SOLAR PLANNING

SCOTTSDALE GREEN BUILDING PROGRAM

- Solar Incentives
- Solar Hot Water
- Solar Integration
- Passive Design

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Solar Energy Incentives

Central Arizona

Utility Incentives

APS – Solar Partner Incentive Program
Applies To: Residential customers of APS
System Type: Photovoltaic (solar electric), and solar thermal water heating systems (SDHW) for on and off grid residential systems.

APS customers can receive a rebate of $3 for each DC Watt of rated solar electric power installed in a grid-tied application (or 50% of the total system cost – whichever is less) up to 10,000 Watts. For an off-grid application the rebate is $2 for each DC Watt of rated solar electric power up to 5,000 Watts. You must be an existing APS customer or your property must be located in APS service territory. A licensed electrical contractor must install the system in order to qualify for the incentive.
http://www.aps.com/main/green/choice/choice_13.html
New solar water heater installations must meet OG-300 ratings. Systems cannot exceed 10,000 kW hours per year. Payment is based on a system's yearly kW hour rating of 0.75 cents per kW hour up to 50% of system cost.
Customer receives payment directly from APS or can assign it over to the installer once the system has been activated. Funding is limited and a reservation process is in place to guarantee funds for those customers pursuing projects. Projects must be installed within 180 days of acceptance by the utility. Participants are required to contribute a minimum of 15 percent of the actual system cost.
http://www.aps.com/main/green/choice/choice_14.html
Solar Day lighting 0.20 cents per kWh estimated first year savings.

For more information visit -
http://dsireusa.org/library/includes/map2.cfm?CurrentPageID=1&State=AZ&RE=1&EE=1

SRP – EarthWise Solar Energy Program
Applies To: Residential customers of SRP
System Type: Photovoltaic (solar electric), and solar thermal water heating systems (SDHW), for on and off grid residential systems.

SRP customers can receive a rebate of $3 for each DC Watt of rated solar electric power installed in a grid-tied application (or 50% of the total system cost – whichever is less) up to 20,000 Watts. For off-grid application the rebate is $3 for each DC Watt of rated solar electric power. A licensed electrical contractor must install the system in order to qualify for the incentive.
New solar water heater installations must meet OG-300 ratings. Systems cannot exceed 10,000 kW hours per year. Payment is made on a systems yearly kW hour rating of .50 cents per kW hour.
Customer receives payment directly from SRP once the application has been processed and approved. Funding is limited and a reservation process is in place to guarantee funds for those customers pursuing projects. Projects must be installed within 180 days of acceptance by the utility.
For more information visit - http://www.srpnet.com/environment/earthwise/solar/default.aspx

Government Incentives

State of Arizona – Personal Income Tax Credit
Applies To: Retail sale of solar systems used in residential applications

System Types: Any solar energy devices including systems or series of mechanisms which collect and transfer solar generated energy.
Amount: 25% of system cost; to a $1,000 maximum; one-time use per house. Unused credits carry forward up to 5 years.
For more information visit - http://www.revenue.state.az.us/brochure/543.pdf

State of Arizona – Sales Tax Exemption
Expenditures for Solar Energy Devices are now exempt from Arizona State Sales Tax. (Arizona House Bill # 2429 - http://www.dsireusa.org/documents/Incentives/AZ08F.pdf)
Note: Municipalities do not exempt solar energy devices from sales tax.

State of Arizona - Solar Energy Property Tax Exemption
Solar Energy Devices add zero value to property value for property tax assessment purposes. (Arizona House Bill #2429, page 25 lines 16-18, see link above).

Federal Tax Credits – Personal Income Tax Credit

Applies To: Residential Properties
System Types: Solar Hot Water, Photovoltaic (Solar Electric), Wind, Fuel Cells, Geothermal Heat Pumps. And other Solar
Amount: 30% of a system cost no cap except for Solar Hot Water that is capped at $2,000

Solar hot water heating must provide at least 50% of annual hot water needs. Not to be used for Hot Tubs or Swimming pools. Solar Hot Water systems must be OG-300 certified in Arizona.
The Tax Credit can only be used on a dwelling unit located in the USA and is the residence of the taxpayer.
If the federal tax credit exceeds tax liability, the excess amount may be carried forward to the succeeding taxable year.
Consumers who receive other incentives are advised to consult with a tax professional regarding how to calculate this federal tax credit.

For more information visit - http://seia.org/galleries/pdf/ITC_Frequently_Asked_Questions_10_9_08.pdf

http://dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=US37F&state=us&CurrentPageID=1&RE=1&EE=1

****For Solar Energy resources, visit the AZ Solar Center web site – www.azsolarcenter.com**

rev. G Sutton 11/11/08

HOT WATER FROM THE SUN

Hot water - it is a regular part of our daily lives - it is used to clean our clothes, wash our dishes, and to bathe and relax us. It is used to heat our buildings and even extends use of our swimming pools into the winter months. But then, hot water doesn't come that way naturally.

Water must be heated in order to meet these purposes. In the past, fires heated water for cooking, cleaning and bathing Today we use electricity and/or natural gas to excite water molecules to such a point that it becomes hot. Electricity is generated at some distant point source location such as a river whose force spins turbines, or near a coal resource to fire up generators, or even at isolated and highly security conscious nuclear plants. Natural gas is captured and piped distances to the end user where it is then burned, creating heat for maintaining comfort, or for transfer to another medium - like food, or water.

The remote site generation of electricity and/or capturing of gas both require transfer to get the product to the consumer. This transfer requires a sophisticated and complex network to assure both quality and quantity needs are met. Transport of energy always has some losses of product and efficiencies along the way but most arrives ready for use.

In the recent past, serious issues and questions have arisen regarding environmental impacts, resource access, energy distribution, and energy cost and today there are concerns regarding energy resource stability and security.

Today, some utility companies are incorporating renewable energy systems of wind and sun and biomass into their energy generation palette. Although these renewable energy farms continue the approach of centralized collection, generation, and complex distribution system, the llocations are much closer to the consumer, often within the boundaries of communities they serve. In Arizona communities of Tucson, Springerville, Prescott, Phoenix and Yuma, utility solar plants are springing up, due in part to Arizona's mandated Energy Portfolio Standard which designates that Arizona utility companies must derive a prescribed amount of their energy from solar and renewable energy resources.

The use of the sun to meet people's needs isn't restricted to the actions of large utility companies. More energy, in the form of sunlight, falls upon the roof of a typical house than the entire house uses! Solar energy is the most democratic of energy sources - available to everyone and it doesn't require a sophisticated and complex system of extraction, conversion, and transport for people to use. Best of all it is free and directly under your control.

Many Arizonans use the sun's energy to meet daily hot water requirements for bathing, washing, pool heating, and heating of buildings, and many more are interested.

BENEFITS

The benefits of using the sun to heat water include:

* Solar water heating reduces the amount of energy required from the utility company thereby reducing monthly energy bills;

* Less energy demand means less use of finite oil and gas resources, and reduction in the infrastructure required to create and deliver energy to users;

*In replacing other energy sources, the use of solar energy will enhance the reduction of pollution, improve air quality, and lessen negative impacts on the environment

* Solar water heating is direct, simple, safe and within the individual's direct control

*Solar water systems can meet all hot water needs if incorporated appropriately.

* Water will be hot, and some even claim it is healthier

* To quote an Arizona utility - "Just a portion of your house's roof receives more solar energy than you need to heat house hot water all year long. To take advantage of that pollution-free energy you need a solar water heating system."

There's nothing mysterious about heating water with the sun - a lot of hot water with simple operation and little maintenance, and monthly energy bills will be reduced - a return on your investment, something a traditional water heating system doesn't provide, and when savings surpass initial investment - it is free!!

What more could you ask for?

SOLAR WATER HEATING SYSTEMS - The Technology

Using sunlight to heat water is simple and has been done by Arizonans for quite some time. A "batch" water heater was discovered on an outbuilding of the historic Tempe Bakery, and Phoenix's historic Ellis - Shackleford house had a Day/Night solar water heating system.

A solar water heater system has a short list of component elements. Basically, there is

* The collector - used to capture the heat in sunlight, and
* the water storage tank which is part of the heat collection system, storage, and distribution when hot water is needed.

In some applications as in pool heating or some radiant floor installations, a tank is not a necessary element.

Additionally there are other elements of a solar water heating system that may be incorporated. These include

* an auxiliary heating system used in periods of additional hot water demand; and.
* a Control system for monitoring and coordinating the operation of all a solar system's components in more sophisticated systems.

A Solar Collector - What Is It?

Simply - a container with a glass cover, that allows sunlight to impact the interior surface which contains pipes or tubes through which water or other heat collecting and transferring liquid travel.

Arizonans are familiar with the direct heating action of sun through windows of an uncovered car in the summer, and even on a sunny winter day. Sunlight impacts the interior surfaces and the resulting heat is prevented from escaping by the glass, and the car interior heats up to quite intolerable levels. This is the same action that occurs with the solar collector in a solar water heating system.

Solar collectors capture the sun's light, converting it into heat, which then heats water, or another heat transfer fluid. This collection of the sun's energy happens at the collector's dark color absorbing surface (absorber), below the glazing. As the absorber heats from exposure to sunlight, water moving through the absorber picks up the heat and carries it to storage or to direct use.

Since the collector glazing reduces heat loss to the outside air, colder climate conditions may warrant multiple glazing to increase heat retention capabilities.

What About Hot Water Storage?

Like typical water heating systems, the storage tank holds heated water. In a solar system, water is heated by continued circulation through the collector and the tank and is always hot. Solar hot water system tanks may be integral to the collector, or separate altogether.

Solar hot water tanks can be a primary hot water storage element, or a preheater, feeding into a regular tank. In all cases, solar tanks are highly efficient, and better insulated than standard tanks and are usually of larger capacity than regular tanks, in order to provide large hot water storage capacity for nighttime use and days of limited sunlight.

Tank Size

Tank size is directly related to the amount of hot water used, and needed for times of no solar access A typical Arizona family use is 20 gallons per day per person. This number, multiplied by the number of days of storage desired, gives a desired tank capacity.

Physical Protections

Super hot water - Solar water heating systems can generate water much hotter than conventional water heaters so a mixing valve is usually incorporated. This protective measure tempers hot water from the tank by adding cool water.

Cold climate impact - Solar equipment, just like any other water system exposed to cold conditions can be susceptible to freezing, but this issue is mitigated in modern solar water heating systems. State requirements mandate that safeguards must be built into all solar systems sold Arizona.

SOLAR WATER HEATING METHODS

A variety of solar hot water approaches are used in Arizona. All have the means of capturing the sun and heating water for use - they vary in the details of solar capture, transport of captured heat, and approach to storage and storage placement. Basically there are 2 fundamental approaches

Direct Heat Exchange - where water to be used is heated directly by the collectors,

Indirect Heat Exchange – where an efficient heat transfer fluid other than water, like propylene glycol a non-toxic antifreeze compound, is run through the collector to pick up heat, then run through a heat exchanger where it transfers its collected heat to the water to be used or stored in the tank.

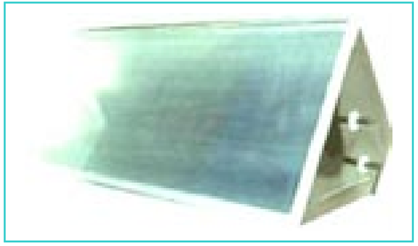
Direct heat transfer is highly effective, and even more so when attention is given to water quality in dealing with scale, which can affect collector performance and useable life. Water treatment, a common installation due to Arizona's hard water, often mitigates the condition, and regular care and maintenance is always a good practice.

Indirect heat transfer solar systems, beside providing higher heating and lower heat loss inherent to the glycol liquid used, have the additional benefit of no scaling at the collector since there is no water at this part of the system.

SOLAR WATER APPLICATIONS

Passive Systems

Batch or Integrated Collector/Storage (ICS) System



The simplest of systems - water in a dark container exposed to the sun. Contents will get hot, and in an Arizona summer, get very hot. This is the basis of an ICS and batch or "breadbox" system, which combines collector and storage into a single unit. Water flow occurs when hot water is drawn off. Direct heating of the tank, or tanks, makes this system compact, simple, and effective. It can be used as a pre-heater to a regular water heater, or as some Arizonans have done, to meet all needs.

These units do not rely on external equipment and/or energy to work. The "batch" approach has been used in Arizona for quite some time, and evolved improvements have enhanced the effectiveness in water heating and storage.

Newer ICS systems incorporate a number of connected small-diameter storage tanks to expose more surface area to the sunlight, thereby heating the water at a faster rate. Improvements in glazings and containers have made the systems more efficient in heat retention and the pure volume of the water mitigates the issue of freezing. Some ICS systems use evacuated glass tubes (like a thermos bottle) around the tanks to keep heat loss to a minimum. As a result, Batch and ICS systems do not usually operate at temperatures high enough for scale build-up to clog the system

In some cases reflectors are integrated, bouncing more of the sun's rays onto the water tank, and when the sun falls, the reflectors, made of highly insulating material, fold over the glazing to provide for better heat retention.

Thermosiphon Systems

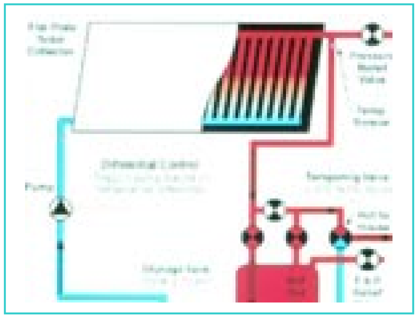
Hot water rises - cold water settles. This is because hot water is less dense than cold water due to its molecular excitement in heating.

A thermosiphon solar hot water heating system incorporates natural convection to move fluid heated by the collector to a storage tank. To do this, the storage tank is located higher than the collector. Cool water from the tank flows to the bottom of the collector where it is heated, becomes less dense, and rises all the way to the top of the storage tank. This continuous convective process occurs whenever there is enough sunlight to warm the liquid in the collector. Since this is a natural process, not needing pumps, the thermosiphon water heater is con- side red a passive system

Active Systems/Forced Circulation Systems

These applications, called active systems because a pump is used to move fluid through the solar collector, allow hot water storage to be placed at any convenient location within the building. Forced circulation systems transfer heat either directly by water circulating through the collector to the tank, or indirectly, by use of a heat transfer fluid at the collector and transferring that collected heat via a heat exchanger to water in the storage tank. Variations of a forced circulation include Open Loop and Closed Loop Systems

Open Loop System



Open loop forced circulation systems transfer heat directly to water to be used. When water in the collector loop is hotter than the water in the storage tank, the pump is activated and water from the tank is circulated through the collector.

> NOTE: State requirements stipulate provision of equip- ment to prevent freeze damage, and open loop systems come with recircu- lation and/or drain down con- figurations, as well as with freeze plugs or a "dribble" valve.

* A recirculation system controller activates a pump when collector temperatures near freezing, and circulates storage tank hot water through the collector loop to raise its temperature to prevent freezing.

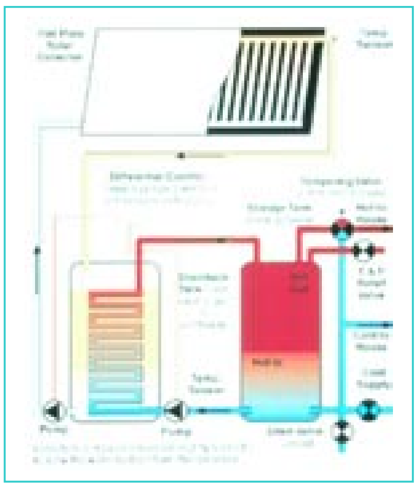
* A drain down system valve opens when the temperature drops near freezing, and all water in the collector is automatically drained from the collector and piping, into the tank.

* A freeze plug is simply a valve that opens when the pressure in the

collector rises above a certain point. As water changes from liquid to ice, it expands which forces the freeze plug to open and relieve that pressure, thereby avoiding freeze damage to the solar collector and piping.

* A "dribble" valve is much like a freeze plug. When it gets cold, the valve opens, allowing water to drain from the collector. Open loop and Closed loop systems also are installed with a check valve, which allow fluid in the collector loop pipe to move in only one direction in the collector in order to prevent undesired reverse siphoning and loss of heat when the sun is not available.

Closed Loop



Closed loop forced circulation systems transfer heat to water to be used in a 2-part operation. Fluid not susceptible to freezing is used in he collector loop. It is heated by the sun and circulated to a heat exchanger which transfers the heat to a second loop containing the water to be used and/or stored, and the collection fluid is circulated back to the collector. There are two separate fluid loops, one for the heat collecting liquid, and the other for the water to be used. Separately, each moves through the heat exchanger that implements the heat transfer process. A system controller turns the circulating pump on when the collector fluid is hotter than the storage tank water.

There are two primary types of closed loop systems:
The drain back system
The non-freeze system.

Drain-back

Forced-circulation systems have an additional tank (drain-back tank) for ensuring protection against freezing. When the pump is off, collector fluid flows into the drain-back tank.

Non-freeze

Forced circulation systems that use an antifreeze mixture in the collector loop. The antifreeze mixture provides protection against very high and low collector operating temperatures. An expansion tank is usually included on these systems to allow the collector loop fluid to expand and contract without damaging the pipes.

PERFORMANCE

Arizona is a great location for solar water heaters because of year around bright sunny, cloud-free days. Some installations, in continuous operation, have provided up to 100% of the daily hot water requirement. Others have realized energy savings ranging from 75-90% with a modicum of back-up. As a general rule, savings depend on the system performance, the amount of hot water demand, and the timing of use.

If large amounts of hot water is needed, or early morning hot water is necessary, inclusion of auxiliary heating may be desirable. The amount of electricity or gas used for the auxiliary is dependent on the capacity of storage, and the amount and timing of demand.

Seasonal conditions also impact upon the effectiveness of a system. Summer has more exposure to the sun than winter. Summer conditions easily provide 100% of the requirement, while winter may necessitate larger storage capacity or ancillary heating and back-up.

Collector Placement

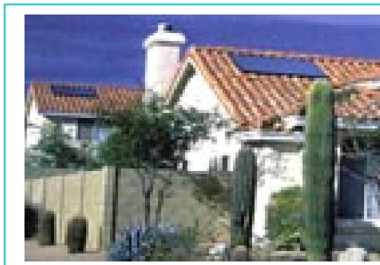
Collectors are best located in an area where there is unobstructed access to the sun throughout the year. The ideal location, of course, is the roof. If hot water storage is within a building, a collector system should be located to minimize piping runs. This reduces materials, and cost, as well as heat loss in the pipes. Collector placement considerations include:

* A collector facing true south gains equal amounts of sunlight in the morning and the afternoon. If more hot water is desired in the morning, the collector should face somewhat east of true south, and if hot water is more desirable later in the day, the collector should face west of true south.

Collector performance is maximized when tilted perpendicular to the sun. Typically, a solar water collector is placed to operate at its optimum during the winter, with the short days of sunlight, lower sun angles, and colder temperatures. For this reason the upright angle of the collector is important in maximizing solar heating of water during wintertime conditions.

* **NOTE:** Optimum collector angle and angle of a roof may not be compatible. This condition may require an independent support system or integration into the building form. It is said that the difference between an ideal angle and a flush roof angle is about $30 per year in savings.

It is important to also note that some subdivisions have restrictions (CC&R) regarding equipment on rooftops, and although recent Arizona court judgment has decided against Homeowner Association prevention of solar installations at rooftops, there may still be conflicts regarding aesthetics and maintenance of style and impact upon the building and neighborhood "look".



SAVINGS/BENEFITS

* Energy bills will be lower due to less demand of electricity and/or gas. Savings are directly proportional to efficiency of the system, cost of energy, and amount of hot water used.

* Solar energy replacement for heating water reduces supplier provided gas and/or electricity and avoids new, costly generation and transmission systems

* Solar water heating replacement of electricity and gas systems results in avoiding additional pollution created by generating electricity and burning gas - a solar water heater avoids the equivalent pollution of .3 cars/year

* Conventional water heating uses electric energy or gas, at plants or on site, and burning of hydrocarbon based fuels (such as coal, oil, or natural gas) emits oxides of carbon (Cox), nitrogen (Nox) and sulfur (Sox). Use of solar water heaters significantly reduce pollutants and contribute to a more clean and healthy environment.

* Local, county, and state government incentives for incorporation of solar energy equipment. The State has a tax credit, and no sales tax, for the purchase and installation of approved solar water heating systems. The community of Marana waives building permit fees for solar photovoltaic and hot water installations on new and existing buildings

* In response to the Arizona. Corporation Commission Environmental Portfolio Standard requirement that Az. Utilities provide a specific percent-age of their energy from green sources, some utility providers have incentive programs for solar hot water system utilization.

* A solar water heating system is a good investment. Return on investment will be result in reduced energy bills, increased savings and disposable income, and a cleaner environment over the lifetime of the system

CONSUMER PROTECTIONS

*All system components and systems must meet State requirements. Contact the Az. Dept. of Commerce Energy Office for information

*Arizona Registrar of Contractors, the Better Business Bureau and the Az. Solar Energy Industries Association are information sources about solar companies and certified installers.

*Arizona Dept of Revenue and Az. Dept. of Commerce Energy Office are information sources re: approved solar systems and tax benefits

A properly installed, approved system must have the following warranties and certifications for the equipment and installation

* Product meets Az. Dept. of Commerce Energy Office Certifications and Installation Requirements

* Installation meets or exceeds all applicable Codes

* System conforms to the guidelines procedures, and certifications of the Solar Rating & Certification Corp.

* Parts and Labor Warranty for the entire system for a minimum period of two years from the date of installation.

* System has a Warranty against freezing for a minimum of five years.

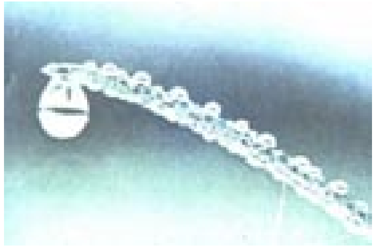
* Installer of system must have a Solar Contractors License

* Work is executed By Certified Solar Technicians (Contact the Az. Solar Energy Industries Association and the AZ. Department of Commerce Energy Office for a list of Certified Installers)

A Solar Water Heater Can Deliver Hot Water All Year Round

In Arizona we have fewer cloudy and cool days than almost anywhere else in the country, so solar energy can carry much of the load.

We have an inexhaustable resource all year around
We have the technology
We have a stable industry
We have consumer protections
We have the capability to provide for our own energy stability and security and at the same time improve environmental conditions.



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SOLAR APPLICATION and INTEGRATION

Active and passive solar systems and equipment - those elements which capture the sun's energy for heating bath and wash water; heating swimming pools for extended season use; generating electricity to power devices; cooking food; warming and cooling buildings, etc.

Solar equipment use is growing in Arizona neighborhoods, cities and towns. Buildings are incorporating solar as part of the basic equipment package. People want to use solar equipment because it is cost effecttive, resource saving, simple to use and understand, and there is a logical, direct and unencumbered energy resource in the sun as it moves across the sky

Solar applications and technology which provide for a building's performance and resident needs, is no longer some "future" thing. Today, solar elements and equipment are a growing part of the mainstream palette of a building, along with electric service and meters, piping, water heaters, fire sprinkler systems; air conditioners and coolers, etc.

All of these are integral elements to a buildings' operation in meeting needs as well as comforts. To this list, and in many cases, replacing some items on the list, Arizonans are incorporating solar devices, equipment, and design elements.

Reasons for this incorporation may vary - from saving money to saving the environment, and the applications range from use of solar hot water heaters to photovoltaic panels to cool towers. Whatever the reason, the resultant application of solar strategies and equipment have a physical and visual impact on the built environment.

Just as in the use of any other type of equipment, the use of solar equipment can have a direct impact upon a building - its' performance, its' look, functional layout, and even its' form and shape. At the same time, the building also has an impact upon the optimal use of solar strategies and equipment, affecting both placement and performance. .

ISSUE

Codes, Covenants, and Restrictions

As Arizona's population and economy grow, there is also growth in the building market. Increasing numbers of people need more buildings, and meeting the need for more buildings results in developments and subdivisions. These developments reflect the public desire and demand for value. neighborhood identity and integrity, and to this end, developments often have defined conditions of building and site appropriateness, identified as Covenants, Conditions and Restrictions (CC&R).

Historically, CC&Rs were drafted to mitigate, among other things, unsightly installations of roof mounted equipment - television aerials, evaporative coolers and heating/air conditioning equipment

Definitive CC&R's established an aesthetic standard in order to maintain visual integrity, which was believed to be a primary element in maintaining property value. Today, subdivision requirements have a common restriction - no equipment visible on a building, most notably on the roof.

Unfortunately, this "no equipment on the roof" restriction comes into conflict with optimal conditions of solar equipment placement, effective solar equipment utilization, good solar design, and sometimes even in direct conflict with Arizona law. Ideally, the installation of solar equipment should achieve optimum performance for the owner, but restrictive CC&Rs have negatively impacted performance by forcing placement of equipment in situations of limited exposure to the sun; locations that require longer runs (of piping, wiring, etc.) than necessary; locations which require restrictive, and sometimes costly, screens; and/or placement of equipment in less than optimum exposure angle to the sun - each and all of which provide less than optimal results for the owner.

Recently, in litigation involving a Home Owner Association's (HOA) attempt to restrict resident use of solar equipment on building rooftops (the only, and most effective, place it could be used), Arizona courts ruled against the restriction, and reinforced the solar rights of Arizona citizens.

The Arizona Solar Energy Industries Association (ARISEIA) has initiated workshops and activities with HOAs throughout Arizona to provide appropriate standards of solar equipment incorporation, and solar installation guidelines, in order to mitigate future conflicts between homeowners and HOAs, and to meet State legislative intent. To this end, the Arizona. Department of Commerce Energy Office has supported this endeavor, and continues to be a resource for Arizona citizens.

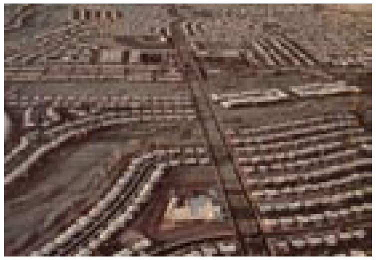
ISSUE

Design and Aesthetics

The desire for optimum equipment performance is sometimes in conflict with site and building conditions, especially with existing buildings.. Poorly oriented or sloped roof conditions require use of mounting structures to achieve optimum and correct relationship between equipment and the solar resource.

While effective in establishing proper orientation and attitude of solar panels, these installations project a discontinuity with the building form and design, and are perceived by many as unsightly appendages to otherwise attractive buildings.

Today's Arizona subdivisions have fallen away from response to local conditions into copying stylistic characterizations (California Style, Santa Fe style, etc.), instead of evolving an appropriate environmental response which would result in a truly Arizona style. Subdivisions are laid out with numerous considerations - density, views, circulation, etc. but with little or no consideration for basic tenets of good energy, solar and environmental design.



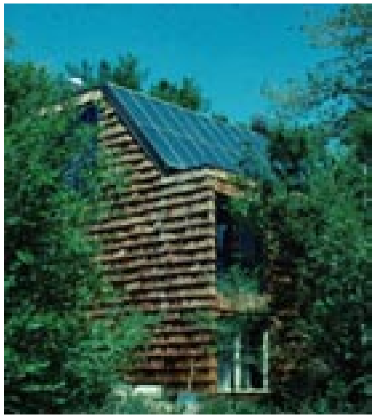
Energy issues are dealt with by adding insulation and efficient mechanical systems without consideration of using the positive aspects, or mitigating the negative impacts, of the site and the climate to reduce both the amount of equipment used, and amount of energy required to run it.

Effective energy actions involving orientation, building shape, space planning, glazing, and/or incorporation of active and passive solar and energy efficient equipment as part of the building are overlooked. Desert houses face west into the intense sun; roofs are flat in snow country; inordinate areas of glass wrap buildings, and building forms and structure do not readily allow for integration of solar equipment as part of the building fabric.

While the idea and the ideal of maintaining a neighborhood character and quality is desirable, current design and construction practices make integration of solar strategies and equipment problematic, and when coupled with restrictive CC&Rs, provide conditions for conflict, litigation and unhappiness - all which are counter to the heart of a neighborhood environment and value (one of belonging and being a part of shared community), and being able to use Arizona's most prevalent resource - the sun.

Integration

Solar integration is easily implemented in the design and construction of a new building - equipment and solar element incorporation can be executed to make the project a seamless and integrated "whole". Proper building orientation and siting can be established. Appropriate building form can simplify the incorporation of equipment into the structure. Proper space planning can optimize the distribution systems related to solar equipment use (piping, wiring, etc



Problematic is the integration of solar devices and elements into the existing Arizona building stock.

Existing buildings come in an array of orientations, forms, roof shapes, construction and materials - some are very compatible with use of solar strategies and integration of equipment, and others are not, posing negative conditions for the owner wishing to use solar.

Even award winning Arizona architecture suffers from poor energy considerations, with glass walled boxes in the dessert. Poorly planned existing building sites may not have any appropriate location for a solar installation. Building roofs may not have appropriate angle or orientation to the sun. Restrictive CC&Rs may prohibit the placement of equipment on a effective south facing roof, or require screening that may effectively reduce equipment performance, or force placement of equipment in locations, which effect performance.

Whether it be new or old buildings, Arizonans respond positively to the idea of an integrated "whole". New construction and additions can provide a solar continuity that is more acceptable than and those that look stuck on and have an incompatibility of material or form. What is needed is a result, which meets both the functional requirements of the equipment and aesthetic sensibilities of the people, providing the best for Arizonans and Arizona architecture.

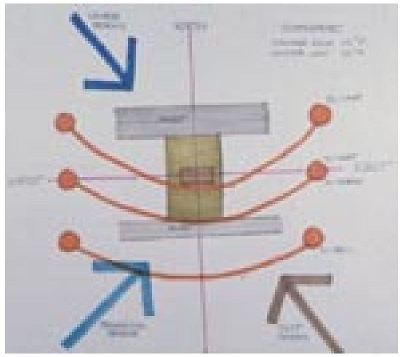
SOLAR EQUIPMENT INTEGRATION & AN APPROPRIATE ARCHITECTURE

The sun's movement is in a predictable pattern. As the earth makes its annual elliptical trip around the sun, its axial tilt provides for the seasonal changes in the northern hemisphere. The summer sun is high overhead and its appearance and impact are longer in duration and more intense during summers, whereas the sun's appearance is shorter in duration and lower in the horizon as it traverses the winter sky. Like all applications that use the sun's energy, exposure is a primary and critical element. While simple direct exposure will get results, ideal positioning provides the optimum performance of any piece of solar equipment or strategy, whether it is a solar water heater, a photovoltaic panel, a solar cooker or even a passive solar heated building.

The 3 primary aspects of optimizing performance of solar equipment are uninterrupted exposure to the sun through orientation; appropriate angle to the sun (tilt angle); and effective placement.

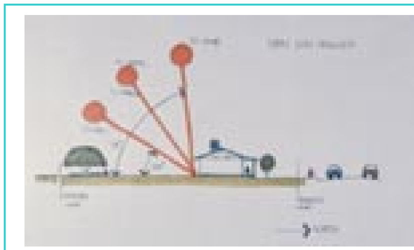
Orientation

Maximum performance of solar equipment and passive heating strategies is based on continued exposure to the sun. Outputs are optimized when there is clear connection to the sun for the entirety of daylight hours - the more exposure to the sun, the more water can be heated, the more electricity generated, and the more heat can be collected for comfort. Collector locations must be face the sun's path as it traverses the south sky, free of shade, for the entirety of daylight hours



Tilt Angle

Solar water heating is most effective when it can provide hot water under coldest conditions - i.e. winter. The winter sun is lower on the horizon so the ideal angle of a collector should more vertical (to 45 degrees). Solar pool heating is more in demand in the colder parts of the year so this angle of exposure can be equally important. PV modules tilted at an angle equal to the local latitude give the maximum yearly output for a fixed tilt mounting. This tilt angle is a very necessary condition for optimizing solar equipment use.



Positioning and orientation have significant impact upon the performance of any system. Location of equipment is a critical consideration. Placement optimizes conditions by having short runs of delivery - water heated by a solar collector should have as short a run to the storage and/or use as possible to minimize transfer heat losses. Electrical installations benefit from short connections to control systems. Reduced runs mean less material, less labor and materials for installation, less maintenance in the future, and less overall cost.

Toward Energy Architecture

An additional benefit of solar equipment placement is one that directly impacts the shape and form of a building, adding visual interest as a byproduct of the solar functionality. Passive solar buildings take their form and shape from the direct relationship in using natures resources. - Elongation along the East/West axis provides more southern exposure and minimizes unwanted east and west exposures to intense summer sun; roof forms and/or elements which incorporate solar equipment and strategies; vertical forms of cooling tower projections; recessed windows and doorways for thermal tempering; and colors and textures which take advantage or mitigate conditions.

APPLICATIONS AND EXAMPLES

Implementation of solar equipment and solar strategies have a range of options, from integration on site to integration as part of a building.

Currently, there are 2 major pieces of solar equipment - solar water heater systems (panels, piping, storage) and photovoltaic systems (modules, wiring, electrical equipment, electrical "storage" for off grid installation). There are also a number of other pieces of solar applications like cookers, roof ponds, thermal chimneys, cool towers, etc.

Arizonans have been resourceful, creative and ingenious in the incorporation of solar equipment and strategies. Rural Arizona with less governmental restriction, more sense of rootedness, and more commitment to using solar and renewables have been in the forefront of solar integration and use. The variations of solar integration range across the State from urban areas to rural sites, and they all are responses to conditions, type of equipment and application, and needs of their Owners.

Equipment Placement Adjacent the Building

*** Ground Mounting** -

If there is appropriate access to the sun, ground mounting has been used successfully for fixed photovoltaic arrays as well as individual modules on trackers, which follow the course of the sun to optimize operation. Panels mounted in open areas on a site allow for freedom of operation and movement necessary for a tracking system, and/or for ease of installation, access for maintenance and adjustment for both tracking and fixed systems.

Rural Arizona application of this strategy has been applied to passive water heating (thermosiphon), or for radiant floors. Since hot water rises, and cold water settles, the thermosiphon system has the collector lower than the tank or application. This convective loop runs continuously as the sun shines

Some applications with south sloping sites, place collector panels lower than the floor level of the house (and storage tank) to capitalize on the thermosiphon effect of this passive approach.

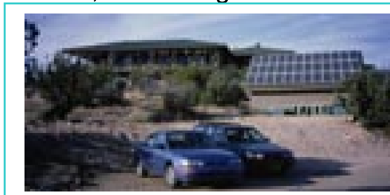
In these ground-mounting applications, solar equipment is located in response to the ease of location; ease of access, and direct and easy maintenance, or in response to the terrain, equipment type, and end use. Some installations have integrated equipment as part of a building element such as a porch.

In all cases, proper orientation as well as proper tilt angles can be easily achieved, thereby having equipment operate at its optimum in providing electricity and/or hot water.

*Separate Building Mount -

Sometimes, equipment is mounted on an adjacent structure. Photovoltaic systems that are completely off-grid and provide all of electrical service and power needs, require an extensive amount of batteries in order to store enough electricity for nighttime and overcast day usage.

Batteries require a well-ventilated area. Some applications provide a dedicated structure for this purpose, and incorporate the photovoltaic panels onto the roof, and equipment such as inverters and controls are placed within the structure, thereby minimizing runs between panels, inverters, and storage



Solar water heating systems used for heating pool water in order to extend the swimming season can be incorporated into trellis and shading structures that are part of a patio and pool area. Since there is no necessity for storage (the pool water is heated directly) this provides a direct connection with short runs and minimal line loss inefficiencies.

Equipment Placement on the Building

Equipment can be mounted directly on buildings as separate attachments. While solar equipment can be attached to any part of a building that has good southern exposure, the most advantageous location may be at the roof. Roofs generally provide a condition of unencumbered and unshaded access to the sun's path, and the location puts equipment out of the way. Additionally, a roof appli-cation may allow for placement of equipment directly above other elements of a system (hot water tank area or mechanical room for photovoltaic equipment, etc.) thereby reducing runs which then reduce installation and materials costs.

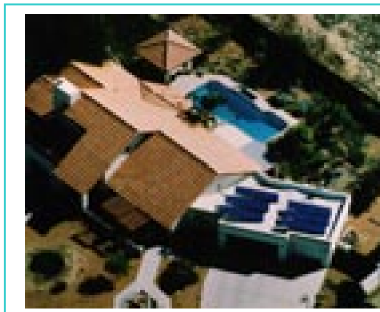
Ideal exposure of photovoltaic and solar water heating panels is at an angle that maximizes the performance of the equipment. Since the winter sun is available for a shorter time than in the summer, and is lower to the horizon, water heating equipment performance is optimized when tilted perpendicular to the sun's rays. Photovoltaic placement is more variable and dependent on time of year usage.

Unfortunately, most buildings are not designed for inclusion of these optimal exposures and angles and Arizonans have had to apply creativity to attaining performance from the solar systems they are using.

* Rack installations

Equipment can be placed on building mounted racks which place panels at the correct orientation and angle to the sun, mitigating. conditions of poorly oriented and sloped roofs. While effective in providing proper conditions for equipment performance, these installations are perceived as unsightly and incompatable with the building design.

To address the issue of visual discontinuity some installations have incorporated screens, which prevent viewing the equipment and racks. While screening can be executed in a manner to blend with the building architecture in flat roof situations, it is much more problematic in pitched roof and poor orientation conditions. Screening and other such visual barriers must be large enough and spaced from the equipment sufficiently enough in order to minimize shading which negatively impacts performance.



Flush Mounting

Equipment is placed flush to existing roof slopes in order to provide a visually compatible installation with the architecture. of the building Arizona owners and contractors have successfully installed solar equipment that is accommodating to existing roof slope configurations. While effectively addressing the aesthetic issue, such placements result in less than optimal performance of equipment due to less than ideal orientations.

INTEGRATION NOW

Solar Integration - Combining building structure and form; optimal functional requirements of solar strategies; and solar equipment into the fabric of a building as a single, unified expression. Integration combines solar equipment and strategies as a part of the building fabric and architectural expression and design, sometimes coupling multiple energy and resource efficiency strategies. The building planning, design and construction provide appropriate conditions for energy efficient operations and integration of active and passive solar equipment.

Solar Integrated Buildings

A solar integrated building incorporates ideal conditions for both passive and active solar applications, from space heating and cooling to power generation to incorporation of solar hot water systems. Integrated energy buildings, and building elements, are correctly located in terms of orientation, and exposure to the sun and correctly structured to provide appropriately angled roofs and elements for optimal solar equipment performance. Additionally, an integrated solar energy building is one that evolves its design and expression - its character and style - from the attributes of its solar (active and passive) and energy.

Integrated systems solar buildings vary in execution and expression, even while maintaining common attributes and premises related to environmental conditions and resources in both passive and active solar applications

Integrated Photovoltaic Systems

New developments in photovoltaic systems are bringing panels that both generate electricity and are part of the building system. This dual function application easily incorporates to solar building design and construction that provides appropriate roof pitches for optimum solar exposure.

The photovoltaic system, a solid state semiconductor technology converting the sun's energy directly to electricity, without moving parts, or making noise, is developed as a Building Integrated PV system which integrates photovoltaic technology into the building construction, sometimes replacing or integrating with existing building materials that form the structure's exterior "skin" - i.e. the roof or wall system. The PV system then becomes a dual-purpose element, not only generating electricity for the inhabitants but also acting as the roof and/or wall of segment of the building.

Appropriately oriented and pitched roofs are also compatible for inclusion of solar hot water panels that benefit from ideal exposure and placement, and benefit the building aesthetic with integrated design elements much like skylights, that add visual interest.

Integrated Solar/Energy Building Elements –

Not all integrated energy applications must encompass entire roofs on a monolithic building block. Buildings derive aesthetic interest from component elements like clerestorey windows, chimney structures, overhangs and facial designs, and from building massing and variations in wall planes.

The integrated solar energy building incorporates solar equipment and applications. North facing rooftop clerestories can provide structure for south facing solar equipment on the back side, thereby combining two functions - one of introducing daylight - the other of producing hot water and/or electricity, within the same structural element.

This solar/day lighting element can also include operable windows and glazing to facilitate building natural ventilation exhaust of unwanted interior heat. Now there are four functions for one building element.

It provides natural illumination; it provides for natural ventilation and building cooling; it provides a place for solar water or photovoltaic panels, and it provides an interesting and dramatic building design element

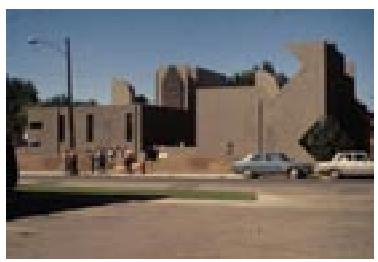
Multiple functional building elements are a strategy that lends itself to solar installations in existing buildings. While it may not be desirable to incorporate a solar device into an existing building because of installation costs related to that single action, it may be quite feasible and desirable to do a specific modifying action that has multiple benefit providing energy free illumination by day lighting; no-energy cooling by ventilation; no energy venting of undesirable hot air, and low energy water heating with the integrated solar equipment.

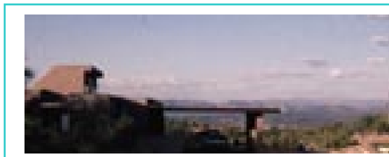
The integration approach meets multiple needs in a single action, and the energy efficiency/solar equipment savings realized will pay for itself and the construction in reduced energy bills and increased property value.

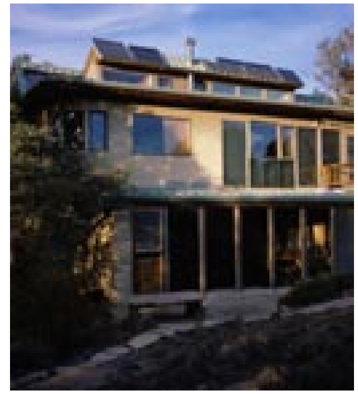
Solar applications are a growing reality in the building landscape. Traditional perceptions of aesthetics, appropriateness, and value are changing in response to the realities of energy and environmental considerations, need for energy security, and desire for energy stability and self-sufficiency.

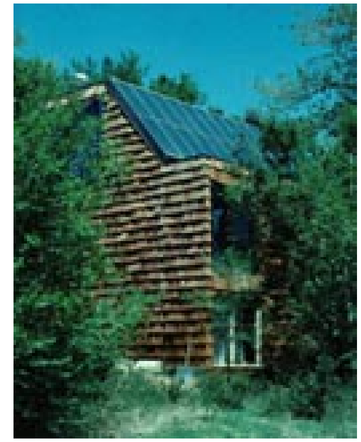
Buildings are incorporating environmental design strategies in response to site conditions, and available natural resources, and are incorporating solar strategies and equipment, which in turn affect building design and construction. Solar architecture is evolving as integrated energy buildings that define themselves in a form and expression that reflects local conditions and resources – a local environmental vernacular

The careful and considerate integration of solar, energy and environmental elements into the building, whether existing or new, is a benefit that manifests itself as the basis of a truly indigenous and local architecture.









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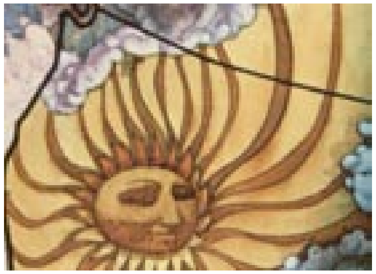
PASSIVE SOLAR ENERGY – The Starting Point

The sun's energy is an incredible bounty. The energy contained in solar rays makes its way through filtering atmosphere and is fundamental to human survival. It can also provide for our comfort.



The use of the sun's power is usually identified in 2 contexts -

PASSIVE SOLAR - that which uses natural processes without mechanical equipment or electricity and/or gas energy to operate, and

ACTIVE SOLAR - that which uses nature's resources with the inclusion of mechanical equipment driven by electricity and/or gas.

Passive and Active solar applications should be considered as the one-two punch of living with the sun. Both rely on the same strategies of heat flow, orientation, access to the sun, behavior of materials, and use of on-site resources, and vary only in the inclusion of mechanical equipment driven by external energy resources of gas and electricity,.

All passive solar applications start from a simple question -

WHAT CAN BE ACCOMPLISHED USING SITE SPECIFIC RESOURCES WITHOUT MECHANICAL EQUIPMENT AND EXTERNAL ENERGY ?

Even active system solar folks counsel starting with considerations of passive solar actions because it can:

1) directly meet needs so mechanical equipment is not necessary;
2) improve conditions in which equipment, both solar or standard, is required;
3) reduce the amount of equipment required;
4) reduce the amount of maintenance required due to less equipment used, &
5) minimize costs that accompany purchase, maintenance, and use of equipment.

What can be done by passive means – then what can be accomplished by active solar means, then how do the two combine in tandem to provide optimal effectiveness

PASSIVE SOLAR FIRST

The term Passive Solar has been identifed with heating and cooling of buildings. There is a broader context.- passive solar water heating, solar cooking, daylighting, and even passive solar devices which move louvers. Even the process of sunlight conversion to electricity can be considered a passive action since there ae no moving parts and no reliance on external energy sources.

NATURE'S CONTRIBUTION

Nature provides the tools to use - sunlight for a warming system breezes, water, earth, vegetation and materials for a cooling system We know the sun's position every day of the year and the amount of radiation it provides at any given location..

A south facing wall gets most energy from the sun than any other orientation. An angle directly perpendicular to the sun gets more energy per square foot than any other angle. The sun is less available in the winter (shorter days) than in the summer. Cool air settles and warm air rises, and this action occurs with fluids like water. Heat flows to cold, and materials have varying capability to absorb, hold, and give up heat.

We know how to capture sunlight for use, and how to mitigate unwanted heat. It is the application of this knowledge about natural processes and resources that makes passive, and active, solar so effective.

IN TUNE WITH NATURE

Passive solar use is dependent on natural elements and processes in providing comfort to people in a manner that is healthy and non-depleting of resources. Quite simply, a nature incorporating , comfort generating, security providing environment in which the building elements themselves are the "machinery" that provides security, health and comfort, and incorporates appropriate solar equipment to provide higher degrees of performance.

HISTORY

Arizona history is replete with examples of people living with the sun - both in use as a resource as well as dealing with its impacts. Arizona buildings, both private and public, used passive design straegies. Batch solar water heaters were prevalent in Arizona and included such notable historic buildings as the Ellis-Shackleford House in Phoenix and the Tempe Bakery .

ELLIS-SHACKLEFORD HOUSE

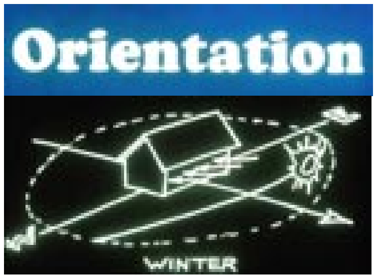
PASSIVE SOLAR ENERGY

PRELUDE TO SOLAR EQUIPMENT CONSIDERATION

There are a number of passive energy fundamentals which can be considered in reducing the amount of equipment and/or its' operation.

orientation-

It's the necessary thing



Like all direct solar applications, capturing the sun is as simple as providing a clear path to where it can do its work - be it heating water, cooking food, generating electricity, or warming a space. Orientation is a fundamental concept of solar use for passive and active systems -

A properly oriented building is critical - one that presents a south face to the sun. Likewise, properly oriented solar equipment, (solar water heater, photovoltaic panel) will have optimum performance

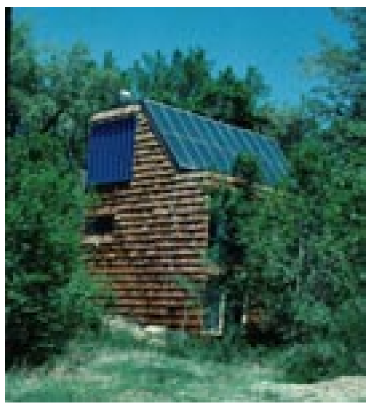
Proper building orientation establishes the context for passive design elements and the foundation for the integration of solar equipment into the building form and shape without conflict, and optimal use of solar energy.

form -

It's the right thing

Solar buildings employ a form and that is responsive to the elements that impinge upon it, as well as the passive solar design elements that are within it Good building form is also beneficial when it comes to integration of solar equipment. Instead of racks, collector panels can be blended into the building architecture, and be as seamless as a skylight or clerestorey window.

For this reason roof design (slope and orientation) is important since this is a prime and sometimes ideal location for equipment placement.



location

It's the effective thing

Location of a building. and especially the placement of the spaces within it, is a critical passive element. Habitable spaces that benefit from passive solar heating are best located on the south side, and support spaces (closets, storage areas, etc.) are placed as environmental buffers, reducing heating and cooling loads. and amount of equipment needed.

Proper location and space planning also optimizes integrated solar equipment by minimizing piping runs and complex plumbing and wiring distribution. Efficient location of equipment coupled with effective equipment reducing passive applications result in significant cost savings.

materials

It's the smart thing

All solar heating and cooling systems are based on the ability to gather and store energy for a period of time. This is accomplished by using materials which absorb and hold heat until it is needed - for heating, or to be dispelled later as in cooling. Solar water heaters use water. Solar buildings use their own structure - floors, walls, even roofs.

Some material is better than others. Glass, wood, and insulation are not good. Dense material (adobe, stone, brick,etc.) are very good. This attribute is called **thermal mass.**

Thermal mass is used in passive heating – sunlight strikes the interior surfaces which absorb the heat, then release it back later as the space cools. Cooling uses the mass as a thermal sponge, absorbing undesirable daytime heat, then dissipating it in the evening with ventilation..

Passive solar buildings utilize the very fabric of the building as part of the heating and cooling system. Heating can be enhanced by integrating a solar hot water system to run heated water through a thermal mass wall, radiant floor or roof. Integrating a PV panel to move cool water through the system also enhances mitigating unwanted heat for cooling..

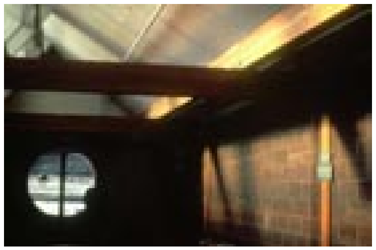
windows –

It's the clear thing

A major condition affecting building energy consumption is size and location of windows, the weakest point of the building envelope relative to heat transfer. The leakiest when it comes to energy, a square foot of glass will lose 12 times more energy than a wood wall with insulation.

As a rule, for heating, a majority of window area should be on the south side - **where the sun is!!**
East and west sides of dessert buildings should be minimized - these are the 2 worst exposures for early morning/late afternoon summer sun. Typical designer over-sizing of windows for the "feel of the great outdoors" is not an optimal situation good dessert solar design.

Clerestorey windows are a passive design tool to gain sunlight benefit to poorly lit or heated areas;.difusing direct solar impact, moderating glare, and with operable windows, for house ventilation cooling. North facing clerestorey windows, capitalizing on the eveness of light, can provide a south facing structural loca-tion for solar equipment integration..



thermal decompression–

It's the healthy thing

> Thermal Decompression – Transitioning through successive temperature zones until the zone adjacent to the building is closest to the interior temperature

A buildings' internal temperature will always be in conflict with the outdoor temperatures adjacent to it.. Heat always moves to cold - winter interior warmth moves to the exteror.. Summer heat moves to interior coolness.

In both situations, the greater the difference between inside and outside temperatures, the faster the movement of heat and the greater the amount of heat moved. More heat and cold means more equipment for mitigation. Additionally, sudden and abrupt changes in temperature is not good thing for the human health.

Mitigating extremes through Thermal Decompression is simply the layering of thermal zones, like rings of an onion, from buildingr to property line. The zones are of sequential density, in the form. of landscaping, vegetation, and built elements.

Summer heat is mitigated by the gradual density of the environment (light shading to heavy) to a point where temperatures adjacent to the building are cooler and much closer to the internal temperature,

Cold climate design is the reverse – rings of gradual warming (sun exposure, north side reflectors, heat absorbing, materials, etc) .ring the building.

Both conditions are enhanced with interior thermal zones at doorways (air locks), and the passive application of thermal decompression impact the amount cooling/heating/solar equipment needed.

PASSIVE APPLICATIONS

NATURAL LIGHTING

The sunlight received by a building will provide more than sufficient illumination. Natural lighting means no need for daytime artificial lighting, no energy used for those lights, and no utility cost..Natural light can be incorporated into most spaces, directly or indirectly, with light reflecting color choice, light shelves, and transparent and transluscent walls

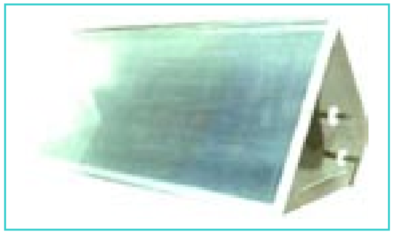
This has dual benefit - illumination, iand wintertime heating. Multi-faceted and multi-applicable, daylighting design is an effective passive solar approach which has a direct impact on the building's energy performance and energy consumption.

Add to this a solar electricity generation system (now smaller due to good design) and both daytime and nightime illumination requirements are met using the sun.

WATER HEATING

Batch or Integrated Collector Storage (ICS) System

Simply - ater in a tank or tubes within a container, exposed directly to the sun - the batch system combines solar collection, water heating, and storage into a single unitt. Direct heating makes this system compact, simple, and effective.



The "batch" approach has been used for some time and improvements in design have enhanced effectiveness.

Thermosiphon Systems

Hot water rises and cold water settles. A thermosiphon solar water heating system incorporates natural convection (without pumps) to move fluid heated by the collector to the storage tank. Hot water from the collector rises naturally to the top of the tank, cold water from the tank drops to the collector and the whole processs is a continuous circulation loop.

HEATING/COOLING

Passive solar applications for heating and cooling a building replace expensive heating and cooling using conventional electricity and gas.

Basics of passive applications are rooted in dealing with the sun (exposure to and capture of the sun's energy for warmth; protection from the sun for coolth); the materials used (for effective capture, storage, and use); and natural processes of physics for both.

Every passive system for solar heating requires exposure to the sunlight and trapping it - this is done by glazing - windows for a building and glass covers for solar panels. Every passive system is dependent upon materials which will absorb the sun's heat, store a good quantity of it and easily give it up. In a building, the effective solar material can be the structure itself, in the form of thermal mass (masonry, water, adobe,etc.).

Heat capture, storage and distribution follow a natural, predictable action.. Sunlight heats the surfaces it strikes. The amount of heat held depends on the material composition (straw is terrible, masonry is better. Generally there are 3 passive heating building concepts -

> Direct Gain,
> Indirect Gain and
> Isolated Gain

These concepts have inherant within them cooling applications as well

DIRECT GAIN

HEATING - Simply stated, sunlight comes through windows warming people directly. The thermal mass of floors and walls, or even strategically placed containers of water, struck by the sunlight, absorb the heat. Later, as the space cools, the absorbed heat is reradiated, keeping people warm in the cooler evenings..

A Direct gain system is always working, letting in not only direct sunlight but also the diffuse light of cloudy days. Like any system, optimization is the goal - so building eaves and overhangs become a design element for seasonal heat control.. Unwanted summer sun is mitigated by the eaves, keeping sunlight off of the windows, while during winter conditions, with lower sun position, sunlight skirts under the building's brow to impact building interiors..

This approach, requires careful consideration of the site, solar energy availability, and seasonal conditions, to determine the appropriate amount of windows, thermal mass, and eave design. Too many windows in an Arizona desert setting will result in a human cooker; too few windows in the mountains will result in not enough capture

COOLING - Direct Gain Avoidance is the rule, BUT the thermal mass of the building can still be used in a cooling cycle. Mass walls, floors, and roofs bcan be used as "thermal sponges" drawing heat away from people, and dumping it in the evening by ventilation (or mechancially at off peak utility rate hours).

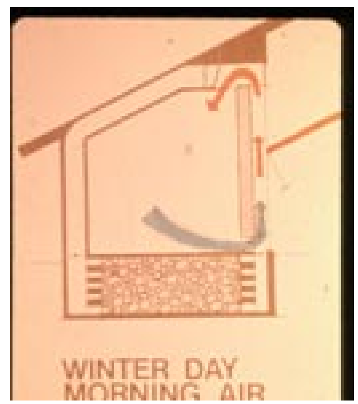
Interior control is done with moveable blinds or insulation, and cross ventiation strategic placement of wall vents (low intake at the cool side, high exhaust at the warm side). .

INDIRECT GAIN -

Indirect Gain is the "next step" from a Direct Gain system. Sunlight penetrates south facing windows (or glazing) , but instead of going into a living space, it strikes a thermal mass located directly behind the windows. The thermal mass acts as an absorber/radiator for heating and a thermal sponge absorber/disapator for cooling. There are three types of in-direct gain systems, each defined by where the thermal mass is located. The three strategies are

> * Thermal Wall and Plenum
> * Sunspace
> * Thermal Roof

Thermal Wall and Plenum



South facing windows front a thermal mass wall, to create a vertical plenum. The dark color sun side of the wall absorbs, and stores heat while acting as a buffer to the interior spaces. This moderates temperature changes and provides for extended use of thermal gain well into the evening as a delayed action radiator.

At the same time the air between the windows and the mass heats up, and exits at upper wall vents and is replaced by incoming room air at lower wall vents in a convective loop action

There are a number of examples of this application - the Trombe wall which uses masonry, and water as in Steve Baer's application using water barrel walls..

Sunspaces

Sunspaces are a combination of Direct Gain and Thermal Wall systems, with a dedicated Direct Gain area (Sunspace) adjacent to the living spaces but separated by a thermal wall or mass element.

The Sunspace has south glazing and large daily fluctuations, while the adjacent living spaces are protected from these fluctuations by the separation mass. Vents or windows in the dividing wall allow warmed Sunspace air to circulate by natural convective actions during the day, and radiate the absorbed Sunspace heat to the living spaces in the evening. The additional area of the Sunspace is often used as an enclosed solar greenhouse for plants with operable windows and vents for temperature control.

Thermal Roof

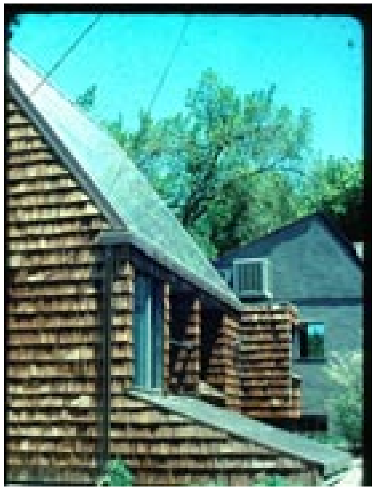
The Thermal Roof is simply thermal mass, in the form of water, on top of a building rather than at a wall. The system replaces a number of separate typical building elements. It is the roof, ceiling, heat/cool distribution system, as well as the heating and cooling system..

Water contained within clear UV inhibiting plastic beds, lie on a roof liner and heat transferring metal ceiling. Movable insulation, .the thermal "switch" for summer cooling or winter heating is above the ponds.

Winter condition – Insulation moves to expose the water beds to the sun The water beds absorb sunlight and transfer the heat to the spaces below. Panels close at night to extend the radiation process into the evening. The entire ceiling is a solar radiator, and heat is both gentle and even – no air blowing, no hot spots/cold spots..

Summer condition – Panels remain closed, and cool ponds are a thermal sponge, absorbing heat from the building.. Panels open at night, expose the beds to the night for heat dissipation by radiation and convection, and beds cool for another cycle.

ISOLATED GAIN



An indirect system - Solar collection for heat and storage is independent, using air heaters and rock bins, or water heaters and water storage tanks i a separate loop. Distribution to the building occurs in a separate, convective loop with interior air circulating through the bins or across the tanks to pick up heat and move it to the habitable spaces.

A hybrid of this system is moving solar heated water or air through a radiant floor system where the floor itself acts as the heat storage container. This variation can also use house supply or pool water to create a "cool" floor..

COOLING

Heating installations may be elements for cooling strategies. The thermal roof and some plenum wall systems can provide for both heating and cooling. Additional strategies include:

Cool Towers

Cool Towers are gravity driven evaporative coolers. Wet pads mounted high, cool warm air directly, which becomes more dense and falls to living spaces below. The falling cool air spills into the building, cooling both people and thermal mass surfaces, and pushes warmer out at strategicly placed vents. As the process continues, the cooler air settles at low points, creating cool zones and puddles - a cool enviroment in Az. desert conditions.

A "distribution" variation is the addition of a south facing thermal "chimney" - a solar air heater - to increase cool air distribution throughout the building. The Thermal chimney, located opposite and remote from the cool tower, drives interior evacuating air out of the building. This rapid venting has a drawing effect on the cool tower air which is pulled further than it would normally go, and is distributed more extensively through the building.

The solar chimney can also be designed to be a recirculating air heater, warming and distributing air from adjacent spaces during winter conditions.

Natural Cooling

There are three sources of undesirable heat -

*direct summer sun light through windows and impacting on walls and roofs;
*outside heat transmission through the building materials to the interiror; and
i*nternal heat produced by people and their equipment.

Direct solar heat gain at windows and walls can be easily controlled by preventing the sun's impact (except for good daylighting and operation of solar equipment) with vegetation, trellises, and external shading devices as wel as interior thermal insulating shutters.

Heat transmission conditions can be nullified by thermal decompression - setting up layers of vegetation and built structures like porches, water features, etc. to cool the temperatues adjacent to the building. Additionally, rough textures and light colors add to the cooling arsenal..

Heat from equipment can be mitigated by careful placement and venting, careful selection of energy efficient equipment, and by good timing - do the laundry in the evening.

SHADE
THERMAL DECOMPRESSION
EFFICIENT APPLIANCES
ACTIVITY TIMING

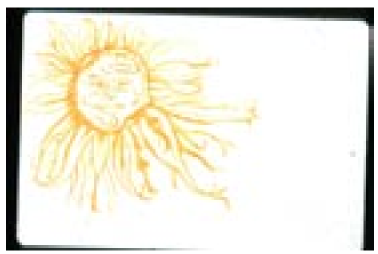
SOLAR COOKING

Use of the sun for food preparation is fun, energy saving, and saves money, both in the cooking operation, and in the cooling costs saved when the heat is taken out of the kitchen during the summer. A variety of cooking tools from box cookers to slat faced ovens are available - whether they be commercial products or hand built by the aspiring Solar Chef.

Arizona has long had a relationship in cooking with the sun, from the annual Solar Potluck in Tucson to the development of the Kerr/Cole box cooker used throughout the world.

Solar Energy has many faces and applications, and an effective Passive Solar strategy, whether in a building, a piece of equipment, or the ideal interelationship of both, incorporates natural processes and site elements to provide for comfort as well as mitigation of untoward conditions.

Passive solar applications are the first consideration in solar design and action in meeting needs, and reducing dependency and reliance on unecessary equipment. Passive design results in less dependency on equipment, less equipment, and less costs for equipment purchase, maintenance, and operation



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