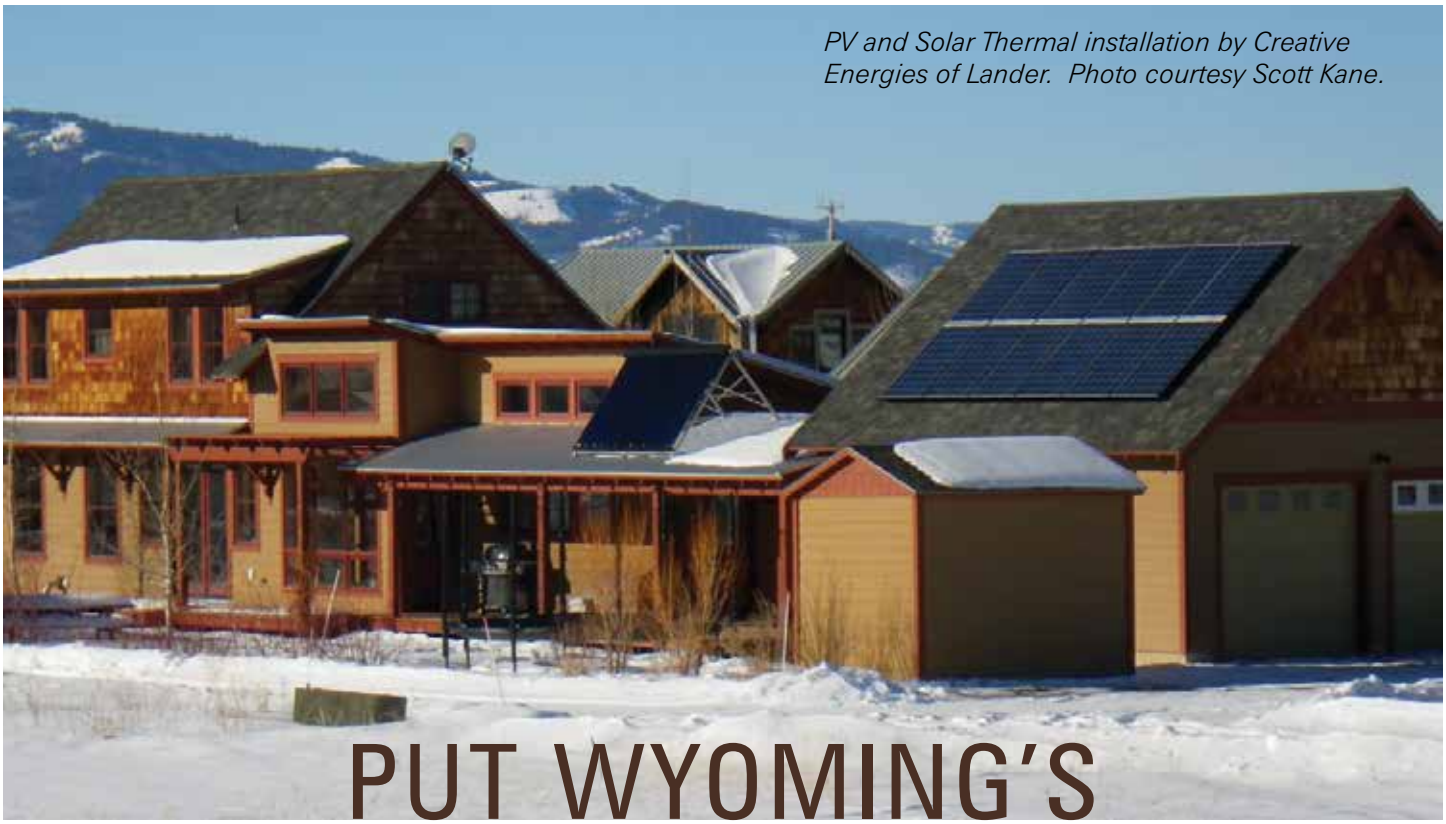


PV and Solar Thermal installation by Creative Energies of Lander. Photo courtesy Scott Kane.

PUT WYOMING'S SUNNY DISPOSITION TO WORK

Is solar electric or solar thermal best for you? We guide you through the benefits of each

Jon Gardzelewski and Anthony Denzer

Wyoming – one of the coldest and sunniest states in the country – is ideal for taking advantage of solar energy.

In the last issue, we discussed passive solar design, which utilizes south-facing windows to allow low-angle winter sunlight to heat living spaces. Now, we'll turn our attention to active solar systems.

Active solar requires mechanical and electrical equipment to capture and store the sun's energy as heat or electricity. If the collection, storage, and delivery of solar heat requires electricity (fans, pumps, etc.), then it is an active system. Active solar technologies are solar thermal or solar electric, both of which should be used if interested in a Net Zero energy home – a home that produces as much energy as used.

Solar Thermal

Solar thermal systems capture, store, and deliver heat from the sun using rooftop collectors. There are two types: flat plate collectors and evacuated tubes, but both rely on a glass-encased metal plate that collects and transfers solar heat to a fluid – usually water or an anti-freeze solution.

Heat loss from the collector to the air becomes a critical issue with decreasing outdoor air temperatures. The evacuated tube system is more efficient because the vacuum decreases heat loss to the outside air.

Heat captured with solar thermal systems can produce hot water for domestic use or heat for a house. The efficiency of each system at any given time depends on the outdoor temperature and the solar intensity. Expect 35-50 percent of the solar energy reaching collectors delivered as useful heat.

Storage is another consideration for solar thermal systems. After two days of cloudy, cold, winter weather, a solar thermal system could be ineffective and drained of all heat. Also, availability of solar energy is at its lowest in winter when space heating requirements are highest; therefore, if you design a solar thermal heating system for adequate winter heating, it will overproduce heat the remainder of the year.

Overproduction in the summer isn't as much a problem as it is a waste, considering that the equivalent photo-voltaic (PV) panels would be producing energy.

Some solar thermal systems heat air rather than water. Transpired solar

collectors, which have metal covers instead of glass, are used at UW's Indoor Practice Facility. They pre-heat the outdoor air before sending it through the furnaces. This system saves UW a lot of energy. Solar air heaters can be effective for specialized applications, but storing heat collected in the daytime for use at night is difficult.

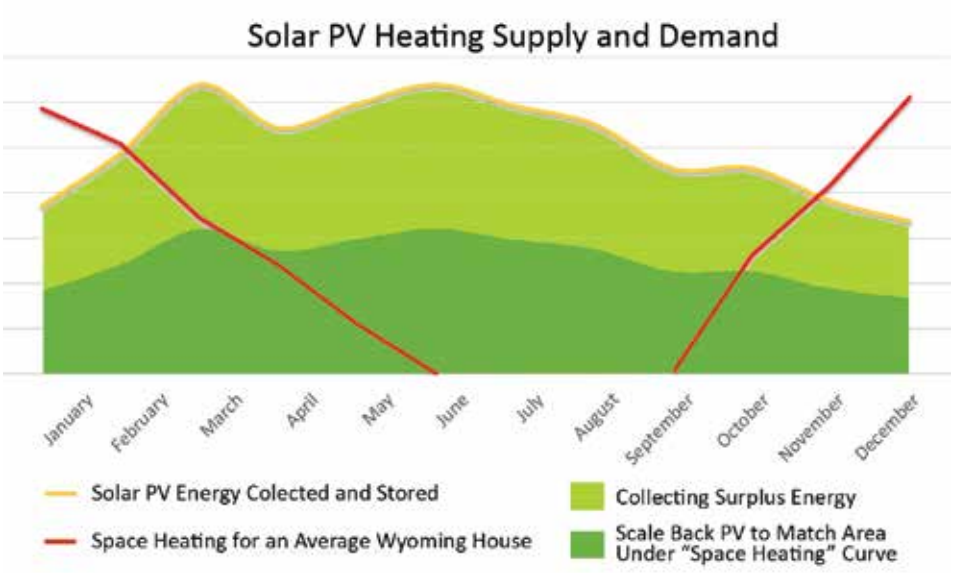
Solar Electricity

The most common form of solar electricity produced at residential scale uses crystalline, silicon-based, flat plate PV technology. PV panels are often mounted on the south-facing roof of a home or garage where they can produce a tremendous amount of free electrical energy. Electricity, as opposed to heat, is a high-quality form of energy that can be converted into multiple other forms of energy (thermal energy, mechanical energy, electromagnetic radiation) with very little loss in the conversion.

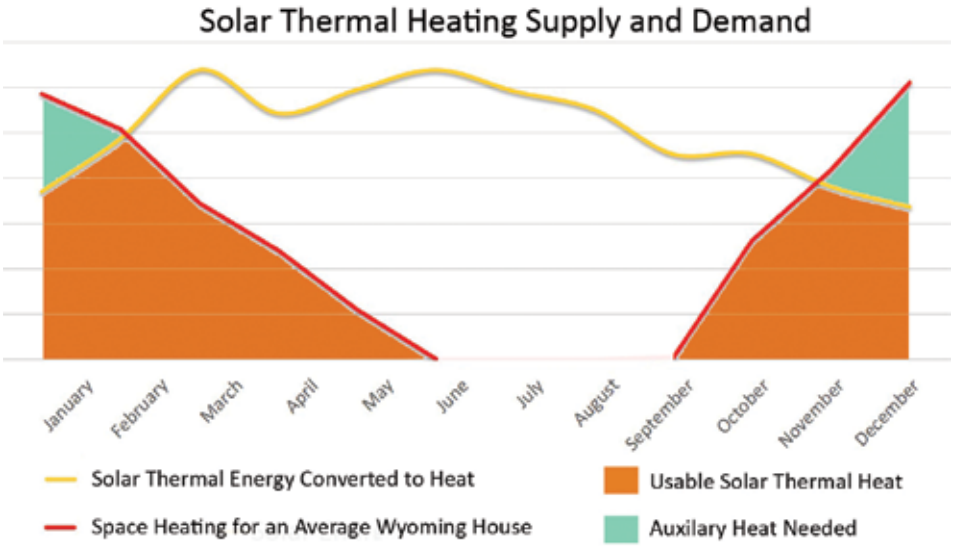
While a PV panel might only convert 15 percent of the solar energy received into usable electricity, that electricity can power electronics and appliances and ultra-efficient heat pump systems as an alternative to natural gas or propane.

Electricity can be fed into the grid just as it is taken out. Wyoming is primarily a net metering state, in which energy fed into the grid can be paid for by the power company or credited to the user for later use. This means electricity added to the grid in summertime can be credited and taken back out in winter when there is less solar energy available.

If your home is off-grid, the ability to store electricity depends on large batteries, which are expensive and may degrade over time. Connecting to the grid will decrease the number of PV panels to meet annual electrical needs.



Solar PV energy can be "stored" in the grid or credited to the user. "Net Metering" enables peak production in the summertime to be utilized year-round or sold. For Net Zero homes, PVs are often already being utilized, and the additional number of PVs to supply the annual heating demand is relatively small if you have installed an efficient heat pump.



Solar thermal heating is **most** *needed when solar energy is* **least** *available. Heat cannot be stored for more than a couple of days, so auxiliary heating is often necessary during the coldest months while excess heat is produced during the remainder of the year.*

Comparing the Two

When deciding whether to cover a roof with solar thermal or PV panels, an obvious choice may be solar thermal because of the dominant need for heating energy coupled with the higher efficiency of solar thermal systems (35-50 percent) in comparison to PVs (15 percent). However, the demand for hot water remains constant most of the year, while space heating demand peaks in the winter when the sun happens to be at its lowest intensity. Once you evaluate the seasonal heating demand, the seasonal availability of solar energy, and consider the problem of heat storage, this logic quickly cools.

Having enough of the more energy-efficient solar thermal panels to meet the constant water heating demand and using PV panels to satisfy your house heating demands is a better plan.

The costs vary, and you should work with a certified contractor to obtain a quote and explore the available rebates. In general, PV systems are skyrocketing in popularity because the cost of the panels is dropping. Panels dropped from $3.30 per watt in 2010 to $1.83 per watt in 2012!

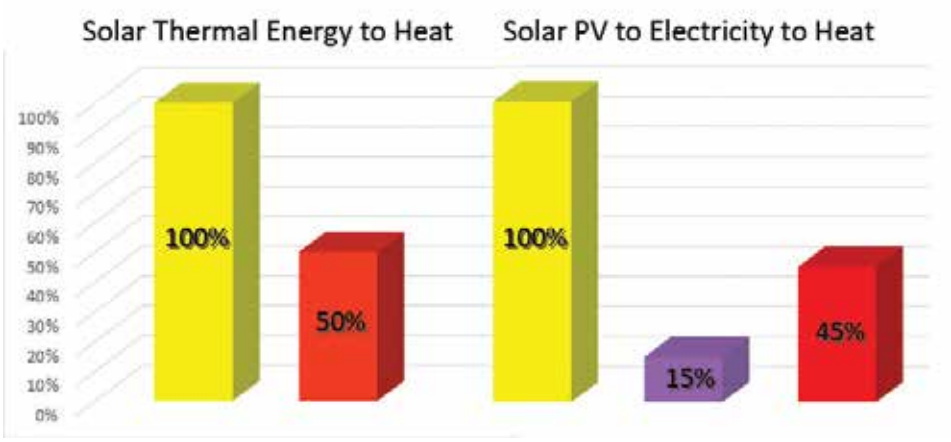
The cost of PV versus solar thermal is roughly equivalent; expect to pay $1,000-plus per installed PV panel or solar thermal panel. Costs start to vary, however, when looking at the different efficiencies of heating systems.

Heat pumps convert electricity into usable heat. Heat pumps and PVs are not tied together but since they require electricity, extra PV panels are needed to reach zero energy.

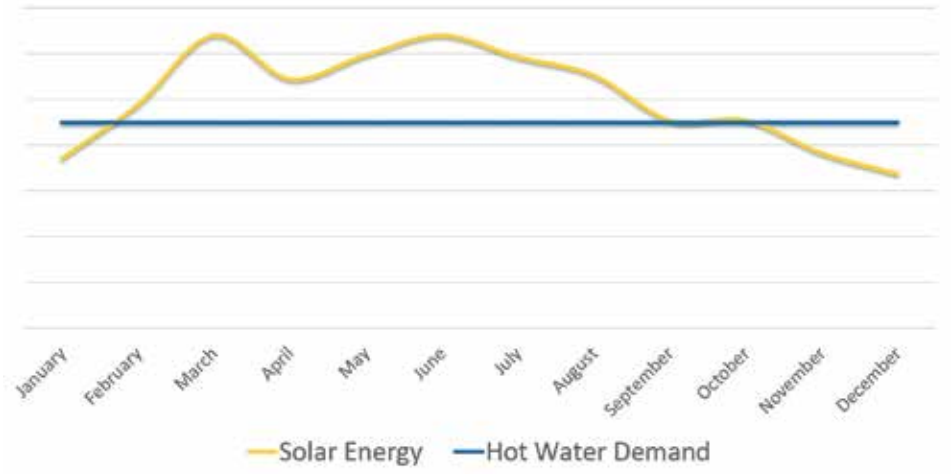
Ultra-efficient ground source heat pumps that run on electricity often cost more than double a standard heating system – not including additional construction costs for drilling and/or excavating into the ground during installation.

Similar, but less efficient, air source heat pumps fueled by electricity will cost about the same as a gas or propane system.

Air source heat pumps generally range from 200-300 percent efficient, while ground source heat pumps can be well over 300 percent efficient. Three hundred percent efficient means that for every 1 unit of energy (electricity) used, 3 units of heat are added to the space. With gas or propane, maximum efficiencies are generally 80-90 percent – meaning that for every 1 unit of energy (gas) used, maybe .85 units of heat are added to the space.



A comparison of the conversion efficiencies of solar energy to usable heat through solar thermal and solar electric systems. Solar thermal heat cannot be stored over time, while solar electricity can be credited or "stored" in the power grid.



Hot water energy demand remains generally constant year-round, and therefore a solar hot water heater generally makes good economic sense.

PV and solar thermal installation by Creative Energies of Lander. Photo courtesy Scott Kane.

Solar thermal "evacuated tube" heating system on the roof of the UW Visual Arts Building. These active solar systems are an integral part of the aesthetic design and are not perceived as an eye-sore by most.

Going for (Net) Zero

To make a home or building Net Zero energy, you theoretically only need to produce as much electrical energy as you will use during the year. Energy use and energy costs are not always equivalent, and some power companies will pay a lower rate for the energy you produce than what you pay them for theirs. If you're going for Zero, gas heating is not considered a viable option since you can't recreate the gas you've burned. Supplemental heating with wood is okay.

Let's do some math: For 1 unit of solar energy, you can get .5 units of solar thermal heat into your space or .15 units of solar electricity. If you take that .15 units of electricity and put it into a heat pump that is 300 percent efficient, then you are up to .45 units of heat in your space for 1 unit of solar energy. When you compare this 0.45 from solar electric to the 0.5 for solar thermal, it is almost a wash.

Now, if the storage abilities of electricity vs. heat are factored in, the PV system makes a lot more sense because you can capture useable energy all year long. But what kind of heat do you want? Radiant floor heating is often desirable and works well with solar thermal and ground source heating systems, both of which are the more expensive options.

For a Net Zero home, you will already need PV installed for domestic electricity needs and would likely already use solar thermal for domestic hot water. The heating system chosen requires a careful evaluation of: energy needed; energy produced; and system costs including installation and longevity.

Conclusion

The upfront costs of an active system are significant, and the savings will not pay back these costs for several years. But you can save in the long run, market your home for greater re-sale, and you might gain some security or satisfaction from being an energy producer.

If you want to go all the way and make your home Net-Zero, consider contacting UW's Building Energy Research Group (BERG) http://bit.ly/bergatuw.

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