Home Innovation
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ESTIMATED COSTS OF THE 2014, 2017, AND 2020 NEC CODE CHANGES FOR SINGLE-FAMILY AND MULTIFAMILY BUILDINGS

Prepared For

National Association of Home Builders

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ACRONYMS, ABBREVIATIONS, AND DEFINITIONS

AFCI	Arc-Fault Circuit Interrupter
EA	Each
GFCI	Ground-Fault Circuit Interrupter
IBC	International Building Code
IRC	International Residential Code
LF	Linear feet
NAHB	National Association of Home Builders
NEC	National Electric Code
O&P	Overhead and profit
SF	Square feet
T.H.	Townhouse

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BACKGROUND

The National Association of Home Builders (NAHB) identified 10 changes in the 2014 and 2017 National Electrical Code[1] (NEC), which were approved for buildings built under the 2015 and 2018 International Residential Code (IRC) and International Building Code (IBC)[2], respectively, and six changes in the 2020 NEC which could have a significant cost impact for builders. Home Innovation Research Labs (Home Innovation) reviewed the code changes and performed a cost analysis on several reference houses and buildings to estimate the expected cost impact.

METHODOLOGY

Baseline metrics were defined for four representative single-family houses, built to the IRC, and four multifamily buildings and one 4-story townhouse, built to the IBC, in order to determine the cost impact of the code changes.

The Reference Houses and their site locations were initially defined in a report titled "Estimated Costs of the 2015 Code Changes" prepared by Home Innovation for NAHB. These single-family houses were selected for their similarity to new home offerings in the six metropolitan areas selected as site locations - Miami, Dallas, Los Angeles, Seattle, New York, and Chicago, and their size proximity to a national average of 2,607 SF. Features of the Reference Houses are summarized in the next section.

The Reference Buildings were initially defined in a report titled "Estimated Costs of the 2018 Code Changes for Multifamily Buildings" prepared by Home Innovation for NAHB (April 2018). The Reference Buildings were adopted from the studies documented in the report. Features of the Reference Buildings are summarized in the next section.

The Reference Houses and Reference Buildings serve as the baselines for the analysis to estimate the cost impact of the 2014, 2017, and 2020 NEC code changes. All buildings are in compliance with the minimum requirements of the 2015 IRC/IBC (for the 2014 NEC changes) and 2018 IRC/IBC (for the 2017 NEC changes).

The cost impacts in this analysis have been developed primarily with data adapted from the following sources: 2019 Residential Cost (for Reference Houses) and Electrical Cost (for Reference Buildings) with RSMeans Data[3]; distributors' or big box retailers' websites. The cost for individual code changes are shown in Appendix A. 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. Appendix A costs are reported as both total to the builder and total to consumer. The total cost to builder includes overhead and profit (designated in the tables as "w/O&P") applied to individual component costs (i.e., materials and labor) to represent the cost charged by the sub-contractor. The total cost to consumer is based on the builder's gross margin, reported as 18.9% of construction cost in the 2016 Cost of Doing Business. The cost summary tables shown in the Results section below show the total cost to consumer only.

[1] NFPA 70, National Electrical Code (NEC), https://www.nfpa.org/NEC

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

[3] RSMeans, https://www.rsmeans.com/

Reference Houses

The features of the Reference Houses are summarized in the table below. Additional details and basis for selection of building criteria are provided in Appendix C. Elevations and floor plans are provided in Appendices E-H.

Table 1. Reference House Features

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
Laundry Room/Closet	Yes	Yes	Yes	Yes

Reference Buildings

The features of the Reference Buildings are summarized in the table below. Additional details and basis for selection of building criteria are provided in Appendix D. Elevations and floor plans are provided in Appendices I-M.

Table 2. Reference Building Features

Reference Building	1	2	3	4	T.H.
Approx. Total Size	19,500 SF	43,150 SF	44,500 SF	462,600 SF	2,500 SF
Number of Stories	2	3	4	5	4
Number of Units	24	36	48 + shared	167	1
Parking	Surface Lot	Surface Lot	Surface Lot	Enclosed public parking garage	Private garage
Laundry	Communal	In unit	In unit	In unit	In unit

RESULTS

Estimated Cost Impact of 2014, 2017, and 2020 NEC Code Compliance

The Tables below summarize the estimated cumulative impact of the selected code changes on the cost of constructing the Reference Houses and Reference Buildings. The costs represent cost to consumers (homeowners or building owners). See Appendix A for details and costs to builders.

Table 3. Estimated Cost Impact of 2014 NEC Code Changes

Description	Code Section	Cost ($)								
		Reference Houses				Reference Buildings				
		1	2	3	4	1	2	3	4	T.H.
GFCI within 6-ft. of kitchen sink	210.8(A)(7)	47	32	32	32	742	1,074	1,342	2,637	16
GFCI within 6-ft. of shower or bathtub	210.8(A)(9)	0	0	32	0	0	568	0	963	16
GFCI for 15- & 20-amp receptacle in laundry	210.8(A)(10)	16	16	16	16	0	568	758	2,637	16
GFCI for 15- & 20-amp receptacles in garages of multifamily buildings	210.8(B)(8)	0	0	0	0	0	0	0	111	0
GFCI for outlets supplying dishwashers in dwelling units	210.8(D)	16	16	16	16	379	568	758	2,637	16
AFCI for branch circuits supplying kitchen and laundry areas	210.12(A)	184	184	184	184	2,951	6,639	5,778	30,796	184
One receptacle for each car parking space that should not supply receptacle outside garage	210.52(G)(1)	172	172	172	172	0	0	0	0	211
One 125V 15- or 20-amp receptacle outlet within 50-ft. of electrical service equipment for multifamily buildings.	210.64	0	0	0	0	401	401	401	801	0
Total		**435**	**420**	**452**	**420**	**4,473**	**9,818**	**9,037**	**40,582**	**459**

Table 4. Estimated Cost Impact of 2017 NEC Code Changes

Description	Code section	Cost ($)								
		Reference Houses				Reference Buildings				
		1	2	3	4	1	2	3	4	T.H.
Measurement for GFCI within 6-ft. of kitchen sink is from the inside edge of sink	210.8(A)(7)	(16)	(16)	(16)	(16)	(395)	(568)	(758)	(2,637)	(16)
One 120V 20-amp branch circuit in garage and it can supply only readily accessible receptacle outside garage	210.11(C)(4)	19	19	19	19	0	0	0	0	19
Total		**3**	**3**	**3**	**3**	**(395)**	**(568)**	**(758)**	**(2,637)**	**3**

Table 5. Estimated Cost Impact of 2020 NEC Code Changes

Description	Code Section	Cost ($)								
		Reference Houses				Reference Buildings				
		1	2	3	4	1	2	3	4	T.H.
GFCI for 250-volt receptacles	210.8(A)	273	273	136	273	3,272	9,817	13,089	45,540	273
GFCI for all basement receptacles	210.8(A)(5)	0	0	63	0	0	0	0	0	0
GFCI for 250-volt outdoor outlets	210.8(F)	136	136	136	136	0	4,368	5,824	20,263	136
Surge Protection for dwellings	230.67	246	246	246	246	5,907	8,860	11,813	41,100	246
Emergency Disconnects for one- and two-family dwellings	230.85	86	86	86	86	0	0	0	0	86
Total		**741**	**741**	**667**	**741**	**9,179**	**23,045**	**30,727**	**106,903**	**741**

APPENDIX A: INCREMENTAL COST FOR EACH CODE CHANGE

Reference Code Section

2014 NEC 210.8(A)(7) Ground-Fault Circuit Interrupter Protection for Personnel, Dwelling Units, Sinks

Summary of the Code Change:

The code change revised this section to require GFCI protection of 125-volt, 15- and 20-ampere receptacles installed within 6 ft. of the outside edge of a sink that are not covered by the kitchen countertop rule in 210.8(A)(6). Previously, kitchen sinks were excluded.

Cost Implication of the Code Change:

This code change may increase the cost of construction. The change is applicable where an outlet for a food waste disposal under the kitchen sink is within 6 ft. of the sink, or where an outlet in a wall space, not already covered by the kitchen countertop rule, is within 6 ft. of the kitchen sink. For example, this change would apply where a receptacle located in a low wall beneath a kitchen counter pass through and facing an adjacent room, as required by 210.52(A)(2) Wall Space, and not covered by the kitchen countertop requirement because the receptacle is located more than 12-in. below the countertop per 210.52(C)(5), is within 6 ft. of the kitchen sink. Reference House 1 has two such receptacles; the other reference houses and some reference buildings each have one. It is also assumed that each dwelling unit has one food waste disposal receptacle outlet within 6 ft. of the kitchen sink.

The analysis is based on a review of the reference houses and reference buildings to evaluate applicability and summarized in the tables below. Costs are based on duplex outlets that are tamper-resistant for all outlets as required by Section 406.4(D)(5) and GFCI outlets that are self-testing as required by their listing.

Component	Unit	Material	Total	w/O&P	Quantity	Cost
GFCI duplex outlet, 15- or 20-amp	EA	13.34	13.34	14.67	1	14.67
Standard duplex outlet, 15-amp	EA	1.06	1.06	1.17	(1)	(1.17)
Standard duplex outlet wall plate	EA	0.20	0.20	0.22	(1)	(0.22)
Total to Builder						**13.28**
Total to Consumer						**15.79**

Reference Houses	GFCI protection for receptacle outlets			
	Unit	Unit Cost	Quantity	Cost
Reference House 1	EA	15.79	3	47.37
Reference House 2	EA	15.79	2	31.58
Reference House 3	EA	15.79	2	31.58
Reference House 4	EA	15.79	2	31.58

Reference Buildings	GFCI protection for receptacle outlets			
	Unit	Unit Cost	Quantity	Cost
Reference Building 1	EA	15.79	47	742.13
Reference Building 2	EA	15.79	68	1,073.72
Reference Building 3	EA	15.79	85	1,342.15
Reference Building 4	EA	15.79	167	2,636.93
Reference Townhouse	EA	15.79	1	15.79

Reference Code Section

2014 NEC 210.8(A)(9) Ground-Fault Circuit Interrupter Protection for Personnel, Dwelling Units, Bathtubs or shower stalls

Summary of the Code Change:

The code change is a new requirement for GFCI protection of 125-volt, 15- and 20-ampere receptacles installed within 6 ft. of the outside edge of a bathtub or shower stall.

Cost Implication of the Code Change:

This code change may increase the cost of construction. This change is applicable to receptacle outlets located in the wall of the master bedroom or hallway outside of the bathroom that are within 6 ft. of the edge of the shower or bathtub when measured through the door. The receptacles inside the bathroom were already required to be GFCI protected in the previous codes. The analysis is based on an estimate of the number of applicable outlets that now require GFCI protection. For Reference House 3, there are 2 receptacles in the master bedroom that are within 6 ft. of the edge of the bathtub. Similarly, there were several receptacle outlets within 6 ft. of the bathtub or shower for Reference Buildings 2 and 4 and the Reference Townhouse.

Component	Unit	Material	Total	w/O&P	Quantity	Cost
GFCI duplex outlet, 15- or 20-amp	EA	13.34	13.34	14.67	1	14.67
Standard duplex outlet, 15-amp	EA	1.06	1.06	1.17	(1)	(1.17)
Standard duplex outlet wall plate	EA	0.20	0.20	0.22	(1)	(0.22)
Total to Builder						**13.28**
Total to Consumer						**15.79**

Reference Houses	GFCI protection for receptacle outlets			
	Unit	Unit Cost	Quantity	Cost
Reference House 3	EA	15.79	2	31.58

Reference Buildings	GFCI protection for receptacle outlets			
	Unit	Unit Cost	Quantity	Cost
Reference Building 2	EA	15.79	36	568.44
Reference Building 4	EA	15.79	61	963.19
Reference Townhouse	EA	15.79	1	15.79

Reference Code Section

2014 NEC 210.8(A)(10) Ground-Fault Circuit Interrupter, Dwelling Units, Laundry areas

Summary of the Code Change:

The code change is a new requirement for GFCI protection of 125-volt, 15- and 20-ampere receptacles installed in laundry areas.

Cost Implication of the Code Change:

This code change will increase the cost of construction as it will require GFCI protected receptacle outlet instead of standard outlet for dwelling units with laundry areas. This change applies to dwelling units and therefore does not apply to common laundry areas in multifamily buildings. One receptacle per dwelling unit is assumed for all Reference Houses, Reference Buildings 2 and 4, and the Reference Townhouse.

Component	Unit	Material	Total	w/O&P	Quantity	Cost
GFCI duplex outlet, 15- or 20-amp	EA	13.34	13.34	14.67	1	14.67
Standard duplex outlet, 15-amp	EA	1.06	1.06	1.17	(1)	(1.17)
Standard duplex outlet wall plate	EA	0.20	0.20	0.22	(1)	(0.22)
Total to Builder						**13.28**
Total to Consumer						**15.79**

Reference Houses	GFCI protection for receptacle outlets			
	Unit	Unit Cost	Quantity	Cost
Reference House 1	EA	15.79	1	15.79
Reference House 2	EA	15.79	1	15.79
Reference House 3	EA	15.79	1	15.79
Reference House 4	EA	15.79	1	15.79

Reference Buildings	GFCI protection for receptacle outlets			
	Unit	Unit Cost	Quantity	Cost
Reference Building 2	EA	15.79	36	568.44
Reference Building 3	EA	15.79	48	757.92
Reference Building 4	EA	15.79	167	2,636.93
Reference Townhouse	EA	15.79	1	15.79

Reference Code Section

2014 NEC 210.8(B)(8) Ground-Fault Circuit Interrupter, Other Than Dwelling Units, Garages, service bays and similar areas other than vehicle exhibition halls and showrooms.

Summary of the Code Change:

The code change is a new requirement for GFCI protection of 125-volt, 15- and 20-ampere receptacles installed in garages, service bays and similar areas located at other than dwelling units. The requirement does not apply to receptacles installed in showroom or exhibition areas.

Cost Implication of the Code Change:

This code change will increase the cost of construction for buildings with garage. This code change is applicable to garages, service bays and similar areas in multi-family residential homes. This code change is only applicable to Reference Building 4 which is the only multi-family building with garage. Receptacle outlets are required to be GFCI protected.

Component	Unit	Material	Total	w/O&P	Quantity	Cost
GFCI duplex outlet, 15-amp or 20-amp	EA	13.34	13.34	14.67	1	14.67
Standard duplex outlet, 15-amp	EA	1.06	1.06	1.17	(1)	(1.17)
Standard duplex outlet wall plate	EA	0.20	0.20	0.22	(1)	(0.22)
Total to Builder						**13.28**
Total to Consumer						**15.79**

Reference Buildings	GFCI protection for receptacle outlets			
	Unit	Unit Cost	Quantity	Cost
Reference Building 4	EA	15.79	7	110.53

Reference Code Section

2014 NEC 210.8(D) Ground-Fault Circuit Interrupter, Kitchen Dishwasher Branch Circuit

Summary of the Code Change:

The code change is a new requirement for GFCI protection of outlets that supply dishwashers installed in dwelling areas.

Cost Implication of the Code Change:

This code change will increase the cost of construction with the new requirement of GFCI protection for outlets supplying dishwashers. It is assumed that each dwelling unit has one outlet for dishwasher.

Component	Unit	Material	Total	w/O&P	Quantity	Cost
GFCI duplex outlet, 15- or 20-amp	EA	13.34	13.34	14.67	1	14.67
Standard duplex outlet, 15A	EA	1.06	1.06	1.17	(1)	(1.17)
Standard duplex outlet wall plate	EA	0.20	0.20	0.22	(1)	(0.22)
Total to Builder						**13.28**
Total to Consumer						**15.79**

Reference Houses	GFCI protection for receptacle outlets			
	Unit	Unit Cost	Quantity	Cost
Reference House 1	EA	15.79	1	15.79
Reference House 2	EA	15.79	1	15.79
Reference House 3	EA	15.79	1	15.79
Reference House 4	EA	15.79	1	15.79

Reference Buildings	GFCI protection for receptacle outlets			
	Unit	Unit Cost	Quantity	Cost
Reference Building 1	EA	15.79	24	378.96
Reference Building 2	EA	15.79	36	568.44
Reference Building 3	EA	15.79	48	757.92
Reference Building 4	EA	15.79	167	2,636.93
Reference Townhouse	EA	15.79	1	15.79

Reference Code Section

2014 NEC 210.12(A) Arc-Fault Circuit Interrupter, Dwelling Units

Summary of the Code Change:

The code change is a revision to expand the AFCI protection requirement to kitchens and laundry areas, and to specify that AFCI protection is required for branch circuits supplying outlets and devices.

Cost Implication of the Code Change:

This code change will increase the cost of construction with the new requirement of AFCI protection for branch circuits supplying kitchen and laundry areas. Following the minimum code requirement, we will assume that there are 2 branch circuits supplying the kitchen and 1 branch circuit supplying the laundry area. The cost of standard circuit breaker is deducted from the cost of AFCI combination-type circuit breaker.

Component	Unit	Material	w/O&P	Quantity	Cost
AFCI combination-type 20-amp, 1-pole circuit breaker	EA	58.00	63.80	1	63.80
Standard 20-amp, 1-pole Circuit Breaker	EA	11.00	12.10	(1)	(12.10)
Total to builder					**51.70**
Total to Consumer					**61.47**

Reference Houses	AFCI protection for branch outlets			
	Unit	Unit Cost	Quantity	Cost
Reference House 1	EA	61.47	3	184.41
Reference House 2	EA	61.47	3	184.41
Reference House 3	EA	61.47	3	184.41
Reference House 4	EA	61.47	3	184.41

Reference Buildings	AFCI protection for branch outlets			
	Unit	Unit Cost	Quantity	Cost
Reference Building 1	EA	61.47	48	2,950.56
Reference Building 2	EA	61.47	108	6,638.76
Reference Building 3	EA	61.47	94	5,778.18
Reference Building 4	EA	61.47	501	30,796.47
Reference Townhouse	EA	61.47	3	184.41

Reference Code Section

2014 NEC 210.52(G)(1) Dwelling Unit Receptacle Outlets; Basements, Garages, and Accessory Buildings; Garages

Summary of the Code Change:

The code change is a revision to require at least one receptacle outlet for each car parking space in a dwelling unit garage and to restrict the branch circuit supplying garage receptacle outlets from supplying outlets located outside of the garage. This is only applicable to a one-family dwelling.

Cost Implication of the Code Change:

This code change will increase the cost of construction for single-family houses with a garage. The analysis assumes that the branch circuit serving the garage also served outlets outside the garage before the code change, so the cost will include one additional branch circuit dedicated to the garage, plus one additional outlet on this same circuit for the second parking space for the two-car garages of the Reference Houses and Reference Townhouse.

Component for Reference Houses	Unit	Material	Labor	Total	w/O&P	Quantity	Cost
Duplex outlet, 15-amp recep., metal box, plate, Type NM cable	EA	8.70	23.00	31.70	46.50	1	46.50
Wire 14/2 NM	LF	0.18	1.32	1.50	2.36	40	94.40
Circuit Breaker 15-amp, 1-pole	EA	4.10	4.10		4.10	1	4.10
Total to Builder							**145.00**
Total to Consumer							**172.41**

Component for Reference Buildings	Unit	Material	Labor	Total	w/O&P	Quantity	Cost
Duplex outlet, 15-amp recep., metal box, plate, Type NM cable	EA	8.70	33.00	41.70	59.00	1	59.00
Wire 14/2 NM	LF	0.18	1.78	1.96	2.86	40	114.40
Circuit Breaker 15-amp, 1-pole	EA	4.10	4.10		4.10	1	4.10
Total to Builder							**177.50**
Total to Consumer							**211.05**

Reference Houses	Addition of standard outlet and dedicated circuit			
	Unit	Unit Cost	Quantity	Cost
Reference House 1	EA	172.41	1	172.41
Reference House 2	EA	172.41	1	172.41
Reference House 3	EA	172.41	1	172.41
Reference House 4	EA	172.41	1	172.41

Reference Buildings	Addition of standard outlet and dedicated circuit			
	Unit	Unit Cost	Quantity	Cost
Reference Townhouse	EA	211.05	1	211.05

Reference Code Section

2014 NEC 210.64 Electrical Service Areas

Summary of the Code Change:

The code change is a new requirement specifying the installation of at least one 125-volt, 15- or 20-ampere receptacle outlet within 50 feet of electrical service equipment for all buildings other than one- and two- family dwelling units.

Cost Implication of the Code Change:

This code change will increase the cost of construction for multifamily buildings. The analysis is based on installing one additional branch circuit with outlet for each electrical service equipment room or area in a building.

Component	Unit	Material	Labor	Total	w/O&P	Quantity	Cost
Circuit breaker, 15-amp, 1-pole	EA					1	0.00
Conduit, EMT, 1/2-in.	LF	0.80	2.74	3.54	4.96	25	124.00
Wire, #14 THW	LF	0.06	0.36	0.42	0.60	75	45.00
Duplex outlet, 15-amp recep., metal box, plate, EMT & wire	EA	30.50	90.00	120.50	168.00	1	168.00
Total to Builder							**337.00**
Total to Consumer							**400.69**

Reference Buildings	Addition of standard outlet with conduit			
	Unit	Unit Cost	Quantity	Cost
Reference Building 1	EA	400.69	1	400.69
Reference Building 2	EA	400.69	1	400.69
Reference Building 3	EA	400.69	1	400.69
Reference Building 4	EA	400.69	2	801.38

Reference Code Section

2017 NEC 210.8(A)(7) Ground-Fault Circuit Interrupter Protection for Personnel, Dwelling Units, Sinks

Summary of the Code Change:

The code change clarifies how to establish the measurement of receptacles from a sink – the 6 ft. measurement is now made from the top inside edge of the sink bowl instead of the outside edge. Additionally, language was added under the main section 210.8(A) that this distance be measured as the shortest path "without piercing a floor, wall, ceiling, or fixed barrier, or passing through a door, doorway, or window". This change may be interpreted as not requiring a GFCI protected receptacle for a food waste grinder within a cabinet beneath the kitchen sink. Note that GFCI protection is still specifically required for outlets that supply dishwashers installed in dwelling units per 210.8(D).

Cost Implication of the Code Change:

This code change may decrease the cost of construction. The analysis assumes GFCI protection is no longer required for receptacles serving disposals under the sink for all Reference Houses and Buildings.

Component	Unit	Material	Total	w/O&P	Quantity	Cost
GFCI duplex outlet, 15- or 20-amp	EA	13.34	13.34	14.67	1	14.67
Standard duplex outlet, 15A	EA	1.06	1.06	1.17	(1)	(1.17)
Standard duplex outlet wall plate	EA	0.20	0.20	0.22	(1)	(0.22)
Total to Builder						**13.28**
Total to Consumer						**15.79**

Reference Houses	Removal of GFCI protection in receptacle outlet			
	Unit	Unit Cost	Quantity	Cost
Reference House 1	EA	15.79	(1)	(15.79)
Reference House 2	EA	15.79	(1)	(15.79)
Reference House 3	EA	15.79	(1)	(15.79)
Reference House 4	EA	15.79	(1)	(15.79)

Reference Buildings	Removal of GFCI protection in receptacle outlet			
	Unit	Unit Cost	Quantity	Cost
Reference Building 1	EA	15.79	(25)	(394.75)
Reference Building 2	EA	15.79	(36)	(568.44)
Reference Building 3	EA	15.79	(48)	(757.92)
Reference Building 4	EA	15.79	(167)	(2,636.93)
Reference Townhouse	EA	15.79	(1)	(15.79)

Reference Code Section

2017 NEC 210.11(C)(4) Branch Circuits Required, Dwelling Units, Garage Branch Circuits

Summary of the Code Change:

The code change is a new requirement to install at least one 120-volt 20-ampere branch circuit. This applies to attached garages and to detached garages supplied with power. The circuit cannot supply lighting outlets inside or outside of the garage, but an exception permits the circuit to supply readily accessible outdoor receptacle outlets.

Cost Implication of the Code Change:

This code change will increase the cost of construction for the Reference Houses and Reference Townhouse as this code change is only applicable for single-family residential houses. The 15-ampere branch circuit is replaced with a new 20-ampere branch circuit to supply the receptacles in the garage.

Component for Reference Houses	Unit	Material	Labor	Total	w/O&P	Quantity	Cost
Wire, 12/2 NM	LF	0.24	1.51	1.75	2.73	20	54.60
Circuit Breaker, 20-amp, 1-pole	EA	4.10		4.10	4.51	1	4.51
Duplex outlet, 20-amp recep., metal box, plate, Type NM cable	EA	9.85	27.00	36.85	55.00	1	55.00
Wire, 14/2 NM	LF	0.18	1.32	1.50	2.36	(20)	(47.20)
Circuit Breaker, 15-amp, 1-pole	EA	4.10			4.51	(1)	(4.51)
Duplex outlet, 15-amp recep., metal box, plate, Type NM cable	EA	8.70	23.00	31.70	46.50	(1)	(46.50)
Total to Builder							**15.90**
Total to Consumer							**18.91**

Component for Reference Buildings	Unit	Material	Labor	Total	w/O&P	Quantity	Cost
Wire, 12/2 NM	LF	0.24	1.92	2.16	3.15	20	63.00
Circuit Breaker, 20-amp, 1-pole	EA	4.10		4.10	4.51	1	4.51
Duplex outlet, 20-amp recep., metal box, plate, Type NM cable	EA	9.85	39.00	48.85	69.00	1	69.00
Wire, 14/2 NM	LF	0.18	1.78	1.96	2.86	(20)	(57.20)
Circuit Breaker, 15-amp, 1-pole	EA	4.10			4.51	(1)	(4.51)
Duplex outlet, 15-amp recep., metal box, plate, Type NM cable	EA	8.70	33.00	41.70	59.00	(1)	(59.00)
Total to Builder							**15.80**
Total to Consumer							**18.79**

Reference Houses	Replacing 15-amp branch circuit with 20-amp branch circuit			
	Unit	Unit Cost	Quantity	Cost
Reference House 1	EA	18.91	1	18.91
Reference House 2	EA	18.91	1	18.91
Reference House 3	EA	18.91	1	18.91
Reference House 4	EA	18.91	1	18.91

Reference Buildings	Replacing 15-amp branch circuit with 20-amp branch circuit			
	Unit	Unit Cost	Quantity	Cost
Reference Townhouse	EA	18.79	1	18.79

Reference Code Section

2020 NEC 210.8(A) Ground-Fault Circuit Interrupter Protection, Dwelling Units

Summary of the Code Change:

The code change will require receptacles serving 250-volt appliances, such as electric ranges and clothes dryers, to have GFCI protection when located in bathrooms, garages, crawl spaces, basements, laundry areas, or within 6 feet of sinks, bathtubs, or showers. This section previously applied to 125-volt appliances only.

Cost Implication of the Code Change:

This code change will increase the cost of construction for dwellings with electric clothes dryers and dwellings with electric ranges or stoves within 6 feet of the kitchen sink. As the receptacle outlets are typically not readily accessible, the cost analysis is based on substituting a GFCI circuit breaker for a standard circuit breaker for typical appliance ratings: 30-amp for electric dryers; 50-amp for electric ranges. The analysis will assume electric appliances for the Reference Houses and Reference Buildings: a review of the drawings shows all have applicable dryers except Reference Building 1 (common laundry) and all have applicable ranges except Reference House 3 (range is more than 6 feet from the sink).

Component	Unit	Material	Labor	Total	w/O&P	Quantity	Cost
GFCI 30- or 50-amp 2-pole breaker	EA	114.00		114.00	125.40	1	125.40
Standard 30- or 50-amp 2-pole breaker	EA	9.75		9.75	10.73	(1)	(10.73)
Total to Builder							**114.68**
Total to Consumer							**136.35**

Reference Houses	GFCI protection for 250-volt receptacles			
	Unit	Unit Cost	Quantity	Cost
Reference House 1	EA	136.35	2	272.70
Reference House 2	EA	136.35	2	272.70
Reference House 3	EA	136.35	1	136.35
Reference House 4	EA	136.35	2	272.70

Reference Buildings	GFCI protection for 250-volt receptacles			
	Unit	Unit Cost	Quantity	Cost
Reference Building 1 (24 units)	EA	136.35	24	3,272.37
Reference Building 2 (36 units)	EA	136.35	72	9,817.10
Reference Building 3 (48 units)	EA	136.35	96	13,089.46
Reference Building 4 (167 units)	EA	136.35	334	45,540.42
Reference Townhouse	EA	136.35	2	272.70

Reference Code Section

2020 NEC 210.8(A)(5) Ground-Fault Circuit Interrupter Protection, Dwelling Units, Basement Receptacles

Summary of the Code Change:

This code change requires GFCI protection for all receptacles in basements (the exception remains for receptacles supplying only a fire or burglar alarm). This section previously only applied to unfinished portions or areas of basements not intended as habitable rooms.

Cost Implication of the Code Change:

This code change will increase the cost of construction for houses with basements where a basement or portion of a basement is finished. The cost analysis is based on Reference House 3 that shows optional finished rooms in the basement (see Appendix G). These finished areas are estimated to require four independent circuits for wall receptacles with each circuit protected by one GFCI receptacle.

Component	Unit	Material	Total	w/O&P	Quantity	Cost
GFCI duplex outlet, 15- or 20-amp	EA	13.34	13.34	14.67	1	14.67
Standard duplex outlet, 15A	EA	1.06	1.06	1.17	(1)	(1.17)
Standard duplex outlet wall plate	EA	0.20	0.20	0.22	(1)	(0.22)
Total to Builder						**13.28**
Total to Consumer						**15.79**

Reference Houses	GFCI protection for basement receptacles			
	Unit	Unit Cost	Quantity	Cost
Reference House 3	EA	15.79	4	63.16

Reference Code Section

2020 NEC 210.8(F) Ground-Fault Circuit Interrupter Protection, Outdoor Outlets for Dwellings

Summary of the Code Change:

This new code section requires GFCI protection for outdoor outlets, single-phase, up to 250-volts and 50-amps, other than those covered in 210.8(A)3 outdoor receptacles. There is an exception for lighting outlets other than those covered in 210.8(C). This section is applicable to a condensing unit – the outdoor component of a typical HVAC split system air conditioner or heat pump system.

Cost Implication of the Code Change:

This code change will increase the cost of construction for dwellings with a condensing unit. The analysis is based on substituting a GFCI circuit breaker for a standard circuit breaker using typical condensing unit ratings: 30-amp for a 3-ton unit for all Reference Houses and the Reference Townhouse; 15/20-amp for a 1.5/2-ton unit for Reference Buildings 2, 3, and 4.

Component	Unit	Material	Labor	Total	w/O&P	Quantity	Cost
GFCI 30-amp 2-pole breaker	EA	114.00		114.00	125.40	1	125.40
Standard 30-amp 2-pole breaker	EA	9.75		9.75	10.73	(1)	(10.73)
Total to Builder							**114.68**
Total to Consumer							**136.35**

Component	Unit	Material	Labor	Total	w/O&P	Quantity	Cost
GFCI 15- or 20-amp 2-pole breaker	EA	101.45		101.45	111.60	1	111.60
Standard 15- or 20-amp 2-pole breaker	EA	8.68		8.68	9.55	(1)	(9.55)
Total to Builder							**102.05**
Total to Consumer							**121.33**

Reference Houses	GFCI protection for outdoor outlets			
	Unit	Unit Cost	Quantity	Cost
Reference House 1	EA	136.35	1	136.35
Reference House 2	EA	136.35	1	136.35
Reference House 3	EA	136.35	1	136.35
Reference House 4	EA	136.35	1	136.35

Reference Buildings	GFCI protection for outdoor outlets			
	Unit	Unit Cost	Quantity	Cost
Reference Building 1 (24 units)	EA	121.33	0	0.00
Reference Building 2 (36 units)	EA	121.33	36	4,368.02
Reference Building 3 (48 units)	EA	121.33	48	5,824.03
Reference Building 4 (167 units)	EA	121.33	167	20,262.76
Reference Townhouse	EA	136.35	1	136.35

Reference Code Section

2020 NEC 230.67 Surge Protection, Dwelling Units.

Summary of the Code Change:

This new code section requires a surge-protective device (SPD) for all services supplying dwelling units.

Cost Implication of the Code Change:

This code change will increase the cost of construction. This change applies to all Reference Houses and each dwelling unit in all Reference Buildings. The cost analysis is based on a Type 2 installation: installing the SPD on the load side of and adjacent to the main electrical panel.

Component	Unit	Material	Labor	Total	w/O&P	Quantity	Cost
Surge-Protective Device	EA	97.89	60.00	157.89	197.44	1	197.44
20-amp 2-pole breaker	EA	8.68		8.68	9.55	1	9.55
Total to Builder							**206.99**
Total to Consumer							**246.11**

Reference Houses	Surge Protection			
	Unit	Unit Cost	Quantity	Cost
Reference House 1	EA	246.11	1	246.11
Reference House 2	EA	246.11	1	246.11
Reference House 3	EA	246.11	1	246.11
Reference House 4	EA	246.11	1	246.11

Reference Buildings	Surge Protection			
	Unit	Unit Cost	Quantity	Cost
Reference Building 1 (24 units)	EA	246.11	24	5,906.58
Reference Building 2 (36 units)	EA	246.11	36	8,859.87
Reference Building 3 (48 units)	EA	246.11	48	11,813.16
Reference Building 4 (167 units)	EA	246.11	167	41,099.96
Reference Townhouse	EA	246.11	1	246.11

Reference Code Section

2020 NEC 230.85 Emergency Disconnects, One- and Two-family Dwelling Units.

Summary of the Code Change:

This new code section requires a service disconnecting means that is labeled and installed in a readily accessible outdoor location for one- and two-family dwelling units. The intent of this change is to allow firefighters to quickly shut off electrical power before entering a house.

Cost Implication of the Code Change:

This code change will increase the cost of construction for one- and two-family dwellings. The analysis is based on the estimated cost to substitute a standard outdoor meter socket with a combination meter socket with integral main breaker. Further, the analysis includes the estimated cost to substitute a main breaker type indoor load center with a main lug type (no main circuit breaker). The analysis assumes that the labor to install these items does not change.

Component	Unit	Material	Labor	Total	w/O&P	Quantity	Cost
Combination meter socket with integral 200-amp main circuit breaker	EA	154.86		154.86	170.35	1	170.35
Standard meter socket	EA	60.10		60.10	66.11	(1)	(66.11)
Main lug type indoor load center, 200-amp, 30-space	EA	91.99		91.99	101.19	1	101.19
Main breaker type indoor load center, 200-amp, 30-space, with 200-amp main breaker	EA	121.00		121.00	133.10	(1)	(133.10)
Total to Builder							**72.33**
Total to Consumer							**85.99**

Reference Houses	Emergency Disconnect			
	Unit	Unit Cost	Quantity	Cost
Reference House 1	EA	85.99	1	85.99
Reference House 2	EA	85.99	1	85.99
Reference House 3	EA	85.99	1	85.99
Reference House 4	EA	85.99	1	85.99

Reference Buildings	Emergency Disconnect			
	Unit	Unit Cost	Quantity	Cost
Reference Townhouse	EA	85.99	1	85.99

APPENDIX B: LOCATION ADJUSTMENT FACTORS

State	City	Cost Adjustment Factor	State	City	Cost Adjustment Factor
Alabama	Birmingham	0.84	Montana	Billings	0.87
Alabama	Mobile	0.82	Nebraska	Omaha	0.90
Alaska	Fairbanks	1.24	Nevada	Las Vegas	1.02
Arizona	Phoenix	0.87	New Hampshire	Portsmouth	0.95
Arizona	Tucson	0.85	New Jersey	Jersey City	1.18
Arkansas	Little Rock	0.81	New Mexico	Albuquerque	0.83
California	Alhambra	1.16	New York	Long Island City	1.40
California	Los Angeles	1.14	New York	Syracuse	0.99
California	Riverside	1.14	North Carolina	Charlotte	0.94
California	Stockton	1.20	North Carolina	Greensboro	0.94
Colorado	Boulder	0.91	North Carolina	Raleigh	0.93
Colorado	Colorado Springs	0.86	North Dakota	Fargo	0.90
Colorado	Denver	0.89	Ohio	Columbus	0.91
Connecticut	New Haven	1.09	Oklahoma	Oklahoma City	0.81
Delaware	Dover	1.01	Oklahoma	Tulsa	0.82
District of Columbia	Washington, D.C.	0.92	Oregon	Bend	1.01
Florida	Fort Meyers	0.80	Pennsylvania	Norristown	1.09
Florida	Miami	0.81	Pennsylvania	State College	0.92
Florida	Orlando	0.82	Rhode Island	Providence	1.08
Florida	Tampa	0.80	South Carolina	Greenville	0.94
Georgia	Atlanta	0.88	South Dakota	Sioux Falls	0.87
Hawaii	Honolulu	1.22	Tennessee	Memphis	0.84
Idaho	Boise	0.90	Texas	Austin	0.79
Illinois	Carbondale	1.00	Texas	Dallas	0.83
Indiana	Indianapolis	0.93	Texas	Houston	0.83
Iowa	Des Moines	0.92	Texas	San Antonio	0.80
Kansas	Wichita	0.81	Utah	Ogden	0.82
Kentucky	Louisville	0.86	Utah	Provo	0.83
Louisiana	Baton Rouge	0.85	Utah	Salt Lake City	0.84
Maine	Portland	0.92	Vermont	Burlington	0.93
Maryland	Baltimore	0.93	Virginia	Fairfax	1.01
Massachusetts	Boston	1.18	Virginia	Winchester	1.01
Michigan	Ann Arbor	0.99	Washington	Tacoma	1.03
Minnesota	St. Paul	1.07	West Virginia	Charleston	0.95
Mississippi	Biloxi	0.83	Wisconsin	La Crosse	0.97
Missouri	Springfield	0.88	Wyoming	Casper	0.83

*Source: RSMeans *Residential Cost Data 2019*. Sample cities are listed in this table; check RSMeans for additional locations.

APPENDIX C: REFERENCE HOUSES

Reference House Characteristics

The four residential building designs used in this analysis are based on the data contained in the Census Bureau report, *Characteristics of New Single-Family Construction Completed*[4]. The report provides information about building foundation type and number of stories for new single-family detached construction over the previous nine-year period.

Table C-1. New Construction Foundation Types

Slab	54%
Crawlspace	17%
Basement	30%

Table C-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

The table below covers the locations where each type of reference house foundation would be pragmatically constructed. All these selected cities, except Chicago, lie within the top ten states for construction starts in 2013.[5] Chicago was selected to represent a Climate Zone 5 house.

Table C-3. Sites for Reference Houses

Reference House	Climate Zone	1	2	3	4
Foundation		Slab	Slab	Basement	Basement
Miami	1	X	X		
Los Angeles	3	X	X		X*
Dallas	3	X	X		X*
Seattle	4	X	X	X	X
New York	4	X	X	X	X
Chicago	5			X	X
Fairbanks	8			X	X

[4] www.census.gov/construction/chars/completed.html

[5] www.census.gov/construction/bps/pdf/2013statepiechart.pdf

Based on the data compiled by Home Innovation from the *2013 Builder Practices Survey* (BPS)[6], a nationwide annual survey, the typical Heating, Ventilation, and Cooling (HVAC) systems used in new houses are summarized in the table below. 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 as the HVAC system in each of the reference houses.

Table C-4. Typical HVAC Systems Supplied with New Houses

Feature	% 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 Houses Defined

The statistics presented in the foregoing tables support defining the features of the Reference Houses as detailed in the table below.

Table C-5. 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/Closet	Yes	Yes	Yes	Yes
Walls, 2x4 (Climate Zones 1 & 2)	Yes	Yes	n/a	n/a
Walls, 2x6 (Climate Zones 3 thru 8)	n/a	n/a	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
Roof Pitch	12/12	6/12	9/12	4/12

The furnace location has been designated as a platform in the attic for both slab reference houses, a common practice in mild climates; furnace would be located within conditioned space for cold climates.

[6] www.homeinnovation.com/trends_and_reports/data/new_construction

APPENDIX D: REFERENCE BUILDINGS

Reference Building Characteristics

The five multifamily building designs used in this analysis were selected based on data contained in the Census Bureau report, *Characteristics of New Multifamily Buildings Completed*[7] and a tabulation provided by Home Innovation of multifamily buildings certified to the National Green Building Standard. The Census Bureau report provides information as to the number of stories and number of dwelling units in multifamily new construction.

Table D-1. New Construction Number of Stories

One- and two-story	38%
Three story	43%
Four-story or more	19%

Table D-2. New Construction Number of Units

2 – 9	43%
10 – 49	48%
50 or more	9%

Using the Census Bureau and Home Innovation data, five reference buildings were selected as follows:

- Two-story apartment building with 24 units
- Three-story "garden-style" building (non-enclosed shared stairways, no elevators) and 36 units
- Four-story enclosed building on grade with 48 units and communal spaces (amenities)
- Four-story enclosed building with 167 units on top of a one-story podium
- Four-story townhouse with three bedrooms and a garage

[7] www.census.gov/construction/chars/mfb.html

Reference Buildings Defined

The statistics presented in the foregoing tables support defining the features of the Reference Buildings as detailed in the table below.

Table D-3. New Construction Number of Units

Reference Building	1	2	3	4	T.H.
Approx. Total Size	19,500 SF	43,150 SF	44,500 SF	462,600 SF	2,500 SF
Approx. Footprint	60' x 162'	62' x 263'	57'x175'	186'x348'	16'x37'
Foundation	Crawlspace	Slab on grade	Slab on grade	Basement (garage)	Slab on grade
Number of Stories	2	3	4	5	4
Number of Units	24	36	48 + shared	167	1
Large Projections	None	Wood-framed balconies	None	Bolt-on balconies	Deck
Elevators	1	0	2	2	0
Stairways	3	6	2	2	1
Type/Location	Enclosed	Open	Enclosed	Enclosed	In-Unit
Parking	Surface Lot	Surface Lot	Surface Lot	Enclosed public parking garage	Private garage
Sprinklers		Yes	Yes	Yes	Yes
HVAC	Building boiler + in-unit radiators	Split system air cond. (outdoor condenser + in-unit air handler)	Split system heat pump (roof condenser + in-unit air handler)	Split system heat pump (roof condenser + in-unit air handler)	Outdoor condenser + indoor furnace
Laundry	Communal	In unit	In unit	In unit	In unit
1st Floor Ceiling	9 ft	9 ft	10 ft	13 ft	11 ft
2nd Floor Ceiling	8ft	9 ft	10 ft	11 ft	10 ft
3rd Floor Ceiling	N/A	9 ft	10 ft	11 ft	10 ft
4th Floor Ceiling	N/A	N/A	10 ft	11 ft	10 ft
5th Floor Ceiling	N/A	N/A	N/A	10 ft	N/A
Attic Height	12 ft	12 ft	12 ft	N/A	N/A
Building Height	29 ft	39 ft	52 ft	56 ft	41 ft
Roof Slope	5/12 pitch	7/12 pitch	8/12 pitch	¼"/foot slope	¼" foot slope

APPENDIX E: REFERENCE HOUSE 1

One-Story House with Slab Foundation

Courtesy: LionsGate Homes at The Creekside

APPENDIX F: REFERENCE HOUSE 2

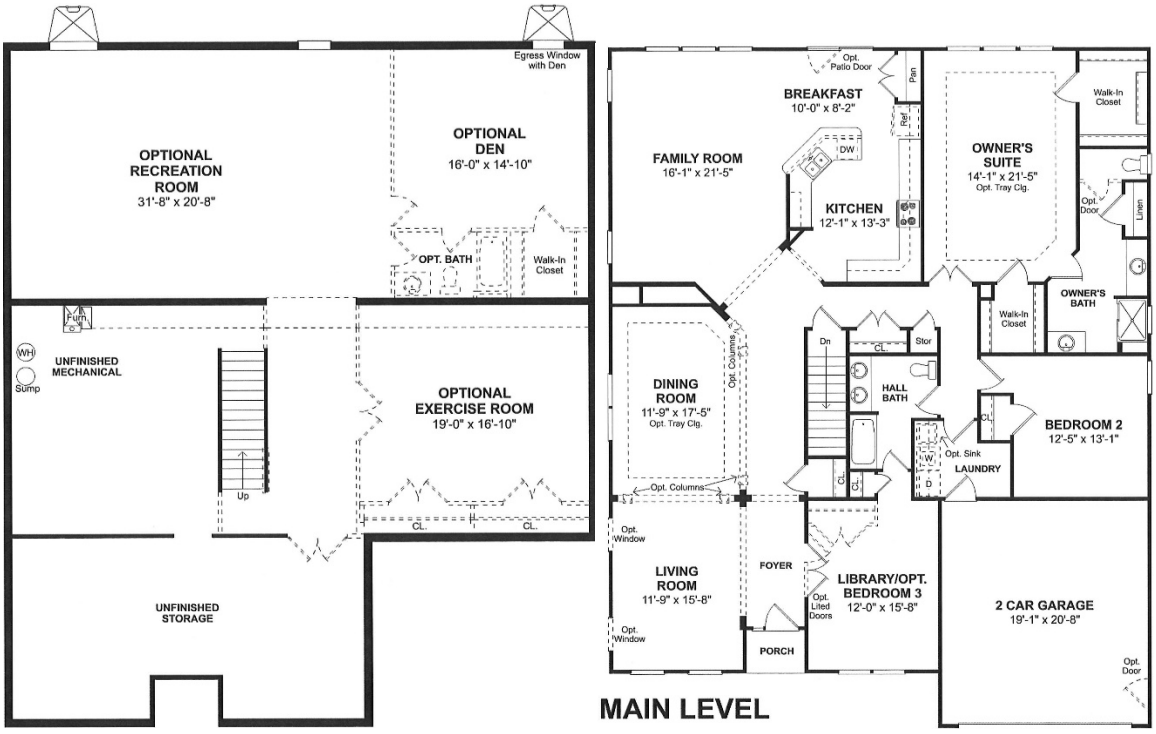
Two-Story House with Slab Foundation

Courtesy: Meritage Homes at Riverstone

APPENDIX G: REFERENCE HOUSE 3

One-Story House with Basement Foundation

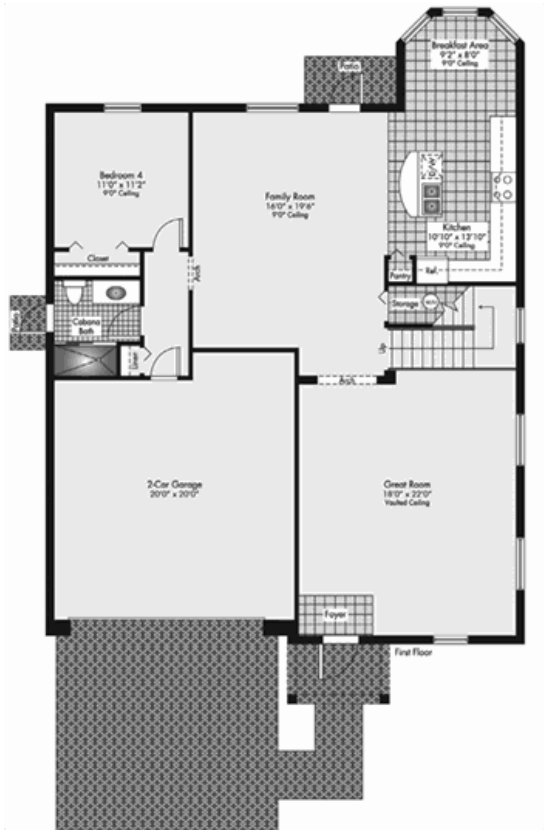
Courtesy: K Hovnanian Four Seasons at New Kent Vineyards

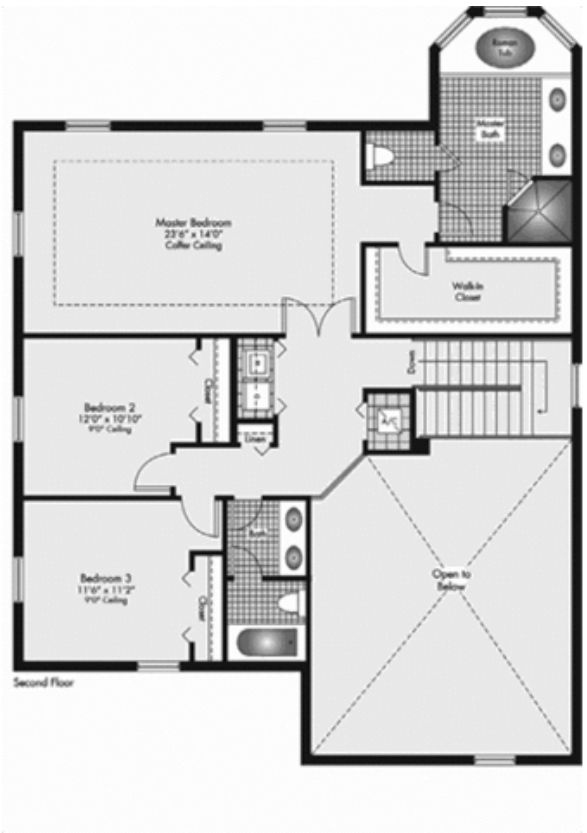


APPENDIX H: REFERENCE HOUSE 4

Two-Story House with Basement Foundation

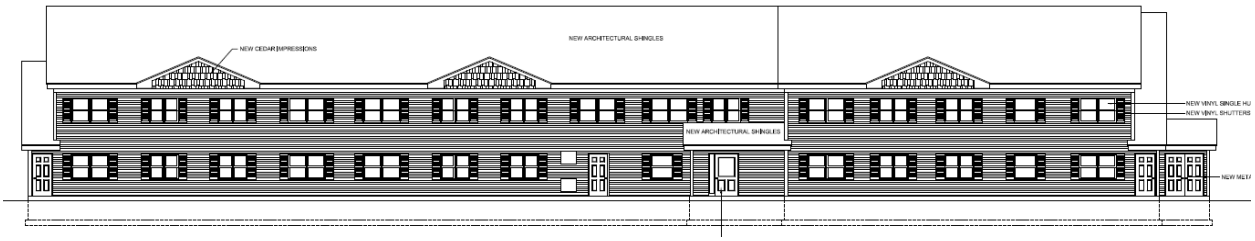
Courtesy: Lennar at Sorento Estates



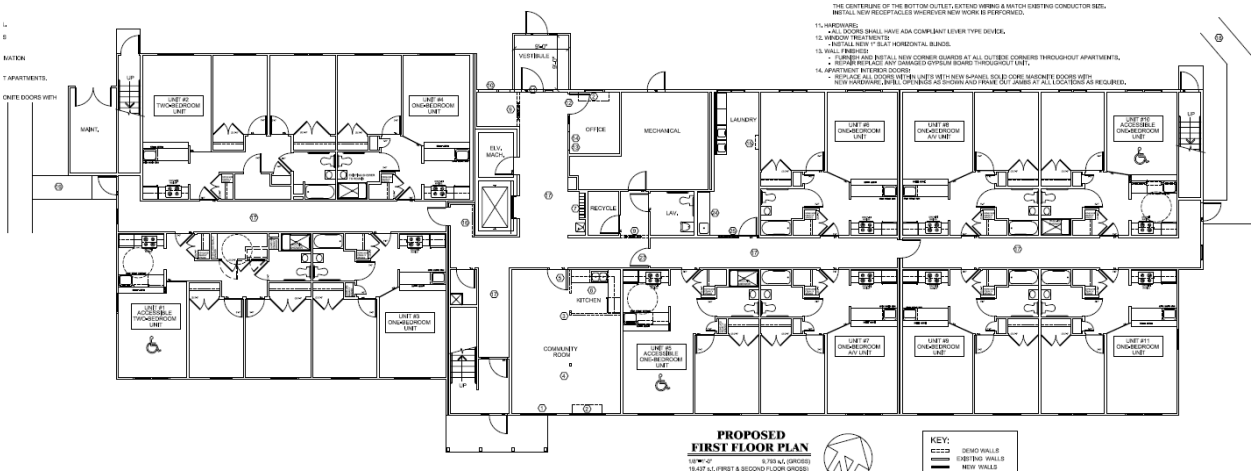


APPENDIX I: REFERENCE BUILDING 1

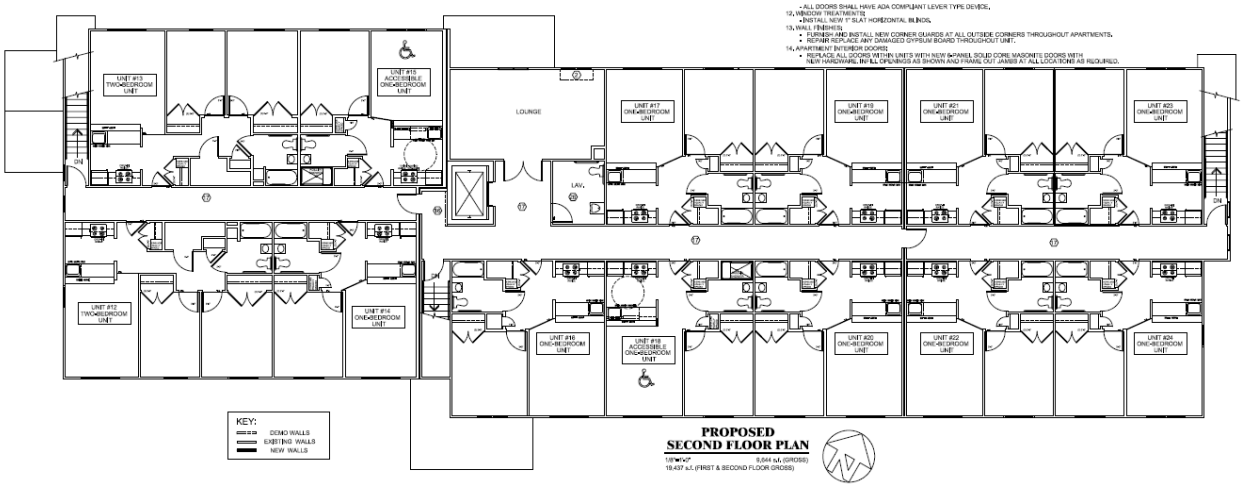
Two-Story Apartment Building, 24 Units



[ELEVATION]



[FIRST FLOOR PLAN]

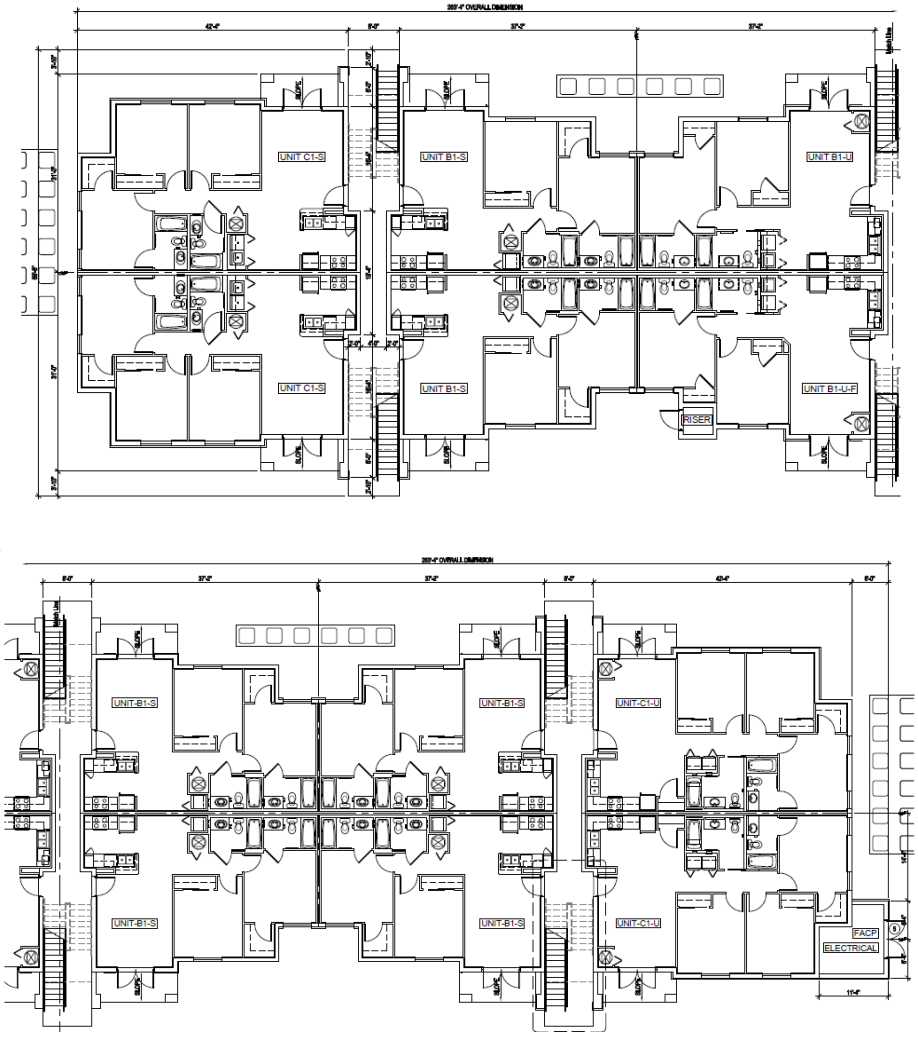


[SECOND FLOOR PLAN]

APPENDIX J: REFERENCE BUILDING 2

Three-Story Garden Style Building, 36 Units

[ELEVATION]

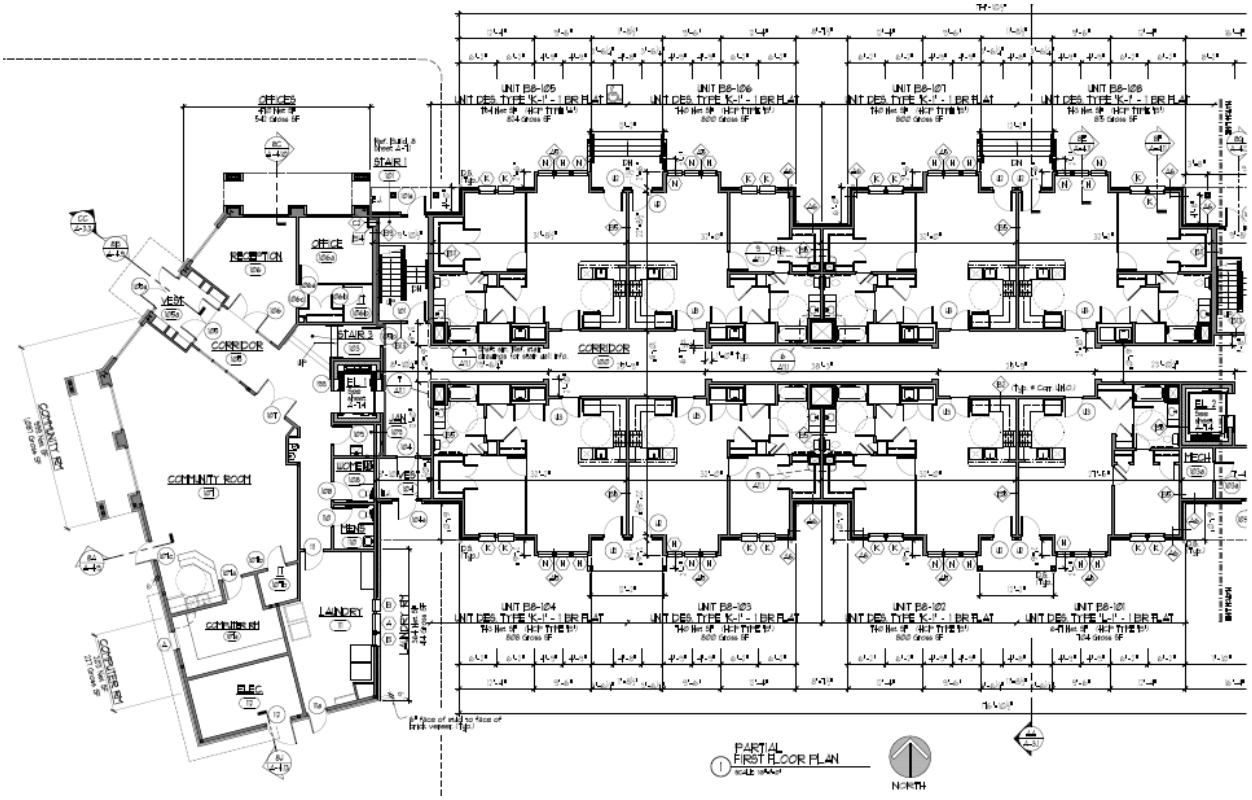


[FIRST FLOOR PLAN]

APPENDIX K: REFERENCE BUILDING 3

Four-Story Building on Grade, 48 Units & Common Areas

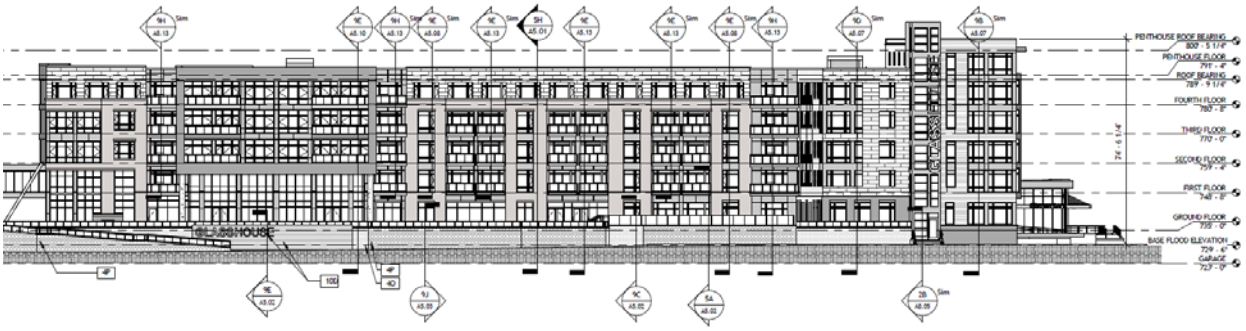
[ELEVATION]



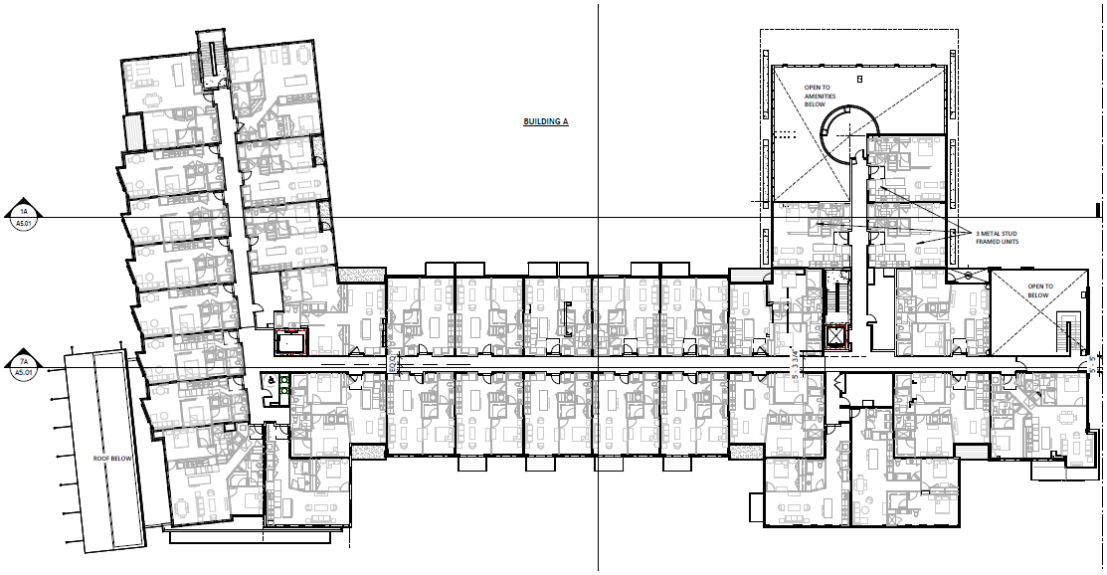
[PARTIAL FIRST FLOOR PLAN]

APPENDIX L: REFERENCE BUILDING 4

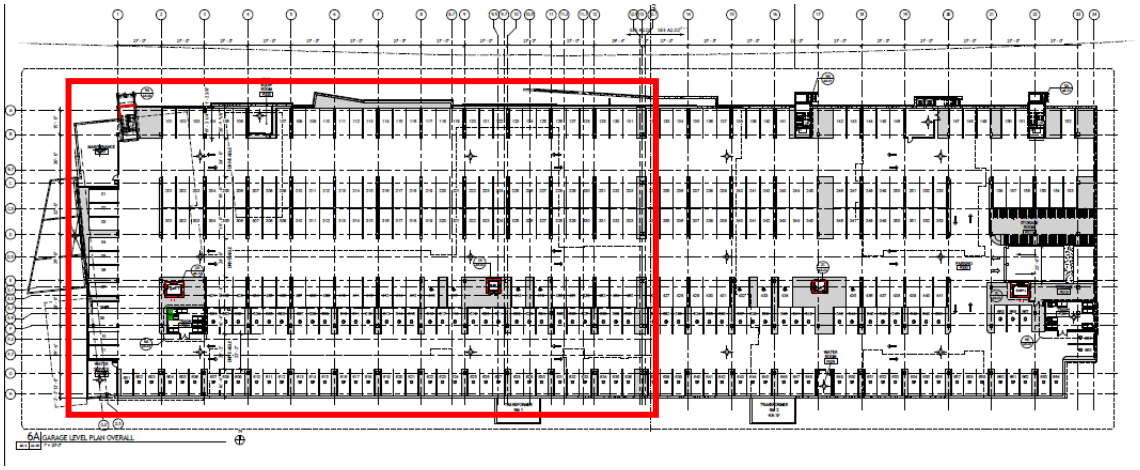
Five-Story Building on Two-Story Podium, 167 Units



[ELEVATION]



[FIRST FLOOR PLAN]

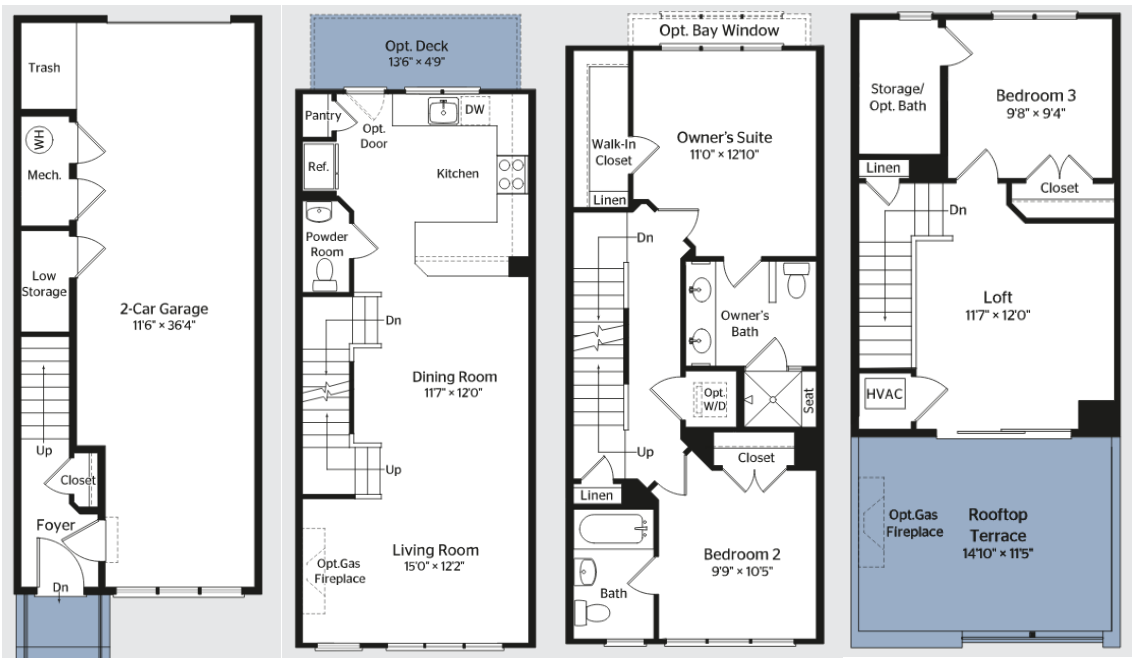


[GARAGE PLAN]

APPENDIX M: REFERENCE TOWNHOUSE

Four-Story Townhouse

[ELEVATION]



[FLOOR PLANS]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