Home Innovation RESEARCH LABS™

ESTIMATED COSTS OF THE 2015 IRC CODE CHANGES

Prepared For

National Association of Home Builders

January 2015

Report No. 5946-002_11192014

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ACRONYMS, ABBREVIATIONS, AND DEFINITIONS

AHS	American Housing Survey—national survey conducted biennially by the U.S. Census Bureau in odd years
A Zone	A coastal area defined by breaking waves and erosion during base flood[1]
BFE	Base flood elevation
BPS	Builder Practices Survey—national survey conducted annually by Home Innovation Research Labs
CAZ	Combustion appliance zone
CDD	Cooling degree days—in the IECC 2012, sum of the differences of mean daily temperature above 50° F
CFM	Cubic feet per minute (a measure of flow)
CFS	Cold-formed steel
CS-PF	Continuous sheathed portal frame—a term for the frame around a two-car garage door opening in the IRC
C.Y.	Cubic yards
CZ	Climate zone, as defined by the International Code Council (ICC)
EE	Energy efficiency
EERO	Emergency escape and rescue opening
ERI	Energy rating index
FG	Fiberglass (batt insulation)
FIRM	Flood Insurance Rate Map (Developed by FEMA to denote flood risk areas)
HDD	Heating degree days—sum of the differences of mean daily temperature below 65°F
HVAC	Heating, ventilation, and cooling
IBC	International Building Code
ICC	International Code Council
IECC	International Energy Conservation Code

[1] https://www.fema.gov/pdf/rebuild/mat/coastal_a_zones.pdf

IRC	International Residential Code
LiMWA	Limit of Moderate Wave Action, defined as the landward extent of a coastal area expected to experience breaking waves 1.5 feet or greater in height. The LiMWA typically defines the landward limit of the Coastal A Zone.
LF	Linear feet
NAHB	National Association of Home Builders
O&P	Overhead and profit
PSF	Pounds per square foot
SF	Square feet
SYP	Southern yellow pine
XPS	Extruded polystyrene (rigid foam sheathing)

BACKGROUND

The National Association of Home Builders (NAHB) provided a list of 47 code changes to the 2012 International Residential Code (2012 IRC) which were approved for incorporation into the 2015 IRC. Home Innovation Research Labs estimated the expected cost impact of these code changes on construction practices and materials. In the process, a number of the selected code changes were found to be inconsequential (e.g. no cost increase or savings). NAHB opted not to include these changes in this report.

Reported as cost variance to the builder, the results are also aggregated in cost estimate ranges in an effort to estimate a cumulative cost impact on an average house in selected climate zones.

METHODOLOGY

Baseline metrics for four single family houses built to the 2012 IRC and 2012 International Energy Conservation Code (2012 IECC) building codes[2] were defined in order to determine the cost impact resulting from the revisions approved for the 2015 codes. The houses were selected for their similarity to new home offerings in the six metropolitan area(s) that were deemed representative locations for this study by the NAHB. The metros identified were Miami, Dallas, Los Angeles, Seattle, New York, and Chicago. Elevations and floor plans for these reference houses are provided in Appendices C through F.

The reference houses defined a starting point for the analysis of the cost impact to a newly-constructed home resulting from adoption of the 2015 IRC and IECC building codes (relative to a 2012 IRC/IECC baseline).

National Construction Cost

Cost impacts in this analysis have been developed primarily with data adapted from the following sources: (1) RSMeans' *Residential Cost Data 2014*,[3] (2) *ASHRAE 1481 RP*[4] and similar reports by the Home Innovation Research Labs (Home Innovation), (3) distributors' or big box retailers' websites, and (4) U.S. government reporting from the Census[5] and the Bureau of Labor Statistics[6]. Other cost sources are cited in *Appendix A* of this report as applicable to a specific code change. Costs are reported at the national level and can be modified for a region using builders' known bid prices or by applying a location factor adjustment shown in *Appendix B*. Costs reported are the cost to the builder and do not include the builder's gross margin, reported as ranging between 17 to 20% of construction cost per *2012 Cost of*

2 International Code Council, www.iccsafe.org/Pages/default.aspx

3 http://rsmeans.reedconstructiondata.com

4 NAHB Research Center, 2009. Economic Database in Support of ASHRAE 90.2 1481 RP. https://www.google.com/#q=ashrae+1481+rp

5 http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=bkmk

6 http://www.bls.gov/oes/current/oes_nat.htm#47-0000

Doing Business[7] and *2013 Construction Cost Survey for Single-Family Homes*[8]. Therefore, the compiled costs do not reflect the consumer price.

Reference House Configurations

The four single-family detached building designs (see *Appendices C-F)* used in this analysis are based on the data contained in the Census Bureau report, *Characteristics of New Single Family Construction Completed*.[9] The report provides information as to building foundation type (Table 1) and number of stories for new single family detached construction over the previous nine year period. (Table 2).

Table 1. New Construction Foundation Types

Slab	54%
Crawlspace	17%
Basement	30%

Table 2. New Construction Number of Stories

One-story	53%
Two-story	43%
Three-story	3%

The Census data supports defining the four reference houses as follows to encompass approximately 85% of the last decade's new single-family construction:

- One-story on slab foundation
- Two-story on slab foundation
- One-story on basement foundation
- Two-story on basement foundation

House Size, Cost, and Features

A reference house and lot size have been defined based on a report by Heather Taylor, *The Cost of Constructing a Home,* for the NAHB Housing Economics division, January, 2014[10]. The report covers results from a 2013 survey using national averages and indicates that the average 2,607 SF house cost the builder $246,453 to construct on a lot that cost $74,509, for a sales price of $399,352.

Based on the data compiled by Home Innovation from the *Builder Practices Survey 2013* (BPS)[11], a nationwide annual survey, the typical Heating, Ventilation, and Cooling (HVAC) systems used with new houses are summarized in Table 3. According to the BPS, 44% of new homes are cooled with a central air conditioner. These results influenced the selection of a gas furnace with central (electric) air conditioner for each of the reference houses.

7 NAHB Business Management & Information Technology, 2009. http://secure.builderbooks.com/cgi-bin/builderbooks/965?id=hGY9PfM8&mv_pc=22

8 Taylor, H. for NAHB, 2014. www.nahb.org/generic.aspx?sectionID=734&genericContentID=221388&channelID=311

9 www.census.gov/construction/chars/completed.html

10 Taylor, H. for NAHB, 2014. www.nahb.org/generic.aspx?sectionID=734&genericContentID=221388&channelID=311

11 www.homeinnovation.com/trends_and_reports/data/new_construction

Table 3. Typical HVAC Systems Supplied with New Houses

Feature	Quantity or % of Stock
Furnace or Boiler, natural gas or propane	48%
Central Air Conditioner, electric	44%
Standard Heat Pump with Backup Heat	41%
Geothermal Heat Pump	4%
Electric furnace, baseboard, or radiant	4%
Furnace or Boiler, oil	2%

Reference House Definition

The statistics presented in the foregoing tables support reference house features that are enumerated in Table 4. These four houses, in compliance with the minimum requirements of the 2012 IRC, will serve as the baseline(s) for adding or subtracting costs to estimate the impact of the code changes approved for the 2015 IRC.

Table 4. Features of the Reference Houses

Reference House	1	2	3	4
Square Feet	2,607	2,607	2,607	2,607
Foundation	Slab	Slab	Basement	Basement
Number of Stories	1	2	1	2
Number of Bedrooms	3	4	3	4
Number of Bathrooms	2	2.5	2	3
Garage, attached	2-car	2-car	2-car	2-car
Heat, Gas Furnace	Yes	Yes	Yes	Yes
Cooling, (Electric) central air	Yes	Yes	Yes	Yes
Hot Water, Gas 50 gallon tank	Yes	Yes	Yes	Yes
9 ft. Ceilings, 1st	Yes	Yes	Yes	Yes
8 ft. Ceilings, 2nd	n/a	n/a	Yes	Yes
Energy Star appliances	Yes	Yes	Yes	Yes
Laundry Room	Yes - Mudroom	Yes	Yes - Mudroom	Yes - Closet
Walls, 2x4 (Zones 1&2)	Yes	Yes	n/a	n/a
Walls, 2x6 (Zones 3 thru 8)	Yes	Yes	Yes	Yes
Bsmt., Conditioned, Unfinished	n/a	n/a	Yes	Yes
Furnace Location	Attic	Attic	Basement	Basement
Water Heater Location	Interior	Garage	Basement	Basement
Window SF/% gross wall	360/18%	315/12%	360/18%	330/12%
Cladding	Brick, 4 sides	Brick, 4 sides	Brick, 4 sides	Stucco

The furnace location has been designated as a platform in the attic for both slab reference houses, a practice that is common in Florida and Texas, where the weather is temperate year round, and thus, the location is practical. A house built on a slab foundation in a cold climate zone would have the HVAC and water heating equipment located within conditioned space, therefore, some additional costs might be incurred to build that house to the 2015 code. For example, if the HVAC equipment were naturally drafted, a special sealed room with combustion air supply would have to house the equipment, whereas, having defined the reference slab houses as having the equipment outside of conditioned space within the attic eliminates the need (and cost) to specially seal the equipment space. Likewise, if a house contained all electric equipment, then any expense associated with combustion equipment within the conditioned space would be eliminated.

It was also assumed that the path to compliance with the 2012 IRC required that the reference houses in climate zones 3 through 8 be constructed of 2x6 to accommodate appropriate thickness of cavity insulation.

RESULTS

Estimated Cost of 2015 Code Compliance for Reference Houses by Location

Table 5 summarizes the estimated cumulative impact of the 2015 code changes on the cost of constructing the reference houses. For the purpose of cost aggregation, it was assumed that reference houses were not built in coastal zones or subject to flooding. The aggregated costs are reported in ranges of “High” and “Low” impact based on the applicability of the changes to the features of the reference houses. The results are also grouped into two climate zones categories (CZ 1&2 and CZ3-8) to illustrate the degree of climatic effects on the aggregated costs.

Table 6 summarizes the cost estimates of the code changes that do not directly apply to the selected reference houses and are not included in the aggregated summary. Those costs can be added or subtracted from the aggregated costs in Table 5 if applicable to a particular location or a specific building. A detailed analysis of each individual code change is provided in Appendix A.

Table 5. Estimated Cost of 2015 Code Compliance

Climate Zones			1 & 2		3-8		
			Range				Applicability
Description	2015 IRC Reference	Report Reference	High ($)	Low ($)	High ($)	Low ($)	
Footing Size	R403	FDN1	$406	$0	$508	$0	If snow load is less than or equal to 30 psf & soil has bearing capacity of at least 2,000 psf
Garage (CS-PF)	R602	FR1	$0	($808)	$0	($808)	If garage front sidewalls are narrow and opening is wide, as with 2-car garages
King Studs, Zones 1&2	R602	FR2	$253	$69			Based on 2x4 construction and the window opening widths in the reference houses
King Studs, Zones 3 thru 8	R602	FR2			$317	$0	Based on 2x6 construction and the window opening widths in the reference houses
Box nails in lieu of common	R602	FR3	$328	$259	$328	$259	Where pneumatic nailing equipment is used
Condensate pump wired to air handler	M1411.4	HVAC1	$29	$0	$29	$0	If design has an air handler in unihabitable location like attic
Isolated combustion room	N1102	HVAC2	$878	$214	$878	$214	If furnace and water heater are natural draft and equipment is in the basement, attic, or garage
Seal snap & button lock duct seams	N1103	MAT1	$215	$103	$314	$232	If a ducted HVAC system is used ; ranges assume slab houses in CZ1-2; basements in CZ3-8
Plumbing fixture flow rates adjusted for green building	P2903.1	PL1	$0	($14)	$0	($14)	If fixtures with lower flow rates are used
No pipe Insulation on 1/2" or less diam.	N1103	PL2	($149)	($331)	($287)	($456)	If prescriptive path to EE is followed
TOTAL			$1,961	($507)	$2,088	($572)	

Table 6. Additional Costs of 2015 Code Compliance not Attributed to the Reference Houses

Special Cases							
Climate Zones			**1 & 2**		**3 through 8**		
			Range				
Description	**2015 IRC Reference**	**Report Reference**	**High ($)**	**Low ($)**	**High ($)**	**Low ($)**	**Applicability**
CAZ Testing	**R201**	**AA1**	$207	$157	$207	$157	If Appendix T adopted & house has natural draft gas equipment
Carbon monoxide alarm	**R315**	**FEA1**	($58)	$0	($58)	$0	Applies to Remodeling special conditions
Zone V exterior door above break-away walls	**R322**	**FEA2**	$366	$0	$366	$0	Pier foundation in V Zone where interior door was installed at head of stairs
R-value of access panel to unconditioned area	**R402, N1102**	**FEA3**	$12	($55)	$12	($55)	If design has a wall-mounted access to an unconditioned area
Emergency exit from basement	**R310**	**FEA4**	$0	$0	$0	($1,555)	Applies to Remodeling special conditions
Safety glazing near stairs	**R308**	**FEA5**	$0	($181)	$0	($181)	Applies to certain designs with glass adjacent to stairs
3-Story Structure	**R301**	**FEA6**	($2,196)	($2,416)	($2,196)	($2,416)	If wood structural panels are used for wind resistance instead of approved aluminum shutters
Retaining walls 2'-4' do not require engineered design	**R404**	**FEA7**	($450)	($450)	($450)	($450)	If the design included retaining walls from 2' - 4' in height
Zone A special flood hazard area - Slab Foundation	**R322**	**FDN2**	$14,269	$12,661	$14,269	$12,661	Slab foundation in A Zone
A Zone special flood hazard area - Pier Foundation	**R322**	**FDN2**	$96	$0	$96	$0	Pier foundation in A Zone
Treated Lumber Deck, 20'x14'	**R507**	**FR4**	$176	$0	$176	$0	If a treated lumber deck is added, joist & beam span or spacing reduction may be required.
High-heeled trusses (12")	**R301**	**FR5**	($719)	($388)	($719)	($388)	If trusses with heel heights greater than 15 1/4" are used
Engineered Design for Braced Wall Lines	**R602**	**FR6**	$0	($1,150)	$0	($1,150)	Range of engineering fees that could be saved if braced walls for irregularly-shaped house designs do not require engineering
Add central AC condensate pump when equipment is in uncond. Space	**M1411**	**HVAC1**	$29	$0	$29	$0	If air handler is in undconditioned space as in slab units and some two zone systems.
Direct vent furnace and water heater (instead of isolated combustion room)	**N1102**	**HVAC2**	$883	$883	$883	$883	If furnace and water heater are direct vent so that equipment room does not have to be sealed
Kitchen exhaust fan, eliminate motorized damper	**N1503.4**	**HVAC3**	$0	($150)	$0	($150)	If 400 cfm kitchen fan was installed, the requirement for a motorized damper is eliminated
Demand circulation pump	**N1103.5**	**HVAC4**	$568	$0	$568	$0	If a demand circulation pump system is added to the the water supply
Tropical Climate Zone added		**LOC1**	$0	($4,008)	$0	($4,008)	Special envelope features are allowed for small houses located between Tropics of Cancer and Capricorn.
ERI-Alternate Performance Method for Energy Efficiency	**N1101, N1106**	**LOC2**	$1,194	$1,121	$5,604	$1,337	If alternate performance method is selected
Engineered fastening schedules required for cladding in high wind speed zones and open terrain	**R703.3**	**LOC3**	$450	$0	$450	$0	If exposure category is C or D and wind speed zone is 115 mph or greater; special cladding type/fastening required
Duct diameter matched to fan flow	**M1506/7**	**MAT2**	$6	$2	$7	$2	If not previously engineered correctly
Spray polyurethane foam in exposed bandboards without thermal barrier	**R316.5**	**MAT3**	($176)	($159)	($260)	($235)	If exposed band boards are insulated with spray foam. NOTE: Only applies to houses with basements or exposed bandboards and through Climate Zone 5
Deck joist hardware for tiedown	**R507**	**MAT4**	$0	($42)	$0	($42)	If the house has a deck
Submit Energy Analysis Report at plan review	**R405**	**METH2**	$88	$0	$88	$0	If this option is selected
Submit Energy Analysis Report at U&O	**R405**	**METH3**	$44	$0	$44	$0	If this option is selected
Emergency floor drain traps require evaporation protection	**P3201**	**PL3**	$203	$0	$203	$0	Applies when emergency floor drains are installed in a house

APPENDIX A
DESCRIPTION AND COST IMPACT OF 2015 IRC CODE CHANGES

Appendix A-AA: CAZ Testing Appendix

Report Reference No: AA1

2015 IRC Code Sections: Appendix T

Summary of Code Change:

The code change adds an Appendix T that (if adopted by the jurisdiction) establishes a requirement for testing of atmospheric venting of systems at ≤ 5ACH50 or tighter construction, referred to as combustion appliance zone (CAZ) testing.

Cost Implication of the Code Change:

If Appendix T is adopted as part of the 2015 code, a CAZ test is required to be performed where naturally vented combustion equipment is present. The CAZ test is performed in addition to a Blower Door test which is required for all new houses. A CAZ test would be less expensive if scheduled at the same visit as the Blower Door test that is also required by code, but CAZ testing can only be performed after the combustion naturally drafting appliances are installed and operational which is usually just before occupancy. (Whereas a blower door test can be conducted at the mid-point of construction or "close-in" of the frame.) The estimated cost for a CAZ test under various scenarios is reported in Table AA1. The average added cost is reported in the roll-up in Table 6 of this report.

Table AA1. Estimated Additional Cost of a Combustion Appliance Zone (CAZ) Test

	Hours	Burdened Wages	Total ($)
Cost of a CAZ test with blower door test[1]	Flat fee		100
Cost of CAZ test without blower door test[1]	Flat fee		150
Construction Manager's Time[2]	1	57	57
Added Cost Low Range			157
Added Cost High Range			207
Average Added Cost			182

1. Informal telephone survey of Energy and Green Raters, 5/8/14.

2. Bureau of Labor Statistics; mean annual salary for Construction Manager, burdened by 40%.

Appendix A-FEA: Features

Report Reference No: FEA1

2015 IRC Code Sections: R315.2.2

Summary of Code Change:

The code section defines remodeling/retrofit activities that can trigger a requirement for a carbon monoxide detector in older homes with attached garages and/or combustion equipment. The code change exempts exterior, mechanical, and plumbing improvements from triggering a carbon monoxide (CO) detector requirement and is consistent with similar code provisions for requiring smoke detectors.

Cost Implications of the Code Change:

A plug-in CO detector is the lowest cost method for complying with the 2012 IRC. The remodeling projects that are exempt by the 2015 IRC from installing the CO detector (exterior decks/porches, mechanical, and plumbing improvements) would realize the savings shown in Table FEA1.

Table FEA1. Estimated Savings for Some Remodeling Jobs

	Cost	8% Sales Tax	O & P	Total ($)
Kidde Plug-In CO Alarm with Battery Backup	(44)	(4)	(10)	(58)

HomeDepot.com

Report Reference No: FEA2

2015 IRC Code Sections: R322.3.5.1

Summary of Code Change:

Construction in V Zones requires that walls installed below the base flood elevation (BFE) be breakaway walls. Under the 2012 IRC, an enclosed stairway providing access to the elevated house might have a security (exterior) door at the bottom of the stairs and an interior door at the top at the entry to the house. Because the wall assembly is designed to break away, thus exposing the stairway to flooding and waves as well as wind, the 2015 IRC requires that the door at the top of the stairway must be an exterior door.

Cost Implication of the Code Change:

In accordance with the 2015 IRC, the thermal envelope is defined by the house that has been built above the BFE regardless of whether or not an exterior door is installed at grade level at the bottom of an enclosed stairway. Under the 2012 IRC, the builder had an option to define the stairway as part of conditioned space and install an interior door at the top of the passage. In this case, the transition to the 2015 IRC will result in an added cost to install an exterior door at the head of the stairway, as shown in Table FEA2. The pricing for the exterior door is based on the cost of an impact resistant door.

Table FEA2. Estimated Added Cost for Replacing an Interior Door with an Exterior Door

	Material	Labor	O & P	Total ($)
Exterior Door, 3068, metal face, insulated, brickmold, jamb, flashing	410	64	100	574
Interior Door, 3068 split jamb hollow core	140	32	36	208
Added Cost for Exterior Door				366

RSMeans RCD 2014
Home Depot.com

Report Reference No: FEA3

2015 IRC Code Sections: N1102.2.4

Summary of Code Change:

Access hatches and doors from conditioned space to unconditioned space must be insulated to a level equivalent to the insulation on the surrounding surface with the exception of vertical doors that provide access from conditioned to unconditioned spaces, which shall be permitted to meet the fenestration requirement of Table R402.1.1 based on climate zone. Table FEA3-A shows the reduction in R-values allowed by the code change recognizing the difference in possible R-values for exterior doors versus exterior walls.

Table FEA3-A. Comparative Insulating Values of a Vertical Door or Hatch

Climate Zone	2012 Frame Wall		2015 Fenestration	
	U-value	R-value	U-value	R-value
1	0.082	12.2	0.50	2.0
2	0.082	12.2	0.40	2.5
3	0.057	17.5	0.35	2.9
4 < Marine	0.057	17.5	0.35	2.9
5 + Marine 4	0.057	17.5	0.32	3.1
6	0.048	20.8	0.32	3.1
7 & 8	0.048	20.8	0.32	3.1

IRC Table R402.1.1

Cost Implication of the Code Change:

The code change permits vertical doors to follow the thermal requirements of exterior doors versus the previous code's requirement that vertical access panels meet exterior wall requirements. Table FEA3-B presents the cost/benefit of the code revision two ways – as an interior door layered with a lesser thermal value of rigid foam insulation than the previous code required or as the replacement of a modified interior door with an exterior door and no added overlay of rigid foam.

Table FEA3-B. Estimated Cost of Vertical Door

	Material	Labor	O & P	Total ($)
2012 - Interior Door, w/ rigid foam insulation	155	45	60	260
2015 - Interior Door, w/ rigid foam insulation	123	38	44	205
2015 - Exterior Door, 3068, insulated	192	27	52	272
Cost Savings for Reduced Insulation OR				(55)
Added Cost for Exterior Door				12

RSMeans RCD 2014

Home Depot.com/Lowes.com

Report Reference No: FEA4

2015 IRC Code Sections: R310.5, R310.6

Summary of Code Change:

The code change provides exceptions from requiring an emergency escape and rescue opening (EERO) in homes undergoing additions that include basements. The code change also exempts basement alterations and repairs from adding an EERO to the existing basement.

Cost Implication of the Code Change:

Table FEA4-A shows the cost savings if a new EERO does not need to be added to an existing basement. Table FEA4-B indicates the cost savings from not having to add an EERO with a basement addition.

Table FEA4-A. Estimated Cost of an Emergency Escape and Rescue Opening Added to Existing Basement

Construction Activity	Material	Labor (hrs)	Cost/Hr	w/ O & P	Total ($)
Excavation, by hand[1]		12	24	40	481
Window Well - 63" Tall[2]	844				1,055
Saw Cut Foundation[1]		4	32	55	219
Frame Window[1]		2	32	55	110
Tie into Draintile[1]		1	32	55	55
Gravel[1]		1	32	55	55
Window[2]	268				335
Backfill[1]		3	24	40	120
Seed[1]		1	24	40	40
Haul and Disposal[1]		4	24	40	160
Cost Savings					(2,630)

1. RSMeans RCD 2014

2. Home Depot/Lowes

Table FEA4-B. Estimated Cost of an Emergency Escape and Rescue Opening Added with a Basement Addition

Construction Activity	Material	Labor (hrs)	Cost/Hr	w/ O & P	Total ($)
Window Well - 63" Tall[2]	844				1,055
Frame Window[1]		2	32	55	110
Tie into Draintile[1]		1	32	55	55
Window[2]	268				335
Cost Savings					(1,555)

1. RSMeans RCD 2014

2. Home Depot/Lowes

Report Reference No: FEA5

2015 IRC Code Sections: R308.4.7

Summary of Code Change:

The code change narrowed the range where safety glazing for windows in proximity to the bottom stair nosing is required. The revised provisions require safety glazing only within a 180 degree arc from the bottom tread nosing.

Cost Implication of the Code Change:

The cost impact would be dependent on the architectural configuration of the stairs and adjacent glazing. In the reference houses there is a window at a stair landing in the two story house with a basement foundation that would require an impact resistant window that would not have been exempted by this code change, however, it would also have been required in the previous code; for a net cost effect of zero.

Table FEA5 shows the additional cost of safety glazing if a design required its addition. Note that safety glazing might be allowed to be omitted by this code change in some design cases, in which case the estimate in Table FEA5 would indicate the savings per window due to the code change.

Table FEA5. Added Cost of Safety Glazing in a 3040 Window

Component	Additional Cost	Material	w/O & P ($)
3' x 4' Double Hung		279	363
Tempered Windows Add 50%	50%		181
Total - Impact Resistant 3040 Window			181

RSMeans RCD 2014

Report Reference No: FEA6

2015 IRC Code Sections: R301.2.1.2

Summary of Code Change:

This code change expands the use of 7/16 in. wood structural panels for protection of openings from windborne debris in high wind zones to three-story buildings with a mean roof height of 33 ft or less. Previously only one- and two- story buildings qualified for use of wood structural panels for windborne debris protection. Where three-story buildings are built on a sloped surface or with the first story partially embedded in the ground, the mean roof height can be at or below 33 ft.

Cost Implication of the Code Change:

The cost implication of this can vary widely depending on the selected type of hurricane shutters, or alternate opening protection. The low-end cost savings is described in Table FEA6 based on the quantity of windows in a three-story house on a sloped grade (the window quantity was estimated based on extrapolation of the number of windows in the two-story reference homes to a three-story house on a sloped grade). Similar hardware was expected to be used to mount the two products that are compared in the Table.

Table FEA6. Estimated Cost Savings for Hurricane Panels

Component	3-Story	3-Story
Estimated Windows(vary in size)	21	22
7/16" Wood Structural Panels	529	554
Aluminum Hurricane Panels	2,945	2,750
Cost Savings ($)	(2,416)	(2,196)
Average Savings		(2,306)

Home Depot.com

Report Reference No: FEA7

2015 IRC Code Sections: R404.4

Summary of Code Change:

The trigger for engineered design for retaining walls is changed from 24 to 48 in.

Cost Implication of the Code Change:

Retaining walls with height between 24 and 48 in. do not require engineered design and can be constructed based on accepted industry practice. Therefore, there is an opportunity for cost savings on engineering fees. Retaining walls can vary greatly in configuration and complexity. Based on an estimate of an engineer’s time of three hours to complete the work and a labor rate of $150/hour that was established by informal telephone surveys with local Professional Engineers, a 2 to 4 ft. retaining wall could be designed without an engineer for a savings of approximately $450.

Appendix A-FDN: Foundation

Report Reference No: FDN1

2015 IRC Code Sections: R403.1.1, Tables 403.1(1-3)

Summary of Code Change:

Minimum sizes for concrete footings were increased for construction on soil with low load-bearing value. The tables with new footing sizes have been expanded to include additional snow loads and soil bearing capacities. Significant footing size changes applied to "poor" soil conditions – in the 1,500 and 2,000 psf soil bearing capacity range.

Cost Implication of the Code Change:

The four reference houses were assumed to be constructed on 2,000 psf soil. The footing that the code currently requires (IRC 2015) was compared to a 12 in. wide x 6 in. deep footing for one- and two-story homes, as was typical for 2,000 psf soil in 2012. The cost increase is shown in Table FDN1.

Table FDN1. Footing Cost For Reference Houses on 2,000 psf Soil

Number of Stories and Roof Load	LF of Footing	2012		2015		Cost/C.Y.	Added Cost ($)
		Footing size	C.Y.	Footing Size	C.Y.		
1 Story Slab ≤ 70 psf snow load	256	12"x6"	4.7	12"x6"	4.7	350	0
2 Story Slab ≤ 70 psf snow load	196	12"x6"	3.6	12"x6"	3.6	350	0
1 Story Bsmt. ≤ 30 psf snow load	256	12"x6"	4.7	14"x6"	5.5	350	277
2 Story Bsmt. 20 psf snow load max.	188	12"x6"	3.5	16"x6"	4.6	350	406
2 Story Bsmt 30 psf snow load max.	188	12"x6"	3.5	17"x6"	4.9	350	508

RSMeans RCD 2014

Because this report focused on 2,000 psf soil and 20-30 psf snow loads for the referenced houses, it does not fully represent the costs that could be incurred in northern climates with heavy annual snowfalls, or where a house will be constructed on soils with less than 2,000 psf capacity.

Report Reference No: FDN2

2015 IRC Code Sections: R322.1, R322.1.6, R322.1.8, R322.1.9, R322.2, R322.2.1, R322.3, R322.3.2, R322.3.3, R322.3.4, R106.1.4

Summary of Code Change:

The code change requires a one-foot freeboard (or additional minimum height of the lowest floor of the structure) above base flood elevation (BFE) or design flood elevation whichever is higher in Zone A - special flood hazard areas. This essentially added a one-foot safety factor to the BFE.

Cost Implication of the Code Change:

The reference houses are not assumed to be located in coastal or riverine hazard areas. For affected houses, it is agreed that the initial cost of construction will increase.

Slab houses, where the BFE is the slab elevation, would be required to be built on a compacted area that is an additional one foot higher than BFE. The compacted mound is required to continue 10 ft beyond the house foundation's edge and be stabilized with plantings. Table FDN2-A covers the cost to create the compacted area based upon the assumption that the additional soil required to raise the grade is available on the site.

Table FDN2-A. Cost to Raise a Slab Foundation by One-Foot on a Compacted Mound

Reference House (slabs, only)	1	2
Slab size	2,987	3,007
Additional 10' all around perimeter	2,160	1,560
Total compacted area, sq. ft.	5,147	4,567
Convert to cu. yds. (divide by 9)	572	507
Cost/ per cu. yd. at 1' depth[A]	$25	$25
Total Cost per compacted area	$14,269	$12,661

[A]RSMeans RCD

An additional tread and two risers would be required to reach the 1 ft higher than grade elevation of the first floor. If the elevation change has not been accommodated with sloped grading of the compacted mound then the stairway would be required for access and Tables FDN2-A and FDN2-B would both apply for the elevated slab. A 3-ft-wide treated wood stairway with one tread and two risers would cost approximately $100, as per the estimate developed in Table FDN2-B.

Table FDN2-B. Estimated Cost of a Stairway Rising One Foot

Component Type	Material	LF	Cost	Total
Stair Treads	5/4x4	3	$8.30	$24.90
Stringers	2x10	6	$8.15	$48.90
Railings	2x4	4	$5.45	$21.80
Total				$95.60

RSMeans RCD

Appendix A-FR: Framing

Report Reference No: FR1

2015 IRC Code Sections: Table R602.10.5

Summary of Code Change:

This code change permits calculating the effective length of a continuously sheathed portal frame (CS-PF) by multiplying the actual length by 1.5. This adds design flexibility in meeting architectural specifications by using narrow wall segments, such as the walls at either side of a garage door opening. The limited width of available garage walls required the use of proprietary shear wall products to meet increased wall bracing amounts at garage doors specified by the 2009 IRC. The 2015 code increases the contributing length of the CS-PF by 1.5 times, allowing the use of conventional framing around these large openings.

Cost Implication of the Code Change:

A Strong Wall®[12] portal frame wall segment or similar proprietary product would have been required to meet the requirements of the previous code. Using the 2015 IRC, a portal frame consisting of a 16 in. wall either side of a 17 ft opening can be conventionally constructed. Table FR1 compares the cost of these two wall designs, indicating the savings that can be attributed to the code change.

Table FR1. Cost Difference of Shear Wall Construction

Items	Material	Labor	Total	w/O&P	Quantity	Unit	Unit Cost ($)
	Cost ($)						
Plywood sheathing - 1/2" pnuematic nailed	0.60	0.44	0.97	1.27	27	sf	34
2x4@12"o.c. wall w/ bottom and dbl top plate	4.93	6.40	11.33	14.84	3	lf	45
Anchor bolts & washers - 1/2"	1.08	1.98	3.06	4.01	4	ea	16
Metal strap - 1 - 1/4" x 21 - 5/8"	2.96	1.61	4.57	5.95	2	ea	12
Subtotal - Cost for field framed CS-PF wall (2015 IRC)							72
Simpson shear wall pair; SW16"x8'x4"[A] (2012 IRC)	608	64	672	880	1	pr	880
Total Cost Savings - 2015 IRC							(808)

[A]Telephone quote by HD Supply; limited availability on East Coast; does not include shipping.

[12] http://www.strongtie.com/products/strongwall/wood-strongwall/index.asp

Report Reference No: FR2

2015 IRC Code Sections: R602.7.5, Table R602.7.5, Fig 602.3(2)

Summary of Code Change:

This code change provides new requirements for additional king studs at each side of a wall opening. The required number of king studs varies with the opening's width. Designs with wide windows or several windows in one opening require additional king studs. The 2012 code does not specifically reference any use of king studs, however, standard practice in conventional light-frame construction is to install one king stud at each side of an opening against the header.

Cost Implication of the Code Change:

Each of the four reference homes have differing opening quantities and sizes. Table FR2-A shows the additional quantity of 2x4 king studs required for each reference house under the new code. Table FR2-B indicates the additional number of 2x6 studs required under the new code. Table FR2-C provides the cost estimate for providing the required king studs.

In aggregating these costs, 2x4 construction was assumed in Climate Zones 1 and 2, and 2x6 construction was assumed in Climate Zones 3-8. (Where construction includes exterior continuous foam sheathing, substitute Table FR2-A for FR2-B, as applicable.)

Table FR2-A. Additional King Stud Requirement in 2x4 Walls– Climate Zones 1 & 2 Houses

Table R602.7.5 (2015 IRC)			Reference Homes (Zones 1&2)							
			Slab on Grade				Basement			
			1 Story*		2 Story*		1 Story*		2 Story*	
Header Span (ft)	# King studs per side		# openings	# add'l king studs	# openings	# add'l king studs	# openings	# add'l king studs	# openings	# add'l king studs
	Spacing									
	16" o.c.	24" o.c.								
3	**1**	**1**	0	0	2	0	9	0	19	0
4	**2**	**1**	4	0	10	20	4	0	4	8
8	**3**	**2**	3	6	4	16	3	6	0	0
12	**5**	**3**	4	16	1	8	0	0	0	0
Total Additional King Studs Required				22		44		6		8

* 1-story of all reference houses assumed to have 24" o.c. spacing. 2-story houses of 2x4 construction assumed to have 16" spacing.
Note: Conventional framing (reference houses) assumed to have had one king stud each side of opening prior to code change.

Table FR2-B. Additional 2015 King Stud Requirement in 2x6 Walls – Climate Zones 3-8

Table R602.7.5 (2015 IRC)			Reference Homes (Zones 3-8)							
			Slab on Grade				Basement			
			1 Story*		2 Story*		1 Story*		2 Story*	
Header Span (ft)	# King studs per side Spacing 16" o.c.	24" o.c.	# openings	# add'l king studs	# openings	# add'l king studs	# openings	# add'l king studs	# openings	# add'l king studs
3	1	1	0	0	2	0	9	0	19	0
4	2	1	4	0	10	0	4	0	4	0
8	3	2	3	6	4	8	3	6	0	0
12	5	3	4	16	1	4	0	0	0	0
Total Additional King Studs Required				22		12		6		0

* All 2x6 construction assumed to have 24" o.c. spacing - 1st and 2nd floors.

Note: Conventional frames (reference houses) assumed to have had one king stud each side of opening prior to code change.

Table FR2-C. Cost of Additional King Studs

Component	Material	Labor	Total	w/ O&P	8' Stud Cost ($)	Total Cost ($)			
						Slab on Grade		Basement	
	LNF				EACH	1 Story	2 Story	1 Story	2 Story
2x4 King Studs - Zones 1,2	0.50	0.54	1.04	1.44	11.52	253	507	69	92
2x6 King Studs - Zones 3-8	0.77	0.57	1.34	1.80	14.40	317	173	86	0

RSMeans RCD 2014

Report Reference No: FR3

2015 IRC Code Sections: Table 602.3(1)

Summary of Code Change:

This code change modified the fastening schedule for better consistency with the IBC fastening schedule and the American Wood Council's (AWC) National Design Specification (NDS). In general, use of "common" nails with larger diameters will be required, or an additional "box" nail is required at most framing junctions. Pneumatic nail gun nails have the same gauge as "box" nails, thus, this change affects all construction where nail guns are used.

Cost Implication of the Code Change:

The four reference homes depicted in Appendices C-F were used to estimate the number of "box" nails required before and after the code change. The difference in quantities suggests a roughly 40% increase in the quantity of "box" nails required, which impacts both cost and time to construct. Table FR3-A shows the estimated difference in nails required to comply with the new code and Table FR3-B tabulates the cost.

Table FR3-A. Nail Requirements Using "Box" Nails

	Slab on Grade		Basement		Average
	1 Story	2 Story	1 Story	2 Story	
2012 Code	3,828	4,129	4,032	4,500	4,122
2015 Code	5,252	5,675	5,593	6,301	5,705
Difference (qty. nails)	1,448	1,576	1,584	1,832	1,610
Nail Quantity Increase (%)	38%	38%	39%	41%	39%

Table FR3-B. Cost Increase for "Box" Nails

	Slab on Grade		Basement		Average
	1-Story	2-Story	1-Story	2-Story	1- and 2-story
Quantity of Nails	1,448	1,576	1,584	1,832	739
Cost per Nail[1,2]	0.18	0.18	0.18	0.18	1022
Added Cost ($)	259	282	284	328	288

1RSMeans RCD 2014

2 Homedepot.com and Nailgundepot.com

Report Reference No: FR4

2015 IRC Code Sections: R507.1, R507.4, R507.5, Fig 507.5, R507.5.1, R507.6, R507.7, R507.8, R507.8.1, Fig R507.7.1, R507.8.1

Summary of Code Change:

This code change provides a set of prescriptive details, including joist, beam, and deck span tables, for constructing an exterior deck. Many local jurisdictions had developed deck construction guidelines because building codes previously has limited details addressing the construction of an exterior deck. The new code requirements are based on AWC's DCA6 "Prescriptive Residential Deck Details."

Cost Implication of the Code Change:

Based on comparison with a prescriptive design details required by a local county's permit department, the deck code changes include decreased span tables for Southern Yellow Pine (SYP) lumber, consistent with an industry-wide adjustment. The effect of the changes on a 20 ft x 14 ft, or 280 square foot deck, are shown in Table FR4.

A deck was not defined on any of the reference houses, as decks are most often offered on single family homes as optional features. The deck is accessed from the house interior and has no exterior stairs to grade.

The code change to a 12'-0" clear span either requires spacing of the 2x8s to be reduced from 16 in. on center to 12 in. on center, or the use of 2x10 joists at 16 in. centers, or installation of the support beam below the joists at 11'-10" and the loss of 2 in. of deck width. The costs in Table FR4 represent the use of 2x10 joists at 16 in. on center in lieu of 2x8 joists.

Table FR4. Cost Increase for a 20'x14' Treated Lumber Deck (2x10 versus 2x8 Joists)

Components	Qty	Mat'l	Labor	Total w/O&P ($)
Material Per 2012 IRC		Per LF		
2x8 - 14@ 16" (2' cant.)	223			
Band boards 2x8x10	40	1	1.14	3.02
2-ply 2x8-10 beam under cant	40			
Material Per 2015 IRC		Per LF		
2x10 - 14 (cant 2') @ 16"	223			
Band boards 2x10x10	40	1.31	1.28	3.60
2-ply 2x10-10 beam under cant	40			
Subtotal 2x8				915
Subtotal 2x10				1,091
Difference in Cost				176

RSMeans RCD.

Report Reference No: FR5

2015 IRC Code Sections: R602.10.8.2

Summary of Code Change:

This code change allows high heeled roof trusses to be braced with just wood structural panels provided the wall sheathing is extended from the supporting wall onto the truss heels. This exception eliminates the requirement for additional blocking between high-heel trusses when OSB structural sheathing is installed over the wall top plate to the truss ends and fastened in the stated pattern.

Cost Implication of the Code Change:

Exterior structural sheathing installed across the face of the high heels and properly fastened and secured to the structural wall below the truss is sufficient, outside of hurricane-prone coastal areas and high-seismic regions, to secure the truss ends against rotation and to transfer lateral loads through the truss heels and sheathing without the use of blocking. Previously, four wood scabs (blocking) were required to be installed along the truss heel height, wall top plate, and near the top of the heel, to provide surfaces for fastening additional sheathing and securing the truss ends to the structure. The cost to provide the 2x blocking is shown in Table FR5-A. Each of the four reference homes have different roof shapes (gables and hips), thus truss heel length was estimated for each and shown in Table FR5-B along with the estimated savings from the less stringent blocking requirement.

Table FR5-A. Cost for Truss Blocking

Component	Unit	Material	Labor	Total	w/O&P
2x4 Truss Blocking	LNF	$ 0.50	$ 0.54	$ 1.04	$ 1.44

RSMeans RCD

Table FR5-B. Cost Savings under Revised Bracing Method for High-Heeled Trusses

	Slab on Grade		Basement	
	1 Story	2 Story	1 Story	2 Story
Roof Shape	Hip	Hip/Gables	Gable	Hip
2015 - LF plateline	216	172	116	163
2012 - LF of 2x4 blocking at plateline x 2 plus 15 1/2" (1.3 LF) x 2 x truss quantity for heel height (all 4 sides of space between trusses)	715	570	385	541
Difference in LF of blocking req'd by bracing methods (2015 versus 2012)	(499)	(398)	(269)	(378)
Cost of Blocking per LF	$ 1.44	$ 1.44	$ 1.44	$ 1.44
Savings ($)	(719)	(573)	(388)	(544)

Report Reference No: FR6

2015 IRC Code Sections: Table R602.10.3(1)

Summary of Code Change:

This code change modified the braced wall requirements to account for irregularly-shaped (multiple inside and outside corners) house designs and plans with highly variable braced wall line spacings. The new provision allows the designer to determine the minimum braced wall amount for wind based on the average braced wall line spacing instead of the maximum spacing. The change provide simplification and added flexibility in bracing design for complex-shaped houses.

Cost Implication of the Code Change:

Because of the added design flexibility, there is a potential for savings on engineering fees for a wall bracing design. Instead of hiring a structural engineer to perform detailed wall bracing calculations, the house designer will be able implement prescriptive IRC provisions.

Several structural engineering firms from different regions of the country were contacted for estimates of their engineering fees for wall bracing design. Engineering fees from the survey averaged $1,150 for an analysis, documentation, and drawings based on the reference homes, which could represent the potential savings. These savings are not quantified in Tables 5 and 6 because of the complexity of braced wall design.

Appendix A-HVAC: HVAC Systems

Report Reference No: HVAC1

2015 IRC Code Sections: M1411.4

Summary of Code Change:

The code change requires that condensate pumps located in uninhabitable spaces, such as attics and crawl spaces, shall be connected to the appliance or equipment served such that when the pump fails, the appliance or equipment will be prevented from operating. Pumps shall be installed in accordance with the manufacturer's instructions.

Summary of Code Change:

A majority of condensate pumps are factory equipped with float switches that are not connected to the appliance[13]. Table HVAC1 summarizes the cost to connect the condensate pump's failure shutoff to the air handler.

Table HVAC1. Cost to Connect Float Switch to HVAC Equipment

Trade	Labor (hrs)	Unit	Cost	w/ O & P	Total ($)
HVAC Contractor	0.5	hrs	36	59	29

RSMeans RCD

[13] From FAQs on Little Giant condensate removal pump. "The Little Giant VCMA-15UL 65 GPH Automatic Condensate Removal Pump Model# 554401 comes with a power cord and a safety switch which has the 2 short wires. They are to be wired to the low voltage of the thermostat and will cause unit to shutoff if pump fails." https://www.acwholesalers.com/Little-Giant-Water-Pumps/554401-VCMA-15UL-65-GPH-Automatic-Condensate-Removal-Pump/32783.ac?gclid=CPrhzP_0g8ACFa_m7AodvQYAew

Report Reference No: HVAC2

2015 IRC Code Sections: N1102.4.4

Summary of Code Change:

The code change requires that combustion appliances that are not direct vented (e.g., furnaces and water heaters) be installed outside of the thermal envelope, or enclosed in a room isolated from the thermal envelope in Climate Zones 3-8. (An exception is made for direct vent combustion appliances with continuous air intake and exhaust pipes.) Entry from conditioned space to the combustion equipment room shall be via an air sealed door and the walls, floors, and ceilings of the sealed room, shall be insulated to the minimum R-value required for basement walls in the same climate zone.

Cost Implication of the Code Change:

Two approaches were used in calculating the cost of this code change. One approach looked at providing a finished, insulated enclosure for the equipment, made airtight and separated from the conditioned space of the house with a door with gasket and floor sweep. Houses with basement foundations would typically have both pieces of equipment located in the enclosed equipment room in the basement. Combustion make up air would be supplied from an outside vent. Table HVAC2 summarizes these costs for the reference houses built on basement foundations.

For the reference houses with slab foundations, the furnace is assumed to be located in the attic and the water heater is located in the garage; both of which are outside of the thermal envelope. For this case the plenum, distribution duct, and hot water lines in the attic or garage would require insulation. Table HVAC2-A summarizes these costs.

Table HVAC2-A. Cost to Seal Equipment Room

Component		slab on grade		basement	
	Unit Cost ($)	1 story	2 story	1 story	2 story
Insulated Wall - LNF	11			217	217
Insulated Ceiling - Sq. Ft.	3			135	135
Interior Prehung 3068 Door	208			208	208
Cost to Gasket/Seal Door	80			80	80
Duct Combustion Air to Closet	105	105	105	105	105
Duct Insulation at Plenum	3	85	85	84	84
Pipe Insulation at Hot Water Supply - LNF	5	24	24	49	49
Added Cost ($)		214	214	878	878

RSMeans RCD

Tables HVAC2-B and HVAC2-C show the cost associated with upgrading atmospheric vent equipment to direct vent equipment, to avoid construction of a special room or adding insulation to pipes and ducts.

Table HVAC2-B. Cost for Direct Vent Furnace

Component	Cost ($)
Atmospheric Gas Furnace	(1,404)
Direct Vent Furnace	2,103
B-Vent	(615)
PVC Direct Vent	415
Added Cost for Direct Vent Furnace ($)	499

Table HVAC2-C. Cost for Direct Vent Water Heater

Component	Cost ($)
Atmospheric Gas 50 gal Water Heaters	(601)
Direct Vent Gas 50 gal Water Heater	1,184
B-Vent	(615)
PVC Direct Vent	415
Added Cost for Direct Vent Water Heater($)	384

Note that for houses with basements, the cost to build the isolation room comes within $5 of the cost to upgrade the equipment ($878 vs $883), and in cases where a direct vent furnace is standard, it would cost less to upgrade the water heater from draft to direct vent than to seal the equipment room. Direct vent appliances would also save the $179 estimated cost of CAZ testing (referenced at AA1 in this Appendix).

Report Reference No: HVAC3

2015 IRC Code Sections: N1503.4

Summary of Code Change:

The code change added some explanatory language to allow that make up air that is required for kitchen exhaust fans rated in excess of 400 cfm can be supplied by either a gravity or electrically operated damper to preclude the previous interpretation that the damper was to be "automatically controlled" versus "automatically opened."

Cost Implication of the Code Change:

In jurisdictions where the code was being interpreted to require a motorized damper, this change provides potential cost savings of $150 (RSMeans, RCD 2014). The reference houses were not assumed to have this fan feature. However, the savings are listed in Table 6 to reflect those instances where a high-end kitchen is provided as an option or for marketability, or where range hoods rated for less than 400 cfm are not commonly available.

Report Reference No: HVAC4

2015 IRC Code Sections: N1103.5.1, N1103.5.1.1, N1103.5.1.2, P2905.1

Summary of Code Change:

This code change points readers accustomed to using the Plumbing chapter(s) of the IRC, only, to the Energy Efficiency chapter if hot water circulation and heat trace systems are installed.

Section N1103.5 Service hot water systems, is pointed to (from P2905) and expanded by this code change. Certain pumps and controls are required of circulation systems, heat trace systems, or demand recirculation systems.

Cost Implication of the Code Change:

The reference houses' cost would be unaffected by this option. For those that utilize a demand recirculating pump, Table HVAC4 is an estimate of the cost to install the system.

Table HVAC4. Cost of a Demand Circulation Pump

Component	Material	Labor[B]	Cost w/O&P[B]
Recirculating pump[A]	200.34	57.00	421
Sensor Valve Kit[A]	52.97	19.00	118
Electrical Connection		17.88	29
Total ($)			568

[A]Homedepot.com

[B]RSMeans RCD

Appendix A-LOC: Location

Report Reference No: LOC1

2015 IRC Code Sections: N1101.8, N1101.13.1

Summary of Code Change:

The code created a Tropical Climate Zone. It was created for houses located on islands between the Tropic of Cancer and the Tropic of Capricorn that have no heating system; limited air conditioning; use the trade winds, windows, and ceiling fans for ventilation and temperature regulation. The code allows reduced requirements for the thermal envelope.

Additional provisions of the code include:

1. *Not more than one-half of the occupied space is air conditioned.*
2. *The occupied space is not heated.*
3. *Solar, wind or other renewable energy source supplies not less than 80 percent of the energy for service water heating.*
4. *Glazing in conditioned space has a solar heat gain coefficient of less than or equal to 0.40, or has an overhang with a projection factor equal to or greater than 0.30.*
5. *Permanently installed lighting is in accordance with Section N1104 (75% fixtures or lamps are high efficacy).*
6. *The exterior roof surface complies with one of the options in Table C402.2.1.1 of the International Energy Conservation Code, or the roof/ceiling has insulation with an R-value of R-15 or greater. If present, attics above the insulation are vented and attics below the insulation are unvented.*
7. *Roof surfaces have a minimum slope of 1/4 inch (6.4 mm) per foot of run. The finished roof does not have water accumulation areas.*
8. *Operable fenestration provides ventilation area equal to not less than 14 percent of the floor area in each room. Alternatively, equivalent ventilation is provided by a ventilation fan.*
9. *Bedrooms with exterior walls facing two different directions have operable fenestration or exterior walls facing two directions.*
10. *Interior doors to bedrooms are capable of being secured in the open position.*
11. *A ceiling fan or ceiling fan rough-in is provided for bedrooms and the largest space that is not used as a bedroom.*[14]

Cost Implication of the Code Change:

The code change was applied to one of the reference houses – the one-story on slab foundation. The house was assumed to have no wall insulation. Attic insulation was foregone and replaced with a radiant barrier on the underside of the roof sheathing. Because Hawaii has a temperate climate ranging between 65-88°F[15], no HVAC system was attributed to the house. An open loop solar thermal water

[14] International Code Council, 2014. *IECC 2015, Section NN1101.13.1 (R401.2.1) Tropical zone*. p.455 http://shop.iccsafe.org/2015-international-energy-conservation-coder-1.html

[15] http://www.weather.com/weather/wxclimatology/monthly/graph/USHI0026

heater was assumed to be installed to comply with the 80% renewable energy requirement of this code provision. The roof surface does not require any special reflective qualities because the building is not air conditioned with equipment. Overall, fenestration in the reference house accounts for 14% (rounded up) of floor area; room by room counts were not calculated to assure compliance, but the ventilation requirement was assumed to have been satisfied with windows. Ceiling fans were added to bedrooms and the family room. Given these assumptions, this code change provides a savings to the cost of the reference house as shown in Table LOC1.

Table LOC1. Savings Associated With Tropical Climate Zone Code Change

Features	Quantity	Cost Per	Total
Sq. Ft. of Exterior Wall Insulation, R-13	2052	1.03	(2,114)
Sq. Ft. of Attic, R-30 blown insulation	2212	1.23	(2,721)
Radiant Barrier (integral with roof sheathing)[1]	2212	0.10	212
Central Air Conditioning & Ductwork (Remove)	1	5,706.00	(5,706)
Open Loop Solar Thermal Water Heat System[2]	1	5,000.00	5,000
Ceiling Fans	5	264.00	1,320
Total			(4,008)

[1]HomeDepot.com

[2]American Solar Energy Society median price with credit for $500.

http://www.ases.org/solar-home-basics/solar-water-heating/

Report Reference No: LOC2

2015 IRC Code Sections: N1101.13, N1106.1-N1106.7.3

Summary of Code Change:

The code change gives an alternative performance compliance method. The Energy Rating Index (ERI) compliance alternative stipulates a mandatory percentage of energy savings. The base design for comparison is the same home built to the 2006 International Energy Conservation Code (IECC) prescriptive requirements, however, the reference house must also include the prescriptive envelope requirements from the 2009 IRC. The ERI for Climate Zones 1-8 ranges from 51-55%, i.e., energy savings of almost 50% over the prescriptive 2006 design.

Cost Implication of the Code Change:

This is an alternative method, thus the cost of complying with this option does not affect the reference houses. Figure LOC2-A summarizes the results of a study showing the cost impact of achieving performance 50% above 2006 IECC (which percentage can be used to approximate the ERI indexes required in the 2015 IRC).

Table LOC2-A. Incremental Cost for 50% Energy Efficiency Savings above the 2006 IECC[16]

Climate Zone/City	Construction Cost w/Standard Equipment	Construction Cost w/High Efficiency Equipment
1 Miami	$4,974	$4,669
2 Phoenix	$7,540	$5,491
3 Memphis	$8,660	$5,569
4 Baltimore	$23,349	$8,572
5 Chicago	$18,978	$7,119
6 Helena	$18,981	$12,766
7 Duluth	$18,500	$12,327
8 Fairbanks	$18,500	$12,327
Weighted Average	$14,681	$7,031

Note: Base reference point is 2006 IECC.

The costs in Table LOC2-A are shown relative to the cost of the 2006 IECC, rather than the 2012 IECC as this analysis requires. Figure LOC2-B graphs the energy savings attributed to each revision of the IECC and indicates that an approximate 38% energy savings occurs between the 2006 to 2012 IECC versions. And, while expenditures for energy efficiency do not necessarily have a linear relationship with savings, for the sake of arriving at estimated cost associated with this new method, Table LOC2-C indicates the 12% of Table LOC2-A cost that may be attributed to this new method. Note that cost development of the other two performance methods contained in the 2015 IECC is beyond the scope of this analysis, thus Table LOC2-C may not represent the least cost approach to 2015 IECC compliance.

[16] Home Innovation Research Labs, 2013. *Cost-Optimized 50% IECC Prescriptive Analysis*. www.homeinnovation.com/trends_and_reports/featured_reports/cost_optimized_50_percent_iecc_prescriptive_analysis

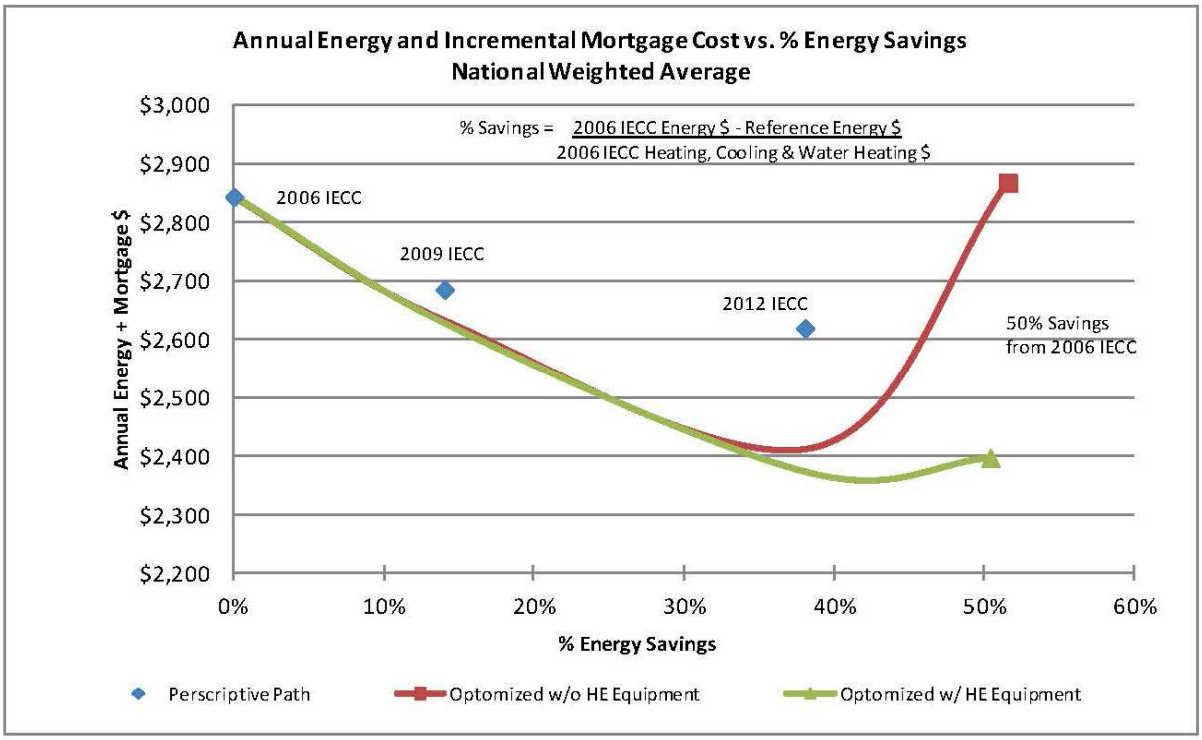


Figure LOC2-B. Energy Savings Attributable to Code Versions[17]

Table LOC2-C. Estimated Additional Cost of ERI Method (2012 IECC to 2015 IECC)

Climate Zone/City	Construction Cost w/Standard Equipment	Construction Cost w/High Efficiency Equipment
1 Miami	$1,194	$1,121
2 Phoenix	$1,810	$1,318
3 Memphis	$2,078	$1,337
4 Baltimore	$5,604	$2,057
5 Chicago	$4,555	$1,709
6 Helena	$4,555	$3,064
7 Duluth	$4,440	$2,958
8 Fairbanks	$4,440	$2,958
Weighted Average	$3,523	$1,687

[17] Home Innovation Research Labs, 2013. *Cost-Optimized 50% IECC Prescriptive Analysis*.
www.homeinnovation.com/trends_and_reports/featured_reports/cost_optimized_50_percent_iecc_prescriptive_analysis

Report Reference No: LOC3

2015 IRC Code Sections: R703.3.1, Table 703.3.1(1)

Summary of Code Change:

The code change defines building height limits for use with Table R703.3(1) (cladding attachment and thickness) based on design wind speed and building height and exposure category as shown in new Table R703.5.

Cost Implication of the Code Change:

Homes built in open terrain and near large bodies of water (exposure categories C & D) and where the design wind speed is 115 mph or above are limited to heights of 15 to 30 ft in order to use the cladding fastening schedules in Table R703.3(1). Otherwise, either an alternative cladding could be selected (i.e., stucco) or an engineered fastening schedule devised. The cost of an engineered fastening approach is estimated at $0-$450 based on whether a fastener or cladding manufacturer provides the solution or an engineer is hired for $150/hour.

Appendix A-MAT: Materials

Report Reference No: MAT1

2015 IRC Code Sections: N1103.2.2, M1601.4.1

Summary of Code Change:

The code change no longer exempts snap-lock and button-lock type seams from mandatory air sealing (but still exempts longitudinal duct sealing for ducts having a static pressure classification of less than 2 in. of water column at 500 Pa and continuously welded joints and seams and locking-type joints and seams of other than the snap-lock and button-lock types). Snap-lock horizontal joints are typical of residentially-used metal ducting.

Cost Implication of the Code Change:

The cost implication of sealing horizontal joints in snap lock metal ducting vary with the HVAC layout and labor costs. The reference houses have been assumed to have a main trunk servicing each story. Branch ducts from the main trunks are assumed to be metal (and snap-lock) when located in first and second floor framing and insulated flexible ducting in attics. Table MAT1 indicates the costs associated with the added sealing of horizontal seams for the reference houses. The sealant is estimated as mastic applied with a brush.

Table MAT1. Cost to Seal Snap Lock Metal Ducting

	1-Story Slab	2-Story Slab	1-Story IG Bsmt.	2-Story IG Bsmt.
LF 6" Branch - flexible (no seams)	216	180		
LF trunk line (2)	144	168	128	128
LF Vertical supply seams (2)	14	25	14	20
LF Return seams (2)	28	50	28	40
LF 6" Branch seams - metal (1)		144	248	378
Subtotal, LF seams to duct seal	186	387	418	566
Cost to duct seal per LF[1]	0.56	0.56	0.56	0.56
Total Cost	103	215	232	314

[1]RSMeans RCD Sheet Metal Apprentice applying one gallon of mastic/hr. (125 lf/hr.)

Report Reference No: MAT2

2015 IRC Code Sections: M1506.1-3, Table 1506.2

Summary of Code Change:

The code change established a new Table M1506.2 in the IRC with the maximum duct length based on the duct diameter and type. The purpose of the change is to assure that the fan reaches its intended flow rate.

Cost Implication of the Code Change:

In accordance with the new IRC table, the air movement per length of smooth-wall duct versus flex duct is nearly 50% more cubic feet per minute (CFM). Builders servicing 50 CFM bath fans and 100 CFM kitchen fans with flexible duct will be required to either minimize the length of the flexible ducting's run to the outside, buy a more powerful fan, or switch to smooth duct. There is no cost implication for the bath fans in the reference house as each of these is located within 56 ft of an exterior wall, which is the maximum length for the minimum flexible duct size (4 in.) servicing a 50 CFM fan. The kitchen fans, on the other hand, would require flexible ducting with a minimum diameter of 5 in.; assuming the longest run, Table MAT2 indicates the cost differential between 4 in. and 5 in. flexible ducting at the lengths required by each design. Other unit costs have been included in the table to assist in the cost calculation for alternatives.

Table MAT2. Cost Difference of Kitchen Fan Ducting ($)

Components	Size	Cost Each/Lnf (Installed)	LF	1-Story Slab	LF	2-Story Slab	LF	1-Story IG Bsmt.	LF	2-Story IG Bsmt.
Flexible Duct	4"	5.40								
Flexible Duct	5"	5.75	18	6.30	6	2.10	20	7.00	6	2.10
Flexible Duct	6"	6.55								
Smooth Duct	4"	4.09								
Smooth Duct	5"	5.41								
Smooth Duct	6"	6.03								
Bath fan	50 CFM	114.00								
Bath fan	80 CFM	138.00								
Bath fan	100 CFM	154.00								
Kitchen fan	100 CFM	100.00								
Kitchen fan	150 CFM	151.00								
Kitchen fan	200 CFM	242.00								

RSMeans, RCD 2014

Home Depot.com

Report Reference No: MAT3

2015 IRC Code Sections: R316.5.11

Summary of Code Change:

The code change allows the application of spray/rigid foam in sill plates, headers, and perimeter joist spaces without a thermal barrier if it meets specific thickness (up to 3-1/4 in.), density, flame spread index, and smoke development index criteria.

Cost Implication of the Code Change:

The code change may broaden the use of foams that comply. There may be a cost savings to builders using foams in unfinished basements, crawlspaces, and attics that will be able to eliminate the thermal barrier if they use foam plastics that comply with the specifications, however the maximum thickness in the code limits the ability of foam to be able to meet the wall thermal requirement by itself in all Climate Zones. (Rigid and spray foams range from R-3.8 to R-6 per inch. At the high end of the thermal resistance range, a 3 1/14 in. depth of material is equal to R-19 to R-20 which will satisfy the code for wall insulation up to Climate Zone 5, only.) Table MAT3 contains an estimation of the possible cost savings in homes with basements where the insulation is used as wall insulation.

Table MAT3. Cost Savings When Spray Polyurethane Foam without a Fire Rating is Applied to Exposed Bandboards

	Basement Houses	
Quantities and Costs	**1-story**	**2-story**
LF and Sq. Ft. of 1st floor bandboard (exposed to basement); 12" deep	204	185
Cost to install 1"x1 Sq. Ft. SPF (R-6)	0.89	
Cost to install 1"x1 Sq. Ft. SPF (R-6), fire resistance rated	1.28	
Difference in Cost from Fire rated to Non-rated SPF	(0.39)	
Savings Zone 1 & 2, (2.2")	($176)	($159)
Savings Zones 3-5 (3.25")	($260)	($235)

Report Reference No: MAT4

2015 IRC Code Sections: R507.2.4, Fig R507.2.3(2)

Summary of Code Change:

This code change allows an alternative to the deck joist tension ties required at each end of the deck for resisting lateral loads. The alternative utilizes an angle connector at four locations.

Cost Implication of the Code Change:

Two prescriptive methods of using hardware to resist lateral loads on an exterior deck have been detailed in Table MAT4. The difference between the two methods, $42, is the savings that may be realized by employing Method 2, which was introduced with this code change.

Table MAT4. Two Methods for Detailing Exterior Decks for Lateral Loads

Hardware	Quantity	Each	Estimated Labor[B]	Cost w/O&P	Method 1 - Deck Tension Tie	Method 2 - Angle Brackets
Simpson Model #DTT2Z-R2 Deck Tension Tie (2-pack with screws)[A]	2	16.71	16.05	55	110	
Simpson RFB#4X5HDG 1/2" Threaded Rod[A]	2	3.24	incl. above	5	11	
Simpson Model # A33 A Angle[A]	4	2.72	8.03	18		72
Simpson SD Connectors (box 100)	0.34	12.69		21		7
Total Cost by Method ($)					121	79

[A]HomeDepot.com

[B]RSMeans RCD 2014

Report Reference No: MAT5 and MAT6

IRC submission no. RB369-13
2015 IRC Code Sections: R703.6.1, Table R703.6.3 (1-2), Table R703.6.1, R703.6.3, R905.7.5, Table905.7.5(2), R905.8.6

Summary of Code Change:

The code change modifies cedar shake wall and roof installation, fastener type, and fastener spacing requirements, as requested by a representative of the industry to minimize failures seen on wood shake roofs. Additionally, where shakes or shingles are installed over a non-permeable WRB, [vertical] furring strips shall be installed before the shakes or shingles.

Cost Implication of the Code Change:

The reference houses in the study were deemed not to have this cladding or roofing option. Per this code change, effective shingle exposure, or cedar shake overlapping requirement, was reduced by an average of 7% of surface area, fastener penetration into sheathing was increased by 50% (to 3/4 in.), and fastener specifications were modified to require galvanized or stainless steel fasteners. Overall, a 7% increase in cost (based on the 7% reduction in coverage) is a reasonable assumption if using cedar shake wall or roof cladding.

Appendix A-METH: Method

Report Reference No: METH1

2015 IRC Code Sections: N1103.3.4

Summary of Code Change:

The code change defines the duct leakage measurement method and changes the duct leakage testing requirement from Mandatory to Prescriptive. The distinction allows builders pursuing energy efficiency (EE) compliance by other methods to trade off a ductwork level of air tightness for other efficiencies.

As with the previous code version, where ducts and equipment are completely within conditioned space, testing is not required.

Duct testing remains required under this amendment, however, where EE compliance is via a method other than the prescriptive approach, no leakage specific metric needs to be met.

Where a duct leakage test metric is required, the maximum duct leakage metric that was established (RE112-13) is 4 cfm per 100 square feet leakage to outdoors and total.

Cost Implication of the Code Change:

Because the specifications for performance under this test did not change, merely its applicability, there should be no additional cost for compliance. The effect of the savings attributable to this trade off was not calculated due to the numerous possible alternatives.

Once again, this code change is applicable to one of four EE compliance approaches – specifically, the performance approach has been freed from the constraint of a duct leakage metric.

Report Reference No: METH2 and METH3

2015 IRC Code Sections: N1105.4.2, N1105.4.2.1, N1105.4.2.2

Summary of Code Change:

This code change refines energy efficiency (EE) reporting requirements for performance method code compliance to include submission of energy analysis report(s) with the building permit application and resubmission of an "as built" analysis at completion.

The change defines the [permit] submission requirements for building permit application and adds submission requirements for occupancy permit application. The following requirements have been added:

For permit application (METH 2):

- A statement that the proposed design complies with N1105 (IRC); and
- A site specific energy analysis report.

For occupancy permit application (METH 3):

- Building street address, or other building site identification;
- A statement indicating that the as-built building complies with Section N1105;
- A certificate indicating that the building passes the performance matrix for code compliance and the energy saving features of the buildings;
- A site-specific energy analysis report that is in compliance with Section N1105;
- Name of the individual performing the analysis and generating the report; and
- Name and version of the compliance software tool.

Batch samplings are prohibited.

Cost Implication of Code Change:

The performance method of energy efficiency compliance is one of three approaches that can be selected, but because of the popularity of the approach, an estimate of the additional cost was included. The code provision does not require that an independent third party perform the EE analysis. The cost estimate, Table METH2-3, supposes that a staff member completes the analysis. If the EE were performed by a third party, then an 18% markup for overhead and profit (O&P) could be added.

Table METH2-3. Estimated Costs for Submission of Energy Efficiency Analysis with Permit and Use and Occupancy Applications with the Performance Method of EE Compliance

Professional Designation	Report Reference	Hours	Burdened Wages ($/hr.)[A]	Total ($)
Energy Auditor perform analysis	METH2	2	44	88
Energy Auditor simulate as built	METH3	1	44	44

[A]Bureau of Labor Statistics; annual mean salary burdened 35%.

Appendix A-PL: Plumbing Systems

Report Reference No: PL1

2015 IRC Code Sections: Table P2903.1

Summary of Code Change:

The code change amends minimum fixture flow rates to align with green building and water efficiency specifications. The code change adds an option to use a combination thermostatic/balanced pressure mixing valve at showers and tubs.

Cost Implication of the Code Change:

Table PL1-A shows the text changes to the existing Table in the code. Deleted references are crossed through and new language is in red and underlined. Costs were developed based on a web search for complying fixtures and a minimum average of three was used to compile the costs estimated in Table PL1-B.

Table PL1-A: Altered Code

TABLE P2903.1		
REQUIRED CAPACITIES AT POINT OF OUTLET DISCHARGE		
FIXTURE SUPPLY OUTLET SERVING	FLOW RATE (gpm)	FLOW PRESSURE (psi)
Bathtub, ~~pressure balanced~~ balanced-pressure ~~or~~, thermostatic or combination balanced-pressure/thermostatic mixing valve	4	20
Bidet, thermostatic mixing valve	2	20
Dishwasher	2.75	8
Laundry ~~tub~~ tray	4	8
Lavatory	~~2~~ 0.8	8
Shower, ~~pressure balanced~~ balanced-pressure ~~or~~, thermostatic or combination balanced-pressure/thermostatic mixing valve	~~3~~ 2.5	20
Sillcock, hose bibb	5	8
Sink	~~2.5~~ 1.75	8
Water closet, flushometer tank	1.6	20
Water closet, tank, close coupled	3	20
Water closet, tank, one piece	6	20

Table PL1-B: Cost Comparison of Fixtures

Fixture	Cost ($)	
	2012	2015
Lavatory	135	145
Shower, ~~pressure balanced~~ balanced-pressure ~~or~~, thermostatic or combination balanced-pressure/thermostatic mixing valve	N/A	N/A
Sink	119	105

Report Reference No: PL2

2015 IRC Code Sections: N1103.5.3

Summary of Code Change:

The requirement for interior hot water pipe insulation for pipes located within conditioned space is simplified by eliminating Table R403.4.2 (N1103.4.2) and requiring R-3 insulation on interior hot water supply pipes of 3/4 in. diameter and greater (along with sub-slab, unconditioned crawl space, etc. locations). The amendment exempts 3/8 and 1/2 in. piping from previously-required insulation (based on the length of the pipe run).

Cost Implication of the Code Change:

The four reference homes depicted in appendices C-F were used to estimate the total length of hot water pipe in the houses (Table PL2-A). The material and labor costs per linear foot are shown in Table PL2-B. Using these tables for quantity and cost per linear foot reference, Tables PL2-C and PL2-D were developed to estimate the cost to insulate these pipes under each code and the resultant savings is tallied in PL2-D.

Table PL2-A: Estimated Pipe

	Slab on Grade		Basement	
	1 Story	2 Story	1 Story	2 Story
Pipe Diam.	Linear Feet			
3/4"	25	15	20	35
1/2"	30	70	60	95

Table PL2-B: Cost Data for Pipe Insulation

Pipe Diam.	Material	Labor	Cost	w/ O&P
3/4"	1.04	2.21	3.25	4.89
1/2"	0.97	2.11	3.08	4.65

Table PL2-C: Cost to Insulate Pipe – 2012 IRC

2012 Code	Slab on Grade		Basement	
	1 Story	2 Story	1 Story	2 Story
Pipe Diam.	Cost ($)			
3/4"	122	73	98	171
1/2"	140	326	279	442
total	262	399	377	613

Table PL2-D: Cost to Insulate Pipe – 2015 IRC with Savings over 2012 IRC

2015 Code	Slab on Grade		Basement	
	1 Story	2 Story	1 Story	2 Story
Pipe Diam.	Cost ($)			
3/4"	112	67	90	157
Difference 2012-2015	(149)	(331)	(287)	(456)

Report Reference No: PL3

2015 IRC Code Sections: P3201.2, P3201.2.1, P3201.2.1.(1-4)

Summary of Code Change:

This code change added a requirement for a trap primer device to emergency floor drain traps and traps subject to evaporation. The trap primer device can be a potable water supplied trap seal primer valve, a reclaimed or gray water supplied trap seal primer valve, a waste water supplied trap primer device, or a barrier type trap seal protection device.

Cost Implication of the Code Change:

Table PL3 shows the cost of a trap primer when installed with a new plumbing and waste system in a location within 20 feet of an existing water supply line.

Table PL3. Cost to Install a Floor Drain Trap Primer

Component	Quantity	Cost	Labor[B]	Total w/O&P
Trap Primer[A]	1	59.95	38	160
1/2" CPVC[C]	20	7.66	19	43
Total ($)				203

[A]globalindustries.com

[B]RSMeans RCD

[C]homedepot.com

APPENDIX B:
LOCATION ADJUSTMENT FACTORS

State	City	Cost Adjustment Factor	State	City	Cost Adjustment Factor
Alabama	Birmingham	0.86	Montana	Billings	0.90
Alabama	Mobile	0.81	Nebraska	Omaha	0.90
Alaska	Fairbanks	1.24	Nevada	Las Vegas	1.03
Arizona	Phoenix	0.86	New Hampshire	Portsmouth	0.97
Arizona	Tucson	0.84	New Jersey	Jersey City	1.13
Arkansas	Little Rock	0.8	New Mexico	Alburquerque	0.83
California	Alhambra	1.08	New York	Long Island City	1.33
California	Los Angeles	1.09	New York	Syracuse	0.98
California	Riverside	1.07	North Carolina	Charlotte	0.86
California	Stockton	1.11	North Carolina	Greensboro	0.85
Colorado	Boulder	0.91	North Carolina	Raleigh	0.86
Colorado	Colorado Springs	0.86	North Dakota	Fargo	0.79
Colorado	Denver	0.89	Ohio	Columbus	0.95
Connecticut	New Haven	1.11	Oklahoma	Oklahoma City	0.82
Deleware	Dover	1.01	Oklahoma	Tulsa	0.78
District of Columbia	Washington, D.C.	0.94	Oregon	Bend	1.00
Florida	Fort Meyers	0.86	Pennsylvania	Norristown	1.10
Florida	Miami	0.86	Pennsylvania	State College	0.91
Florida	Orlando	0.87	Rhode Island	Providence	1.10
Florida	Tampa	0.90	South Carolina	Greenville	0.85
Georgia	Atlanta	0.87	Tennessee	Memphis	0.84
Hawaii	Honolulu	1.22	Texas	Austin	0.78
Idaho	Boise	0.88	Texas	Dallas	0.84
Illinois	Carbondale	1.02	Texas	Houston	0.85
Indiana	Indianapolis	0.93	Texas	San Antonio	0.80
Iowa	Des Moines	0.91	Utah	Ogden	0.79
Kansas	Wichita	0.79	Utah	Provo	0.79
Kentucky	Louisville	0.92	Utah	Salt Lake City	0.80
Louisiana	Baton Rouge	0.82	Vermont	Burlington	0.95
Maine	Portland	0.97	Virginia	Fairfax	1.02
Maryland	Baltimore	0.90	Virginia	Winchester	1.01
Michigan	Ann Arbor	1.03	Washington	Tacoma	1.01
Minnesota	St. Paul	1.11	West Virginia	Charleston	0.97
Mississippi	Biloxi	0.80	Wisconsin	La Crosse	0.96
Missouri	Springfield	0.89	Wyoming	Casper	0.75

Source: RSMeans® *Residential Cost Data 2014* .

APPENDIX C:
ONE-STORY HOUSE WITH SLAB FOUNDATION

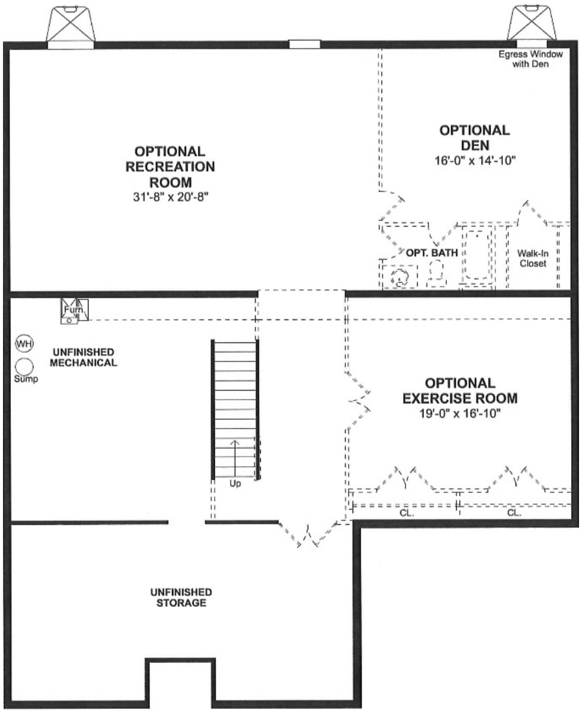
Courtesy: LionsGate Homes at The Creekside

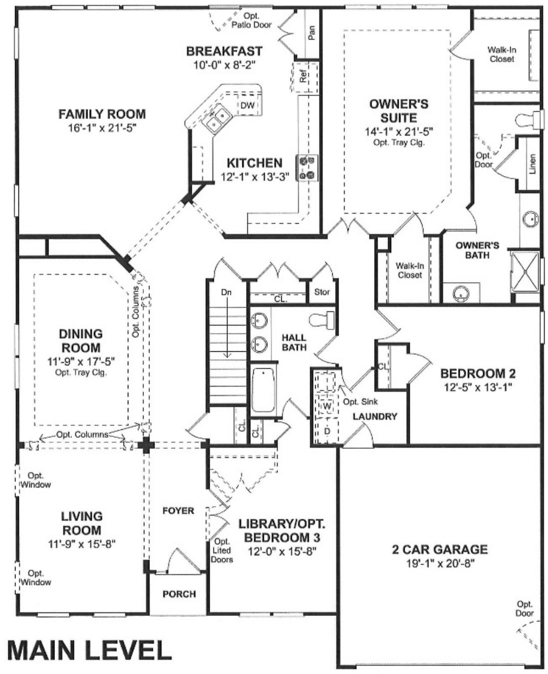
APPENDIX D:
TWO-STORY HOUSE WITH SLAB FOUNDATION

Courtesy: Meritage Homes at Riverstone

APPENDIX E:
ONE-STORY HOUSE WITH BASEMENT FOUNDATION

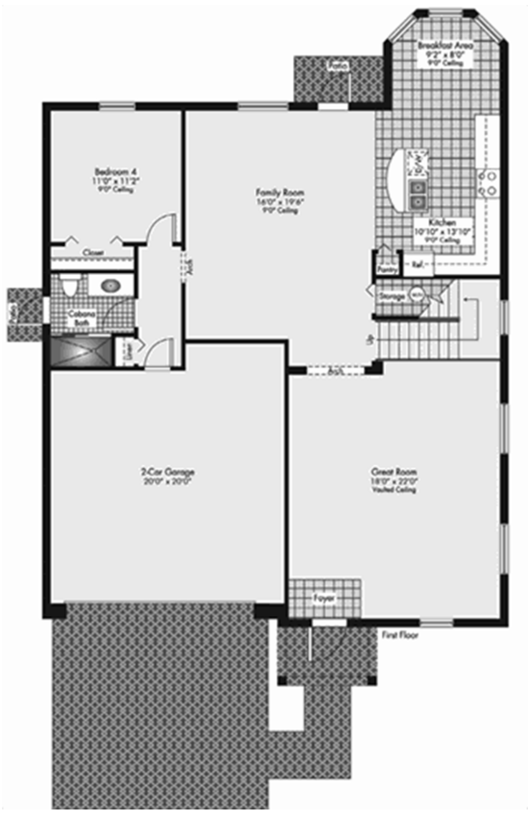
Courtesy: K Hovnanian Four Seasons at New Kent Vineyards

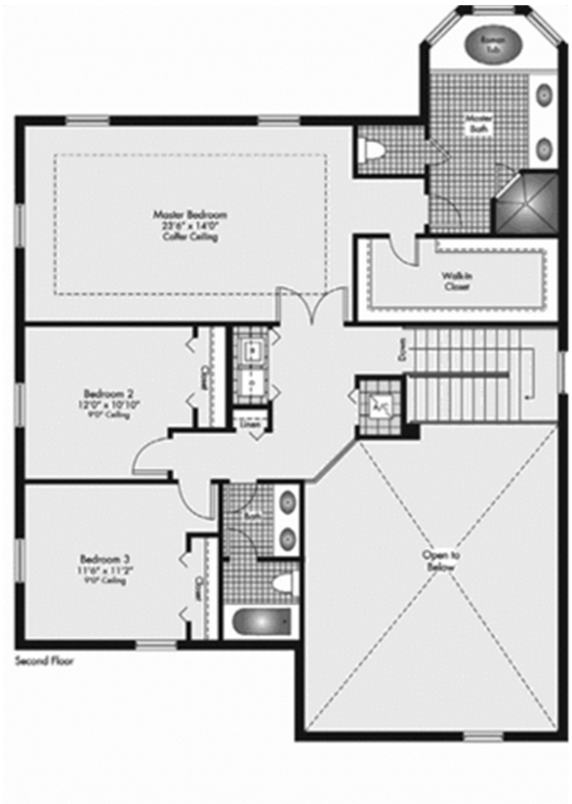




APPENDIX F:
TWO-STORY HOUSE WITH BASEMENT FOUNDATION

Courtesy: Lennar at Sorento Estates





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