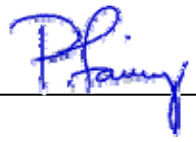
RESNET
Residential Energy Services Network

Proposed Standards Revision

Date: 03/07/11 (revised 09/27/11) Amendment #2011-01

As last modified by Auxiliary Energy Subcommittee on 09/27/2011

Title: Revision of Economic Cost Effectiveness Calculations

Proponent: Philip Fairey Signature: 

Organization: Florida Solar Energy Center

Mailing Address: 1679 Clearlake Road

City: Cocoa State: FL Phone:(321) 638-1005

Proposed Revision: (Specify Section to be revised. ~~Line through deleted text.~~ Underline added text.)

Modify Section 303.3.3 as follows:

303.3.3 Economic Cost Effectiveness. If ratings are conducted to evaluate energy saving improvements to the home for the purpose of an energy improvement loan or energy efficient mortgage, ~~in addition to the information set forth under Section 303.3.2 of this Standard, each rating report shall include~~ indicators of economic cost effectiveness shall use present value costs and benefits, which shall be calculated as follows:

$$\mathbf{LCC_E = P1*(1^{st}\ Year\ Energy\ Costs)} \qquad \textbf{Eqn 303.3.3-1}$$

$$\mathbf{LCC_I = P2*(1^{st}\ Cost\ of\ Improvements)} \qquad \textbf{Eqn 303.3.3-2}$$

where:

LCC_E = Present Value Life Cycle Cost of Energy

LCC_I = Present Value Life Cycle Cost of Improvements

P1 = Ratio of Life Cycle energy costs to the 1^{st} year energy costs

P2 = Ratio of Life Cycle Improvement costs to the first cost of improvements

Present value life cycle energy cost savings shall be calculated as follows:

$$\mathbf{LCC_S = LCC_{E,b} - LCC_{E,i}} \qquad \textbf{Eqn 303.3.3-3}$$

where:

LCC_S = Present Value Life Cycle Energy Cost Savings

$LCC_{E,b}$ = Present Value LCC of energy for **baseline** home configuration

$LCC_{E,i}$ = Present Value LCC of energy for **improved** home configuration

Standard economic cost effectiveness indicators shall be calculated as follows:

$SIR = (LCC_S) / (LCC_I)$ **Eqn 303.3.3-4**

$NPV = LCC_S - LCC_I$ **Eqn 303.3.3-5**

where:
SIR = Present Value Savings to Investment Ratio
NPV = Net Present Value of Improvements

303.3.3.1 Calculation of P1 and P2. The ratios represented by P1 and P2 shall be calculated in accordance with the following methodology[1]:

P1 = 1/(DR-ER)*(1-((1+ER)/(1+DR))^nAP) **Eqn 303.3.3-6a**

or if DR = ER then

P1 = nAP / (1+DR) **Eqn 303.3.3-6b**

where:
P1 = Ratio of Present Value Life Cycle Energy Costs to the 1st year Energy Costs
DR = Discount Rate as prescribed in section 303.3.3.2
ER = Energy Inflation Rate as prescribed in section 303.3.3.2
nAP = number of years in Analysis Period as prescribed in section 303.3.3.2

$P2 = DnPmt + P2_A + P2_B + P2_C - P2_D$ **Eqn 303.3.3-7**

where:
P2 = Ratio of Life Cycle Improvement costs to the first cost of improvements
DnPmt = Mortgage down payment rate as prescribed in section 303.3.3.2
$P2_A$ = Mortgage cost parameter
$P2_B$ = Operation & Maintenance cost parameter
$P2_C$ = Replacement cost parameter
$P2_D$ = Salvage value cost parameter

$P2_A = (1-DnPmt)*(PWFd/PWFi)$ **Eqn 303.3.3-8a**

where:
PWFd = Present Worth Factor for the discount rate = 1/DR*(1-(1/(1+DR)^nAP))
PWFi = Present Worth Factor for the mortgage rate = 1/MR*(1-(1/(1+MR)^nMP))
DR = Discount Rate as prescribed in section 303.3.3.2
MR = Mortgage interest Rate as prescribed in section 303.3.3.2
nAP = number of years of the Analysis Period as prescribed in section 303.3.3.2
nMP = number of years of the Mortgage Period

[1] Duffie, J.A. and W.A. Beckman, 1980. *Solar Engineering of Thermal Processes*, pp. 381-406, John Wylie & Sons, Inc., New York, NY.

$P2_B$ = MFrac*PWinf **Eqn 303.3.3-8b**

where:
MFrac = annual O&M costs as a fraction of first cost of improvements[2]
PWinf = ratio of present worth discount rate to present worth general inflation rate
= 1/(DR-GR)*(1-(((1+GR)/(1+DR))^nAP))
or if DR = GR then
= nAP/(1+DR)
GR = General Inflation Rate as prescribed in section 303.3.3.2

$P2_C$ = Sum {1/((1+(DR-GR))^(Life*i))} for i=1, n **Eqn 303.3.3-8c**

where:
i = the i^{th} replacement of the improvement
Life = the expected service life of the improvement

$P2_D$ = RLFrac / ((1+DR)^nAP) **Eqn 303.3.3-8d**

where:
RLFrac = Remaining Life Fraction following the end of the analysis period

303.3.3.2 Determination of Economic Parameters. The following economic parameter values shall be determined by RESNET in accordance with this Section each January using the latest available specified data and published on the RESNET website.

- General Inflation Rate (GR)
- Discount Rate (DR)
- Mortgage Interest Rate (MR)
- Down Payment Rate (DnPmt)
- Energy Inflation Rate (ER)

The economic parameter values used in the cost effectiveness calculations specified in Section 303.3.3.1 shall be determined as follows:

303.3.3.2.1 General Inflation Rate (GR) shall be the greater of the 5-year and the 10-year Annual Compound Rate (ACR) of change in the Consumer Price Index for Urban Dwellers (CPI-U) as reported by the U.S. Bureau of Labor Statistics,[3] where ACR shall be calculated as follows:

[2] The maintenance fraction includes all incremental costs over and above the operating and maintenance cost of the "standard" measure. Where components of a system have various lifetimes, the longest lifetime may be used and the components with shorter lifetimes may be included as a maintenance cost at the present value of their future maintenance cost. The maintenance fraction may also be used to represent the degradation in performance of a given system. For example, photovoltaic (PV) systems have a performance degradation of about 0.5% per year and this value can be added to the maintenance fraction for PV systems to accurately represent this phenomenon in this cost calculation procedure.
[3] http://www.bls.gov/CPI/#tables

ACR = ((endVal)/(startVal))^(1.0/((endYr)-(startYr)))-1.0 Eqn 303.3.3-9

where:
ACR = Annual Compound Rate of change
endVal = Value of parameter at end of period
startVal = Value of parameter at start of period
endYr = Year number at end of period
startYr = Year number at start of period

303.3.3.2.2 Discount Rate (DR) shall be equal to the General Inflation Rate plus 2%.

303.3.3.2.3 Mortgage Interest Rate (MR) shall be defaulted to the greater of the 5-year and the 10-year average of simple interest rate for fixed rate, 30-year mortgages computed from the Primary Mortgage Market Survey (PMMS) as reported by Freddie Mac unless the mortgage interest rate is specified by a program or mortgage lender, in which case the specified mortgage interest rate shall be used. The mortgage interest rate used in the cost effectiveness calculation shall be disclosed in reporting results.

303.3.3.2.4 Down Payment Rate (DnPmt) shall be defaulted to 10% of 1st cost of improvements unless the down payment rate is specified by a program or mortgage lender, in which case the specified down payment rate shall be used. The down payment rate used in the cost effectiveness calculation shall be disclosed in reporting results.

303.3.3.2.5 Energy Inflation Rate (ER) shall be the greater of the 5-year and the 10-year Annual Compound Rate (ACR) of change in the Bureau of Labor Statistics, Table 3A, Housing, Fuels and Utilities, Household Energy Index[4] as calculated using Equation 303.3.3-9.

303.3.3.2.6 Mortgage Period (nMP) shall be defaulted to 30 years unless a mortgage finance period is specified by a program or mortgage lender, in which case the specified mortgage period shall be used. The mortgage period used in the cost effectiveness calculation shall be disclosed in reporting results.

303.3.3.2.7 Analysis Period (nAP) shall be 30 years.

303.3.3.2.8 Remaining Life Fraction (RLFrac) shall be calculated as follows:

RLFrac = (nAP/Life) – (Integer (nAP/Life)) Eqn. 303.3.3-10
or if Life > nAP
RLFrac = (Life-nAP) / nAP

where:
Life = useful service life of the improvement(s)

[4] http://www.bls.gov/cpi/cpi_dr.htm

303.3.3.2.9 Improvement Costs. The improvement cost for Energy Conservation Measures (ECMs) shall be included on the Economic Cost Effectiveness Report.

303.3.3.2.9.1 For New Homes the improvement costs shall be the full installed cost of the improvement(s) less the full installed cost of the minimum standard or code option less any financial incentives that accrue to the home purchaser.

303.3.3.2.9.2 For Existing Homes the improvement costs shall be the full installed cost of the improvement(s) less any financial incentives that accrue to the home purchaser.

303.3.3.2.10 Measure Lifetimes. The ECM service life shall be included on the Economic Cost Effectiveness Report. Appendix C of this standard provides informative guidelines for service lifetimes of a number of general categories of ECMs.

303.3.3.~~1~~3 The annual energy cost savings for the Rated home shall be estimated by comparing the projected annual energy cost of the Rated home to the projected annual energy ~~use~~ cost of a ~~reference~~ baseline home. For new homes ~~in which the results will be used to apply for an Energy Efficient Mortgage (EEM)~~, the most recent HERS ~~r~~Reference home shall be the baseline, except when an alternative reference home is specified by the lender or program underwriter. For existing homes, ~~in which the results will be used to apply for an Energy Improvement Mortgage (EIM)~~ the unimproved home shall be used as the baseline. ~~For savings calculations unrelated to EEM's or EIM's, the user may select any reference home as the baseline.~~

303.3.3.~~2~~4 The estimated monthly energy cost savings for the Rated home shall be equal to the annual energy cost savings divided by 12.

~~**303.3.3.3** The Energy Value for the Rated home (e.g., present value of the energy cost savings) shall be calculated as follows:~~

303.3.3.~~3.1~~5 For Fannie Mae energy efficient mortgages the Net Present Value (NPV) of the improvements shall be as calculated by Equation 303.3.3-5. ~~present value factor shall be calculated as:~~

~~**pvf = [1- (1 + r)^-n] / r**~~
~~where:~~
~~pvf = present value factor~~
~~r = prevailing mortgage rate (Assumed Rate)~~
~~n = weighted life of the measures (23 years)~~

~~To determine the Energy Value of the improved home, the present value factor (pvf) shall be multiplied by the annual energy savings.~~

~~**303.3.3.3.2** For Fannie Mae energy efficient mortgage products, the financing interest rate (Assumed Rate) shall be provided by RESNET annually from the information provided by Fannie Mae.~~

~~**303.3.3.3.3** A weighted lifetime of 23 years shall be used in determining the present value factor for the energy cost savings.~~

303.3.3.2~~5~~6 For FHA and Freddie Mac energy mortgages, the present ~~worth~~ value of energy savings shall be calculated in accordance with Equation 303.3.3-3 where the baseline home is as specified by the most current HUD Mortgage Letter. ~~by taking the net annual energy savings (the annual energy savings minus the annual maintenance costs) times the present value factor developed by the U.S. Department of Housing and Urban Development. The present value factor is contained in the "HUD Mortgage Letter 93-13", as posted on RESNET's web site at http://www.natresnet.org/resources/lender/lhandbook/hud_93-13.htm.~~

Appendix C
(Informative)
General Guidelines for Determining Energy Conservation Measure (ECM)
Service Lifetimes and Maintenance Fractions

Improvement Category	ECM Life	Maint. Frac.
Air Sealing, Ducts	20	0
Air Sealing, Envelope	30	0
Attic, Ventilation	30	0
Attic, Radiant Barrier	30	0
Color, Roof Shingles	15	0
Color, Wall Paint	10	0
HVAC, Replacement	15	0
Furnace, Replacement	20	0
Hot Water, Heat Pump	15	0.009
Hot Water, Heat Recovery	15	0
Hot Water, Pipe Insulation	15	0
Hot Water, Tank Wrap	12	0
Hot Water, Solar, Direct	40	0.011
Hot Water, Solar, ICS	40	0.004
Hot Water, Solar, Indirect	40	0.011
Hot Water, Standard System	12	0
Hot Water, Tankless, Gas	12	0.024
Insulation, Block Wall	40	0
Insulation, Ceiling	40	0
Insulation, Frame Wall	40	0
Lighting, High Efficiency	5	0
Pool Pump, High Efficiency	15	0
Refrigerator, Replacement	15	0
Showers, Low Flow	15	0
Window, Replacement	40	0
Window, Film Tinting	15	0
Window, Solar Screen	15	0

Effective Date: This amendment shall become effective 120 days following final approval by the RESNET Board of Directors.

Justification:

Fannie Mae has recently changed its Energy Improvement Mortgage (EIM) requirements to include a provision that the energy improvements to the home must be cost effective as measured by their Net Present Value (NPV), with positive values considered cost effective and negative values considered not cost effective. In other words, the present value of the energy cost savings must exceed the present value of the improvement costs. However, Fannie Mae has not provided standards or guidance for the calculation of NPV. Section 303.3.3 of the RESNET Standards addresses the calculation of a present value factor for the purposes of completing the previous requirements of Fannie Mae EEMs and EIMs. However, this calculation is insufficient for calculating the new Fannie Mae requirement for NPV.

Furthermore, at their 2008 meeting, the member nations of the G8, signed on to a set of building energy policies that includes a requirement that building energy standards be set based on the 30-year total (life cycle) costs of building energy improvements. RESNET has been collaborating wherever possible with the European Community on such policies and this proposed change to Section 303.3.3 of the RESNET Standards represents an opportunity to establish a standard for calculating the economic cost effectiveness of mortgaged building energy improvements using a 30-year analysis period. While this approach may not be the most appropriate method in all cases (e.g. where home improvements are not mortgaged or where procedures are already specified as in the Federal Weatherization and Federal Energy Management Programs), the method is likely to suit the needs of most mortgage financiers without being overly burdensome to users.

For example, by state regulation, Florida has implemented a rule within the Florida Administrative Code (FAC) specifying how cost effectiveness tests are to be performed with respect to building energy code requirements (see FAC Rule 9-B13.0071, attached). This proposal bases the large part of its specifications on this Florida Administrative Rule.

In summary, it is in the best interest of RESNET to establish a set of standard procedures that can be uniformly used for the calculation of economic cost effectiveness parameters that are required (or likely to be required) by secondary mortgage market energy efficiency financing programs such as Fannie Mae, Freddie Mac or FHA..

Florida Administrative Code
9B-13.0071

Cost Effectiveness Test for Amendments to the Florida Energy Efficiency Code for Building Construction (the Code)

The following are the criteria for the cost-effective test which shall be used to determine whether proposed increases in energy efficiency to residential and commercial buildings as defined in Section 13-101 of the Code result in a positive net financial impact:

(I) Energy Analysis Methodology:

The energy analysis necessary to determine energy savings for Energy Conservation Measures (ECMs) for residential and commercial buildings shall be conducted using the Energy Gauge USA published by the Florida Solar Energy Center. The analysis shall be conducted for both single EMCs and packages of ECMs. Each ECM shall be evaluated for cost effectiveness based on calculation of energy savings it provides when modeled with a package of ECMs that all together achieve the target percent efficiency improvement as established by law for the given Code edition.

(II) Economic Analysis Assumptions:

The following economic assumptions shall be used in conducting the cost-effective analysis for residential and commercial buildings:

(1) The cost of an ECM shall be the full, installed incremental cost of improvements. The incremental cost shall be 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, with an option to consider encumbering utility incentives.

(2) Study life period. The economic analysis shall be conducted using cash flow analysis over a 30-year study period.

(3) ECM service life. The economic evaluation shall be conducted using the appropriate service lives of the measures.

(4) Mortgage Parameter values:

(a) Mortgage interest rate for residential buildings shall be 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. The residential mortgage down payment rate shall be 10%.

(b) Mortgage interest rate for commercial buildings shall be 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 plus 2%. The commercial buildings mortgage down payment rate shall be 20%.

(5) Annual rate parameter values.

(a) The General inflation rate shall be the greater of the most recent 5-year and 10-year Annual Compound Inflation Rate (ACIR) computed from the annual average Consumer Price Index (CPI) as reported by the U.S. Bureau of Labor Statistics. ACIR shall be calculated as follows:

ACIR = [(ending value) / (starting value)] ^ {1.0 / [(ending year) – (starting year)]} – 1.0.

(b) The Discount rate shall be general inflation rate plus 2%.

(c) The Fuel escalation rate shall be 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. ACIR shall be calculated as follows:

ACIR = [(ending value) / (starting value)] ^ {1.0 / [(ending year) – (starting year)]} – 1.0.

(d) The baseline electricity and natural gas prices used in the analysis shall be as follows:

(1) For residential buildings, the statewide, revenue-based average residential price for the most recent available 12 months as provided by the Florida Public Service Commission shall be used; and
(2) For commercial buildings, the statewide, revenue-based average commercial price for the most recent available 12 months as provided by the Florida Public Service Commission shall be used

(6) The present value cash flow streams of the benefits and costs for ECMs and packages of ECMs shall be calculated as follows:

(a) Benefits – the annual present value benefits cash flow stream shall be calculated as follows:

(i) The present value of the energy cost savings for years 1 through 30 with energy savings determined in accordance with clause (I) multiplied by the baseline electricity and natural gas prices as specified by clause (II)(5)(d), escalated at the general inflation rate plus the fuel escalation rate, calculated as follows:

PV Energy Cost Savings = {[(Annual Energy Savings) * (Baseline Fuel Cost)] * [(General Inflation Rate) + (Fuel Escalation Rate)] ^Year} / [(Discount Rate) ^Year].

(ii) The present value of any salvage value, applied in the 30th year of the study period, for ECMs that have been replaced during the study period and for which the service life of the replacement has not been reached by the end of the 30th year. Salvage value shall be calculated as follows:

PV Salvage Value = [(ECM final replacement cost) * (remaining ECM life) / (full ECM service life)] / [(1+Discount Rate) ^30].

(b) Costs – the annual present value cost cash flow stream be calculated as follows:

(i) The down payment cost applied in year 0, calculated as the full cost of the improvements (ECMs) as specified in clause (II)(1) multiplied by the down payment rate as specified in clause (II)(4)(a) for residential buildings or as specified in clause (II)(4)(b), whichever is appropriate.

(ii) The annual mortgage payment on the balance of the ECM costs after the down payment has be subtracted for years 1 through 30, as calculated at the mortgage rate specified by clause (II)(4)(a) for residential buildings or as specified by clause (II)(4)(b) for commercial buildings.

(iii) For all ECMs with service lives less than 30 years, replacement costs shall be applied to the annual cost cash flow stream. Excepting the 30th year of the study period, replacement costs shall be applied during each year for which ECM end of life has been reached. Replacement cost shall be the original ECM cost inflated at the general inflation rate, calculated as follows:

Replacement Cost = (Original ECM Cost)*(1+General

Inflation Rate) ^ (Replacement Year).

(iv) Where incremental maintenance costs exist, they shall be incorporated into the annual cost cash flow stream during the year(s) the maintenance costs occur. All such maintenance costs shall be inflated at the General Inflation Rate over the study period and calculated as follows:

Maintenance Cost = (Base Maintenance Cost) * (1 + General Inflation Rate) ^ (Maintenance Year)

(v) For years 1 through 30, the above annual costs shall be summed and this summation shall be brought to its present value by discounting at the rate specified in clause (II)(5)(b), calculated as follows:

Annual Present Value Cost = [(Mortgage Cost) + (Replacement Cost) + (Maintenance Cost)] / [(1+ Discount Rate) ^Year].

(7) The Present Value Benefit-to-Cost (PVBC) Ratio shall be calculated as the sum of the annual present value benefits for years 1 through 30 divided by the sum of the annual present value costs for years 0 through 30.

(III) Economic Indicators of Cost Effectiveness:

The following economic indicators shall be used to determine whether the cost-effective test results in a "positive net financial impact":

(1) Present Value Benefit-to-Cost Ratio (PVBC). A value of 1.0 or greater shall be used for present value cost-to-benefit ratio (PVCB);

(2) Internal Rate of Return (IRR).

A value equal to 8% shall be used for IRR on investments.

(3) Levelized Cost of Conserved Energy (LCCE).

(a) For residential applications, 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) shall be used for LCCE.

(b) For commercial applications, a value equal to the statewide commercial 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) shall be used for LCCE

(IV) Evaluation Methodology for Measures and Packages of Measures:

The ECM and packages of ECMs shall be evaluated as follows:

(1) Multiple packages of ECMs shall be created that result in the target percentage efficiency increase for each Code cycle update (20, 30, 40 and 50%) based on comparison to the 2007 Code (without the 2009 supplement).

(2) Each ECM shall be evaluated using cost effectiveness indicators (PVBC, IRR, LCCE), within their specific package of ECMs. PVBC shall 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.

(3) Validation of the cost effectiveness of the Code 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.

(V) Definitions:

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.

Consumer: A class of economic system participant that makes no distinction between the owner of the building and the utility rate payer.

Discount rate*:* The periodic compound interest rate at which future cash flow streams are discounted back to their present value (PV).

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

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.

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

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