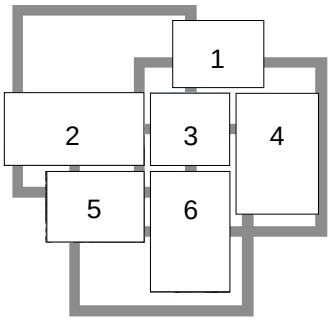
Montana Solar House

A Guide to Adding Solar to Your Home

Paid for by NorthWestern Energy Universal System Benefits Funds
Prepared by the National Center for Appropriate Technology



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This guide was written and published with the support of NorthWestern Energy. It includes information published by the North Carolina Solar Center and the U.S. Department of Energy.

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Introduction

Solar electric power generated using "photovoltaics," or "PVs," is used in hundreds of applications throughout Montana. Applications vary from road-side signs to high mountain communications towers and from hand-held calculators to stockwater pumping systems. This guide focuses on the use of solar electricity in homes and small businesses. It provides basic information about system components and what to expect when shopping for a solar electric system.

Using solar energy produces immediate environmental benefits. Electricity is often produced by burning fossil fuels such as oil, coal, and natural gas. The combustion of these fuels releases pollutants into the atmosphere, including carbon dioxide (CO_2), sulfur dioxide (SO_2), and nitrogen oxide (NO_x), which create acid rain and smog. Carbon dioxide from burning fossil fuels is a significant component of greenhouse gas emissions. These emissions could significantly alter the world's environment and lead to the global warming predicted by most atmospheric scientists.

Solar energy uses fewer non-renewable resources than conventional energy sources. Using energy from sunlight can replace the use of stored energy in natural resources such as petroleum, natural gas, and coal. Energy industry researchers estimate that the amount of land required for photovoltaic (PV) cells to produce enough electricity to meet all U.S. power needs is less than 60,000 square kilometers, or roughly 20 percent of the area of Arizona.

Solar energy is a renewable resource. Some scientists and industry experts estimate that renewable energy sources, such as solar, can supply up to half of the world's energy demand in the next 50 years, even as energy needs continue to grow.

A two-kilowatt photovoltaic systems in Montana will:

- Avoid emissions of .68 lbs of NO_x and 3,643 lbs. of CO_2
- Reduce carbon dioxide emissions equal to driving 4,553 miles in an average passenger car
- Reduce carbon dioxide emissions equal to the carbon dioxide absorbed by 1 acre of trees in one year

Montana's abundant solar resource can be used to save energy in residential and commercial construction, and farming, ranching, recreation and other industries. The amount of sunshine available at a given location is called the "solar resource" or insolation. The amount of electrical energy produced by a PV array depends on the insolation at a given location, on the collector bank orientation, on tilt angle, and on module efficiency.

Montana can be divided for insolation roughly the way it is divided geographically—Eastern Montana and Western Montana. Eastern Montana receives an annual average of 5 hours of full sun; Western Montana receives an annual average of 4.2 hours.

Homeowners who draw electricity from PV systems can get the most out of their self-generated electricity by using efficient appliances with the "Energy Star" logo.

Insolation in Montana cities compares favorably with insolation in other locations that are encouraging solar energy technologies, such as Sacramento, CA; Eugene, OR; and Madison, WI. Billings has a better solar resource than either Eugene or Madison, while Helena is about the same as those two cities.

Are you thinking about buying a photovoltaic system or solar water heater for your home or business? If so, this booklet will provide basic information you need to know.

Montanans are showing increased interest in solar energy systems for their homes and businesses. Most of that interest is in photovoltaic—or solar electric—systems. These photovoltaic (PV) systems are reliable, pollution free, and use a renewable source of energy—the sun. They are also becoming more affordable. To make PV systems more affordable to Montana consumers, the Montana Department of Revenue offers financial incentives through solar tax credits.

This booklet is designed to guide you through the process of buying a solar electric system or a solar water heating system. A word of caution: This is not a technical guide for designing or installing your system—for that information, we recommend that you consult an experienced system designer or system supplier ("PV installer") who will have detailed technical specifications and other necessary information. (You'll find a list of Montana businesses that sell and install systems in **Appendix A**.) A PV system can be a substantial investment, and as with any investment, careful planning will help ensure that you make the right decisions.

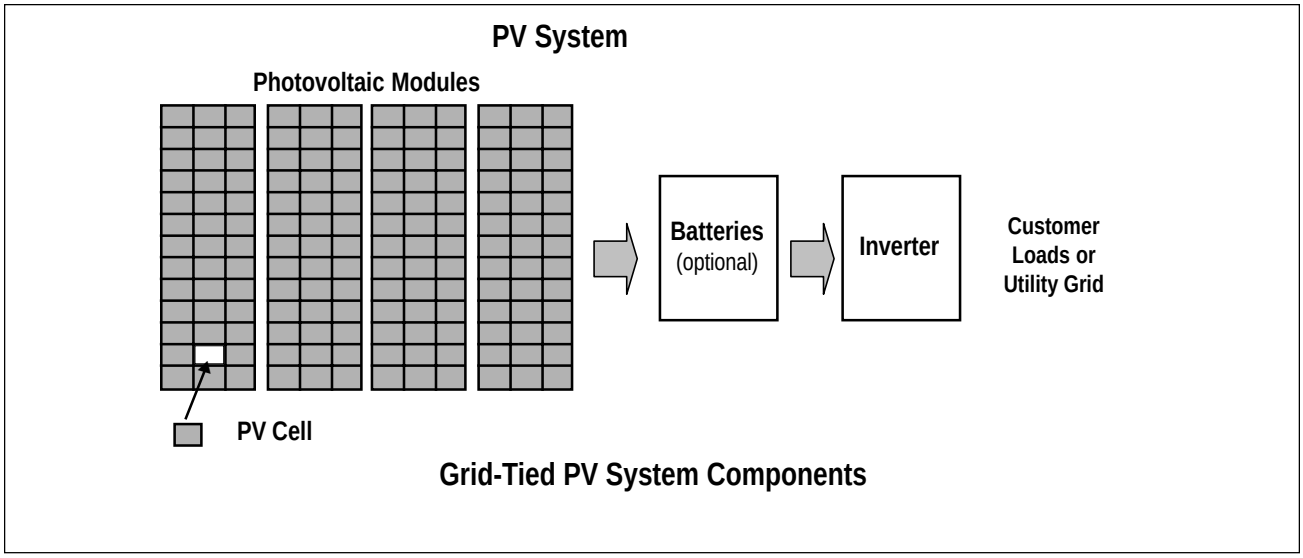
Make Your Home Energy Efficient

First things first. Before installing a PV system, consider how you are using electricity. Reducing electricity demand is the best and least expensive way to save energy and money.

Consider these energy-efficiency strategies:

- Replace any refrigerator, freezer or air conditioner that is more than 10 years old with an ENERGY STAR® model;
- Switch electric space heating, water heaters and clothes dryers to natural gas or propane;
- Replace incandescent lights with compact fluorescent lamps.

Every kilowatt-hour you trim off your projected annual use in a PV-based system will reduce your initial setup cost by $10-$12. Being smart about the appliances and lights you choose will allow you all the convenience of a typical 23 kWh per day Montana home while consuming less than 15 kWh per day. That can shave thousands of dollars off the initial system cost.



Grid-Tied PV System Components

What is a photovoltaic system?

PV technology converts sunlight directly into electricity. It works any time the sun is shining, but more electricity is produced when the light is more intense (a sunny day) and is directly over the PV modules. Unlike solar systems for heating water, PV technology does not use the sun's energy to generate heat. Instead, PV produces electricity directly from the electrons freed by the interaction of sunlight with semiconductor materials in the PV cells.

But you don't need to understand quantum physics to understand the appeal of photovoltaics: investing in PV allows you to produce your own electricity with no noise, no air pollution, and no moving parts while using a clean, renewable resource. A PV system will never run out of fuel, and it won't increase our oil imports from overseas. In fact, it won't even contribute to the trade deficit, because many PV system components are manufactured in the United States. Because of these unique characteristics, PV technology has been called the ultimate energy source for the 21st century.

The basic building block of PV technology is the solar "cell." PV cells are wired together to produce a PV "module," the smallest PV component sold commercially, and these modules range in power output from about 10 watts to 300 watts. A typical PV system consists of one or more PV modules connected to an inverter that changes the system's direct-current (DC) electricity to alternating current (AC).

AC power is compatible with the utility grid and able to power common household devices such as lights, appliances, computers, and televisions. You may also include batteries in the system to provide backup power.

What are the different PV system configurations?

PV systems are typically divided between on-grid (or "utility tied") and off-grid (or "independent"). Off-grid PV systems for homes or other buildings must have battery storage for times when PV power is not available. For on-grid systems, batteries are optional.

One of the advantages of a grid-tied system is that you can use the utility to store power and forego the purchase of batteries. If you have a grid-tied system with batteries, you will be

able to run your system and supply loads even when the utility power goes down. Grid-tied systems without batteries will not supply power when the grid is down. Non-battery grid-tied systems require a different inverter than battery grid-tied systems, so the choice of inverter must be made up front

What is the status of the technology?

Before you decide to buy a PV system, you should understand the status of the technology:

- First, it produces power intermittently because it works only when the sun is shining.This is not a problem for PV systems connected to the utility grid, because additional electricity you need is automatically delivered to you by your utility. And, systems with batteries can provide energy even when there is no sun.
- Second, PV-generated electricity is more expensive than conventional utility-supplied electricity. Improved manufacturing has reduced the cost to less than one percent of what it was in the 1970s, but the cost (amortized over the life of the system) is still about 25 cents per kilowatt-hour. This is roughly four times the retail price that most Montana residents now pay for electricity from their utilities. The Montana solar tax credits help make PV more affordable, but it can't match today's price for electricity from your utility.
- Third, unlike electricity purchased month by month from a utility, PV power comes with a high initial investment and no monthly charge thereafter. This means that buying a PV system is like paying years of electric bills up front. You'll probably appreciate the reduction in your monthly electric bills, but the initial expense is significant. By financing your PV system, you can spread the cost over many years.
- Finally, solar panels produce power during peak use periods when the value of electricity is the highest. Since air conditioning drives this peak use, solar naturally matches the peak load. If utilities switch time-of-day metering in the future, as many experts recommend, this added value of solar, which is not metered now, will be recognized and included. In California, one current Pacific, Gas & Electric rate is 8¢/kwhr non-peak, 32¢ summer afternoons, making most of the solar power worth four times regular power.

What tax incentives are available and how can I use them?

Montana offers property tax reductions for non-fossil energy property.

In addition to other energy-related tax benefits, a portion of the appraised value of certain non-fossil energy property is eligible to be exempt from property taxation for up to 10 years following the date of installation. Eligible property includes alternative energy generating systems, such as those that use sun, wind and hydropower. Up to $20,000 of the value of a system installed in a single-family residential building can be exempt from property taxation, or up to $100,000 of a system installed in a multi-family residential dwelling or a non-residential structure.

Application for property tax exempt status must be submitted to the county assessor's office by March 1 to be considered for exemption that tax year. For installations made after

March 1, an application for property exempt status must be submitted before the following March 1 to be considered for exemption starting the following tax year. Applications may be submitted for installations made within 10 years prior to the given tax year, but will be eligible for property tax exemption only for the remainder of 10 years from the date of installation.

A state property tax exemption form is available at your county assessor's office.

NOTE: ***Senate Bill 506, passed by the 2001 Legislature, made substantial changes to the tax incentives offered for using renewable energy. The Department of Revenue (DoR) is writing the regulations to put these changes into effect.***

Net Metering

The 1997 Montana Legislature passed a law requiring utilities to provide net metering. By signing a metering agreement with your utility you will be able to sell your momentary surplus power (e.g., on a sunny afternoon) to the utility at the full retail rate. What this means is that your electric meter effectively spins backward when power is flowing from the building to the utility and spins forward when electricity is flowing from the utility into the building. At the end of the billing period, you are billed only for net consumption – that is, the amount of electricity consumed, less the amount of electricity produced. The utility behaves much the same as a battery crediting your energy "account" for later use. Other than the renewable energy system and appropriate meter, no special equipment is needed.

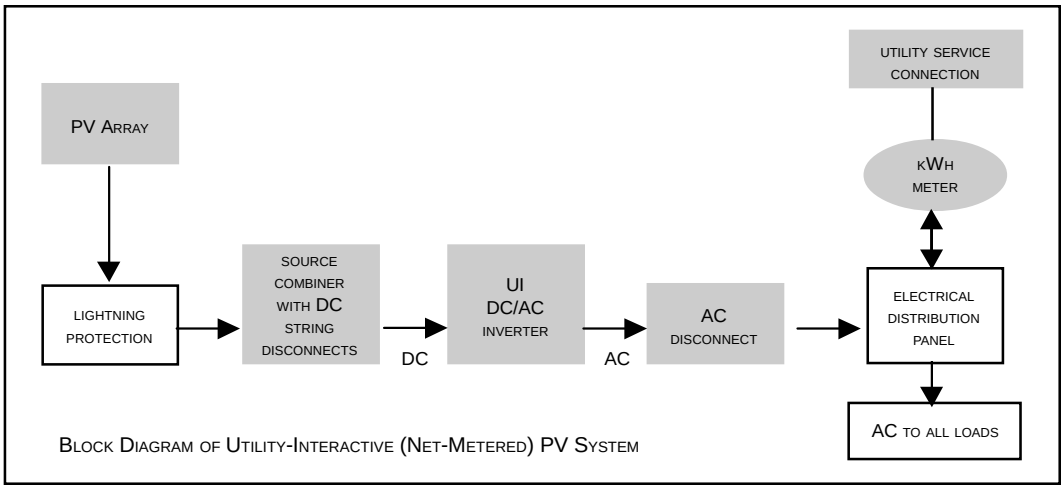
Even in the absence of net metering, consumers can use the electricity they produce to offset their electricity demand on an instantaneous basis. But if the consumer happens to produce any excess electricity (beyond what is needed to meet the customer's own needs at the moment), the utility purchases that excess electricity at the wholesale or 'avoided cost' price, which is much lower than the retail price. Net metering simplifies this arrangement by allowing the consumer to use any excess electricity to offset electricity used at other times during the billing period.

WHY IS NET METERING IMPORTANT?

There are three reasons net metering is important. First, as increasing numbers of primarily residential customers install renewable energy systems in their homes, there needs to be a simple, standardized protocol for connecting their systems into the electricity grid that ensures safety and power quality.

Second, many residential customers are not at home using electricity during the day when their systems are producing power, and net metering allows them to receive full value for the electricity they produce without installing expensive battery storage systems.

Third, net metering provides a simple, inexpensive, and easily-administered mechanism for encouraging the use of renewable energy systems, which provide important local, national, and global benefits.



Net metering provides a variety of benefits for both utilities and consumers. Utilities benefit by avoiding the administrative and accounting costs of metering and purchasing the small amounts of excess electricity produced by these small-scale renewable generating facilities. Consumers benefit by getting greater value for some of the electricity they generate, by being able to interconnect with the utility using their existing utility meter, and by being able to interconnect using widely accepted technical standards.

The only cost associated with net metering is indirect: the customer is buying less electricity from the utility, which means the utility is collecting less revenue from the customer. That's because any excess electricity that would have been sold to the utility at the wholesale or 'avoided cost' price is instead being used to offset electricity the customer would have purchased at the retail price. The revenue loss is roughly comparable to having the customer reducing electricity use by investing in energy efficiency measures, such as compact fluorescent lights and efficient appliances.

The bill savings for the customer (and corresponding revenue loss to the utility) will depend on a variety of factors, particularly the difference between the 'avoided cost' and retail prices. In general, however, the difference will be between $5 - $15 a month for a residential-scale PV system (2 kW), and between $25 - $70 a month for a farm-scale wind turbine (10 kW). Revenue losses associated with net metering are at least partially offset by the administrative and accounting savings, which are not included in the above figures.

METERS

The standard kilowatt-hour meter used by the vast majority of residential and small commercial customers accurately registers the flow of electricity in either direction. This means the "netting" process associated with net metering happens automatically—the meter spins forward (in the normal direction) when the consumer needs more electricity than is being produced, and spins backward when the consumer is producing more electricity than is needed in the house or building.

Safety

During the last decade there has been tremendous technological progress in the design of the equipment that integrates small-scale generators with the utility grid. Called "inverters" because they were originally designed only to 'invert' the DC electricity produced by solar arrays and wind turbines to the AC electricity used in our homes and businesses, these devices have evolved into extremely sophisticated power management systems.

Inverters now include all the necessary protective relays and circuit breakers needed to synchronize safely and reliably with the utility grid, and to prevent "islanding" by automatically shutting down when the utility grid suffers an outage. Moreover, this protective equipment operates automatically, without any human intervention needed.

Most new inverters comply with all nationally-recognized codes and standards, including the National Electrical Code (NEC), Underwriters Laboratories (UL), and the Institute of Electrical and Electronic Engineers (IEEE). These systems are now operating safely and reliably in every state in the nation.

By adopting net metering early, a utility establishes itself in a leadership role in providing customers the option of generating some of its own electricity. The 1997 Montana net metering legislation effectively applies only to the Montana Power Company and Montana Dakota Utilities. Electric cooperatives *are not* required to provide net metering. The electric cooperatives are free to adopt net metering requirements different than the state law.

The Montana Law

A "Net metering system" is a facility for the production of electric energy that: (a) uses as its fuel solar, wind, or hydropower; (b) has a generating capacity of not more than 50 kilowatts; (c) is located on the customer-generator's premises; (d) operates in parallel with the distribution services provider's distribution facilities; and (e) is intended primarily to offset part or all of the customer-generator's requirements for electricity.

The legislation also requires that a distribution services provider allow net metering systems to be interconnected using a standard kilowatt-hour meter capable of registering the flow of electricity in two directions. The distribution services provider shall charge the customer-generator a minimum monthly fee that is the same as other customers of the electric utility in the same rate class.

Net Metering Calculation

In calculating the net energy measurement the distribution services provider measures the net electricity produced or consumed during the billing period, in accordance with normal metering practices. At the end of the month, if the customer has generated more electricity than that used, the utility credits the net kilowatt-hours produced at the wholesale power rate. If the customer uses more electricity than they generate, they pay the difference. The billing period for net metering may be either monthly or annually.

Montana has an annual billing period. On January 1, April 1, July 1, or October 1 of each year, as designated by the customer-generator as the beginning date of a 12-month billing

period, any remaining unused kilowatt-hour credit accumulated during the previous 12 months must be granted to the electricity supplier, without any compensation to the customer-generator.

Net metering allows homeowners who are not home when their systems are producing electricity to still receive the full value of that electricity without having to install a battery storage system. The power grid acts as the customer's battery backup, which saves the customer the added expense of purchasing and maintaining a battery system.

NET METERING SYSTEM — RELIABILITY AND SAFETY

A net metering system used by a customer-generator must include, at the customer-generator's own expense, all equipment necessary to meet applicable safety, power quality, and interconnection requirements established by the National Electrical Code, National Electrical Safety Code, Institute of Electrical and Electronic Engineers, and Underwriters Laboratories.

Why should you buy a PV system?

People decide to buy PV systems for a variety of reasons. Some want to help preserve the earth's fossil-fuel resources and reduce air pollution.

Others believe that it makes more sense to spend their money on an energy-producing improvement to their property than to send their money to a utility. Some people like the security of reducing the amount of electricity they buy from their utility, because it makes them less vulnerable to future increases in the price of electricity. Others like to be early adopters of high technology and want to support the advancement of high technology. Finally, some people just don't like paying utility bills and appreciate the independence that a PV system provides.

Whatever the reason, solar energy is widely thought to be one of many energy sources of choice for the future, and Montanans have an opportunity to help make it their energy choice for today and tomorrow.

IS YOUR HOME OR BUSINESS A GOOD PLACE FOR A SOLAR SYSTEM?

A well-designed PV system needs clear and unobstructed access to the sun's rays for most or all of the day, throughout the year. You can make an initial assessment yourself, and if the location looks promising, your PV installer has the tools to trace the sun's path at your location and determine whether your home or business can make use of a PV solar system. It is important to note that even though the area where a system is mounted may be unshaded during one part of the day, it may be shaded during another.

If this is the case, then this shading may substantially reduce the amount of electricity that your system will produce. A well-designed PV system will be unshaded for the six hours around noon on March 21 and September 23.

The orientation of your PV system (the compass direction that your system faces) will affect performance. In Montana, the sun is always in the southern half of the sky and is higher

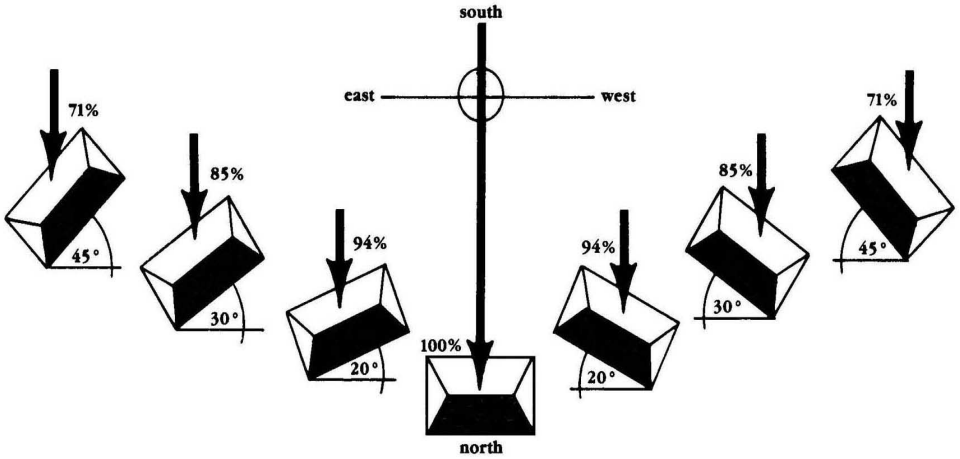


Fig. 1: The further a home is turned from south, the less its ability to collect solar energy in the winter.

in the summer and lower in the winter. Usually, the best location for a PV system is a south-facing roof, but roofs that face east or west may also be acceptable. Flat roofs also work well for solar systems because the PV modules can be mounted flat on the roof facing the sky or mounted on frames tilted toward the south at the optimal angle. For the most part, if your modules are oriented at slopes 45° or less and oriented within 30° of south, your system will provide at least 90 percent of the optimal energy output.

If a rooftop can't be used, your solar modules can also be placed on the ground, either on a fixed mount or a "tracking" mount that follows the sun to orient the PV modules for maximum performance. Other options (used most often in multifamily or commercial applications) include mounting structures that create covered parking or provide shade as window awnings.

Net-metering helps make grid-tied photovoltaic systems more economical.
This home in Bozeman gets some of its power from a 1-kilowatt PV system that is tied to the utility grid.

DO YOU HAVE ENOUGH AREA ON YOUR ROOF OR PROPERTY?

The amount of space needed by a PV system is based on the physical size of the system you purchase. Most residential systems require as little as 50 square feet (for a small "starter" system) up to as much as 1,000 square feet. Commercial systems are typically even larger.

If your location limits the physical size of your system, you may want to install a system that uses more-efficient PV modules. Greater efficiency means that the module uses less surface area to convert sunlight into a given amount of electric power. PV modules are available today in a range of types, and some offer higher efficiency than do others. System sizing is discussed later in this booklet and should also be discussed with your PV installer.

With a net-metered system, keep in mind that the solar electric system will only produce electricity when the sun shines and the utility's grid is energized.

By design, for the protection of utility linemen, whenever the utility experiences an outage, the inverter shuts down the solar electric system's electrical output. When the inverter senses that the utility is back on-line, it once again converts DC electricity from the solar electric array into AC electricity at the utility's voltage and frequency.

On a bright, sunny day, a one-kilowatt PV system will have an electrical output of about 1000 watts. A one-kilowatt solar electric system in Montana is expected to produce about 1590 kWh of electricity annually. This is equivalent to about 17 percent of the annual electrical consumption of an average household. To put the PV's electrical production another way, 1590 kWh is approximately the amount of electricity three 60-watt incandescent bulbs would consume if left "turned on" for a year.

Building Characteristic Requirements

One of the building's roofs should be south-facing and have an area of at least 300 square feet. While solar electric arrays do not require guaranteed access to sunlight from sunrise to sunset, they should be shaded as little as possible between 9 A.M. and 3 P.M., when nearly 85 percent of the sun's energy reaches the site. In any solar energy system design, shading should be avoided and solar access maximized; even partial shading on a solar electric array, such as trees or utility poles, will significantly reduce the system's electrical output.

Although the solar electric system should ideally face true south, a deviation of 45 degrees or less from true south will not substantially reduce a roof-mounted system's annual performance. Therefore, a roof oriented 45 degrees or less from true south may be considered for the solar electric system installation.

The preferred roof slope is 45 degrees (a 12/12 pitch), but roof slopes between 20 and 60 degrees (roughly 4/12 – 20/12 pitch) are acceptable.

Although most roofs can support the added weight of a solar electric system, you should check the condition of the rafters. The roof must be able to safely support the added dead load of the PV array and mounting rack and the temporary live load imposed by the installation crew. The PV array and mounting rack will add approximately 3 pounds per square foot of dead load to the roof.

Ideally the south-facing roof should be near the main electrical service entrance. To minimize wiring runs, the breaker panel containing the building's main disconnect switch and the household's electrical end-use breakers should be easily accessible and relatively close to the PV array. The breaker panel should have space available for installing a 120/240V breaker; this is the PV system's connection to the electrical grid.

What kind of roof do you have, and what is its condition?

Some roof types are simpler and cheaper to work with, but a PV system can be installed on any type. Typically, composition shingles are easiest to work with, and slate is the most difficult. In any case, an experienced solar installer will know how to work on all roof types and can use roofing techniques that eliminate any possibility of leaks. Ask your PV installer how the PV system affects your roof warranty. If your roof is older and needs to be replaced soon, you may want to replace it at the time the PV system is installed to avoid the cost of removing and reinstalling your PV system.

Panels often can be integrated into the roof itself, and some modules are actually designed as three-tab shingles or raised-seam metal roof sections. One benefit of these systems is their ability to offset the cost of roof materials.

A 1-kilowatt system provides some power needs for this on-grid home in Helena. Twenty-four such PV arrays and components have been installed by Montana Power Company as part of a project to demonstrate utility-tied renewable energy systems.

How big should my PV system be, and what features should it have?

As a starting point, you might consider how much of your present electricity needs you would like to meet with your PV system. For example, suppose that you would like to meet 50 percent of your electricity needs with your PV system. You could work with your PV installer to examine past electric bills and determine the size of the PV system needed to achieve that goal. You can contact your utility and request the total electricity usage, measured in kilowatt-hours, for your household or business over the last 12 months (or consult your electric bills if you save them).

Ask your PV installer how much your new PV system will produce on an annual basis (also measured in kilowatt-hours) and compare that number to your annual electricity demand to get an idea of how much you will save. In the next section, you'll find more information on estimating how much you will save. As you size your system, you should consider the economies of scale that can decrease the cost per kilowatt-hour as you increase the size and cost of the system.

For example, many inverters are sized for systems up to 5 kilowatts, and if your PV array is smaller (say 3 kilowatts), you may still end up buying the same inverter. Labor costs for a small system may be nearly as much as those for a large system. Therefore, it's worth remembering that your PV installer is likely to offer you a better price to install a 2-kilowatt system all at once, than to install a 1-kilowatt this year and another similar system next year—because multiple orders and multiple site visits are more expensive. One optional feature you might consider is a battery system to provide backup power in case of a utility power outage. Batteries add value to your system, but at an increased price.

How much will your PV system save you?

The value of your PV system's electricity will depend on how much you pay your utility for electricity. If your system is net metered (so that the utility pays the full retail price for your excess electricity), your calculation may be fairly easy because you and your utility will each pay the same price for each other's electricity.

Keep in mind that actual energy production from your PV system will vary by up to 20 percent from these figures, depending on your geographic location, the angle and orientation of your system, the quality of the components of your system, and the quality of the installation. Also keep in mind that you may not get full retail value for excess electricity produced by your system on an annual basis, even if your utility does offer net metering. Be sure to discuss these issues with your PV installer.

Consider asking for a written estimate of the average annual energy production from the PV system. However, you should realize that even if an estimate is accurate for an average year, actual electricity production will fluctuate from year to year due to natural variations in weather and climate. But determining its value is much trickier because your excess electricity will not be worth as much as the electricity you actually use. You may earn only 2 cents per kilowatt-hour—or less than half of the retail rate—for your excess power. PV systems produce most of their electricity during the middle of the day when residential electric loads tend to be small. If net metering is not offered by your utility, you may want to size your system to avoid generating electricity significantly beyond your actual needs.

How much does a PV system cost?

There is no single answer. The system price will depend on a number of factors, including whether the home is under construction or whether the PV is integrated into the roof or mounted on top of an existing roof. The price also varies depending on the PV system rating, manufacturer, retailer, and installer. The size of your system may be the most significant factor in any equation measuring your costs against your benefits. Small, single PV-panel

systems with built-in inverters that produce about 75 watts may cost around $900 installed, or $12 per watt.

These small systems will offset only a small fraction of your electricity bill. A 2-kilowatt system that will offset the needs of a very energy-efficient home may cost as much as $20,000 installed, or $10 per watt. At the high end, a 5-kilowatt system that will completely offset the energy needs of many conventional homes may cost $40,000 to $50,000 installed, or $8 to $10 per watt. These prices, of course, are just rough estimates, and your costs will depend on the way your system is configured, your equipment options, and other factors. Your local PV installers can provide you with estimates or bids.

Calculating Electricity Bill Savings for a Net-Metered Grid-Tied PV System

- Step 1: Multiply the kWh / kW-yr times the PV system rating (in kW) to get the yearly PV system production in kWh / yr.
- Step 2: Multiply the PV system kWh / yr times your retail rate in $ / kWh to get the annual bill savings. Example: A 2-kW system in Helena, MT, at an electricity rate of $0.07 / kWh, will save about $236 per year (1,691 kWh / kW- year x 2 kW x $0.07 / kWh = $236 / year).

Photovoltaic System Production (kWh/ kW-yr)

Photovoltaic system production estimates are for a 1-kW rooftop PV system facing due south at a 20° tilt. Example: A 2-kW rooftop PV system located in Helena, MT, will produce about 3,180 kWh per year (2 kW x 1,691 kWh / kW-yr)

How can you finance the cost of your PV system?

There is nothing magical about financing the cost of purchasing and installing your PV system. Although there are some special programs available for financing solar and other renewable-energy investments, most of the options will be familiar to you. The best way to finance PV systems for homes is through a mortgage loan. Mortgage financing options include your primary mortgage, a second mortgage such as a U.S. Department of Housing and Urban Development (HUD) Title 1 loan, or a home-equity loan that is secured by your property.

There are two advantages to mortgage financing. First, mortgage financing usually provides longer terms and lower interest rates than other loans such as conventional bank loans. Second, the interest paid on a mortgage loan is generally deductible on your federal taxes (subject to certain conditions). If you buy the PV system at the same time that you build, buy, or refinance the house on which the PV system will be installed, adding the cost of the PV system to your mortgage loan is likely to be relatively simple and may avoid additional loan application forms or fees.If mortgage financing is not available, look for other sources of financing, such as conventional bank loans. Remember to look for the best possible combination of low rate and long term.

This will allow you to amortize your PV system as inexpensively as possible. Because your PV system is a long-term investment, the terms and conditions of your PV financing are likely to be the most important factor in determining the effective price of your PV-generated power. PV systems purchased for business applications are probably best financed through a company's existing sources of funds for capital purchases—usually Small Business Administration loans or conventional bank loans.

Who sells and installs PV systems?

Montana is home to many reputable contractors with experience in installing PV systems. Here are several suggestions for finding a contractor near you:

- Check Montana Green Power's directory of solar and renewable energy dealers and installers, available on the World Wide Web at: www.montanagreenpower.com
- Contact regional solar equipment vendors to see if they have installers with whom they regularly work.
- Conduct a search on the Internet.

How do I choose among PV installers?

Compile a list of prospective PV installers. You might first consider those closest to you, because the contractor's travel costs might add to your system price. Next, contact these installers and find out what products and services they offer.

Ask whether the company has installed grid-connected PV systems or, if not, grid- independent PV systems.

Experience installing grid-connected systems is valuable because some elements of the installation—particularly interconnection with the local utility—are unique to these systems. Because grid-connected systems are relatively uncommon, most contractors with PV experience have worked only on systems such as those that power remote cabins far from the nearest utility line.

This means they have experience with all aspects of PV system installation except the connection with the utility grid. Although grid-connection work is different from "off-grid" work, a competent company with PV experience should not be eliminated just because it has not installed grid-connected PV systems in the past. In fact, experience with off-grid systems is valuable because grid-independent systems are more technically complicated than grid-tied systems. Here are other questions you should ask:

How many years of experience does the company have installing photovoltaic systems?

This issue speaks for itself: A company or contractor that has been in business a long time has demonstrated an ability to work with customers and to compete effectively with other firms.

Is the company properly licensed?

PV systems should be installed by an appropriately licensed contractor. This means that either the installer or a subcontractor has an electrical contractor's license. The State Electrical Board (406-841-2329) can tell you if a contracting firm has a valid license. Local building departments also may require that the installer have a general contractor's license. Consumers should call the city and county in which they live for additional information on licensing.

Does the company have any pending or active judgements or liens against it?

As with any project that requires a contractor, due diligence is recommended. The State Electrical Board (406-841-2329) can tell you about any judgments or complaints against a state-licensed electrician. Consumers should call the city and county in which they live for additional information on how to check up on contractors.

How do you choose among competing bids?

If you have decided to get more than one bid for the installation of your PV system (and it's generally a good idea to do so), you should take steps to ensure that all of the bids you receive are made on the same basis.

For example, comparing a bid for a system mounted on the ground against another bid for a rooftop system is like comparing apples to oranges. Similarly, different types of PV modules generate more electricity per square foot than others. Bids should clearly state the maximum generating capacity of the system (measured in watts or kilowatts). If possible, have the bids specify the system capacity in AC watts, or specify the output of the system at the inverter. You may want to obtain some estimate of the amount of energy that the system will produce on an annual basis (measured in kilowatt-hours).

Because the amount of energy depends on the amount of sunlight—which varies by location, season, and year to year—it is unrealistic to expect a specific figure. A range of ±20% is more realistic.

Bids also should include the total cost of getting the PV system up and running, including hardware, installation, connection to the grid, permitting, sales tax, and warranty. Your warranty is a very important factor for evaluating bids. Many manufacturer's warranties include repair or replacement of equipment but don't cover labor for equipment removal and reinstallation. Your PV installer should provide you with a written full-system warranty that makes the installer responsible for system diagnosis, repairs, equipment removal, shipping and equipment reinstallation. Consider the length of your full-system warranty when comparing competing bids. A minimum two year full-system warranty is recommended. Also ask yourself, "Will this company stand behind the full-system warranty for the entire warranty period?"

Is the lowest price the "best deal"?

It might not be. Often, you get what you pay for. Remember that a PV company is a

business just like any other, with overhead and operating expenses that must be covered. It's always possible that a low price could be a sign of inexperience. Companies that plan to stay in business must charge enough for their products and services to cover their costs, plus a fair profit margin. Therefore, price should not be your only consideration.

WHAT ABOUT PERMITS?

If you live in a community in which a homeowners association requires approval for a solar system, you or your PV installer may need to submit your plans. Gain approval from your homeowners association before you begin installing your PV system. Under Montana law, you have the right to install a solar system on your home. Most likely, you will need to obtain permits from your city or county building department.

You will probably need a building permit, an electrical permit, or both before installing a PV system. Typically, your PV installer will take care of this, rolling the price of the permits into the overall system price. However, in some cases, your PV installer may not know how much time or money will be involved in "pulling" a permit. If so, this task may be priced on a time-and-materials basis, particularly if additional drawings or calculations must be provided to the permitting agency. In any case, make sure the permitting costs and responsibilities are addressed at the start with your PV installer.

Code requirements for PV systems vary somewhat from one jurisdiction to the next, but most requirements are based on the National Electrical Code (NEC). The NEC has a special section, Article 690, that carefully spells out requirements for designing and installing safe, reliable, code-compliant PV systems. Because most local requirements are based on the NEC, your building inspector is likely to rely on Article 690 for guidance in determining whether your PV system has been properly designed and installed.

If you are among the first people in your community to install a grid-connected PV system, your local building department may not have approved one of these systems. If this is the case, you and your PV installer can speed the process by working closely and cooperatively with your local building officials to help educate them about the technology and its characteristics.

WHAT ABOUT INSURANCE?

If you interconnect your PV system to the utility grid, your electric utility will require you to enter into an interconnection agreement, described more fully in the next section.

Usually, these agreements set forth minimum insurance requirements that you must keep in force. If you are buying a PV system for your home, your standard homeowner's insurance policy is usually adequate to meet the utility's requirements.

Connecting your PV system to the utility grid will require you to enter into an interconnection agreement and a purchase and sale agreement. Montana Public Service Commission regulations and federal law require utilities to supply you with an interconnection agreement.

The interconnection agreement specifies the terms and conditions under which your system will be connected to the utility grid. These will include your obligation to obtain permits and insurance, maintain the system in good working order, and operate it safely.

The purchase and sale agreement specifies the metering arrangements, the payment for any excess generation, and any other related issues. The language in these contracts should be simple, straightforward, and easy to understand. If you are unclear about your obligations under these agreements, you should contact the utility or your electrical service installer for clarification.

National standards for utility interconnection of PV systems are quickly being adopted by many local utilities. The most important of these standards focuses on inverters. Traditionally, inverters simply converted the DC electricity generated by PV modules into the AC electricity used in our homes. More recently, inverters have evolved into remarkably sophisticated devices to manage and condition power.

Many new inverters contain all the protective relays, disconnects, and other components necessary to meet the most stringent national standards. Two of these standards are particularly relevant:

- Institute of Electrical and Electronic Engineers, P929: Recommended Practice for Utility Interface of. 13 Photovoltaic Systems. Institute of Electrical and Electronic Engineers, Inc., New York, NY (1988, with revision being finalized in 1999).
- Underwriters Laboratories, UL Subject 1741: Standard for Static Inverters and Charge Controllers for Use in Photovoltaic Power Systems. Underwriters Laboratories, Inc., Northbrook, IL (1999).

You don't need to fully understand these standards, but your PV installer and utility should. It is your obligation to ensure that your PV installer uses equipment that complies with the relevant standards, so be sure to discuss this issue.

How do I get a net-metering agreement?

Net metering allows eligible customers with PV systems to connect to the grid with their existing single meter. Almost all standard utility meters are able to measure the flow of energy in either direction. The meter spins forward when electricity is flowing from the utility into the building and spins backward when power is flowing from the building to the utility.

Net metering customers are billed monthly for the "net" energy consumed. If the customer's net consumption is negative in any month (i.e., the PV system produces more energy than the customer uses), the balance is credited to subsequent months.

Net metering allows customers to get more value from the energy they generate. Net metering simplifies both the metering process (by eliminating the need for a second meter) and the accounting process (by eliminating the need for monthly payments from your utility).

In 1999, the Montana Legislature adopted legislation (SB 409) requiring all investor-owned

utilities in the state to offer net metering to customers with solar, wind, and hydroelectric systems of 50 kilowatts or less. All classes of customers are eligible to receive net metering and there is no statewide limit.

Customers can apply the credit for electricity generated from their system to the following month. Montana has an annual billing period. On January 1, April 1, July 1, or October 1 of each year, as designated by the customer-generator as the beginning date of a 12-month billing period, any remaining unused kilowatt-hour credit accumulated during the previous 12 months must be granted to the electricity supplier, without any compensation to the customer-generator.

Under the federal Public Utility Regulatory Policies Act (PURPA), utilities must allow you to interconnect your PV system, and they must also buy any excess electricity you generate (beyond what you use in your home or business). If your utility does not offer net metering, it will probably require you to use two meters: one to measure the flow of electricity into the building, the other to measure the flow of electricity out of the building. If net metering is not available, the utility will only pay you a wholesale rate for your excess electricity.

In this case, you will have a strong incentive to use all the electricity you generate so that it offsets electricity you would otherwise have to purchase at the retail rate. This may be a factor in how you optimize your system size, because you may want to limit the excess electricity you generate. This "dual metering" arrangement is the norm for industrial customers who generate their own power.

What about utility and inspection sign-off?

After your new PV system is installed, it must be inspected and signed off by the local permitting agency (usually a building or electrical inspector) and most likely by the electric utility with which you entered into an interconnection agreement. Inspectors may possibly require your PV installer to make corrections, but don't be alarmed—this is fairly common in the construction business.

What about warranties?

Warranties are key to ensuring that your PV system will be repaired if something should malfunction during the warranty period. A warranty should cover all parts and labor, including the cost of removing any defective component, shipping it to the manufacturer, and reinstalling the component after it is repaired or replaced. Your PV installer's full-system warranty should supercede any other warranty limitations.

In other words, even if the manufacturer's own warranty on a particular component is less than two years, the PV installer should still provide you with a two-year warranty. Similarly, even if the manufacturer's warranty is a limited warranty that does not include the cost of removing, shipping, and reinstalling defective components, the PV installer should cover these costs. Note that the warranties on PV modules themselves will range from 5 to 25 years.

Be sure you know who is responsible for honoring the various warranties associated with your system—the installer, the dealer, or the manufacturer. The vendor should disclose the warranty responsibility of each party. Know the financial arrangements, such as contractor's bonds, that assure the warranty will be honored. Remember, a warranty does not guarantee that the company will remain in business. Get a clear understanding of whom you should contact if there is a problem. To avoid any later misunderstandings, be sure to read the warranty carefully and review the terms and conditions with your retailer.

WHAT ABOUT SYSTEM OPERATION AND MAINTENANCE?

Make sure that you have all the owner's manuals for your system components, and before your PV installer leaves once the system is installed, be sure that he or she walks you through the PV system and inverter manuals. You will save yourself (and your installer) headaches down the line if you are familiar with your system and where to look for information.

Unless you have batteries, there are normally not any periodic maintenance needs for a grid-tied system, but a basic understanding of the system will serve you well in the event that there are any problems.

Before accepting the completed installation, make sure you understand the controls and any maintenance requirements. This includes learning:

- Where not to touch
- How to read the current status of the system
- How much energy is being produced
- What is the charge in the batteries
- What maintenance is required for the batteries
- What to do in case of a utility power disruption
- How to disconnect the system

2 Solar Water Heating

Introduction

Solar water heating is a technology every homeowner can use to save on utility bills. Did you know that the average person uses between 15 and 20 gallons of hot water a day? At 6-7 cents per kilowatt hour for electricity, an average family of four spends between $300 and $400 a year to heat water. That figure probably will continue to rise each year as the cost for energy rises. You can cut your hot water costs by half with a properly sized solar water heater.

A solar water heater uses the sun's energy, rather than electricity or gas, to heat water, thus reducing your monthly utility bill. When installed properly, solar water heaters are more economical over the life of the system than heating water with electricity, but likely not as economical as heating water with natural gas or propane.

Conservation First

Before investing in any solar energy system, it is important to take steps to make the existing hot water system as efficient as possible. Simple conservation steps can reduce the amount of hot water required and make the conventional equipment operate more efficiently. Good first steps are:

1) install low-flow showerheads or flow restrictors in the showerheads and faucets;
2) insulate your current water heater and any hot water pipes that pass through unheated areas; and
3) if you don't have a dishwasher, or your dishwasher is equipped with its own automatic water heater, lower the thermostat on your household water heater to 120°F.

Most solar heating systems use the "greenhouse effect" to collect the sun's energy. Sunlight is transmitted through the collector glazing and absorbed by the materials behind the glazing. The thermal energy reradiated by these materials will not pass back out through the glass. The heat collected in a car with closed windows on a sunny day is an example of the greenhouse effect.

In addition to collectors, solar water heating systems also consist of storage tanks, piping and, usually electric pumps and controls.

While most commercially available solar water heaters use a second well-insulated storage tank, a few systems can use existing hot water tanks. Many systems use converted electric water heater tanks or plumb the solar storage tank in series with the conventional water heater. In this arrangement, the solar water heater preheats water before it enters the conventional water heater.

Solar water heating systems are seldom designed to provide 100 percent of a home's hot water demand. A system providing 50 percent to 60 percent of the demand may prove most cost effective in Montana.Savings from solar water heating systems depend on water usage, system size, system design and local climate. Perhaps the single greatest factor determining monetary savings is the cost of the fuel being displaced.

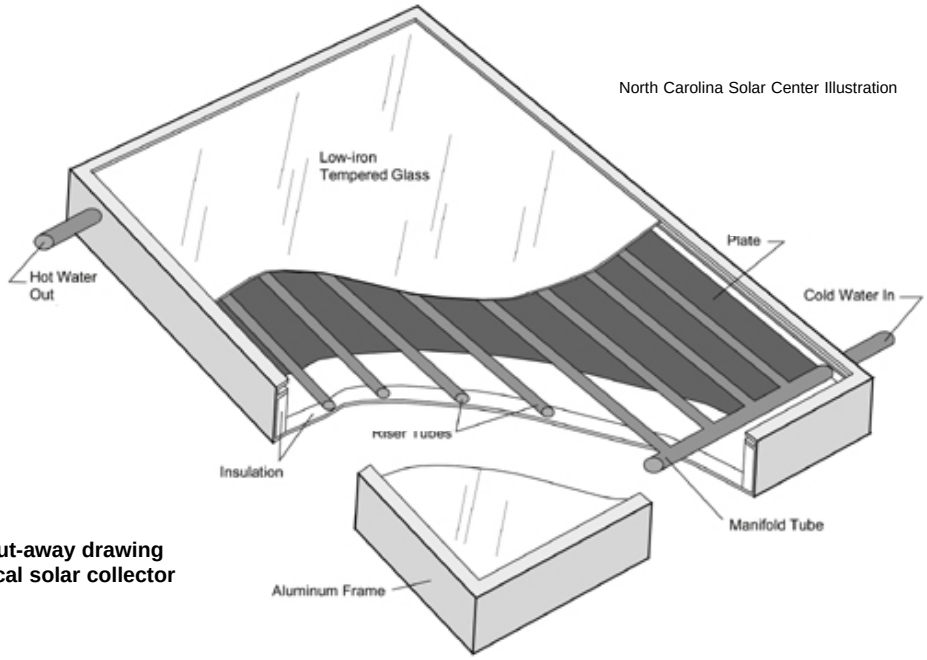


Fig. 2: Cut-away drawing of a typical solar collector

Solar collectors heat a fluid, either air or liquid. This fluid then is used to heat—directly or indirectly—the following.

- Water for household use
- Indoor spaces
- Water for swimming pools
- Water or air for commercial use
- Air to regenerate desiccant (drying) material in a desiccant cooling system.

Types of Solar Water Heaters

Solar water heaters can be classified as active or passive, direct or indirect. An active system uses electric pumps, valves and controllers to circulate water or other heat-transfer fluids through the collectors; a passive system relies on natural convection for fluid circulation.

The amount of hot water a solar water heater produces depends on the type and size of the system, the amount of sun available at the site, proper installation, and the tilt angle and orientation of the collectors. Passive systems are feasible in warmer climates or for three season operation, but are generally not feasible for year-round operation in Montana.

A direct system circulates household (potable) water through the collector loop. Direct water heating systems should not be used where the water is extremely hard or acidic to avoid scale deposits or corrosion. An indirect (closed-loop) system uses a heat-transfer fluid (water or diluted antifreeze for example) to collect heat and a heat exchanger to transfer the heat to household water.

Three types of solar systems are most often used: direct circulation, integral collector storage (ICS), and thermosiphon. The direct circulation system circulates potable water from the water storage tank through one or more collectors and back into the tank.

The solar collector is the main component of the solar system *(Figure 2)*. It is usually a metal box with insulation and a black absorber plate that collects solar radiation and heats the water. The circulating pump is regulated by either an electronic controller, a common appliance timer, or a photovoltaic (PV) panel.

In integral collector storage systems, the solar water storage system is built into the collector. The potable water in the collector unit is heated by the sun and delivered by city or well water pressure to an auxiliary tank (which contains non-solar backup heating) or directly to the point of use.

A thermosiphon solar water heating system *(Figure 3)* has a tank mounted above the collector (normally on the roof) to provide a natural gravity flow of water. Hot water rises through piping in the collector, which is mounted below the tank; heavier cold water sinks to the lowest point in the system (the collector), displacing the lighter hot water which rises to the tank.

The ICS and thermosiphon systems are simple since they use no pumps or controllers and water always flows through the collector.

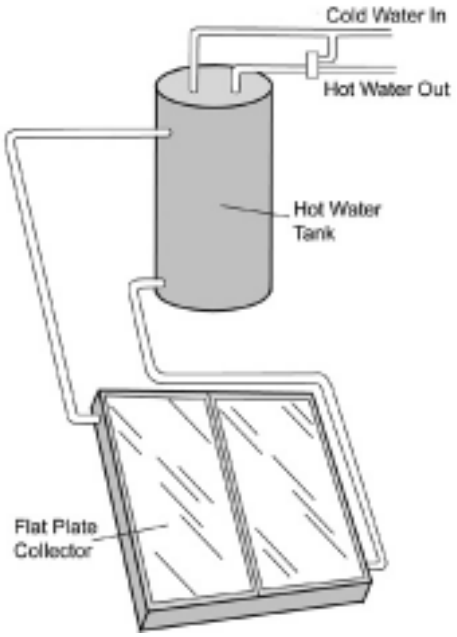


Fig. 3: Thermosiphoning solar water system

Direct circulation solar systems

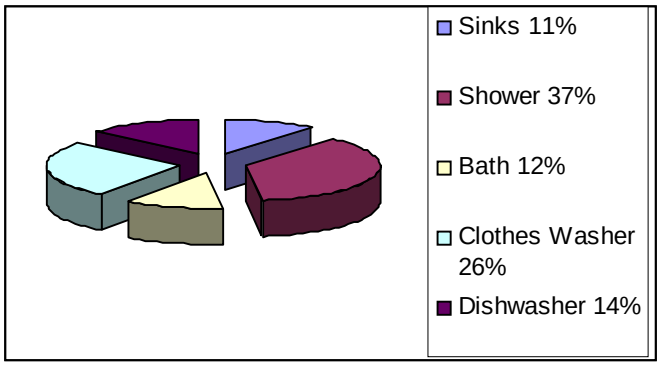
As sunshine strikes the collector, the water inside it is heated. If the circulating pump is regulated by a PV panel, the pump starts turning as the PV panel is activated by the same sunshine. This direct current (DC) motor pump moves water from the tank through the collector and back to the tank. As the sun's intensity changes throughout the day, the circulating pump also changes its speed accordingly. By the end of the day, the water in the tank has been circulated many times through the collector and has been heated to usable hot water temperatures.

If the circulating pump is regulated by an electronic differential controller, a sensor at the outlet of the collector and a sensor at the bottom of the tank activate the circulating pump when the water in the collector is about 15-200° F warmer than the water at the bottom of the tank. The pump then circulates water from the collector and the tank. This process continues as long as the water temperature at the collector outlet is about 50° F higher than that in the bottom of the tank. If the temperature difference decreases further, the controller automatically shuts off the pump.

Common appliance timers also may control system operation. The timer is set to operate during a period of the day when solar radiation is available to heat the potable water. It is

Where Does the Hot Water Go?

The major uses of hot water in your home are among the major opportunities to save energy in your home. You can get an idea of how much money you're spending on hot water by looking at utility bills for the months when neither heating nor air conditioning are used much.



important that the timers used in these systems incorporate battery backup in the event of power failures. In order to avoid loss of energy from the tank during overcast days, the collector feed and return lines are both connected at the bottom of the storage tank. During normal operation, natural stratification allows the warmer water to rise to the top part of the tank. During periods of insufficient sunshine or high hot water demand, a backup electrical element in the storage tank heats the water.

The check valve prevents heat loss when the circulating pump is off. The circulating pump consumes only a small amount of electricity—around $5 to $10 worth per year—or in the case of PV, none.

Sizing a solar system

For a home with a dishwasher and an automatic clothes washer, a rough rule of thumb is 10 square feet of collector area, per person, and 20 gallons of water storage, per person. Thus, for a family of four, 40 square feet of collector and a total tank storage of 80 gallons are typical. It must be noted that ICS and thermosiphon systems will include two tanks, the solar system tank as well as the auxiliary tank. Families can also purchase a solar-assisted system that uses a 20- to 26-square-foot collector that is retrofitted to their existing 40- or 52-gallon water heater.

Due to the reduced storage tank capacity and smaller collector size, these systems will only provide 50 percent to 60 percent of the hot water used. The installed price will of course be lower since the existing tank and smaller collector are used.

Expected savings

Monthly savings will depend on the amount of hot water used, storage tank size and type and price of fuel used for backup water heating. For a family of four, the typical hot water usage is 70 gallons per day, thus using 3990 kilowatt-hours per year to heat the water electrically, or $399 per year worth of electricity at 10¢ per kilowatt hour.

A solar water heater should save between 50 percent and 85 percent of the hot water portion of the monthly utility bill, or $200 to $300 per year for a family of four, if the backup element is kept at 120° F**.**

A solar water heater can save even more if the user turns off the backup and relies solely on the sun for hot water. During summer months, when hot water demands are lower and the sun shines longer, most solar owners turn off the backup element circuit breaker, or switch. As electricity and other fuel prices go up, solar savings will increase accordingly.

Installation

Solar water heaters are always installed with a backup heating system in the storage tank to ensure that hot water is available at all times.

However, to maximize solar utilization and savings, the owner should try to use the most hot water in the late morning and early afternoon when the solar system is operating at its peak due to the available sunshine. Also, the solar system will be more effective if the use of hot water is spread more evenly over the week. For example, if you use hot water for laundry, instead of washing seven loads of clothes in a single day, wash one load each day. This will reduce the amount of backup energy required for your solar system.

Solar water heater costs

An installed solar water heating system can cost anywhere from $2,500 to $4,500 in Montana. Why the large range? System cost depends upon certain variables, such as following:

- Size of family to be served
- Size and type of solar system
- Type of financing available
- Type of roof on which the collector is to be installed
- Amount of possible utility rebate incentive
- Building code requirements
- Professional versus do-it-yourself installation.

Solar water heating is economically competitive with electrical and propane heating. It also competitive with dedicated heat pumps and heat recovery units, depending upon individual situation.

Solar collectors

There are basically two types of solar collectors available for solar water heating. The first is referred to as a flat-plate glazed solar collector. The second is the integral collector storage (ICS) collector. Both collectors are mounted in a fixed position throughout the year and do not track the sun as do some collectors that are used primarily for high-temperature applications.

A basic flat-plate collector consists of a metal enclosure, an absorber plate and flow tubes, insulation, and a glass covering. Flat-plate collectors can be 2 to 4 feet wide, 5 to 12 feet long, and 4 inches thick. The absorber takes in the sun's energy, which is then transferred to the water flowing through the tubes attached to the absorber.

An ICS collector consists of large tubes, often 4 inches in diameter, in which potable water is both heated and stored in a combined heat storage and collection unit. As with the flat-plate collector, the ICS unit also consists of a metal enclosure, insulation, and a glass covering. ICS units are available in sizes ranging from 30 to 50 gallons, and can range from 4 feet in width to 8 feet in length to 10 inches in depth.

To reduce heat losses, all flat-plate and ICS collectors generally have insulation behind the absorber plate and a glass cover on the front, facing the sun. The best cover material is tempered glass of low iron content. Some edge insulation inside the enclosure box is also necessary. The absorber plate is made of copper and is coated with a black chrome or nickel material called a selective surface. This surface greatly enhances the collector's ability to capture and retain solar energy. Some manufacturers also use black paint as an absorber coating.

To be safe, you should buy a collector tested and certified by the Florida Solar Energy Center. A document entitled Thermal Performance Ratings, available from the FSEC Public Information office, contains the performance rating for each solar collector certified the Center. The document also provides an approximate efficiency-per-dollar comparison method you can use as a guide for rejecting inefficient or overly expensive collectors.

Orienting the solar collector

Collectors should be mounted on an unshaded area of a south-facing roof. They can face up to 45 degrees east or west of south without a significant decrease in performance.

For all shingle roofs that generally have pitches greater than 3 in 12 (i.e., 14 degrees), collectors should be mounted parallel to the roof. Collectors mounted in this manner are more aesthetically pleasing. However, for flat or very low-sloping roofs, collectors should be tilted at an angle (to the horizontal) that is approximately equal in degrees to the local latitude. Montana latitudes range between 45° in Alzada and 49° Sweetgrass. Since the sun is lower on the horizon during the winter months, tilting the collector at an angle up to 15° greater than latitude will increase winter performance, which is desirable in most cases.

Buying a solar system

Firms installing solar water heaters are listed in the telephone book or advertised in local papers. You'll find a list of Montana solar dealers in Appendix A. Compare price, efficiency, service options, dealer reputation and warranties.

Ask the solar dealer for a list of previous customers, and talk to them. Ask the owners about performance. Does the system provide sufficient hot water? Was it affected by last winter's freeze? Inquire whether service has been necessary and if it was satisfactory. Ask about the warranty offered and read it carefully. A reputable dealer/installer will normally repair or replace a system component that malfunctions in the first year if the problem is caused by faulty materials, workmanship or installation.

The quality of installation can radically affect the reliable operation of a solar system. Installers should be licensed to install solar water heating systems.

Freeze protection

In some cases, thermosiphon systems also incorporate a heat exchanger in their design, which makes the thermosiphon design quite suitable for colder climates.

Two other types of freeze protection methods—automatic draindown and drainback systems—are used extensively in the northern United States. Draindown systems *(Figure 4)* nor-

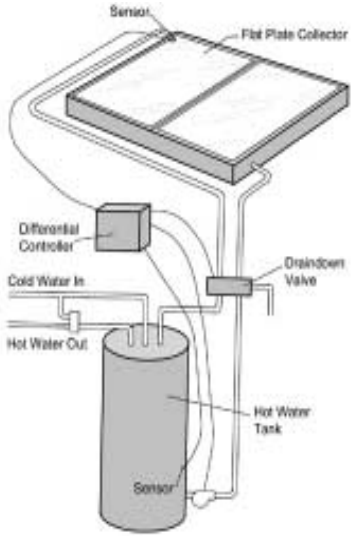


Fig. 4: Draindown solar water system.

mally use electrically operated pumps that automatically drain the water from the collector during freezing temperatures. In drainback systems *(Figure 5)*, the collector is automatically drained whenever the circulating pump stops.

With careful design and installation, both draindown and drainback systems can be fail-safe and cost effective.

Reliability

Properly designed and installed systems with glass-covered collectors should perform well for more than 20 years. Controllers, like other electronic devices, may require servicing during the life of the system, and the pump and hot water tank may have to be replaced after 10 years.

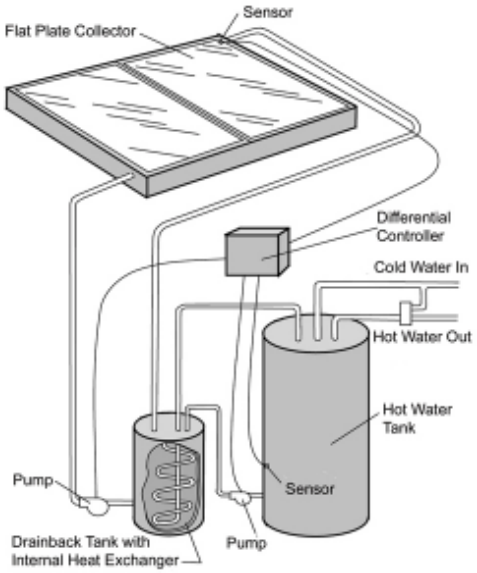


Fig. 5: Drainback solar water system.

Since conventional water heaters have the same expected lifetime, water tank replacement costs are not regarded as unique to solar energy systems.

Normal maintenance consists of checking pipe insulation, roof penetrations and collector mounting, pump operation and tank flushing. The latter is also recommended for conventional water heating systems, as is periodic replacement of the water heater sacrificial anode rod.

Many installation firms provide yearly maintenance checkups of their solar systems similar to annual air-conditioning system maintenance programs. These can be beneficial in extending the life of the system and ensuring optimum performance.

It is important to request that the installer put an indicator on your solar system showing that the system is working. It can be as simple as a small light that comes on when the system is operating.

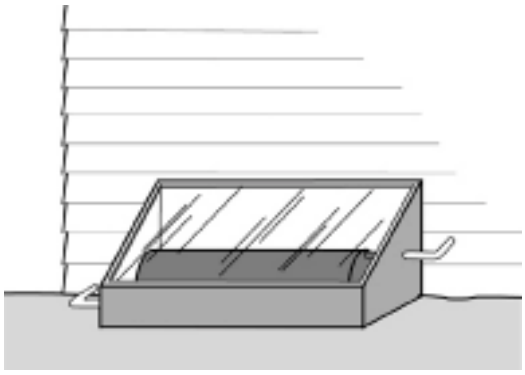


Fig. 6: Breadbox batch solar water heater.

Several inexpensive, “low-tech” solar collectors with specific functions are also available commercially. Batch heaters *(Figure 6)* are simple, effective solar water heaters; solar box cookers are used for cooking and for purifying water; and solar stills produce inexpensive distilled water from virtually any water source.

Solar box cookers are inexpensive to buy and easy to build and use. They consist of a roomy, insulated box lined with reflective material, covered with glaz-

ing, and fitted with an external reflector. Black cooking pots serve as absorbers, heating up more quickly than shiny aluminum or stainless steel cookware. Box cookers can also be used to kill bacteria in water if the temperature can reach the boiling point.

Solar stills provide inexpensive distilled water from even salty or badly contaminated water. They work on the principle that water in an open container will evaporate. A solar still uses solar energy to speed up the evaporation process. The stills consist of an insulated, dark-colored container covered with glazing that is tilted so the condensing fresh water can trickle into a collection trough. A solar still, about the size of a kitchen stove, can produce two gallons of distilled water on a sunny day.

Batch heaters, also known as "breadbox" or integrated collector systems, use one or more black tanks filled with water and placed in an insulated, glazed box. Some boxes include reflectors to increase the solar radiation. Solar energy passes through the glazing and heats the water in the tanks. These devices are inexpensive solar water heaters but must be drained or protected from freezing when temperatures drop below freezing.

Technological Improvements

The efficiency of solar heating systems and collectors has improved from the early 1970s and costs have dropped somewhat. The efficiencies can be attributed to the use of low-iron, tempered glass for glazing (low-iron glass allows the transmission of more solar energy than conventional glass), improved insulation, and the development of durable selective coatings.

Also, a new solar air collector, formerly used primarily for commercial buildings, is now available for homes. Called a transpired collector, it eliminates the cost of the glazing, the metal box, and the insulation.

This collector is made of black, perforated metal. The sun heats the metal, and a fan pulls air through the holes in the metal, heating the air. For residential installations, these collectors are available in 8-foot by 2.5-foot panels capable of heating 40 cubic feet per minute of outside air. On a sunny winter day, the panel can produce temperatures up to 50 °F (28 °C) higher than the outdoor air temperature. Transpired air collectors not only heat air, but also improve indoor air quality by directly preheating fresh outdoor air.

These collectors have achieved very high efficiencies—more than 70 percent in some commercial applications. Plus, because the collectors require no glazing or insulation, they are inexpensive to manufacture. All these factors make transpired air collectors a very cost-effective source of solar heat.

There are other prototype cooling systems operating today. Some use heat from solar collectors for absorption cooling. Others are being used to renew the desiccant material in desiccant cooling systems. Desiccants, such as silica gel, naturally attract moisture. They are used to reduce humidity and the resulting cooling loads in hot, humid climates.

System Cost and Performance

Active system applications for space heating are rare today. This discussion will concentrate solely on hot water systems. On a national basis, the cost of commercially installed ac-

tive hot water systems adequate for families of two to five people range from $1,700 to $6,000. In hard freeze climates such as Montana the realistic cost range is likely to be $3,500 to $6,000. It is believed that as the number of systems installed increases, the installed cost will decrease somewhat. Because active systems use electricity, they will not function in a power outage, except in the case where a PV module is used to power the pump.

Solar Rating and Certification Corporation (SRCC). The SRCC is a non-profit organization whose primary purpose is the development and implementation of certification programs and natural ratings standards for solar energy equipment. SRCC was incorporated in 1980 as an independent third-party certification entity. The SRCC publishes a directory of certified collector and water-heating system performance and will provide computer simulated performance analysis for sites throughout the United States.

System Performance. Savings from solar water heating systems depend on water usage, system size, system design and local climate conditions. Perhaps the single greatest determinant of monetary savings is the cost of the fuel being displaced. Following are brief summaries of programs that have recently demonstrated the cost and performance of active solar hot water systems. In our brief research, we could not find similar information about manufactured passive (batch) hot water heaters.

Collector Performance Ratings

When you are shopping for solar collectors, you can compare their performance. Look for a Solar Rating & Certification Corporation (SRCC) or Florida Solar Energy Center (FSEC) sticker on the equipment you are considering to check their comparative performance ratings. For more information on SRCC's or FSEC's performance standards, contact the Energy Efficiency and Renewable Energy Clearinghouse at (800) 363-3732.

Solar Rating and Certification Corporation (SRCC). The SRCC is a non-profit organization whose primary purpose is the development and implementation of certification programs and natural ratings standards for solar energy equipment. SRCC was incorporated in 1980 as an independent third-party certification entity. The SRCC publishes a directory of certified collector and water-heating system performance and will provide computer simulated performance analysis for sites throughout the United States.

SRCC is a nonprofit, independent third-party organization formed by the solar industry, state energy officials, and consumer advocates to certify and rate solar water heaters. SRCC was discussed earlier in this section.

Solar Rating & Certification Corporation (SRCC)
C / O FSEC
1679 Clearlake Road
Cocoa, FL 32922-5703
(407) 638-1537
Fax: (407) 638-1010
Florida Solar Energy Center (FSEC) is an alternative energy center. The FSEC staff conducts research on a range of solar technologies, offers solar energy workshops, and distributes many free publications to the public.

Reading List

The following publications provide further information about solar collectors. The list is not exhaustive, nor does the mention of any publication constitute a recommendation or endorsement:

Consumer Guide to Solar Energy, S. Sklar and K. Sheinkopf, Bonus Books, Inc., 160 East Illinois Street, Chicago, IL 60611, 1991.

Directory of SRCC Certified Solar Collector and Water Heating System Ratings, Solar Rating and Certification Corp., 1998.

Home Energy Magazine, 2124 Kittredge Street, No. 95, Berkeley, CA 94704-9942, (510) 524-5405. Home Energy Magazine is a source of information on reducing energy consumption.

Home Power Magazine, P.O. Box 520, Ashland, OR 97520, (800) 707-6585 or (541) 512-0201. Written by and for people who appreciate independence from the utility grid, *Home Power* prides itself on giving its readers practical information about home-scale renewable energy technologies.

Solar Today, 2400 Central Avenue, Unit G-1, Boulder, CO 80301. Solar Today covers all the solar technologies, both mature and emerging, in a general interest format. Each issue includes a solar building case study.

The Fuel Savers, B. Anderson, Morning Sun Press, Lafayette, CA, 1991.

The New Solar Home Book, B. Anderson and M. Riorden, Brick House, Amherst, NH, 1987.

To get more information on solar electric systems and solar heating systems, please contact:

National Center for Appropriate Technology
Box 3838
3040 Continental Drive
Butte, MT 59702
Phone: 406-494 4572
Toll-free: 1-800-275-6228
Fax : 406- 494-2905
E-mail: info@montanagreenpower.com
Web: www.montanagreenpower.com

Appendix A

Montana Renewable Energy Dealers

Shawn Coggins
Advanced Composting Systems
195 Meadows Road
Whitefish, MT 59937
Phone: 406-862-3854

Mark Gray
Alternative Energy Systems LLC
P. O. Box 83
1223 25th Ave. NE
Black Eagle MT 59404
Phone: 406-761-7200
alternativeeng@cs.com

Stan Nash
Anaconda Electronics Co.
111 Woodstack Trail
Anaconda, MT 59711
Phone: (406) 560-2109

Michael & Lumarie Strickland
Dearborn Solar Electric Co.
633 Dearborn River Rd
Cascade, MT 59421
Phone: 406-788-0118

William E Gross
Gross Electric
638 Badrock Drive
Columbia Falls, MT 59912
Phone: 406-892-4940
Fax: 406-892-4914

Tony Boniface
Independent Power Systems
1627 W. Main St
Bozeman, MT 59715
Phone: 406-587-5295
Fax: 406-587-5295
E-mail: tboniface@imt.net

Steve Hicks
Mountain Pass Wind Co.
P.O. Box 394
White Sulphur Springs, MT 59645
Phone: 406-547-2266
E-mail: steveahicks@yahoo.com

Glenn Nelson
195 Meadows Road
Whitefish, MT 59937
Phone: 406-862-3854

Chris Daum
Oasis Montana, Inc.
436 Red Fox Lane
Stevensville, MT 59828
Phone: 877-627-4768 or 4778
Fax: 406-777-2632
E-mail: info@oasismontana.com
URL: http://www.oasismontana.com

Larry & Annette Chain
Obadiah's Woodstoves & Alternative Energy
305 Silver Dr. N.
Troy, MT 59935
Phone: 1-800-968-8604
E-mail: woodstoves@montanasky.net

Jenni Bryce
PineRidge Products
P.O. Box 2334
Great Falls, MT 59403
Phone: 406-738-4284
E-mail: wlbryce@direcpc.com
URL: www.pineridgeproducts.com

William von Brethorst
Planetary Systems
Box 340 or 262 Badger Rd.
Ennis, MT 59729
Phone: 406-682-5646
Fax: 406-682-5644
E-mail: brethors@3rivers.net
URL: http://www.planetarysystems.com/

Bruce Bannister
Prairie Wind & Sun
P.O. Box 1296
Miles City, Montana 59301
Phone: 406-232-4223
E-mail: solarb@mcn.net

Jimmy Martin
Quality Solar
31923 South Fork
Yaak River Rd
Troy, MT 59935
Phone: 406-295-5072

Dale Picard
Radiant Engineering, Inc.
501 E Peach Suite C
Bozeman, MT 59715
Phone: 406-587-3442
E-mail: radiant@mcn.net
URL: http://www.radiantengineering.com

Chris Borton and Linda Welsh
Sage Mountain Center
79 Sage Mountain Trail
Whitehall, MT 59759
Phone: 406-494-9875
E-mail: smc@sagemountain.org
URL: www.sagemountain.org

Lee Tavenner
Solar Plexus
130 West Front Street
Missoula, MT 59802
Phone/Fax: 406-721-1130
E-mail: solplex@montana.com
URL: http://www.montana.com/solplex

Dale Picard
Suncraft, Inc.
501 E Peach Suite C
Bozeman, MT 59715
Phone: 406-587-3442

Henry & Barbara Dykema
Sundance Solar Systems
P.O. Box 4404
Luther, MT 59051
Phone: 406-425-1153
URL: http://www.sundancesolarmt.com/

Tom & Nilda Bishop
Sunelco, Inc.
100 Skeels Street
Hamilton, MT 59840
Phone: 1-800-338-6844
Fax: 406-363-6046
E-mail: info@sunelco.com
URL: http://www.sunelco.com

Gail Snow
Sun Power Plus
85 Skyline Road
Three Forks, MT 59752
Phone: 406-539-9782

Joanne Smith
Sunwize Technologies, Inc.
108 Rosewood Court
Hamilton, MT 59840
Phone: 406-375-9195
Fax: 406-375-9194
E-mail: sunwize@montana.com
URL: www.sunwize.com

Dan O'Neil
West Wind Energy, Inc.
P.O. Box 638
Columbus, MT 59019
Phone: 406-321-0175
E-mail: danowwenergy@yahoo.com

Directories of Dealers

Home Power

A complete list of solar and renewable energy equipment dealers can be found at Home Power Magazine's web site under "Search for RE Dealers." Home Power also features informative articles on renewable energy, how-to downloads, solar and wind maps, and numerous helpful links.
http://www.homepower.com/

PV Directory

This directory includes U.S. organizations involved in PV includes manufacturers of PV modules and those who support the manufacturing industry, designers and installers of PV systems, companies who manufacture components that make up the balance of PV systems (including batteries), companies that manufacture related products like pumping and lighting systems, and consultants for PV systems. It also includes organizations that set standards or test PV equipment, and organizations that provide information and training in PV technology.
http://www.eren.doe.gov/pv/pvdirectory.html

National Center for Appropriate Technology