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CONTRACT REPORT

Cost-Effective Energy-Efficiency and Florida's Residential Energy Code

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Background

The 2007 Florida Legislature authorized the Florida Building Commission (FBC) and Department of Community Affairs (DCA) to evaluate cost effectiveness of energy conservation measures including appliance efficiencies that could be implemented through the Florida Energy Code for certain buildings. Additionally, Governor Crist's Executive Order #07-127 requires the Secretary of DCA to "convene the Florida Building Commission for the purposes of revising the Florida Energy Code for Building Construction to increase the energy performance of new construction in Florida by at least 15% from the 2007 Energy Code. The Commission should consider incorporating standards for appliances and standard lighting in the Florida Energy Code."

The DCA has contracted with the Florida Solar Energy Center (FSEC) to perform an economic analysis to evaluate the cost-effectiveness of energy conservation measure options available to the FBC for inclusion in Florida energy codes and standards.

Methods

The study was conducted using Florida's proposed 2007 hourly code compliance software (EnergyGauge USA) to predict energy savings from 27 energy conservation measures (ECM) relative to Florida's energy code requirements. The characteristics of the baseline home used in the study are provided in Table A-1 following this summary.

The ECMs were simulated in each of Florida's three climate zones as represented by the long-term Typical Meteorological Year (TMY) climate data for Jacksonville, Tampa and Miami. Energy savings were determined by taking the difference in projected energy use between the home without the ECM (baseline) and that same home including the ECM.

Cost data for each of the ECMs included in the study were derived from RSMeans Residential Cost Data[1] as modified in certain cases by the experiential judgment of the authors where RSMeans data appeared to have lower cost than might be expected in Florida residential construction markets. Where RSMeans did not have data for certain ECMs, such as energy efficient appliances, the author relied on online purchase sources to determine costs and cost differences. In an effort to bracket cost uncertainty, the study

[1] RSMeans. 2005. *Residential Cost Data: 24th Edition*. Construction Publisher & Consultants, Kingston, Mass.: RSMeans.

evaluates costs that are 90%, 120% and 150% of these base ECM costs. A list of the ECMs evaluated and their associated base costs are provided in Table A-2 following this summary.

Economic Indicators

A number of economic indicators are generated by the analysis. Results of these economic calculations are dependant on interest rate assumptions. The base interest rate assumptions used by the analysis are as follows:

- Mortgage interest rate = 6.5%
- General inflation rate = 3.0%
- Energy escalation rate = 0.0%
- Discount rate = 4.5%

Note: The energy escalation rate is the rate at which energy prices increase in excess of the general inflation rate.

Each of the above base rates (and base cost assumptions) is varied in the analysis to examine the sensitivity of the results to the base values, as follows:

- Mortgage interest rates: 5.5% and 7.5%
- General inflation rates: 2.0% and 4.0%
- Energy escalation rates: 1.0% and 2.0%
- Discount rates: 3.0% and 6.0%
- Cost inflators: 90%, 120% and 150%

The economic indicators described below are calculated for each energy improvement (ECM) using the above assumptions.

NPV **–** the Net Present Value of all cash flows associated with an investment. This normally (but not always) involves a negative cash flow at time equals 0, representing the investment, followed by a series of regular, periodic positive cash flows in the future, representing the financial returns on the investment. An investment in the stock market that pays regular, periodic dividends is an excellent example of such a cash flow stream. NPV is calculated as follows:

$$\mathrm{NPV} = \sum_{i=1}^{n} \frac{values_i}{(1+rate)^i}$$

where:

n = total number of regular cash flow periods
i = the period number
$values_i$ = the i^{th} cash flow
rate = the discount rate

For the purposes of NPV, the cost of home improvements is assumed to be incorporated into a 30-year mortgage using a 10% down payment rate. Thus, 10% of the total improvement cost becomes the “investment” (occurring at time equals 0) and the difference between the annual mortgage payment for the improvement and the energy cost savings resulting from the improvement becomes the regular, periodic cash flow in the future. This regular, periodic cash flow can be a series of all positive values, some negative values followed by some positive values, or all negative values, depending on the energy improvement investment cost and the savings it produces. Annual future energy costs are inflated by the general inflation rate plus the annual fuel escalation rate (if any).

While the general inflation rate and the fuel escalation rate are used to determine energy cost savings in the future, they remain distinct from the discount rate used in the NPV equation. This discount rate is used to discount all future cash flows back to their present value such that they represent "constant dollars" (i.e. the present value of these future dollars). As a result, the NPV calculation represents the present value of the investment (normally negative) added to a stream of future cash flows (normally positive) that have been discounted to their present value to account for the time value of money. This is also sometimes referred to as the "Net Worth" of an investment.

IRR – the Internal Rate of Return on an investment. This value is closely related to NPV in that IRR is the interest rate that produces a net present value of 0 (zero). In other words, IRR is the discount rate at which the initial investment exactly equals the present value of all future cash flows. IRR is calculated by iterative solution of the following equation:

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

where:
- N = number of payments
- P_i = the i^{th} payment
- rate = the Internal Rate of Return
- d_i = the i^{th} payment date
- d_1= the 0^{th} payment date

The same 30-year, mortgage-based investment (down payment) and cash flow stream is used in the calculation of both NPV and IRR. The future cash flow stream from the "investment" is equal to the difference between the annual mortgage payment for the home improvement and the annual energy cost savings from the home improvement.

Since NPV will always yield a positive value when IRR is greater than the discount rate assumed by the NPV calculation, IRR is generally considered the better economic indicator. While NPV was calculated for each energy measure considered in this analysis, only IRR is reported here.

CCE – the Cost of Conserved Energy is the levelized, life-cycle cost (net improvement cost amortized at the discount rate over the lifetime of the improvement) of an energy improvement divided by the annual energy savings of the energy improvement.[2]

$$CCE = [(\text{Net Cost}) * (\text{Rate} / (1- (1+ \text{Rate})^{\text{Life}}))] / (\text{Annual Energy Savings})$$

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

Thus, the units of CCE are the same as the units of price for energy services ($/kWh for electricity or $/therm for natural gas), providing a means to directly compare the cost of conserved energy (or energy savings) with the retail cost of energy. If CCE for an energy improvement is less than the retail cost of energy, then the energy improvement is considered cost effective for the home owner. This is what the utility industry often refers to as the "participant cost test."

SP – the Simple Payback is the amount of time (in years) that it takes for the net cost of an energy improvement to pay for itself using first-year energy cost savings.

$$SP = (\text{Net Cost}) / (1^{st}\ \text{Year Energy Cost Savings})$$

Cautionary Notes:

1. All economic indicators are calculated using the net cost of the improvements. The net cost of improvements is calculated as the difference in between the baseline measure cost and the improved measure cost less any federal tax credits and Florida rebates that are currently available for renewable energy and energy efficiency home improvements.
2. Neither net present value (NPV) nor internal rate of return (IRR) considers the income tax advantages of a mortgaged home energy improvement. These two financial 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, however, that energy cost savings (monies that you do not pay out) are not taxed as they are not considered income. Thus, an "investment" in home energy efficiency is actually much more valuable than a typical investment on two fronts – the interest paid on the increased mortgage principle qualifies as a tax deduction and the returns on that investment (the energy cost savings) are not considered income and are, thus, not taxable.
3. The cost of conserved energy (CCE) considers only the discount rate and the lifetime of the improvement. As such, it does not consider general inflation or energy escalation rates that may occur during the life of the energy improvement.
4. Simple Payback does not account for the time value of money. As such, future increases in energy cost due to general inflation or energy cost 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 net down payment) is significantly less than the net total cost of the improvement and where the net first-year cash flow is often positive.

The criteria used to determine cost-effectiveness are all based on cost-effectiveness to the consumer. The following criteria values are used:

- For the levelized cost of conserved energy (CCE), a value of $0.12/kWh, equivalent to the 2006 statewide residential retail cost of electricity, is selected as the cut-off point for determining consumer cost-effectiveness. This is based on the fact that each of these measures will cost the same or less than purchasing electricity from the grid. Note also that for natural gas devices, the cut-off value for consumer cost-effectiveness is set at the 2006 statewide residential retail cost of natural gas of $2.15/therm.[3]

- For the internal rate of return (IRR) on investments, a value of 10% is selected. Any value greater than the personal discount rate that an individual home owner views as their threshold for making an investment can be valid. The value selected is considered large enough that any rational investor would consider the investment very wise as compared with any other traditional low-risk, long-term investment, such as blue-chip stocks, mutual or index funds, bonds, bank CDs, etc., which all generally have an after-tax, inflation-adjusted IRR less than 5%.
- For simple payback (SP), a value of 7 years is selected. This is significantly shorter than the lifetime of almost all the ECMs evaluated in this study. Additionally, for new homes, the incremental costs of the ECMs will likely be incorporated into a home mortgage of 30 years. As a result, the 7-year payback period is a misleading economic indicator that fails to take into account most of the economic advantages of new home energy improvements.

Summary Findings

For all economic indicators, results were found to be most sensitive to ECM cost. Variation of mortgage interest rate, general inflation rate, discount rate and energy escalation rate impacted the results but not as much as did ECM cost variation. Tables 1 through 3 below provide the degree of this variation for each of the economic indicators.

Using IRR >= 10% as the cost effectiveness criteria, more than 60% of the 27 ECMs were found to be cost effective in all climates under all cost scenarios. Table 1 presents these results.

Table 1. Number of ECMs (Out of 27 Total) Found to be Cost-Effective by IRR >= 10%

Climate:	90% of cost	100% of cost	120% of cost	150% of cost
Jacksonville	26	24	22	18
Tampa	25	24	22	19
Miami	23	21	21	19

Using CCE <= $0.12 as the cost effectiveness criteria, more than 50% of the 27 ECMs were found to be cost effective in all climates under all cost scenarios. Table 2 presents these results.

Table 2. Number of ECMs (Out of 27 Total) Found to be Cost-Effective by CCE <= $0.12

Climate:	90% of cost	100% of cost	120% of cost	150% of cost
Jacksonville	24	23	22	15
Tampa	23	22	19	14
Miami	22	19	19	15

Using the SP <= 7 years as the cost effectiveness criteria, more than 40% of the 27 ECMs were found to be cost effective in all climates under all cost scenarios. Table 3 presents these results.

[3] Statewide residential retail energy cost data from U.S. Energy Information Administration

Table 3. Number of ECMs (Out of 27 Total) Found to be Cost-Effective by SP <= 7 years

Climate:	90% of cost	100% of cost	120% of cost	150% of cost
Jacksonville	18	17	14	13
Tampa	19	15	14	12
Miami	14	14	12	12

The effectiveness of the energy conservation measures on a statewide basis can be estimated by weighting the results by the populations of the three Florida climate zones. This is accomplished using data from Rose (1993).[4] According to these data, the population percentages of the three Florida climate zones are as follows: North – 20%; Central – 41%; and South – 39%. Applying these as weighting factors to the results and using the cost effectiveness criteria that IRR must greater than 10%, 23 of the 27 ECMs are found to be cost effective on a statewide basis using their base cost estimates. Table 1 above indicates that this list would be reduced by the 3 least cost-effective measures if ECM costs are inflated by 150%. This would mean that the last 3 measures shown in Table 4 below would be eliminated from the list at 150% of base ECM costs.

Table 4. Cost effective ECMs using Baseline Assumptions and IRR Criteria

Energy Conservation Measure	Internal Rate of Return	% Savings (of Total)	% Savings (of Code)**
Shng	10005.8%	1.5%	3.3%
Wwalls	7758.5%	0.8%	1.6%
HW2 (gas)	448.5%	5.7%	11.2%
Lgts*	447.2%	6.9%	NA
Ducts	338.2%	3.9%	8.3%
Fridg*	333.7%	1.1%	NA
effPool*	269.9%	9.0%	NA
dWash*	222.6%	0.5%	NA
HW1 (gas)	220.1%	1.5%	3.0%
Pstat	200.8%	2.2%	4.7%
HAcloths*	195.8%	0.7%	NA
cFan*	156.4%	2.7%	NA
Furn1 (gas)	128.7%	0.8%	1.6%
HW	114.7%	0.5%	1.0%
Furn2 (gas)	98.2%	1.2%	2.4%
HVAC2	84.2%	6.1%	13.2%
HPWH	74.7%	7.9%	16.9%
WinU	64.7%	2.7%	5.7%
Package***	57.2%	24.9%	53.5%
SHW	54.6%	10.4%	22.4%
RBS	40.7%	3.2%	7.0%
HRU	35.9%	4.4%	9.4%
IDucts	32.0%	8.6%	18.5%
HVAC3	13.9%	8.7%	18.6%

* Not currently covered by Florida's Building Code
** Only 46% of total home energy use is covered by Florida's Code
*** Package consists of all highlighted individual measures

[4] Rose, Matthew, Craig McDonald, Peter Shaw, and Steve Offutt. 1993. *Electricity Conservation and Energy Efficiency in Florida: Appendix C-D Technical and Achievable Potential Data Inputs.* SRC Report No. 7777-R8. Synergic Research Corporation, Bala Cynwyd, Penn.

Based on these finding, there are a significant number of energy conservation measures that produce cost-effective energy savings with respect to Florida's minimum residential building code requirements. When the non-competing ECMs with the largest energy savings are simulated as a package of measures, the result shows total energy savings of almost 25% with an internal rate of return greater than 57% (see highlighted cells of Table 4). If we limit the savings basis to only those energy uses currently covered by Florida's Energy Code,[5] which is the same criteria used in selecting the package of measures, the savings with respect to Florida's Code requirements are greater than 53%.

If we assume ECM costs of 150% of their base costs, the internal rate of return for this package of measures is reduced from 57% to 19%, which is still a highly attractive internal rate of return that can not be matched by normal investments without taking extreme risks with investment capital.

Conclusions

The new home energy savings of 15% above 2007 Code requested by Executive Order #07-127 is cost-effectively achievable. This is true even if the lighting and appliance energy uses of the typical home are included in the basis from which this energy savings percentage is calculated. Note that interpretation of Executive Order #07-127 as applying to total home energy use, as opposed to only those energy uses covered by the current energy code, would result in more than double the energy savings.

There are six energy conservation measures for lighting and appliance energy use shown in Table 4 that are not included by Florida's Residential Energy Code. Each of these lighting and appliance ECMs are highly cost-effective with the lowest-ranked one on the list (ENERGY STAR ceiling fans) having an IRR greater than 150%. Inclusion of these measures as options within Florida's performance-based Residential Energy Code would provide more opportunities for additional, and often more cost-effective, improvements to be selected as part of residential code compliance.

[5] This study shows that Florida's Residential Energy Code, which regulates only heating, cooling and hot water energy uses, accounts for about 46% of total typical residential energy use. A previous study entitled "Effectiveness of Florida's Residential Energy Code: 1979 – 2007" resulted in the same finding. See http://www.fsec.ucf.edu/en/publications/pdf/FSEC-CR-1717-07.pdf for a copy of this study.

Table A-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 (^{o}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 A-2. ECM Acronyms, Descriptions and Costs

Acronym	Description of Measure	Incremental Gross Cost	Federal Tax Credit	Florida Rebate	Incremental Net Cost
HVAC2:	SEER-15; HSPF-9.0 high efficiency heat pump ($300 federal tax credit)	$1,000	$300		$700
HVAC3:	SEER-17; HSPF-9.2 ultra high efficiency heat pump ($300 federal tax credit)	$2,500	$300		$2,200
RBS:	Attic radiant barrier system	$563			$563
Ducts:	Tight ducts (normalized leakage from 0.10 to 0.03)	$165			$165
Roof:	White metal roof (solar reflectance = 70%)	$2,941			$2,941
SHW:	Solar hot water system* (closed loop; 40 ft^2-80 gal; PV pumped – 30% federal tax credit + $500 Florida rebate)	$3,092	$1,050	$500	$1,692
Lgts:	50% fluorescent lighting	$240			$240
IDucts:	Entire forced air distribution system inside conditioned space boundary	$1,650			$1,650
Fridg:	Energy Star refrigerator (~80% of baseline energy use)	$50			$50
WinU:	Window upgrade to vinyl frame; U=0.39; SHGC=0.28	$396			$396
Pstat:	Programmable thermostat with 2 ^oF setup/setback	$150			$150
cFans:	Energy Star ceiling fans (Gossamer Wind – 140 cfm/watt)	$200			$200
Shng:	White composite shingles (solar reflectance = 25%)	$3			$3
HW:	50 gal hot water heater EF increased from 0.90 to 0.92	$50			$50
WallS:	Add R-3 wall sheathing	$406			$406
Wwalls:	White walls (solar reflectance = 60%)	$2			$2
HAcloths:	Horizontal axis cloths washer (1.5 gpd hot water savings)	$50			$50
HRU:	Heat recovery water heater	$750			$750
HPWH:	Heat pump water heater (COP = 3.0)	$1,092			$1,092
dWash	Energy Star dishwasher (EF=0.58; 1.06 gpd hot water savings)	$30			$30
2kW-PV:	2.1 kW-peak PV system ($2000 federal tax credit + $4/peak watt Florida rebate)	$16,800	$2,000	$8,400	$6,400
effPool:	Efficient, downsized pool pump and oversized piping (40% energy savings)	$500			$500
Furn1:	High-efficiency non-condensing furnace (AFUE=90%)	$150			$150
Furn1:	High-efficiency condensing furnace (AFUE=95%)	$400	$150		$250
HW1:	Medium efficiency gas hot water heater (EF=0.63)	$100			$100
HW2:	High efficiency gas hot water heater (EF=0.80)	$300	$100		$200

* For solar hot water systems closed-loop systems were assumed in north Florida and open-loop systems were assumed in central and south Florida.