UNIVERSITY OF FLORIDA

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A Guide to Residential Energy Efficiency in Florida[1]

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This guide looks at various construction options that can help a builder meet or exceed the Florida Energy Efficiency Code's minimum Energy Performance Index (EPI) requirements. Approached sensibly, energy efficiency can be accomplished at a reasonable cost and without sacrificing aesthetics or living standards.

This guide can also help buyers and real estate agents identify home features that save energy and evaluate the potential energy performance of a home with respect to heating, air conditioning and water heating.

Each construction feature that affects the energy use in a home is discussed.

ENERGY EFFICIENCY - A FACT OF LIFE

As a result of the oil crises of 1973-1974, 1980 and the more recent 1992 Gulf War, many Americans have become concerned that our dependence on foreign oil can be counterproductive to our national interest. Priorities have changed as Americans have begun buying more fuel-efficient cars, adjusting thermostats, adding insulation and avoiding unnecessary driving. United States automobile manufacturers failed to recognize the public concern for energy efficiency and, as a result, lost millions of dollars to foreign manufacturers of smaller, fuel-efficient cars (Figure 1).

Public interest in energy efficiency has grown steadily, and people now want houses and cars that save energy and money. Contractors, builders, real estate agents and financial institutions can avoid the mistakes of the automobile industry by recognizing this consumer concern. Some older homes have energy bills as high as mortgage payments. Many prospective home buyers are now asking to see utility billing histories. They want to know what they can expect to pay for energy.

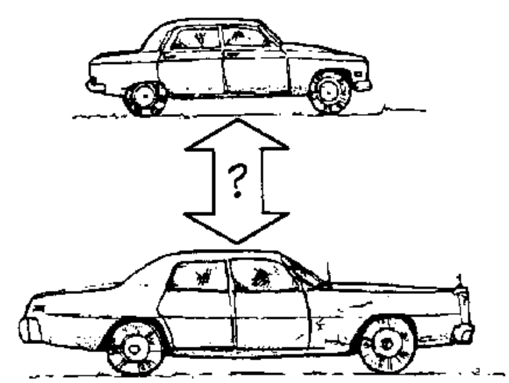

Figure 1. Is your home an energy guzzler like an older car?

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Builders and real estate agents are finding that energy-efficient houses are easier to sell than conventional houses. Some lending institutions are also considering energy efficiency when qualifying prospective home buyers, since lower utility bills can make monthly mortgage payments more affordable.

Almost everyone is familiar with the Environmental Protection Agency (EPA) mileage estimates for automobiles. Homes built under Section 9 of the Florida Energy Efficiency Code have a similar energy indicator, the Energy Performance Index or EPI. Car manufacturers strive to achieve the highest possible EPA mileage ratings for their automobiles. For builders, however, a low EPI means a more energy-efficient house.

In order to comply with Section 9 of Florida's Model Energy Efficiency Code for Building Construction, new homes must have an EPI of 100 points or less. Section 9 of the Code focuses on three main areas that affect home energy efficiency:

- thermal envelope (see Glossary) and the associated heating system
- thermal envelope and the associate air conditioning system, and
- the hot water system.

Since Florida extends through more than six degrees of latitude, there are significant climatic differences between the northern and the southern portions of the state. In preparing Section 9 of the Code, the state was divided into three zones to reflect these climatic differences (Figure 2).

Since October 1980, new homes must meet requirements of Florida's Energy Efficiency Code. By law, the Code is reviewed every two years. Each time

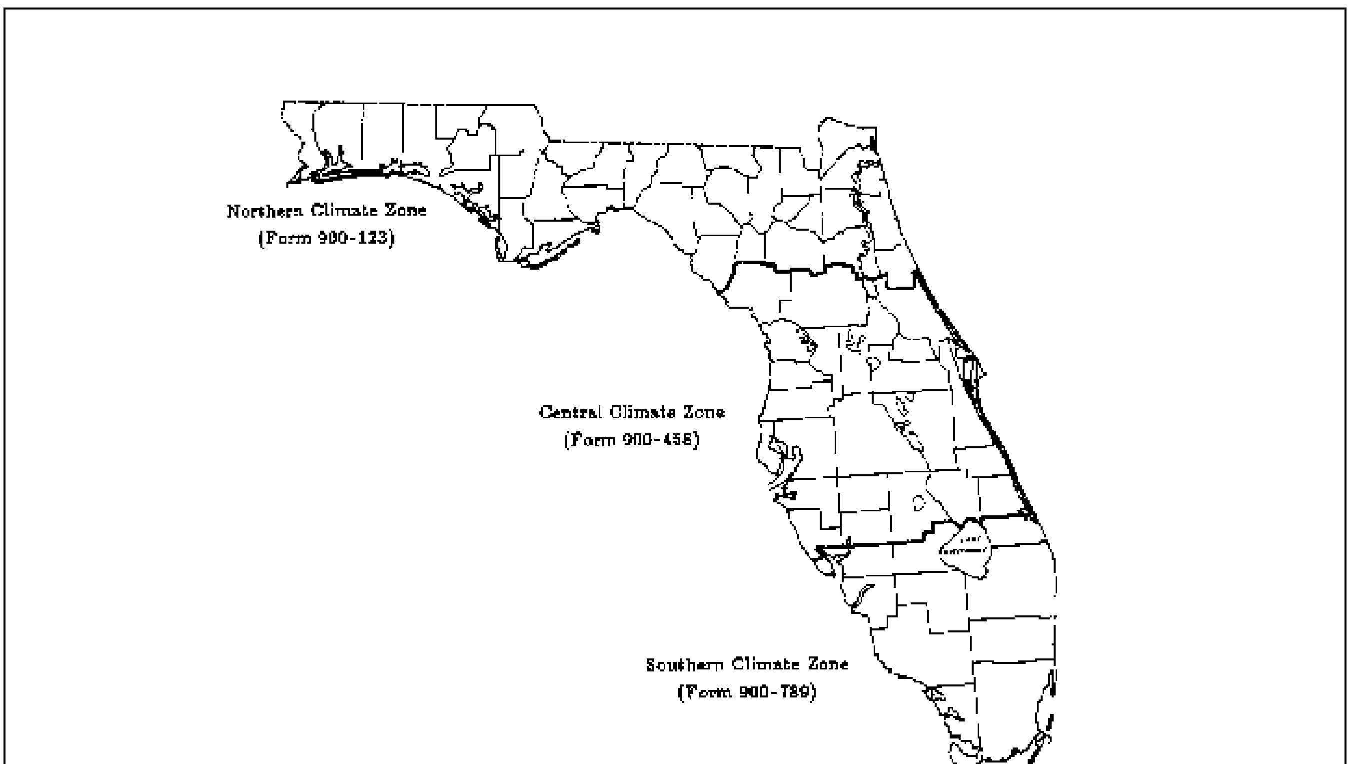

Figure 2. Florida climate zones.

the Energy Code has been modified it has been made more stringent. In many cases, homes built after April 1993 with an EPI of 90 are more energy efficient than a home built in 1981 with an EPI of 60 points. (The lower the EPI number, the higher the energy efficiency, as a general rule.)

The Energy Performance Index is an excellent indicator of the potential energy performance of the air conditioning, heating and water heating systems of a house. It can be very useful when comparing the potential energy efficiency of one house to that of another. Considering only these factors, a 50-point house should use half the energy of a 100-point house with the same square footage and number of bedrooms if they were built under the same edition of the Energy Code.

However, a family's lifestyle is a major influence on real energy efficiency. Two families living in the same home at different times may use energy very differently. In general, the number and age of family members as well as the amount of time they spend at home affect energy consumption. The way lights, appliances and equipment are used by a family also influences energy usage.

If you plan to buy a new home, it is prudent to ask the builder about the EPI. Remember, the lower the EPI, the better. Some new homes may have been built under the Prescriptive Section (10) of the Energy Code. This method allows builders to construct each component to a prescribed standard without having to calculate the total EPI. Generally, homes built to these standards will have a computed EPI of less than 100 points (Figures 3a and 3b).

Currently, the Florida legislature and the Department of Community Affairs are developing procedures for adoption of a Building Energy Rating System, which is similar in format to some of the appliance rating systems that people have been accustomed to seeing on yellow tags. The appliance rating systems indicate how much money would be spent to operate the most and least efficient appliance of that category, and then indicates how that particular appliance compares. The Building Energy Rating System will consider energy and use factors such as space cooling, space heating and water heating to develop the final Florida Building Energy Rating Guide. Currently, this program is voluntary for residential applications, but may be required for all new residential buildings in the near future (Figure 4).

FACTORS AFFECTING ENERGY USE

Each house is unique. Design, function and cost will be given different emphases by different builders and buyers. Energy efficiency can be satisfied without excessive expense and without sacrificing aesthetics. Construction costs will depend on the route taken to achieve the point goal.

The energy use of a house is affected by many factors (Figure 5) including:

- floor plans (location of kitchen, bedrooms, etc.)*
- north-south orientation
- window type and function
- man-made shading or overhangs

- trees and shrubbery
- insulation and construction materials
- water heating method
- characteristics and efficiency of air conditioning and heating units
- door selection
- use of fans
- location of washer and dryer.

* No credit given in energy code.

USING THE GUIDE

This guide examines various construction features. Each has several characteristics that influence energy efficiency. For example, the energy efficiency of a window may be affected by its size and the area that opens, as well as by tinting, shading, insulation values and orientation. Each of these main factors will be examined with recommendations offered.

HEAT TRANSFER CONCEPTS AND COMFORT

Before looking at energy efficient design and construction techniques, a brief discussion of the physics of heat transfer and the physiology of comfort might be helpful. Heat always flows from hot to cold. Heat is transferred by conduction, convection, radiation and change of state (heats of vaporization and fusion). The greater the temperature difference, the greater the potential for heat transfer. One way to decrease temperature differences would be to adjust the thermostat to a level required for comfort. Utility companies recommend settings of 78° to 82°F in summer and 65° to 68°F in winter. If the temperature outside is 92°F and the thermostat is set at 75°F, there is a 17°F temperature difference. Setting the thermostat to 78°F means only a 14°F temperature difference, almost an 18% reduction of conductive heat transfer.

Conductive heat transfer occurs between surfaces of different temperatures that are in contact with any substance or combination of substances between them. It is the transfer of energy between agitated molecules or atoms. Metals are good conductors because they transfer heat rapidly. Insulations are poor conductors. Conductive heat transfer can be reduced by insulation materials such as batts, fill, or foam plastics. Conductive heat transfer occurs in direct proportion to the temperature difference between the outside surface and inside surface, i.e., wall or ceiling. Conductive heat transfer is less extensive in Florida than in northern states where temperature differences are more extreme from winter to summer.

Convective heat transfer occurs when a gas or liquid, such as water or air, at one temperature is replaced with a gas or liquid having a different temperature. Rising warm air replacing cooler air is an example of convection. In the winter, warm air leaks out of cracks and holes in the house and is replaced by cold air. In the summer, hot moist air replaces cooler dry air through the same cracks and holes. This process is called infiltration. Convective heat loss is reduced by making the home reasonably air-tight through sealing, weather-stripping, caulking and proper design. Convection occurs at the outer skin of a structure via wind, which is usually greater in winter than summer.

Radiant heat transfer occurs when electromagnetic waves travel through a vacuum or air between surfaces with different temperatures. The earth receives all its solar heat through radiation. Generally, dark, rough surfaces will absorb radiant heat and become warm; smooth, shiny surfaces will reflect the radiation. Dark, rough surfaces typically are more effective at radiating heat than smooth, shiny surfaces. Radiant heat transfer can be limited by shades and use of radiant barriers such as aluminum foil (Figure 6).

Our feelings of warmth or coldness are influenced by the surface temperature of objects around us, air circulation and humidity. Depending on our level of activity, we feel cold when objects around us are cold, when air is blowing around us (wind chill factor) and when the humidity is high.

Keeping in mind the ways heat is transferred and how our comfort is affected will aid in the understanding of how energy saving design and construction techniques work.

FLOOR PLAN AND GEOMETRY

Geometry

The design of a house will influence both its cost and its energy efficiency. A 1600-square-foot house with a length-to-width ratio of one-to-one (square) will have 25% less material in its exterior walls than a comparable house having a four-to-one radio (long rectangle). Reducing wall area usually translates into reduced energy losses.

Some designers believe that a house with a length-to-width ratio of 1.7 to 1 is best for Florida's hot, humid climate. This is true only if the long sides face north and south and if the house has adequate overhangs. If a long rectangular home is desired, it is best to orient the long sides so they face south or north (Figure 7).

Floor Plan

The floor plan of a home should be carefully considered. A house that is compactly designed is more efficient on a square foot basis than one that rambles. Floor plan design can reduce losses through the thermal envelope and improve the water heating efficiency of a house. For example, unconditioned areas such as the closets, workshop and garage can provide a thermal and infiltrating barrier if located adjacent to the exterior walls, especially on the east or west sides of the house.

Trees and Shrubbery

A house construction site should be carefully selected. Trees can save large amounts of energy that would otherwise be required to cool or heat a house. In south Florida, deciduous or evergreen trees that shade a house can substantially reduce the amount of energy needed for air conditioning. In central and north Florida, it pays to take advantage of trees with deciduous leaves. They provide shade in summer, and, after losing leaves in the fall, allow the warming rays of the run to strike the house in the winter. Deciduous trees on the east, southeast and southwest sides of a house save energy that would otherwise be spent to cool the house in summer, yet do not interfere with the sun's natural warming in winter.

If you are able to choose your site or choose your landscaping that will be near the home, select wind resistant trees. The less wind resistant trees should be placed at a considerable distance from the home, if practical.

One of the most durable trees is our Florida state tree — the Sabal palm. Palm trees in general are very resistant to high winds. Other wind resistant trees were shown to be hickory, pecan, live oak, bluff oak, bald cypress and American ash. Trees that do not do well in high winds and could cause damage to homes and buildings were identified to be laurel oak, water oak, sweet gum, sugarberry, cherry laurel and pine trees.

Planting fast-growing trees on a bare lot can provide savings in just a few years. Evergreens located north and northwest of a house are a barrier against cold winds. Shrubbery can be strategically planted to channel prevailing summer breezes into the home or placed close to the house on the north side to help reduce infiltration and the wind chill factor. This saves energy that would otherwise be needed for heating (Figure 8). Your county Cooperative Extension Agent will be able to advise you about the type and location of trees and shrubbery best suited for your needs.

GLASS

While glass is necessary for aesthetics, ventilation and lighting, it is the major cause of energy loss through the thermal envelope. Generally, about 55% of the total energy used in a Florida house is for heating and cooling. Approximately 20% of the energy used is for heating water; the remainder goes for operating equipment or appliances. Windows, skylights and glass doors can account for up to 60% of the energy used for heating and cooling.

Glass Areas

Minimizing glass areas, while maintaining design and ventilation requirements, can be energy efficient. Good design practice provides no more than 10% of the wall areas of single-story houses should be allocated for windows and glass doors; in two-story houses, no more than 6%. In addition to saving energy, reducing glass areas will lower construction costs. Horizontal glass provides more panoramic views and better ventilation than vertical windows of the same square footage. Windows extending below 3 feet or above 6 1/2 feet in height add little to function.

Orientation, Overhangs, Shading/Tinting

The amount of solar radiation coming through glass areas is directly affected by regional factors such as the brightness and angle of the sun. As much as 270 British thermal units (heat units called BTUs) of direct and diffused solar radiation can enter a home or building through each square foot of glass. In other words, if sunlight strikes one 6 x 8 foot clear glass window on the west wall of a room, the cooling effect of more than one ton of air conditioning is required to remove the heat gained from this source alone. This is more than eight times the heat gain due to conduction and infiltration through the rest of the wall. Windows facing other directions, such as north or south, may still have twice as much indirect radiant heat gain than conduction and infiltration losses through the rest of that wall.

House orientation, overhangs and shading or tinting are interdependent characteristics that affect the energy gained and lost through glass. The direction windows face (orientation) will greatly influence the energy required for heating and cooling. As a result of seasonal variations in the sun's declination, properly designed overhangs (about 2 1/2 feet) can almost entirely eliminate direct solar radiation through south-facing glass in the summer, yet still allow the sun's heat to enter a house in the winter. New hurricane concerns may effectively limit overhangs to between 18 and 24 inches. If so, awnings can provide a dual function of shading glass and providing hurricane protection. West-facing and east-facing windows and glass doors should be kept to a minimum. This is because the sun's direct radiation is difficult to control in the summer and, therefore, overhangs must be excessively long (and expensive) to be effective (Figure 9).

Awnings placed just above windows can be helpful in controlling the sun's direct radiation. If properly designed, awnings can also provide protection against wind damage from hurricanes.

Installing solar screens or tinted windows having a low shading coefficient (Sc) may be an attractive energy saving option. The lower the shading coefficient, the more efficient the screen or tint is at reducing solar radiation. Clear glass has an Sc of 1, while some of the better solar screens or films have an Sc as low as 0.2. An Sc of 0.2 would reduce the direct solar radiation by 80%.

If a significant number of east- or west-facing windows are desired, it may be necessary to use solar screen or window tint to reduce the EPI to an acceptable value and to maintain comfort. Disadvantages of solar screen or tinted glass are reduction of natural lighting and solar gain in the winter. Use of solar screen or tinted glass on north- and south-facing windows, while providing some benefit in south Florida, is not considered cost effective.

Ventilation

In Florida's moderate climate, there are between 90 and 120 days of the year when outside temperatures and humidity levels fall within the comfort zone, if humidity levels permit (if dew point is below 60°F). During this mild weather, use of natural ventilation can result in large energy savings. Glass areas should be designed so natural ventilation is provided.

Cross Ventilation

A house that provides cross ventilation during periods of mild weather can achieve considerable energy savings. Each room designed for cross ventilation should have operable windows located in the middle of adjacent walls or on opposite walls. Properly designed wing walls can provide natural ventilation through the windows on the same wall (Figure 10).

In general, a two-story house offers better opportunities than a single-story house for incorporating ventilation into the design. If picture windows or clerestory windows are used, they should be designed to open.

Insulated Glass and Infiltration Control

Glass is a poor insulator against cold and heat. Double-pane windows are better than single-pane windows because they provide an insulating air space between layers of glass. Cracks around window frames are another way unwanted cold or hot air enters a house. Storm windows can be effectively used as added insulation and as an extra barrier against infiltrating winds.

Double-pane windows, because of their expense, generally provide a poor economic payback in Florida. However, to lower the EPI of a house with large window areas or to reduce outside street or airport noise, it may be necessary to install double-pane windows. Where a large expanse of glass causes an infiltration problem, proper caulking or weather-stripping will help. Do-it-yourself storm windows may be the best option in the cost vs. benefit equation.

It should be noted that double-pane windows will still allow 15 to 20 times more cold or hot air to be transmitted into or out of a house by conduction and infiltration than a well-insulated wall of equivalent size. Since there are many characteristics affecting the energy efficiency of glass (orientation, overhangs, shading coefficient, insulation and infiltration), the best overall solution is to reduce window areas as much as possible (Figure 11).

INSULATION - GENERAL CONSIDERATIONS

Insulation materials come in many forms and types. Some have long chemical names such as ureaformaldehyde, polyisocyanurate, polyurethane and polystyrene. Other materials such as mineral wool and cellulose are also common. Each type of insulation has distinct characteristics that should beevaluated: some are less expensive than others; some will shrink, thus reducing performance; and some may produce unpleasant odors. In the past, some insulation materials were attacked by insects and provided a refuge for vermin, and some were not properly treated or installed, causing fire hazards. New standards have eliminated many of the above problems. Some foil-back insulation boards can be used as radiant and vapor barriers, if applied correctly with an air gap. Insulation should be selected for its quality, characteristics and, most importantly, its insulating capability — commonly referred to as "R" value. R-10 insulation is twice as effective as R-5 (Figure 12).

Proper selection and installation of insulation are very important if the theoretical R-value of the insulation is to be attained and retained. Tests supervised by the American Society of Testing and Materials, Owens-

Corning and the University of Florida have shown that walls insulated with R-11 batts often performed at only R-7 or less because of shoddy installation techniques. For example, an R-11 fiberglass batt will perform at less than R-6 if compressed to half the designed thickness (3 1/2 inches). Also, if insulation is blown or poured into an attic, it will not perform as expected unless it is evenly raked to the proper depth and density.

Gaps that are often found around wiring, electrical outlet boxes and piping runs, and next to framing members create areas of high heat transfer and convective thermal drafts. This causes a disproportionate degradation of the insulation system. In fact, research has shown that gaps in insulation within wall cavities amounting to only 3% of the total area will reduce the actual performance up to 20%.

Installation of insulated exterior sheathing will significantly improve the overall performance by insulating studs and gaps (Figure 13).

Infiltration Control and Vapor Barriers

The Energy Code encourages the use of an "infiltration barrier" on the exterior side of the insulation. This prevents wind from circulating air within the insulation. If properly sealed at the seams and ends, plywood and builders felt will serve as an infiltration barrier, but not as a moisture retardant. A vapor barrier/retarder will essentially stop moisture transmission of diffusion in addition to serving as an infiltration barrier. Common vapor barriers or retarders are 6-mil polyethylene sheet and aluminum foil-backed paper or boards. Contrary to northern construction practices, a vapor barrier, including vinyl wall coverings, installed next to the conditioned space is not recommended. Otherwise, water may condense on the vapor retarder surface within the wall cavity when the inside temperature is below the outside dew point in the summer. This could wet and degrade insulation, deteriorate wall components and contribute to mold and mildew. **Vapor barriers are not recommended on the conditioned side of walls in Florida buildings** (Figure 14).

If a house is to be constructed on a concrete slab, a vapor barrier of plastic sheeting should be placed under the slab. Without a vapor barrier, moisture will migrate from the ground through the porous slab and into the house. If a house is to be built off-grade, a sheet of 6-mil polyethylene plastic should always be placed directly on the ground under the house to prevent moisture from moving upward from the soil. If a vapor barrier is not used on the ground, higher than normal humidity levels will occur in the crawl space and moisture will infiltrate (Figure 15). Ground and under-slab vapor retarders that are installed with seal seams and without holes or tears will also restrict radon entry into a home.

To further control air and moisture infiltration, windows and doors should fit snugly in their frames. Weather seals should be used, and window and door frames should be caulked. If frame construction is used, the sole and top plate should be sealed with a high-grade caulk or foam sealant. Holes drilled for electrical wiring and plumbing should be sealed also. Low-cost foam covers for wall outlets may be added in existing homes. If possible, kitchen and bathroom exhaust fans should be designed with automatic dampers and timer switches. Gas and oil heating systems should have automatic flue dampers if local building codes permit.

Since most of the moisture entering the home in the summer and exiting in the winter occurs through infiltration, taking steps to control infiltration will make the house more comfortable. Keeping humidity at manageable levels also eases control of mold and mildew.

Humidity, air movement and temperature determine comfort levels. High humidity helps our bodies hold heat. Dry air absorbs moisture from the skin at a rapid rate and produces a chilling effect which can only be offset by increasing air temperature. In the winter, for example, a properly humidified house is as comfortable at 68°F as a dry one is at 72°F. By lowering the temperature four degrees, up to 20% can be saved on heating bills.

WALLS

Next to glass, walls generally account for the largest amount of energy lost from a house--about 15 to 20%. There are several major factors affecting the energy performance of walls. These include insulating characteristics, surface area, infiltration and thermal mass.

Insulating the exterior walls is important to energy performance. Wall insulation with a value between R-11 and R-19 is recommended for Florida. This is equivalent to 3 1/2 to 5 1/2 inches of fiberglass batt or about 1 1/2 to 2 1/2 inches of expanded polyisocyanurate (Figure 16).

Sealing the openings where wiring and piping run through floors and ceilings at the sole and top plates is very important. In residential construction, up to 20% of infiltration heat losses are caused by this problem. There are a variety of caulking and foam products suitable for this purpose. Some local codes forbid use of foam sealants because of fire safety concerns.

For builders desiring to super-insulate their walls, using a 2 x 4 inch stud system with R-11 batts and R-5.4 or 7.2 foil-back rigid insulation as sheathing provides an excellent system complete with infiltration and moisture control if the seams are caulked or sealed properly (Figure 17). This system will be superior to a 2 x 6 inch stud system with R-19 batt insulation because the studs and gaps in the batts are insulated by the insulated sheathing, i.e., the sheathing will provide better infiltration control.

Thermal Mass

Thermal mass refers to the ability of building materials to store heat. Thermal mass tends to delay the effect of large temperature variations occurring over short periods of time.

In all climate zones in Florida, the average daily temperatures for both summer and winter are just a few degrees above or below the comfort zone. Florida winters may produce an early morning temperature of 35°F which often climbs to 70°F later in the day. Concrete walls and slabs, through their thermal mass, can dampen the effect of this large fluctuation in temperature. If insulation is placed on the outside of a massive wall, the positive effect of thermal mass can be maximized. Houses with large thermal mass will use less energy for heating and cooling than a frame house of light construction insulated to the same value. Taking advantage of the temperature stabilization effect of thermal mass, heating and cooling systems can be down-sized to provide better humidity control and lower investment costs.

Earth-sheltering or berming a home will provide energy savings through thermal mass and temperature stabilization, but it is usually more expensive than conventional construction. Nevertheless, there may be cases where it is appealing and cost effective. An architect or engineer should be consulted about the feasibility of earth-sheltering because of special structural and moisture problems.

Use of fiberglass batt insulation between furring strips is not recommended on block walls, especially if plastic sheeting is used to hold it in place before the drywall is installed. This insulation is likely to become damp from moisture condensation, thereby degrading its performance and causing mildew problems. In addition, moisture may also cause corrosion or rotting of metal and wood building components. The preferred method is to install 3/4 to one-inch foil-back rigid insulation directly to the block, nailing the furring strips through this insulation into the block and applying the gypsum board over this to make an excellent wall system complete with vapor and radiant barrier (Figure 17).

CEILING

Between 10 and 25% of the energy lost from a house is lost through the ceiling/roof system. The surface area of a ceiling also affects the EPI rating. Once again, the shape of a home will influence heat transfer. Given the same air conditioned square footage and insulation values, a two-story house has up to 50% less of its ceiling and floor areas exposed to the outside environment as a one-story house. This means reduced energy losses. A two-story house may have slightly more surface area, but there will still be a net gain in energy efficiency.

Adequate ceiling insulation is important in Florida. Ceiling insulation should have an "R" value between 19 and 30. R-19 is equivalent to about 6 inches of fiberglass batts, 3 inches of expanded polyurethane or 6 inches of blown cellulose. Conductive insulation is particularly enhanced by installation of radiant heat barriers (Figure 18).

Radiant Heat Barriers

Florida Solar Energy Center studies show that use of radiant heat barriers provides excellent savings in both summer and winter. This is especially true when installed in the attic. A radiant heat barrier is material that either reflects radiant heat or inhibits the emission of radiant heat. Aluminum foil or plastic with a reflective film coating are excellent examples.

Radiant barriers are not very expensive. The cost varies between 6 and 20 cents per square foot. This compares with 12 to 50 cents a square foot for conventional conductive insulation such as fiberglass batt, cellulose and rigid foam.

Radiant barriers are effective because radiation heat gain is often larger than either conductive or convective heat gains during the summer. For example, in an attic, the conductive heat gain that conventional insulation corrects is usually the smallest component of the three forms of heat transfer (conduction, radiation, convection). A radiant heat barrier must have an air space next to a reflective side to be effective (see Figure 19). It cannot be sandwiched between two materials; the air space is critical to its performance. A 1/4 inch air space will work fairly well, but 3/4 inch or more of air space seems to work better. Also, by covering 90% of your attic, the radiant heat barrier performs at 90% of its potential effectiveness. This is not the case with conventional insulation, which is much less than 90% effective with 90% coverage.

The Florida Solar Energy Center did some interesting studies with radiant insertion. A test cell was built duplicating the infrared heat conditions typical in attics. Conventional R-19 (5 1/2 inch) fiberglass insulation was placed on one side of the cell and one thin sheet of aluminum foil placed on the other side between the infrared heat source and a surface simulating the inside ceiling. The results showed one thin sheet of aluminum foil performed better than the conventional R-19 insulation in reducing the total rate of heat transfer.

Placing a radiant heat barrier at either the option 1 or option 2 location shown in Figure 19 will allow the insulation to perform near the theoretical values and will reduce attic heat gain up to 50%. Option 2 is better because dust accumulation is minimized (Figure 19).

Radiant barriers also provide an excellent benefit in the winter by keeping the warmer inside temperatures from radiating to the cold outside. Studies by Philip Fairey, a Florida Solar Energy Center researcher, indicates that the winter benefit from radiant insulation is larger than originally suspected, particularly when used with conventional insulation. His findings suggest that when a radiant barrier is used with R-19 conventional insulation the combination outperforms R-30 insulation in Florida's winter conditions.

If there is no natural or man-made shade on east and west walls, radiant heat barriers should be considered. The surface of sunlit walls may get 20 to 30 degrees warmer than the air temperature. A radiant barrier again will enhance the conventional wall insulation (Figures 16, 17 and 19).

The most cost effective approach is to staple radiant heat barriers directly to the underside of the roof sheathing during construction (foil side down toward air space).

One other word of caution. Try to keep aluminum foil from coming in direct contact with anything alkaline, such as masonry surfaces, unless it is protected by waterproofed paper or plastic coating. Aluminum will deteriorate or corrode when in the presence of alkaline materials.

FLOOR

If a house is built off-grade (a crawl space under the house), the floors should be insulated to about R-11. If the insulation has a vapor barrier, it should be neutralized by puncturing or slicing to avoid condensation problems. However, a vapor retarder such as 6-mil plastic sheeting should be placed on top of the soil under the home.

SLAB

A house built on-grade (a concrete slab for the floor) should have a closed-cell, expanded insulation board of about R-6 placed around the perimeter of the slab. This is equivalent to 1 inch of expanded polyisocyanurate board or about 1 1/2 inches of expanded polyurethane board. The insulation should extend from the top of the slab to the top of the foundation, or down at least 18 inches. Perimeter insulation is not as critical in south Florida, where winters are mild, as it is in the colder climate of north Florida (Figure 20).

DOORS

Doors should be carefully selected since they can account for up to 10% of the energy lost from a house. Tight-fitting, foam-filled metal doors have magnetic weather-stripping and thermal break should be considered. Properly fitted solid wood doors are also effective. Because of air leaks around the edges, avoid the use of sliding glass doors. In north Florida, longer and colder winters make the addition of storm doors effective in reducing energy losses.

Duct Design

With most central heating and cooling systems, all conditioned air is transported to the living area of the home through ductwork. Duct design, therefore, merits special attention in order to improve energy efficiency.

The best option is to place ducts inside the conditioned area so that less energy is lost by thermal transmission or air leakage. Ductwork can be concealed by placing it along the edge where the ceiling meets the wall and covering it with paneling. Ducts placed in the attic or the crawl space beneath the floor lose as much as 15% of the heating and cooling energy even if insulated. If it is not possible to locate ductwork inside the conditioned space, it should be insulated to R-6 with aluminum foil reflective backing. Insulation batts can often be placed over ducts in attic spaces with success, but only after insuring ducts are wrapped with insulation with a vapor retarder on the outside and connections are tight and properly sealed. If flex ducts are used, individual lengths should be kept under ten feet (Figure 21).

Air Conditioning

In south and central Florida the majority of the energy used in a house is for cooling. In north Florida the amount of energy used for cooling is about the same as that used for heating. Since they are major energy users, air conditioners should be selected based on their efficiency. The EER (Energy Efficiency Ratio) or SEER (Seasonal Energy Efficiency Ratio) are indicators of an air conditioner's efficiency. The higher the EER and SEER, the better. Currently, most units are still rated with EER values. EER and SEER values may differ for the same model and are not suitable, therefore, for direct comparison.

An air conditioner with a SEER ratomg of 10.0 is 25% more efficient than one with a SEER of 8.0. Water-source geothermal heat pumps with SEER ratings of over 18 are currently available. Theoretically, this model would use less than half as much energy to produce the same cooling effect as a conventional air conditioner with a SEER of 9.0. At 8¢ per kilowatt hour, a three-ton air conditioner with a SEER of 8.0 would cost about $176 per month if operated 16 hours each day; one with a SEER of 8.5 would cost about $117 per month to operate, representing a savings of $59 a month. The total cost--initial and energy--must be considered when selecting equipment to provide the most environmental package.

There are relatively few gas-absorption cooling systems in Florida. The efficiency of gas-absorption systems is measured by their COP (Coefficient of Performance). Since it takes heat to operate absorption systems, COP is defined as BTUs removed (cooling) per BTUs used (heat supplied).

Properly sizing an air conditioning system is very important. In the past, many builders or air conditioning installers selected air conditioners based on one ton per 500 square feet. With the new tighter energy standards, this rule of thumb is no longer a good approximation. To be accurate, a sophisticated sizing procedure and calculation that includes latent (humidity) load should be done by a qualified air conditioning contractor. There still is a tendency to select a larger unit than is necessary for cooling. Bigger is not better. Oversizing the air conditioning systems, say 3 1/2 tons instead of 2 1/2 tons, may lead to high humidity and mildew problems. Oversized systems tend to quickly cool the air to the desired temperature. Longer running times are necessary to lower the relative humidity to the 50 to 60% range. In addition, units that frequently cycle on and off will wear out quicker and have more maintenance problems.

If the air conditioner has an air-cooled condenser, it should be placed in a shaded area free from obstructions to air flowing to and from it.

Multi-zone Air Conditioning and Heating

A multi-zone air conditioning and heating system saves energy by providing selective conditioning for only those areas of a house that are occupied. Generally, a house having two or more thermostats that control temperature levels in areas separated by solid doors qualifies as utilizing a multi-zone system. Occupants of a house with one air conditioning system for the living areas and another system for bedrooms will normally have the bedroom unit turned off in the daytime and the living area unit turned off at night. This can result in significant energy savings when compared to a single air conditioning system of the same size and efficiency (Figure 22).

Heating System

In south Florida, the heating system is not as important as the cooling system. However, even in mild winters heating may still account for 18% of the total energy used to condition a house. Many houses have electric heating systems that are not as efficient as natural gas or heat pump systems. Electric strip heat is not cost effective in north and central Florida. Even in south Florida, strip heaters should be critically evaluated before making that selection.

If natural gas is available, serious consideration should be given to using a natural gas furnace for heating. Generally, this will cost two-thirds less to operate than electric resistance heating. The efficiencies of gas furnaces are rated by their Annual Fuel Utilization Efficiency (AFUE). The higher the rating, the better. A gas furnace with an AFUE over 0.80 should be selected. Some of the newer models have AFUEs over 0.90, which means they effectively use over 90% of the heat contained in the gas. Liquid petroleum gas (LPG) is considerably more expensive than natural gas per unit of heat available and falls behind electric heat pumps and oil as a fuel of choice.

Heat pumps are a close second to natural gas in terms of utility cost savings. A heat pump used as an air conditioner in the summer is designed so its operation can be reversed to supply heat in winter. The efficiencies of different heat pump models vary considerably. The efficiency of a heat pump in the heating mode is measured by the Coefficient of Performance (COP). The COP of conventional models (air-source) drops as outside temperatures get colder. When temperatures approach freezing, the COP of some models may drop to 1.0 (about the same as electric resistance heat). On a seasonal basis, however, the COP of a conventional air-to-air heat pump may average between 3.0 and 4.0 depending on the model (Figure 23).

Water-source heat pumps take advantage of the moderate ground water temperatures in Florida to exchange heat and are generally more efficient than air-source models. Even when outside temperatures are below freezing, some water-source heat pumps may have a COP of 5.0 or higher (five times better than resistance heat) in the heating mode. High cooling efficiencies, SEERs greater than 15, are also frequently obtained with these models.

To heat a typical 1500-square-foot home in north Florida in January may cost $160 (at (0.08 per kilowatt-hour) if an electric strip heater is used. If this heat were supplied by a water-source heat pump with an average COP of 5.0, the electric heating bill would be about $32. This is a savings of $128 for one month. Since water-source heat pumps require between one and two gallons of water per ton per minute, the price and availability as well as the quality of water should be considered prior to their selection. Due to high water and sewage costs, water-source heat pumps may be practical for all areas of Florida, particularly west central Florida, unless closed loop systems are used. Most of Florida's water management district offices have regulations/requirements which must be followed.

WATER HEATING

After the energy required for air conditioning and heating, the next largest user of energy in a home is the water heater. Water heating normally consumes 15 to 25% of all home energy. Although hot water consumption varies greatly from one family to another, the average Florida household consumes more than 24,000 gallons per year.

Natural gas water heaters are the most cost- effective way to heat water. If natural gas is available, savings of 50 to 70% may be realized if this option is chosen compared to using electric water heaters.

If 24,000 gallons per year is considered to be an average family’s hot water requirement, using a conventional electric water heater will cost from about $305 per year in south Florida to $361 per year in north Florida (assuming 10% jacket and line losses and electricity costs of $0.08 per kilowatt-hour).

To make electric water heaters more efficient, they may be used in conjunction with solar energy or heat recovered from air conditioners or heat pumps. Heat recovery methods hold a first-cost advantage over solar. Life-cycle costing gives properly designed and installed solar water heating systems a comparable economic benefit.

Heat recovery units designed to remove heat normally wasted in air conditioning systems are usually an attractive option. These are relatively low in cost and provide a good energy saving payback, especially if used with a heat pump system.

Dedicated heat pump water heaters should be considered as a replacement for worn-out water heaters. A heat pump water heater provides hot water at 1/3 to 1/2 the cost of heating water with electric resistance elements. They provide cool air as a by-product. The disadvantage is that they may cost three to five times more than a conventional electric water heater. Contact your county Cooperative Extension office or utility company for information and fact sheets on both heater types.

Some builders and homeowners may eliminate solar systems from consideration because they mistakenly believe that a home is not properly oriented or that the collector must be located in a manner that is unattractive. Generally, collectors should be mounted on an unshaded area of a south-facing roof and tilted horizontally at an angle between latitude -5° and +15°. They can also be placed on a suitable ground location. In most of Florida, collectors can face up to 45° east or west of south, and can be tilted horizontally at angles between 15° and 40° without major decreases in annual performance. However, a reliable authority should be consulted about each specific application and location of solar equipment.

Winter performance of a solar system can be improved by tilting it at a higher angle. A collector can often be placed flat on the roof and parallel to the roof slope. In this way the collector resembles a skylight and looks more attractive (Figure 24).

A solar water heating system designed to supply 80% of the home’s hot water needs and supple- mented with electric heat can save a typical household about $214 per year in south Florida when compared to a conventional electric heater supplying all the hot water. In north Florida almost $253 per year can be saved. (For more information, contact the Florida Solar Energy Center, 300 State Road 401, Cape Canaveral, FL 32920-4099, (407) 783-0300.)

When designing a new home, clustering the kitchen, bathroom and laundry areas near the hot water heater will reduce pipe transmission losses. Long pipe runs will result in the water cooling before it arrives at the point of withdrawal, and the water remaining in the pipes will lose heat through dissipation. Heat dissipation from hot water pipes can be reduced by insulating them from the tank to the point of use.

Although a greater volume of hot water is used in bathrooms, the number of withdrawals is the important consideration. Since there are more withdrawals of hot water from kitchen faucets than bathroom faucets, it is important that the pipe leading to the kitchen sink to be a short one.

Although many water heaters have built-in insulation, it pays to use additional insulation. Two or more inches of additional insulation is generally less expensive and more energy and efficient and cost effective than water heater timers (Figure 25).

Selecting durable, efficient plumbing fixtures can also save energy. A water faucet developing a leak of 90 drops a minute will waste about 1000 gallons of hot water per year.

VENTILATION

Ceiling Fans

In the summer, the cooling effect of ceiling fans can allow the thermostat to be raised as much as 4°F. Raising the temperature from 78°F to 82°F can reduce cooling costs as much as 20%. This relationship applied to all areas in Florida.

Ceiling fans may also be effective in the winter because they reduce hot air stratification that normally occurs near the ceiling. They can reduce the energy lost at the ceiling and provide a more even and comfortable temperature distribution (Figure 26).

Whole House Fans

A fan that ventilates the entire house can quickly empty the house of unwanted cigarette or cooking smoke. Fans can also save energy by reducing the number of hours an air conditioner works, providing outside temperature and humidity conditions permit. Generally, a whole house fan will pull outside air through the home, expelling it out the attic. This reduces attic temperatures and introduces a wind chill effect throughout the house. A whole house fan can be used during mild weather, such as morning and evening hours of summer and during the spring and fall. Neither ceiling nor whole house fans are as effective during periods of high summer humidity. A whole house fan should be sized to move at least 1 1/2 cubic feet of air per minute (CFM) for each square foot of conditioned area. Thus, a 1200-square-foot home should have at least an 1800 CFM fan. Whole house fans should not be operated during periods of high humidity such as after thunderstorms. If they are, the air's moisture is absorbed by wood, paper and cloth. A good rule is to operate them only if the dew point temperature is below 60°F.

Washer and Dryer Location

Washers and dryers should be located in an unconditioned space. If you place a clothes dryer in a conditioned area, this will allow warm, humid outside air to infiltrate through the dryer vent during the summer, and cold air to enter the house during the winter. Both a washer and a dryer will add to the air conditioning load by transmitting heat and moisture during the washing and drying cycles.

Thermostats

Installing automatic setback thermostats on the heating and cooling systems is a wise investment. Automatic thermostats turn off or reduce the operating time of an air conditioner when a family is away from the house. In the winter, night setback timers can automatically reduce the temperature at bedtime. Blankets can then be used effectively. Remember that the energy required for heating and cooling can be reduced up to 30% for each six degrees that inside temperatures are brought closer to outside temperatures (Figure 27).

Fireplaces

A crackling fire on a cold winter night is an undeniable source of enjoyment and comfort. However, its value as a heat source can be very deceptive. A fire generates a large flow of air through the house and up the chimney, as the air in the house that has already been heated rises. Although the fire is heating the immediate area by radiant heat, it is cooling the rest of the house by expelling warm air up the chimney. If the thermostat is set at 68°F and the outside temperature is below 38°F, a fire in the fireplace can cause the heating system to use more energy than it otherwise would by pulling in cold, outside air for combustion. Energy losses can be reduced some by lowering the thermostat setting and closing the doors to the rest of the house while the fireplace is being used.

A fireplace that supplies the fire with air from a direct outside duct eliminates the above problem. Installing glass doors in front of the fireplace is also an effective way of reducing heat losses. Some fireplaces are manufactured with a double wall which allows room air to circulate behind and around the fire. These can be very energy efficient if coupled with an outside air source (Figure 28).

COSTS OF CONSERVING

Many of the energy-efficient techniques and measures suggested in this guide cost little or nothing to incorporate into the design of a house. Most can be incorporated into the mortgage. Utility savings often exceed the increase in mortgage payment.

By building wisely, compliance with the **Florida Model Energy Efficiency Code for Building Construction** is possible without greatly increasing construction costs. The end result is an energy-efficient house that will benefit builders, real estate agents and homeowners (Figure 29).

GLOSSARY OF TERMS

AFUE (Annual Fuel Utilization Efficiency). AFUE is the efficiency rating required by the Department of Energy (DOE) for residential gas- and oil-fired heating equipment. Unlike steady-state conditions, this rating is based on average usage conditions, including on and off cycling, as described in standardized DOE test procedures.

AIR CONDITIONING. The process of treating air to control simultaneously its temperature, humidity, cleanliness and distribution to meet requirements of the conditioned space.

BTU (British Thermal Unit). The standard unit for measuring a quantity of heat energy, such as the heat content of fuel. It is the amount of heat energy necessary to raise the temperature of one pound of water one degree Fahrenheit. 1 BTU per minute = 17.6 watts.

BUILDING ENVELOPE. The elements of a building which enclose conditioned spaces through which thermal energy may be transferred to or from the exterior.

COEFFICIENT OF PERFORMANCE (COP). An efficiency rating of heating equipment determined by the ratio of the output (the heat supplied to the conditioned space) to the input (the energy required to run the equipment, usually measured in BTU/hr).

CONDENSATION. The process of changing a vapor into a liquid by extracting heat from the vapor (for water vapor it produces or gives off the removal of about 960 BTU/lb).

CONDITIONED FLOOR AREA. The horizontal projection (outside measurements) of that portion of space which is conditioned directly or indirectly by an energy-using system.

COMMUNICATION, SOIL. Ability of soil to breath or pass gases. Good communication is necessary to disperse soil-polluting gases such as radon.

DEGREE-DAY. A unit measuring the extent to which the outdoor mean (average of maximum and minimum) daily dry-bulb temperature falls below (in the case of heating) or rises above (in the case of cooling) an assumed base. The base, unless otherwise designated, is normally taken at 65°F for heating and cooling. One degree day is counted for each degree of difference below (for heating) or excess over (for cooling) the assumed base for each calendar day on which such deficiency or excess occurs.

EFFICIENCY, OVERALL SYSTEM. The ratio of useful energy (at the point of use) to the thermal energy input for a designated time period, expressed as a percentage.

EMISSIVITY. The ratio of the total radiant flux emitted by a body to that emitted by an ideal blackbody at the same temperature.

ENERGY. The capacity for doing work; taking a number of forms which may be transformed from one into another, such as thermal (heat), mechanical (work), electrical and chemical; in customary units, measured in kilowatt-hours (kwh) or British thermal units (BTU).

ENERGY EFFICIENCY RATIO (EER). The ratio of net cooling capacity in BTU/hr to total rate of electric input in watts under specified operating conditions.

ENERGY PERFORMANCE INDEX (EPI). Measure of the relative energy performance of a residential building with the same geometry and orientation for which the envelope, HVAC and water heating components have been optimized.

FUEL. A substance which may be burned to give heat or generate electricity; a nuclear substance used to generate electricity.

HEAT. The form of energy that is transferred by virtue of a temperature difference.

HEAT TRAP. A device designed to prevent the convection of heat from a hot water tank through the hot water distribution line.

HEAT PUMP. A device consisting of one or more factory-made assemblies which normally include an indoor conditioning coil, compressor(s) and a refrigerant-based heat exchanger, including means to provide heating or cooling functions.

HUMIDISTAT. An instrument which measures changes in humidity and controls a device(s) for maintaining desired humidity.

HVAC SYSTEM. A system that provides either collectively or individually the processes of comfort heating, ventilating and/or air conditioning within or associated with a building.

INFILTRATION. The uncontrolled flow of air into or out of a building through cracks around windows and doors, other openings, and porous materials caused by differences in air pressure and/or density resulting from wind and/or temperature changes.

INFILTRATION BARRIER. A product or system designed to limit the free passage of air through a building envelope component (wall, ceiling or floor). Such products and systems may be continuous or noncontinuous discrete elements which are sealed together to form a continuous barrier against air infiltration.

INSULATION. Any material with a high resistance to heat transmission (R) normally used to retard heat transfer in buildings.

KILOWATT (kW). 1000 watts. 1 kW hr = 3414 BTUs.

MULTI-ZONE SYSTEM. A building is considered to have a multi-zone heating and/or cooling system if the building is divided into more than one zone or area by walls and closeable doors, and each area has a separate temperature control.

NONDEPLETABLE ENERGY SOURCES. Sources of energy (excluding minerals) derived from incoming solar radiation, including wind, waves and tides, lake or pond thermal differences; and energy derived from the internal heat of the earth, including nocturnal thermal exchanges.

OPAQUE AREAS. All exposed areas of a building envelope which enclose conditioned space, except openings for windows, skylights, doors and building service systems.

OUTSIDE AIR. Unconditioned air taken from the outdoors and, therefore, not previously circulated through the system.

PACKAGED TERMINAL AIR-CONDITIONER or HEAT PUMP (PTAC). A factory-selected combination of heating and cooling components, assemblies or sections contained wholly in a single cabinet and intended to serve a room or zone.

PERMEABILITY. A property of a substance which permits passage of water vapor.

PERMS (PERMEANCE). The ratio of water vapor transmission through a surface to the vapor pressure difference across that surface; permeance or perms is normally expressed in grains/(sq ft)(hr) per mercury vapor pressure difference.

POWER. In connection with machines, power is the time rate of doing work. In connection with the transmission of energy of all types, power refers to the rate at which energy is transmitted; in customary units, it is measured in watts (W) or British thermal units per hour (BTU/hr).

RADIANT BARRIER. A system consisting of an air space with a minimum 3/4-inch thickness bounded by at least one surface with high reflectance and low emissivity in the thermal (infrared) radiation spectrum.

RADIATION or RADIANT. The flow of energy across an open space via electromagnetic waves such as visible light; the process in which energy in the form of rays of light and heat is transferred from body to body without heating the intermediate air acting as a transfer medium.

RECOVERED ENERGY. Energy utilized which would otherwise be wasted from an energy utilization system.

REFLECTANCE. The ratio of the light reflected by a surface to the light falling upon it.

RELATIVE HUMIDITY (RH). The ratio of water vapor in the air to the amount it could potentially hold at that given temperature.

REHEAT. The application of sensible heat to supply air that has been previously cooled below the temperature of the conditioned space by either mechanical refrigeration or the introduction of outdoor air to provide cooling.

ROOF ASSEMBLY. All components of the roof/ceiling envelope through which heat flows, thereby creating a building transmission heat loss or gain, where such assembly is exposed to outdoor air and encloses a heated or mechanically cooled space. The gross area of a roof assembly consists of the total interior surface of such assembly, including skylights exposed to the heated or mechanically cooled space.

ROOM AIR CONDITIONER. An encased assembly designed as a unit primarily for mounting in a window or through a wall or as a console. It is designed to provide free delivery of conditioned air to an enclosed space, room or zone. It includes a prime source of refrigeration for cooling and dehumidification and means for circulating and cleaning air, and may also include means for ventilating and heating.

SEASONAL ENERGY EFFICIENCY RATIO (SEER). The total cooling of a central air conditioner in BTUs during its normal usage period for cooling (not to exceed 12 months) divided by the total electric energy input in watt-hours during the same period.

SPLIT SYSTEM. Air conditioning system or heat pump with condenser and air handler in separate cabinets. For the purpose of the Code, both sections of the unit must be matched and tested by ARI standards or certified by testing procedures established by ARI to meet the minimum HVAC efficiency standards established in this Code.

SPECIFIC HEAT. The property of a material's ability to absorb heat; the quantity of heat in BTUs needed to raise the temperature of 1 pound of the material 1°F (specific heat for water = 1 BTU/(lb)(°F).

SUN SPACE. A totally enclosed, unconditioned space which is built substantially of glass, attached to the conditioned space of the building, and is designed primarily for winter space heating.

SYSTEM. A combination of central or terminal equipment or components and/or controls, accessories, interconnecting means and terminal devices by which energy is transformed to perform a specific function, such as HVAC, service water heating or illumination.

TASK LIGHTING. Lighting designed to provide illumination over a relatively small area or confined space without providing any significant general surrounding lighting.

TEMPERATURE. The measurement of the level of motion or agitation of molecules and atoms, with reference to the tendency to communicate heat or matter.

THERMAL ENVELOPE. Exterior portions of a house through which energy is transferred. This energy transfer is the major influence on the amount of heating or cooling required to maintain comfort levels.

THERMAL MASS or INERTIA. The tendency of heavy materials used in construction to resist temperature change through their ability to store large quantities of heat; ability of materials to dampen or average significant daily temperature swings.

THERMAL RESISTANCE (R-VALUE). A measure of a material's resistance to the flow of heat; the unit time for a unit area of a particular body or assembly having defined surfaces with a unit average temperature difference established between the two surfaces per unit of thermal transmission; (ft^2-hr-°F/BTU); it is the reciprocal of the U-value or (1/BTU/hr-ft^2-°F). The higher the (R) value, the higher the insulating value of the material.

THERMAL TRANSMITTANCE (U). Overall coefficient of heat transmission (air to air) expressed in units of BTU per hour per square foot per degree F. It is the time rate of heat flow. The U value applied to combinations of different materials used in series along the heat flow path, single materials that compose a building section, cavity air spaces and surface air films on both sides of a building element.

THERMOSTAT. An instrument which measures changes in temperature and controls device(s) for maintaining a desired temperature range.

UNITARY COOLING AND HEATING EQUIPMENT. One or more factory-made assemblies which include an evaporator or cooling coil and a compressor and condenser combination. It may include a heating function as well. Where such equipment is provided in more than one assembly, the separate assemblies are designed to be used together.

VAPOR BARRIER. A moisture resistant layer of material, such as plastic sheet and aluminum foil, applied to the surface enclosing a space or building to prevent moisture penetration.

VENTILATION. The process of supplying or removing air by natural or mechanical means to or from any space. Such air may or may not have been conditioned.

WHOLE HOUSE FAN. A mechanical ventilation system used to exhaust air from the interior of a building to the exterior or attic space, which can transfer the air to the exterior with little or not resistance. To be recognized for credit points, a fan must be sized to exhaust a minimum of 1.5 CFM per square feet of floor area.

WING WALLS. An architectural projection which is designed to create positive pressure over one window and negative over another. This redirects winds or augments natural ventilation through windows or doors. The wing wall must extend from the ground to eave height, be located on the windward side of the building, and extend outward from the building a distance at least equal to one-half the width of the window.

ZONE. A space or group of spaces within a building with heating and/or cooling requirements sufficiently similar so that comfort conditions can be maintained throughout by a single controlling device and isolated from other temperature needs.

INFORMATION SOURCES

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