FLORIDA SOLAR ENERGY CENTER®
Creating Energy Independence

Energy Efficiency Cost-Effectiveness Tests for Residential Code Update Processes

FSEC-CR-1794-09

Final Report
February 27, 2009

Authors

Philip Fairey
Robin Vieira

1679 Clearlake Road
Cocoa, Florida 32922, USA
(321) 638-1000

www.floridaenergycenter.org

A Research Institute of the University of Central Florida

Energy Efficiency Cost-Effectiveness Tests for Residential Energy Code Update Processes

Philip Fairey
Robin Vieira

Florida Solar Energy Center
February 27, 2009

1. Background

In 2008, the Florida Legislature passed the Florida Energy Act of 2008. A portion of this Act (Section 109, HB 7153) directs the Florida Building Commission (FBC) to develop a rule for determining the cost effectiveness of energy conservation measures considered for inclusion in the Florida Energy Code, as follows:

> *"(3) The Florida Building Commission shall, prior to implementing the goals established in subsection (1), adopt by rule and implement a cost-effectiveness test for proposed increases in energy efficiency. The cost-effectiveness test shall measure cost-effectiveness and shall ensure that energy efficiency increases result in a positive net financial impact."*

The administrative rule directed by this legislation is to be completed and applied to the 2010 update of the energy provisions of the Florida Building Code.

In recent years, energy codes for new buildings have also been of specific interest to the G8 ("Group of Eight" world economic leaders). At their Gleneagles meeting in 2005, the G8 developed and began implementation through the International Energy Agency (IEA) of an energy action plan aimed at significantly improving the efficiency of buildings. The Gleneagles Energy Action Plan provides specific policy guidance with respect to the cost effectiveness of building energy codes, as follows:

> *"Energy efficiency standards for new buildings should be set by national or state governments and should aim to minimize total costs over a 30-year lifetime."* [1]

To assist in meeting their charter to develop a rule for a cost effectiveness test for the Florida Building Code, the Florida Department of Community Affairs (DCA) has contracted with the Florida Solar Energy Center (FSEC) to draft this report on economic indicators and to make recommendations on economic assessment standards that might be included in a cost effectiveness test rule.

---

[1] OECD/IEA, 2008, "In Support of the G8 Plan of Action: Energy Efficiency Policy Recommendations." International Energy Agency, Paris, France (http://www.iea.org/G8/2008/G8_EE_recommendations.pdf).

2. Definitions

A number of terms that are common to economic analysis and that are used in this report are defined below. The terms and definitions are provided in alphabetical order.

Benefit-to-Cost Ratio: The sum of the present value of the benefits from an investment divided by the sum of the present value of the costs of the investment.

Capital Recovery Factor (CRF): The fraction of a capital investment present value that represents the levelized annual cost of the investment compounded at the Discount Rate over the useful lifetime of the capital investment.

Discount rate: The periodic compound interest rate at which future cash flow streams are discounted back to their present value (PV). This value is normally 1.5% - 2% greater than the General Inflation Rate.

Energy Conservation Measure (ECM): An improvement to a building, a building system or a building component that is intended to reduce building energy consumption.

Externalities: Economic impacts (costs or benefits) of a transaction that accrue to parties that are not directly involved in the transaction. Externality costs are often borne by society as a whole and are sometimes referred to as societal costs. For example, the costs of environmental pollution (climate change, increased health costs, loss of ecosystems, species loss, crop loss, etc) are normally borne by society rather than being explicitly included in the price of the goods and services that produce the pollution.

Fuel Escalation Rate: The periodic rate at which the price of fuel increases minus the General Inflation Rate.

General Inflation Rate: The periodic rate at which general consumer prices increase. The General Inflation Rate is normally determined as an historical trend, using the Consumer Price Index (CPI) as published by the U.S. Bureau of Labor Statistics. This value is normally 1.5% - 2% less than the Discount Rate.

Internal Rate of Return (IRR): The discount rate at which the Net Present Value of an investment exactly equals zero. IRR is also sometimes referred to as return on investment or ROI.

Levelized Cost (LC): The present value cost of a capital investment multiplied by its Capital Recovery Factor.

Levelized Cost of Conserved Energy (LCCE): The Levelized Cost of an energy conservation investment divided by the annual energy savings produced by the investment.

Life Cycle Cost (LCC) Analysis: An economic analysis procedure that sums the total cost of an energy efficiency investment option over its lifetime, comparing the lifetime cost of the investment option against the identical case where the investment option is not taken.

Net Present Value (NPV): The present value of all cash flows resulting from an investment given a specific Discount Rate and investment lifetime. Investment costs are evaluated as negative cash flows and investment returns are evaluated as positive cash flows such that NPV fully accounts for the difference in present value between the investment cost and the investment returns in terms of their combined Present Value.

Present Value (PV): The worth of a future cash flow in today's dollars as calculated using the Discount Rate.

Simple Payback: The period, usually given in years, required for an energy investment to pay for itself through first-year energy cost savings.

3. Economics of Building Energy Efficiency

> "Never make predictions, especially about the future"
> *Casey Stengel*

Regardless of Casey Stengel's warning, we are required by this exercise to make predictions about the future. Much has been written on this subject and the prevailing wisdom is that the efficiency of most buildings, both new and existing, can be cost effectively improved, often by a substantial amount.

For new buildings, the basis used for cost-effectiveness analysis is the cost of the building constructed to minimum code requirements. Building costs used in economic analysis comprise two major, but different elements: 1) the purchase costs of the building and 2) the operating cost of the building.

The purchase cost of most buildings is usually incorporated into a long-term mortgage. The term of most new home mortgages is 30 years with annual interest rates that have varied during the past 30 years from a high of more than 15% in the late 1970's to a low of about 5% today. While the operating costs of a building are rarely considered in purchase and mortgage qualification decisions, they can have a substantial impact on the long-term cost effectiveness of a building. For example, over the mortgage life of a typical new home, energy cost will normally exceed $50,000 in present value.

Economists and researchers often use economic analysis techniques along with building energy simulation tools to determine the interaction of these two costs to determine the cost effectiveness of energy efficiency in buildings. Both the purchase cost (mortgage payments) and the energy costs are considered together in these analyses. Figure 1 illustrates the general principles.

As a new building is improved beyond the minimum code requirements, the incremental purchase costs (mortgage payments) rise, slowly at first as the least costly improvements are made and then much more rapidly as higher cost improvements are needed to yield the next increment of efficiency increase. Likewise, as the energy efficiency is increased, energy costs decrease, producing cost savings. However, energy cost savings are linear with respect to units of energy
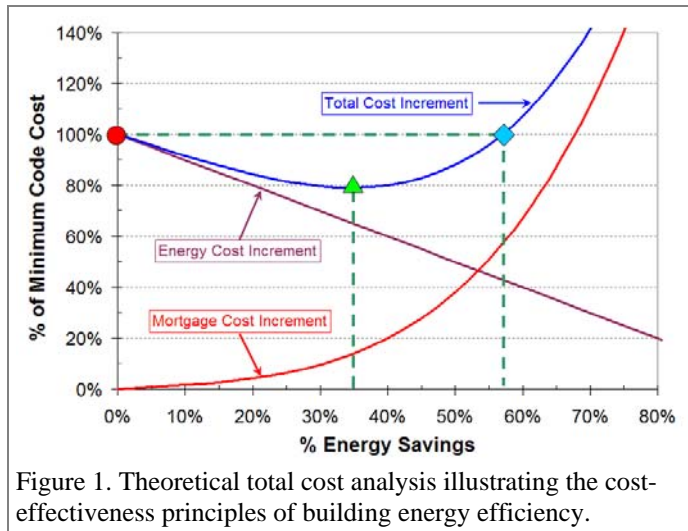

Figure 1. Theoretical total cost analysis illustrating the cost-effectiveness principles of building energy efficiency.

improvement while mortgage cost increases are exponential. Adding these two costs together yields a total cost curve, which declines at first to a minimum cost point (triangle at 35% energy savings on Figure 1) and then subsequently rises, increasing at an ever greater rate (exponentially) as larger and larger energy savings increments are achieved.

Figure 1 shows another interesting characteristic of building energy efficiency cost analysis. The diamond symbol, shown on the total cost curve at about 57% energy savings, has the same total cost as the minimum code building. This point on the curve is known as the neutral cost point. Thus, for determining building energy efficiency cost effectiveness, there are two points of interest on the total cost curve: the minimum cost point and the neutral cost point.

Figure 2 provides a specific example of this type of analysis conducted using BEopt software.[2] The analysis is conducted incrementally, with each of the considered ECMs analyzed separately and then, based on cost effectiveness, added sequentially to the baseline to produce the points on the curve. It is also interesting to note from this analysis that the cost effective energy savings potential for this specific home is significant with a minimum cost point very near 50% energy savings and the

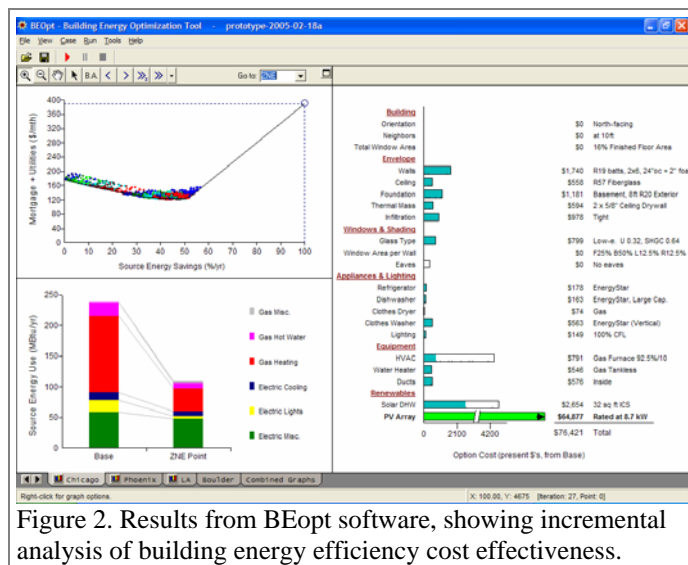Figure 2. Results from BEopt software, showing incremental analysis of building energy efficiency cost effectiveness.

[2] Christensen, C., et al. August 2005, "BEopt: Software for Identifying Optimal Building Designs on the Path to Zero Net Energy." Proceeding of the ISES 2005 Solar World Congress, National Renewable Energy Laboratory Report NREL/CP-550-37733. Online: http://www.nrel.gov/docs/fy05osti/37733.pdf

neutral cost point in excess of 60% savings.

One may argue that it is the minimum cost point that the consumer should be most interested in achieving. However, one may also argue, due to the externalities of energy use, that it is the neutral cost point that should be the focus of cost effectiveness for energy code regulation because it maximizes energy savings without increasing consumer costs.

4. Economic Indicators of Cost Effectiveness

There are multiple indicators of cost effectiveness for building efficiency measures. Some are detailed and some are very simple. Three indicators are detailed here: 1) cash flow analysis, which is the most detailed, 2) levelized cost of conserved energy and 3) simple payback, which, as the name indicates, is the most simplified.

4.1   Cash Flow Analysis

Cash flow analysis is often used for investment decision making. This type of economic analysis is the most comprehensive of the methods presented here. Making decisions on building energy efficiency investments is analogous to making decisions on investing in the stock market or any other investment instrument that is expected to return dividends with one important distinction. If you invest money in the stock market and receive a return on that investment, you will pay taxes on the returns. On the other hand, if you make an investment in the energy efficiency of your home, the return will be money that you do not spend for energy costs. The government does not tax money that you did not spend. Thus, money that is saved through energy efficiency is tax free. As a result, economic indicators that are associated with building energy efficiency investments represent "after tax" returns on those investments.

There are three primary economic indicators in this class: Net Present Value (NPV), Internal Rate of Return (IRR) and present value benefit-to-cost ratio (PVBC). They are all calculated using the investment cost coupled with anticipated future returns from the investment. For example, let us assume that you invest $100 in a 10-year bank Certificate of Deposit (CD) that earns 10% per annum. The annual returns on your investment would be as follows:

Year	Return
1	$10.00
2	$11.00
3	$12.10
4	$13.31
5	$14.64
6	$16.11
7	$17.72
8	$19.49
9	$21.44
10	$23.58
Total	$159.37

Thus, at the end of the 10th year, the returns on your $100 investment would total $159.37. However, due to the time value of money (inflation, etc.), your returns are not actually worth $159.37 in today's dollars. If you want to know what the investment is worth in today's dollars, you have to apply a **discount rate** to all of the future cash flows to determine their present value (PV). This is accomplished by dividing each of the returns by the quantity $(1 + rate)^{year}$.

Assuming a discount rate of 3% per annum, which approximates the general inflation rate, the present value returns on your investments would be as follows:

Year	Return	PV
1	$10.00	$9.71
2	$11.00	$10.37
3	$12.10	$11.07
4	$13.31	$11.83
5	$14.64	$12.63
6	$16.11	$13.49
7	$17.72	$14.40
8	$19.49	$15.38
9	$21.44	$16.43
10	$23.58	$17.55
Total	$159.37	$132.86

Thus, at this discount rate, the present value (PV) of the returns on your investment totals $132.86 rather than $159.37.

The <u>Net</u> Present Value of your investment is equal the total present value of the returns ($132.86) minus the total present value of the investments ($100.00 in this case since the entire investment occurred at the present time rather than at some time in the future) or $32.86.

The general formula for the calculation of NPV is as follows:
$$NPV = \sum_{i=1}^{n} \frac{values_i}{(1 + rate)^i}$$

where:
    n = total number of regular cash flow periods
    i = the period number
    values_i = the ith cash flow
    rate = the discount rate

4.2   <u>Internal Rate of Return (IRR)</u>

The Internal Rate of Return (IRR) on an investment is intimately related to NPV in that it is the discount rate at which the total present value of the returns is exactly equal to the total present value of the investments. We can demonstrate this using the example. If we change the discount rate used to determine the PV from 3% to 8.134% per annum, we achieve the following present value results.

Year	Return	PV
1	$10.00	$9.25
2	$11.00	$9.41
3	$12.10	$9.57
4	$13.31	$9.73
5	$14.64	$9.90
6	$16.11	$10.07
7	$17.72	$10.25
8	$19.49	$10.42
9	$21.44	$10.60
10	$23.58	$10.79
Total	$159.37	$100.00

In this case, the total present value of the returns exactly equals the total present value of the investment. Thus, the IRR for this investment is 8.134% per annum. Note that the IRR on this investment is less than the 10% interest rate earned on the CD because the CD interest was returned in future value dollars rather than in present value dollars.

IRR is calculated by iterative solution of the following equation:

$$0 = \sum_{i=1}^{N} \frac{P_i}{\left(1 + rate\right)^{\frac{(d_i - d_1)}{365}}}$$

where:

N = number of payments
P_i = the ith payment
$rate$ = the Internal Rate of Return
d_i = the ith payment date
d_1 = the 0th payment date

For purposes of cash flow analysis of building energy efficiency, the cost of home improvements is assumed to be incorporated into a 30-year mortgage using the incremental down payment cost as the "investment" (a negative value occurring at time equals 0). The difference between the annual mortgage payment increase due to the improvement and the energy cost savings resulting from the improvement is the regular, periodic cash flow in future years. These future values can be positive or negative, depending on net cash flow during the year. For improvements with lives that are shorter than the life of the mortgage, a replacement cost equal to the original improvement cost inflated at the general inflation rate should be added as a negative value within the cash flow stream during the end of life year(s) for the improvement. If warranted, incremental maintenance costs and any salvage value existing at the end of the mortgage term should be included in the cash flow stream. Future energy cost savings are inflated by the general inflation rate plus the fuel escalation rate (if any).

4.3   Present Value Benefit-to-Cost Ratio (PVBC)

The benefit-to-cost ratio is used by many institutions as a simple and straight forward means of indicating the economic viability of an investment. In simplest terms, a benefit-to-cost ratio greater than 1.0 means that the full cost of an investment will be recovered by the benefits. Likewise, a benefit-to-cost ration of less than 1.0 means that the investment costs will not be recovered by the benefits.

A benefit-to-cost ratio only makes sense when both the costs and the benefits are expressed in like monetary units. Thus, if one is dealing with costs and benefits that are expended and received in the future (as in a home mortgage), it is necessary to bring both the cost cash flow stream and the benefit cash flow stream to their present value, discounting both by the same discount rate.

The **benefits** are the annual energy cost savings accruing during the 30-year home mortgage period deflated by the discount rate. The **costs** are the incremental mortgage down payment **plus** the annual mortgage payments **plus** the ECM replacements costs at end of life inflated at the general inflation rate **plus** any incremental periodic ECM maintenance costs inflated by the general inflation rate, the sum deflated by the discount rate. This procedure effectively divides NPV into its component parts such that the sum of the PV benefits minus the sum of the PV costs equals NPV. To obtain PVBC, the sum of the PV benefits is divided by the sum of the PV costs. Thus,

$$NPV = sum(PVbenefits) - sum(PVcosts)$$

and

$$PVBC = sum(PVbenefits) / sum(PVcosts)$$

Just as NPV does, this indicator fully accounts for the economic inflators and deflators that occur in the cash flows of a 30-year home mortgage. It has the additional benefit of presenting cost effectiveness as a simple ratio that expresses the value of an energy efficiency improvement in easily understood terms. Indeed, while the calculations to arrive at the indicator may be a somewhat complex for much of the general public, the resulting number is quite easily understood in the context of the question "do I get my money back or not?" Greater than 1.0, you do and less than 1.0, you do not – and the larger the benefit-to-cost ratio the better.

4.4   Levelized Cost of Conserved Energy (LCCE) [3]

Levelized cost is often used by industry to determine the annual amortized cost of a capital investment over its useful lifetime. The resulting value gives a good estimate of the annual revenues that must be earned to recover the investment at an acceptable discount rate. For example, levelized cost is often used by electric utilities to determine the amortized annual capital costs of a power plant. Once the annualized cost is determined, it can be divided by the projected annual power production of the plant to

---

[3] Meier, A., J. Wright and A.H. Rosenfeld, 1983, *Supplying Energy through Greater Efficiency,* pp 19-21.
   University of California Press, Berkeley, CA.

derive a reasonable price that must be charged for electricity in $/kWh in order to recover the investment at an acceptable discount rate.

Levelized cost calculation is not overly burdensome, requiring only two primary parameter values: 1) the present value of the capital investment and 2) a capitol recovery factor (CRF) based on a discount rate. CRF is calculated as follows:

$$CRF = Rate / (1-(1+Rate)^{-Life})$$

CRF is the factor, which, when multiplied by the total present value cost of the investment, yields the annual levelized cost of a capital investment.

$$Levelized\ Cost = CRF * (present\ value\ cost)$$

In terms of building energy efficiency, levelized cost represents the annualized cost of an ECM over its useful life.

If one knows the amount of energy that is conserved by an ECM, one can calculate the Levelized Cost of Conserved Energy (LCCE) for the ECM in units that are consistent with the cost of fuel or electricity. For example, let's say we have an ECM with a levelized cost of $40 and an annual electricity savings of 1000 kWh. For this case, LCCE equals $40/1000 kWh or 4¢/kWh. If the utility electricity price is greater than this, the ECM is considered cost effective to the consumer.

LCCE has the advantage of being a relatively simple calculation that considers both the life of the ECM and the discount rate, producing an economic indicator that is expressed in the same units as the price of conventional fuels or electricity.

The full, generalized formula for the calculation of LCCE is as follows:

$$LCCE = [CRF * (Present\ value\ ECM\ cost)] / (annual\ kWh\ energy\ savings)$$
where:
$$CRF = Rate / (1-(1+Rate)^{-Life})$$

4.5   Simple Payback

The most simplistic of the building energy efficiency economic indicators is Simple Payback (SP). Simple payback is the number of years it takes an energy investment to recover its full costs in first-year energy cost savings.

$$SP = (ECM\ cost) / (1^{st}\ year\ energy\ cost\ savings)$$

While very easy to calculate, simple payback does not consider many important economic parameters. Since the indicator, "years to payback", is not cast in either conventional economic terms, like rate of return on investment or benefit-to-cost ratio, or in terms analogous to the alternative, like $/kWh, it is difficult to define an acceptable criteria for cost effectiveness.

For example, a 30-year payback may be most appropriate for a measure that is a long-lasting envelope component but a 15-year payback may be more appropriate for heating and air conditioning equipment. For many years, homebuilder associations have argued that a 7-year payback is required for consumer cost-effectiveness. The basis of the argument is that 7 years is the average period of time a purchaser keeps a new home and that any energy improvements in excess of minimum code requirements should be paid back within that time period. This criteria, dramatically reduces the number of ECMs that qualify as cost effective compared with all other economic indicators. It also greatly devalues the benefits that will accrue to the future owners of the property following the 7-year simple payback period.

5. Discussion

Cash flow analysis (PVCB, NPV and IRR) does not consider the income tax advantages of a building energy improvement. These three indicators are normally used to compare investments for which the returns will be subject to some form of taxation. It is important to point out that energy cost <u>savings</u> (monies that you do not spend) are not subject to taxation. Thus, an "investment" in home energy efficiency is actually more valuable than a typical investment on two fronts – the interest paid on the increased mortgage principle qualifies as a tax deduction <u>and</u> the returns on that investment (the energy cost savings) are not considered income and are, thus, not taxable.

The Present Value Cost-to-Benefit (PVBC) ratio is widely used in the utility industry and is considered by many to be the "gold standard" for cost effectiveness. Florida's investor-owned utilities and the Florida Public Service Commission (FPSC) use this indicator to determine the cost effectiveness of utility energy conservation (EC) and demand side management (DSM) programs conducted under the authority of Florida's FEECA law. While the FPSC currently requires that EC and DSM measures pass the Rate Impact Measure (RIM) test, the underlying analysis method is a present value cash flow analysis resulting in a benefit-to-cost ratio. It is this benefit-to-cost ratio that is used for decision making. This is also true for the "participant" test and would be true for the Total Resource Cost (TRC) test if that were the test authorized by the FPSC for the purpose of determining utility program qualification for energy conservation cost recovery.

The Levelized Cost of Conserved Energy (LCCE) considers only the discount rate and the lifetime of the improvement. It does not consider general inflation or energy price escalation rates that will likely occur during the life of the energy improvement. Thus, it will likely undervalue ECMs with respect to future energy costs paid by the consumer.

Simple Payback (SP) does not account for the time value of money in any way. As such, future increases in energy cost due to general inflation and energy price escalation are not considered. Simple payback also does not account for the fact that most new home improvements are incorporated into a 30-year mortgage, where the out of pocket cost of the improvement (the incremental down payment) is significantly less than the total cost of the improvement and where the net first-year cash flow to the consumer is often positive.

6. Recommendations

The Florida Legislature has directed that the adopted cost effectiveness test "*ensure that energy efficiency increases result in a positive net financial impact.*" This charge could be interpreted as a positive net financial impact to the state economy as a whole. This interpretation would imply that macro-economic and societal impacts must be considered. It is important to point out that the economic indicators described in this report do not consider these macro-economic and externality impacts, which include, but are not limited to, the following:

- Increased job creation through additional construction spending on building energy efficiency
- Increased general economic activity due to added consumer disposable income and spending resulting from energy cost savings
- Decreased importation of expensive fuels for the production of electricity
- Decreased environmental pollution in the form of green house gases and heavy metals from coal-fired power plants – the largest segment of power production
- Decreased health costs due to reductions in environmental pollution.

Thus, from a statewide economic perspective that considers both macro-economic impacts and the societal externalities of energy use, the recommendations presented here are quite conservative.

In constructing a cost effectiveness test rule, a number of factors should be considered and carefully specified to ensure consistency. Without consistency and specificity, misunderstanding and gamesmanship will be likely results from any cost effectiveness test. With this as prologue, the recommendations presented in this section of the report are subdivided into three general categories.

- What should be considered by the energy simulation analysis
- What should be considered by the economic analysis
- What criteria should be used to determine cost effectiveness?

6.1 Energy Analysis Considerations

It is recommended that energy analysis necessary to determine energy savings for ECMs be accomplished using Florida's code compliance software, EnergyGauge® USA FlaRes2008. This will ensure that simulation results and energy savings predictions are fully congruent with Florida's energy code compliance requirements.

Energy simulation analysis should be conducted for both single ECMs and packages of ECMs. It is important to provide results from single ECMs so that the list of available ECMs can be rank ordered based on economic indicators. However, it is also important to provide analysis of groups or packages of ECMs. There are two reasons. First, within any list of available ECMs there will be competing ECMs. For example, a super-efficient hot water system and a solar hot water system are "competing" ECMs and likely should not both be considered for the same package of improvements.

The most important reason that packages of measures should be simulated and analyzed is because results from single measures are not additive. For example, while a high-efficiency air conditioner may save 1000 kWh/year when a home has poorly-performing, single-pane, clear windows, the same high-efficiency air conditioner will not save that same quantity of energy once the windows have been replaced with high performance windows because the high-performance windows significantly lower the load on the air conditioner. Thus, one can not add together the energy savings from a list of single measures and expect the result to be equal to the result from an accurate analysis that considers all of these measures taken together in an energy simulation.

6.2   Determination of Economic Analysis Assumptions

Economic assumptions are required to accomplish any cost effectiveness analyses. The largest number of parameter values is required for detailed cash flow analysis to determine PVBC and IRR. With the assumptions needed for these analyses defined, the other cost effectiveness calculations can also be performed. Recommendations for these values are as follow:
- It is recommended that ECM costs be the full, installed incremental cost of improvements, where the incremental cost is equal to the difference between the baseline measure cost and the improved measure cost unencumbered by any federal tax credits, utility incentives or state rebates
- The following values are recommended for ECM life:
  - 30 years for envelope ECMs unless there is evidence that the measure will not last the life of the mortgage
  - 30 years for solar hot water systems with incremental maintenance costs added at 10 year increments
  - 15 years for HVAC equipment
  - 10 years for major appliances (if considered)
  - 5 years for CFL lamps (if considered)
- The following home mortgage parameter values are recommended:
  - Mortgage term: 30 years
  - Mortgage interest rate: the greater of the most recent 5-year average and 10-year average simple interest rate for fixed-rate, 30-year mortgages computed from the Primary Mortgage Market Survey (PMMS) as reported by Freddie Mac
  - Mortgage down payment: 10%
- The following annual rate parameter values are recommended:
  - General inflation rate: the greater of the most recent 5-year and 10-year Annual Compound Interest Rate (ACIR) computed from the annual average Consumer Price Index (CPI) as reported by the U.S. Bureau of Labor Statistics
  - Discount rate: General inflation rate plus 2%
  - Fuel escalation rate: the greater of 5-year and 10-year ACIR computed from revenue-based prices as reported by Florida Public Service Commission minus the general inflation rate

- It is recommended that the baseline electricity and natural gas prices used in the analysis be the statewide, revenue-based average residential price for the most recent available 12 months as provided by the Florida Public Service Commission.

During early 2008, a study on the cost effectiveness of a number of residential ECMs was conducted for the Florida Department of Community Affairs.[4] Energy savings results from this study have been re-analyzed using the economic analysis assumptions recommended by this report. To accomplish this, the most recent data for general inflation, mortgage interest, and electricity inflation rates have been obtained from the specified sources with the following results:

General Inflation Rate		
Year	CPI	ACIR
2008	$215	
2003	$184	3.2%
1998	$163	2.8%

Electricity Inflation Rate		
Year	$/kWh	ACIR
2008	$0.115	
2003	$0.086	6.1%
1998	$0.079	3.8%

30-Year Mortgage Rates		
Year	Rate	Averages
2008	6.03%	
2007	6.34%	
2006	6.41%	
2005	5.87%	
2004	5.84%	6.10%
2003	5.83%	
2002	6.54%	
2001	6.97%	
2000	8.05%	
1999	7.44%	6.53%

Appendix A provides results from this preliminary economic indicator analysis.

6.3   Cost Effectiveness Criteria

The 2008 Florida Energy Act requires that cost-effectiveness tests result in a "positive net financial impact." It is assumed that the legislative intent is that this positive net financial impact accrues to at least the consumer. Based on this interpretation, the following cost effectiveness criteria are recommended:

---

[4] Fairey, P., January 2008, "Cost-Effective Energy-Efficiency and Florida's Residential Energy Code." Report No. FSEC-CR-1750-08, Florida Solar Energy Center, Cocoa, FL (http://www.fsec.ucf.edu/en/publications/pdf/FSEC-CR-1750.pdf

- For present value cost-to-benefit ratio (PVCB) a value of 1.0 or greater is recommended based on the fact that the investment will fully recover its cost during the typical home mortgage period.
- For the internal rate of return (IRR) on investments, a value equal to 8% is recommended. The recommended value is approximately 1.5% greater than the guaranteed return on State of Florida DROPS (retirement account) investments and is considered large enough that any rational investor would consider the investment wise compared with any other long-term investment
- For the levelized cost of conserved energy (LCCE), a value equal to the statewide residential revenue-based retail cost of electricity adjusted at the fuel escalation rate over one-half of the life of the measure (yields average over the measure life) is recommended. This is based on the fact that, over their life, accepted measures will cost consumers the same or less than purchasing electricity from the utility, where:

$$\text{LCCE criteria} = (\text{current price}) * [(1+\text{fuelEsc})^{(\text{life}/2)}]$$

- The use of simple payback (SP) is not recommended as an economic indicator of cost effectiveness for the purposes of energy code consideration. This recommendation is based on the consideration that SP is a poor indicator of investment value in that it does not accurately consider out of pocket costs and savings and the time value of money. The energy code is promulgated to provide protection of all consumers from excessive future energy costs, including the future purchasers of homes built today. It is also in the interest of the citizens to defray cost increases due to electric generation demand growth, which the code impacts directly. Options that have the least first cost, which simple payback tends to measure, do not meet these goals when there are other, more life-cycle economical options available at the time of construction.

It is further recommended that measures and packages of measures evaluated using this process should be evaluated as follows:

- Create multiple packages of ECMs that result in the target % efficiency increase for each code cycle update (20, 30, 40 and 50%)

- Evaluate each ECM using adopted cost effectiveness indicators (PVBC, IRR, LCCE), within their specific package of ECMs. PVBC will be considered the primary measure with IRR and LCEE used as measures for illustration and communication of individual ECMs and packages of ECMs comparative economic viability

- Validation of the cost effectiveness of Florida Energy Efficiency Code for Building Construction changes shall mean that a number of ECM packages evaluated to comply with the statutory percent energy efficiency increase requirements have a greater benefit than cost as measured in present value dollars.

Table 1. Florida New Baseline Homes

Building Components	Climate:		
	Jacksonville	**Tampa**	**Miami**
Envelope:			
conditioned floor area (ft^2)	2200	2200	2200
no. stories	1	1	1
no. bedrooms	3	3	3
avg. ceiling ht (ft)	8.5	8.5	8.5
attached garage	yes	yes	yes
foundation type	slab on grade	slab on grade	slab on grade
slab area (ft^2)	2200	2200	2200
slab insulation	none	none	none
slab perimeter (ft)	188	188	188
roof type	hip	hip	hip
pitch	5:12	5:12	5:12
cover	comp shingles	comp shingles	comp shingles
color	Dark	Dark	Dark
absorptance	0.92	0.92	0.92
insulation	none	none	none
attic type	standard	standard	standard
ventilation	1:300	1:300	1:300
ceiling type	flat	flat	flat
area (ft^2)	2200	2200	2200
insulation	R-30.0	R-30.0	R-30.0
wall type	Concrete block	Concrete block	Concrete block
insulation	R-3.0	R-3.0	R-3.0
sheathing R	none	none	none
absorptance	0.5	0.5	0.5
door type	insulated	insulated	insulated
area (ft^2)	40	40	40
U-factor	0.75	0.75	0.75
window type	double, low-e	double, low-e	double, low-e
size (% CFA)	18.0%	18.0%	18.0%
orientation	equal	equal	equal
U-Factor	0.75	0.75	0.75
SHGC	0.4	0.4	0.4
overhang (ft)	0	0	0
envelope leakage	standard	standard	standard
rate (ach50)	8	8	8
HVAC Systems:			
mech. vent	none	none	none
cooling type	central	central	central
cooling SEER	13	13	13
heating type	Heat Pump	Heat Pump	Heat Pump
HSPF	7.7	7.7	7.7
thermostat schedule	FL new proto	FL new proto	FL new proto
set points ($^\circ$F)	68/78	68/78	68/78
air distribution system	forced air	forced air	forced air
duct insulation	8	8	8
duct location	Attic	Attic	Attic
AHU location	Garage	Garage	Garage
duct leakage (Qn out)	0.1	0.1	0.1
return leak fraction	0.6	0.6	0.6
hot water (size and fuel type)	50 gal electric	50 gal electric	50 gal electric
EF	0.9	0.9	0.9
Appliances:			
% fluorescent	10%	10%	10%
eStar refrigerator	no	no	no
eStar dishwasher	no	no	no
eStar ceiling fans	no	no	no
eStar washer	no	no	no
dryer	electric	electric	electric
range	electric	electric	electric

Table 2. Description and costs for ECMs evaluated

Acronym	Description of Measure	Incremental Total Cost
HVAC2:	SEER-15; HSPF-9.0 high efficiency heat pump (not counting $300 federal tax credit)	$1,000
HVAC3:	SEER-17; HSPF-9.2 ultra high efficiency heat pump (not counting $300 federal tax credit)	$2,500
RBS:	Attic radiant barrier system	$563
Ceil38	Increase ceiling insulation to R-38	$308
Ducts:	Tight ducts (normalized leakage from 0.10 to 0.03)	$165
Roof:	White metal roof (solar reflectance = 70%)	$2,941
SHW:	Solar hot water system* (closed loop; 40 ft^2-80 gal; PV pumped – not counting 30% federal tax credit + $500 Florida rebate)	$3,592
Lgts:	50% fluorescent lighting	$240
IDucts:	Entire forced air distribution system inside conditioned space boundary	$1,650
Fridg:	Energy Star refrigerator (~80% of baseline energy use)	$50
WinU:	Window upgrade to vinyl frame; U=0.39; SHGC=0.28	$396
Pstat:	Programmable thermostat with 2 ^{o}F setup/setback	$150
cFans:	Energy Star ceiling fans (Gossamer Wind – 140 cfm/watt)	$200
Shng:	White composite shingles (solar reflectance = 25%)	$3
HW:	50 gal hot water heater EF increased from 0.90 to 0.92	$50
WallS:	Add R-3 wall sheathing	$406
Wwalls:	White walls (solar reflectance = 60%)	$2
HAcloths:	Horizontal axis cloths washer (1.5 gpd hot water savings)	$50
HRU:	Heat recovery water heater	$750
HPWH:	Heat pump water heater (COP = 3.0)	$1,092
dWash	Energy Star dishwasher (EF=0.58; 1.06 gpd hot water savings)	$30
2kW-PV:	2.1 kW-peak PV system (not counting $2000 federal tax credit + $4/peak watt Florida rebate)	$16,800
effPool:	Efficient, downsized pool pump and oversized piping (40% energy savings)	$500
Furn1:	High-efficiency non-condensing furnace (AFUE=90%)	$150
Furn2:	High-efficiency condensing furnace (AFUE=95%)	$400
HW1:	Medium efficiency gas hot water heater (EF=0.63)	$100
HW2:	High efficiency gas hot water heater (EF=0.80)	$300
eStar:	eStar heat pump; eStar windows; ach50=7; 3-eStar light fix; Ducts; Shng; Fridg; WallR; dWash	$1,516
TaxC:	HVAC2; Ducts; IDucts; WallR; Pstat; WinU	$3,737
Pkg1:	HVAC2; Ducts; RBS; SHW; Lgts, Fridg; WinU; Pstat; cFan; Shng; Wwalls; HAcloths; dWash	$6,660
* For solar hot water systems closed-loop systems were assumed in north Florida and open-loop systems were assumed in central and south Florida.		

Table 3. Economic Indicator results for Jacksonville

ECM:	PVBC	IRR	LCCE	Total%	Code%
Shng	116.07	6624.6%	$0.002	0.9%	1.8%
Wwalls	48.75	3876.8%	$0.004	0.3%	0.6%
Ducts	6.37	308.3%	$0.033	3.1%	6.5%
Furn1	5.22	362.5%	$0.700	3.5%	6.2%
dWash	5.10	352.7%	$0.040	0.6%	0.6%
WinU	4.88	112.2%	$0.049	3.5%	7.3%
Fridg	4.71	321.6%	$0.043	1.0%	0.1%
effPool	4.47	301.6%	$0.046	7.6%	0.0%
HW2	4.29	287.2%	$0.852	5.8%	10.2%
HW1	3.63	234.5%	$1.006	1.6%	2.9%
HAcloths	3.62	233.4%	$0.056	0.8%	0.8%
Lgts	3.30	436.2%	$0.059	6.2%	0.9%
HWwrap	3.12	193.2%	$0.065	0.7%	1.4%
HPWH	2.76	101.9%	$0.077	9.0%	18.8%
eStar	2.68	91.9%	$0.069	11.7%	19.9%
Furn2	2.66	155.8%	$1.376	4.8%	8.4%
HW	2.59	150.6%	$0.079	0.5%	1.1%
WallS	2.46	35.3%	$0.098	1.8%	3.8%
RBS	2.46	35.2%	$0.098	2.5%	5.2%
WallR	2.46	35.2%	$0.098	1.7%	3.5%
Misc	2.43	303.6%	$0.080	5.7%	0.6%
IDucts	2.32	31.6%	$0.104	6.9%	14.4%
cFan	2.10	111.0%	$0.097	1.8%	0.6%
Pstat	2.00	235.6%	$0.097	2.3%	4.9%
Ceil38	1.90	22.1%	$0.126	1.1%	2.2%
Pkg1	1.86	50.1%	$0.103	34.6%	53.8%
TaxC	1.74	43.7%	$0.106	18.8%	39.0%
HVAC2	1.71	43.4%	$0.125	5.1%	10.6%
SHW	1.48	14.7%	$0.149	10.5%	21.7%
HVAC3	0.92	3.1%	$0.231	6.9%	14.4%
HRU	0.85	0.6%	$0.241	2.7%	5.5%
2kW-PV	0.59	0.0%	$0.405	18.1%	0.0%
Roof	0.59	0.0%	$0.406	3.2%	6.6%

Column Key:

PVBC: Present value benefit-to-cost ratio of ECM

IRR: Internal Rate of Return on ECM investment

LCCE: Levelized Cost of Conserved Energy in $/unit of energy (note that gas and electric units are therms and kWh, respectively)

Total%: Percent energy savings with respect to total home energy use

Code%: Percent energy savings with respect to energy uses regulated by code (heating, cooling and hot water)

Table 4. Economic Indicator Results for Tampa

ECM:	PVBC	IRR	LCCE	Total%	Code%
Shng	187.76	10740.6%	$0.001	1.5%	3.1%
Wwalls	96.47	7717.8%	$0.002	0.6%	1.3%
Ducts	7.06	348.1%	$0.030	3.5%	7.6%
Fridg	5.27	367.0%	$0.039	1.1%	0.3%
effPool	4.47	301.6%	$0.046	7.7%	0.0%
HW2	3.91	257.1%	$0.934	6.1%	12.2%
WinU	3.75	74.3%	$0.064	2.7%	5.9%
dWash	3.59	230.9%	$0.057	0.5%	0.6%
Lgts	3.57	477.5%	$0.054	6.8%	2.1%
HAcloths	3.49	223.3%	$0.058	0.7%	0.8%
HW1	3.35	212.0%	$1.089	1.7%	3.5%
eStar	3.05	112.1%	$0.061	13.6%	29.2%
RBS	3.05	52.3%	$0.079	3.2%	6.8%
HWwrap	2.93	178.1%	$0.070	0.6%	1.3%
cFan	2.72	161.2%	$0.075	2.3%	0.9%
IDucts	2.71	42.1%	$0.089	8.2%	17.6%
Misc	2.59	328.2%	$0.075	6.2%	1.5%
HPWH	2.59	92.3%	$0.082	8.6%	18.5%
HW	2.43	138.0%	$0.084	0.5%	1.1%
TaxC	2.22	67.7%	$0.083	24.3%	39.7%
Furn1	2.05	107.0%	$1.782	1.6%	3.2%
Ceil38	1.98	23.6%	$0.122	1.1%	2.4%
Pkg1	1.95	54.0%	$0.099	36.8%	59.3%
Pstat	1.81	204.6%	$0.108	2.2%	4.6%
HVAC2	1.73	44.6%	$0.123	5.3%	11.3%
SHW	1.60	17.4%	$0.138	11.5%	24.8%
WallS	1.58	15.7%	$0.153	1.2%	2.5%
WallR	1.42	12.8%	$0.170	1.0%	2.1%
HRU	1.13	10.2%	$0.181	3.6%	7.8%
Furn2	1.05	6.8%	$3.486	2.2%	4.4%
HVAC3	1.00	5.2%	$0.213	7.6%	16.4%
Roof	0.96	4.3%	$0.252	5.2%	11.1%
2kW-PV	0.60	0.0%	$0.400	18.5%	0.0%

Column Key:

PVBC: Present value benefit-to-cost ratio of ECM

IRR: Internal Rate of Return on ECM investment

LCCE: Levelized Cost of Conserved Energy in $/unit of energy (note that gas and electric units are therms and kWh, respectively)

Total%: Percent energy savings with respect to total home energy use

Code%:   Percent energy savings with respect to energy uses regulated by code (heating, cooling and hot water)

Table 5. Economic Indicator Results for Miami

ECM:	PVBC	IRR	LCCE	Total%	Code%
Shng	229.58	13139.5%	$0.001	1.7%	3.4%
Wwalls	143.15	11469.9%	$0.001	0.9%	1.8%
Ducts	8.62	438.3%	$0.025	4.1%	8.3%
Fridg	5.68	399.8%	$0.036	1.1%	0.5%
effPool	4.47	301.6%	$0.046	7.3%	0.0%
Lgts	3.97	537.7%	$0.049	7.1%	3.3%
WinU	3.63	70.5%	$0.066	2.5%	5.1%
cFan	3.60	231.5%	$0.057	2.9%	1.0%
HW2	3.54	227.0%	$1.032	5.7%	12.0%
RBS	3.52	67.0%	$0.068	3.4%	7.0%
dWash	3.43	218.3%	$0.059	0.4%	0.5%
HAcloths	3.37	213.3%	$0.061	0.7%	0.7%
IDucts	3.17	55.9%	$0.076	9.0%	18.4%
eStar	3.17	118.2%	$0.058	13.2%	22.9%
Misc	2.84	366.3%	$0.068	6.3%	2.5%
TaxC	2.81	98.6%	$0.066	28.8%	40.8%
HW1	2.80	167.1%	$1.307	1.5%	3.2%
HWwrap	2.65	155.6%	$0.077	0.5%	1.1%
HPWH	2.44	84.0%	$0.087	7.6%	15.6%
Pkg1	2.29	72.0%	$0.086	40.6%	64.2%
HVAC2	2.24	72.7%	$0.095	6.4%	13.1%
HW	2.22	120.4%	$0.092	0.4%	0.9%
Pstat	1.95	226.6%	$0.100	2.2%	4.4%
WallS	1.76	19.1%	$0.137	1.2%	2.5%
Ceil38	1.65	17.0%	$0.146	0.9%	1.8%
WallR	1.61	16.3%	$0.150	1.0%	2.1%
HRU	1.60	68.8%	$0.128	4.8%	9.8%
SHW	1.54	16.1%	$0.143	10.4%	21.4%
Roof	1.28	10.4%	$0.188	6.5%	13.3%
HVAC3	1.28	15.9%	$0.167	9.1%	18.6%
2kW-PV	0.62	0.0%	$0.388	17.9%	0.0%
Furn2	0.07	#NUM!	$52.286	0.2%	0.3%
Furn1	0.00	#NUM!	#DIV/0!	0.0%	0.0%

Column Key:

PVBC: Present value benefit-to-cost ratio of ECM
IRR: Internal Rate of Return on ECM investment
LCCE: Levelized Cost of Conserved Energy in $/unit of
energy (note that gas and electric units are therms
and kWh, respectively)
Total%: Percent energy savings with respect to total home
energy use
Code%: Percent energy savings with respect to energy uses
regulated by code (heating, cooling and hot water)