



# **MA RNC Program Incremental Cost Report**

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**Submitted to:**

**Berkshire Gas**

**Cape Light Compact**

**Columbia Gas of Massachusetts**

**National Grid**

**New England Gas Company**

**NSTAR Electric & Gas**

**Unitil**

**Western Massachusetts Electric Company**

**Submitted by:**

**NMR Group, Inc.**

**Dorothy Conant**

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## Executive Summary

This report provides estimates of the incremental costs per square foot involved in building high efficiency homes that meet the criteria of the 2013 MA Residential New Construction (RNC) Program. Incremental costs above the costs of typical homes being built outside the program are estimated for single family (SF), low-rise multifamily buildings of three or fewer stories (MF 1-3), and mid- to high-rise multifamily buildings of four stories or more (MF 4+) for each of the incentive options offered by the program. The 2013 MA RNC Program offers five incentive options for the SF and MF 1-3 building sectors — two based on prescriptive measures and three performance options based on percent savings — and three incentive options for the MF 4+ building sector. Incremental costs are estimated for each of these program options.

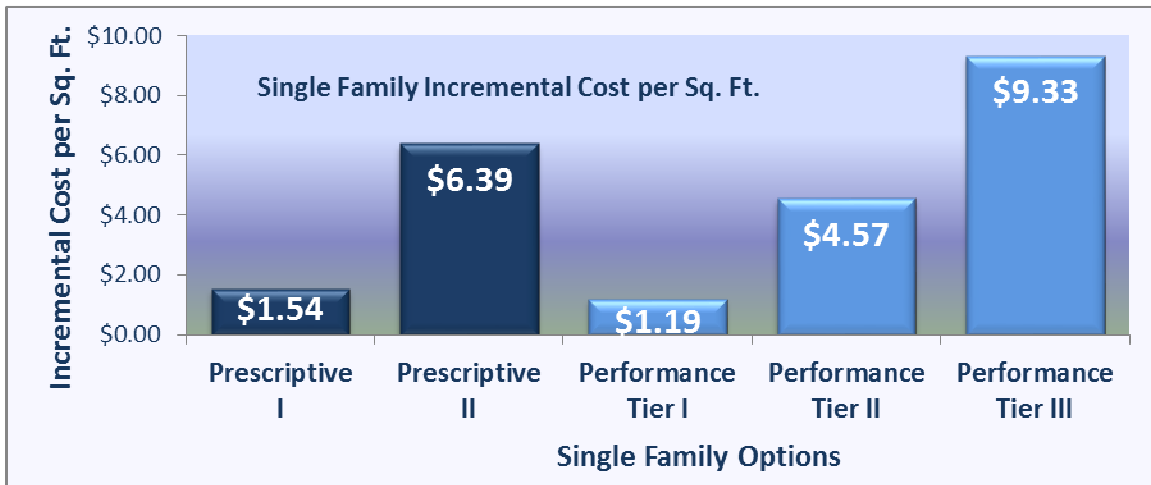
The measures implemented to achieve the SF and MF 1-3 option requirements are determined by comparing the average home characteristics of homes qualifying for each option to those specified by the 2012 User Defined Reference Home (UDRH). Building enhancements required for the two prescriptive options are defined by the program. Those for the performance options are based on the characteristics of the homes enrolled in the 2011 MA RNC program, with savings adjusted to reflect the change to the 2012 UDRH.

Baseline and upgraded building specifications for the new 2013 incentive options for the MF 4+ building sector were specified by ICF International based on their experience implementing the Multifamily New Construction Pilot (MFNCP).

The incremental costs of measures implemented to achieve the various efficiency option requirements were estimated by Ekotrope using a proprietary building energy optimization tool and the business relationships that Ekotrope has developed with building contractors for their work.

Figure ES-1 illustrates how the estimated incremental costs vary among the incentive options for homes in the SF building sector. The variation is due to both the kinds of measures that were implemented to satisfy the option requirements and the degree to which the measures were enhanced. Prescriptive II measures include all the Prescriptive I measures plus enhanced shell insulation measures. Performance Tier II is also more costly than Performance Tier I because of enhanced shell insulation measures. Performance Tier III homes have higher efficiency shell insulation than Tier II homes plus a higher efficiency central air conditioning system and a more expensive mechanical ventilation system.

**Figure ES-1: Incremental Cost by SF Program Option**



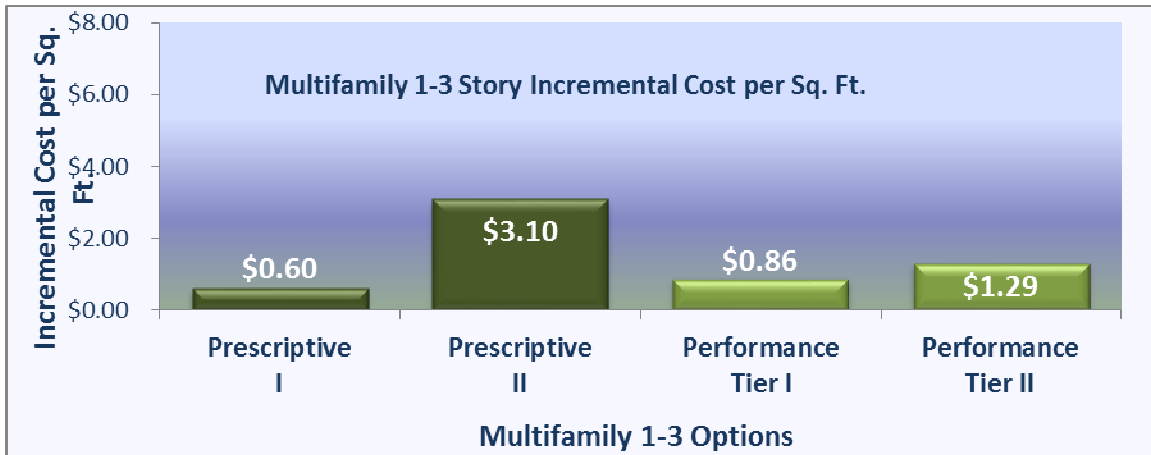
The MF 1-3 sector of the program includes both single family attached homes and low rise multifamily homes. The low-rise multifamily homes are also characterized by whether they have central or distributed utilities. Incremental costs were determined for the three predominant home types observed in the MF 1-3 sector: single family attached, multifamily no master meter, and multifamily master meter gas. The incremental costs of each of these types of homes were determined separately. Table ES-1 illustrates how the estimated incremental costs vary among the types of homes and the incentive options for homes in the MF 1-3 building sector. Incremental cost was not determined for the Prescriptive Tier III option because only one 2011 program home qualified for this option after savings were adjusted for the 2012 UDRH baseline.

**Table ES-1: Incremental Cost by MF 1-3 Home Type and Program Option**

MF 1-3 Home Type	Prescriptive I	Prescriptive II	Performance Tier I	Performance Tier II
Single Family Attached	\$1.38	\$5.61	\$1.03	\$1.27
Multifamily No Master Meter	\$0.10	\$1.50	\$0.65	\$1.18
Multifamily Master Meter Gas	\$0.08	\$1.48	\$0.79	\$1.35
MF 1-3 Overall	\$0.60	\$3.10	\$0.86	\$1.29

The overall MF 1-3 incremental costs were determined by weighting the costs for each home type by their frequency in the 2011 program. The overall incremental cost for MF 1-3 homes by program incentive option is illustrated in Figure ES-2.

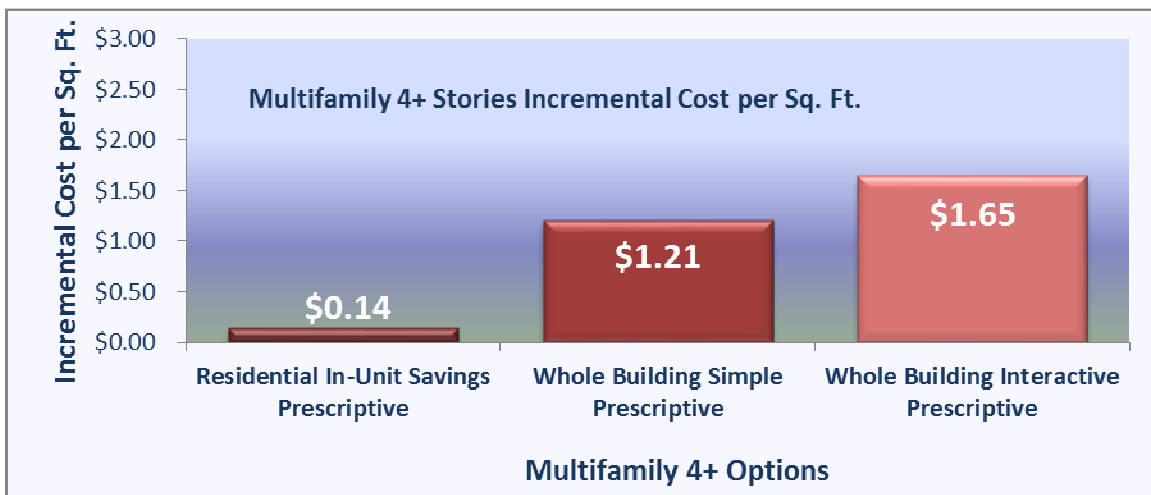
**Figure ES-2: Incremental Cost by MF 1-3 Program Option**



Similar to the results for the SF sector, the MF 1-3 Prescriptive II incremental cost is significantly higher than the Prescriptive I incremental cost because of enhanced shell insulation measures. Unlike the results for the SF sector, MF 1-3 Performance Tier II is only moderately more costly than Performance Tier I. MF 1-3 Performance Tier II homes do not have the more costly enhanced wall and ceiling insulation observed in SF homes. The single family attached homes in the MF 1-3 sector tend to have higher conditioned basement foundation wall insulation and lower duct leakage. The multifamily homes in the MF 1-3 sector tend to have higher efficiency windows, better slab insulation, and lower duct leakage than Tier I homes.

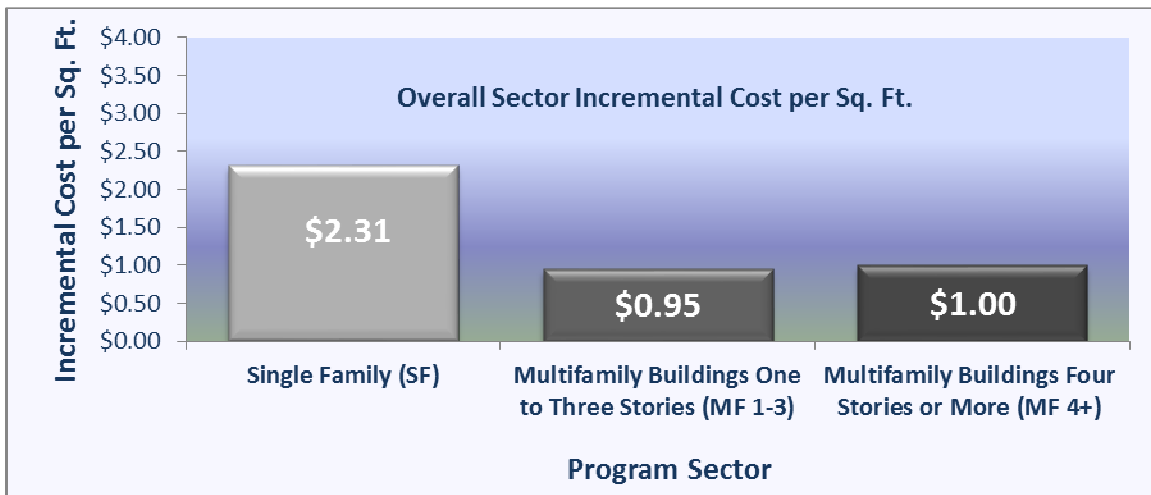
Figure ES-3 illustrates how the estimated incremental costs vary among the incentive options for homes in the MF 4+ building sector. The incremental costs increase gradually as the Whole Building Simple Prescriptive option adds building and common area measures to the appliance, lighting, and water fixture measures of the Residential In-Unit Savings Prescriptive option, and as the Whole Building Interactive Prescriptive option increases the efficiency requirements for lighting, shell insulation, space heating and water heating.

**Figure ES-3: Incremental Cost by MF 4+ Program Option**



By combining the incremental costs of a sector’s options in proportion to the number of homes that qualified for each option, the sponsors are able to calculate an incremental cost representative of the program sector. For this report, the SF and MF 1-3 incremental costs are based on homes enrolling in the program in 2011 and completed in 2011 with savings adjusted to reflect the 2012 UDRH. This is assumed to be representative of the home type distribution and measure implementation of the program in general. In this case, all qualifying homes have been distributed into the three performance tiers based on their projected savings results, so the incremental costs of the prescriptive options are not included in the overall average. Because incentive options for mid- to high-rise buildings are new offerings for the 2013 RNC program, NMR assumed an equal distribution of homes among the three MF 4+ options. Overall sector incremental costs calculated on this basis are illustrated in Figure ES-4. Alternative distributions of program homes can easily be applied by program administrators to reflect different existing or projected program results.

**Figure ES-4: Incremental Cost per Square Foot by Sector**





# 1 Introduction

The objective of this study is to estimate the incremental costs involved in building high efficiency homes that meet the criteria of the 2013 MA RNC Program (Program). The Program provides incentives for homes that are more energy efficient than the typical home being built outside the Program. The 2013 MA RNC Program offers five incentive options—two based on prescriptive measures and three performance options based on percent savings relative to the 2012 User Defined Reference Home (UDRH)—for single family (SF) and low-rise multi-family buildings of three or fewer stories (MF 1-3):

- Prescriptive Option I: efficient lighting, heating, hot water, and cooling systems; low air infiltration with mechanical ventilation; ducts in conditioned space; and programmable thermostats
- Prescriptive Option II: Option I requirements plus enhanced envelope thermal performance
- Performance Tier I: 15% to less than 30% energy savings relative to the 2012 UDRH
- Performance Tier II: 30% to less than 45% energy savings relative to the 2012 UDRH
- Performance Tier III: 45% or better energy savings relative to the 2012 UDRH

The program also established a trial Code Plus option for SF and MF 1-3 homes. This is a default option for homes that do not meet the minimum Tier I savings relative to the 2012 UDRH but achieve 10% to less than 15% improvement over the 2012 UDRH and are compliant with Sections 3 and 5 of the ENERGY STAR Thermal Enclosure System Rater Checklist. NMR did not develop separate incremental costs for homes that fall within this category.

The Program also promotes three incentive options for higher efficiency mid- to high-rise multi-family buildings of four stories or more (MF 4+):

- Residential In-Unit Savings Prescriptive Option – electric savings for appliances, lighting, domestic hot water usage, and in-unit production.
- Whole Building Simple Prescriptive Option—a simplified package of offerings including both in-unit and whole building energy savings for gas and electric energy conservation measures (ECMs) including envelope, HVAC, DHW, pumps & motor and common area lighting.
- Whole Building Interactive Prescriptive Option– comprehensively addressed in-unit and whole building ECMs.

The NMR team used 2012 User Defined Reference Home specifications to define the baseline characteristics of SF and MF 1-3 homes. We then determined the typical measures implemented

in upgraded homes based on the home characteristics documented in REM/Rate™<sup>1</sup> files for homes that participated in the 2011 MA RNC Program. ICF International (ICF), the Program’s implementation contractor, provided baseline and upgraded building specifications for MF 4+ homes based on their experience implementing the Multifamily New Construction Pilot (MFNCP). NMR engaged the services of Ekotrope, a company headquartered in Cambridge, MA, to develop the incremental costs of measures implemented to achieve the various efficiency options, based on specifications developed by NMR. Ekotrope applied their proprietary building energy optimization tool and business relationships developed with building contractors to accomplish this task.

NMR determined incremental cost estimates in dollars per square foot (\$/sq. ft.) for single-family, multifamily, and mid- to high-rise buildings for each incentive option offered by the program. A single \$/sq. ft. value for each building type and incentive option was derived by weighting measure options by their implementation frequency and then summing all the costs of individual measures.

Cost data are provided in a format that allows program administrators to adapt it to different home mix compositions by territory or to changes in the projected mix of participating projects over the planning period. The incremental costs developed for this study can be used for future program planning, including program design and incentive levels, and for determining cost effectiveness.

This study did not attempt to estimate what percentage incremental costs per square foot are of base construction cost per square foot. The program does not collect construction cost data and construction cost per square foot varies widely for every housing type. The Census Bureau reports price per square foot, including builder mark-up, data for new single-family housing sold. Table 1-1 shows Census Bureau estimates of 2012 median and average building price per square foot for new single-family detached and attached houses in the Northeast.<sup>2,3</sup>

**Table 1-1: 2012 Median and Average Price per Square Foot of Floor Area in New Single-Family Houses in the Northeast Excluding Land Value**

Housing Type	Median	Average
Single-Family Detached	\$ 121.90	\$ 124.03
Single-Family Attached	\$ 104.36	\$ 114.81

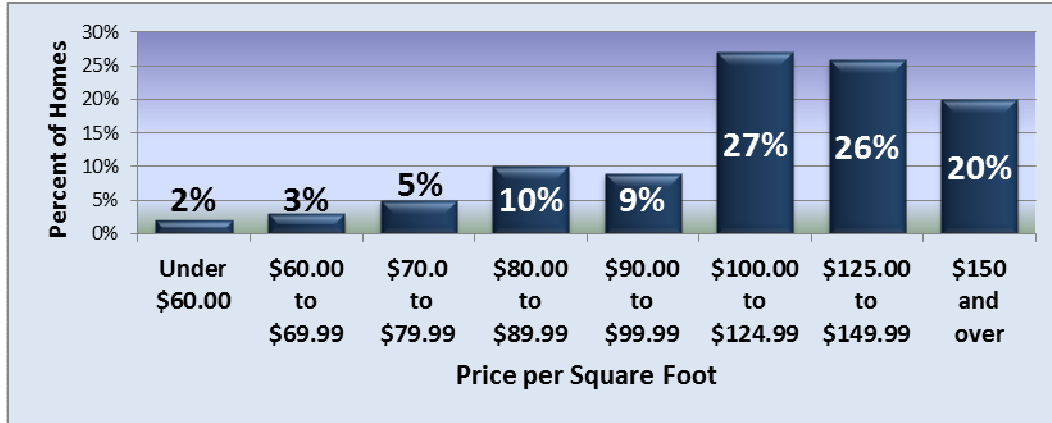
<sup>1</sup> *REM/Rate*™ software produces a home energy rating report based on the RESNET® National HERS Technical Standards. A REM/Rate file documenting savings is required by the MA RNC program as evidence of compliance with program performance options.

<sup>2</sup> “Characteristics of New Single Family Houses Sold,” accessed June 11, 2013, <http://www.census.gov/construction/chars/sold.html>.

<sup>3</sup> The Northeast Region includes Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont.

Figure 1-1 and Figure 1-2 show, respectively, the percentages of new single-family detached and single-family attached housing units sold in 2012 by price per square foot range.<sup>4</sup>

**Figure 1-1: Percent of 2012 New Detached Single-Family Housing Units in the Northeast Sold by Price per Square Foot Excluding Land Value**



**Figure 1-2: Percent of 2012 New Attached Single-Family Housing Units in the Northeast Sold by Price per Square Foot Excluding Land Value**



The Census bureau does not report price or cost per square foot for new multi-family buildings. In calls to HERS raters working with program homes and ICF staff working with multi-family projects, all agreed multi-family building construction cost per square foot also varies significantly and would not necessarily be lower than single-family construction cost: no one was aware of any free access database of multi-family construction cost.

<sup>4</sup> Ibid.

## 2 Methodology

This report section describes our approach for estimating the incremental costs involved in building high efficiency homes that meet the criteria of the 2013 MA RNC Program. NMR conducted parallel incremental cost analyses for SF and MF 1-3 since the same five program options are available for both building sectors and the measures implemented to achieve the required efficiency levels are very similar for the buildings in these two categories.

Because the mid- to high-rise building incentive options are new offerings for the 2013 RNC program, there is no directly transferable experience of specific measures that would characteristically be implemented for each of the three MF 4+ building program options. However, based on their experience implementing the Multifamily New Construction Pilot (MFNCP), ICF provided information on appropriate baselines and the changes that projects participating in the Residential In-Unit Savings Prescriptive, Whole Building Simple Prescriptive, and Whole Building Interactive Prescriptive program options would be likely to make.

### 2.1 SF and MF 1-3 Specifications

NMR first developed a list of efficiency measures to include in the incremental cost analysis for SF and MF 1-3 building types based on program requirements and REM/Rate file inputs. The list included the following mechanical system, envelope, and other measures required by SF and MF 1-3 Prescriptive Options I and II:

- Gas Furnace
- Gas Boiler
- Central Air Conditioning System
- Gas Water Heater , Conventional or Instantaneous
- Air Infiltration
- Water Fixtures
- Thermostats
- Mechanical Ventilation

In addition, a review of REM/Rate files indicated that other measures were often implemented to achieve the energy savings required by the three SF and MF 1-3 Performance Tiers. These measures were also included in the incremental cost specifications.

- Duct Leakage
- Duct Insulation
- Windows
- Wall, Ceiling, and Frame Floor Insulation

- Foundation Wall and Slab Insulation

NMR used this list of measures in an incremental cost specification spreadsheet developed to document the baseline standard and high efficiency standards for each incentive option.

This report does not address the incremental costs of lighting measures for the SF and MF 1-3 program sectors. Instead, as requested by the study sponsors, estimates of the typical cost of a standard incandescent bulb and a CFL bulb, a pin based bulb, and an LED bulb are provided in [Appendix A](#) for reference

### 2.1.1 Measure Specifications

Since the 2013 program baseline for savings is the 2012 UDRH for residential measures, NMR used this reference to specify the baseline standard for each incremental cost measure. In the few cases where the 2012 UDRH does not specify the standard for a measure, Massachusetts 2011 Baseline Study of Single-family Residential New Construction report<sup>5</sup> values were used to specify the standard.

For the prescriptive incentives, the measures required for SF and MF 1-3 homes are defined by the program. For the performance paths, the method of achieving required program savings goals are determined by the home builders. Documentation of the builders' choices is contained in the home savings analysis REM/Rate files. NMR determined the measures and efficiency levels typically installed in program homes that we estimated would achieve the percent savings goals over the reference home specified for each performance tier.

### 2.1.2 Program Homes

NMR used 2011 program homes as a proxy for 2013 program homes to determine the characteristics of homes achieving each performance tier. This was the most recent full set of data available when the study began. The measures implemented to achieve savings for the homes that participated in the 2011 RNC program, as documented in 2011 REM/Rate home files, are assumed to be representative of the measures that will be implemented by the homes that will participate in the program in 2013.

The 2011 REM/Rate files include projects that were enrolled in 2010, with percent savings based on the 2010 UDRH, and projects enrolled in 2011, with percent savings based on 2011 hybrid UDRH<sup>6</sup>. Program homes that enrolled in 2010 were not included in the set of homes used to

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<sup>5</sup> NMR Group, Inc., et al., "Massachusetts 2011 Baseline Study of Single-family Residential New Construction, Final Report," Submitted to Massachusetts Residential New Construction Program Administrators, August 16, 2012.

<sup>6</sup> Due to the new 2009 International Energy Efficiency Code (IECC) being implemented, the User Defined Reference Home (UDRH) was updated in 2011 using the Program Vendor's and the JMC's expertise to come up with assumed baseline values for the various inputs—the result was the 2011 hybrid UDRH. Some 2011 housing units were completed under 2010 agreements with saving percentages based on comparing as-built home

define home characteristics for the incremental cost analysis. Only the homes enrolled in 2011, with percent savings based on 2011 hybrid UDRH were used; this population includes a total of 1,316 homes.. An analysis conducted by ICF estimated that savings for the homes enrolled in 2011 relative to the 2012 UDRH would be 83% of savings relative to the 2011 hybrid UDRH. Therefore, NMR scaled the REM/Rate savings for the homes enrolled and completed in 2011 by this factor to reflect the more stringent 2012 UDRH inputs.

NMR sorted the 2011 single family and multifamily 1-3 homes with adjusted savings by program sectors, heating utility category, and level of efficiency achieved as illustrated in Table 2-1. We then used the homes that met program performance tier savings requirements to define the average characteristics of homes in each program sector at each performance tier level. The characteristics of homes that defaulted to the Code Plus category or did not qualify for any program component because of low savings were not considered in developing SF and MF 1-3 home specifications.

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consumption to 2010 UDRH reference home consumption and other housing units were completed under 2011 agreements with saving percentages based on comparing the as-built home to 2011 hybrid UDRH reference home consumption. Housing units completed under 2010 agreements are referred to as “legacy” housing units and housing units completed under 2011 agreements are referred to as “non-legacy” housing units.

**Table 2-1: 2011 RNC Homes by Program Sector, Heating Utility, and Level of Efficiency**

Program Sector	Incremental Cost Category	All homes		Tier I 15% to 29% savings	Tier II 30% to 44% savings	Tier III 45%+ savings	Code Plus 10% to 14% savings	Non- Qualifying
		Count	% of Sector					
Single Family	SF DETACHED NO MASTER METERED	411	100%	268	90	14	35	4
Multifamily 1-3	MULTIFAMILY 1-3 STORIES NO MASTER METER	322	36%		112		29	
	SF ATTACHED NO MASTER METERED	312	35%	255	35	1	21	
	MULTIFAMILY 1-3 STORIES MASTER METER GAS	233	26%	140	21		22	50
	MULTIFAMILY 1-3 STORIES MASTER METER GAS & ELECTRIC	15	2%	15				
	MULTIFAMILY 1-3 STORIES MASTER METER ELECTRIC	14	2%				14	
	SF ATTACHED MASTER GAS	6	1%	5	1			
	SF ATTACHED MASTER GAS & ELECTRIC	1	0%	1				
	TOTAL MF 1-3	903	100%	416	169	1	86	50

As can be seen in the table above, the single family homes sector consists of homes categorized as single family detached with no master meter. NMR based the specifications for SF efficiency measures on an analysis of the characteristics of the 372 homes (excluding Code Plus and Non-Qualifying) in this group that met Performance Tier I, II and III savings requirements. Most of these homes achieve efficiency levels consistent with the Performance Tier I program option. A good number of homes also achieve Tier II savings, and a small number achieve Tier III savings.

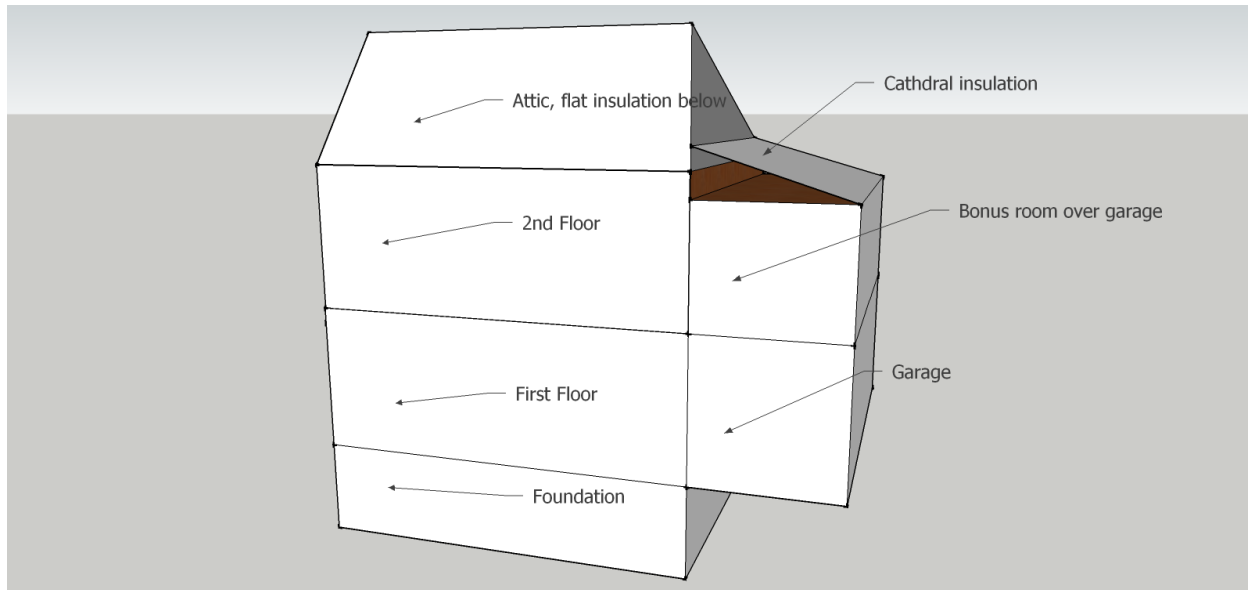
The MF 1-3 program sector, which includes single family attached homes, is well represented by a combination of three types of homes: multifamily 1-3 story with no master meter, multifamily 1-3 story with master meter gas, and single family attached with no master meter. These three categories of homes include 96% of the homes in this sector. We based the specifications for MF 1-3 efficiency measures on an analysis of the characteristics of the 563 homes in these three groups that met the Tier I and Tier II performance savings requirements. For this sector, only one home achieves Tier III savings after adjusting for the 2012 UDRH, so no incremental cost analysis was possible for Tier III in the MF 1-3 sector.

### 2.1.3 Home Configurations

NMR specified the physical dimensions of a representative SF home at each performance tier based on the average parameters of the homes in each group. These dimensions included the square footage of conditioned floor area, ambient walls, ceilings, windows, basement slab floor, and basement wall perimeter. Average physical dimensions of all 2011 program homes were used for defining prescriptive option homes. NMR determined different home physical dimensions for each of the three SF performance tiers because there were significant differences in the average home size among the three tiers.

For the SF detached home design we assumed the foundation was square, the house was 2 stories, and the second floor had a bonus room over the garage. The same configuration was assumed for all efficiency levels with shell measure areas scaled to reflect the different average home sizes among the performance tiers. This building configuration is illustrated in Figure 2-1.

**Figure 2-1: Configuration of Representative Single Family Detached Home**



NMR assumed the same basic home configuration for single family attached homes which the program includes in the MF 1-3 category of buildings. The single family attached home configuration varied only in that we assumed that two single family units shared common walls on one side of the house.

MF 1-3 average unit sizes did not vary significantly by performance tier, so NMR assumed the same multifamily unit and building configuration for all multifamily homes. We developed a typical multifamily building profile based on the characteristics of the 2011 program multifamily homes. We found these to be predominantly 2 and 3 story apartment and townhouse buildings, with apartments outnumbering townhouses by a 3:2 ratio. A few MF units were single story and a few were 4 story buildings in a complex with a mix of 3 and 4 story buildings. Most units



appeared to be in 3 story buildings, and there were an average of 17 units per building. A multifamily residential unit had an average of 1,180 sq. ft. of living space. Based on these multifamily building characteristics, and overall building parameters consistent with those used in the MF 4+ analysis, discussed in Section 2.2, NMR adopted the building configuration represented in Table 2-2 as the basis for development of multifamily 1-3 incremental costs.

**Table 2-2: Multifamily 1-3 Building Configuration**

<b>Building Characteristic</b>	<b>Value</b>
Number of Stories	3
Number of Units per building	18
Units per floor	6
Unit Size (sq. ft.)	1,188
Building Size (sq. ft.)	30,549
Residential Area (sq. ft.)	21,384
Common Area (sq. ft.)	9,165
Wall Height (ft.)	9
Building Length (ft.)	148
Building Width (ft.)	69
Building Wall Area (gross sq. ft.)	11,707
Window Area (net sq. ft.)	2,927
# units with vaulted ceilings	3
% of unit area with vaulted ceiling	25%
Total Flat Ceiling Area (sq. ft.)	9,292
Total Vaulted Ceiling Area (sq. ft.)	996
Slab Area (sq. ft.)	10,183

\*According to program data 14% of units have vaulted ceilings, or approximately 3 of 18 units.

NMR used average REM/Rate values to specify the upgraded efficiencies and capacities of the measures that would likely be implemented to meet performance tier savings targets based on past program home savings results. The measures specified included insulation levels, HVAC and water heating system efficiencies and capacities, air leakage and duct leakage levels, and mechanical ventilation. We also developed specifications for alternative home heating systems, alternative water heating systems, and basement wall insulation for both conditioned and unconditioned basements in order to represent observed variations in program home characteristics.

Tables documenting the average measure values derived for each home type and program path are included in [Appendix B](#).

## 2.2 MF 4+ Specifications

The mid- to high-rise building incentive options are new offerings for the 2013 RNC program. There is no directly transferable experience of the specific measures characteristically

implemented in the units for each of the three MF 4+ building program options. However, based on their experience implementing the Multifamily New Construction Pilot (MFNCP), ICF developed a list of measures that addresses the potential savings achievable for the targeted audience.

The MF 4+ Residential In-Unit Savings Prescriptive Option is designed to capture savings for projects recruited once all, or almost all, building decisions are made. Energy-efficiency improvements are focused on a basic set of measures to be implemented at the unit level including:

- High Efficiency Refrigerators
- High Efficiency Dishwashers
- Hi-efficacy Lighting
- WaterSense® Showerheads
- WaterSense® Lavatory Faucets
- Reduced Air Infiltration

The MF 4+ Whole Building Simple Prescriptive Option is designed for projects recruited after being permitted or after a bid has been awarded. The measures in this option include the basic measures from the Residential In-Unit Savings Prescriptive Option plus the following additional gas and electric measures to capture whole building savings:

- Wall and Ceiling Insulation
- Windows
- Space Heating Systems
- Central Air Conditioning System
- Water Heating
- Variable Frequency Drives (VFDs) for Hot and Chilled Water Pumps
- Common Area Lighting

The MF 4+ Whole Building Interactive Prescriptive Option is designed for projects recruited before the building is permitted. This group of participants offer the most potential for savings because they are still in the design stage, and participants have the opportunity to fine tune their design decisions to maximize energy efficiency and increase incentive opportunities. All the measures identified for the Simple Prescriptive Option are included in the measure list for this option, but with higher efficiency standards for implementation.

ICF provided information on appropriate baselines and efficiency enhancements for each measure based on their multifamily pilot and MA RNC program implementation experience.

ICF also developed a typical multifamily building profile based on the characteristics of the multifamily buildings with four or more stories that have participated in the sponsors' pilot and

other RNC programs. NMR assumed the multifamily unit and building configuration illustrated in Table 2-3 to develop the incremental costs for all three MF 4+ program options.

**Table 2-3: Multifamily 4+ Building Configuration**

<b>Building Characteristic</b>		<b>Value</b>	<b>Percent</b>
Number of Stories		5	
Total Number of Units per Building		52	
Number of Units per Floor	Top Floor	10	
	Middle Floors	36	
	First Floor*	6	
Typical Unit Profile	Size (sq. ft.)	891	
	Floor Position	middle	
	Location Position	inside	
Building Size (sq. ft.)		65,739	100%
Residential Area (sq. ft.)		46,338	70%
Common Area (sq. ft.)		19,401	30%
Common Area Analysis	Corridors	4,464	6.8%
	Stairwells	1,637	2.5%
	Meeting	964	1.5%
	Office	637	1.0%
	Laundry	233	0.4%
	Lobby	1,988	3.0%
	Unaccounted	9,477	14.4%
Building Wall Area (gross sq. ft.)		21,825	
Window Area (net sq. ft.)		5,456	
Ceiling Area (sq. ft.)		14,662	

\* 36% of all projects do not have residential units on the first floor.

### 3 Incremental Cost Analysis

NMR developed an incremental cost template for each program sector (SF, MF 1-3, MF 4+) to document baseline measure and upgraded efficiency measure specifications by program option and to provide a framework for reporting incremental costs. We developed an additional template for single family attached (SFA) homes because, while these homes are included in the MF 1-3 program sector, they are more similar in physical configuration to homes in the SF sector. Each template includes input columns for measure-by-measure incremental cost and calculated incremental cost per square foot for each program option. The completed templates for each program sector and SFA homes are presented in [Appendix C](#).

#### 3.1 Measure Incremental Cost Estimates

NMR engaged Ekotrope Inc. to estimate the incremental costs associated with installation of the measures required to meet program requirements under each of the program options. Ekotrope staff members work directly with contractors to establish cost estimates for various measures of the specified home configurations, including changes in envelope insulation and air sealing, and HVAC and water heating equipment upgrades. NMR met with Ekotrope staff to explain the templates, specifications, and home configurations that we developed and how they should be used. We then reviewed all incremental cost estimates and documentation provided by Ekotrope for consistency and reasonableness.

Ekotrope did not provide independent incremental cost estimates for the SF attached home measures. These measures were similar enough to the SF detached measures to allow NMR to estimate their incremental cost by extrapolating and scaling the costs from the incremental costs for the same SF detached measures.

Measure level incremental costs per square foot for SF attached and SF detached homes (part of MF 1-3 sector) were calculated by dividing measure incremental cost by conditioned space area (sq. ft.). This is the home square footage documented in the REM/Rate files. For multifamily homes in MF 1-3 and MF 4+ sectors, measure level incremental costs per square foot are based on the whole building area (sq. ft.) rather than the residential conditioned space area.

#### 3.2 Measure Weighting Factors

NMR then listed incremental costs per square foot for each program sector by measure and program option along with an associated measure weight. Where variations for a specific home characteristic existed in the reference REM/Rate files, we assumed the predominant characteristic if one was apparent. If a single characteristic did not seem representative of the homes being examined, we determined a weighting factor based on the frequency of occurrence of each variation. We observed variations in home heating system types, water heater types and conditioned versus unconditioned basements. If there were no measure variations, we applied a weighting factor of 1.0. We then summed the weighted costs of all the measures included in a

program option to get the total incremental cost per square foot for each program option. Weighting factors for the prescriptive options were based on the combined home characteristics of all the sector homes that met performance level savings criteria, and are most like the Performance Tier I factors since most homes in each sector qualified at this level of savings.

Weighting factors derived for home characteristic variations for the SF (detached) sector by program option are presented in Table 3-1. Unconditioned basements were more prevalent in SF detached homes that qualified at the Tier I efficiency level, while conditioned basements were more frequent for homes that achieved Tier II and Tier III savings. Gas furnaces were the heating system of choice for most homes that achieved Tier I and Tier II savings. The few Tier III homes that identified a heating system type reported having gas boilers. Water heater type was evenly split between instantaneous gas and conventional gas at the Tier I level, but instantaneous gas water heaters were more frequently reported in Tier II homes.

**Table 3-1: Weighting Factors for SF Detached Home Characteristic Variations by Efficiency Option**

Home Characteristic	Variation	Prescriptive I & II (all)			Performance Tier I			Performance Tier II			Performance Tier III		
		count	% units	% split assumed	count	% units	% split assumed	count	% units	% split assumed	count	% units	% split assumed
Basement Type	Unconditioned Basement	219	59%	<b>65%</b>	187	70%	<b>76%</b>	30	33%	<b>37%</b>	2	14%	<b>18%</b>
	Conditioned & Mixed Type Basements	118	32%	<b>35%</b>	58	22%	<b>24%</b>	51	57%	<b>63%</b>	9	64%	<b>82%</b>
	Enclosed Crawl	2	1%		1	0%		0	0%		1	7%	
	Slab	2	1%		1	0%		1	1%		0	0%	
	No Basement Type	14	4%		10	4%		3	3%		1	7%	
	No Entry	17	5%		11	4%		5	6%		1	7%	
	Total	372	100%	100%	268	100%	100%	90	100%	100%	14	100%	100%
Heating System Type	Gas Furnace AFUE	282	76%	<b>84%</b>	219	82%	<b>87%</b>	63	70%	<b>78%</b>	0	0%	<b>0%</b>
	Gas Boiler AFUE	54	15%	<b>16%</b>	33	12%	<b>13%</b>	18	20%	<b>22%</b>	3	21%	<b>100%</b>
	Other/Not Specified	36	10%		16	6%		9	10%		11	79%	
	Total	372	100%	100%	268	100%	100%	90	100%	100%	14	100%	100%
Water Heater Type	Instantaneous Gas Water Heater EF	141	38%	<b>55%</b>	98	37%	<b>49%</b>	43	48%	<b>74%</b>	na	na	
	Conventional Gas Water Heater EF	117	31%	<b>45%</b>	101	38%	<b>51%</b>	15	17%	<b>26%</b>	1	7%	
	Conventional Electric Water Heater EF	25	7%		17	6%		6	7%		2	14%	<b>100%</b>
	Other/Not Specified	89	24%		52	19%		26	29%		11	79%	
	Total	372	100%	100%	268	100%	100%	90	100%	100%	14	100%	100%

Weighting factors for home characteristic variations were derived separately for the SF attached homes that are part of the MF 1-3 program sector. These factors are presented in Table 3-2 by program option. Basement type was evenly split between unconditioned and conditioned at the Tier I level, but conditioned basements were more frequently reported in Tier II homes. Gas furnaces were the heating system of choice for most homes that achieved Tier I or Tier II savings. Instantaneous gas water heaters were slightly more prevalent than conventional gas water heaters in SF attached homes that qualified at the Tier I efficiency level, and equally split for homes that achieved Tier II savings.

**Table 3-2: Weighting Factors for SF Attached Home Characteristic Variations by Efficiency Option**

Home Characteristic	Variation	Prescriptive I & II (all)			Performance Tier I			Performance Tier II		
		count	% units	% split assumed	count	% units	% split assumed	count	% units	% split assumed
Basement Type	Unconditioned Basement	92	32%	<b>47%</b>	91	36%	<b>51%</b>	1	3%	<b>6%</b>
	Conditioned & Mixed Type Basements & Slab	103	36%	<b>53%</b>	87	34%	<b>49%</b>	16	46%	<b>94%</b>
	Enclosed Crawl	2	1%		2	1%		0	0%	
	No Basement Type	32	11%		21	8%		11	31%	
	No Entry	61	21%		54	21%		7	20%	
	<b>Total</b>	<b>290</b>	<b>100%</b>	<b>100%</b>	<b>255</b>	<b>100%</b>	<b>100%</b>	<b>35</b>	<b>100%</b>	<b>100%</b>
Heating System Type	Gas Furnace AFUE	232	80%	<b>82%</b>	207	81%	<b>83%</b>	25	71%	<b>71%</b>
	Gas Boiler AFUE	52	18%	<b>18%</b>	42	16%	<b>17%</b>	10	29%	<b>29%</b>
	Other/Not Specified	6	2%		6	2%		0	0%	
	<b>Total</b>	<b>290</b>	<b>100%</b>	<b>100%</b>	<b>255</b>	<b>100%</b>	<b>100%</b>	<b>35</b>	<b>100%</b>	<b>100%</b>
Water Heater Type	Instantaneous Gas Water Heater EF	107	37%	<b>57%</b>	99	39%	<b>57%</b>	8	23%	<b>50%</b>
	Conventional Gas Water Heater EF	82	28%	<b>43%</b>	74	29%	<b>43%</b>	8	23%	<b>50%</b>
	Conventional Electric Water Heater EF	7	2%		7	3%		0	0%	
	Other/Not Specified	94	32%		75	29%		19	54%	
	<b>Total</b>	<b>290</b>	<b>100%</b>	<b>100%</b>	<b>255</b>	<b>100%</b>	<b>100%</b>	<b>35</b>	<b>100%</b>	<b>100%</b>

The weighting factors for the multifamily homes with three or fewer stories are based on home characteristic variations of the No Master Meter and Master Meter Gas categories of homes. These two types of homes combined with the SF Attached homes make up 96% of the MF 1-3 program homes under consideration. The weighting factors for these multifamily homes are presented in Table 3-3 by program option. Unlike the SF homes, the multifamily homes had predominantly slab basements so no weighting factor was developed for basement type. Gas boilers were the heating system of choice for most homes that achieved Tier I savings while gas furnaces were more frequently reported in Tier II homes. Instantaneous gas water heaters were the predominant water heating system for homes in both performance tiers.

**Table 3-3: Weighting Factors for MF 1-3 Home Characteristic Variations by Efficiency Option**

Home Characteristic	Variation	Prescriptive I & II (all)			Performance Tier I			Performance Tier II		
		count	% units	% split assumed	count	% units	% split assumed	count	% units	% split assumed
Heating System Type	Gas Furnace AFUE	79	17%	<b>40%</b>	20	6%	<b>16%</b>	59	45%	<b>87%</b>
	Gas Boiler AFUE	118	26%	<b>60%</b>	109	34%	<b>84%</b>	9	7%	<b>13%</b>
	Other/Not Specified	255	56%		192	60%		63	48%	
	Total	452	100%	100%	321	100%	100%	131	100%	100%
Water Heater Type	Instantaneous Gas Water Heater EF	152	34%	<b>93%</b>	84	26%	<b>88%</b>	68	52%	<b>100%</b>
	Conventional Gas Water Heater EF	12	3%	<b>7%</b>	12	4%	<b>13%</b>	0	0%	
	Conventional Electric Water Heater EF	0	0%		0	0%		0	0%	
	Other/Not Specified	288	64%		225	70%		63	48%	
	Total	452	100%	100%	321	100%	100%	131	100%	100%



## 4 Incremental Cost Results

In the final step of the incremental cost analysis, NMR averaged the total incremental costs per square foot for all the incentive options in a program sector weighted by the projected distribution of program homes across the program options to obtain an incremental cost per square foot for each program sector. Since the basis for the SF and MF 1-3 analysis is 2011 program homes with savings adjusted to reflect the 2012 UDRH, all qualifying SF and MF 1-3 homes were assigned to one of the three performance tier options. There was no practical way to assign homes to the two prescriptive options. The total incremental cost per square foot for the three options in the MF 4+ sector weighted all three options equally because these are new program offerings and there is no basis for an alternative weighting scheme.

This results in a format that allows sponsors to evaluate the impact of different distributions of homes among the available program options in a sector simply by adjusting the values for the percentages of homes for each option. It also allows sponsors to look at specific sets of measure mixes by simply changing the weighting factors of measure options. Sponsors can use measure weights to reflect the different types of heating systems prevalent in participating homes in their service territories or assume changes in the mix from year to year. Sponsors can also compare the incremental costs per square foot for homes with gas furnaces versus gas boilers and also for homes with conditioned versus unconditioned basements simply by weighting the desired option with a factor of 1.0 and the other option(s) with a factor of 0.0.

The results of the incremental cost analyses for each of the program sectors are presented in the following report sections.

### 4.1 SF Incremental Costs

As illustrated in Table 4-1, incremental cost per square foot of SF home conditioned space varied from a low of \$1.37/sq. ft. for the Performance Tier I path, to a high of \$9.26/sq. ft. for the Performance Tier III path. The \$1.54/sq. ft. for the Prescriptive I option was only 12% higher than the Performance Tier I \$1.37/sq. ft., while the \$6.39/sq. ft. for the Prescriptive II option fell slightly less than halfway between the \$4.57/sq. ft. for Performance Tier II and \$9.26/sq. ft. for Tier III.

**Table 4-1: SF Detached Incremental Cost per Square Foot by Program Option**

Measure Type	Measure Description	Prescriptive I		Prescriptive II		Performance Tier I		Performance Tier II		Performance Tier III	
		\$/ sq. ft.	% of units	\$/ sq. ft.	% of units	\$/ sq. ft.	% of unit)	\$/ sq. ft.	% of units	\$/ sq. ft.	% of units
Shell	Conditioned Space /Ambient Walls Insulation	\$ -	100%	\$2.46	100%	\$0.14	100%	\$1.89	100%	\$2.73	100%
	Conditioned Space /Garage Walls Insulation	\$ -	100%	\$0.31	100%	\$0.02	100%	\$0.24	100%	\$0.35	100%
	Flat Attic Ceiling Insulation	\$ -	100%	\$0.49	100%	- \$0.18	100%	- \$0.02	100%	\$0.48	100%
	Cathedral Ceiling Insulation	\$ -	100%	\$1.28	100%	\$ -	100%	\$0.33	100%	\$0.82	100%
	Frame Floor Insulation, Conditioned Space over Unconditioned Basement	\$ -	100%	\$ -	100%	\$0.20	100%	\$0.20	100%	\$0.20	100%
	Frame Floor Insulation, Conditioned Space over Garage	\$ -	100%	\$ -	100%	\$ -	100%	\$ -	100%	\$ -	100%
	Higher Efficiency Windows	\$ -	100%	\$ -	100%	\$0.42	100%	\$0.70	100%	\$1.26	100%
	Foundation Walls Insulation, Unconditioned Basement	\$1.39	65%	\$1.80	65%	\$ -	76%	\$ -	37%	\$ -	18%
	Foundation Walls Insulation, Conditioned Basement	\$ -	35%	\$0.40	35%	\$ -	24%	\$0.03	63%	\$1.17	82%
	Slab Insulation *	\$ -	35%	\$0.25	35%	\$0.28	24%	\$0.87	63%	\$1.08	82%
Mechanical	Gas Furnace	\$0.20	84%	\$0.20	84%	\$0.03	87%	\$0.04	78%	\$ -	100%
	Gas Boiler	\$ -	16%	\$ -	16%	\$0.18	13%	\$0.34	22%	\$0.38	100%
	Central Air Conditioning System	\$0.08	100%	\$0.08	100%	- \$0.09	100%	- \$0.03	100%	\$0.46	100%
	Instantaneous Gas Water Heater	\$ -	55%	\$ -	55%	\$0.07	49%	\$0.05	74%	\$ -	100%
	Conventional Gas Water Heater	\$0.33	45%	\$0.33	45%	\$ -	51%	\$0.02	26%	\$0.07	100%
	Conventional Electric Water Heater	\$ -	100%	\$ -	100%	\$ -	100%	\$ -	100%	\$ -	100%
Other	Duct Leakage CFM25/100 sf	\$ -	100%	\$ -	100%	\$0.19	100%	\$0.24	100%	\$0.24	100%
	Duct Insulation	- \$0.18	100%	- \$0.18	100%	\$0.06	100%	\$0.06	100%	\$0.06	100%
	Air Infiltration ACH50	\$0.25	100%	\$0.08	100%	\$0.11	100%	\$0.11	100%	\$0.11	100%
	Mechanical Ventilation	\$0.13	100%	\$0.13	100%	\$0.14	100%	\$0.11	100%	\$0.31	100%
	Thermostat	\$0.03	100%	\$0.03	100%	\$0.03	100%	\$0.02	100%	\$0.02	100%
	Water Sense Fixtures	\$0.01	100%	\$0.01	100%	\$ -	100%	\$ -	100%	\$ -	100%
<b>\$/sq. ft. by Program Option</b>		<b>\$1.54</b>		<b>\$6.39</b>		<b>\$1.19</b>		<b>\$4.57</b>		<b>\$9.33</b>	

\$ - Denotes no change in configuration between baseline and option

\* Based on contractor quotes for basic window upgrades for mid-range homes

\*\*Conditioned and mixed type basements

Table 4-1 shows that the most expensive measures to implement on a \$/sq. ft. basis (more than \$1.00/sq. ft.) were enhanced insulation for conditioned space/ambient walls, foundation wall insulation for unconditioned and conditioned basements, cathedral ceiling insulation, and higher efficiency windows. The cost of these measures varied among the options depending to what degree these measures were enhanced for the home. Savings resulted for Prescriptive I and Prescriptive II options (negative \$/sq. ft.) for duct insulation since it is included as part of baseline home, but it is not included for Prescriptive I and II options since ducting is required to be in conditioned space. It is noteworthy that Performance Tier I included no high cost measures. The highest cost measure for Performance Tier I was enhanced windows at an average cost of \$0.42/sq. ft. Both the Prescriptive I and the Performance Tier II options included one high cost (more than \$1.00/sq. ft.) measure apiece. Foundation wall insulation for an unconditioned basement was the most costly measure specified as part of the Prescriptive I option. Enhanced insulation for conditioned space/ambient walls was the most costly measure selected by builders to achieve the savings required by Performance Tier II. Both Prescriptive II and Performance Tier III included several high costs measures. The most costly measures specified as part of the Prescriptive II option were enhanced insulation for conditioned space/ambient walls and foundation wall insulation for conditioned basements. By far the most costly measure selected to achieve Prescriptive Tier III savings was enhanced insulation for conditioned space/ambient walls which had an incremental cost of \$2.73/sq. ft. On average, the wall insulation was raised from a baseline of R19 using fiberglass batts to R33 using high density foam for the 14 homes that achieved Performance Tier III savings.

It should be noted that the Performance Tier III results are based on a small sample of homes and so are less reliable than the results for the other performance tiers for this sector. There were only 14 SF homes that qualified for the Performance Tier III level after adjusting savings for the 2012 UDRH, and measure specifications were not available in REM/Rate for the 14 homes for every measure.

By combining the incremental costs for each of the SF sector efficiency options in proportion to the number of homes that qualified for each option, we are able to calculate an incremental cost representative of the program sector. For this analysis, the incremental costs are based on homes enrolling in the program in 2011 and completed in 2011 with savings adjusted to reflect the 2012 UDRH. This is assumed to be representative of the home type distribution and measure implementation of the program in general. In this case, all qualifying homes have been distributed into the three performance tiers based on their projected savings results, so the incremental costs of the prescriptive options are not included in the overall average. The SF sector overall incremental cost on this basis is illustrated in Table 4-2. Alternative distributions of program homes can easily be applied to reflect different existing or projected program results.

**Table 4-2: SF Sector Incremental Cost per Square Foot**

	Prescriptive I	Prescriptive II	Performance Tier I	Performance Tier II	Performance Tier III
<b>Number of homes</b>	0	0	268	90	14
<b>% of homes</b>	0%	0%	72%	24%	4%
<b>%/sf</b>	\$1.54	\$6.39	\$1.19	\$4.57	\$9.33
<b>SF Overall \$/sf</b>			<b>\$2.31</b>		

## 4.2 MF 1-3 Incremental Costs

The incremental costs of the two different types of homes included in the MF 1-3 sector are summarized separately below. Incremental costs for SF attached homes are presented by measure and by program efficiency option in Table 4-3 and comparable results for multifamily one to three story homes are presented in Table 4-4. NMR did not develop an incremental cost per square foot for MF 1-3 Performance Tier III homes because only one single family attached home and no three or fewer story multifamily qualified at this performance level.

**Table 4-3: SF Attached Incremental Cost per Square Foot by Program Option**

Measure Type	Measure Description	Prescriptive I		Prescriptive II		Performance Tier I		Performance Tier II	
		\$/ sq. ft.	% of units	\$/ sq. ft.	% of units	\$/ sq. ft.	% of unit)	\$/ sq. ft.	% of units
Shell	Conditioned Space/Ambient Walls Insulation	\$ -	100%	\$1.81	100%	\$ -	100%	\$ -	100%
	Conditioned Space/Garage Walls Insulation	\$ -	100%	\$0.31	100%	\$ -	100%	\$ -	100%
	Flat Attic Ceiling Insulation	\$ -	100%	\$0.49	100%	\$0.18	100%	\$0.02	100%
	Cathedral Ceiling Insulation	\$ -	100%	\$1.28	100%	\$ -	100%	\$ -	100%
	Frame Floor Insulation, Conditioned Space over Unconditioned Basement	\$ -	100%	\$ -	100%	\$0.20	100%	\$ -	100%
	Frame Floor Insulation, Conditioned Space over Garage	\$ -	100%	\$ -	100%	\$ -	100%	\$ -	100%
	Higher Efficiency Windows	\$ -	100%	\$ -	100%	\$0.32	100%	\$0.32	100%
	Foundation Walls Insulation, Unconditioned Basement	\$1.25	47%	\$1.62	47%	n/a	51%	n/a	6%
	Foundation Walls Insulation, Conditioned Basement	\$ -	53%	\$0.40	53%	\$0.03	49%	\$0.03	94%
	Slab Insulation *	\$ -	53%	\$0.25	53%	\$0.28	49%	\$0.28	94%
Mechanical	Gas Furnace	\$0.20	82%	\$0.20	82%	\$0.02	83%	\$ -	71%
	Gas Boiler	\$ -	18%	\$ -	18%	\$0.26	17%	\$0.34	29%
	Central Air Conditioning System	\$0.11	100%	\$0.11	100%	\$0.09	100%	\$0.10	100%
	Instantaneous Gas Water Heater	\$ -	57%	\$ -	57%	\$0.07	57%	\$0.08	50%
	Conventional Gas Water Heater	\$0.49	43%	\$0.49	43%	\$ -	43%	\$0.03	50%
Other	Duct Leakage CFM25/100 sf	\$ -	100%	\$ -	100%	\$0.19	100%	\$0.24	100%
	Duct Insulation	\$0.18	100%	\$0.18	100%	\$0.06	100%	\$0.06	100%
	Air Infiltration ACH50	\$0.25	100%	\$0.08	100%	\$0.09	100%	\$0.11	100%
	Mechanical Ventilation	\$0.19	100%	\$0.19	100%	\$0.20	100%	\$0.15	100%
	Thermostat	\$0.03	100%	\$0.03	100%	\$0.03	100%	\$0.02	100%
	Water Sense Fixtures	\$0.01	100%	\$0.01	100%	\$ -	100%	\$ -	100%
<b>\$/sq. ft. by Program Option</b>		<b>\$1.38</b>		<b>\$5.61</b>		<b>\$1.03</b>		<b>\$1.27</b>	

Total incremental cost per square foot for SF attached homes varied from a low of \$1.03/sq. ft. for the Performance Tier I option, to a high of \$5.61/sq. ft. for the Prescriptive II option. The \$1.38/sq. ft. for the Prescriptive I option was 14% higher than the Performance Tier I \$1.21/sq. ft. The \$5.61/sq. ft. for the Prescriptive II option was much greater than both the Performance Tier I and Tier 2 incremental costs which were \$1.21/sq. ft. and \$1.27/sq. ft., respectively. The overall incremental costs for the SF attached homes were about 90% of the SF Detached

incremental cost for all program options except for Performance Tier II, where SF Attached incremental cost was much lower than expected based on the SF Detached results. The difference appears to be due to the absence of enhanced wall, cathedral ceiling and slab insulation in Tier II single family attached homes compared to single family detached homes. These are all costly measures that were applied in the SF detached homes and not the SF attached homes.

Table 4-3 shows that the most expensive measures to implement on a \$/sq. ft. basis (more than \$1.00/sq. ft.) were enhanced insulation for conditioned basement foundation walls for the Prescriptive I option homes and enhanced insulation for unconditioned basement foundation walls, cathedral ceilings, and conditioned space/ambient walls for the Prescriptive II option homes. Performance Tier I and Tier II homes included no high cost measures. The highest cost measure for Performance Tier I was enhanced windows at an average cost of \$0.32/sq. ft. Higher gas boiler AFUE was the most costly measure selected by builders to achieve the savings required by Performance Tier II at an average cost of \$0.34/sq. ft. Savings (negative \$/sq. ft.) occur for the Prescriptive I and Prescriptive II duct insulation measure since it is included as part of the baseline home but is not included for the Prescriptive I and II options since ducting is required to be in conditioned space.

NMR determined a separate value for the total incremental cost per square foot for multifamily homes with one to three stories for homes categorized as No Master Meter and Master Meter Gas. The shell and other measures implemented for these two categories of multifamily buildings are the same. The only difference between them is assumed to be in the mechanical systems. REM/Rate includes data for gas boilers and furnaces, instantaneous gas water heaters, and central air conditioning systems in the file records for No Master Meter multifamily units. The only mechanical system reported for multifamily Master Meter Gas units is whole building gas boilers. NMR added the distinct incremental cost contributions of the mechanical systems of each multifamily category to the common shell and other measure incremental costs to obtain an overall \$/sq. ft. value for each multifamily home category, as illustrated in Table 4-4.

The incremental costs for both categories of multifamily homes are very similar for the Prescriptive I incentive options at \$0.08/sq. ft. and \$0.10/sq. ft. Likewise, the costs for both categories are very similar for Prescriptive II incentive options at \$1.48/sq. ft. and \$1.50/sq. ft. For the Performance Tiers the incremental costs for the No Master Meter multifamily homes are slightly lower than those for the Master Meter Gas homes: \$0.65/sq. ft. versus \$0.79/sq. ft. for Tier I, and \$1.18/sq. ft. versus \$1.35/sq. ft. for Tier II, respectively. Similar to the costs for SF Attached homes, the multifamily homes are lowest for the Prescriptive I option and highest for the Prescriptive II option. Unlike the SF Attached results, the Performance Tier II incremental costs are 70% to 80% higher than the Performance Tier I costs.

**Table 4-4: Multifamily One to Three Story Incremental Cost per Square Foot by Program Option**

Measure Type	Measure Description	Prescriptive I		Prescriptive II		Performance Tier I		Performance Tier II	
		\$/ sq. ft.	% of units	\$/ sq. ft.	% of units	\$/ sq. ft.	% of units	\$/ sq. ft.	% of units
Shell - No Master Meter and Master Meter Gas	Conditioned Space/Ambient Walls Insulation	\$ -	100%	\$0.98	100%	\$0.06	100%	\$0.06	100%
	Flat Attic Ceiling Insulation	\$ -	100%	\$0.24	100%	-\$0.03	100%	-\$0.03	100%
	Cathedral Ceiling Insulation	\$ -	100%	\$0.17	100%	\$ -	100%	\$0.06	100%
	Higher Efficiency Windows	\$ -	100%	\$ -	100%	\$0.17	100%	\$0.34	100%
	Slab Insulation	\$ -	100%	\$0.07	100%	\$0.18	100%	\$0.37	100%
Mechanical - No Master Meter (per 1188 sq.ft. unit)	Gas Furnace	\$0.02	40%	\$0.02	40%	\$0.00	16%	\$0.00	87%
	Gas Boiler	\$ -	60%	\$ -	60%	-\$0.01	84%	\$0.01	13%
	Central Air Conditioning System	\$0.01	100%	\$0.01	100%	\$0.00	100%	-\$0.01	100%
	Instantaneous Gas Water Heater	\$ -	93%	\$ -	93%	\$0.01	88%	\$ -	100%
	Conventional Gas Water Heater	\$0.03	7%	\$0.03	7%	\$0.00	13%	\$0.03	0%
Mechanical - Master Meter Gas (whole building)	Whole Building Boiler	\$ -	100%	\$ -	100%	\$0.13	100%	\$0.17	100%
Other - No Master Meter and Master Meter Gas	Duct Leakage CFM25/100 sf	\$ -	100%	\$ -	100%	\$0.19	100%	\$0.24	100%
	Duct Insulation	-\$0.06	100%	-\$0.06	100%	\$ -	100%	\$0.01	100%
	Air Infiltration ACH50	\$0.11	100%	\$0.05	100%	\$0.06	100%	\$0.11	100%
	Mechanical Ventilation	\$0.01	100%	\$0.01	100%	\$0.01	100%	\$0.01	100%
	Thermostat	\$0.01	100%	\$0.01	100%	\$0.01	100%	\$0.01	100%
	Water Sense Fixtures	\$0.00	100%	\$0.00	100%	\$ -	100%	\$ -	100%
<b>No Master Meter - \$/ft2 by Program Option</b>		<b>\$0.10</b>		<b>\$1.50</b>		<b>\$0.65</b>		<b>\$1.18</b>	
<b>Master Meter Gas - \$/ft2 by Program Option</b>		<b>\$0.08</b>		<b>\$1.48</b>		<b>\$0.79</b>		<b>\$1.35</b>	

Table 4-4 shows that the most expensive measure to implement in low rise multifamily buildings on a \$/sq. ft. basis was enhanced insulation for conditioned space/ambient walls, although the incremental cost of this measure was less than \$1.00/sq. ft. (\$0.98/sq. ft.). All other measures

cost less than \$0.37/sq. ft. to implement. All of the measures implemented for the Prescriptive I option were low cost measures with incremental costs of less than \$0.12/sq. ft. Savings (negative \$/sq. ft.) occur for the Prescriptive I and Prescriptive II duct insulation measure since it is included as part of baseline home but is not included for the Prescriptive I and II options since ducting is required to be in conditioned space. Enhanced insulation for conditioned space/ambient walls, and flat and cathedral ceilings accounted for more than 90% of the incremental costs of the Prescriptive II option buildings. Incremental costs for the multifamily Performance Tier homes are attributable to higher efficiency windows, slab insulation, and reduced duct leakage. Higher efficiency standards applied in Tier II versus Tier I account for the higher incremental costs for Tier II.

By combining the incremental costs for the SF Attached, MF No Master Meter and MF Master Meter Gas homes for each of the program efficiency options in proportion to the number of homes that qualified for each option, we are able to calculate an incremental cost representative of each home category. For this analysis, NMR distributed all qualifying homes into the two performance tiers based on their projected savings. Table 4-5 shows that incremental costs vary from \$0.75/sq. ft. for MF No Master Meter homes to \$1.21/sq. ft. for SF Attached homes.

NMR determined the overall MF 1-3 sector incremental cost by weighting costs by the observed distribution of homes among the three home categories. The MF 1-3 sector overall incremental cost is determined to be \$0.95/sq. ft. on this basis as illustrated in Table 4-5. These distributions can be altered by sponsors as appropriate with alternative program assumptions or planning projections.

**Table 4-5: MF 1-3 Sector Incremental Cost per Square Foot**

Option	Single Family Attached			No Master Meter			Master Meter Gas		
	Number of homes	% of homes	\$/sq. ft.	Number of homes	% of homes	\$/sq. ft.	Number of homes	% of homes	\$/sq. ft.
<b>Prescriptive I</b>	0	0%	\$1.38	0	0%	\$0.10	0	0%	\$0.08
<b>Prescriptive II</b>	0	0%	\$5.61	0	0%	\$1.50	0	0%	\$1.48
<b>Performance Tier I</b>	255	88%	\$1.03	168	81%	\$0.65	153	62%	\$0.79
<b>Performance Tier II</b>	35	12%	\$1.27	39	19%	\$1.18	92	38%	\$1.35
<b>Performance Tier III</b>	1	0%	n/a	0	0%	n/a	0	0%	n/a
<b>\$/sq. ft. by Home Type</b>	<b>291</b>	<b>39%</b>	<b>\$1.06</b>	<b>207</b>	<b>28%</b>	<b>\$0.75</b>	<b>245</b>	<b>33%</b>	<b>\$1.00</b>
<b>MF 1-3 Overall \$/sq. ft.</b>	<b>\$0.95</b>								



### 4.3 MF 4+ Incremental Costs

The incremental costs per square foot for each of the MF 4+ buildings program efficiency options are presented in Table 4-6. The total incremental cost for the program options varies from a low of \$0.14/sq. ft. for the Residential In-Unit Savings Prescriptive option, to a high of \$1.65/sq. ft. for the Whole Building Interactive Prescriptive option. All three MF 4+ program options include the same basic In-Unit measures of high efficiency appliances and lighting, low flow water fixtures, and reduced air infiltration. Enhanced building shell insulation, mechanical systems, and common area lighting are energy conservation measures added to the whole building program options. ICF specified higher efficiency levels for the Interactive Prescriptive option than the Simple Prescriptive option for the following measures: in-unit and common area lighting, wall and ceiling insulation, heating and DHW. These increases in efficiency account for the increase in total incremental cost between the Simple Prescriptive and Interactive Prescriptive options.

**Table 4-6: MF 4+ Incremental Cost per Square Foot by Program Option**

Measure Type	Measure Description	Residential In-Unit Savings Prescriptive		Whole Building Simple Prescriptive		Whole Building Interactive Prescriptive	
		\$/sq. ft.	% of units	\$/sq. ft.	% of units	\$/sq. ft.	% of units
In-Unit	Refrigerator (ENERGY STAR® 30% better than federal standard )	\$0.08	100%	\$0.08	100%	\$0.08	100%
	Dishwasher (ENERGY STAR® 1.0 EF or greater)	\$0.02	100%	\$0.02	100%	\$0.02	100%
	Hi-efficacy Lighting	-\$0.01	100%	-\$0.01	100%	-\$0.02	100%
	Showerheads, WaterSense® <= 1.75 GPM	\$0.01	100%	\$0.01	100%	\$0.01	100%
	- Lavatory Faucets, WaterSense® <= 1.5 GPM	\$0.01	100%	\$0.01	100%	\$0.01	100%
	Infiltration (maximum air leakage rates of ≤ 7.0 ACH50)	\$0.04	100%	\$0.04	100%	\$0.04	100%
Building	Wood wall construction – Wall Insulation	\$ -	100%	\$0.07	100%	\$0.14	100%
	Ceiling Insulation	\$ -	100%	\$0.10	100%	\$0.21	100%
	Windows - ENERGY STAR:	\$ -	100%	\$0.42	100%	\$0.42	100%
	Heating - Condensing Boiler	\$ -	100%	\$0.25	100%	\$0.39	100%
	Cooling - Chiller - air cooled with condenser	\$ -	100%	\$0.14	100%	\$0.26	100%
	DHW - Condensing Boiler	\$ -	100%	\$0.05	100%	\$0.06	100%
	VFD - Hot Water Circ Pump	\$ -	100%	\$0.02	100%	\$0.02	100%
	VFD - Chilled/Cond Water Pump	\$ -	100%	\$0.02	100%	\$0.02	100%
Common Area	General Common Area Lighting Wattage Reduction	\$ -	100%	\$0.004	100%	\$0.003	100%
	Corridors Lighting Wattage Reduction	\$ -	100%	-\$0.001	100%	-\$0.001	100%
	Laundry Rooms Lighting Wattage Reduction	\$ -	100%	\$0.000	100%	\$0.000	100%
	Lobby/Elevator Lighting Wattage Reduction	\$ -	100%	\$0.001	100%	\$0.001	100%
	Meeting Room Lighting Wattage Reduction	\$ -	100%	\$0.001	100%	\$0.001	100%
	Office Lighting Wattage Reduction	\$ -	100%	\$0.000	100%	\$0.000	100%
	Stairwells Lighting Wattage Reduction	\$ -	100%	\$0.001	100%	\$0.001	100%
<b>\$/sq. ft. by Program Option</b>		<b>\$0.14</b>		<b>\$1.21</b>		<b>\$1.65</b>	

Table 4-6 shows that the In-Unit measures are generally very inexpensive to implement. The most expensive measure, high efficiency refrigerators with a cost of \$0.08/sq. ft., accounts for almost 60% of the In-Unit option incremental cost. The most expensive measures for the two whole building program options are the Energy Star windows, and the heating and cooling systems. These three measures account for approximately 67% and 64%, respectively, of the total incremental cost of the Whole Building Simple Prescriptive and Interactive Prescriptive program options. Common area lighting is a low cost measure for all of the MF 4+ program

options, adding only approximately \$0.005/sq. ft. to the total incremental cost. High efficacy lighting and corridor lighting wattage reduction both show negative cost per sq. ft. for all three MF 4+ options because the lowest cost way to meet the maximum and reduced watts/sq. ft. while providing the recommended lumens/sq. ft. for both the baseline home and the upgraded home was to use CFL bulbs. Therefore, the upgrade represents only a reduction in the number of bulbs and results in a cost reduction.

By combining the incremental costs for each of the MF 4+ sector efficiency options in proportion to the number of homes that qualified for each option, we are able to calculate an incremental cost representative of the program sector. Because the mid- to high-rise building options to high efficiency are new offerings for the 2013 RNC program, NMR assumed an equal distribution of homes among the three options. The MF 4+ sector overall incremental cost on this basis is illustrated in Table 4-7. Alternative distributions of program homes can easily be applied to reflect different existing or projected program results.

**Table 4-7: MF 4+ Sector Incremental Cost per Square Foot**

Option	MF 4+ Sector	
	% of Buildings	\$/sq. ft.
<b>Residential In-Unit Savings Prescriptive</b>	33%	\$0.14
<b>Whole Building Simple Prescriptive</b>	33%	\$1.21
<b>Whole Building Interactive Prescriptive</b>	33%	\$1.65
<b>MF 1-4 Overall \$/sq. ft.</b>	<b>\$1.00</b>	

## Appendix A Estimates of Light Bulb Costs

This report does not address lighting in the incremental cost per square foot analysis of the SF and MF 1-3 program sectors. Instead, as requested by the sponsors, NMR has provided cost estimates for a standard incandescent bulb, a CFL bulb, a pin based bulb, and an LED bulb.

NMR staff reviewed our recent work on residential lighting in addition to published reports on the MA EEAC web site, including the most recent evaluation of the Massachusetts ENERGY STAR® Lighting Program, but we did not find the type of information requested.

As an alternative, NMR determined costs for different bulb types with the lumen per sq. ft. output equivalent to a 60W and a 100W incandescent bulb. These costs were calculated using data developed by Ekotrope to estimate MF 4+ lighting measure costs. Ekotrope did an internet survey of the most common bulb units (CFL, Incandescent, Halogen, LED) and determined average \$/Watt and Lumens/Watt for each bulb type. These values and the derived bulb costs for 60W and 100W incandescent equivalents are presented in Table A-1.

**Table A-1: Light Bulb Cost Estimates**

Bulb Type	\$/Lumen	Lumen / Watt	\$/ Watt	705 Lumens (60W incandescent equivalent)	1175 Lumens (100W incandescent equivalent)
Avg Halogen	\$0.0028	16.72	\$0.0464	\$1.96	\$3.26
Avg CFL (Screw)	\$0.0023	63.50	\$0.1435	\$1.59	\$2.66
Avg CFL (Pin)	\$0.0064	66.32	\$0.4244	\$4.51	\$7.52
Avg LED	\$0.0254	65.43	\$1.6633	\$17.92	\$29.87
Avg Incandescent	\$0.0016	11.75	\$0.0191	\$1.15	\$1.91

\*Bulb costs only. Pin based CFLs are usually non-integrated, which means they need fixtures with ballasts. Fixtures may add cost that is not accounted for here.

## Appendix B Adjusted 2011 Program Home REM/Rate Average Measure Values

**Table B-1: Adjusted 2011 Program Home REM/Rate Average Measure Values for Single Family Detached Homes**

Measure Type	Measure	Measure Parameter	TIER I 15% to 29%		TIER II 30% to 44%		TIER III 45% Plus		
			SF Detached No Master Meter		SF Detached No Master Meter		SF Detached No Master Meter		
			count*	average*	count*	average*	count*	average*	
Shell	Conditioned Space	Total Area Square Feet	268	2,722	90	3,702	14	3,408	
	Building Insulation	Average Cond/ Ambient Wall R-value	265	20	89	24	14	33	
		Attic R-Value	246	40	65	44	9	63	
		Vault R-value	161	36	66	39	8	45	
		Cond>Bsmt Floor R-Value	131	32	45	36	3	37	
		Cond>Grg Floor R-Value	225	29	41	30	2	30	
	Windows	Average Window U-Value	268	0.31	89	0.29	14	0.25	
	Foundation Insulation	Average Foundation Wall R-value Unconditioned Basement	188	1	30	1	2	0.8	
		Average Foundation Wall R-value Conditioned Basement**		14		15		26	
	Slab Insulation**	AvgPerimeterR	58	3.1		5.5	9	7.6	
		AvgtUnderR	58	2.1	51	5.4	9	10	
		AvgWidth	58	3.3	51	8.2	9	16.7	
		Avgdepth	58	0.6	51	0.5	9	0.5	
	Mechanical	Heating Systems	Average Capacity Btuh per Square Foot all Gas Furnaces	218	45	63	34	0	none
			Average of Gas Furnace AFUE	219	94.0	63	94.5	0	none
			Average Capacity Btuh per Square Foot all Gas Boilers	29	39	11	30	2	15
Average of Gas Boiler AFUE			33	92.1	18	94.4	3	95.7	
CAC		Average of A/C Btuh/sq. ft.	223	16	68	12	5	16	
		Average of AC System #1 SEER	231	13.3	14	15.7	11	19.3	
Water Heater: Instantaneous Gas		Average of Energy Factor	98	0.88	43	0.87	na	na	
Water Heater: Conventional Gas		Average of DHW Tank Volume	101	51	15	58	1	70	
		Average of Energy Factor	101	0.63	15	0.63	1	0.56	

Measure Type	Measure	Measure Parameter	TIER I 15% to 29%		TIER II 30% to 44%		TIER III 45% Plus	
			SF Detached No Master Meter		SF Detached No Master Meter		SF Detached No Master Meter	
			count*	average*	count*	average*	count*	average*
	Water Heater: Conventional Electric	Average of DHW Tank Volume	17	57	6	69	2	65
		Average of Energy Factor*	17	0.91	6	0.90	2	0.92
Other	Air Infiltration	Average of Air Infiltration (ACH50)	268	3.57	89	2.18	14	1.61
	Duct Leakage	Average of Duct Leakage (Value)	243	3.53	68	2.18	6	2.08
	Duct Insulation	Average of Avg Supply-Attic Duct R-Value	142	7.8	28	7.5	2	8.0
		Average of Avg All Other UC Duct R-Value	234	6.9	52	7.5	2	7.3
	Mechanical Ventilation	Average of Adjusted CFM - Balanced	15	106.1	24	105.8	9	86.9
		Average of Adjusted CFM - Exhaust Only	246	79.5	62	101.3	3	66.7

\* Excludes "#NA" & "Blanks" \*\* Conditioned and mixed type basements

**Table B-2: Adjusted 2011 Program Home REM/Rate Average Measure Values for Single-Family Attached Homes**

Measure Type	Measure	Measure Parameter	TIER I 15% to 29%		TIER II 30% to 44%	
			SF Attached No Master Meter		SF Attached No Master Meter	
			count*	average*	count*	average*
Shell	Conditioned Space	Total Area Square Feet	255	1,948	35	2,601
	Building Insulation	Average Cond/ Ambient Wall R-value	242	18	35	18
		Attic R-Value	180	41.2	23	43
		Vault R-value	149	36.0	26	38
		Cond>Bsmt Floor R-Value	79	31	11	30
		Cond>Grg Floor R-Value	125	27	5	30
	Windows	Average Window U-Value	252	0.31	35	0.31
	Foundation Insulation	Average Foundation Wall R-value Unconditioned Basement	91	n/a	1	n/a
		Average Foundation Wall R-value Conditioned Basement**	47	11	14	14
	Slab Insulation**	AvgPerimeterR	87	4.4	16	3.3
		AvgtUnderR	87	2.8	16	3.0
		AvgWidth	87	5.1	16	5.3
		Avgdepth	87	0.6	16	0.8
	Mechanical	Heating Systems	Average Capacity Btuh per Square Foot all Gas Furnaces	194	50	25
Average of Gas Furnace AFUE			207	93	25	91.5
Average Capacity Btuh per Square Foot all Gas Boilers			42	74	10	50
Average of Gas Boiler AFUE			42	93	10	95.0
CAC		Average of A/C btuh/sq. ft.	216	17	25	16
		Average of AC System #1 SEER	230	13.6	1	13.0
Water Heater: Instantaneous Gas		Average of Energy Factor	99	0.89	8	0.87
Water Heater: Conventional Gas		Average of DHW Tank Volume	74	50	8	56
		Average of Energy Factor	74	0.64	8	0.65
Water Heater: Conventional Electric		Average of DHW Tank Volume	7	63	none	none
		Average of Energy Factor*	7	0.92	none	none
Other		Air Infiltration	Average of Air Infiltration (ACH50)	253	4.50	35
	Duct Leakage	Average of Duct Leakage (Value)	224	3.35	27	2.35
	Duct Insulation	Average of Avg Supply-Attic Duct R-Value	117	7.5	16	7.4
		Average of Avg All Other UC Duct R-Value	168	6.5	17	6.9
	Mechanical Ventilation	Average of Adjusted CFM - Balanced	12	136.7	5	76.2
		Average of Adjusted CFM - Exhaust Only	230	74.9	27	71.1

\* Excludes "#NA" & "Blanks" \*\* Conditioned and mixed type basements

**Table B-3: Adjusted 2011 Program Home REM/Rate Average Measure Values for Multifamily 1-3 Story Homes**

Measure Type	Measure	Measure Parameter	TIER I 15% to 29%		TIER II 30% to 44%	
			Multifamily 1-3 Stories No Master Meter & Master Meter Gas		Multifamily 1-3 Stories No Master Meter & Master Meter Gas	
			count*	average*	count*	average*
Shell - No Master Meter and Master Meter Gas	Conditioned Space	Total Area Square Feet	321	1,203	131	1,155
	Building Insulation	Average Cond/ Ambient Wall R-value	321	20	109	20
		Attic R-Value	195	39.7	71	40
		Vault R-value	41	37.2	22	39
	Windows	Average Window U-Value	321	0.32	131	0.30
	Slab Insulation**	AvgPerimeterR	173	5.8	65	9.7
		AvgtUnderR	173	6.6	65	10.2
		AvgWidth	173	6.9	65	12.4
Avgdepth		173	0.4	65	0.6	
Mechanical - No Master Meter (per 1188 sq.ft. unit)	Heating Systems	Average Capacity Btuh per Square Foot all Gas Furnaces	20	50	59	47
		Average of Gas Furnace AFUE	20	95	71	93
		Average Capacity Btuh per Square Foot all Gas Boilers	81	92	9	97
		Average of Gas Boiler AFUE	109	88.5	9	91
	CAC	Average of A/C btuh/sq. ft.	132	21.9	68	18
		Average of AC System #1 SEER	154	13.1	90	12.7
	Water Heater: Instantaneous Gas	Average of Energy Factor	84	0.87	68	0.83
	Water Heater: Conventional Gas	Average of DHW Tank Volume	12	40	none	none
		Average of Energy Factor	12	0.63	none	none
Mechanical - Master Meter Gas (for building)	Whole Building Boiler	Average Capacity Btuh per Square Foot all Gas Boilers	79	40	30	63
		Average of Gas Boiler AFUE	168	95	41	94
Other	Air Infiltration	Average of Air Infiltration (ACH50)	321	3.42	131	2.20
	Duct Leakage	Average of Duct Leakage (Value)	149	4.19	92	2.49
	Duct Insulation	Average of Avg Supply-Attic Duct R-Value	44	5.3	48	8.0
		Average of Avg All Other UC Duct R-Value	49	4.7	13	6.2
	Mechanical Ventilation	Average of Adjusted CFM - Balanced	none	none	10	33.3
		Average of Adjusted CFM - Exhaust Only	319	50.6	101	37.9

\* Excludes "#NA" & "Blanks" \*\* All basements



# Appendix C - Completed Incremental Cost Data Templates

**Table C- 1: Completed Incremental Cost Data Template for Single Family Detached Homes**

Shell Measures	Reference Home Data				Prescriptive I			Prescriptive II			Performance-Tier I (268 homes)			Performance-Tier II (90 homes)			Performance-Tier III (14 homes)		
	Average Sq. Ft.	Framing	Insulation Type	R-value	Upgrade	Incremental Cost	\$/ft²	Upgrade	Incremental Cost	\$/ft²	Upgrade	Incremental Cost	\$/ft²	Upgrade	Incremental Cost	\$/ft²	Upgrade	Incremental Cost	\$/ft²
Conditioned Floor Area	2,917				2,917			2,917			2,722			3,702			3,408		
Conditioned > Ambient Walls	2,551	2x6x16	FG Batts	19	No change	\$	\$	R-40 walls : double stud, 4" gap filled with blown cellulose.	\$7,159.00	\$2.45	20 : R21 FG Batts, 2x6x16	\$381.00	\$0.14	24 : 4" High Density Foam, 2x6x16	\$6,991.00	\$1.89	33 : 5" High Density Foam, 2x6x16	\$9,295.28	\$2.73
Conditioned > Garage Walls	325	2x6x16	FG Batts	19	No change	\$	\$	R-40 walls : double stud, 4" gap filled with blown cellulose.	\$912.00	\$0.31	20 : R21 FG Batts, 2x6x16	\$49.00	\$0.02	24 : 4" High Density Foam, 2x6x16	\$891.00	\$0.24	33 : 5" High Density Foam, 2x6x16	\$1,185.52	\$0.35
Flat Attic Ceiling	1561	2x10x24	FG Batts	36	No change	\$	\$	R-60 ceilings : 18" blown cellulose	\$,418.00	\$0.49	40 : 10" blown cellulose, 2x10x24	\$(492.00)	\$(0.18)	44 : 12" blown cellulose, 2x10x24	\$(68.00)	\$(0.02)	63 : 18" blown cellulose, 2x10x24	\$1,648.00	\$0.48
Cathedral Ceiling	540	2x12x16	FG Batts	35	No change	\$	\$	R-60 ceilings : 9.25" high density spray foam	\$3,724.00	\$1.28	36 : essentially no change	\$	\$	39 : 11" low density spray foam, 2x12x16	\$1,240.00	\$0.33	45 : 7" High Density Foam, 2x10x16	\$2,806.40	\$0.82
Conditioned > Unconditioned Basement Frame Floor	1,344	2x12x16	FG Batts	26	No change	\$	\$	No change	\$	\$	32 : R38 FG Batts, 2x12x16	\$538.00	\$0.20	36 : 2x12, R38 FG Batts	\$732.00	\$0.20	37 : 2x12, R38 FG Batts	\$674.00	\$0.20
Conditioned > Garage Frame Floor	499	2x12x16	FG Batts	27	No change	\$	\$	No change	\$	\$	29 : R30 FG Batts, 2x12x16	\$	\$	30 : R30 FG Batts, 2x12x16	\$	\$	30 : R30 FG Batts, 2x12x16	\$	\$
Windows	409			U-0.34	No change	\$	\$	No change	\$	\$	U - 0.31	\$1,144.98	\$0.42	U - 0.29	\$2,585.00	\$0.70	U - 0.25	\$4,283.04	\$1.26
Foundation Walls- Unconditioned Basement	140 linear ft.		Uninsulated	0	R-13, FG Batts, 2x4x16	\$4,047	\$1.39	R-20 basement walls : 2x6, R-21 FG Batts	\$ 5,238.00	\$1.80	n/a	\$	\$	n/a	\$	\$	n/a	\$	\$
Foundation Walls- Conditioned Basement	140 linear ft.	2x4x16	FG Batts	13	No change	\$	\$	R-20 basement walls : 2x6, R-21 FG Batts	\$1,179.90	\$0.40	13.7 : 2x4, R13 FG Batts	\$	\$	15.2 : 2x4, R15 FG Batts	\$120.20	\$0.03	26 : 2x6, High density spray foam, ~4"	\$3,973.00	\$1.17
Slab Insulation (Conditioned & Mixed Type Basements)								R-10 under slab, 2', R-10 perimeter	\$741.48	\$0.25	R-3.1 Perim, R-2.1 under (0.6' depth, 3.3' under)--R5 perimeter and under set to depth and width specifications	\$771.00	\$0.28	R-5.5 perim,R-5.4 under (full under, cover slab edge at perim)	\$3,233.42	\$0.87	R-7.6 perim, R-10.0 under (full under, cover slab edge at perimeter)	\$3,664.00	\$1.08

**Table C-1 (continued). Completed Incremental Cost Data Template for Single Family Detached Homes**

Mechanicals	Reference Home Data		Prescriptive I				Prescriptive II				Performance-Tier I (268 homes)				Performance-Tier II (90 homes)				Performance-Tier III (14 homes)			
	Capacity	Efficiency	Capacity	Efficiency	Inc. Cost	\$/ft <sup>2</sup>	Capacity	Efficiency	Inc. Cost	\$/ft <sup>2</sup>	Capacity	Efficiency	Inc. Cost	\$/ft <sup>2</sup>	Capacity	Efficiency	Inc. Cost	\$/ft <sup>2</sup>	Capacity	Efficiency	Inc. Cost	\$/ft <sup>2</sup>
Gas Furnace	SAME AS RATED HOME	91.5 AFUE	43 Btuh/ft <sup>2</sup> 125,500 Btuh	95 AFUE w/ECM motor	\$589.00	\$0.20	43 Btuh/ft <sup>2</sup> 125,500 Btuh	95 AFUE w/ECM motor	\$589.00	\$0.20	45 Btuh/ft <sup>2</sup> 122,500 Btuh	94.0 AFUE	\$80.00	\$0.03	34 Btuh/ft <sup>2</sup> 126,000 Btuh	94.5 AFUE	\$131.00	\$0.04	none	none	\$0.00	\$0.00
Gas Boiler variation	SAME AS RATED HOME	89.8 AFUE	35 Btuh/ft <sup>2</sup> 102,000 Btuh	90 AFUE (no change)	\$0.00	\$0.00	35 Btuh/ft <sup>2</sup> 102,000 Btuh	90 AFUE (no change)	\$0.00	\$0.00	39 Btuh/ft <sup>2</sup> 106,000 Btuh	92.1 AFUE	\$500.00	\$0.18	30 Btuh/ft <sup>2</sup> 111,000 Btuh	94.4 AFUE	\$1,265.00	\$0.34	15 Btuh/ft <sup>2</sup> 51,000 Btuh	95.7 AFUE	\$1,309.00	\$0.38
Central Air Conditioning System	19 Btuh/ft <sup>2</sup> 2917 ft <sup>2</sup> 60,000 Btuh	13.7 SEER	60,000 Btuh	14.5 SEER	\$224.00	\$0.08	60,000 Btuh	14.5 SEER	\$224.00	\$0.08												
CAC System Tier 1	19 Btuh/ft <sup>2</sup> 2722 ft <sup>2</sup> 54,000 Btuh	13.7 SEER									16 Btuh/ft <sup>2</sup> 48,000 Btuh	13.3 SEER	(\$255.00)	(\$0.09)								
CAC System Tier 2	19 Btuh/ft <sup>2</sup> 3702 ft <sup>2</sup> 72,000 Btuh	13.7 SEER												12 Btuh/ft <sup>2</sup> 48,000 Btuh	15.7 SEER	(\$115.00)	(\$0.03)					
CAC System Tier 3	19 Btuh/ft <sup>2</sup> 3408 ft <sup>2</sup> 66,000 Btuh	13.7 SEER																16 Btuh/ft <sup>2</sup> 54,000 Btuh	19.3 SEER	\$1,572.00	\$0.46	
Instantaneous Gas Water Heater		0.83 EF	Instantaneous Gas	0.82 EF (no change)	\$0.00	\$0.00	Instantaneous Gas	0.82 EF (no change)	\$0.00	\$0.00	na	0.88 EF	\$200.00	\$0.07	na	0.87 EF	\$200.00	\$0.05	na	na	\$0.00	\$0.00
Conventional Gas Water Heater	50 gallon	0.62 EF, 0.81 Recovery	Conventional Gas	0.79 EF, 0.95 Recovery	\$975.00	\$0.33	Conventional Gas	0.79 EF, 0.95 Recovery	\$975.00	\$0.33	51 gal	0.63 EF (baseline 0.62)	\$0.00	\$0.00	58 gal	0.63 EF (baseline 0.61)	\$90.00	\$0.02				
Conventional Electric Water Heater	50 gallons	0.89 EF																65 gal	0.92 EF (baseline 0.87 EF)	\$250.00	\$0.07	

**Table C-1 (continued). Completed Incremental Cost Data Template for Single Family Detached Homes**

Other Measures	Reference Home Data	Prescriptive I			Prescriptive II			Performance-Tier I (268 homes)			Performance-Tier II (90 homes)			Performance-Tier III (14 homes)		
		Upgrade	Incremental Cost	\$/ft <sup>2</sup>	Upgrade	Incremental Cost	\$/ft <sup>2</sup>	Upgrade	Incremental Cost	\$/ft <sup>2</sup>	Upgrade	Incremental Cost	\$/ft <sup>2</sup>	Upgrade	Incremental Cost	\$/ft <sup>2</sup>
Air Infiltration ACH50	4.88 ACH50	2.5 ACH50	\$741.00	\$0.25	2.5 ACH50	\$232.00	\$0.08	3.57 ACH50	\$313.00	\$0.11	2.18 ACH50	\$416.00	\$0.11	1.61 ACH50	\$366.65	\$0.11
Duct Leakage CFM25/100 sf	11.9 CFM25/100 ft <sup>2</sup>	4 CFM25/100 ft <sup>2</sup>	\$0.00	\$0.00	4 CFM25/100 ft <sup>2</sup>	\$0.00	\$0.00	3.53 CFM25/100 ft <sup>2</sup>	\$513.00	\$0.19	2.18 CFM25/100 ft <sup>2</sup>	\$889.00	\$0.24	2.08 CFM25/100 ft <sup>2</sup>	\$818.00	\$0.24
Duct Insulation	R6.5 Attic Supply, R5.5 other UC spaces and Attic Returns	Ducts and equipment in conditioned spaces	(\$512.00)	(\$0.18)	Ducts and equipment in conditioned spaces	(\$512.00)	(\$0.18)	R7.8 Attic Supply, R6.9 other UC duct	\$160.00	\$0.06	R7.5 Attic Supply, R7.5 other UC duct	\$217.00	\$0.06	R8.0 Attic Supply, R7.3 other UC duct	\$200.00	\$0.06
Water Sense Fixtures	None	All low-flow "Water Sense" fixtures	\$15.00	\$0.01	All low-flow "Water Sense" fixtures	\$15.00	\$0.01	All low-flow	\$0.00	\$0.00	All low-flow	\$0.00	\$0.00	All low-flow	\$0.00	\$0.00
Thermostat	Manual	Programmable	\$75.00	\$0.03	Programmable	\$75.00	\$0.03	Programmable	\$75.00	\$0.03	Programmable	\$75.00	\$0.02	Programmable	\$75.00	\$0.02
Mechanical Ventilation	None	Exhaust Only - 60 CFM	\$376.00	\$0.13	Exhaust Only - 60 CFM	\$376.00	\$0.13	Exhaust Only-80 CFM	\$394.00	\$0.14	Exhaust Only - 100 CFM	\$412.00	\$0.11	Balanced (ERV/HRV)- 90 CFM, 69% Recovery Eff.	\$1,066.00	\$0.31

**Table C-2: Completed Incremental Cost Data Template for Single Family Attached Homes**

Shell Measures	Reference Home Data				Prescriptive I			Prescriptive II			Performance-Tier I (255 homes)			Performance-Tier II (35 homes)		
	Average Sq. Ft.	Framing	Insulation Type	R-value	Upgrade	Incremental Cost	\$/ft²	Upgrade	Incremental Cost	\$/ft²	Upgrade	Incremental Cost	\$/ft²	Upgrade	Incremental Cost	\$/ft²
Conditioned Floor Area	1990				1990			1990			1950			2600		
Conditioned > Ambient Walls	1281	2x6x16	FG Batts	19	No change	\$	\$	R-40 walls : double stud, 4" gap filled with blown cellulose.	\$ 3,595.51	\$ 1.81	18 - no change	\$ -	\$ -	18 - no change	\$ -	\$ -
Conditioned > Garage Walls	222	2x6x16	FG Batts	19	No change	\$	\$	R-40 walls : double stud, 4" gap filled with blown cellulose.	\$ 622.39	\$ 0.31	18 - no change	\$ -	\$ -	18 - no change	\$ -	\$ -
Flat Attic Ceiling	1065	2x10x24	FG Batts	36	No change	\$	\$	R-60 ceilings : 18" blown cellulose	\$ 967.70	\$ 0.49	41.2 - 10" blown cellulose, 2x10x24?	\$ (352.46)	\$ (0.18)	43 - 11?" blown cellulose, 2x10x24	\$ 47.76	\$ 0.02
Cathedral Ceiling	368	2x12x16	FG Batts	35	No change	\$	\$	R-60 ceilings : 9.25" high density spray foam	\$ 2,541.41	\$ 1.28	36 - no change	\$ -	\$ -	38 - no change	\$ -	\$ -
Conditioned > Unconditioned Basement Frame Floor	917	2x12x16	FG Batts	26	No change	\$	\$	No change	\$ -	\$ -	31 - R38 FG Batts, 2x12x16?	\$ 385.42	\$ 0.20	30 - R30 FG Batts, 2x12x16	\$ -	\$ -
Conditioned > Garage Frame Floor	340	2x12x16	FG Batts	27	No change	\$	\$	No change	\$ -	\$ -	27 - no change	\$ -	\$ -	30 - R30 FG Batts, 2x12x16	\$ -	\$ -
Windows	205			U-0.34	No change	\$	\$	No change	\$ -	\$ -	U - 0.31	\$ 615.18	\$ 0.32	U - 0.31	\$ 820.24	\$ 0.32
Foundation Walls- Unconditioned Basement	85 Linear ft		Uninsulated	0	R-13, FG Batts, 2x4x16	\$ 2,493.24	\$ 1.25	R-20 basement walls : 2x6, R-21 FG Batts	\$ 3,226.98	\$ 1.62	n/a	n/a	n/a	n/a	n/a	n/a
Foundation Walls- Conditioned Basement	86 Linear ft	2x4x16	FG Batts	13	No change	\$	\$	R-20 basement walls : 2x6, R-21 FG Batts	\$ 804.94	\$ 0.40	R - 11	\$ (63.31)	\$ (0.03)	R - 14	\$ 84.42	\$ 0.03
Slab Insulation (Conditioned & Mixed Type Basements)								R-10 under slab 2', R-10 perimeter	\$ 505.84	\$ 0.25	R-4.4 Perim, R-2.8 under (0.6' depth, 5.1' under)--R5 perimeter and under set to depth and width specifications	\$ 552.33	\$ 736.44	R-3.3 Perim, R-3.0 under (0.8' depth, 5.3' under)--R5 perimeter and under set to depth and width specifications	\$ 736.44	\$ 0.28

Table C-2 (continued). Completed Incremental Cost Data Template for Single Family Attached Homes

Mechanicals	Reference Home Data		Prescriptive I				Prescriptive II				Performance-Tier I (255 homes)				Performance-Tier II (35 homes)			
	Capacity	Efficiency	Capacity	Efficiency	Inc. Cost	\$/ft <sup>2</sup>	Capacity	Efficiency	Inc. Cost	\$/ft <sup>2</sup>	Capacity	Efficiency	Inc. Cost	\$/ft <sup>2</sup>	Capacity	Efficiency	Inc. Cost	\$/ft <sup>2</sup>
Gas Furnace	SAME AS RATED HOME	91.5 AFUE	48 Btuh/sqft 93,600 Btuh 95 AFUE w/ECM motor	95 AFUE w/ECM motor	\$ 401.82	\$ 0.20	48 Btuh/sqft 93,600 Btuh	95 AFUE w/ECM motor	\$ 401.82	\$ 0.20	50 Btuh/sqft 97,500 Btuh	93 AFUE	\$ 39.00	\$ 0.02	34 Btuh/sqft 88,400 Btuh	91.5 AFUE	\$ -	\$ -
Gas Boiler variation	SAME AS RATED HOME	89.8 AFUE	70 Btuh/sqft 136,500 Btuh 90 AFUE (no change)	90 AFUE (no change)	\$ -	\$ -	70 Btuh/sqft 136,500 Btuh	90 AFUE (no change)	\$ -	\$ -	74 Btuh/sqft 144,300 Btuh	93AFUE	\$ 512.26	\$ 0.26	50 Btuh/sqft 130,000 Btuh	95 AFUE	\$ 888.44	\$ 0.34
Central Air Conditioning System	(20 Btuh/sq. ft.) 1950 sq. ft. ~42,000 Btuh	13.7 SEER	Same capacity as reference home 14.5 SEER	14.5 SEER	\$ 224.00	\$ 0.11	Same capacity as reference home 14.5 SEER	14.5 SEER	\$ 224.00	\$ 0.11								
CAC System Tier 1	(20 Btuh/sq. ft.) 1950 sq. ft. ~42,000 Btuh	13.7 SEER									17 Btuh/sqft 33150 ~36000 Btuh	13.6 SEER	\$ (175.50)	\$ (0.09)				
CAC System Tier 2	(20 Btuh/sq. ft.) 2600 sq. ft. ~54,000 Btuh	13.7 SEER													16 Btuh/sqft 41600 ~42000 Btuh	13.0 SEER	\$ (260.00)	\$ (0.10)
Instantaneous Gas Water Heater		0.83 EF		0.82 EF (no change)	\$ -	\$ -	Instantaneous Gas	0.82 EF (no change)	\$ -	\$ -		0.89 EF	\$ 143.28	\$ 0.07		0.87 EF	\$ 200.00	\$ 0.08
Conventional Gas Water Heater	50 gallon	0.62 EF, 0.81 Recovery		0.79 EF, 0.95 Recovery	\$ 975.00	\$ 0.49	Conventional Gas	0.79 EF, 0.95 Recovery	\$ 975.00	\$ 0.49	50 gal .64 EF (baseline 0.62)	0.64 EF (0.62 baseline)	\$ -	\$ -	56 gal	.65 EF (baseline 0.61)	\$ 90.00	\$ 0.03

**Table C-2 (continued). Completed Incremental Cost Data Template for Single Family Attached Homes**

Other Measures	Reference Home Data	Prescriptive I			Prescriptive II			Performance-Tier I (255 homes)			Performance-Tier II (35 homes)		
		Upgrade	Incremental Cost	\$/ft <sup>2</sup>	Upgrade	Incremental Cost	\$/ft <sup>2</sup>	Upgrade	Incremental Cost	\$/ft <sup>2</sup>	Upgrade	Incremental Cost	\$/ft <sup>2</sup>
Air Infiltration ACH50	4.88 ACH50	2.5 ACH50	\$ 505.52	\$ 0.25	2.5 ACH50	\$ 158.27	\$ 0.08	4.5 ACH50	\$ 166.68	\$ 0.09	3.16 ACH50	\$ 292.17	\$ 0.11
Duct Leakage CFM25/100 sf	11.9 CFM25/100 ft <sup>2</sup>	4 CFM25/100 ft <sup>2</sup>	\$ -	\$ -	4 CFM25/100 ft <sup>2</sup>	\$ -	\$ -	3.35 CFM25/100 ft <sup>2</sup>	\$ 367.51	\$ 0.19	2.35 CFM25/100 ft <sup>2</sup>	\$ 624.37	\$ 0.24
Duct Insulation	R6.5 Attic Supply, R5.5 other UC spaces and Attic Returns	Ducts and equipment in conditioned spaces	\$(349.29)	\$ (0.18)	Ducts and equipment in conditioned spaces	\$(349.29)	\$ (0.18)	R7.5 Attic Supply, R6.5 other UC duct	\$ 114.62	\$ 0.06	R7.4 Attic Supply, R6.9 other UC duct	\$ 152.40	\$ 0.06
Water Sense Fixtures	None	All low-flow "Water Sense" fixtures	\$ 10.23	\$ 0.01	All low-flow "Water Sense" fixtures	\$ 10.23	\$ 0.01	All low-flow	\$ -	\$ -	All low-flow	\$ -	\$ -
Thermostat	Manual	Programmable	\$ 51.17	\$ 0.03	Programmable	\$ 51.17	\$ 0.03	Programmable	\$ 53.73	\$ 0.03	Programmable	\$ 52.67	\$ 0.02
Mechanical Ventilation	None	Exhaust Only - 60 CFM	\$ 376.00	\$ 0.19	Exhaust Only - 60 CFM	\$ 376.00	\$ 0.19	Exhaust Only-75 CFM	\$ 394.00	\$ 0.20	Exhaust Only - 71 CFM	\$ 394.00	\$ 0.15

**Table C-3: Completed Incremental Cost Data Template for Multifamily 1-3 Story Homes**

Shell - Non-Master Metered and Master Metered Gas	Reference Home Data				Prescriptive I			Prescriptive II			Performance-Tier I (255 homes)			Performance-Tier II (35 homes)		
	Average Sq. Ft.	Framing	Insulation Type	R-value	Upgrade	Incremental Cost	\$/ft²	Upgrade	Incremental Cost	\$/ft²	Upgrade	Incremental Cost	\$/ft²	Upgrade	Incremental Cost	\$/ft²
Residential Floor Area	21,384															
Building Total Area	30,549															
Conditioned>Ambient Walls	11,707	2x6x16	FG Batts	19	No change	\$ -	\$ -	R-40 walls-double stud, 4" gap filled with blown cellulose.	\$ 29,952	\$ 0.98	R-20-R21, FG Batts, 2x6x16	\$ 1,839	\$ 0.06	R-20-R21, FG Batts, 2x6x16	\$ 1,839	\$ 0.06
Flat Attic Ceiling	9,292	2x10x24	FG Batts	36	No change	\$ -	\$ -	R-60 ceilings-(18" blown cellulose)	\$ 7,368	\$ 0.24	39.7-R40, 12" Blown cellulose	\$ (772)	\$ (0.03)	40-R40, Blown cellulose,2x10x24	\$ (772)	\$ (0.03)
Cathedral Ceiling	996	2x12x16	FG Batts	35	No change	\$ -	\$ -	R-60 ceilings-(9.25" high density spray foam)	\$ 5,162	\$ 0.17	37.2-R38 FG Batts, 2x12x16	\$ -	\$ -	39-R39, 11" low density foam, 2x12x16	\$ 1,725	\$ 0.06
Windows	2,927			U-0.34	No change	\$ -	\$ -	No change	\$ -	\$ -	0.32	\$ 5,249	\$ 0.17	0.30	\$ 10,498	\$ 0.34
Slab Insulation (alll basements)	10,183							R-10 under slab, 2", R-10 perimeter	\$ 2,195	\$ 0.07	R-5.8 Perim, R-6.6 under (0.4' depth, 6.9' under)	\$ 5,420	\$ 0.18	R-9.7 Perim, R-10.2 under (0.6' depth, 12.4' under)	\$ 11,160	\$ 0.37

**Table C-3 (continued). Completed Incremental Cost Data Template for Multifamily 1-3 Story Homes**

Mechanicals	Reference Home Data		Prescriptive I				Prescriptive II				Performance-Tier I				Performance-Tier II			
	Capacity	Efficiency	Capacity	Efficiency	Inc. Cost	\$/ft <sup>2</sup>	Capacity	Efficiency	Inc. Cost	\$/ft <sup>2</sup>	Capacity	Efficiency	Inc. Cost	\$/ft <sup>2</sup>	Capacity	Efficiency	Inc. Cost	\$/ft <sup>2</sup>
<i>Non-Master Metered per 1188 sq.ft. unit</i>																		
Gas Furnace	SAME AS RATED HOME	91.5 AFUE	(48 Btuh/sq. ft.) 57,000 Btuh	95 AFUE w/ECM motor	\$ 580	\$ 0.02	(48 Btuh/sq. ft.) 57,000 Btuh	95 AFUE w/ECM motor	\$ 580	\$ 0.02	(50 Btuh/sq. ft.) 59,400 Btuh	95 AFUE	\$ 25	\$ 0.00	(47 Btuh/sq. ft.) 55,800 Btuh	93 AFUE	\$ 10.00	\$ 0.00
Gas Boiler variation	SAME AS RATED HOME	89.8 AFUE	(61 Btuh/sq. ft.) 72,500 Btuh	90 AFUE (no change)	\$ -	\$ -	(61 Btuh/sq. ft.) 72,500 Btuh	90 AFUE (no change)	\$ -	\$ -	(92 Btuh/sq. ft.) 109,300 Btuh	89 AFUE	\$ (250)	\$ (0.01)	(97 Btuh/sq. ft.) 115,200 Btuh	91 AFUE	\$ 250.00	\$ 0.01
Central Air Conditioning System	(19 Btuh/sq. ft.) 22,600	13.7 SEER	(19 Btuh/sq. ft.) 22,600	14.5 SEER	\$ 210	\$ 0.01	(19 Btuh/sq. ft.) 22,600	14.5 SEER	\$ 210	\$ 0.01	(21.9 Btuh/sq. ft.) 26,000 Btuh	13.1 SEER	\$ (60)	\$ (0.00)	(18 Btuh/sq. ft.) 21,400 Btuh	13.0 SEER	\$ (210.00)	\$ (0.01)
Instantaneous Gas Water Heater		00.83 EF	Instantaneous Gas	0.82 EF (no change)	\$ -	\$ -	Instantaneous Gas	0.82 EF (no change)	\$ -	\$ -	Instantaneous Gas	0.87	\$ 200	\$ 0.01	Instantaneous Gas	0.84	\$ -	\$ -
Conventional Gas Water Heater	46 gallon	0.64 EF, 0.81 Recovery	Conventional Gas	0.79 EF, 0.95 Recovery	\$ 926	\$ 0.03	Conventional Gas	0.79 EF, 0.95 Recovery	\$ 926	\$ 0.03	40 gal	0.63 EF	\$ (90)	\$ (0.00)	none	none	\$ -	\$ -
<i>Master Metered Gas for Building</i>																		
Whole Building Boiler Variation	SAME AS RATED HOME	89.8 AFUE	no change		\$ -	\$ -	no change		\$ -	\$ -	860,000	95 AFUE	\$ 4,109	\$ 0.13	1,350,000	94 AFUE	\$ 5,062	\$ 0.17



**Table C-3 (continued). Completed Incremental Cost Data Template for Multifamily 1-3 Story Homes**

<i>Other Measures</i>	Reference Home Data	Prescriptive I			Prescriptive II			Performance-Tier I (255 homes)			Performance-Tier II (35 homes)		
		Upgrade	Incremental Cost	\$/ft <sup>2</sup>	Upgrade	Incremental Cost	\$/ft <sup>2</sup>	Upgrade	Incremental Cost	\$/ft <sup>2</sup>	Upgrade	Incremental Cost	\$/ft <sup>2</sup>
Air Infiltration ACH50	4.88 ACH50	2.5 ACH50	\$ 3,459	\$ 0.11	2.5 ACH50	\$ 1,477	\$ 0.05	3.42 ACH50	\$ 1,826	\$ 0.06	2.20 ACH50	\$ 3,304	\$ 0.11
Duct Leakage CFM25/100 sf	11.9 CFM25/100 ft <sup>2</sup>	4 CFM25/100 ft <sup>2</sup>	\$ -	\$ -	4 CFM25/100 ft <sup>2</sup>	\$ -	\$ -	4.19 CFM25/100 sf	\$ 5,762	\$ 0.19	2.49 CFM25/100 sf	\$ 7,333	\$ 0.24
Duct Insulation	R6.5 Attic Supply, R5.5 other UC spaces and Attic Returns	Ducts and equipment in conditioned spaces	\$ (1,788)	\$ (0.06)	Ducts and equipment in conditioned spaces	\$ (1,788)	\$ (0.06)	R-5.3 Attic Supply, R-4.7 other UC spaces and Attic Returns	\$ -	\$ -	R-8.0 Attic Supply, R-6.2 other UC spaces and Attic Returns	\$ 299	\$ 0.01
Water Sense Fixtures	None	All low-flow "Water Sense" fixtures	\$ 135	\$ 0.00	All low-flow "Water Sense" fixtures	\$ 135	\$ 0.00	All low-flow	\$ -	\$ -	All low-flow	\$ -	\$ -
Thermostat	Manual	Programmable	\$ 405	\$ 0.01	Programmable	\$ 405	\$ 0.01	Programmable	\$ 405	\$ 0.01	Programmable	\$ 405	\$ 0.01
Mechanical Ventilation	None	Exhaust Only, 51 CFM	\$ 363	\$ 0.01	Exhaust Only, 51 CFM	\$ 363	\$ 0.01	Exhaust Only, 51 CFM	\$ 363	\$ 0.01	Exhaust Only, 51 CFM	\$ 363	\$ 0.01

**Table C-4: Completed Incremental Cost Data Template for Multifamily 4+ Residential In-Unit Savings Prescriptive Option**

Measure	Baseline Assumption	RNC Program Requirement	Incremental Cost (for building)	\$ / sq. ft.	Baseline Notes	Efficiency Definition Notes
Refrigerator	530kWh/yr	ENERGY STAR® Labeled and 30% better than federal standard (≤ 408 kWh/year)	\$5,290	\$0.08	Residential refrigerator that meets the federal minimum standard (National Appliance Energy Conservation Act ) for volume and configuration 2012 TRM, p 119 and <a href="http://www.energystar.gov/index.cfm?c=refrig_pr_crit_refrigerators">http://www.energystar.gov/index.cfm?c=refrig_pr_crit_refrigerators</a>	Oregon Energy Trust provides additional incentives for appliances that significantly exceed the ES minimum threshold. ENERGY STAR/CEE Tier 3 performance threshold.
Dishwasher	≤ 355 kwh and ≤ 6.5 gallons/cycle. EF 0.46	(ENERGY STAR® Labeled and rated at 1.0 EF or greater)	\$1,040	\$0.02	Non-ENERGY STAR standard-size dishwasher: meeting federal standards effective January 1, 2010: 2012 TRM, p 44; <a href="http://www.energystar.gov/index.cfm?c=dishwash_pr_crit_dishwashers">http://www.energystar.gov/index.cfm?c=dishwash_pr_crit_dishwashers</a> ; and <a href="http://www.cce1.org/resid/seha/dishw/dw-spec.pdf">http://www.cce1.org/resid/seha/dishw/dw-spec.pdf</a>	
Hi-efficacy Lighting	Overall in-unit lighting power density may not exceed 0.75 W/ft2. When calculating overall lighting power density, use 1.1 W/ft2 for spaces where lighting is not installed.	Wattage Reduction Threshold of ≥15% @ .75 watts per square foot	-\$748	-\$0.01	EPA ENERGY STAR MFHR Standard	Mirroring the C&I program design and performance threshold
Showerheads,	(2009 IRC Table P2903.2); Note: current Tool J uses 2.2gpm.	WaterSense® Labeled and rated at 1.75 GPM or less	\$390	\$0.01		From DOE energy cost calculator assumptions: <a href="http://www1.eere.energy.gov/femp/technologies/eep_faucets_showerheads_calc.html">http://www1.eere.energy.gov/femp/technologies/eep_faucets_showerheads_calc.html</a>
Lavatory Faucets,	2009 IRC Table P2903.2; also SG V1.0 p18 (note: from Energy Policy Act 1992	WaterSense® Labeled and rated at 1.5 GPM or less	\$390	\$0.01		From DOE energy cost calculator assumptions: <a href="http://www1.eere.energy.gov/femp/technologies/eep_faucets_showerheads_calc.html">http://www1.eere.energy.gov/femp/technologies/eep_faucets_showerheads_calc.html</a>
Infiltration	air leakage rates of 11.0 ACH50	maximum air leakage rates of ≤ 7.0 ACH50	\$2,777	\$0.04		

**Table C-5: Completed Incremental Cost Data Template for Multifamily 4+ Whole Building Simple Prescriptive Option**

Measure	Baseline Assumption	Efficiency Requirement	Incremental Cost (for building)	\$/ sq. ft.	Baseline Notes	Efficiency Definition Notes
<b>MF In-Unit Savings – Identical Measures and Savings as Residential In-Unit Savings Prescriptive Option</b>						
<b>MF Simple Prescriptive Whole Building Savings</b>						
Wood wall construction - Walls R-19 (R value = batt + c. i.)	R-13 + 3.8 c.i. (R-16.8)	R-19 (R value = batt + c. i.)	\$4,681	\$0.07	2009 IECC, Table 502.2(1)	Typical above code building practice
Ceiling - R-30 (R value = batt + c. i.)	R-20 c.i. (R-20)	R-30 (R value = batt + c. i.)	\$6,741	\$0.10	2009 IECC, Table 502.2(1)	2012 IECC, Table C402.2
Windows - ENERGY STAR: U-value ≤ 0.27; SHGC= all materials (Assumes 25% window coverage)	U-value ≤ 0.35; SHGC ≤ 0.40	ENERGY STAR: U-value ≤ 0.27; SHGC= any	\$27,468	\$0.42	For residential ≥ 4 stories, IECC-2009, Table 502.3; ASHRAE 90.1, Table 5.5-6	ENERGY STAR Multifamily HR Prescriptive Requirements, Table 3
Heating - 92 % AFUE Condensing Boiler	80% AFUE	92% AFUE(per TRM)	\$16,500	\$0.25	2012 TRM (p302)	added to get additional energy savings
Cooling - Chiller - air cooled with condenser, <150 tons, FL: 10.52 EER; IPLV: 13.75	air-cooled <150 tons, EER=9.562, IPLV=12.5	FL: 10.52 EER; IPLV: 13.75	\$9,000	\$0.14	2012 TRM (p193)	Current Cool Choice program
DHW - Condensing Boiler 90% AFUE	80% Et (Thermal Efficiency, not AFUE)	90 AFUE	\$3,543	\$0.05	2009-IECC Table 504.3	
VFD - Hot Water Circulation Pump	constant speed or 2-speed motor	VFD installed	\$1,000	\$0.02	Current tool, 2012 TRM (p. 237)	Current tool, 2012 TRM (p. 237)
VFD - Chilled/Cond Water Pump	constant speed or 2-speed motor	VFD installed	\$1,000	\$0.02	Current tool, 2012 TRM (p. 237)	Current tool, 2012 TRM (p. 237)
<b>MF Simple Prescriptive Common Area Savings</b>						
Hi-efficacy Lighting with a Wattage Reduction Threshold of ≥15% of 1.25 watts per sq. ft.	Common Area - 1.25 watts per sq. ft.	Wattage Reduction Threshold of ≥15%	\$241.15	\$0.004		
15% better than ASHRE 90.1 baseline	Corridors @ ~0.50 watts per sq. ft.	15% better	-\$48.04	-\$0.001		As per Mass Save C&I Performance Lighting requirements
15% better than ASHRE 90.1 baseline	Laundry Rooms @ ~0.60 watts per sq. ft.	15% better	\$10.56	\$0.000		As per Mass Save C&I Performance Lighting requirements
15% better than ASHRE 90.1 baseline	Lobby/Elevator @ ~1.30 watts per sq. ft.	15% better	\$52.61	\$0.001		As per Mass Save C&I Performance Lighting requirements
15% better than ASHRE 90.1 baseline	Meeting Room @ ~1.30 watts per sq. ft.	15% better	\$94.65	\$0.001		As per Mass Save C&I Performance Lighting requirements
15% better than ASHRE 90.1 baseline	Office @ ~1.10 watts per sq. ft.	15% better	-\$15.08	\$0.000		As per Mass Save C&I Performance Lighting requirements
15% better than ASHRE 90.1 baseline	Stairwells @ ~0.60 watts per sq. ft.	15% better	\$74.18	\$0.001		As per Mass Save C&I Performance Lighting requirements

**Table C-6: Completed Incremental Cost Data Template for Multifamily 4+ Whole Building Interactive Prescriptive Option**

Measure	Baseline Assumption	Efficiency Requirement	Incremental Cost (for building)	\$ / sq. ft.	Baseline Notes	Efficiency Definition Notes
<b>MF In-Unit Savings – Identical Measures and Savings as Residential In-Unit Savings Prescriptive Option except the following:</b>						
Hi-efficacy Lighting with a Wattage Reduction Threshold of $\geq 25\%$ @ .75 watts per sq. ft.	Overall in-unit lighting power density may not exceed 0.75 W/ft <sup>2</sup> . When calculating overall lighting power density, use 1.1 W/ft <sup>2</sup> for spaces where lighting is not installed.	25% better	-\$1,246.67	-\$0.02	EPA ENERGY STAR MFHR Standard	Mirroring the C&I program design and performance threshold
<b>MF Interactive Prescriptive Whole Building Savings</b>						
Wood wall construction - Walls R-25 (R value = batt + c. i.)	R-13 + 3.8 c.i. (R-16.8)	R-25 (R value = batt + c. i.)	\$9,362.00	\$0.14	2009 IECC, Table 502.2(1)	Typical above code building practice
Ceiling - R-38 (R value = batt + c. i.)	R-20 c.i. (R-20)	R-38 (R value = batt + c. i.)	\$13,482.67	\$0.21	2009 IECC, Table 502.2(1)	2012 IECC, Table C402.2
Windows - ENERGY STAR: U-value $\leq 0.27$ ; SHGC= all materials (Assumes 25% window coverage)	U-value $\leq 0.35$ ; SHGC $\leq 0.40$	ENERGY STAR: U-value $\leq 0.27$ ; SHGC= any	\$27,468.00	\$0.42	For residential $\geq 4$ stories, IECC-2009, Table 502.3; ASHRAE 90.1, Table 5.5-6	ENERGY STAR Multifamily HR Prescriptive Requirements, Table 3
Heating - 96 % AFUE Condensing Boiler	80% AFUE	96% AFUE(per TRM)	\$25,800.00	\$0.39	2012 TRM (p302)	added to get additional energy savings
Cooling - Chiller - air cooled with condenser, <150 tons, FL: 10.52 EER; IPLV: 13.75	air-cooled <150 tons, EER=9.562, IPLV=12.5	Exceeding FL: 10.52 EER; IPLV: 13.75	\$17,000.00	\$0.26	2012 TRM (p193)	Current Cool Choice program
DHW - Condensing Boiler 92% AFUE	80% Et (Thermal Efficiency, not AFUE)	92% AFUE	\$4,252.00	\$0.06	2009-IECC Table 504.3	
VFD - Hot Water Circ Pump	constant speed motor or 2-speed motor	VFD installed	\$1,000.00	\$0.02	Current tool, 2012 TRM (p. 237)	Current tool, 2012 TRM (p. 237)
VFD - Chilled/Cond Water Pump	constant speed motor or 2-speed motor	VFD installed	\$1,000.00	\$0.02	Current tool, 2012 TRM (p. 237)	Current tool, 2012 TRM (p. 237)
<b>MF Interactive Prescriptive Common Area Savings</b>						
- Hi-efficacy Lighting with a Wattage Reduction Threshold of $\geq 25\%$ of 1.25 watts per sq. ft.	Common Area - 1.25 watts per sq. ft.	Wattage Reduction Threshold $\geq 25\%$	\$186.14	\$0.003		
25% better than ASHRE 90.1 baseline	Corridors @ ~0.50 watts per sq. ft.	25% better	-\$80.07	-\$0.001		As per Mass Save C&I Performance Lighting requirements
25% better than ASHRE 90.1 baseline	Laundry Rooms @ ~0.60 watts per sq. ft.	25% better	\$8.55	\$0.000		As per Mass Save C&I Performance Lighting requirements
25% better than ASHRE 90.1 baseline	Lobby/Elevator @ ~1.30 watts per sq. ft.	25% better	\$40.61	\$0.001		As per Mass Save C&I Performance Lighting requirements
25% better than ASHRE 90.1 baseline	Meeting Room @ ~1.30 watts per sq. ft.	25% better	\$76.67	\$0.001		As per Mass Save C&I Performance Lighting requirements
25% better than ASHRE 90.1 baseline	Office @ ~1.10 watts per sq. ft.	25% better	-\$25.14	\$0.000		As per Mass Save C&I Performance Lighting requirements
25% better than ASHRE 90.1 baseline	Stairwells @ ~0.60 watts per square foot	25% better	\$60.09	\$0.001		As per Mass Save C&I Performance Lighting requirements