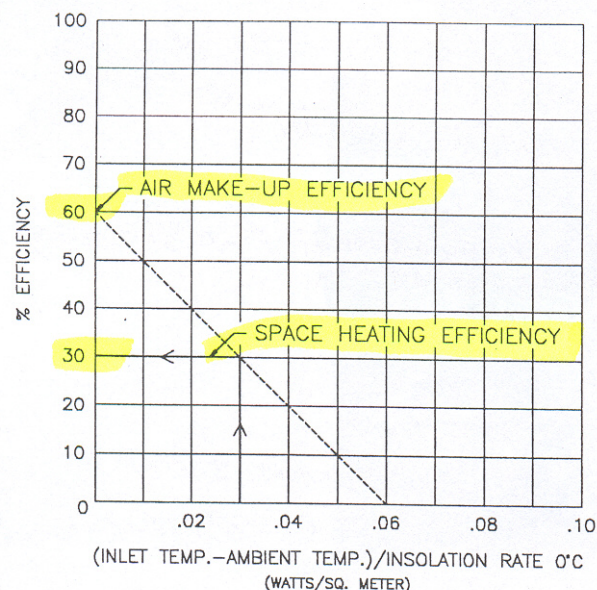


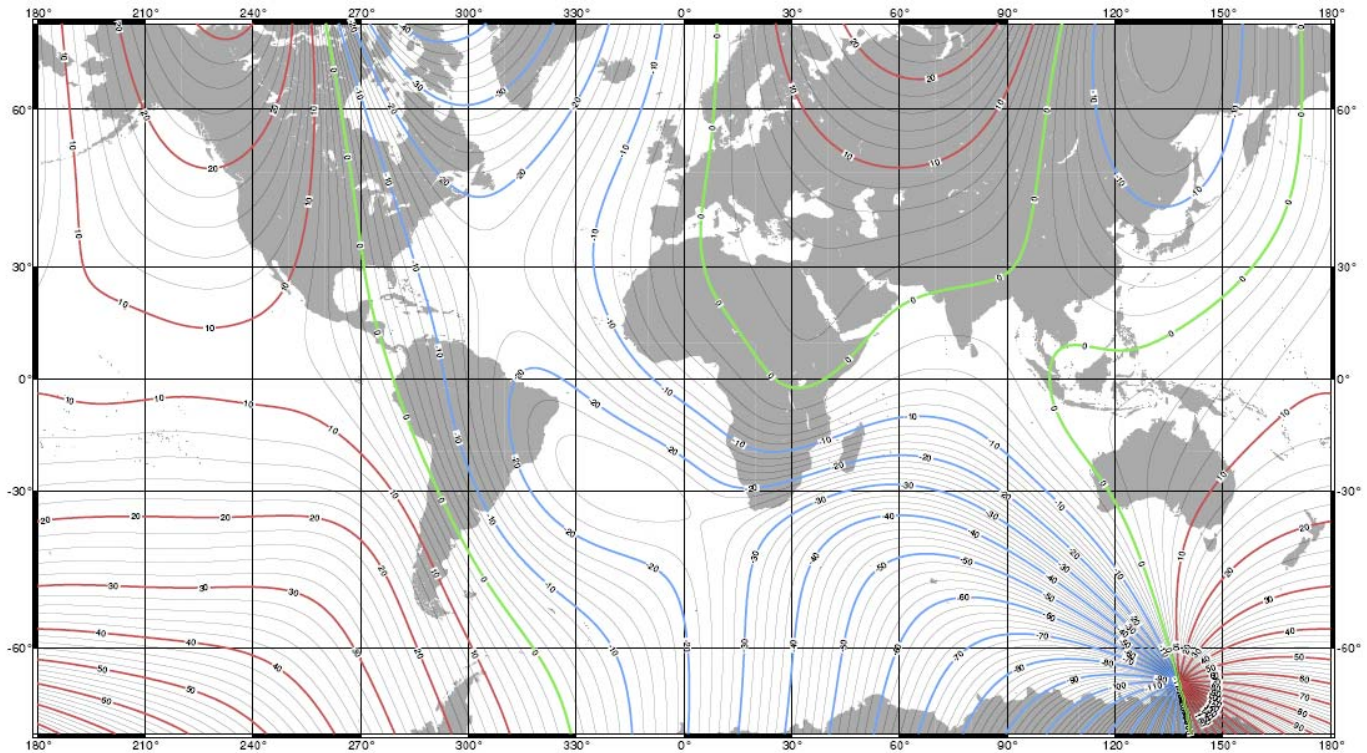
Figure 5. Typical solar efficiency curve for heating fresh air versus heating room air

Magnetic Variation

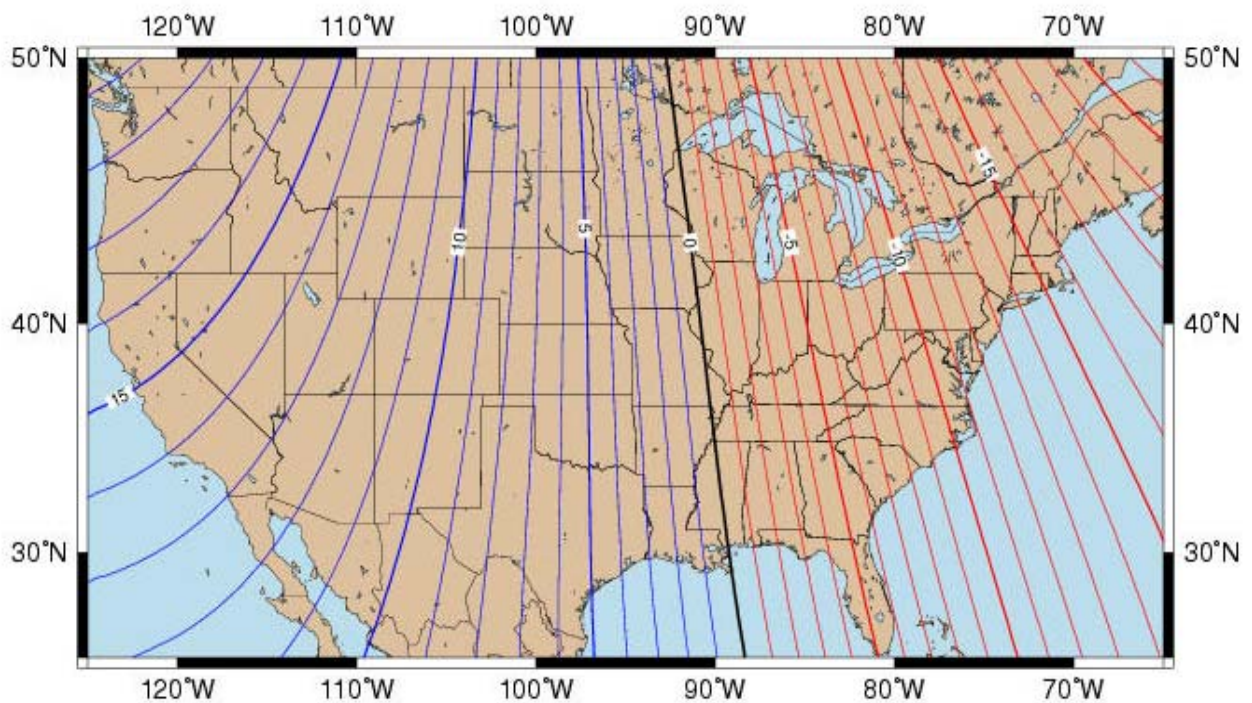
The isogonic maps found on the following page show magnetic compass variations for the world and for the United States. Because of the earth's magnetic field, it is generally necessary to adjust a compass reading by a few degrees east or west to obtain true north. The amount of variation depends upon your location. In the United States, a line of zero variation passes at the western tip of Lake Superior. If you are located on the west side of that line, your compass needle will point to east of true north. This is called an "easterly variation". Similarly, if you are located to the east of the line, your compass needle will point to the west of true north. This is called a "westerly variation".

For example, the isogonic map shows a declination of 11° west for Buffalo and Toronto. This means that the compass is pointing 11° to the west of true north, or true north is 11° to the east of compass indicated north (true south is 11° west of compass south).

The maps can be used for selecting the wall(s) on which to mount the SolarWall panels. The magnetic declination changes each year and updated maps are available on line at <http://www.ngdc.noaa.gov>



Magnetic Declination for the U.S. 2004



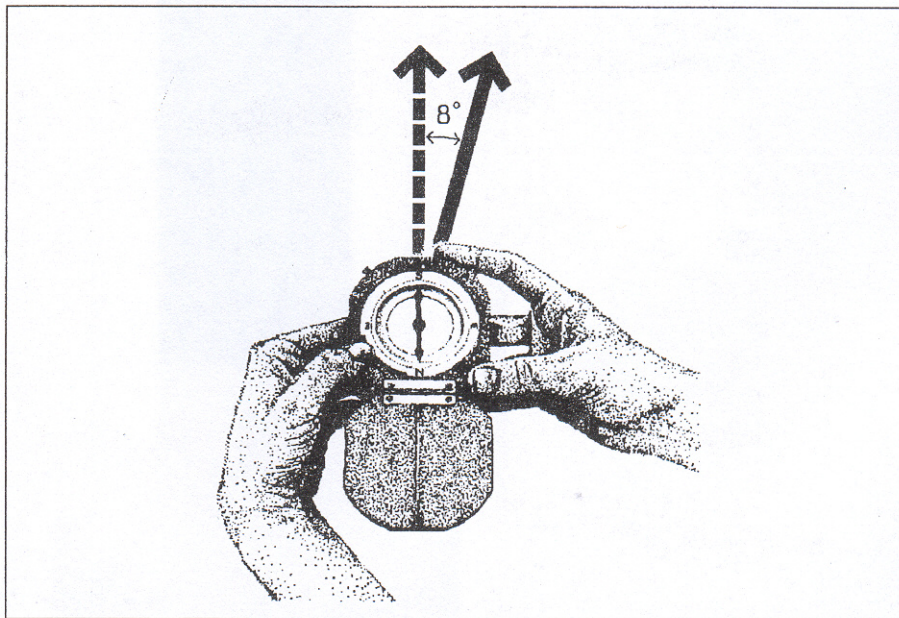
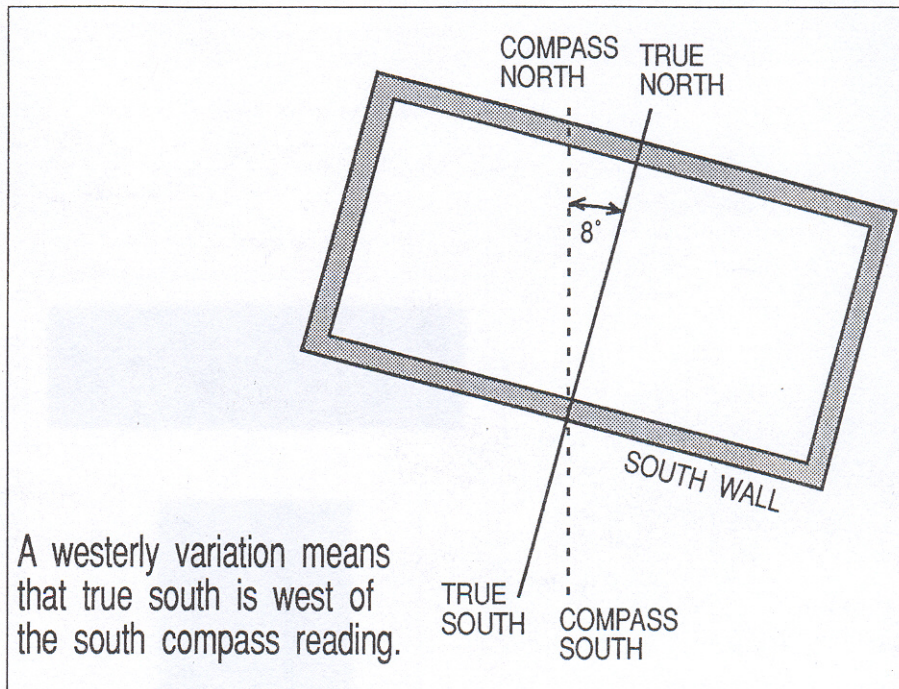


Figure 6. Example of how to read a compass and correct for magnetic declination or variation