Renewable Energy at the Cheyenne Botanic Gardens

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Passive Solar Heating At the CBG

The use of solar energy in the Cheyenne Botanic Gardens is elegantly simple. A passive solar heating system provides 100 per cent of the heat to three separate 30' x 50' greenhouse sections. The rest of the 6,800 square foot building also receives a substantial amount of heat generated from the solar greenhouses

Passive solar energy system is the result of the combined effect of the following:

☼ **South-oriented, triple-thick polycarbonate glazing.** Instead of glass we use a plastic material called polycarbonate. It lasts approximately ten years before it begins to yellow. It is triple thick which allows for two insulating air spaces. Dead air space insulates and slows the cooling of the structure as well as helps to keep it cooler in summer. The glazing faces south at an optimal 45° angle. It is strong and is resistant to both hail and fire.

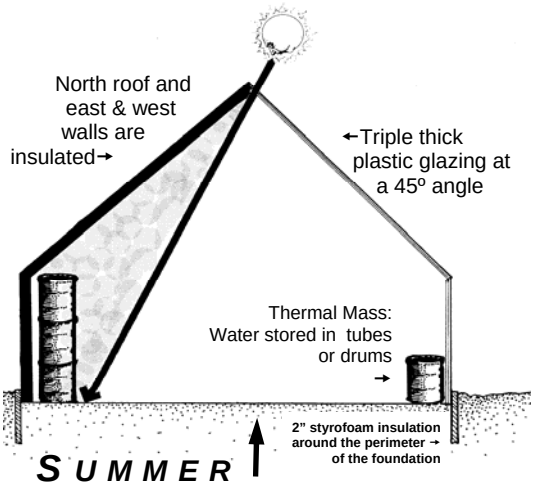
A sample of triple-thick polycarbonate glazing.

☼ **Insulation.** Both the east and west walls as well as the north roof are heavily insulated. The perimeter of the foundation exterior is also insulated into the earth with a two-inch sheet of styrofoam along the outside of the concrete foundation to a depth of two feet. This insulates the ground inside the greenhouse from the cold ground outside the greenhouse during winter.

☼ **Thermal mass.** The daytime sun heats the water-filled fiberglass tubes and 55 gallon metal drums. The containers are located along the north and south walls. The containers heat up to about 70° in the summer and 60° in the winter but will never feel warm to the touch because our body temperature is 98.6° and our skin temperature is usually warmer than the water. These water-filled containers give-off heat because the night/day difference in temperature is great enough to cause the warmer heat from the containers to radiate into the colder greenhouse. In summer they help to keep the greenhouse cooler because they are shaded most of the day.

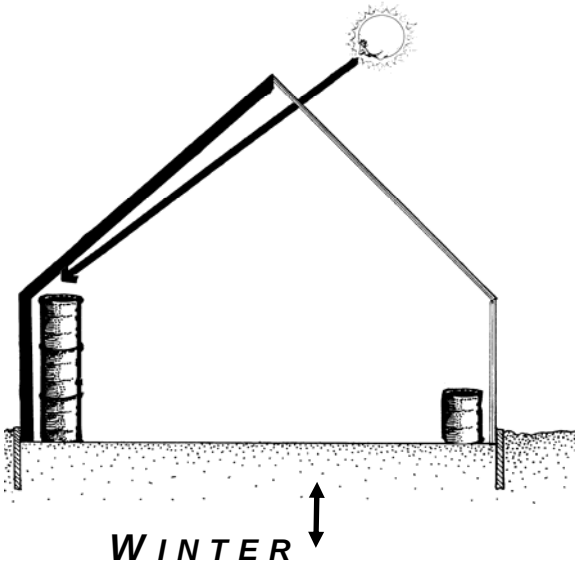
☼ **Weatherized structure**. All windows, doors, fans and vents are well weather-stripped to prevent leaks and cold drafts.

View of the Cheyenne Botanic Gardens showing the south facing plastic glass also called "glazing." ←



SUMMER

Sun is higher in the sky and casts a shadow over the water-filled tubes and drums of the Botanic Gardens greenhouse helping to keep the greenhouse cool.



WINTER

Sun is lower in the sky shining directly into the Botanic Gardens greenhouse directly illuminating and warming the water-filled tubes and drums. This helps keep the greenhouse warm.

Barrels full of water that are one component of passive solar heating

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About using water as a heat storage:

Materials that are relatively heavy provide good thermal mass for storing solar heat. Look at the chart on this page. A thermal storage value is given for each material listed. The higher this value, the more heat the material can store. Notice how water is excellent at storing heat:

Material	Thermal Storage Value in BTU's*
Water	**63**
Adobe	20
Brick	24
Concrete	35
Earth	20
Sand	22
Steel	59
Stone	35

What are the usual temperatures in the conservatory?

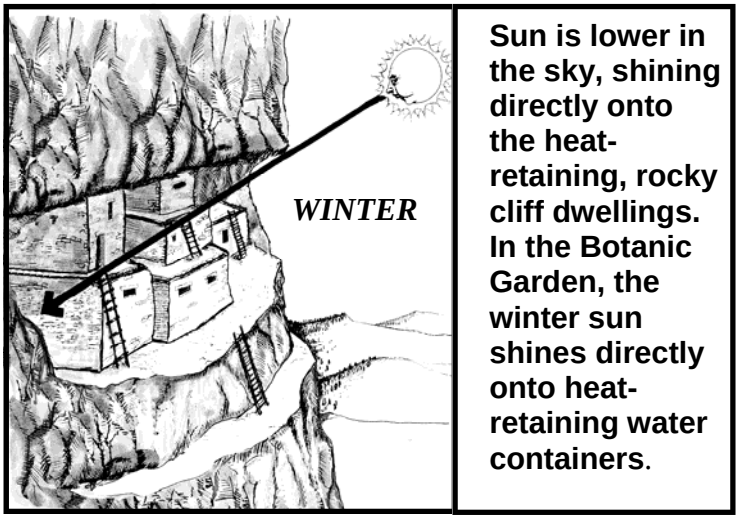
In the winter the Cheyenne Botanic Gardens usually runs in the 60 to 80s during the day. At night the usual low temperature is in the 50s. During extremely cold weather the lows can go down to the 40s. The lowest the CBG gets under the coldest and cloudiest winter conditions is the upper 30s F.

The Cheyenne Botanic Gardens conservatory is one of the few buildings in Wyoming (if not the only building) that uses more energy to keep cool in summer than it does to keep warm in winter.

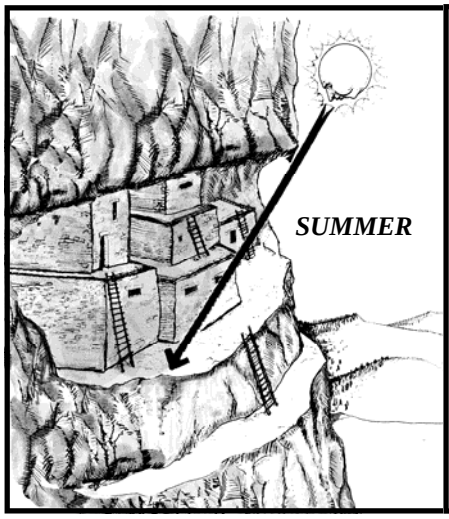
Passive Solar Heating is not new!

The Cheyenne Botanic Garden conservatory greenhouses take advantage of the changing sun angles between winter and summer. The idea of using sun angles was perfected by the Anasazi Indians who lived in cliff dwellings. In winter, the sunlight (and the sun's heat) penetrated deep into the cliff dwelling because the sun was lower in the southern sky. The winter sun heated their massive adobe and rock walls which held the heat well into the night.

In summer, the sun stays higher in the sky and a shadow was cast over most of the dwelling, keeping the buildings pleasantly cool.



Sun is lower in the sky, shining directly onto the heat-retaining, rocky cliff dwellings. In the Botanic Garden, the winter sun shines directly onto heat-retaining water containers.



Sun is higher in the summer sky which casts a shadow over the top of the cliff. This is the same as the sun casting a shadow on the Botanic Gardens water-filled tubes and drums.

Use passive solar energy in your house!

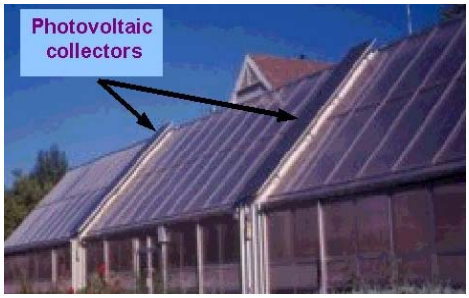
Windows: Utilize the south-facing windows that you already have because they can make a substantial difference in your heating bill. Open the curtains on your south-facing windows, every sunny winter day. Be sure all your windows are sealed tightly and have no leaks. Pull curtains or shades closed at night. Double or triple thick glass is more efficient at holding in heat than single glass. Apply an extra plastic layer to your window (available at most hardware stores). For older leaky windows apply a removable clay caulk to plug air leaks. Also, never plant evergreens in front of south windows. Consider removing existing evergreens that block winter sun. If you are purchasing a home, shop for houses that have lots of windows on the south side.

Insulation: Be sure you have the recommended levels of attic and wall insulation.

New Houses: If you are considering the construction of a new house, insist that it utilize passive solar heat. This means having lots of south facing windows along with other design components. The solar heating will cost more but will more than pay for itself in a short amount of time.

SOLAR RENEWABLE ELECTRICITY– PHOTOVOLTAICS AT THE CHEYENNE BOTANIC GARDENS

The CBG generates approximately 50% of its electricity from a photovoltaic solar energy system. It all begins with an array of solar electric cell modules that are the black rectangles located on the Cheyenne Botanic Gardens south facing roof.



Solar electric collectors (the solar arrays) on the CBG conservatory

Solar Electric Cell– How does it Work?

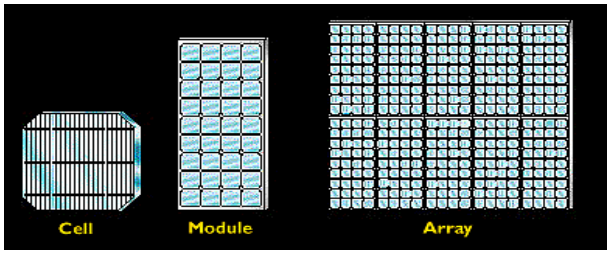
Solar electricity is the conversion of sunlight into electricity. It is the cleanest energy option available today. Solar electricity is nearly inexhaustible and depends upon two of the most plentiful resources on earth: sunshine and sand.

A solar **cell** has layers of very thin films of treated silicon (from sand). When sunlight strikes the solar electric cells placed on the Botanic Gardens roof, an electric current results between the films. The cells are wired together and encapsulated with glass (also derived from sand). Each bank of cells wired together is called a **module**. There are no moving parts involved in the generation of electricity.

THE CHEYENNE BOTANIC GARDENS SOLAR ELECTRIC SYSTEM IS MADE UP OF THE SOLAR ARRAY, SYSTEM CONTROLLER AND INVERTER.

The Solar Array:

The **array** is the term that describes all of the solar cells that are wired together on the roof. It is made up of 24 modules. These modules create a total of 2,040 watts. The power of this array varies in production according to weather and all of this power is wired to a bank of batteries where the power is stored. The batteries are located in the Cheyenne Botanic Gardens basement.



The Battery Bank:

The **battery bank** is made up of industrial grade, lead-acid solar batteries. The batteries store electricity generated by the array for use at night or on cloudy days. The batteries can store electricity from one to three days depending upon the electricity load. If the batteries run low on power they are automatically re-charged from the electric utility.

The System Controller:

The **system controller** is the brain of the solar power system. The controllers function is to regulate the voltage in the battery, distribute power to the battery and to transmit power from the battery to the inverter.

The Inverter:

Direct current power is the type of current the solar cells generate from the sun and store in the batteries. The job of the **inverter** is to change the nature of the electricity stored in the battery bank, which is 'direct current' (DC) power. The inverter changes it to 'alternating current' (AC) power. AC power is the type of electricity provided by our utility grid. AC is the power we use in our homes for running most everything. For instance, a refrigerator, computer or light bulb are all typically run on AC power. Cars and RV's typically run on DC power.

The Whole System:

The Cheyenne Botanic Gardens photovoltaic system generates 50 percent of the Cheyenne Botanic Gardens electrical needs including the paddle fans, irrigation controls, many lights and all of the computers and office equipment in the building. The Cheyenne Botanic Gardens system has a total of 24 modules that produce 24 volts DC (which is converted to 110 volts AC. This creates 2,040 watts at 58.92 amps. The batteries store 1575 amps at a 100 hour discharge rate.

This system was funded by the State of Wyoming to educate the public on the many forms of energy generation. Because the price of solar electricity drops every year, perhaps someday it will power your home's electrical needs. The advantages of a solar electric system include: low maintenance, non-polluting, inexhaustible and solar power reduces our need for foreign imports of energy sources. Solar electric technology is most cost effective for rural areas far from power lines. The benefits of renewable energy to future generations is immeasurable. A skewed energy system that depends upon far away sources of production is partially to blame for world terrorism and instability.

CONSERVATION PLAYS AN IMPORTANT ROLE IN ENERGY USE

Solar heating and solar electricity is important, but the first step before even considering the use of these technologies is conservation. Conservation should not only be your first investment; it may also be one of the best investments you will ever make. Conservation is something anyone can pursue and is well worth your time and money. Let's look at what the Cheyenne Botanic Gardens has done– and what you can do as well.

This is a typical compact fluorescent light bulb, it could save you up to $50!

Lighting:

The typical household spends $110 per year on lighting and most people use incandescent light bulbs which are very inefficient. Incandescent bulbs are heaters in disguise, converting 90% of the electricity to heat and only 10% to light. The alternative is what are sold as compact fluorescent (CF) bulbs. The CF bulbs provide the same luminance, but use one-quarter to one-third as much electricity and last up to ten times as long! Compact fluorescents cost more than traditional bulbs (approx. $6 – $14 each) but save you up to $50.00 over the life of the bulb! Buying a compact fluorescent bulb provides a risk-free "return" of 25-40% a year. Not bad compared to investing in the volatile stock market! Newer LED lights can save you even more! When you visit the CBG, notice the compact fluorescent and LED overhead lighting in the reception room.

Traditional hot water heaters:

Consider these facts: Traditional hot water heaters constantly maintain up to 30 gallons of hot water– whether you need it or not. About 20% of the energy used in residences goes for heating water. Much of a hot water tank's energy is simply lost, keeping the water tank warm and waiting whether you use it or not.

This is the tankless hot water heater installed at the CBG.

Hot water solution?

A tankless hot water heater. While these hot water heaters are more expensive (up to $1000), they last up to 3 times longer (because they don't have a tank that can corrode) and save both energy and money.

A tankless hot water heater flash heats the water as it passes through the unit, instantly heating the water. This eliminates the need for a wasteful storage tank. If your water heater is more than 10 years old, it probably has an efficiency of around 50%. A tankless water heater has an efficiency of around 82%. The Cheyenne Botanic Gardens recently purchased a "Flash" tankless hot water heater. Flash-type tankless hot water heaters never run out of hot water, providing an endless supply because cold water is instantly heated as it passes through the unit.

Economics– Depending upon the current price of gas the average homeowner could save up to $360 per year in energy costs alone. This does not even take into account replacement costs of the shorter-lived traditional tank-type hot water heaters. In 3 years, an investment in a tankless hot water heater is paid back. After that you are saving money!

Other conservation measures at the Cheyenne Botanic Gardens:

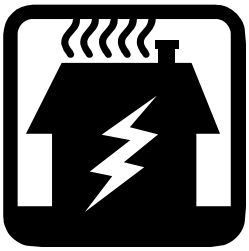
The Cheyenne Botanic Gardens has installed a special heating thermostat for the kitchen and offices that automatically turns the heat down in the evening when the building is unoccupied. A new more energy efficient refrigerator has been installed. Upstairs north facing windows have a coating on the glass known as heat mirror which holds in more of the room's heat.

See the next page for tips on home energy conservation.

TRY THIS AT HOME!

Home conservation measures:

1. **Light bulbs:** Replace as many incandescent light bulbs as possible in your home with compact fluorescent or LED type bulbs. Start with the bulbs that are turned on the most.



2. **Windows:** Replace older singe pane glass windows with newer more energy efficient windows. If you can't afford new windows, seal up window leaks with removable clay caulk.
3. **Hot water:** Consider purchasing a tankless hot water heater. If you can't replace your hot water heater, maximize it's insulation by installing an insulating blanket around the exterior of heater tank (*sold at most hardware and lumber yards*). Turn down your hot water thermostat a bit.
4. **Showers:** Bathing consumes the most hot water. Instead, try to shower more. Install low-flow shower heads on all of your showers. This will reduce your overall hot water consumption and lower your bills!
5. **Heating thermostat:** Install a set-back thermostat for your home's heating system that turns down the heat when you are away or asleep.
6. **Refrigerator:** Refrigerators use up to 50% of your total electricity demand. If your refrigerator is older than 10 to 15 years, consider purchasing a new refrigerator. Newer models use significantly less energy than older refrigerators. They will often pay for themselves in 3 to 4 years! Also check your old refrigerator to be sure the magnetic seals are working properly. Cold air leaks require more energy. Using a vacuum, regularly clean the black-colored elements—a grill-like structure located on the back or the underneath the refrigerator. If the element is dirty and dusty, your fridge will consume more electricity.

7. **Furnace:** If your furnace is older than 15 years, consider replacement. A newer more energy efficient model might actually save you a substantial amount money over the life of the purchase, over and above the replacement costs. Also, replace or clean your furnace filter regularly so that your furnace doesn't have to use extra energy to push air through a clogged filter.
8. **Turn it off:** Turn-off lights when you leave the room and your home computer when not in use.
9. **Insulation:** You can increase the comfort of your home while reducing your heating and cooling needs up to 30% by investing just a few hundred dollars in proper insulation and weatherization products. The easiest and most cost-effective way to insulate your home is to add insulation in the attic. To find out if you have enough attic insulation, measure the thickness of insulation. If there is less than R-22 (7 inches of fiber glass or rock wool or 6 inches of cellulose) you could probably benefit by adding more. Most U.S. homes should have between R-22 and R-49 insulation in the attic. Older homes may lack wall insulation. This can also be installed through small holes that are later patched and become unnoticeable.
10. **Infiltration:** Minimize infiltration around doors, windows and other gaps with caulk, weather-stripping and new seals.
11. **Landscaping:** Well-placed trees and shrubs can reduce your energy needs. Carefully positioned trees can save up to 25% of a typical household's energy for heating and cooling. Computer models from the Department of Energy predicts that three trees, properly placed around the house, can save an average household between $100 and $250 in heating and cooling energy costs annually. During the summer months, the most effective way to keep your home cool is to prevent the heat from building up in the first place. In general place evergreen trees to the north and west and deciduous trees (those that lose their leaves) to the south and east.