# Appendix A

# The Economics of Energy-Saving Features in Home Construction

**by James B. Cummings**
**Florida Solar Energy Center**

This appendix provides an economic analysis of various energy-saving options for new residential construction in Florida. The analysis is presented for a 1500-square-foot frame home described more fully in footnote A on page A-16. Three economic tools are used for evaluating the various energy choices.

The first tool is the determination of net cash flow through a comparison of increased mortgage payment with fuel savings. In this approach, the increased cost of the energy-saving item (for example, insulation, high-efficiency appliance, etc.) is converted to an increased mortgage payment (for a 10%-interest, 30-year loan) less the tax savings for a person in the 15% tax bracket. For applications which have an expected life of less than 30 years, the energy savings in the first year are reduced by a pro-rated system replacement cost. This can be thought of as an annual payment into an escrow account for the purchase of a new unit at the end of its life. Thus, the selected energy-saving option pays for the cost to perpetuate itself over the full 30-year mortgage period. The energy savings are also reduced by maintenance costs for those items expected to need repairs.

The net cash flow is the dollar value of the first year energy savings less the net added annual mortgage payment. If the net cash flow is positive, it is definitely a good deal for the customer. Even if it is negative, the cash flow may become positive after a number of years because of escalating fuel prices. Also keep in mind that since the energy savings are tax-free income, net first year cash flow is, in effect, larger than shown.

A second economic tool presented here is the simple payback period. This is calculated by dividing the cost of the energy feature by the first year fuel savings (less extra maintenance and repair costs). For example, if a heat pump costs $300 more than an air conditioner and saves $100 per year in heating costs compared to electric resistance heating, then the simple payback is 3.0 years. For items with a life expectancy of 15 years or more, a simple payback of less than 10 years is a reasonable option, and less than 7 years is very good. For items which have shorter life expectancy, a shorter payback period is necessary for the option to be considered a good choice. A general rule of thumb is that a simple payback period of less than half the item's life expectancy is a good choice.

The third economic analysis tool is internal rate of return on investment (IRRI). This more accurately reflects an item's economic merit because it takes into account the estimated year-to-year escalation in energy costs. For this analysis we assume the nominal fuel inflation rate is 5% per year. The IRRI can be thought of as the interest rate which an energy investment yields over its life (years of analysis is listed in parentheses next to the IRRI value).

If there are added maintenance and repair costs associated with the energy option, then the fuel savings is reduced by that amount in the calculation of IRRI. Also, if the owner sells the house before the end of the option's expected life, the actual rate of return on investment will be smaller. However, it is likely that at the time of sale the energy option will have market value that increases the selling price of the property. In fact, options having a very long life expectancy may appreciate in value as much as the house itself.

The IRRI should be compared to the return expected from a savings account or other investment. An energy option that has a return on investment of 10% or greater should be a reasonable choice for most home buyers. The fact that the energy savings (though not the interest from reinvesting the energy savings) is tax-free income makes the yield even more favorable than comparable taxable investments. Following this text are tables of these ecomomic performance indicators for a large number of energy-saving features. Caution is advised in using these tables.

First, it should be noted that cost data for the various energy features is subject to considerable variation. This is because product and material costs vary widely, as do labor and contractor costs. If your costs are very different from the values in the tables, you can make calculations to correct for these differences. The net added annual mortgage cost (NAAMC) can be adjusted by a straight proportion method. For example, if your cost for a 2.5-ton, 11.0 SEER air conditioner (compared to a SEER of 8.0) is $700 while the table uses $500, then the NAAMC will be $700/$500 x $45.18 = $63.25. The net first year cash flow (NFYCF) will be reduced by the amount $63.25 - 45.18 = $18.07. The NFYCF of installing an 11.0 SEER rather than an 8.0 SEER air conditioner in central Florida would be reduced by $18.07, from $75.34 to $57.27.

The simple payback (SPB) period would be calculated by dividing the new added system cost by the first year savings (less maintenance costs) found in footnote 82 on page A-22. The simple payback period would increase from 5.4 years to 7.6 years ($700/92.00 = 7.6 years). The rate of return on investment can be calculated for 15- and 30-year life items by means of the following formulas (note that ln is natural log):

$$IRRI = 97.72 - 72.57 * \ln(SPB) + 20.52 \times (\ln(SPB))^2 - 2.35 \times (\ln(SPB))^3 \quad \text{(15 years)}$$

$$IRRI = 91.82 - 63.41 * \ln(SPB) + 16.67 \times (\ln(SPB))^2 - 1.617 \times (\ln(SPB))^3 \quad \text{(30 years)}$$

For life expectancies other than 15 and 30 years we provide no easy means for calculating the IRRI.

A second caution is that in Florida's climate, home space conditioning energy use is strongly dependent upon occupant behavior. Especially important are variations in thermostat setpoints in the cooling and heating seasons, the fraction of the year the house is ventilated, and how much internal heat is generated from appliances and people.

If in the cooling season you raise your thermostat from 78° to 82°F, your cooling energy use will typically drop by about 37%. In the winter, if you lower your thermostat from 72°F to 68°F your heating energy use drops by about 55%. How much you ventilate your house during the summer greatly affects energy use. If you keep your house closed all year and do not ventilate, your cooling energy use in central Florida will be 16% higher than if you cool only May through October, and 49% higher than if you cool only June through September. The generation of heat inside your home affects your space conditioning energy use. In our analysis we have assumed 50,807 Btu/day of sensible internal heat generation. If electricity use within your home (for lights, cooking, television, refrigeration, freezer, dishwasher, heated waterbed, etc.) or the number of people generating heat within your home is greater than our assumption, then your cooling energy will be higher and your space heating requirements will be lower.

The importance of these occupant behavior effects upon space conditioning energy use depends on the extent to which you use your home differently than our stated simulation assumptions (footnote A). If you keep your thermostat at 82°F in the summer, the return on investment for high-efficiency cooling equipment will be lower. If you keep your house at 68°F in the winter in central Florida, then a heat pump may have an 8.1 year simple payback compared to 2.9 years at 72°F setpoint. Therefore, while a 4°F reduction in thermostat setpoint in heating-dominated climates like Minnesota may cause less than a 15% reduction in the heating utility bill, in Florida it can cause a 50% difference.

A third caution is that heating season energy savings are based here upon the use of heat pump. If you use electric resistance heating, those options which reduce heating load (insulation, double-pane windows, etc.) will actually save considerably more than what is shown.

Window shading options are presented on pages A-5 through A-10, for south, central, and north Florida. These options are applied to an unshaded window and to a partially shaded window. The unshaded window is assumed to have no window blinds or curtains and no shading by adjacent vegetation and buildings. Having only an exterior insect screen over half the window area reduces solar radiation striking the window by about 20%. Relatively