AGRICULTURAL EXTENSION SERVICE UNIVERSITY OF MINNESOTA

A List of Terms in Residential Energy (Including Solar)

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Absorber
The part of a solar collector that receives and absorbs solar energy, usually having a blackened surface. The absorber transforms radiant energy into heat which is carried out of the collector by a fluid.

Absorptance
The ratio of solar radiation absorbed by a surface to the amount of radiation incident on the surface.

Active Solar
A solar heat collection system in which a fluid is circulated by mechanical power (pump or blower) through the absorber to storage or load. The absorber is usually covered with glass. Power actuated valves and automatic controls are generally part of an active system but not necessarily so. Heat collected in an active system may be used for hot water, space heating, or space cooling (via absorption cycle or Rankine cycle cooling equipment).

Air Change (see also infiltration)
A method of expressing the amount of fresh air transferred into a space, using the volume of the space as the measurement yardstick. If the fresh air transferred in per hour would fill the space entirely, the rate is expressed as one air change per hour. Air change is due to infiltration, door opening, and intentional ventilation with exhaust fans or open windows. Air change causes added heating load when outside air is colder than 65° F.

Altitude
The angle between horizontal and a line to the sun.

Ambient Temperature
Temperature of the surrounding outdoor air.

Aperture
The opening in the collector that admits sunlight. The aperture is usually covered by a transparent or translucent material. "Aperture area" is the total area admitting sunlight into a solar collector and is generally less than the gross collector area because of cover support structure.

Assembly
A building section, such as wall, ceiling, door, window or floor which is different from other types of sections. A north wall and a south wall are the same assembly if they have identical materials and thickness. A single pane window, however, is not the same assembly as a double pane window.

Audit (energy audit)
Itemizing the energy consumption of a residence in terms of heat loss through various parts of the house, water heating, air conditioning, household appliance use, and other energy uses that occur in the residence.

Auxiliary Heat (backup heat)
The heat provided by a non-solar source to maintain comfortable room temperature when incident solar radiation and stored heat are insufficient. Auxiliary heat is usually oil, gas, coal, electric, or wood. These heat sources can be ready whenever solar cannot provide enough.

Azimuth
The angle between the sun's direction and due south.

British Thermal Unit (BTU)
The quantity of heat needed to raise the temperature of one pound of pure water by 1°F. A BTU is about equal to the energy released from burning a wooden kitchen match.

Capacitance, Heat (see also sensible heat)
The quantity of heat absorbed by a unit mass of a substance (1 lb. or 1 kilogram) when the substance changes temperature by one degree (F or C). When temperature increases, heat is absorbed. When temperature decreases, heat is released. The heat absorbed or released in this fashion is called sensible heat because of the change in temperature.

Cathodic Protection
A technique of providing corrosion protection against electrolytic reactions in metal parts. A liquid in contact with two different metals (e.g., copper and aluminum) causes electrolytic action leading to corrosion, sometimes called galvanic corrosion. Some form of inhibiting the electrolytic action must be used.

Collector Efficiency (see also insolation)
The fraction of insolation which is removed from the collector by the circulating fluid, i.e., the useful energy output divided by the total incident energy. A reference period must be indicated. For example, instantaneous efficiency is defined as collector output divided by incident energy during a 15-minute period in which the incident energy rate and collector temperatures do not change. A daily efficiency, however, implies a summation of collector output during a period between sunrise and sunset, divided by a summation of incident energy during the same period.

The standard method of presenting efficiency for flat-plate solar collectors is a graph of instantaneous efficiency versus $(T_{in}-T_{ambient})/Insolation$, where T_{in} is the temperature of the fluid entering the collector, and $T_{ambient}$ is outside air temperature.

Concentrator (see also tracking collector)
A reflective surface or focusing lens for concentrating insolation onto an absorber that is smaller than the aperture of the collector. Concentrators are designed to raise collection temperature, but generally require that the collector faces squarely at the sun during operation. Hence it is necessary, in general, to track the up and down movement of the sun.

Conduction (see also conductivity)
Transmission of heat by particle-to-particle "agitation" in a solid or liquid. Thermal energy is transferred through contact of the particles (molecules). A measure of the ability of a material to conduct heat is the conductivity. The motion of particles is not visible because it occurs at a microscopic scale.

Conductance (C) (See also UA-factor)
The rate of heat flow through one square foot of an actual material for a temperature difference of one degree Fahrenheit. Conductance equals conductivity divided by thickness of the material in inches.

Conductivity (k)
A property of a material that describes the rate of heat flow through a standard reference section of one square foot area, one inch thickness, and 1°F temperature difference between surfaces. Heat flow direction is through the one square foot area.

$$Q = \frac{(k)\ (A)\ (T_2-T_1)}{(t)}$$

where Q = heat flow
k = conductivity
A = surface area
t = thickness of material
T_2 = temperature surface 2
T_1 = temperature surface 1

Note that thicker material decreases heat flow proportionately for a given surface area and temperature difference. U-value equals k/t.

Copper is an example of a material with high conductivity, glass fiber insulation has a low conductivity.

Convection
Transmission of heat by the movement and circulation of particles in a fluid (liquid or gas). Natural convection is a heat transfer mode where a warmer fluid rises in relation to a cooler fluid, because the particles in a warmer fluid are more agitated and keep themselves farther apart. Hence, the warmer fluid has less density and rises because of buoyancy relative to the cooler fluid. Forced convection means that some external power, such as a blower, causes the fluid to circulate.

Controller
A component that senses a condition in the solar heating system such as collector or room temperature, then signals a pump to begin operating or valves to change position. A control "system" is made up of controllers, and electric, hydraulic or pneumatic powered devices to regulate the processes of collecting, storing, and using solar heat.

Degree-Day (heating degree-day)
A unit defined as one 24 hour period where outside temperature is one degree below 65°F. The number of degree-days per day is equal to 65°F minus the average temperature of the 24-hour period. The monthly heating load is very nearly proportional to the number of degree days in the month.

Design Temperature
A temperature used to calculate the maximum heat loss rate from a building. The heating system is generally sized to maintain comfort room temperature during maximum heat loss conditions.

Dew Point
The temperature at which condensation will begin to occur for a given humidity in the air.

Differential Temperature Controller
A device which senses the difference in temperature between two separated points in a solar system, e.g., collector and storage. When the difference exceeds some preset value, the controller signals pumps and valves to actuate.

Diffuse Solar Radiation
Radiation which reaches the collector after scattering and reflection in the atmosphere. Diffuse is measured by blocking out the direct sun beams with a disc such that no direct radiation can reach a light-sensitive surface directed squarely at the sun. Diffuse is downward directed, i.e., it does not include radiation reflected from atmosphere below the collector or from the earth's surface.

Direct Solar Radiation
Radiation which reaches the collector aperture by passing through the atmosphere on a straight line from the sun. Also called beam component of total radiation.

Emittance
A property of a surface that indicates propensity to emit or release thermal radiation. Emitted radiation energy is a function of temperature as well as emittance. Radiation wavelengths longer than visible light are called infrared. A solar absorber will operate in the temperature range where infrared radiation is emitted. Much higher temperatures, such as for the tungsten filament in an incandescent light bulb, are necessary to emit visible light. Low emittance is a desirable property of absorbers because thermal losses are thereby reduced. Special "selective" coatings are sometimes applied to the absorber to lower emittance while preserving a high absorptance.

Envelope
The part of a building that separates indoor spaces from outside air. Indoor spaces are maintained at a consistent comfortable temperature and, therefore, heat losses occur through the envelope when outdoor air is colder than the comfort setting.

Equinox
Time of the year when the sun is midway between its highest and lowest altitude. The vernal equinox (first day of spring) is March 21. The autumnal equinox (first day of autumn) occurs September 21. Day and night are each 12 hours at the equinox dates.

Fixed Collector (see also tilt)
A solar collector that does not track the sun and cannot be seasonally adjusted. Fixed collectors are stationary, i.e., the tilt does not change.

Flat-Plate Collector (see also aperture and absorber)
A solar collector with an aperture area approximately equal to the absorber area. The transparent cover and absorber are generally flat, although convex clear plastic covers have been used and absorbers sometimes have an extended or corrugated surface to increase heat transfer rate. The back and side of a flat-plate collector are insulated.

Flat-Plate Collector, Augmented
A category of collector designs where reflectors are used to concentrate insolation onto the aperture of the collector.

Fluid
Any non-solid substance such as air, water, antifreeze, freon, etc. used to convey heat.

Greenhouse Effect
The combined effect of a transparent cover over an absorber, where solar radiation is transmitted through the cover and absorbed by the absorber, but infrared (thermal) radiation from the warm absorber has difficulty in radiating back through the cover. The cover is semi-opaque to infrared wavelengths. Hence, a heat buildup occurs in the collector because of the trapping effect of the cover, and the "wavelength shift" of the absorber.

Head Pressure
The maximum pressure before a pump will no longer induce a flow of liquid. Pumps are often rated in feet of water, which can be visualized as a vertical pipe full of water with a pump at the bottom. The maximum height of such a pipe is equal to the head pressure expressed in feet of water.

Header, Inlet
An inlet header is a duct or pipe that directs fluid flow to a number of passageways through an absorber, or directs flow to the inlets of a number of solar collectors. The term "manifold" is sometimes used.

Header, Outlet
An outlet header is a duct or pipe that collects fluid flow from a number of passages through an absorber, or collects flow from a number of solar collectors. The term "manifold" is sometimes used.

Heat-of-Fusion (see also phase change)
A term having the same meaning as "phase change" applied to the case of a liquid to solid change, or vice versa.

Heat Pump
A mechanically powered device, usually with an electric motor driven compressor, that can move heat from a source at a given temperature to a space at a higher temperature. A fluid circuit is utilized, where evaporation of the fluid draws heat from the source and condensation of the fluid releases heat to the space. The source may be any substance so long as the temperature is above some minimum level. Earth, water, air, and rock are commonly used heat source reservoirs for heat pumps. Operation is comparable to an air conditioner "in reverse."

Heat Transfer Medium
A fluid used to transfer heat from one point in a system to another point.

Heat Exchanger
A device with at least one fluid flow passage designed to add or remove heat from a solid or another fluid. The passage is typically a pipe, and exchanges heat to the fluid through the walls of the pipe. The pipe is immersed in another fluid, such as an air stream, or imbedded in a solid such as earth or ice. Extended surface on the pipe, such as fins, allow more rapid heat transfer through the walls. Other heat exchangers include extended surface by creating flow passages between two sheets of metal.

Horizontal Insolation (see also insolation)
The incident solar radiation on a horizontal surface. Most weather observation stations that record insolation measure with a horizontal pyranometer at the earth's surface.

Infiltration (see also air change)
The basic cause of air change, i.e., outside air that leaks into a comfort space through cracks and holes.

Infrared Radiation
Radiation comprised of wavelengths longer than red light in the visible spectrum. The term "thermal radiation" is sometimes used, to indicate radiation from warm or hot surfaces as a mode of heat transfer. Heat radiated by objects less than 1000°F (594°C) is primarily infrared. The term "long-wave" radiation is also used.

Insolation (see also tilt)
Total INcident SOLar radiATION on a surface (horizontal or tilted up to 90°). A combination of direct radiation from the sun and diffuse radiation from the sky, but does not include radiation reflected from the ground. In the English System, insolation is expressed in units of BTU/ft^2-hr. If the surface in question is not horizontal, the tilt must be referenced since insolation varies considerably with tilt. The term "solar flux" is sometimes used.

Insulation (see also R-value)
A material intended to resist the flow of heat. "Insulation value" has the same meaning as R-value.

Joule
A unit of energy in the Metric System (SI) defined as the acceleration of one kilogram one meter per second through a distance of one meter. A Joule is equal to the energy expended by one watt of electric power in one second. Another term for Joule is meter-Newton, analogous to the English "foot-Pound."

Kilojoule (see also joule)
A unit of energy in the Metric System (SI) equal to one thousand joules. A kilojoule is equivalent to 0.948 BTU, i.e., a kilojoule is a slightly smaller amount of energy than a BTU. A kw-hr (kilowatt-hour) is equivalent to 3600 joules, or 3413 BTU.

Kilowatt (see also joule)
One thousand joules per second or one kilojoule per second (a metric units definition of energy or power). A kilowatt of heating is equivalent to 3,413 BTU per hour. A kilowatt of energy delivered by electrical heaters requires, however, about 10,000 BTU per hour of fuel burned at a power plant because of the natural laws of converting energy from one form to another. A kilowatt is equal to about 1-1/3 horsepower.

Kilowatt-hour (kw-hr)
One kilowatt (one thousand joules per second) delivered for a one hour period. Hence, a kw-hr is equal to 3,600,000 joules, or 3600 kilojoules. One kilowatt-hour of heating is equivalent to 3,413 BTU. If electricity is used for heating, however, about 10,000 BTU of fuel is burned at the generating plant to produce one kilowatt-hour of electric heat (because of natural laws of energy conversion).

Langley (see also insolation)
A unit of insolation equal to one calorie/sq. cm. To convert langleys/minute to BTU/sq. ft-hr, multiply by 220. To convert langleys/minute to watts/sq. meter, multiply by 697. To convert langleys/day to BTU/day, multiply by 3.69.

Latent Heat (see also phase change)
Heat energy contained in a fluid or solid by reason of its state rather than by its temperature. Water vapor, for example, releases heat as it condenses even though the temperature of the vapor may remain constant.

Life-Cycle-Cost (LCC)
A method of determining the net result, over a period of time, from investing in an energy-saving improvement such as solar heating, insulation, or better windows. The LCC method uses lifetime ownership and operating costs for comparison of improvement options, rather than just first costs. A complete LCC analysis includes inflation, loan interest rates, and future savings for the expected life of the improvement (often as much as 20 years, resale value can also be included). Property tax and income tax deductions can be included, but the effect is usually minor because these two items tend to cancel each other (unless property tax relief is available, or special income tax credits are offered).

Load
1. The end use of energy in a system, e.g., water heating or space heating.
2. The amount of energy *per unit time* required to perform the task of water heating and/or space heating.
3. The amount of energy *per unit time per degree-per hour* required to perform the task of space heating. Definition three is also called the "UA-factor," where U is the overall thermal transmission coefficient for the building (including air infiltration) and A is the envelope area. A "daily UA-factor" would be equal to 24xUA (BTU/°F-day).

Makeup Air
1. Air which is needed for combustion of a fuel and must be supplied to the furance. If not drawn in from outside, makeup air is taken from heated air in the house. Infiltration replaces the heated air.
2. In ventilation system, makeup air indicates air drawn in from outside that replaces exhausted air.

Management (energy management)
Methods of reducing energy consumption, primarily through changes of habit or household operation. Nighttime thermostat setback is an example. Time of day electricity pricing is a policy to promote management aimed at reducing the peaks in electricity demand.

Micro-climate
Local climate conditions experienced surrounding a building, e.g. wind speed, soil temperature and shading. The slope of the ground, type and height of vegetation, and presence of surface water have an effect on micro-climate. Air pollution also has an effect, over a somewhat broader geographic scale.

Outgassing
Release of gases by materials or components, usually during exposure to prolonged high temperature or reduced pressure.

Orientation
Building or solar collector position with relation to points of the compass.

Passive Solar (see also thermosiphon)
A category of building designs for capturing and retaining solar heat without the use of mechanically powered pumps or blowers. The "aperture" for solar radiation is commonly a window, and the absorber is integral with some method of storage. Surfaces of stone, brick, concrete, or water tanks inside a window typically are used to absorb and retain the solar heat. Natural thermosiphon effect distributes heat to rooms or additional heat storage areas. The heat capacitance of the building's interior is important because surplus heat in the daytime must be absorbed to prevent uncomfortably high room temperature, and heat released from the interior materials at night is necessary to maintain comfort.

Phase Change
Transformation from one state, or phase, to another, e.g. solid to liquid, or vice versa, of a substance. Phase change in solar heating refers to heat storage systems which may be used to absorb heat at a nearly constant temperature as the storage substance liquifies, or to release heat as the storage substance solidifies.

Photovoltaic Conversion
A process of converting solar energy directly to electricity in semiconductor or other photovoltaic devices.

Plenum (see also pressure drop)
An air compartment. A warm air plenum feeds air into a number of distribution ducts. A cool plenum collects air from a number of return ducts. The pressure drop within a plenum is usually very small. The terms trunk duct or main duct are sometimes used where a more noticeable pressure drop occurs.

Pressure Drop
The difference in pressure that is needed to cause a fluid to move steadily through a pipe, duct, collector, or storage system. The direction of flow is always with decreasing pressure, e.g., the inlet to a component will be at a higher pressure than the outlet. Small passageways or other resistance to flow necessitate higher pressure drop for steady flow. Increased flow rate requires either increased pressure drop or lower resistance.

Pyranometer (see also insolation)
A device to measure total (direct and diffuse) insolation.

Refrigerant
A liquid such as freon that is used in heat pumps or air conditioners to absorb heat from a surrounding substance as it evaporates. Refrigerants are cir-

culated under pressure in a pipe circuit, and vaporized through a nozzle within the pipe to induce evaporation.

Relative Humidity
The ratio of water vapor in the air to the amount of vapor (by weight) that the air could hold before condensation would begin, at a given air temperature.

Retrofitting
Designing and installing solar heating for an existing house.

R-value (thermal resistance)
A measure of the ability of a material or air space to resist the flow of heat. For an assembly, R-value is the reciprocal of the U-value, $R = 1/U$. R-value is a simple common denominator for describing all types of insulation and all kinds of dwelling construction. For example, an assembly rated R-19 has the same insulation ability no matter what its material or thickness.

Tables often give resistance per inch of thickness. Simply multiply by thickness to obtain the actual R-value. For example, an assembly of two materials with no interior air spaces would be figured as follows:

$$\text{R-value} = R_o + R_1 t_1 + R_2 t_2 + R_3$$

where R_o = resistance of inside air film
R_1 = R per inch of material 1
t_1 = thickness of material 1
R_2 = R per inch of material 2
t_2 = thickness of material 2
R_3 = resistance of outside air film

Heat flow is equal to temperature difference divided by R-value:

$$Q = \frac{(T_{outside} - T_{inside}) \times \text{area}}{\text{R-value}}$$

Selective Surface (see also emittance, absorptance, absorber)
An absorber surface having a coating with properties of high absorptance and low emittance, i.e. a high fraction of incident solar energy is absorbed but a small fraction of the possible emitted infrared radiation occurs.

Sensible Heat (see also specific heat capacity)
Heat that is associated with a change of temperature, e.g. heat released as a solid object drops in temperature. Often used in discussion of air conditioning systems to distinguish from the latent heat in water vapor mixed with air.

Solar Constant
The average amount of solar radiation reaching the earth's atmosphere (extra-terrestial radiation). Equal to about 2 langleys per minute (2 cal/cm^2-minute) or 442 BTU/ft^2-hr or 1395 watts/meter^2.

Solstice (winter solstice, summer solstice)
Winter solstice is the time of the year when the sun is at its lowest altitude. This occurs on December 21. Summer solstice is the time of the year when the sun reaches its highest altitude, which occurs on June 21. The summer solstice is the longest sunlit day of the year. The winter solstice is the shortest.

Specific Heat Capacity
Amount of heat required to raise one unit mass of a substance by one degree of temperature. In the English system, the specific heat of pure water is 1 BTU/lb-°F. The specific heat of concrete is about 0.20 BTU/lb-°F. Hence only one-fifth as much heat is required for a given temperature increase, or only one-fifth as much heat is released (per pound) for a given temperature drop, when comparing concrete to water.

Stagnation or "No-Flow" Temperature
The maximum temperature of the absorber expected when the heat transfer fluid has not been circulating.

Stratification
Layering of temperature. A rock bed, for example, can be cool at one end and hot at the other, with a "layer" of transition occurring somewhere in-between. A water tank generally has some stratification where warmer water tends to stay at the top.

Sun Path Diagram
A projection of the sky as a vault, similar to a map, that can be used to determine sun position and to calculate shading.

Sun Rights
A legal issue concerning the rights to non-interrupted sunlight, i.e. the right to be free of shading on solar collectors as might be caused by a neighbor's building or trees.

Temperature Swing
A fluctuation of temperature from a maximum to a minimum during a given period. For example, a passive heat storage mass will reach a maximum temperature during sunlight hours, then will drop in temperature as the mass radiates heat into its surrounding space. A large temperature swing means that a larger number of heat units are released during the period, for a given mass. Comfort considerations may impose a limit on the temperature swing in a comfort space.

Thermal Mass (thermal inertia)
1. The tendency of a building made with heavy materials to remain at the same temperature or to fluctuate slowly.
2. The overall heat storage capacity of the materials in a building.

Thermosiphon (see also convection)
Air flow that occurs between areas of different temperature because heated air rises and cool air drops (due to gravity alone and the difference in air density). The terms natural convection or gravity air are also used.

Tilt (see also fixed collector)
Refers to the angle between horizontal and a given flat-plate solar collector. Tilt is generally designed so that the collector is approximately perpendicular to the direct sun beam at mid-day in December.

Tracking Collector (see also fixed collector)
A collector that follows the sun, i.e. maintains the aperture normal to the direct beam of the sun. Concentrating collectors with a point focus must track both altitude and azimuth angles of the sun. Linear focus collectors generally track only the altitude of the sun. A flat-plate collector benefits in terms of performance when tracking is used, but due to complexity and cost of tracking, flat-plate collectors are usually fixed.

UA-factor (see also U-value, load, assembly, degree-day and conductance)
A factor that gives heating load per degree per hour. Combines the U-value (thermal transmission coefficient) of each assembly with the area of each assembly. Also generally includes heating of infiltration air:

$$\text{UA-factor} = U_1 A_1 + U_2 A_2 + \ldots U_n A_n + CV$$

where $A_1, A_2 \ldots A_n$ = Surface areas of assemblies 1,2, . . . n (in ft^2)
C = heat capacity of air per ft^3 = .018 BTU/ft^3-°F
V = volume air change rate (ft^3/hour)

U-value (thermal transmission coefficient)
The overall transmission coefficient of an assembly, equal to the reciprocal of the total resistance offered by the assembly: U = 1/R total. Hence, U-value is calculated by first adding individual resistances (R-values of each component, each air space, and each of the surface air films) then taking the reciprocal of the total. An assembly is a type of building section, such as wall, ceiling, window, door, or floor, which is different from other sections.

Zone
A room or group of rooms within a building that can be controlled for comfort differently than other areas of the building. A residence may be planned with three zones of heating control, for example, depending on the kind of activity in each zone.

Other residential energy publications available from the Agricultural Extension Service, University of Minnesota.

Interested in Solar? Roger A. Peterson, Extension Folder 383.

A List of Terms in Residential Energy, Roger A. Peterson, Extension Folder 384.

First Things First, What to Do Before Investing in Home Insulation, Extension Folder 386.

Minnesota Energy Prices, Roger A. Peterson, Extension Folder 387.

Hot Water and Your Home Energy Budget, Roger A. Peterson and Wanda W. Olson, Extension Folder 388.

Understanding Heat Loss and Energy Conservation Codes, Roger A. Peterson, Extension Folder 389.

Air Conditioner Efficiency, Roger A. Peterson, Extension Folder 394.

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