Home Innovation
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ESTIMATED COSTS OF THE 2023 NEC CODE CHANGES FOR SINGLE-FAMILY AND MULTIFAMILY BUILDINGS

Prepared For

National Association of Home Builders

October 6, 2023

Report No. CR1599-3-1-1-10062023

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ACRONYMS, ABBREVIATIONS, AND DEFINITIONS

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

BACKGROUND

The National Association of Home Builders (NAHB) identified 8 changes approved for the 2023 National Electrical Code[1] (NEC) which could have a significant cost impact for builders. The 2023 NEC is adopted by reference in the 2024 International Residential Code (IRC) and International Building Code (IBC)[2], and key provisions for residential construction are extracted into Chapters 34 through 43 of the IRC. Home Innovation Research Labs (Home Innovation) reviewed the code changes and performed a cost analysis on several Reference Houses and Reference 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 2023 NEC code changes. For the purposes of this report, all buildings are assumed to be in compliance with the minimum requirements of the 2021 IRC and IBC, which referenced the 2020 edition of the NEC. Any changes in the 2024 IRC or IBC that additionally require compliance with the NEC will be addressed in separate cost studies.

Incremental construction costs were estimated using RSMeans 2023 Q2 Data, using national average costs for labor and materials.[3] For specific locations, the national average costs could be modified by applying the appropriate location adjustment factor from RSMeans; selected location adjustment factors from RSMeans are provided in Appendix B. Material costs were sourced from national distributor websites as needed.

Costs in the Results section are reported as cost to consumer (homeowner or building owner). The cost to consumer is calculated by applying a markup to the builder cost to account for builder overhead and profit. For this analysis, the cost to consumer is calculated by applying a markup of 1.182 to the builder cost.[4] The cost to builder represents the cost charged by the subcontractor (RSMeans provides this unit

[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/

[4] Based on average Builder gross margin as reported in The Cost of Doing Business Study, 2022 Edition, by NAHB

cost which includes subcontractor overhead and profit). Cost details for individual code changes are provided in Appendix A and show both builder cost and consumer cost.

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. For this study, all appliances (refrigerator, dishwasher, clothes washer, clothes dryer, and kitchen range) are assumed to be electric.

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. For this study, all appliances (refrigerator, dishwasher, clothes washer, clothes dryer, and kitchen range) are assumed to be electric.

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 2023 NEC Code Compliance

The cumulative impact of the selected code changes on the cost of constructing the Reference Houses and Reference Buildings are summarized in the table below. The costs represent the incremental cost to the consumer (homeowner or building owner). Cost details for individual code changes are provided in Appendix A.

Table 3. Estimated Cost Impact of 2023 NEC Code Changes

Description	Code Section	Cost ($)								
		Reference Houses				Reference Buildings				
		1	2	3	4	1	2	3	4	T.H.
GFCIs for Kitchens	210.8(A)	36	36	18	73	437	1,967	874	6,084	36
GFCIs for Specific Appliances	210.8(D)	346	346	346	346	8,296	12,444	16,592	57,725	346
GFCIs for Outdoor Outlets	210.8(F)	(157)	(157)	(157)	(157)	NA	(5,637)	(7,672)	(2,6147)	(157)
Garage Branch Circuits	210.11(C)(4)	(24)	(24)	(24)	(24)	NA	NA	NA	NA	(24)
Receptacles on Kitchen Islands and Peninsulas	210.52(C)(2)	(20)	(20)	(20)	(20)	NA	NA	NA	(2,331)	(20)
Kitchen Receptacle Outlet Location	210.52(C)(3)	97	464	464	97	NA	NA	NA	54,320	464
Load Calculations	220.5(C)	NA	NA	NA	NA	NA	NA	NA	NA	NA
Surge-Protective Device Ratings	230.67	30	30	30	30	709	1,064	1,448	4,936	30
Total		**$308**	**$675**	**$657**	**$345**	**$9,442**	**$9,839**	**$11,242**	**$94,587**	**$675**

APPENDIX A: INCREMENTAL COST DETAILS FOR EACH CODE CHANGE

The cost analysis was based on a review of the Reference House designs and Reference Building designs to assess the applicability of each code change. The cost details are provided in the tables below by code change. The unit cost tables show both cost to builder and cost to consumer. The summary cost tables for each Reference House and Reference Building show cost to consumer.

The cost to builder represents the cost charged by the subcontractor; RSMeans provides this unit cost which includes subcontractor overhead and profit, designated in the tables as "Total w/O&P". To calculate Total w/O&P, RSMeans adds an overhead burden to the "bare labor" cost, and then adds 10% for profit to this adjusted labor cost and to the "bare material" cost. For this study, where material costs are sourced from national distributor websites, a 10% subcontractor profit is added to "bare material" costs for consistency.

The cost to consumer (homeowner or building owner) is calculated by applying a markup to the builder cost to account for builder overhead and profit. For this analysis, the cost to consumer is calculated by applying a markup of 1.182 to the builder cost.[5]

[5] Based on average Builder gross margin as reported in The Cost of Doing Business Study, 2022 Edition, by NAHB

Topic

GFCIs for Kitchens

Code Section

210.8(A)

Description

This change requires receptacles in the entire kitchen—as well as any area with a sink and permanent provisions for food preparation, beverage preparation, or cooking—to have GFCI protection. This section previously applied to kitchen receptacles serving the countertop surfaces only.

Cost Implication of the Code Change:

This code change may increase the cost of construction. The change is applicable where there is an outlet in a kitchen wall space that was previously not required to have GFCI protection. It may be challenging to define the area of a kitchen or other applicable area particularly for open floor plans, e.g., whether to include an adjoining breakfast area or room as part of the kitchen. The quantity of such receptacles can vary, e.g., a galley kitchen could have none, but a typical kitchen could have two or three, and larger kitchens could have more.

A review of the floor plan designs indicated the quantity of such receptacles for the Reference Houses and Reference Buildings, as shown in the tables below. Costs are based on substituting self-testing GFCI duplex outlets for standard duplex outlets, all tamper resistant.

Table A-1. GFCIs for Kitchens: Unit Cost

Component	Unit	Bare Material	Bare Labor	Bare Total	Total w/O&P	Quantity	Cost
GFCI duplex outlet, 15-amp	EA	15.99		15.99	17.59	1	17.59
Standard duplex outlet, 15-amp	EA	1.50		1.50	1.65	(1)	(1.65)
Standard wall plate	EA	0.48		0.48	0.53	(1)	(0.53)
Total Builder Cost							**15.41**
Total Consumer Cost							**18.22**

Table A-2. GFCIs for Kitchens: Reference Houses

Reference House (IRC)	Unit	Unit Cost	Quantity	Cost
Reference House 1	EA	18.22	2	36
Reference House 2	EA	18.22	2	36
Reference House 3	EA	18.22	1	18
Reference House 4	EA	18.22	4	73

Table A-3. GFCIs for Kitchens: Reference Buildings

Reference Building (IBC)	Unit	Unit Cost	Qty/Unit	Unit/Bldg.	Cost
Reference Building 1	EA	18.22	1	24	437
Reference Building 2	EA	18.22	3	36	1,967
Reference Building 3	EA	18.22	1	48	874
Reference Building 4	EA	18.22	2	167	6,084
Reference Townhouse (4-story)	EA	18.22	2	1	36

Topic

GFCIs for Specific Appliances

Code Section

210.8(D)

Description

This change requires branch circuits or outlets serving specific appliances – electric ranges, wall-mounted ovens, counter-mounted cooking units, clothes dryers, and microwave ovens – to have GFCI protection no matter where they are located. This list of appliances was previously found in Section 422.5(A) and included appliances numbered (1) through (7): automotive vacuum machines; drinking water coolers; high-pressure spray washing machines; tire inflation machines; vending machines; sump pumps; dishwashers. Appliances numbered (8) through (12) (listed above) were not previously included in the list.

Cost Implication of the Code Change

This code change will increase the cost of construction. This analysis assumed an electric range (240-volt, 50-amp circuit), electric clothes dryer (240-volt, 30-amp circuit), and electric microwave oven installed above the range or within a dedicated microwave nook within the kitchen cabinets (120-volt, 15-amp circuit), that now require GFCI protection. The cost was based on substituting a GFCI circuit breaker for a standard circuit breaker for the range and dryer circuits and substituting a GFCI outlet for a standard outlet for the microwave circuit. The cost is applicable to all Reference Houses and each dwelling unit within all Reference Buildings.

Table A-4. GFCIs for Specific Appliances: Unit Costs

Component	Unit	Bare Material	Bare Labor	Bare Total	Total w/O&P	Quantity	Cost
Microwave GFCI ST duplex outlet, 15-amp	EA	15.99		15.99	17.59	1	17.59
Standard duplex outlet, 15-amp	EA	1.50		1.50	1.65	(1)	(1.65)
Standard duplex outlet wall plate	EA	0.48		0.48	0.53	(1)	(0.53)
Dryer GFCI 30-amp 2-pole breaker	EA	158.00		158.00	173.80	1	173.80
Standard 30-amp 2-pole breaker	EA	37.58		37.58	41.34	(1)	(41.34)
Range GFCI 50-amp 2-pole breaker	EA	169.00		169.00	185.90	1	185.90
Standard 50-amp 2-pole breaker	EA	37.58		37.58	41.34	(1)	(41.34)
Total Builder Cost							**292.44**
Total Consumer Cost							**345.66**

Table A-5. GFCIs for Specific Appliances: Reference Houses

Reference House (IRC)	Unit	Unit Cost	Quantity	Cost
Reference House 1	EA	345.66	1	346
Reference House 2	EA	345.66	1	346
Reference House 3	EA	345.66	1	346
Reference House 4	EA	345.66	1	346

Table A-6. GFCIs for Specific Appliances: Reference Buildings

Reference Building (IBC)	Unit	Unit Cost	Quantity	Cost
Reference Building 1	EA	345.66	24	8,296
Reference Building 2	EA	345.66	36	12,444
Reference Building 3	EA	345.66	48	16,592
Reference Building 4	EA	345.66	167	57,725
Reference Townhouse (4-story)	EA	345.66	1	346

Topic

GFCIs for Outdoor Outlets

Code Section

210.8(F)

Description

This change delays the requirement for listed air conditioner and heat pump outdoor units to have GFCI protection until September 1, 2026. Several accessory buildings are listed where outdoor outlets are specifically required to have GFCI protection. It should be noted that a similar change was also made to the 2020 edition through a Tentative Interim Amendment that went into effect September 2022.

Cost Implication of the Code Change:

This code change will decrease the cost of construction. The analysis was based on replacing a GFCI circuit breaker with a standard circuit breaker for each outdoor unit. The analysis assumes a 30-amp circuit breaker for all Reference Houses, typical for a 3-ton outdoor unit, and a 20-amp circuit breaker for each dwelling unit for all Reference Buildings, typical for a 1.5-ton or 2-ton outdoor unit, except Reference Building 1 which does not have central air conditioning. Note that market pricing shows that the costs of 30-amp and 20-amp circuit breakers are commonly the same.

Table A-7. GFCIs for Outdoor Outlets: Unit Cost

Component	Unit	Bare Material	Bare Labor	Bare Total	Total w/O&P	Quantity	Cost
GFCI breaker, 2-pole, 30- or 20-amp	EA	158.00		158.00	173.80	(1)	(173.80)
Standard breaker, 2-pole, 30- or 20-amp	EA	37.58		37.58	41.34	1	41.34
Total Builder Cost							**(132.46)**
Total Consumer Cost							**(156.57)**

Table A-8. GFCIs for Outdoor Outlets: Reference Houses

Reference House (IRC)	Unit	Unit Cost	Quantity	Cost
Reference House 1	EA	(156.57)	1	(157)
Reference House 2	EA	(156.57)	1	(157)
Reference House 3	EA	(156.57)	1	(157)
Reference House 4	EA	(156.57)	1	(157)

Table A-9. GFCIs for Outdoor Outlets: Reference Buildings

Reference Building (IBC)	Unit	Unit Cost	Quantity	Cost
Reference Building 1	EA	(156.57)	0	NA
Reference Building 2	EA	(156.57)	36	(5,637)
Reference Building 3	EA	(156.57)	49	(7,672)
Reference Building 4	EA	(156.57)	167	(26,147)
Reference Townhouse (4-story)	EA	(156.57)	1	(157)

Topic

Garage Branch Circuits

Code Section

210.11(C)(4)

Description

This change clarifies that additional branch circuits, beyond the one required by 210.52(G)(1), are permitted. It also allows additional equipment to be supplied by the required circuit in garages with a single vehicle bay as long as the rating of such equipment does not exceed the limits of 210.23(B)(1) and (2).

Cost Implication of the Code Change:

This code change may decrease the cost of construction in some cases. The analysis is based on the scenario where there is an additional garage circuit, beyond the 20-amp circuit required for each vehicle bay, that no longer needs to be a dedicated circuit and instead can be connected to one of the required 20-amp circuits. The cost analysis is based on deleting a 20-amp circuit breaker and GFCI duplex outlet, adding a standard 20-amp duplex outlet, and assuming the length and size of wire remains the same. This potential cost savings is applicable for all Reference Houses and the Reference Townhouse.

Table A-10. Garage Branch Circuits: Unit Cost

Component	Unit	Bare Material	Bare Labor	Bare Total	Total w/O&P	Quantity	Cost
Circuit Breaker, 20-amp, 1-pole	EA	6.63			7.29	(1)	(7.29)
GFCI duplex outlet, 20-amp	EA	16.78		16.78	18.46	(1)	(18.46)
Standard duplex outlet, 20-amp	EA	4.33		4.33	4.76	1	4.76
Standard wall plate	EA	0.48		0.48	0.53	1	0.53
Total Builder Cost							**(20.46)**
Total Consumer Cost							**(24.18)**

Table A-11. Garage Branch Circuits: Reference Houses

Reference House (IRC)	Unit	Unit Cost	Quantity	Cost
Reference House 1	EA	(24.18)	1	(24)
Reference House 2	EA	(24.18)	1	(24)
Reference House 3	EA	(24.18)	1	(24)
Reference House 4	EA	(24.18)	1	(24)

Table A-12. Garage Branch Circuits: Reference Buildings

Reference Building (IBC)	Unit	Unit Cost	Quantity	Cost
Reference Building 1	EA			NA
Reference Building 2	EA			NA
Reference Building 3	EA			NA
Reference Building 4	EA			NA
Reference Townhouse (4-story)	EA	(24.18)	1	(24)

Topic

Receptacles on Kitchen Islands and Peninsulas

Code Section

210.52(C)(2)

Description

This change removes the requirement for providing receptacles to serve countertops and work surfaces on kitchen islands and peninsulas but requires "provisions" for a future receptacle if none are provided. This section previously included a requirement for one or more receptacles based on the area of the countertops or work surfaces.

Cost Implication of the Code Change

This code change may decrease the cost of construction. The analysis is based on deleting one GFCI outlet installed just below the counter of a kitchen island or peninsula, leaving the outlet box in the same location except facing it to the cabinet space, i.e., turning it 180-degrees, and installing a blank cover, while leaving the circuit wiring to the box intact. This will allow adding a receptacle in the future. This change is considered applicable to all Reference Houses, the Reference Townhouse, 117 of the 167 dwelling units within Reference Building 4 (those with a kitchen island), but not to the dwelling units in the other Reference Buildings.

Table A-13. Receptacles on Kitchen Islands and Peninsulas: Unit Cost

Component	Unit	Bare Material	Bare Labor	Bare Total	Total w/O&P	Quantity	Cost
GFCI duplex outlet, 15-amp	EA	15.99		15.99	17.59	(1)	(17.59)
Blank cover	EA	0.67		0.67	0.74	1	0.74
Total Builder Cost							**(16.85)**
Total Consumer Cost							**(19.92)**

Table A-14. Receptacles on Kitchen Islands and Peninsulas: Reference Houses

Reference House (IRC)	Unit	Unit Cost	Quantity	Cost
Reference House 1	EA	(19.92)	1	(20)
Reference House 2	EA	(19.92)	1	(20)
Reference House 3	EA	(19.92)	1	(20)
Reference House 4	EA	(19.92)	1	(20)

Table A-15. Receptacles on Kitchen Islands and Peninsulas: Reference Buildings

Reference Building (IBC)	Unit	Unit Cost	Quantity	Cost
Reference Building 1	EA			NA
Reference Building 2	EA			NA
Reference Building 3	EA			NA
Reference Building 4	EA	(19.92)	117	(2,331)
Reference Townhouse (4-story)	EA	(19.92)	1	(20)

Topic

Kitchen Receptacle Outlet Location

Code Section

210.52(C)(3)

Description

This change requires receptacle outlets to be installed in, on, or above countertops and work surfaces in kitchens. This section previously allowed receptacle outlets to be installed not more than 12 inches below the countertop or work surface.

Cost Implication of the Code Change

This code change may increase the cost of construction. The analysis is based on installing one pop-up outlet in a kitchen island or peninsula longer than 4-feet. The cost is based on installing a waterproof, hardwired, pop-up type outlet in the counter, wiring it to the circuit provided by 210.52(c)(2), and protecting the circuit using a GFCI circuit breaker (can't use a GFCI outlet in this case because the pop-up outlet is hardwired). Alternatively, if the island or peninsula has a two-level countertop with a short wall, the cost is based on installing a standard GFCI outlet within the short wall.

The pop-up outlet is considered applicable to Reference Houses 2 and 3, the Reference Townhouse, and for 117 of the 167 dwelling units in Reference Building 4. The GFCI outlet in the short wall of a two-level countertop is considered applicable to Reference Houses 1 and 4.

Table A-16. Kitchen Receptacle Outlet Location: Unit Cost for Pop-Up Outlet in Countertop

Component	Unit	Bare Material	Bare Labor	Bare Total	Total w/O&P	Quantity	Cost
Pop up outlet, waterproof, hardwired	EA	195.99	29.00	224.99	263.44	1	263.44
Labor to drill hole in counter for outlet	EA		38.50	38.50	63.53	1	63.53
GFCI circuit breaker, 15-amp, 1-pole	EA	66.47		66.47	73.12	1	73.12
Standard breaker, 15-amp, 1-pole	EA	6.63		6.63	7.29	(1)	(7.29)
Total Builder Cost							**392.79**
Total Consumer Cost							**464.28**

Table A-17. Kitchen Receptacle Outlet Location: Unit Cost for Two-Level Countertop with Short Wall

Component	Unit	Bare Material	Bare Labor	Bare Total	Total w/O&P	Quantity	Cost
GFCI duplex outlet, 15-amp	EA	15.99	29.00	44.99	65.44	1	65.44
Wire, 12/2 NM	LF	0.63	1.62	2.25	3.37	5	16.83
Total Builder Cost							**82.27**
Total Consumer Cost							**97.24**

Table A-18. Kitchen Receptacle Outlet Location: Reference Houses

Reference House (IRC)	Unit	Unit Cost	Quantity	Cost
Reference House 1	EA	97.24	1	97
Reference House 2	EA	464.28	1	464
Reference House 3	EA	464.28	1	464
Reference House 4	EA	97.24	1	97

Table A-19. Kitchen Receptacle Outlet Location: Reference Buildings

Reference Building (IBC)	Unit	Unit Cost	Quantity	Cost
Reference Building 1	EA	97.24	0	0
Reference Building 2	EA	97.24	0	0
Reference Building 3	EA	97.24	0	0
Reference Building 4	EA	464.28	117	54,320
Reference Townhouse (4-story)	EA	464.28	1	464

Topic

Load Calculations

Code Section

220.5(C)

Description

This change requires the floor area of garages to be included when calculating the minimum lighting load for dwelling units. Note: The charging language is found in Section 220.41.

Cost Implication of the Code Change

This code change could increase the cost of construction, but it does not increase cost for the Reference Houses or Reference Buildings.

The Reference Houses are assumed to have a 200-amp electrical service and panel. To determine if including the floor area of the garage would drive the need to upgrade the electrical service, a load calculation was performed in accordance with NEC 220.82 based on the worst-case scenario Reference House: Reference House 3, a one-story design with a fully finished basement and all-electric mechanicals and appliances. The result, provided in the table below, shows that an electrical service upgrade is not required for adding the floor area of the garage, even in the case where one 50-amp EV charger circuit was included. At some point, an electrical service upgrade would be required for a larger house or a house with additional electric loads such as a well, swimming pool, electric baseboard heaters, or a second EV charging circuit.

This code change does not apply to the multifamily Reference Buildings. It is applicable to the 4-story Reference Townhouse, but since there was no need for an electrical service upgrade for the worst-case scenario Reference House, there would not be a cost for the 4-story Reference Townhouse either.

Table A-20. Electrical Service Load Calculation

Electrical Load Component	kVA	Amps
Lighting & general use, 0.003kVA/sq. ft. floor area including finished basement and garage*	16.80	
Kitchen small appliance circuits	3.00	
Laundry circuit	1.50	
Range (oven and cooktop)	10.00	
Water heater	4.50	
Dishwasher	1.20	
Dryer	5.00	
Refrigerator	1.50	
Sub-total	43.50	
100% of first 10 kVA	10.00	
40% of balance	13.40	
Heat Pump system, 100%**	4.76	
Heat Pump supplemental heat, 65% of 15kW	9.75	
Total (without EV circuit)	**37.91**	**158**
EV 50-amp circuit	9.60	
Total with EV circuit	47.51	198
Total available (200-amp service)	48.00	200
***Floor area for electric load calculations**	**Sq. Ft.**	
First floor	2,600	
Basement	2,600	
Garage	400	
Total, sq. ft.	**5,600**	
****3-ton Heat Pump, 14.3 SEER2, 7.5 HSPF2**	**Data**	
Compressor, RLA	16.00	
Condenser fan, FLA	0.97	
Air handler, excluding supplemental heat, FLA	2.85	
Heat Pump system, amps	19.82	
Heat Pump system, kVA	**4.76**	

Topic

Surge-Protective Device Ratings

Code Section

230.67

Description

This change requires surge-protective devices (SPDs) to have a nominal discharge current rating (i-N) of not less than 10kA. SPDs were added to the NEC for the 2020 edition, and no minimum rating was required.

Cost Implication of the Code Change

This code change may increase the cost of construction. The analysis is based on the additional cost of installing an in-panel SPD with a nominal discharge current rating of 10kA compared to 5kA. The code change is applicable to all Reference Houses and each dwelling unit in all Reference Buildings.

Table A-21. Surge Protective Device (SPD): Unit Cost

Component	Unit	Bare Material	Bare Labor	Bare Total	Total w/O&P	Quantity	Cost
SPD, 120/240V, in-panel, 10kA i-N	EA	96.28		96.28	105.908	1	105.91
SPD, 120/240V, in-panel, 5kA i-N	EA	73.68		73.68	81.048	(1)	(81.05)
Total Builder Cost							**24.86**
Total Consumer Cost							**29.56**

Table A-22. Surge Protective Device (SPD): Reference Houses

Reference House (IRC)	Unit	Unit Cost	Quantity	Cost
Reference House 1	EA	29.56	1	30
Reference House 2	EA	29.56	1	30
Reference House 3	EA	29.56	1	30
Reference House 4	EA	29.56	1	30

Table A-23. Surge Protective Device (SPD): Reference Buildings

Reference Building (IBC)	Unit	Unit Cost	Quantity	Cost
Reference Building 1	EA	29.56	24	709
Reference Building 2	EA	29.56	36	1,064
Reference Building 3	EA	29.56	49	1,448
Reference Building 4	EA	29.56	167	4,936
Reference Townhouse (4-story)	EA	29.56	1	30

APPENDIX B: COST ADJUSTMENT FACTORS BY LOCATION

State	City	Cost Factor	State	City	Cost Factor
Alabama	Birmingham	0.87	Montana	Billings	0.92
Alabama	Mobile	0.83	Nebraska	Omaha	0.90
Alaska	Fairbanks	1.19	Nevada	Las Vegas	1.03
Arizona	Phoenix	0.87	New Hampshire	Portsmouth	0.93
Arizona	Tucson	0.86	New Jersey	Jersey City	1.14
Arkansas	Little Rock	0.84	New Mexico	Albuquerque	0.87
California	San Diego	1.09	New York	Long Island City	1.31
California	Los Angeles	1.14	New York	Syracuse	0.99
California	Riverside	1.12	North Carolina	Charlotte	1.00
California	San Francisco	1.27	North Carolina	Hickory	0.95
Colorado	Boulder	0.92	North Carolina	Raleigh	0.98
Colorado	Colorado Springs	0.85	North Dakota	Fargo	0.88
Colorado	Denver	0.91	Ohio	Columbus	0.93
Connecticut	New Haven	1.07	Oklahoma	Oklahoma City	0.85
Delaware	Dover	1.02	Oklahoma	Tulsa	0.84
District of Columbia	Washington, D.C.	0.94	Oregon	Bend	1.05
Florida	Fort Meyers	0.79	Pennsylvania	Norristown	1.01
Florida	Miami	0.85	Pennsylvania	State College	0.91
Florida	Orlando	0.84	Rhode Island	Providence	1.07
Florida	Tampa	0.83	South Carolina	Greenville	0.95
Georgia	Atlanta	0.92	South Dakota	Sioux Falls	0.92
Hawaii	Honolulu	1.16	Tennessee	Memphis	0.87
Idaho	Boise	0.89	Texas	Austin	0.82
Illinois	Chicago	1.21	Texas	Dallas	0.85
Indiana	Indianapolis	0.91	Texas	Houston	0.85
Iowa	Des Moines	0.92	Texas	San Antonio	0.83
Kansas	Wichita	0.83	Utah	Ogden	0.84
Kentucky	Louisville	0.89	Utah	Provo	0.85
Louisiana	Baton Rouge	0.86	Utah	Salt Lake City	0.85
Maine	Portland	0.94	Vermont	Burlington	0.95
Maryland	Baltimore	0.93	Virginia	Fairfax	0.98
Massachusetts	Boston	1.15	Virginia	Winchester	0.97
Michigan	Ann Arbor	0.98	Washington	Tacoma	1.05
Minnesota	Minneapolis	1.08	West Virginia	Charleston	0.96
Mississippi	Biloxi	0.86	Wisconsin	La Crosse	0.93
Missouri	Springfield	0.87	Wyoming	Casper	0.87

*Source: RSMeans *Residential Cost Data 2022*. 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*[6]. 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.[7] 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

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

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

Based on the data compiled by Home Innovation from the *2013 Builder Practices Survey* (BPS)[8], 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.

[8] 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*[9] 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

[9] 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

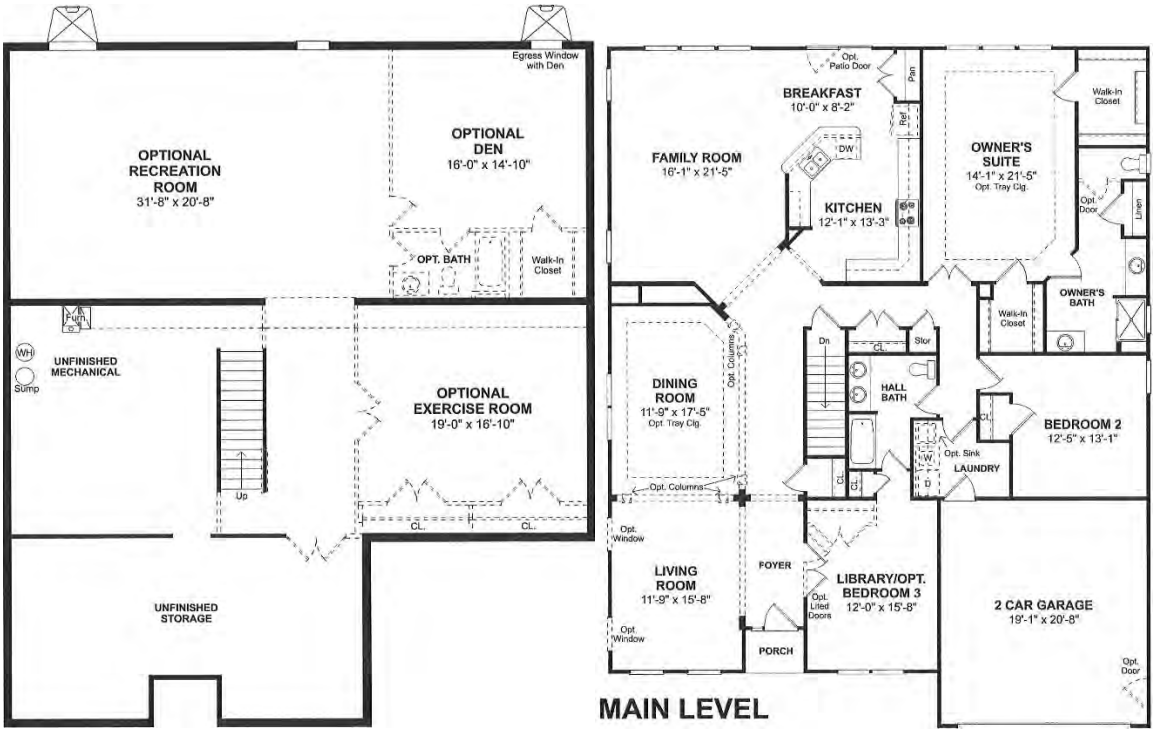
Two-Story House with Slab Foundation

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



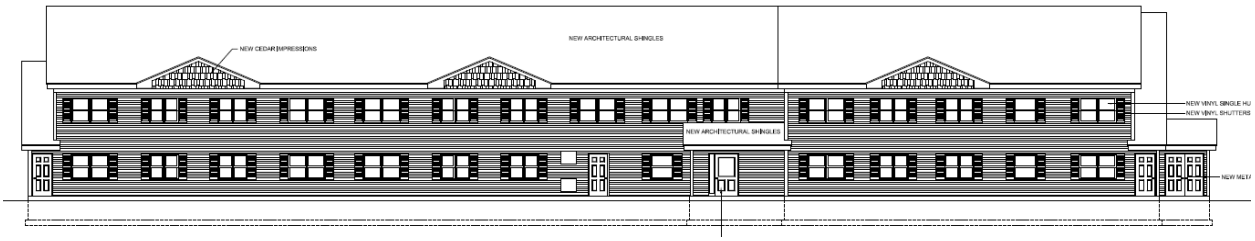
APPENDIX H: REFERENCE HOUSE 4

Two-Story House with Basement Foundation

Courtesy: Lennar at Sorento Estates

APPENDIX I: REFERENCE BUILDING 1

Two-Story Apartment Building, 24 Units



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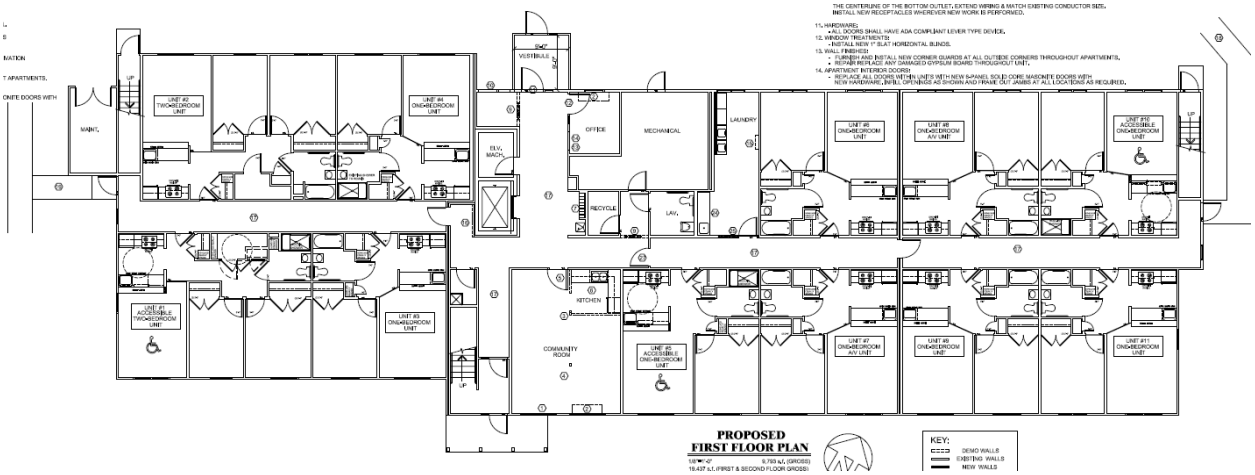
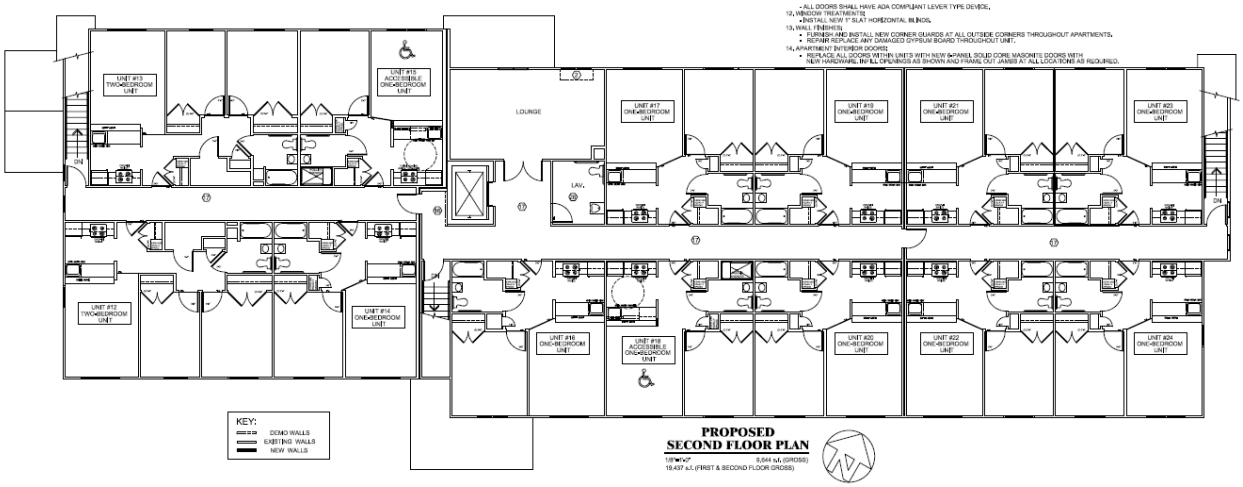


[FIRST FLOOR PLAN]

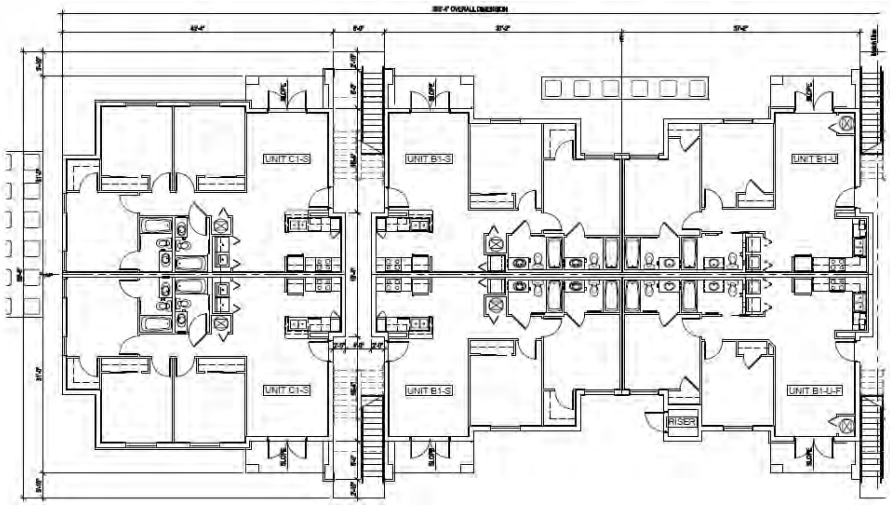


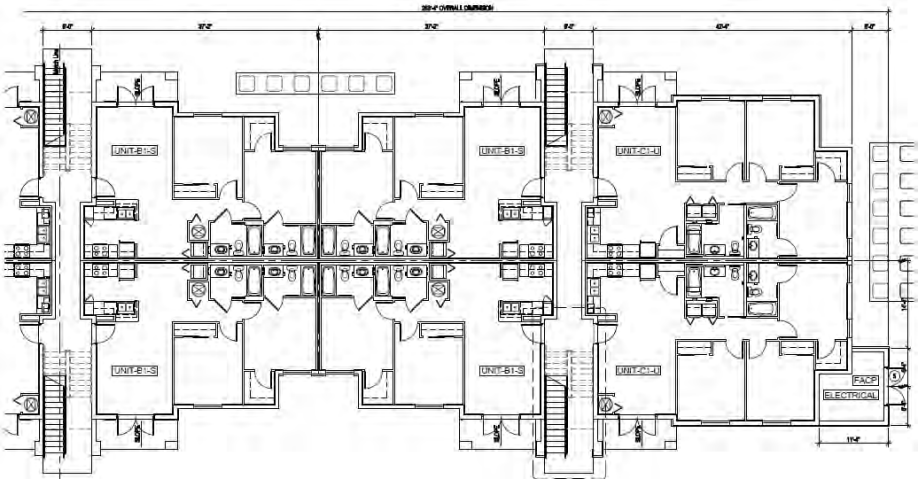
[SECOND FLOOR PLAN]

APPENDIX J: REFERENCE BUILDING 2

Three-Story Garden Style Building, 36 Units

[ELEVATION]



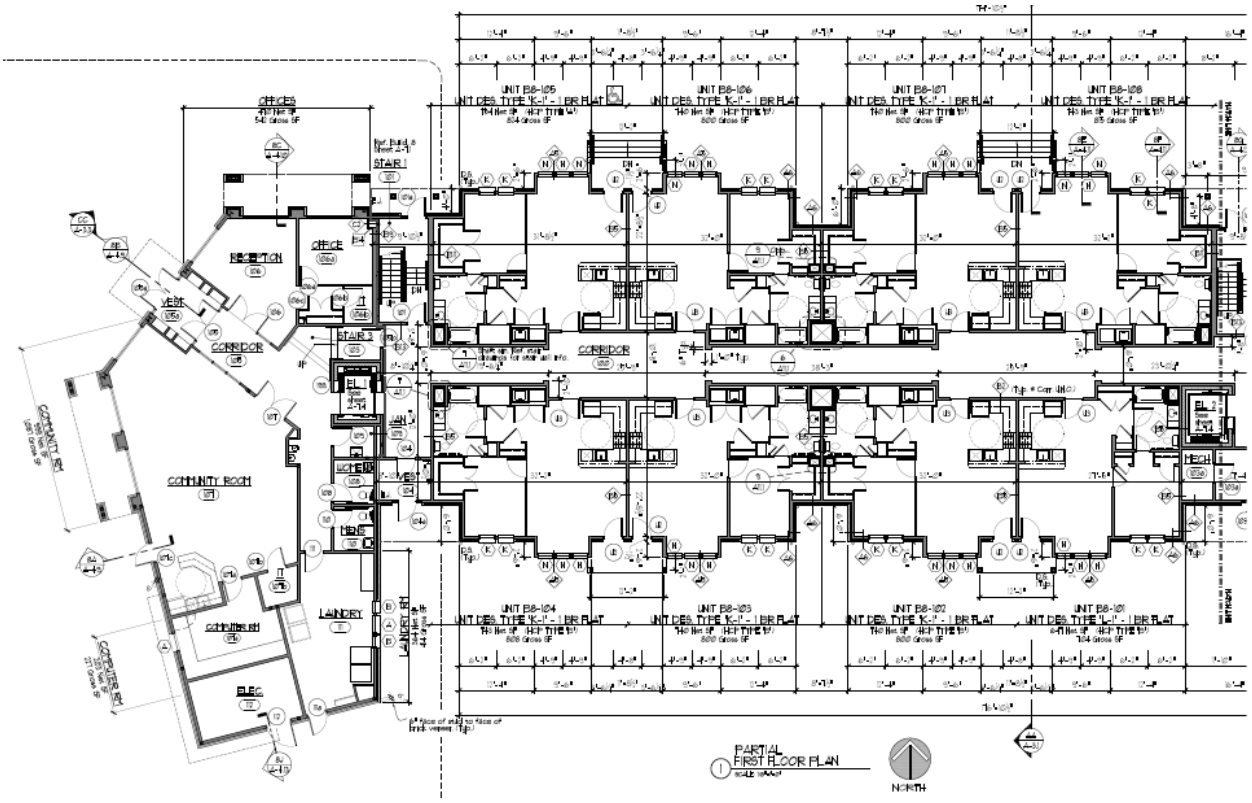


[FIRST FLOOR PLAN]

APPENDIX K: REFERENCE BUILDING 3

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

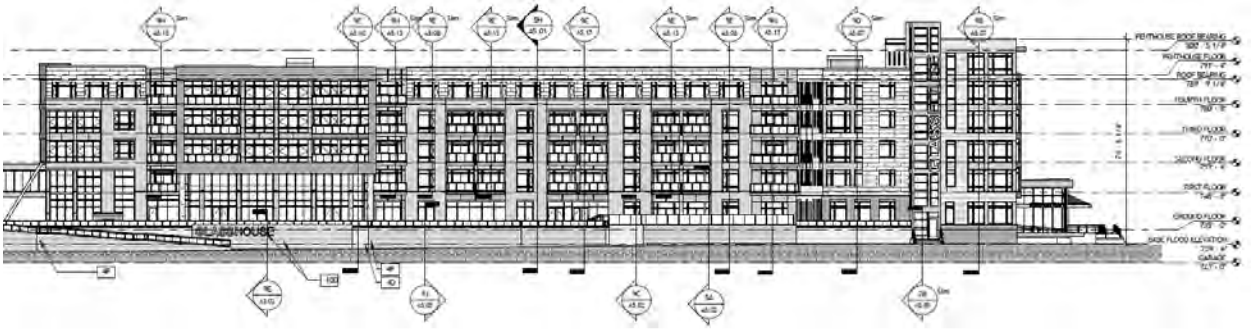
[ELEVATION]



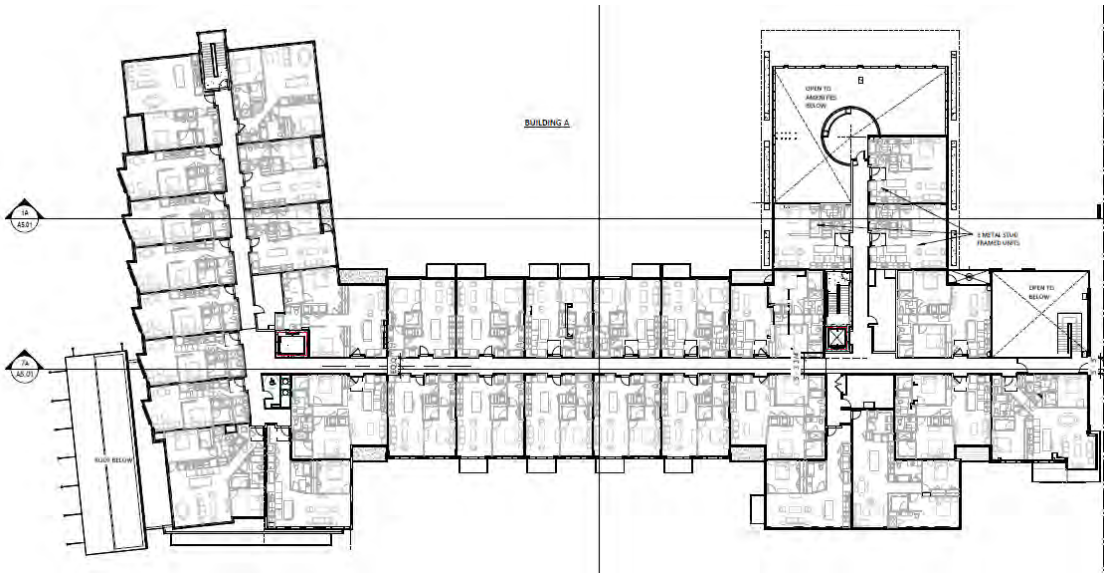
[PARTIAL FIRST FLOOR PLAN]

APPENDIX L: REFERENCE BUILDING 4

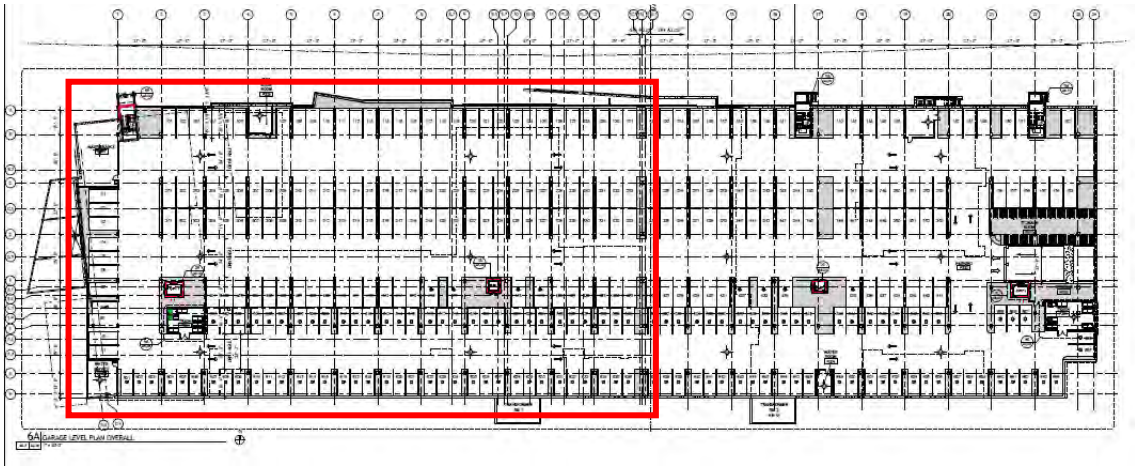
Five-Story Building on Two-Story Podium, 167 Units



[ELEVATION]



[FIRST FLOOR PLAN]



[GARAGE PLAN]

APPENDIX M: REFERENCE TOWNHOUSE

Four-Story Townhouse

[ELEVATION]

[FLOOR PLANS]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