Final Report

Modular Multi-family Construction:

A Field Study of Energy Code Compliance and Performance through Offsite Prefabrication

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

Prefabrication in a controlled, factory setting may improve the energy code compliance and energy performance of modular buildings compared to traditional site-built buildings. To test this premise, the work detailed in this DOE-funded commercial field study (EE0009082) compares the **energy code compliance** of 25 modular and 30 site-built multifamily buildings under construction in Los Angeles, San Francisco, Philadelphia and Seattle representing climate zones 3B, 3C, 4A and 4C respectively (Table 1). This dataset includes full data on 20 modular and site-built buildings and partial data on 35 modular and site-built buildings that had started prior to or were completed after the 18-month data collection period. This study also compares the post-occupancy **energy performance** or energy use intensity (EUI) of an additional 23 modular multifamily buildings and 128 site-built multifamily buildings.

Table 1. Code compliance data set of modular and site-built multifamily buildings.

	Modular		**Site-built**	
Location	Full Data	Partial Data	Full Data	Partial Data
Los Angeles, CA	3	4	2	7
San Fracisco, CA	4	1	4	3
Philadelphia, PA	3	5	2	8
Seattle, WA	2	3	0	4
	25		**30**	

Findings

Results suggest that the performance of key energy conservation measures (ECMs) in modular multifamily construction slightly exceeds the performance of key energy measures in site-built construction, particularly in climate zones 3B and 3C. While no project used the prescriptive path for energy code compliance, most key energy measures for most buildings sampled met or exceeded the prescriptive energy code requirements for each code in each climate zone (Figures 1-4). Although few differences were observed between the types of materials and equipment used in either modular or site-built multifamily construction, the installation quality of envelope measures (e.g. insulation, air barrier, etc.) in modular multifamily construction appeared to be better when compared to site-built construction.

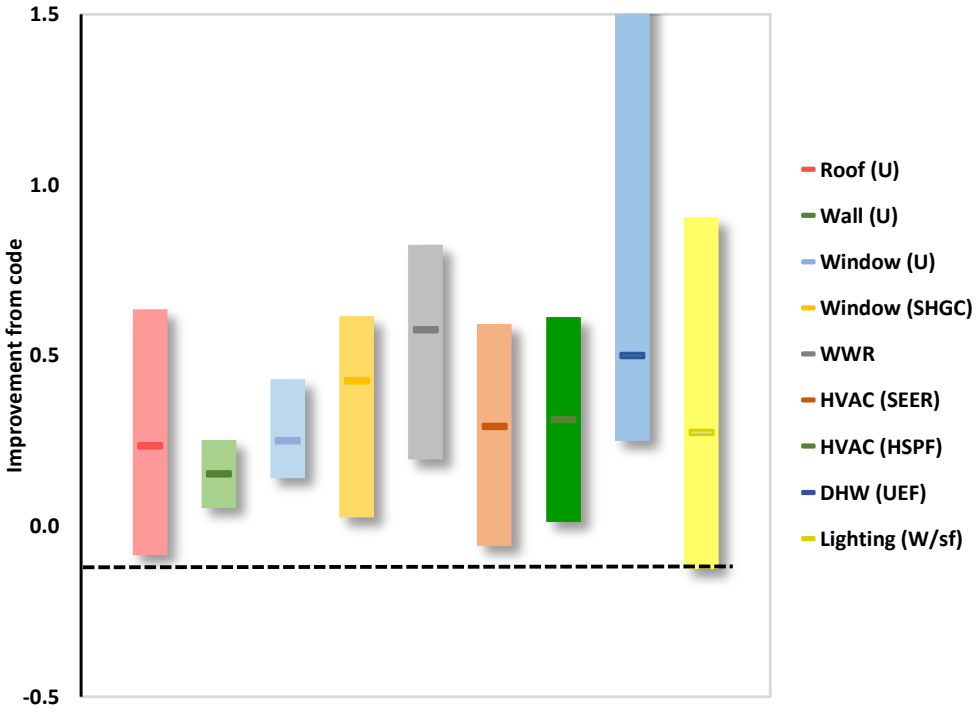


Figure 1. Modular ECM improvement from code (CZ3).

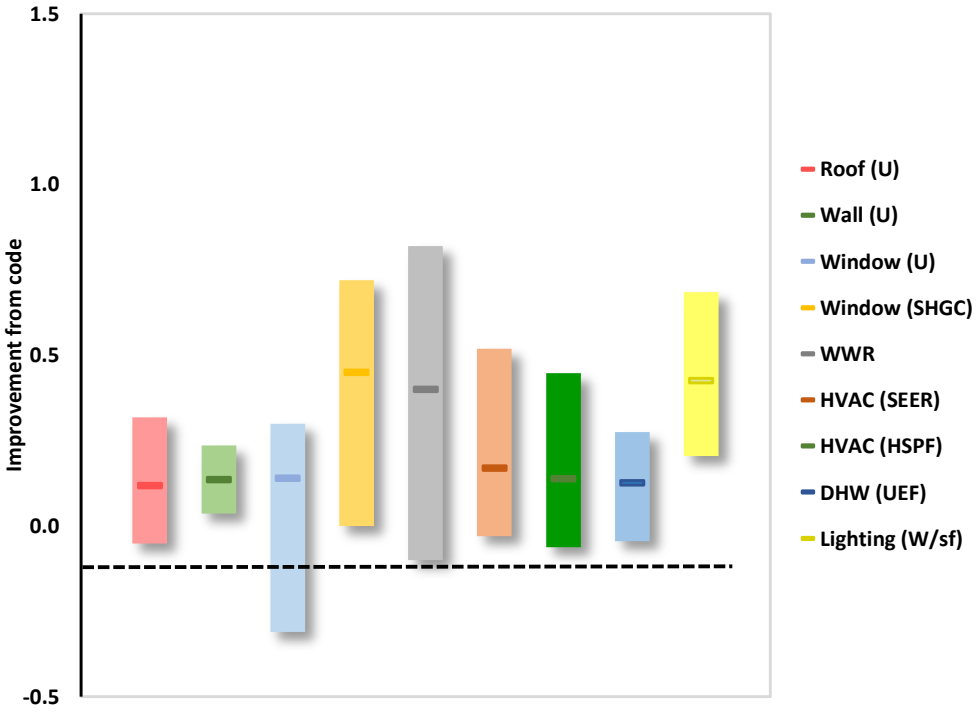


Figure 2. Site-built ECM improvement from code (CZ3).

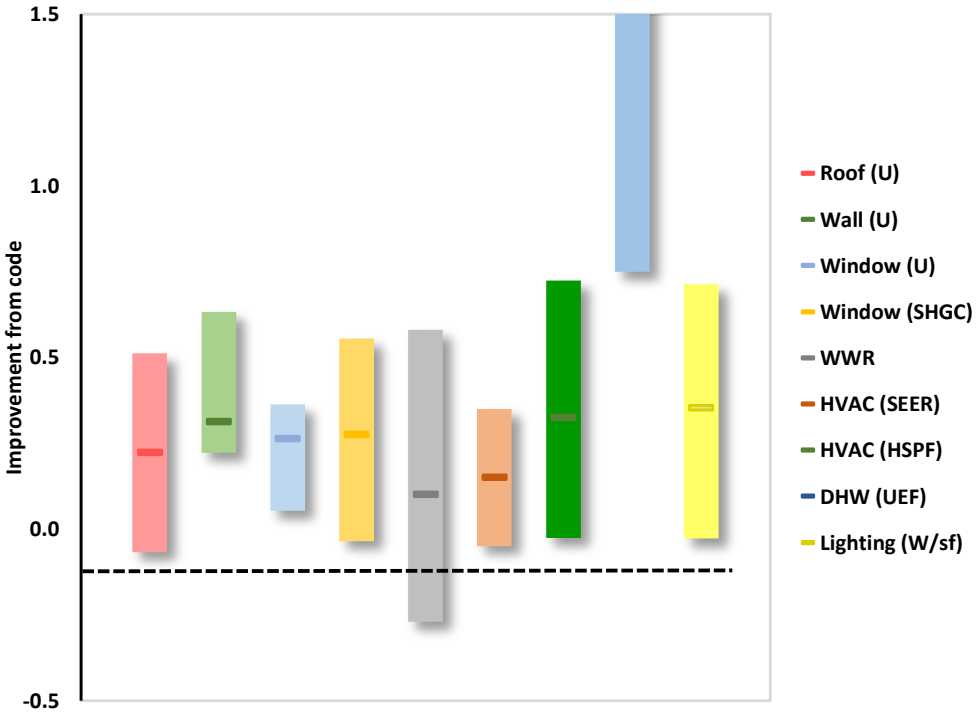


Figure 3. Modular ECM improvement from code (CZ4).

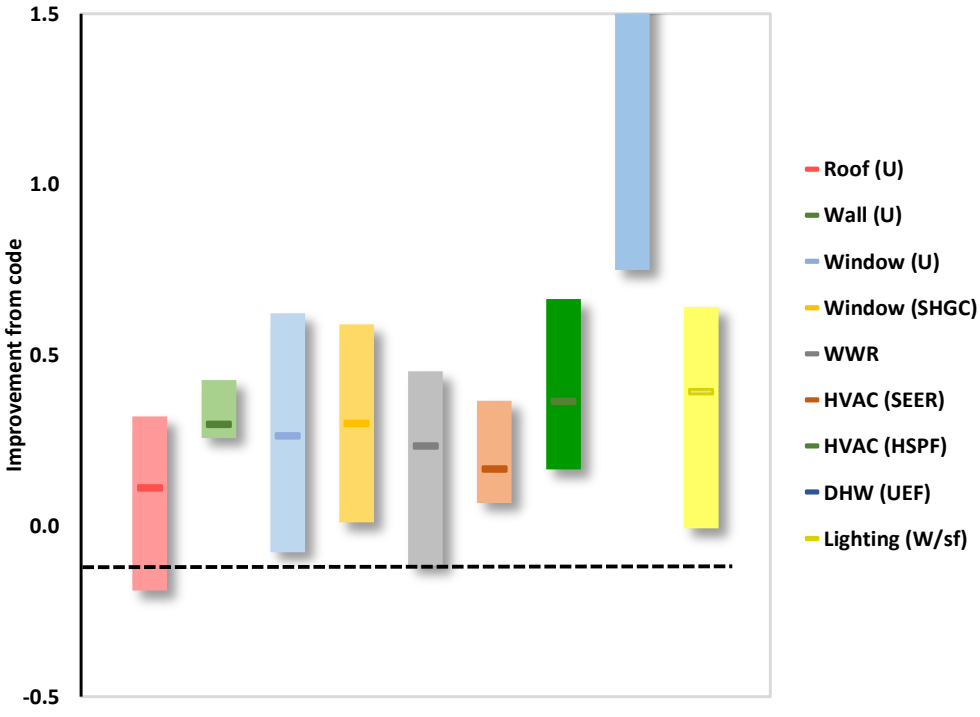


Figure 4. Site-built ECM improvement from code (CZ4).

Similarly, there appeared to be little difference in the post-occupancy energy performance of modular multifamily construction and site-built construction among buildings of similar age and typology. Differences in site energy use intensity between modular (36.0 kBtu/sf/yr) and site-built (35.8 kBtu/sf/yr) multifamily construction were on average <3%. However, ENERGY STAR™ scores for modular multifamily construction (86) were higher on average compared to site-built multifamily construction (81), suggesting that when normalized for occupant density and other energy use factors, the energy performance of modular multifamily construction may slightly exceed the energy performance of site-built construction (Table 2).

Table 2. Energy performance dataset of modular and site-built multifamily buildings.

	Modular			**Site-built**		
Climate Zone	Number of Buildings	EUI (kBtu/sf/yr)	Energy Star Score	Number of Buildings	EUI (kBtu/sf/yr)	Energy Star Score
3B	6	38.9	58	25	35.5	76
3C	9	38.8	91	64	33.0	86
4A	3	35.4	87	19	46.3	63
4C	5	28.0	98	20	32.0	93
	23	**36.0**	**86**	**128**	**35.8**	**81**

INTRODUCTION

The permanent modular construction (PMC) industry in North America has nearly tripled in volume since 2015, generating $12B in revenue in 2022, or roughly 6% of all new commercial construction starts. The reasons for continued growth include schedule savings, greater worker safety and environmental benefits. The Modular Building Institute (MBI) estimates that there are 255 modular manufacturing companies in North America generating some portion of revenue from commercial construction. Twenty-four of these manufacturers surveyed reported total production of 8.1M square-feet (sf) or approximately 338,480sf each. Projects averaged 24,060sf and 37 volumetric modules. The average total cost of these projects was $6.7M or $278.84/sf. Completion from approval to occupancy averaged 309 days. The multi-family sector was the largest market for the modular industry, accounting for more than one-third of all factory output (MBI, 2023).

Background

Off-site construction consists of building assemblies prefabricated in a manufacturing facility which are then transported and assembled onsite. Off-site construction may consist of single and multi-trade assemblies such as pipe racks, headwalls, and bathroom pods to complete volumetric and non-volumetric modular assemblies (Figure 5). Components and modules can be constructed of wood, steel or concrete. Volumetric modules can be completed to >90% finish in the factory. Building components manufactured in a controlled factory setting have the potential to reduce project cost, time, site logistics, and waste while also improving quality, labor productivity and safety.

For schedule or occupancy-driven projects having standardized, repetitive building units such as multi-family housing, offsite prefabrication of building modules can proceed simultaneously with onsite construction, reducing time, project overhead and the impact of weather. MBI found that modular multifamily projects were completed 6-8 months faster on average than comparable site-built projects, reducing costs and improving affordability (MBI, 2019). Modular projects can not only reduce the number of workers onsite, but also reduce or eliminate many of the safety risks common on site-built projects. In contrast to a transient workforce under the control of multiple trade contractors, offsite construction relies on a stable, permanent workforce under a central point of control. The repetitive nature of prefabrication in a controlled factory setting also allows fabricators to better utilize a more diverse workforce. The modular manufacturer can consolidate the scope, mark-ups and contingencies of several subcontractors while providing a productive offsite work environment free of disruptions from other trades and unpredictable site conditions.

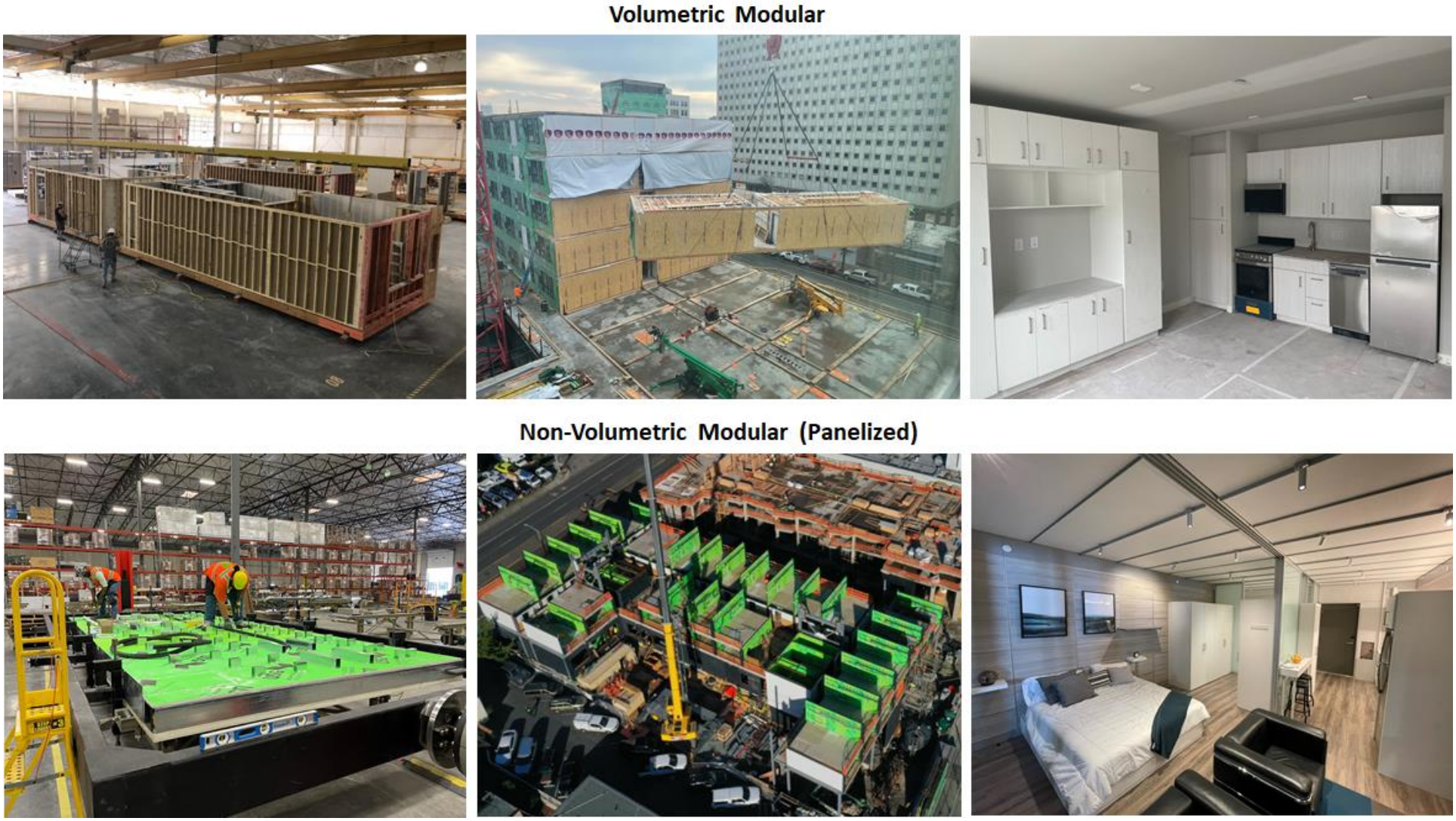


Figure 5. Volumetric and non-volumetric modular construction process.

Unlike manufactured housing (e.g. mobile homes) which are regulated by the U.S. Department of Housing and Urban Development (HUD) code, the modular construction industry is regulated by the same codes as site-built construction. Code compliance for the modular or 'offsite' portion of work is usually certified by the state where the building will be placed. Onsite work is permitted and inspected by local code authorities. In most cases, buildings are constructed in accordance with the International Building Code (IBC), including the International Energy Conservation Code (IECC), although code year may vary by jurisdiction.

Successful modular projects are generally those that incorporate modular construction early in design.[1] These projects generally have repetitive space use types that are amenable to modular dimensions. Typical module dimensions for commercial multifamily buildings are 14-16ft in width by 12ft in height by up to 70ft in length. Most modular multi-family buildings consist of 4-6 stories of Type-III wood or steel frame modules set over 1-2 stories of site-built Type-I podium or slab-on-grade.

Significant growth for modular multi-family construction is being realized on the West Coast and in the Northeast where housing affordability is forcing many residents to transition from single to multifamily housing. According to HUD, 24.6% of the U.S. population now lives in 32.6 million multifamily residences. As a result, the use of both volumetric and non-volumetric modular construction is expected to increase from 16% of multifamily projects to over 50% of projects by 2025 (Dodge, 2020).

Decarbonization has become another important driver for the use of modular construction. McKinsey & Company reports that world-wide, roughly $130 trillion will be spent by 2027 to renew and decarbonize the built environment. According to MBI, modular construction has the potential to reduce construction waste, improve energy efficiency and lower carbon footprint. To date, however, the evidence supporting these assumptions has been largely anecdotal.

[1] https://www.aia.org/resources/6119840-modular-and-off-site-construction- guide.

Purpose and Scope

The purpose of this study is to determine if greater quality controls associated with modular construction improves energy code compliance and energy performance in commercial multifamily buildings. Accordingly, this report is presented two main parts - a code compliance study and an energy performance study.

The goal of the **code compliance study** was to compare the compliance of key energy conservation measures (ECMs) of 10 modular and 10 site-built commercial multifamily buildings under construction in the metro areas of Los Angeles and San Francisco, CA (CZ 3B and 3C), Philadelphia, PA (CZ 4A) and Seattle, WA (CZ 4C). Complete data was obtained on 12 modular and 8 site-built commercial multifamily buildings. Partial data was obtained on an additional 13 modular and 22 site-built multifamily buildings.

The goal of the **energy performance study** was to compare the energy use intensity (EUI) of 25 completed modular multifamily buildings to a baseline of site-built multifamily buildings using post-occupancy energy use data. Post-occupancy EUI data was obtained on 14 completed modular multifamily buildings. Building energy modeling (BEM) was used to obtain EUI data on an additional 9 modular multifamily buildings.

Additionally, the air leakage rates of 7 modular dwelling units were compared to the air leakage rates of 11 site-built dwelling units using blower door tests. Interviews were also conducted with project stakeholders during factory and construction site visits to identify key market benefits and barriers including schedule savings, construction cost, transportation and site logistics, facility investments, financing and project delivery methods. Other factors such as materials and waste, permitting and inspections, safety and productivity, and design flexibility were also discussed.

For this study, commercial multifamily buildings were defined as apartments and similar R-2 occupancies (i.e., condominiums, student dormitories and assisted living) at least 4 stories in height above grade. For mixed-use multifamily projects, data collection was limited to residential units and spaces directly associated with residential units (i.e., corridors, stairwells, lobbies, offices and other common spaces). Applicable commercial codes included the 2016 and 2019 California Title 24 Energy Code and the 2015 and 2018 International Energy Conservation Code (IECC) with state amendments.

CODE COMPLIANCE STUDY

The goal of the code compliance study was to compare the compliance of key energy conservation measures (ECMs) of 10 modular and 10 site-built commercial multifamily buildings under construction in the metro areas of Los Angeles, San Francisco, Philadelphia and Seattle. Complete data was obtained on 12 modular and 8 site-built commercial multifamily buildings. Partial data was obtained on an additional 13 modular and 22 site-built multifamily buildings (Appendix B). Evaluations for each project included identification of key energy conservation measures (ECMs) from construction documents, factory visits and (or) construction site inspections.

Methods

To determine if modular construction improved energy performance compared to traditional site-built construction, a methodology was developed to validate the energy code compliance of modular and site-built commercial multifamily buildings under construction in the metro areas of Los Angeles, CA (CZ 3B), San Francisco, CA (CZ 3C), Philadelphia, PA (CZ 4A) and Seattle, WA (CZ 4C). This methodology consisted of 1) identification of priority energy measures, 2) development of data collection protocols, 3) selection and training of data collection team, 4) project recruitment, 5) data collection and 6) data analysis. Multifamily buildings were defined as apartments and similar R-2 occupancies (i.e., condominiums, student dormitories and assisted living) at least 4 stories in height above grade. For mixed-use multifamily projects, data collection was limited to residential units and spaces directly associated with residential units (i.e., corridors, stairwells, lobbies, offices and other common spaces). Applicable commercial codes included the California Title 24 Energy Code (2016 and 2019) and the International Energy Conservation Code (2015 and 2018) with state amendments.

Energy Measures

A total of 38 measures were selected for code compliance study based on their energy savings potential in commercial multifamily settings (Table 3). ECMs were selected for study based on their energy savings potential. This process began with a PNNL developed inventory of energy code requirements applicable to various building types and climate zones of interest from the non-residential provisions of the IECC and ASHRAE 90.1.[2] Requirements not applicable to the building types or climate zones to be analyzed were removed.

[2] https://www.energycodes.gov/sites/default/files/2021-02/Com_Code_Compliance_Lost_Sav_121720.pdf

The resulting requirements were grouped into measures that could be verified and evaluated. For each measure, the code-compliant condition was identified along with a reasonable worst-case code condition. For measures such as insulation, a reasonable worst-case condition may be omission of insulation. For measures such as HVAC, a reasonable worst-case condition may be the minimum requirements in the previous code edition.

Table 3. Energy conservation measures (ECMs) selected for code compliance study.

Category	**Energy Efficiency Measures**	
Envelope	Roof insulation Wall insulation Window U-factor Continuous air barrier	High reflectance ('cool') roofs Window-to-wall ratio Window SHGC Entrance vestibules
HVAC – Space Cooling Equipment	Split AC efficiency PTAC/VTAC efficiency Mini/multi-split efficiency	Split HP efficiency PTHP/VTHP efficiency
HVAC – Space Heating Equipment	Split HP efficiency Mini/multi-split efficiency Central boiler efficiency	PTHP/VTHP efficiency Gas furnace efficiency
HVAC – Controls	Thermostat dead-band Ventilation night fan control	Thermostat setback Duct leakage
DHW – Equipment	Central boiler (DHW) efficiency In-unit electric storage efficiency Storage unit heat traps	In-unit gas storage efficiency In-unit tankless/instant efficiency Pipe insulation, recirculation
DHW - Controls	Central temperature maintenance	Central recirculation controls
Lighting Systems and Controls	Interior power allowance/LPD Manual control Occupancy sensor control Exterior lighting control	Exterior power allowance/LPD Automatic time switch control Daylighting control
Onsite Renewables	Solar photovoltaics and water heating	

Next, the energy performance and energy cost of code-compliant and worst-case code conditions for each measure were simulated. Prototype building models were used to perform energy simulations for each measure and to quantify the lost energy cost savings of the worst-case condition in relation to the code-compliant condition. PNNL has developed a suite of building models using *Energy Plus* to analyze the energy performance of non-residential energy codes in 16 building types including mid and high-rise multifamily. Code-compliant versions of each prototype in each of the 17 climate zones in the United States are available for each version of the IECC and ASHRAE 90.1 since 2004. Modeling specifications and parameters for a sample mid-rise multifamily apartment building are provided in Appendix A.

To estimate the energy cost, PNNL used annual average commercial building energy prices based on Energy Information Administration (EIA) statistics. The value of lost savings was determined for the life of the building component. For the building envelope, component life was assumed to be 30 years. For all other measures (e.g. HVAC, DHW, lighting, etc.) component life was assumed to be 15 years. To account for the time value of money, future savings were discounted using a discount rate of 3.0% with a factor accounting for escalation of energy prices faster than general inflation. Using a simplified method of projecting life-cycle value of savings, a uniform present value (UPV) factor was applied to the annual savings to reflect the discounted value of savings over the measure life. This approach generally follows the methodology established by the Federal Energy Management Program (FEMP) for federal building energy projects. The annual energy cost increase of the worst-case code condition for each measure was normalized to 1,000sf of conditioned building area so that measures could be compared and ranked according to their lost energy costs savings potential (Figure 6). Measures likely to have the largest impact on energy performance and cost savings were identified and selected for inclusion in the study.

Projects chosen for this study included buildings with Group R-2 occupancies four stories or more in height above grade plane. Group R-2 occupancies included buildings containing more than two dwelling units where occupants are primarily permanent in nature (e.g. apartments, condominiums, dormitories, and senior living). Several buildings included retail, office and other mixed-use occupancies, however, only spaces associated with residential occupancies were included in the data collection and analysis of energy conservation measures (ECMs). Spaces associated with residential occupancies included dwelling units, residential common spaces and corridors.

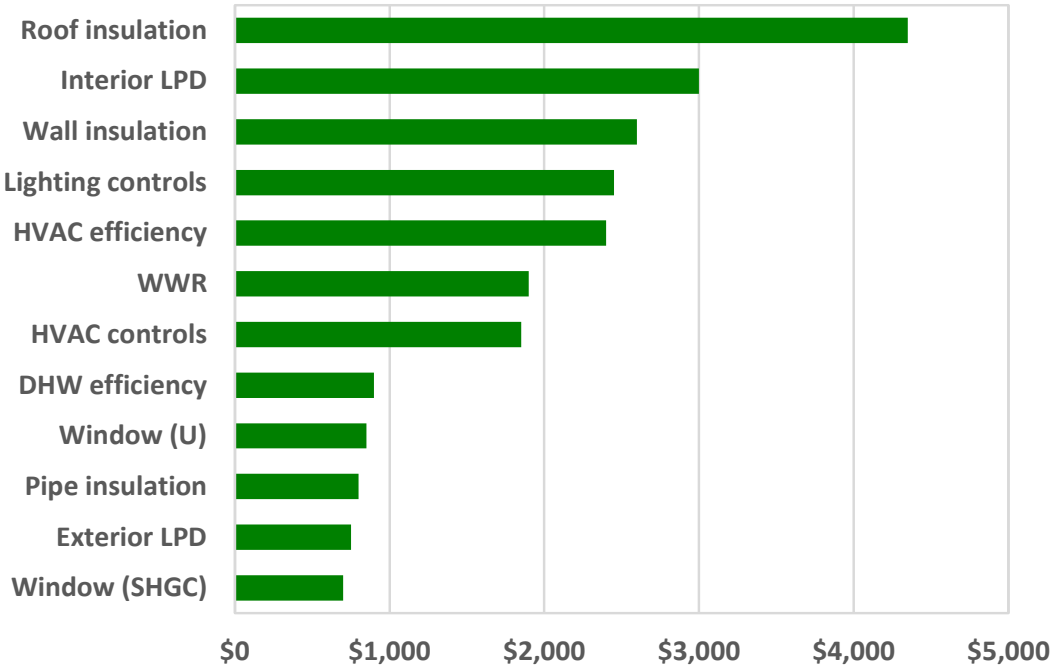


Figure 6. Example lost energy cost savings simulation ($/1,000sf).

Summary of PNNL lost energy cost savings methodology:

1. Identify energy code requirements for building types and climate zones of interest.
2. Combine related requirements into energy conservation measures (ECMs).
3. Determine the worst-case, non-code-compliant condition for each measure.
4. Perform energy simulation using a prototype model of code-compliant and worst-case conditions for each measure in each building type and climate zone of interest.
5. Estimate the lost energy cost savings for each measure based on the worst-case condition.
6. Prioritize and select measures with the highest lost energy cost savings potential.

A sensitivity analysis was performed using a prototype building simulation to estimate the energy cost impact of variation from code requirements for each measure. This allowed lost energy cost savings to be assigned to the range of conditions likely to be encountered in newly constructed buildings. Pre-inspection 'scouting' visits were conducted at several factory and project sites to ensure that the 38 measures selected for code compliance study were applicable to both modular and site-built multifamily construction in climate zones 3B, 3C, 4A and 4C.

Data Collection Protocols

Data collection for each project began with a review of construction documents followed by two (2) field inspections. Project drawings, specifications and energy code compliance reports were used to qualify each project for study inclusion, verify code, code year, code compliance path and, collect code compliance information on each of the envelope, HVAC, water heating and lighting measures identified for study (Table 4). Field inspections were then used to verify that installed materials and equipment were the same or equivalent to those specified in the construction documents. For modular multifamily projects, one inspection was conducted at the manufacturing site to verify envelope compliance and a second inspection was conducted at the construction site to verify HVAC, water heating and lighting compliance. For site-built projects, both inspections were conducted at the construction site; the first prior to installation of finishes and the second near the end of construction prior to occupancy.

Table 4. ECMs observed during plan review, factory inspection and site inspection.

Data Category	Data Collected	Document Review	Factory Inspection	Site Inspection
Building	Location, gross floor area, conditioned area, stories, dwelling units	●		
Code	Climate zone, code, code year, compliance path	●		
Roof	Assembly type, area, reflectance, insulation type, U-factor, quality	●	●	
Wall	Assembly type, area, orientation, insulation type, U-factor, quality	●	●	
Window	Assembly type, area, U-factor, SHGC, frame type, pane type, WWR	●	●	
Air Barrier	Assembly type, air leakage rate	●	●	
HVAC	Type, energy source, capacity, efficiency, unit count, duct location	●	●	●
Controls	Type, thermostat dead-band, setback, ventilation night fan control	●	●	●
DHW	Type, energy source, capacity, efficiency, unit count, pipe insulation	●	●	●
Controls	Temperature, recirculation, heat trap	●	●	●
Lighting	Fixture type, fixture wattage, interior/exterior location, LPD	●	●	●
Controls	Manual, occupancy sensor, dimmer, daylight, photocell, time switch	●	●	●

On-Screen Takeoff (OST) software was used for review of construction drawings. As a scalable PDF plan reader, OST was an effective tool for quantifying gross floor area and conditioned floor area as well as area and orientation of roof insulation, wall insulation and fenestration (Figures 7-8). OST was also effective in accurately accounting for HVAC and DHW equipment systems and lighting fixtures by type and location (Figure 9). OST was also used to calculate both interior and exterior lighting power density (Figures 10-11). The values generated by OST were compared to those used in the project energy reports for energy code compliance and permitting. HVAC and DHW equipment performance data collected from construction documents, energy reports and field inspections were also verified using the Air-Conditioning, Heating, & Refrigeration Institute (AHRI) Directory of Certified Product Performance[3] (Figure 12).

[3] https://www.ahridirectory.org/

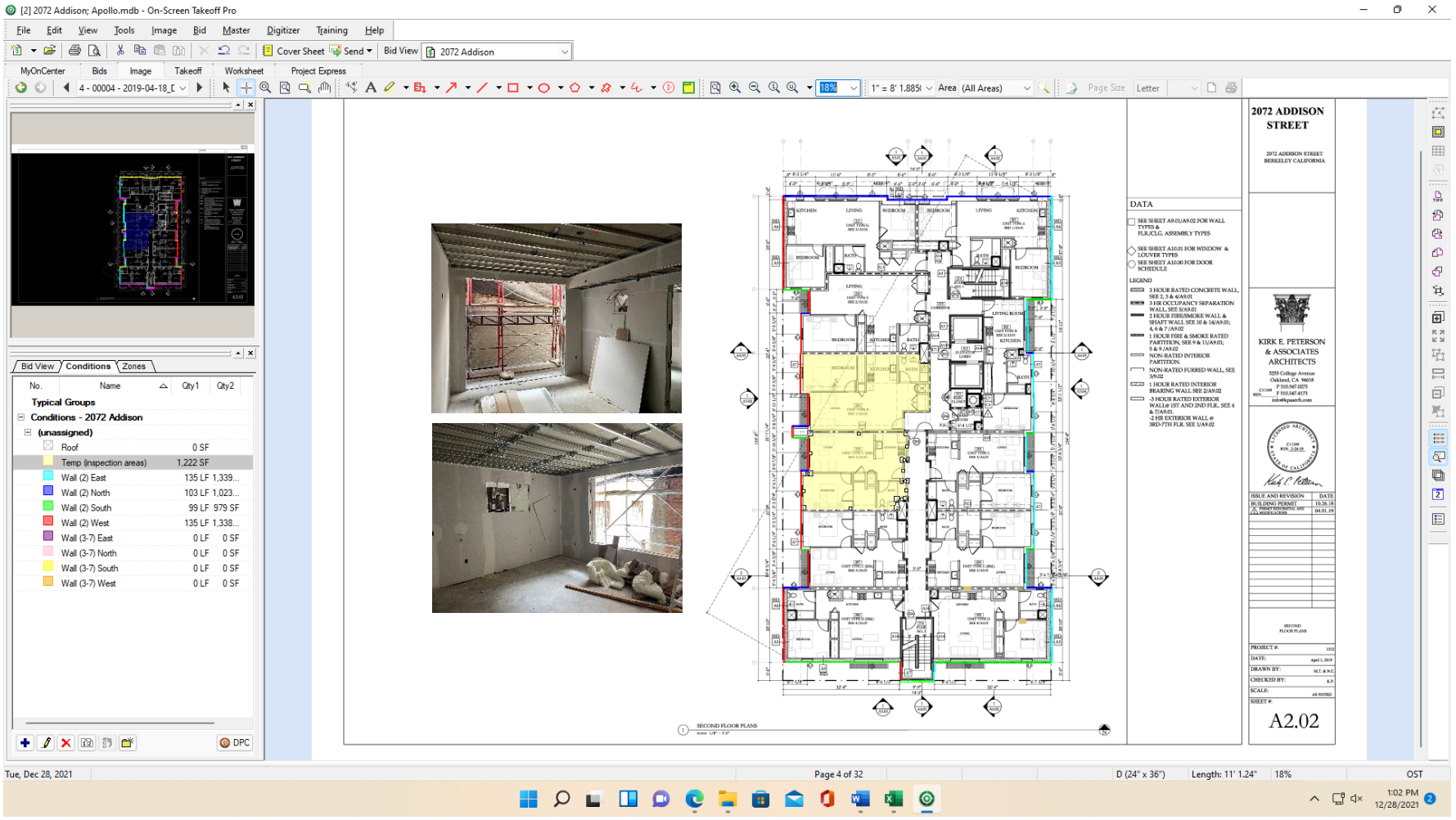


Figure 7. OST building floor area and sample spaces.

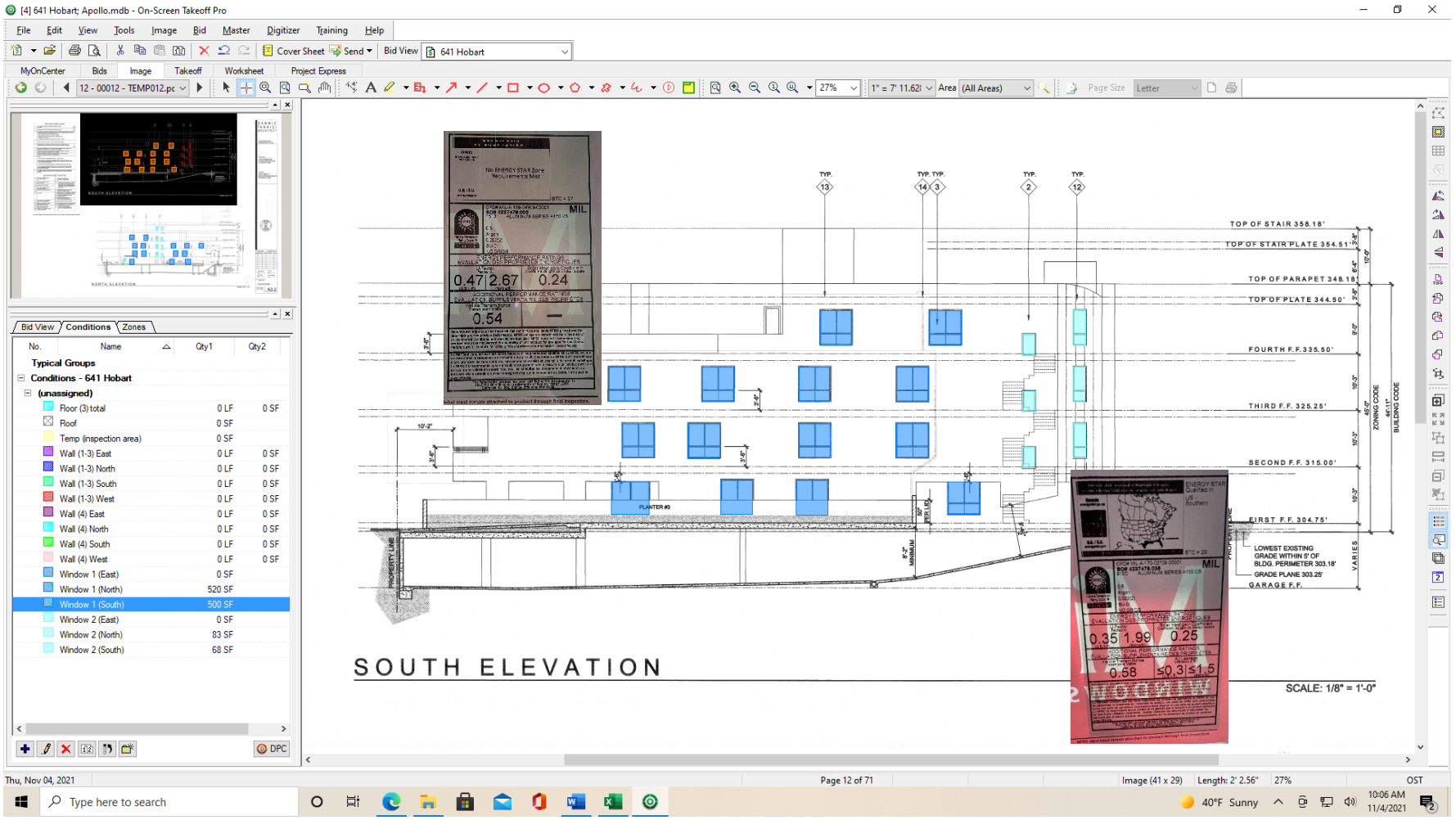


Figure 8. OST building envelope and fenestration.

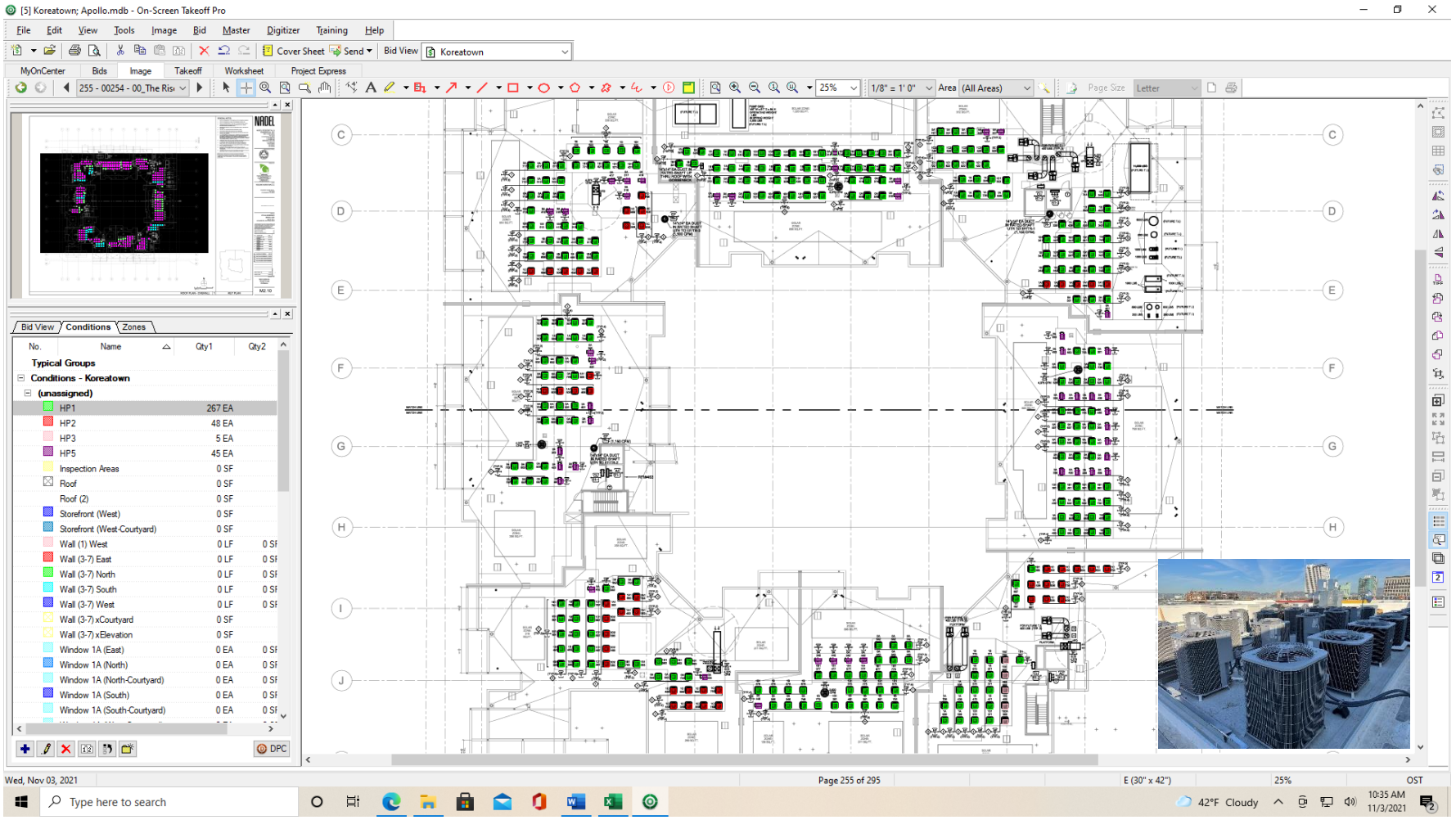


Figure 9. OST HVAC and DHW.

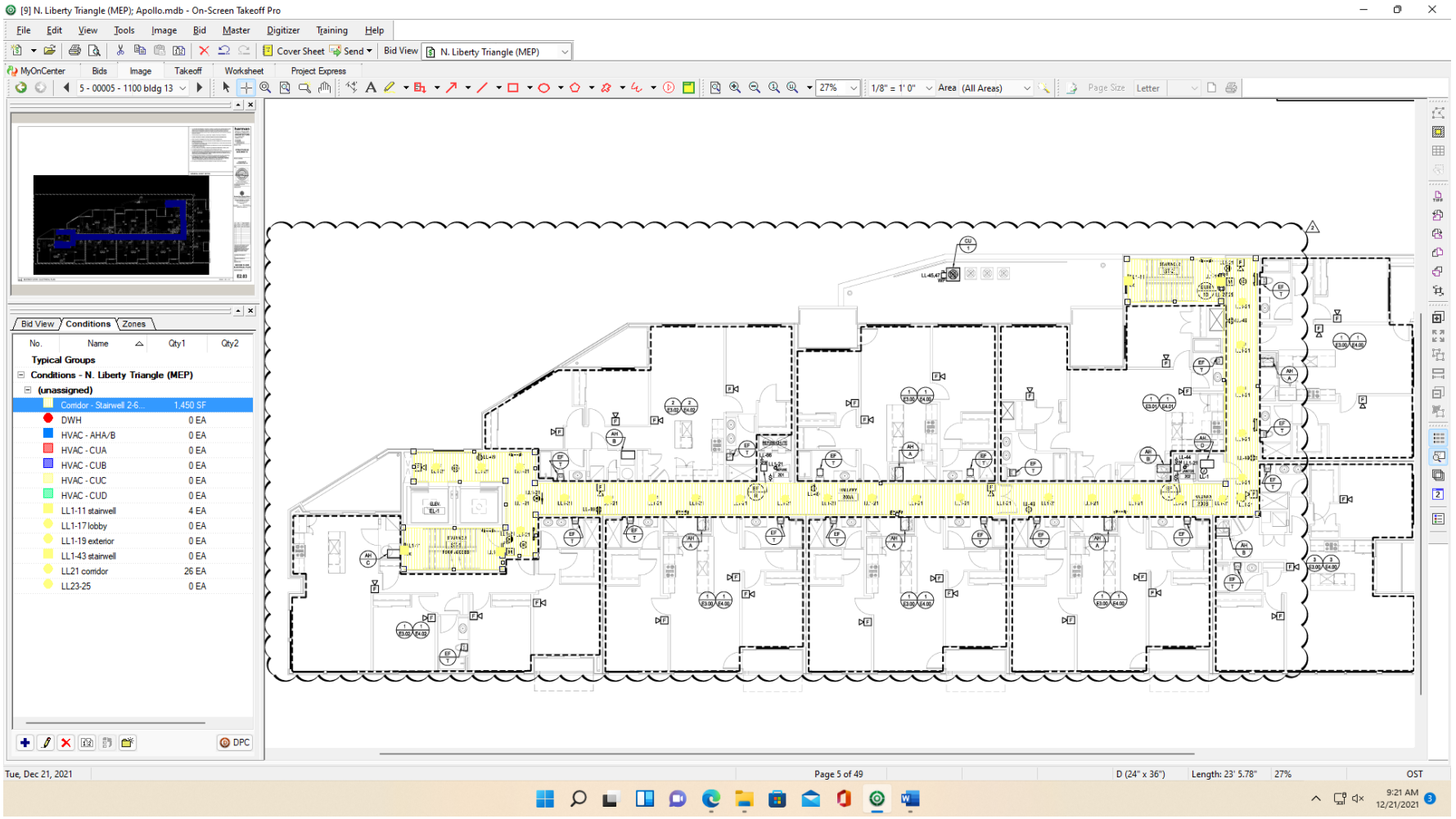


Figure 10. OST Indoor lighting.

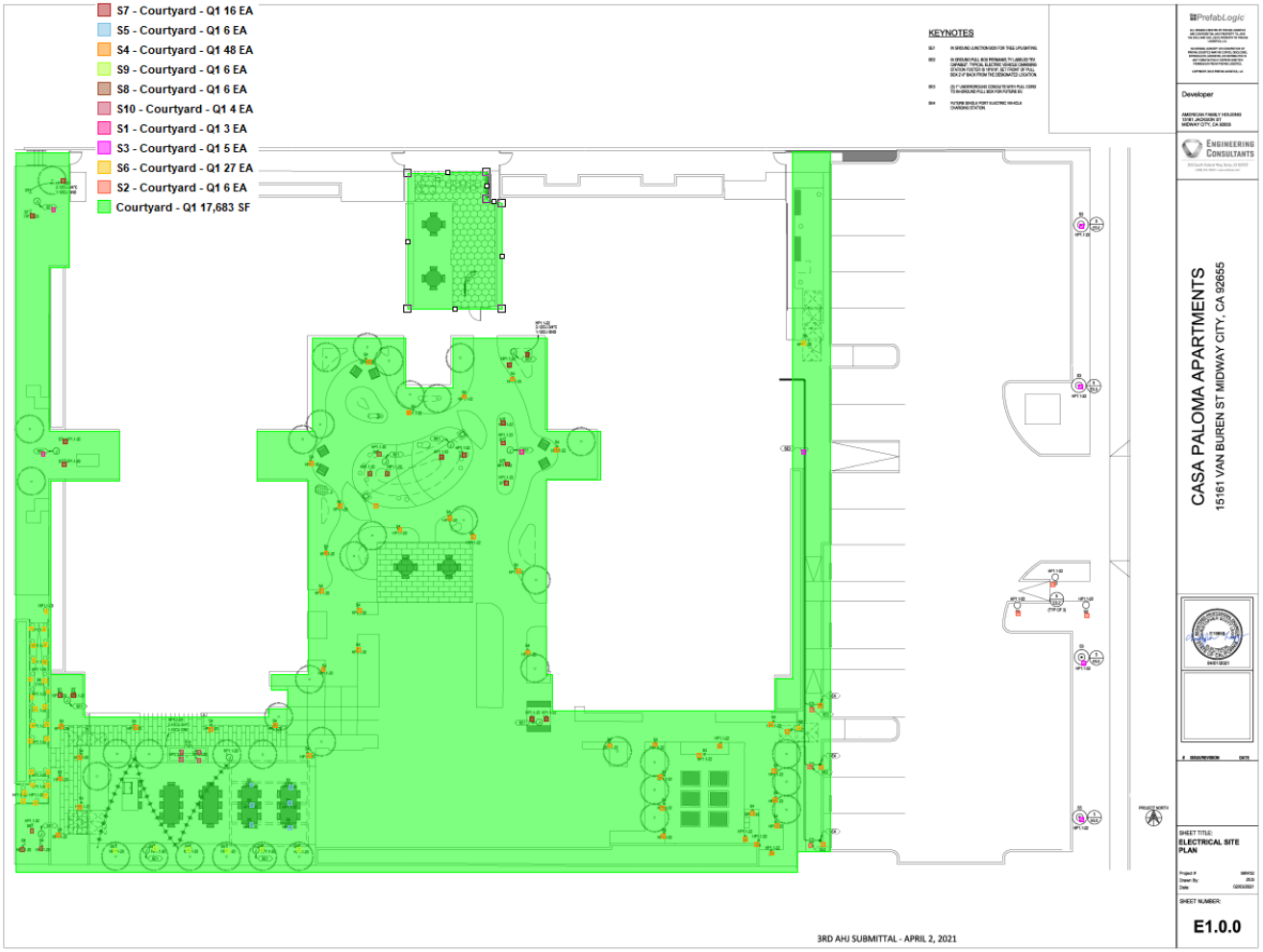


Figure 11. OST outdoor lighting.

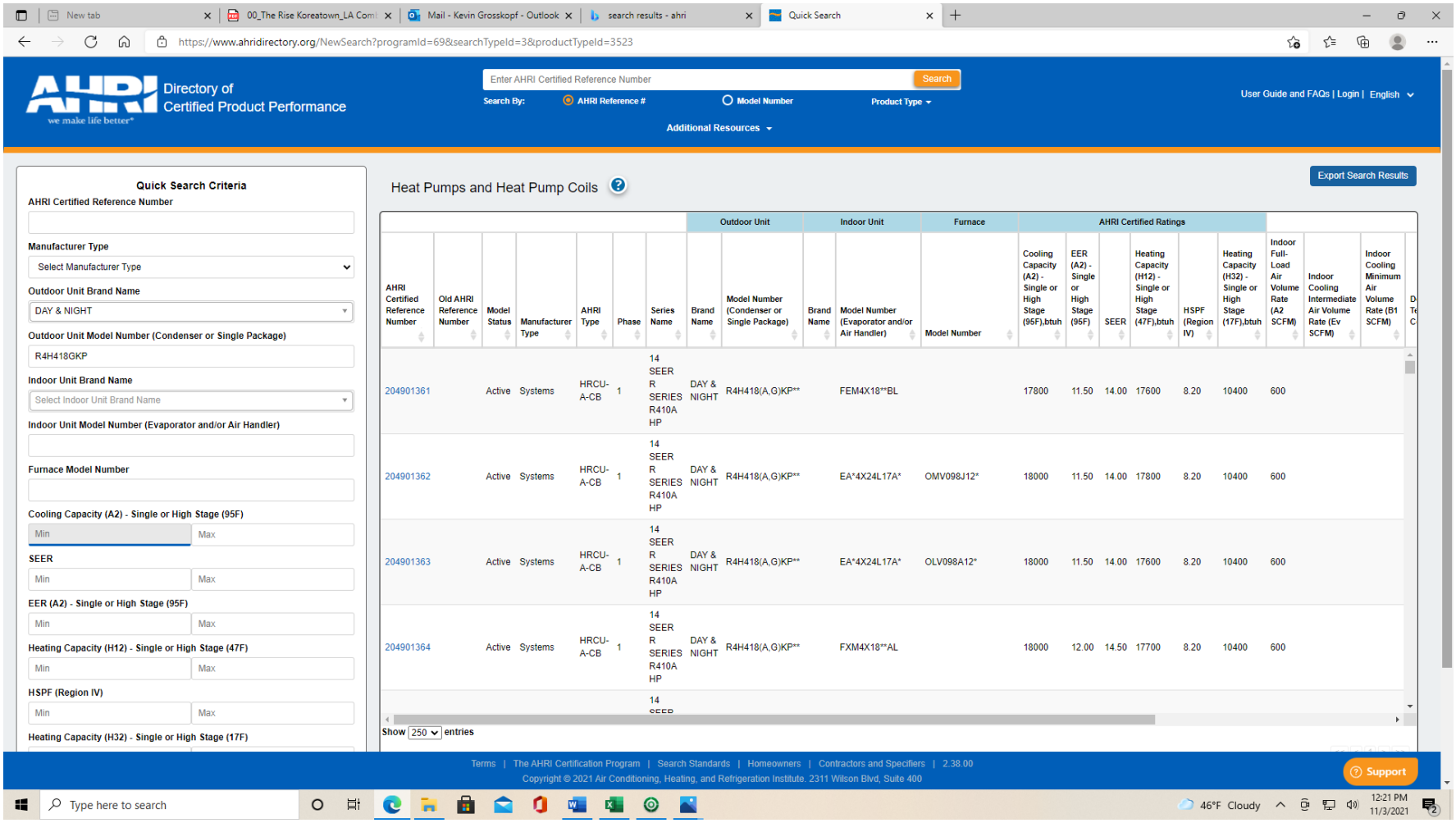


Figure 12. AHRI verification (HVAC and DHW).

A data collection protocol was developed to provide step-by-step instructions on how to collect plan review, factory and site inspection data. Included within this protocol were instructions on minimum sample sizes for space types and use of project data collection forms. Data was collected from 10% of units in buildings up to 50 units (3 minimum). For buildings with more than 50 units, data was collected from 2% of additional units over 50 units. For building with more than 200 units, data was collected from 1% of additional units over 200. Data was also collected from 10% of common spaces, corridors and stairwells in each building (minimum 2 each). Electronic data collection forms were developed to record code compliance information for each measure during document review, factory inspection and site inspection and, to archive this information in a secure database. A photographic journal of products, labels, and observed conditions for each measure was prepared following each factory and site inspection to verify the code compliance information provided in the construction documents and in the data collection forms. Information identifying projects and project participants was redacted.

Project Recruitment

Modular and site-built projects were recruited in each of 4 study climate zones (3B, 3C, 4A and 4C). Modular multifamily buildings were identified with the assistance of known multifamily modular manufacturers prior to construction (approximately 85% of commercial modular multifamily projects in study areas were fabricated by 6-8 manufacturers). Site-built buildings were identified by multifamily internet search sites. 'Walk ups' were then conducted to recruit site-built projects appropriate for inclusion in the field study. For each building included in the field study, written approval was obtained by the project developer or general contractor to provide construction documents and to access the construction site for data collection.

Results

Complete data was obtained on 12 modular and 8 site-built commercial multifamily buildings. Partial data was obtained on an additional 13 modular and 22 site-built multifamily buildings (Appendix B). For each project, data was first collected on general building characteristics to qualify projects for study inclusion and to ensure that the modular sample was comparable to the site-built sample. As shown (Table 5) average building floor area, story height and number of residential units between samples were similar. Of note, residential units in modular multifamily buildings were smaller on average with a greater composition of studio and one-bedroom units compared to site-built buildings with a greater composition of two and three-bedroom units. Related, modular multifamily buildings were found to have a greater composition of affordable residential units (65%) compared to site-built buildings with a greater composition of market-rate units (62%).

Table 5. Modular and site-built building floor area, story height and number of residential units.

	Gross Area	Conditioned Area	Residential Area	Story Height	Number of Units	Unit Area	Affordable
Modular	127,882sf	84%	72%	6	161	556sf	65%
Site-built	157,066sf	77%	67%	6	122	826sf	38%

Buildings included in the sample averaged 140,390 gross square feet (GSF) of floor space (Figure 13). Modular buildings averaged 127,882GSF (range 36,147-535,778GSF) and site-built buildings averaged 157,066GSF (range 21,035-688,165GSF). Buildings in the sample averaged 6 stories in height above grade (Figure 14). Modular buildings averaged 6 stories (range 4-14) and site-built buildings also averaged 6 stories (range 4-9). Buildings included in the sample averaged 144 dwelling units per building (Figure 15). Modular buildings averaged 161 dwelling units (range 36-410). Site-built buildings averaged 122 dwelling units (14-363) per building. Modular dwelling units averaged 556sf per dwelling unit. Site-built dwelling units averaged 826sf per dwelling unit.

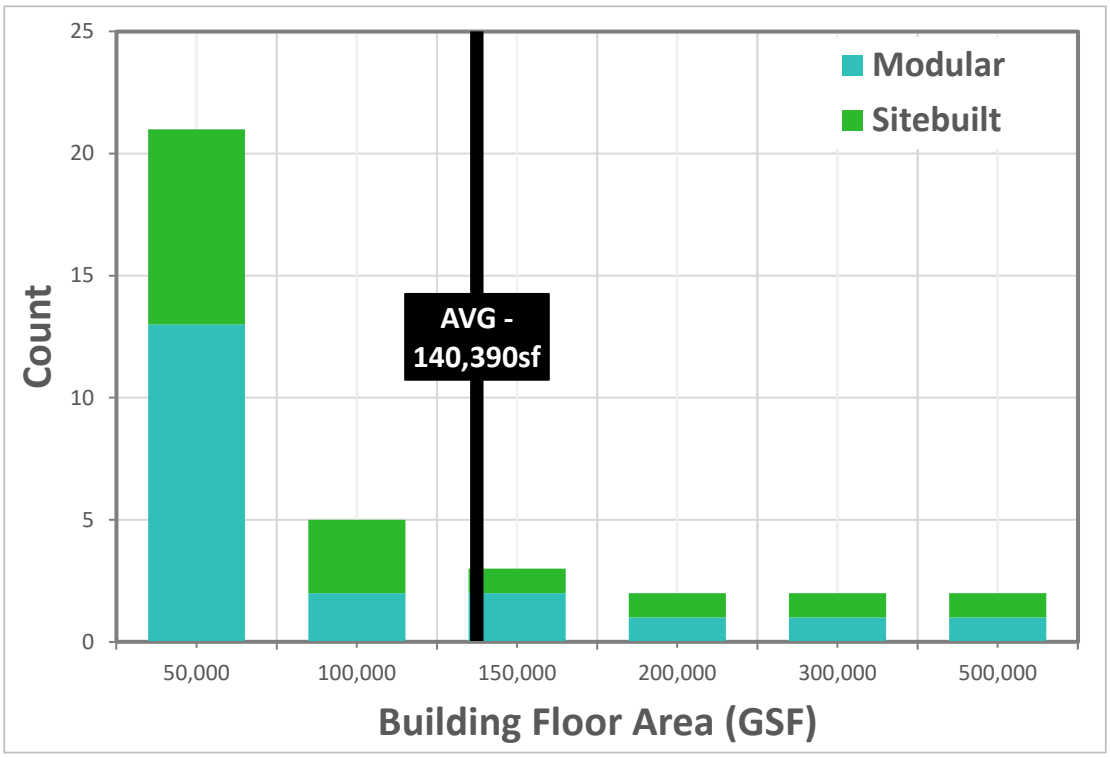


Figure 13. Modular and site-built building floor area.

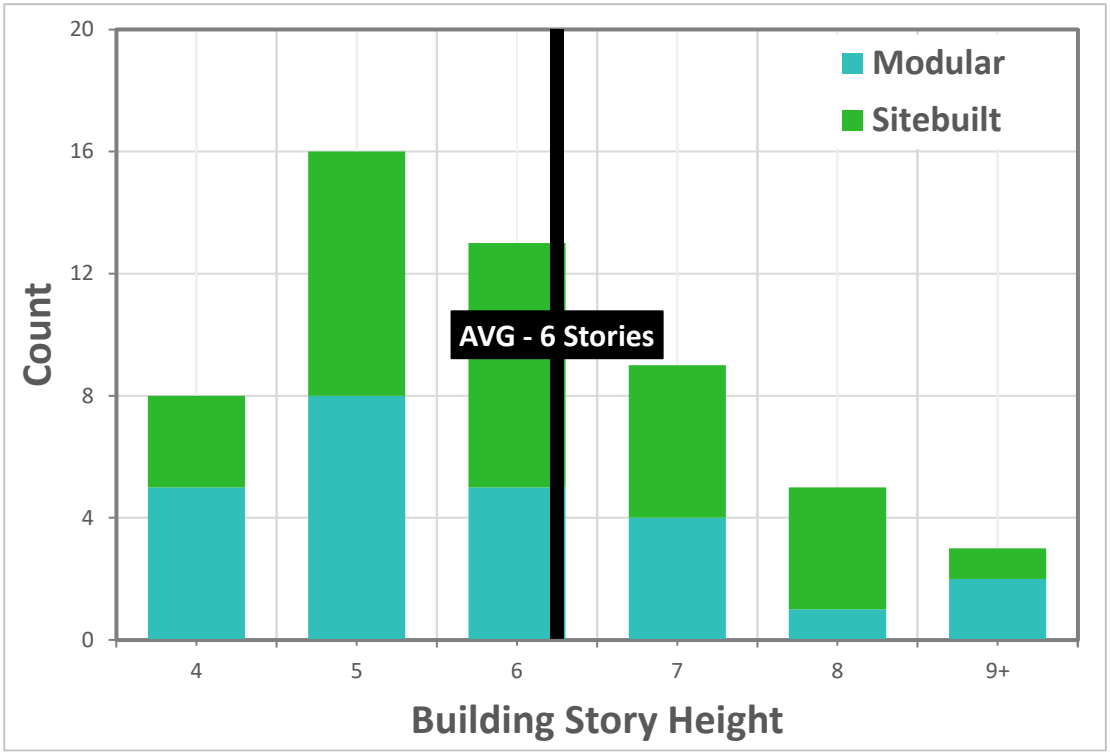


Figure 14. Modular and site-built building story height.

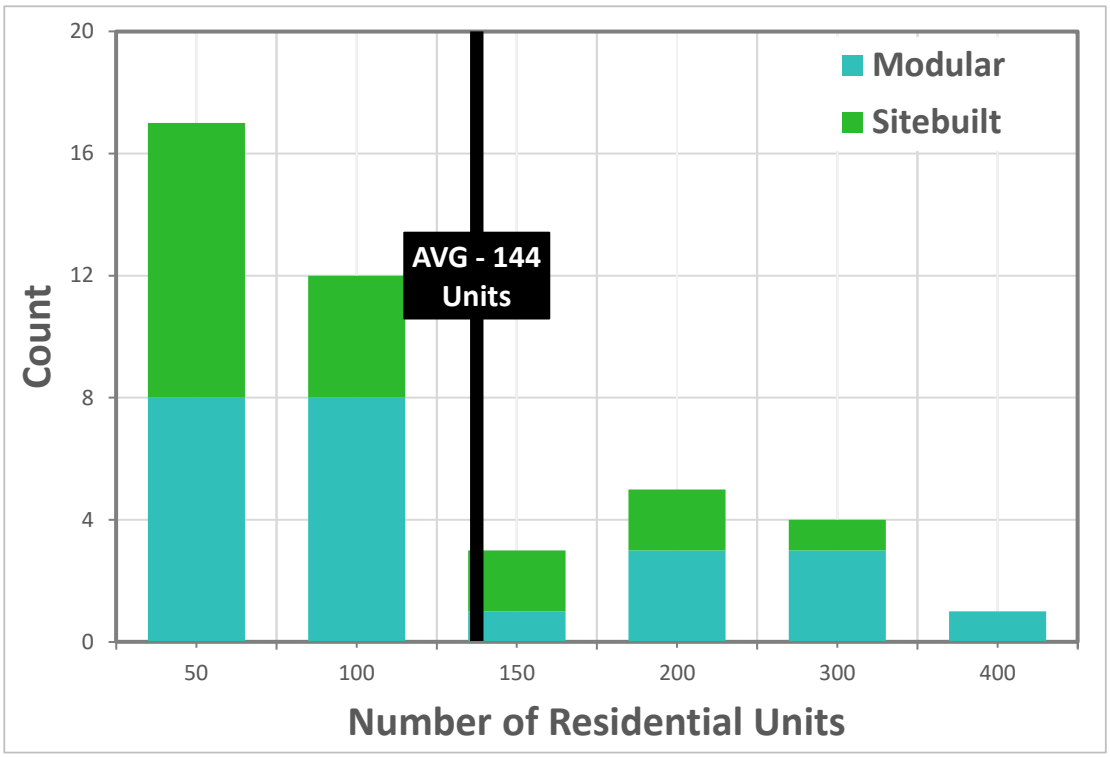


Figure 15. Modular and site-built building number of residential units.

Of 55 total code compliance projects, 28 are located in California. Of these, 16 projects (7 modular and 9 site-built) are located in the greater metro area of Los Angeles (CZ 3B). 12 projects (5 modular and 7 site-built) are located in the San Francisco Bay area (CZ 3C). All California projects were permitted under the 2016 or 2019 version of the Title 24 Energy Code (Figure 16). Of the remaining projects, 18 (8 modular and 10 site-built) are located in Philadelphia, PA and 9 projects (5 modular and 4 site-built) are located within metro Seattle, WA. Projects in Philadelphia were approved under the 2015 or 2018 version of the International Energy Conservation Code (IECC). Projects located in the greater Seattle metro area were approved under the 2018 IECC with Washington State Energy Code (WSEC) amendments or the Seattle Energy Code (SEC). All projects for which code compliance path information was available, were approved by either performance path or envelope trade-off methods.

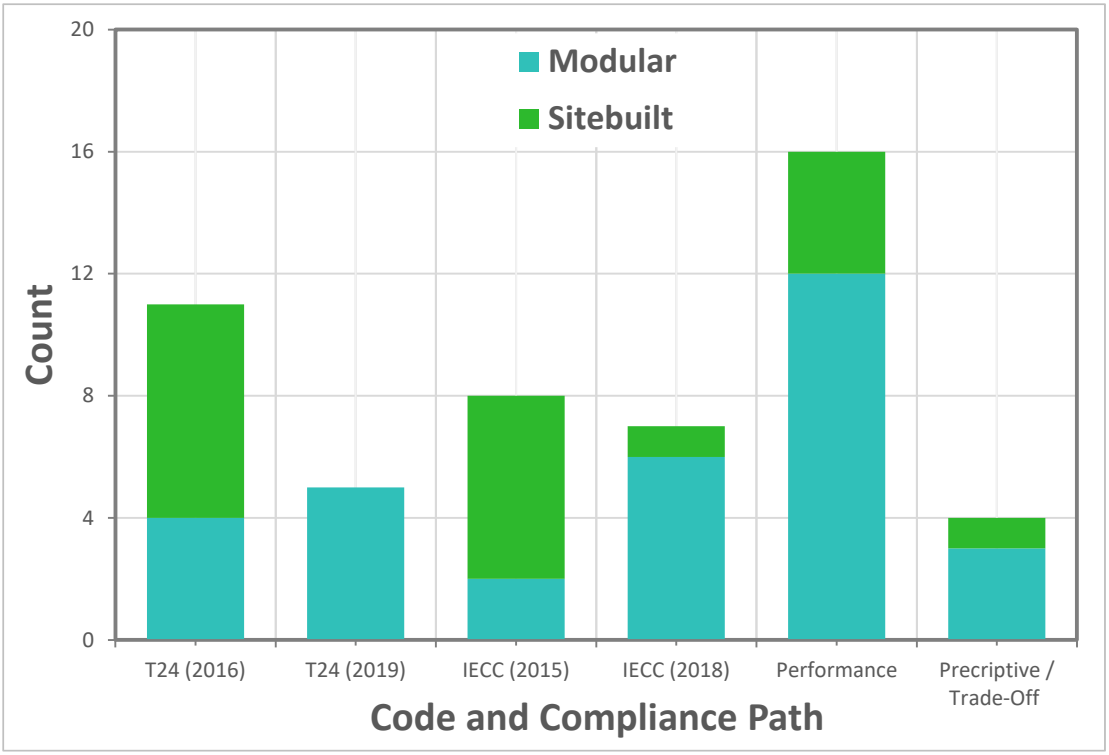


Figure 16. Modular and site-built building energy code and code compliance path.

Since all projects were approved by either performance path or trade-off methods, the prescriptive code compliance rates of individual measures were not used to compare the energy code compliance rates of modular multifamily buildings to site-built buildings. For these projects, prototype energy use simulations will be performed to verify compliance. For illustrative purposes, however, Figures 17-42 show the efficiencies of key energy conservation measures (ECMs) found in both modular and site-built multifamily buildings with respect to prescriptive requirements of the Title 24 energy code in climate zone 3 and, the IECC (with SEC and WSEC amendments) in climate zone 4.

Roof Insulation

Figures 17 and 18 show the *effective* U-values of primary R2 occupancy *roof assemblies* for each building sampled. These values are based on insulation location (e.g. cavity, above deck or both), insulation type (e.g. loose fill, batt, rigid, or spray foam) and insulation thickness and include the effective U-value for all layers of the roof assembly as per ASHRAE 90.1-2022. For modular buildings, cavity insulation was observed in the factory. Above deck insulation was observed in the field. Roofing assemblies consisted mainly of conventional or pre-engineered wood framing (24"o.c.) and both cavity (fiberglass batt) and above deck (continuous rigid) insulation. Of 22 modular and site-built buildings in CZ3, 22 (100%) of were found to have met the T24 prescriptive code requirement. Of 16 modular and site-built buildings in CZ4, 14 (88%) were found to have met the IECC/SEC/WSEC prescriptive code.

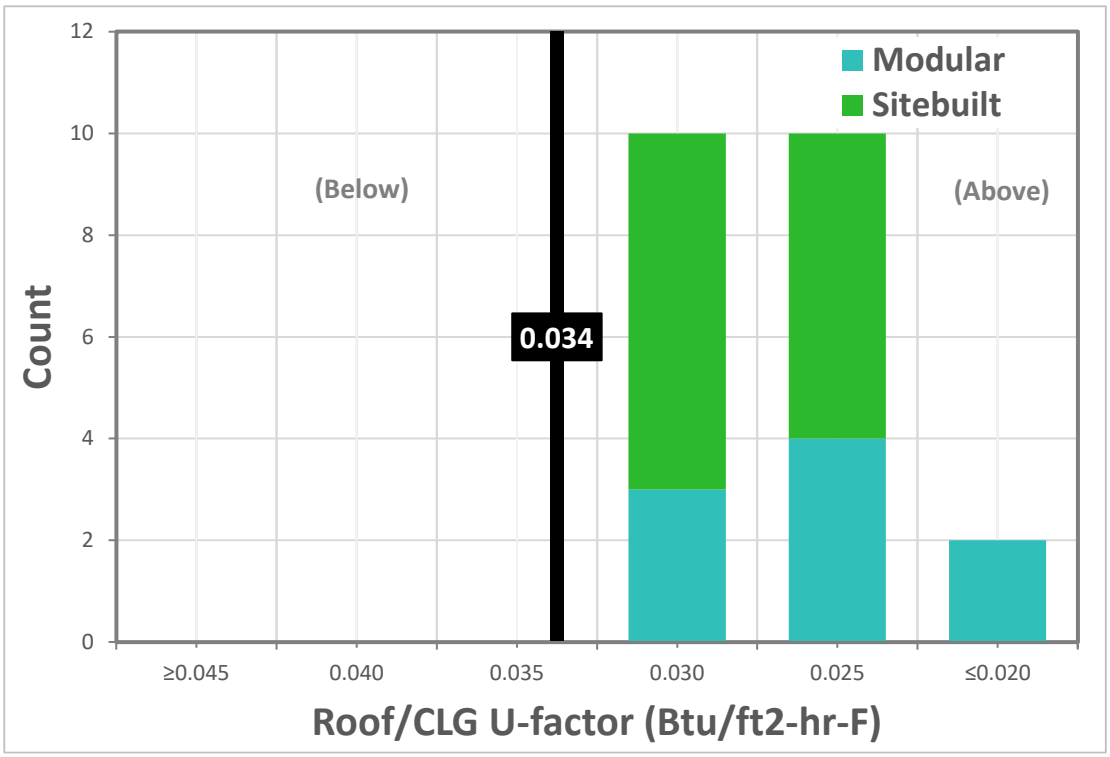


Figure 17. Modular and site-built building roof assembly U-factor (CZ3).

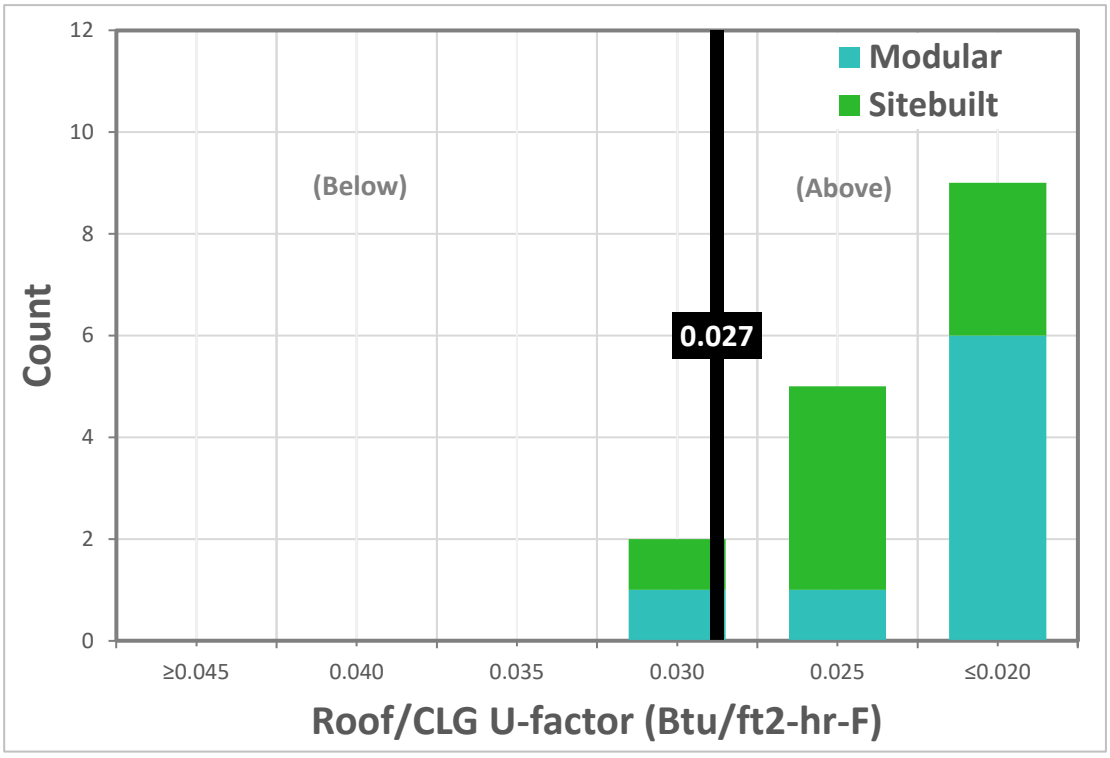


Figure 18. Modular and site-built building roof assembly U-factor (CZ4).

Wall Insulation

Figures 19 and 20 show the *effective* U-values of primary R2 occupancy *above-grade wall assemblies* for each building sampled. These values are based on insulation location (e.g. cavity, continuous or both), insulation type (e.g. batt, rigid, or spray foam) and insulation thickness and include the effective U-value for all layers of the wall assembly as per ASHRAE 90.1-2022 Appendix A. For modular buildings, wall insulation was observed in the factory. Wall assemblies consisted mainly of 2x6 standard wood framing (16"o.c.) and cavity (fiberglass batt) insulation. Of 25 modular and site-built buildings in CZ3, none were found to have met the T24 prescriptive code requirement. OF 17 modular and site-built buildings in CZ4, 17 (100%) were found to have met the IECC/SEC/WSEC prescriptive code requirement. It is unlikely that compliance with the T24 prescriptive code requirement could be achieved with R-19/R-21 insulation in a 2x6 wall cavity without the added use of continuous exterior insulation. For these projects, performance path or envelope trade-off was likely a more cost-effective option.

Window U-factor and SHGC

Figures 21-24 show the *average weighted* U-factor and SHGC of primary R2 occupancy *windows* for each building sampled. These values are based on U-factor and SHGC found in window schedules and verified on NFRC labels in the field. For modular buildings, window U-factor was observed in the factory. Windows consisted of both fixed and operable glazing and both vinyl and aluminum framing (with and without thermal break). Windows consisted mainly of insulated glass (with and without argon gas) and low emissivity (LoE) coatings. Since several different window types were observed for each building sampled, an average weighted U-factor and SHGC was calculated for each building based on the area of each window type relative to the total window area of the building. Of 24 modular and site-built buildings in CZ3, 24 (100%) were found to have met the T24 U-factor and SHGC prescriptive code requirement. Of 23 modular and site-built buildings in CZ4, 23 (100%) were found to have met the IECC/SEC/WSEC U-factor and SHGC prescriptive code requirement.

Window-to-Wall Ratio (WWR)

Figures 25 and 26 show the window-to-wall ratio (WWR) for each building sampled. WWR is the amount of exterior fenestration area (windows, storefronts, non-opaque doors), divided by the exterior gross wall area, expressed as a percentage. WWR accounts for all building fenestration including both dwelling units and common areas. Maximum allowed WWR is 40% under T24 and 30-35% under IECC/SEC/WSEC depending on code year. Of 16 modular and site-built buildings in CZ3, 16 (100%) were found to have met the T24 prescriptive code requirement. Of 14 modular and site-built buildings in CZ4, 13 (93%) were found to have met the IECC/SEC/WSEC prescriptive code requirement.

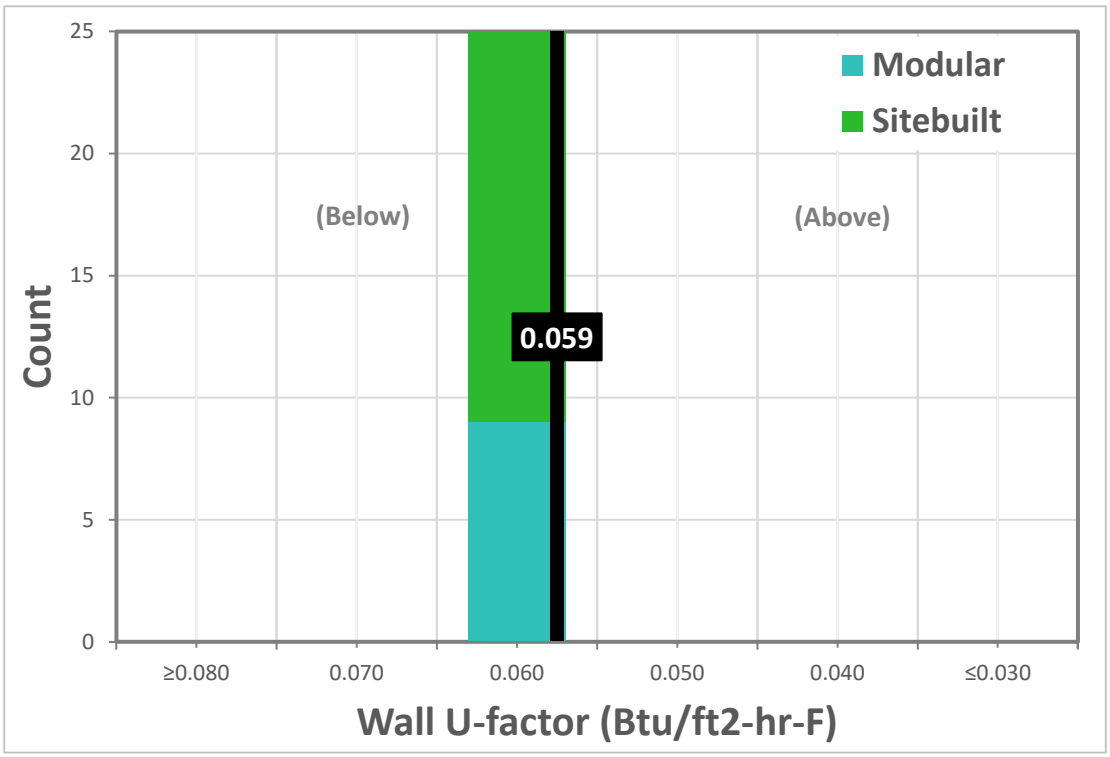


Figure 19. Modular and site-built building wall assembly U-factor (CZ3).

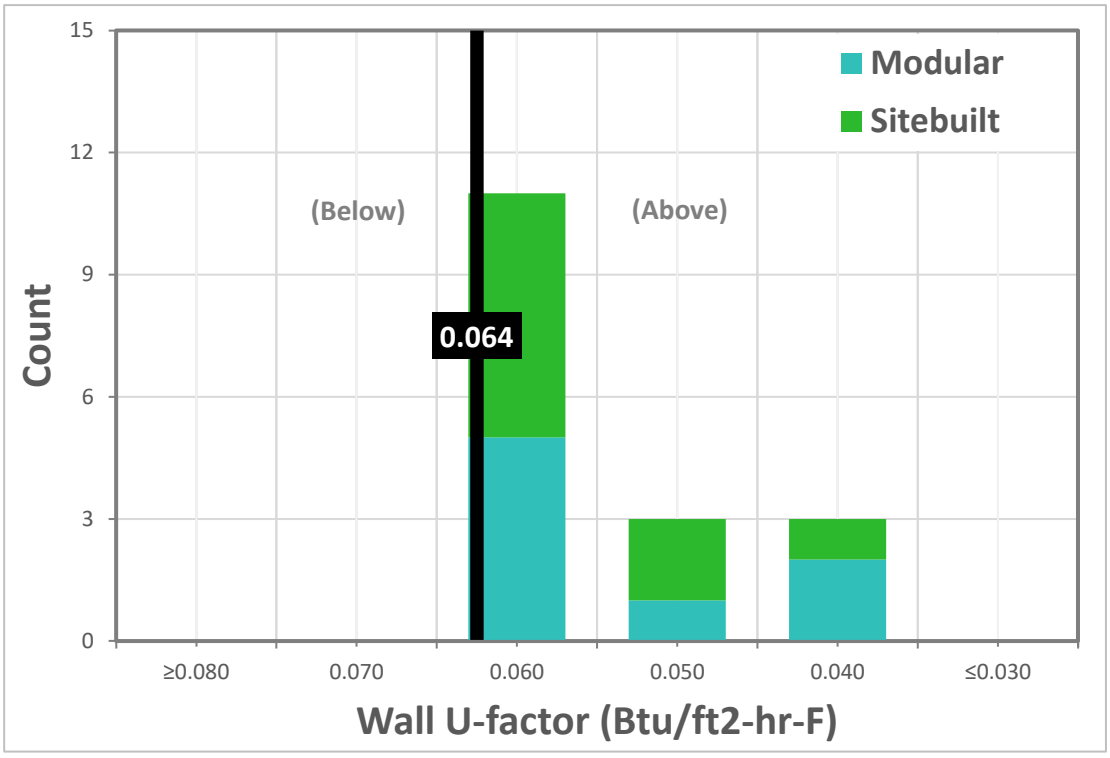


Figure 20. Modular and site-built building wall assembly U-factor (CZ4).

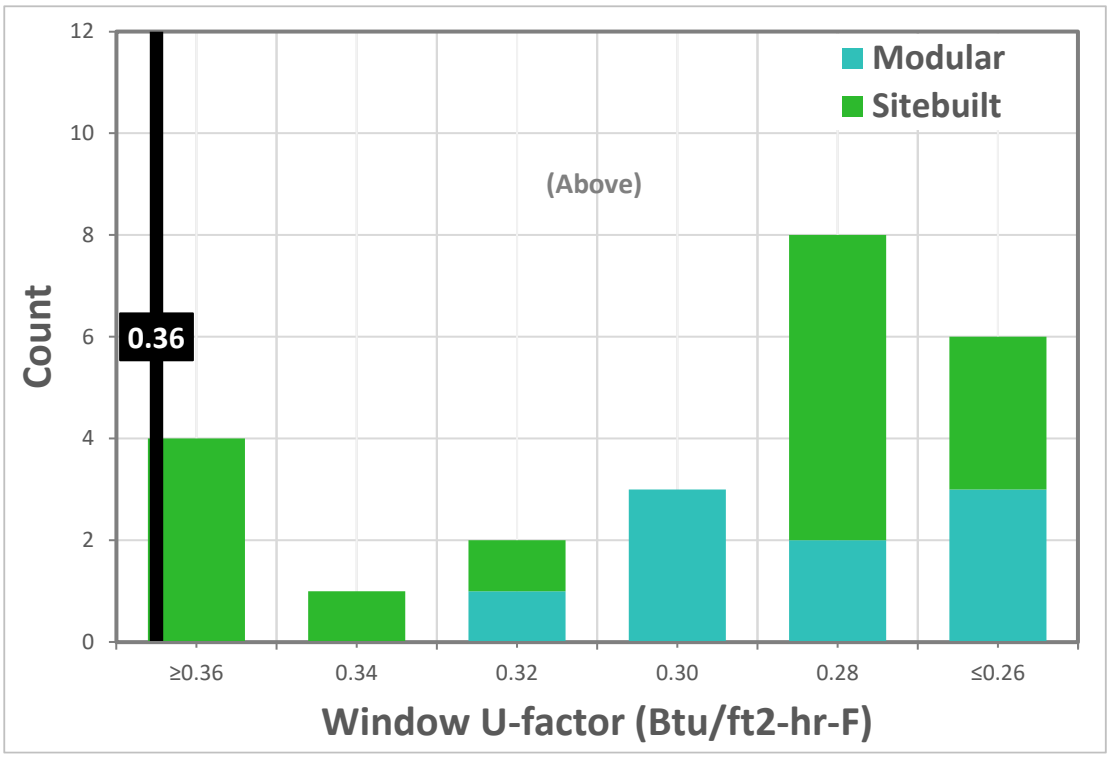


Figure 21. Modular and site-built building weighted average window U-factor (CZ3).

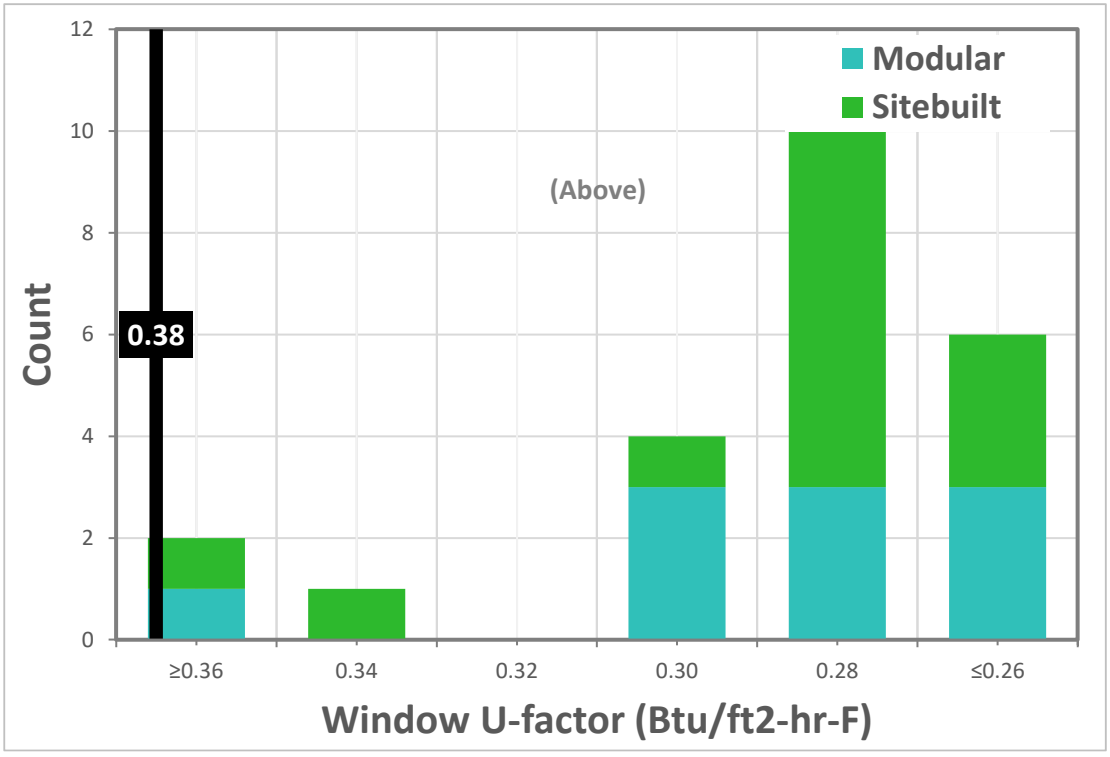


Figure 22. Modular and site-built building weighted average window U-factor (CZ4).

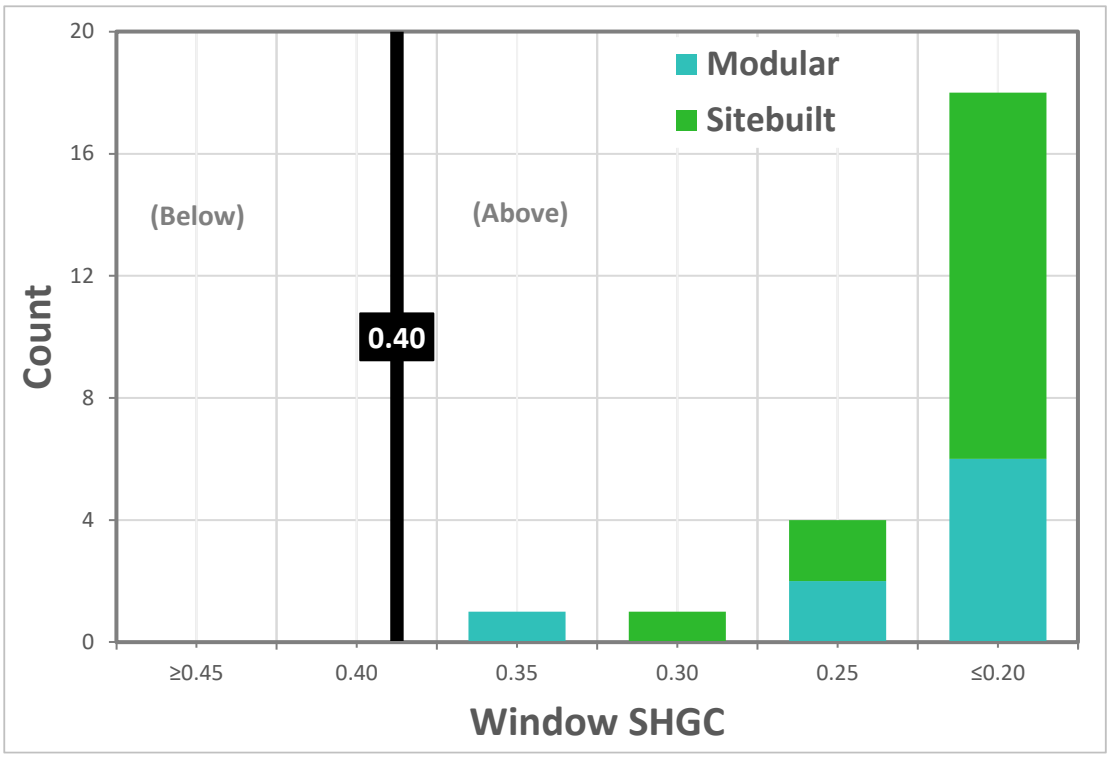


Figure 23. Modular and site-built building weighted average window SHGC (CZ3).

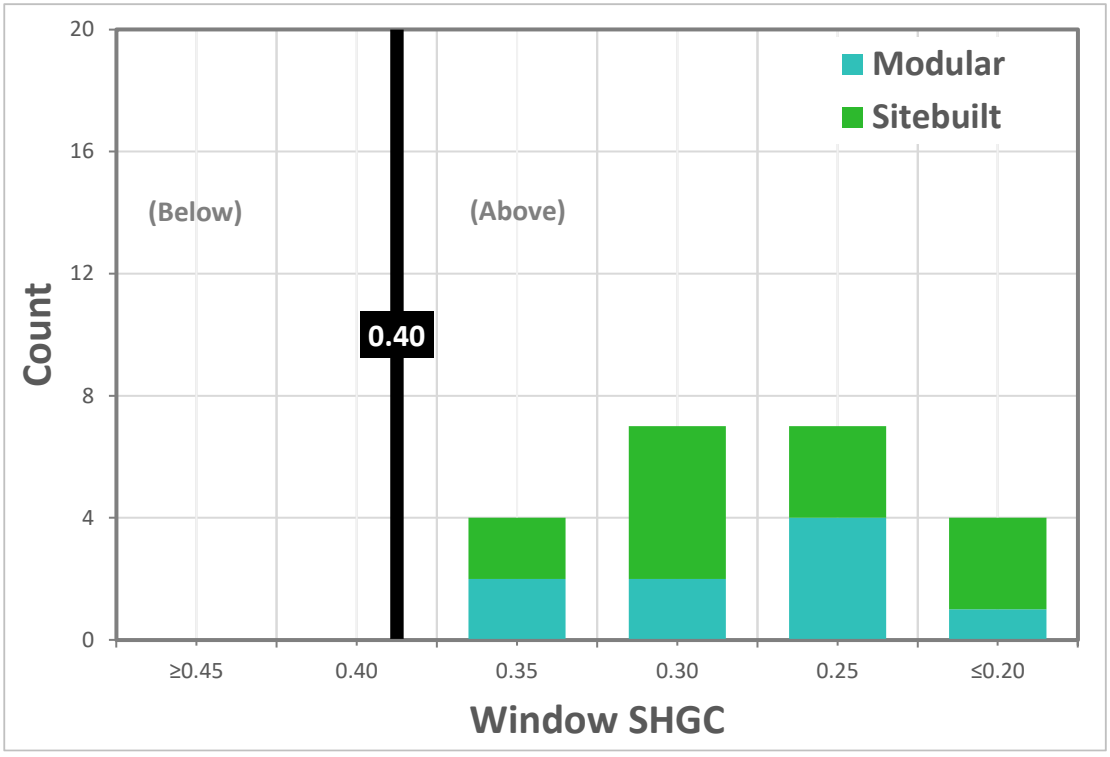


Figure 24. Modular and site-built building weighted average window SHGC (CZ4).

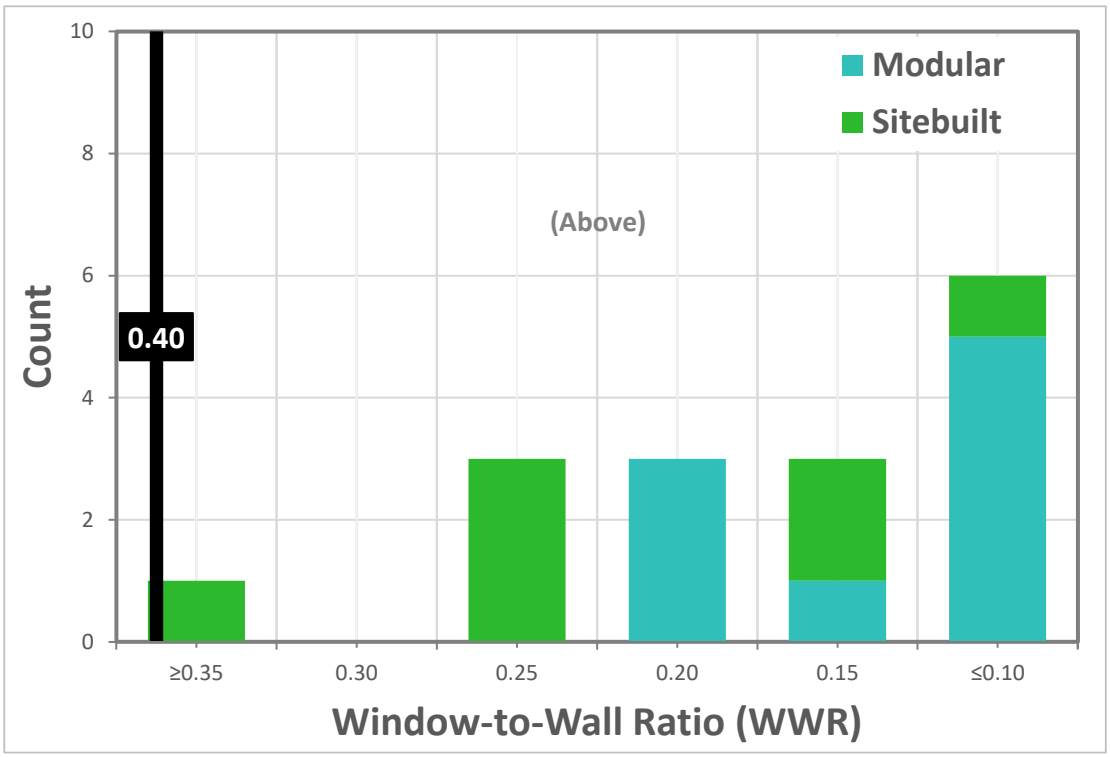


Figure 25. Modular and site-built building window-to-wall ratio (CZ3).

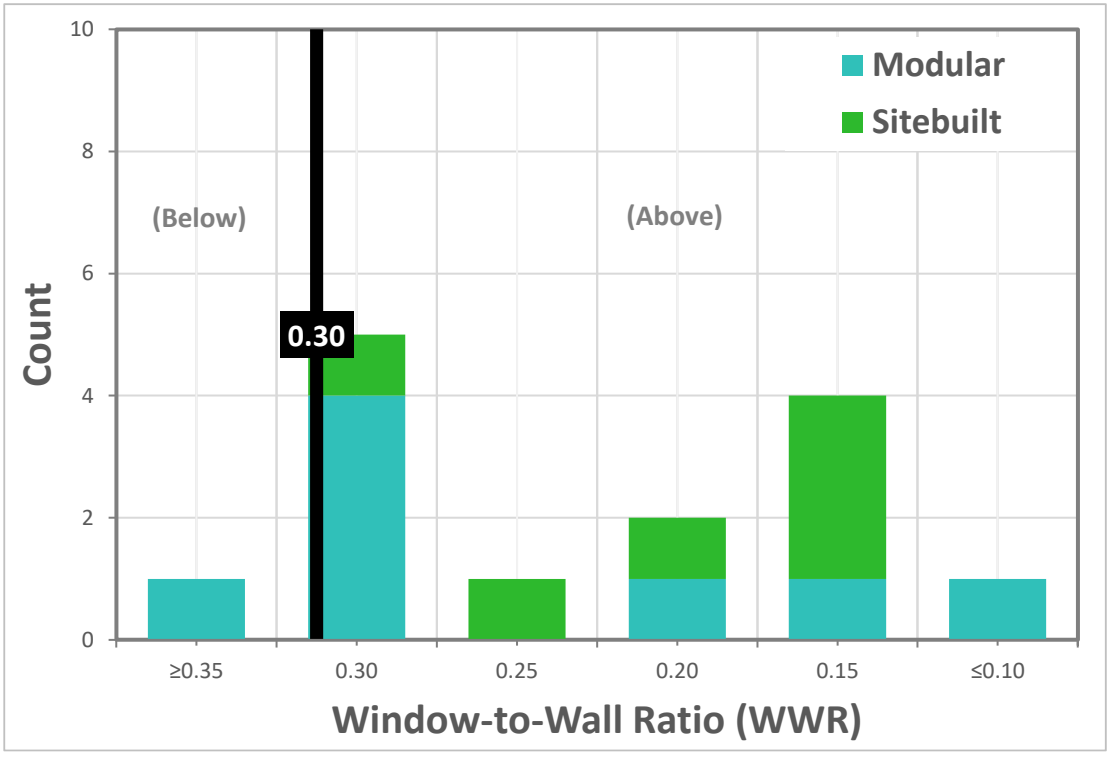


Figure 26. Modular and site-built building window-to-wall ratio (CZ4).

Space Heating and Cooling Equipment

Figures 27-34 show the type and efficiency of the primary residential space heating and cooling equipment found in each building sampled. Data was collected on all HVAC systems except for equipment serving commercial spaces. This includes equipment serving dwelling units, corridors and residential common spaces. Data included a count of each type of equipment, a description of each type of equipment and spaces served by that equipment from mechanical schedules. Additionally, the model number, fuel source, efficiency and rated heating and (or) cooling capacity of each type of equipment was recorded from the equipment name or data plate in the field. Using the model number, performance data was verified using the manufacturer's website or the AHRI product directory (https://www.ahridirectory.org). For both modular and site-built buildings, space heating and cooling equipment was most often observed in the field although modular indoor AHU units and packaged units were often observed in the factory.

In CZ3, the most common HVAC system observed in both modular and site-built multifamily buildings were split heat-pump systems followed by ductless mini-split and variable refrigerant flow (VRF) multi-split systems (≤30MBuh). In CZ4, the most common HVAC system observed was DOAS followed by split air-conditioning and heat-pump systems. Of note, packaged thru-wall systems were only observed in modular multifamily buildings. Split AC systems with gas heating were only observed in site-built multifamily buildings in CZ4a. Of 15 modular and site-built buildings in CZ3, 15 (100%) were found to have met the T24 prescriptive code requirement for HVAC systems efficiency. Of 11 modular and site-built buildings in CZ4, 11 (100%) were found to have met the IECC/SEC/WSEC prescriptive code requirement.

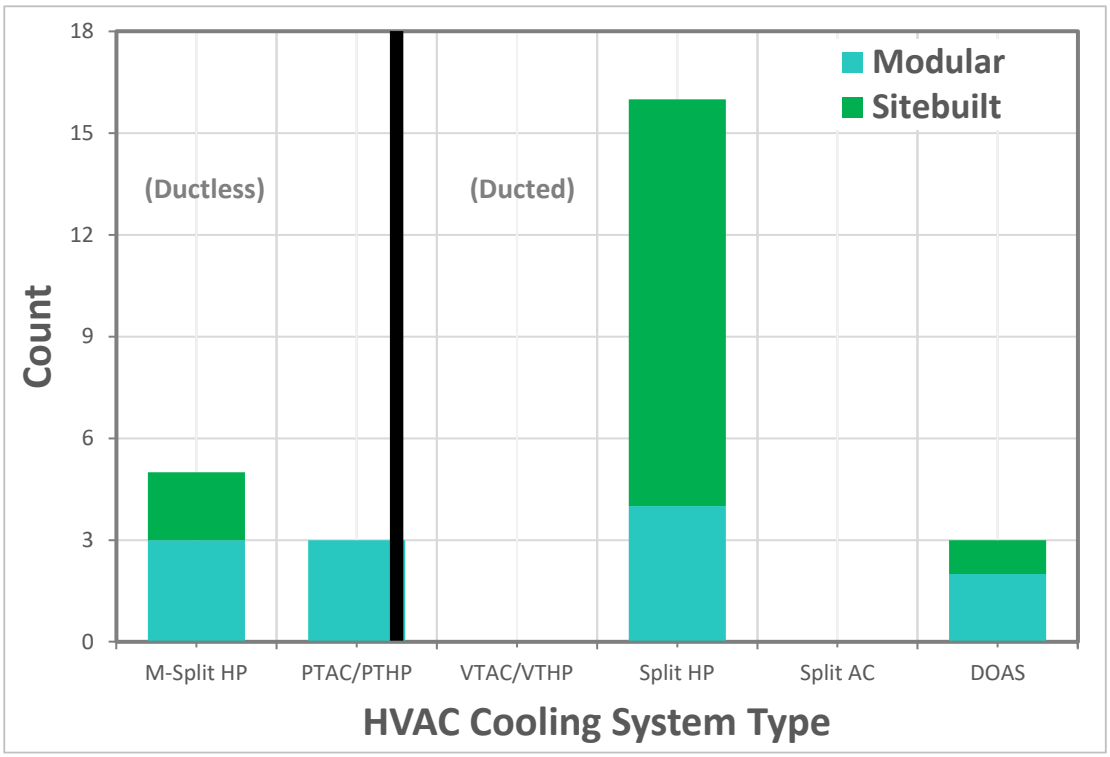


Figure 27. Modular and site-built building primary residential space cooling system type (CZ3).

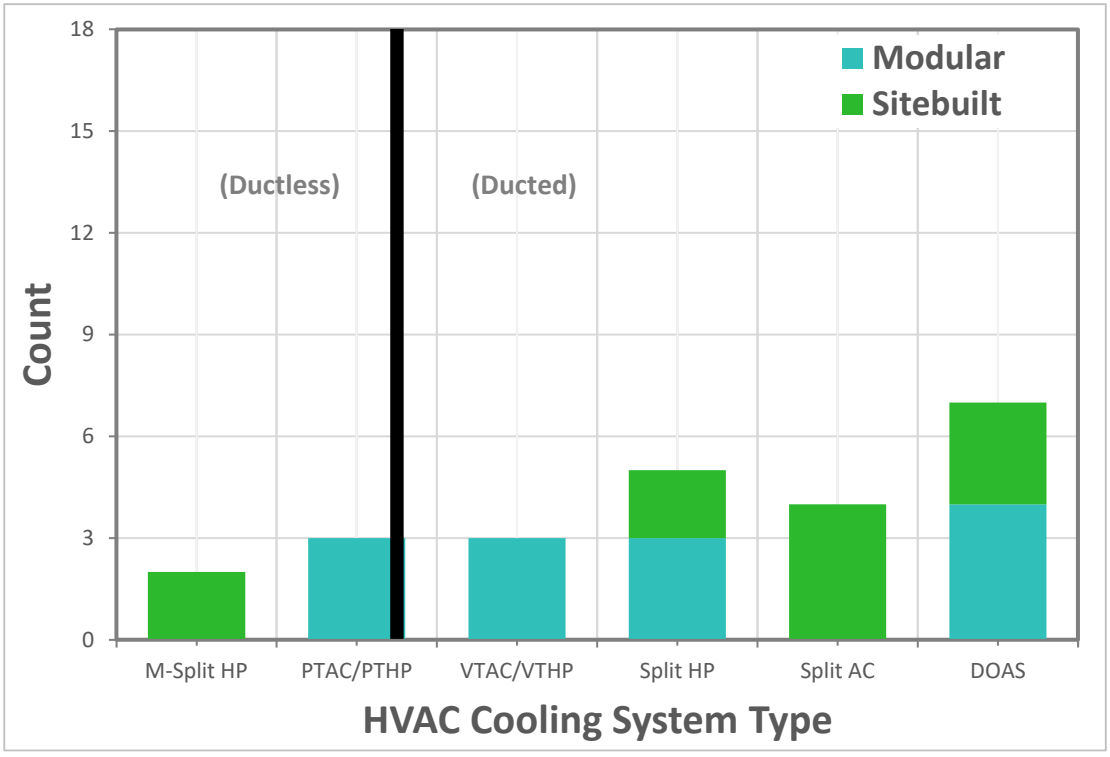


Figure 28. Modular and site-built building primary residential space cooling system type (CZ4).

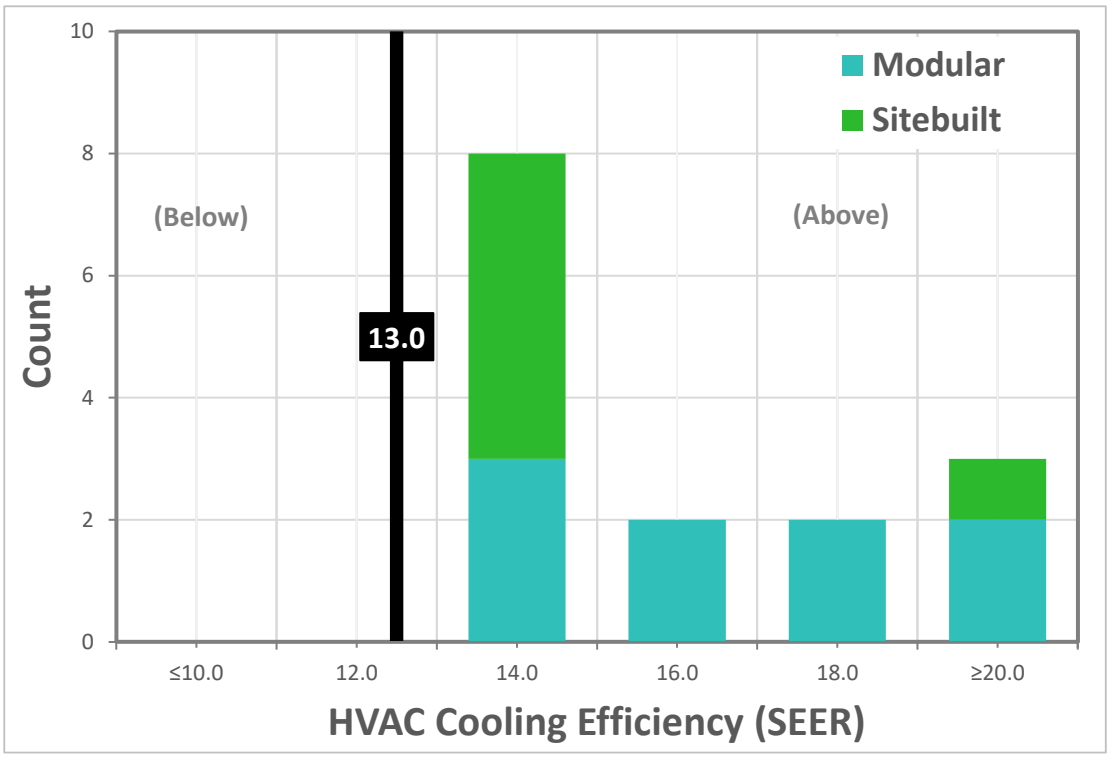


Figure 29. Modular and site-built building primary residential space cooling system efficiency (CZ3).

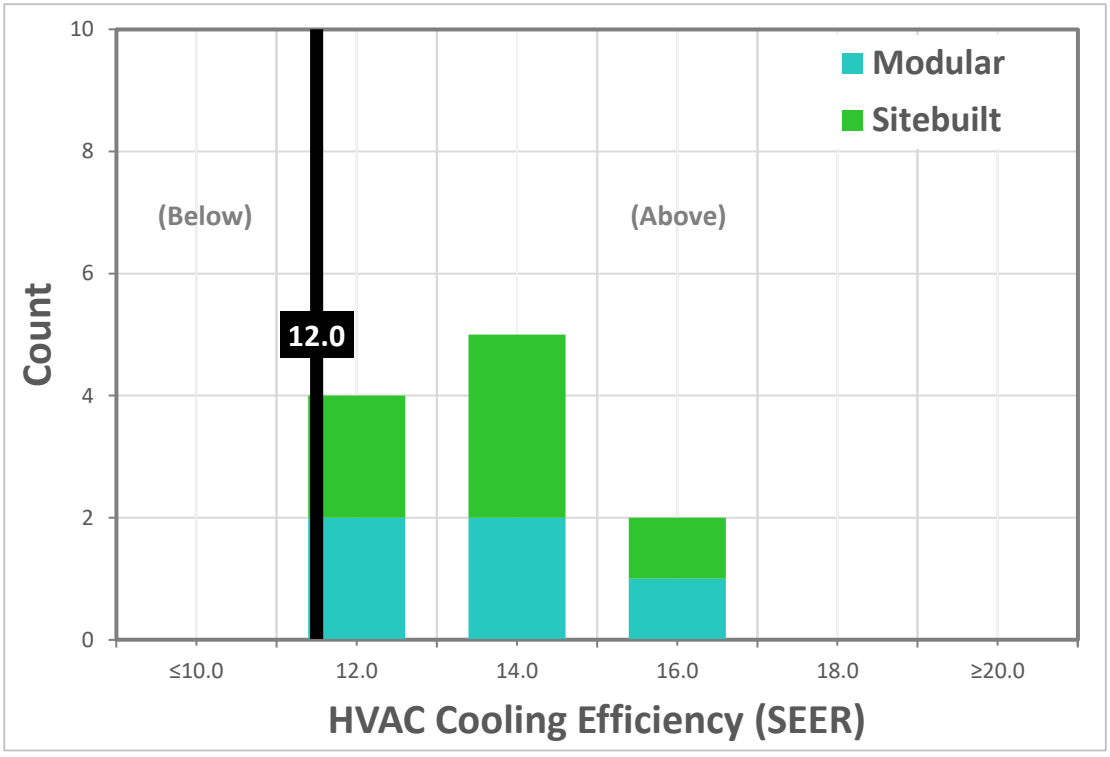


Figure 30. Modular and site-built building primary residential space cooling system efficiency (CZ4).

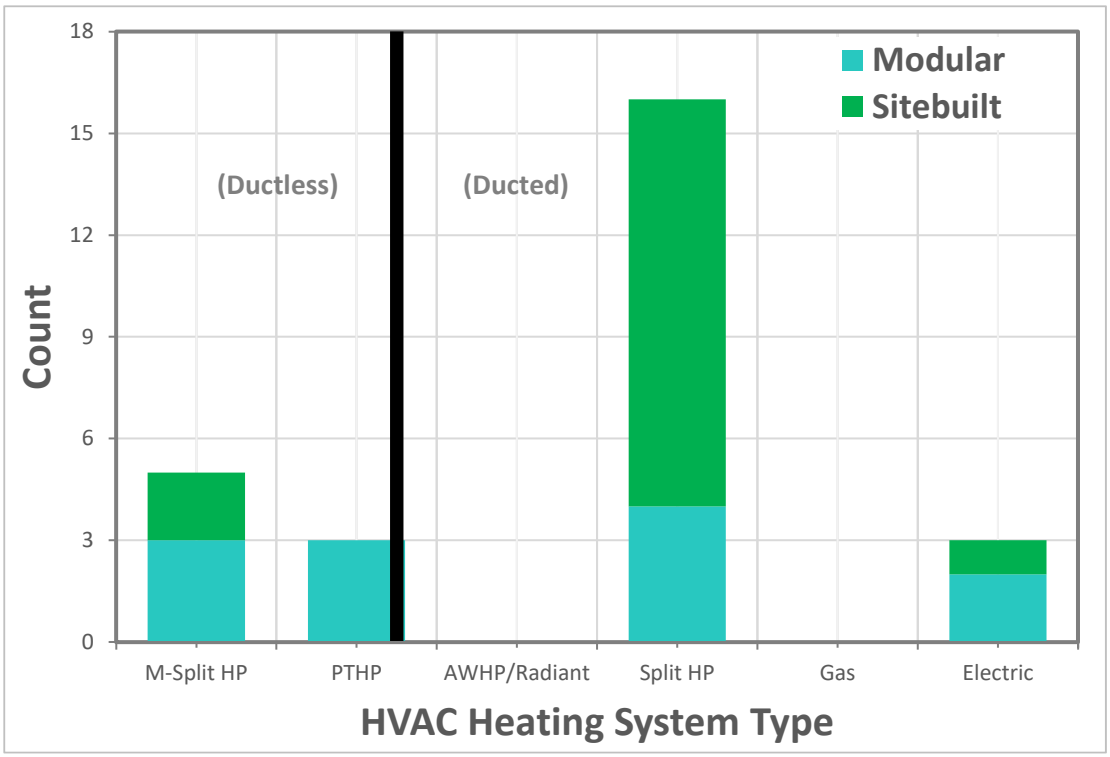


Figure 31. Modular and site-built building primary residential space heating system type (CZ3).

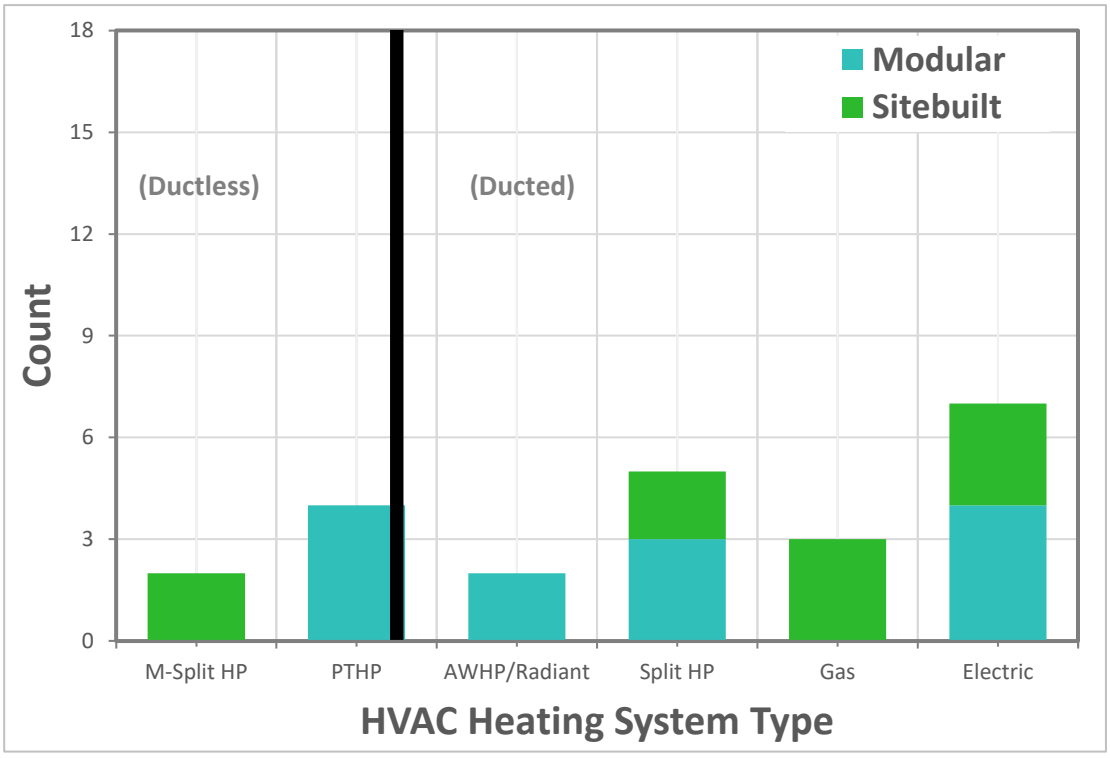


Figure 32. Modular and site-built building primary residential space heating system type (CZ4).

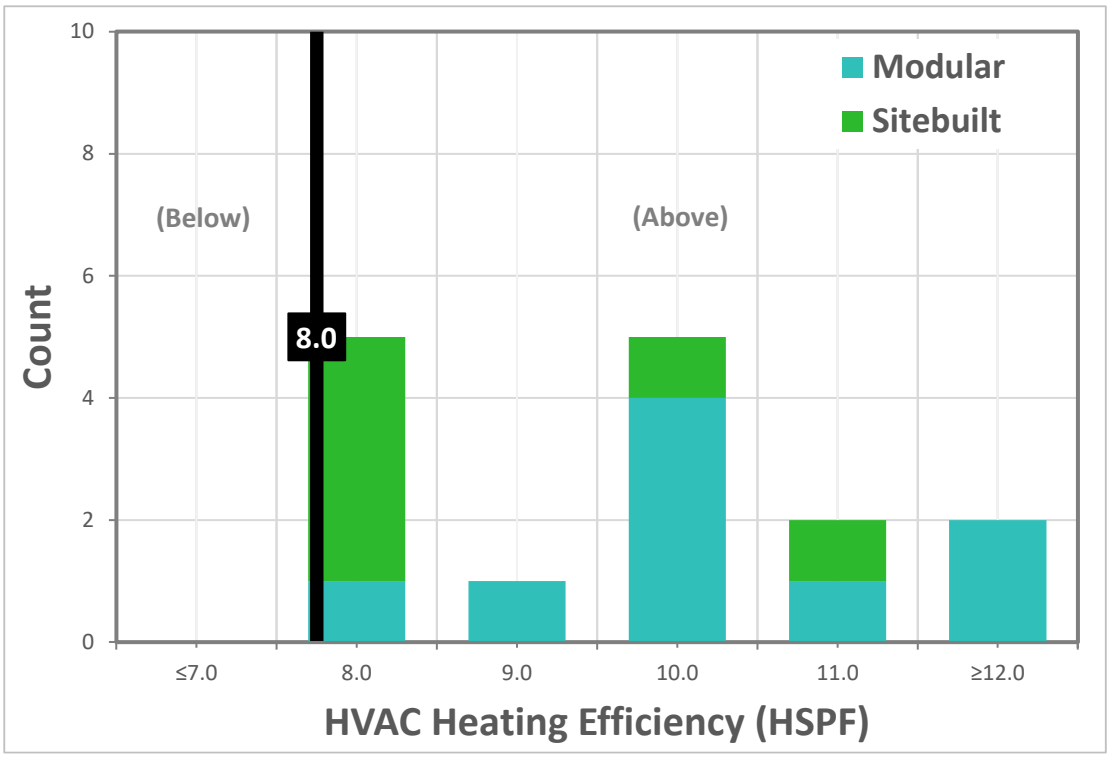


Figure 33. Modular and site-built building primary residential space heating system efficiency (CZ3).

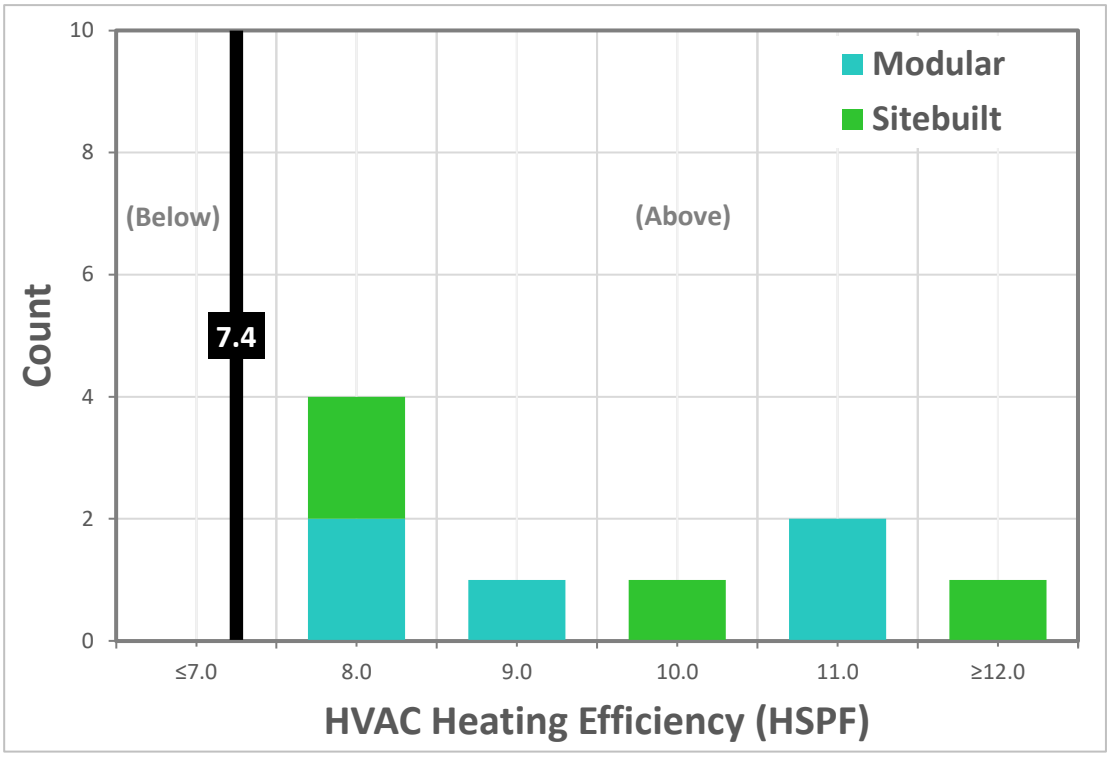


Figure 34. Modular and site-built building primary residential space heating system efficiency (CZ4).

Water Heating Equipment

Figures 35-38 show the type and efficiency of the primary residential water heating equipment found in each building sampled. Data was collected on all DHW systems except for equipment serving commercial spaces. This includes equipment serving dwelling units and residential common spaces. Data included a count of each type of equipment, a description of each type of equipment and spaces served by that equipment from mechanical schedules. Additionally, the model number, fuel source, efficiency and rated water heating capacity (or storage tank size) of each type of equipment was recorded from the equipment name or data plate in the field. Using the model number, performance data was verified using the manufacturer's website or the AHRI product directory (https://www.ahridirectory.org). For both modular and site-built buildings, water heating equipment was most often observed in the field although unitary systems were often observed in the factory.

In CZ3, the most common DHW system observed in both modular and site-built multifamily buildings were central gas boiler systems (≥300MBtuh). Nearly half (45%) of these systems were supplemented by solar water heating. In CZ4, the most common DHW system observed was in-unit electric tank storage water heaters (<50gal) followed by central air-water heat-pump (AWHP) systems. Of 18 modular and site-built buildings in CZ3, 18 (100%) were found to have met the T24 prescriptive code requirement for DHW systems efficiency. Of 13 modular and site-built buildings in CZ4, 13 (100%) were found to have met the IECC/SEC/WSEC prescriptive code requirement.

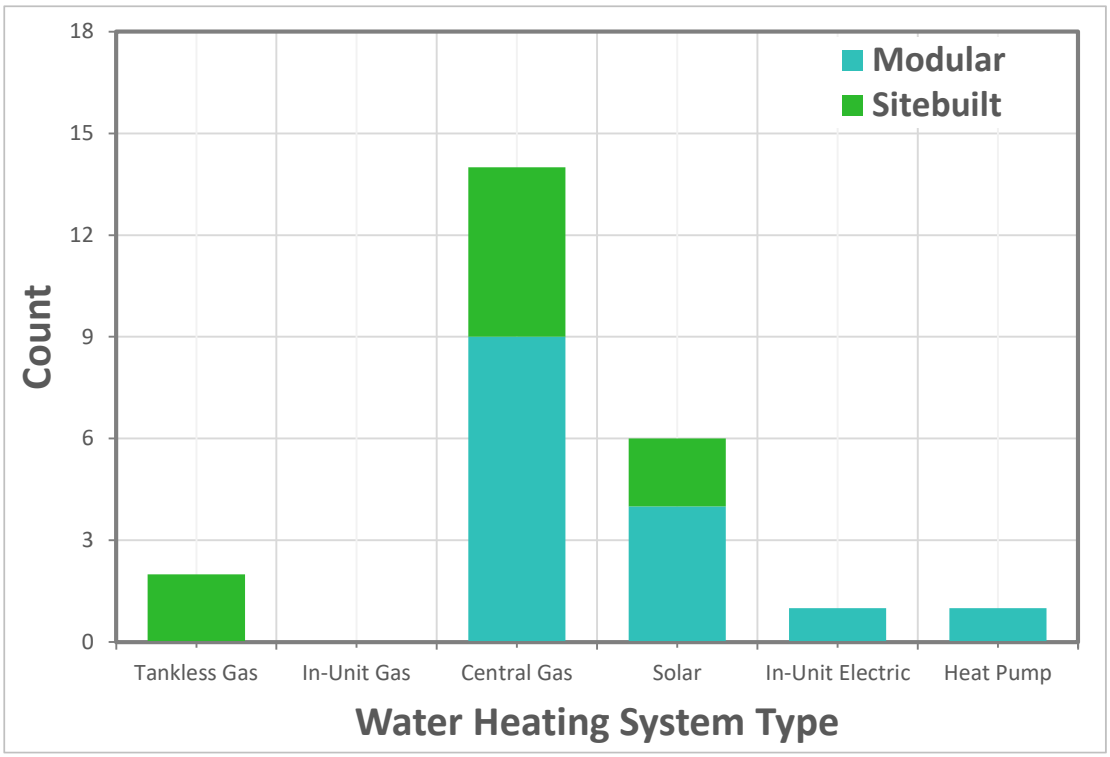


Figure 35. Modular and site-built building primary residential water heating system type (CZ3).

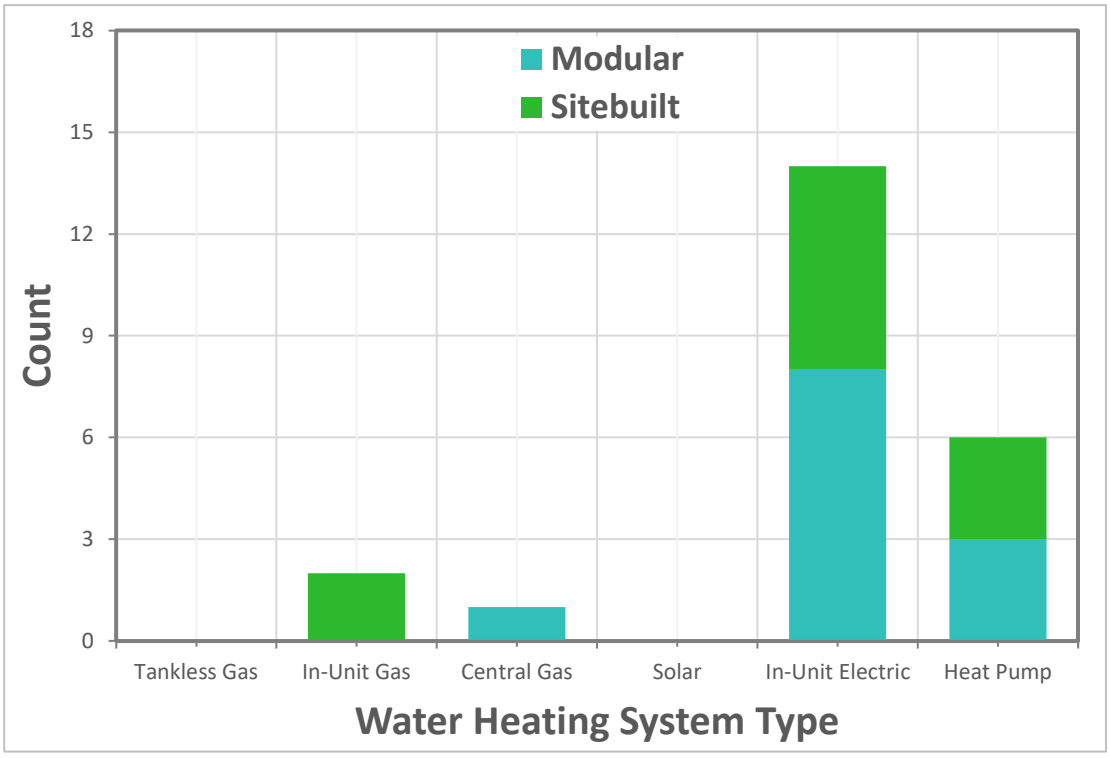


Figure 36. Modular and site-built building primary residential water heating system type (CZ4).

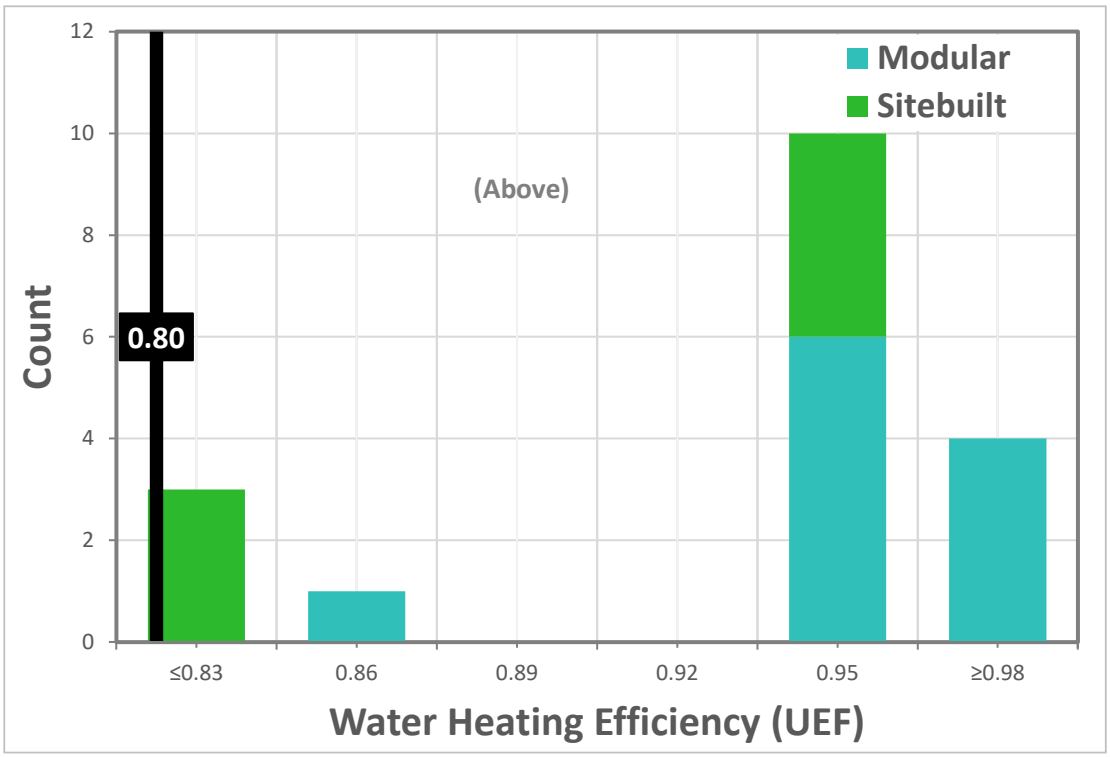


Figure 37. Modular and site-built building primary residential water heating system efficiency (CZ3).

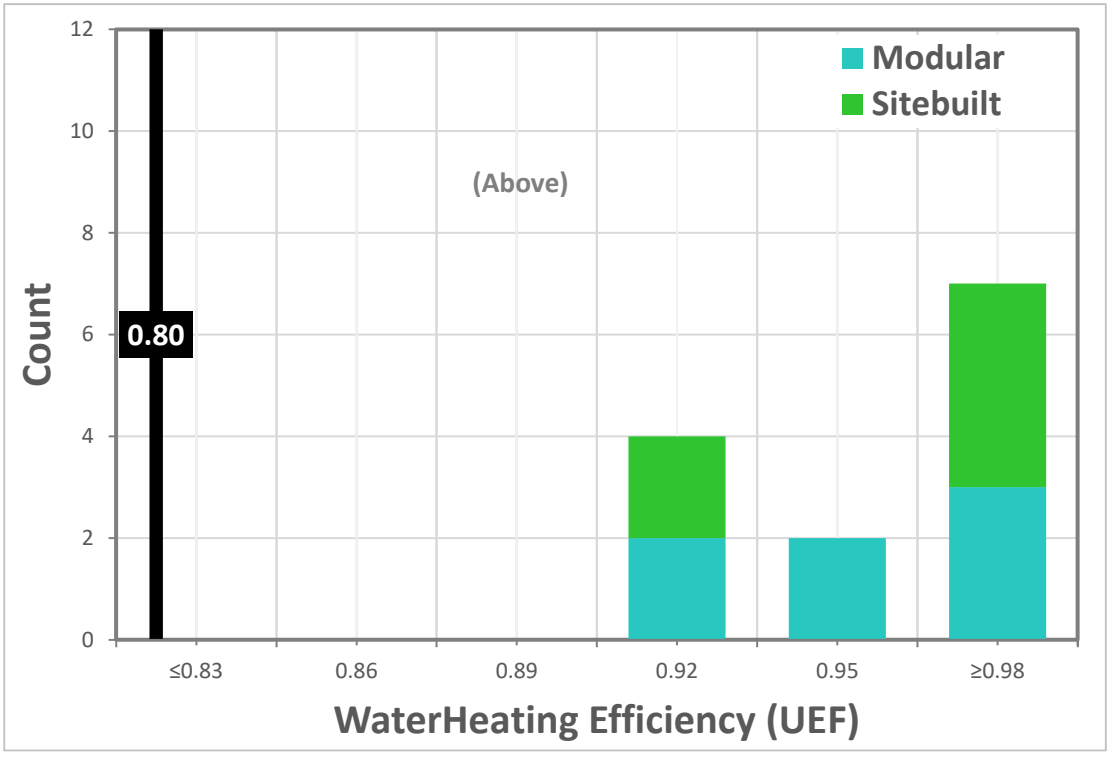


Figure 38. Modular and site-built building primary residential water heating system efficiency (CZ4).

Lighting Power Density (LPD)

Figures 39-42 show the LPD of all dwelling unit and residential commons interior lighting equipment. LPD is the sum of lighting fixture wattage for a space divided by the floor area of a space, expressed as W/sf. Data was collected on all lighting systems except for equipment serving commercial spaces and exempt lighting for public safety. This includes fixtures serving corridors and residential common spaces. Data included a count of each type of fixture and a description of each type of fixture from electrical lighting schedules. Additionally, the lamp type, number of lamps and total watts per fixture was recorded from the lighting schedules and verified in the field for each sample space. Data was also collected on lighting systems within dwelling units although dwelling units are generally exempt from power allowance code requirements.

In CZ3, the LPD of dwelling units averaged 0.29W/sf for modular buildings and 0.23W/sf for site-built buildings. The LPD of residential commons averaged 0.31W/sf for modular buildings and 0.36W/sf for site-built buildings. Of 11 modular and site-built buildings in CZ3, 9 (82%) were found to have met the T24 prescriptive code requirement for residential corridor and common area LPD. In CZ4, the LPD of dwelling units averaged 0.33W/sf for modular buildings and 0.32W/sf for site-built buildings. The LPD of residential commons averaged 0.32W/sf for modular buildings and 0.31W/sf for site-built buildings. Of 8 modular and site-built buildings in CZ4, 8 (100%) were found to have met the IECC/SEC/WSEC prescriptive code requirement for residential corridor and common area LPD.

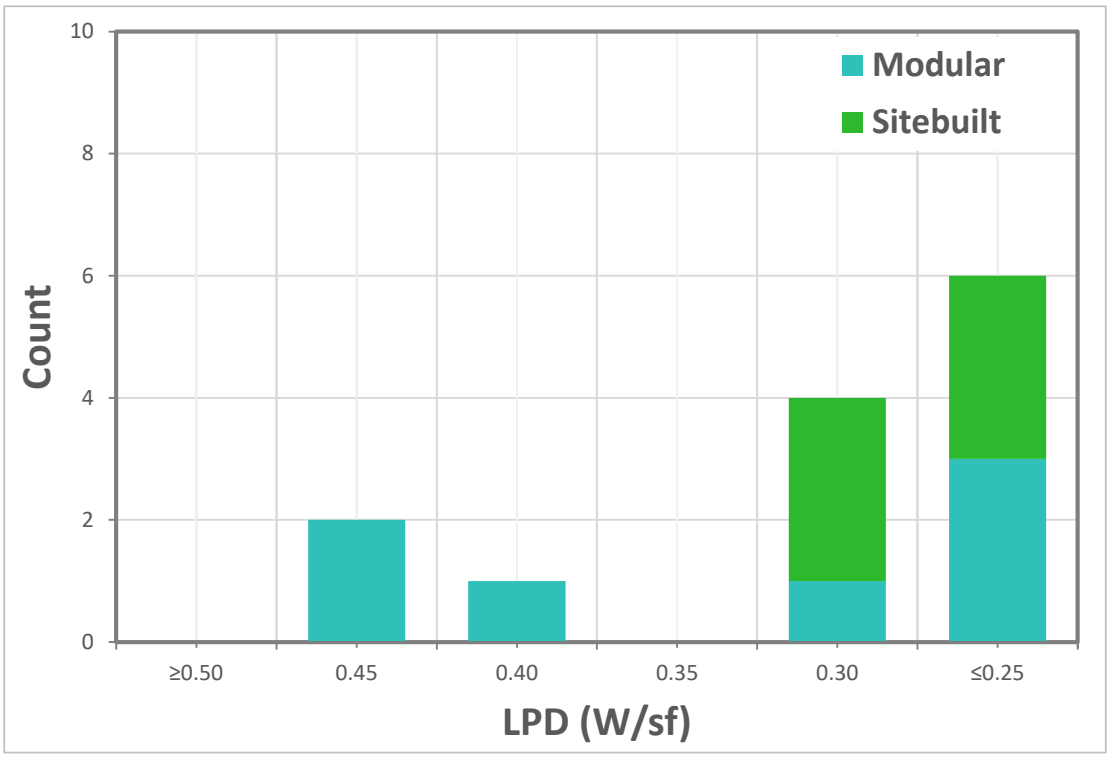


Figure 39. Modular and site-built building dwelling unit lighting power density (CZ3).

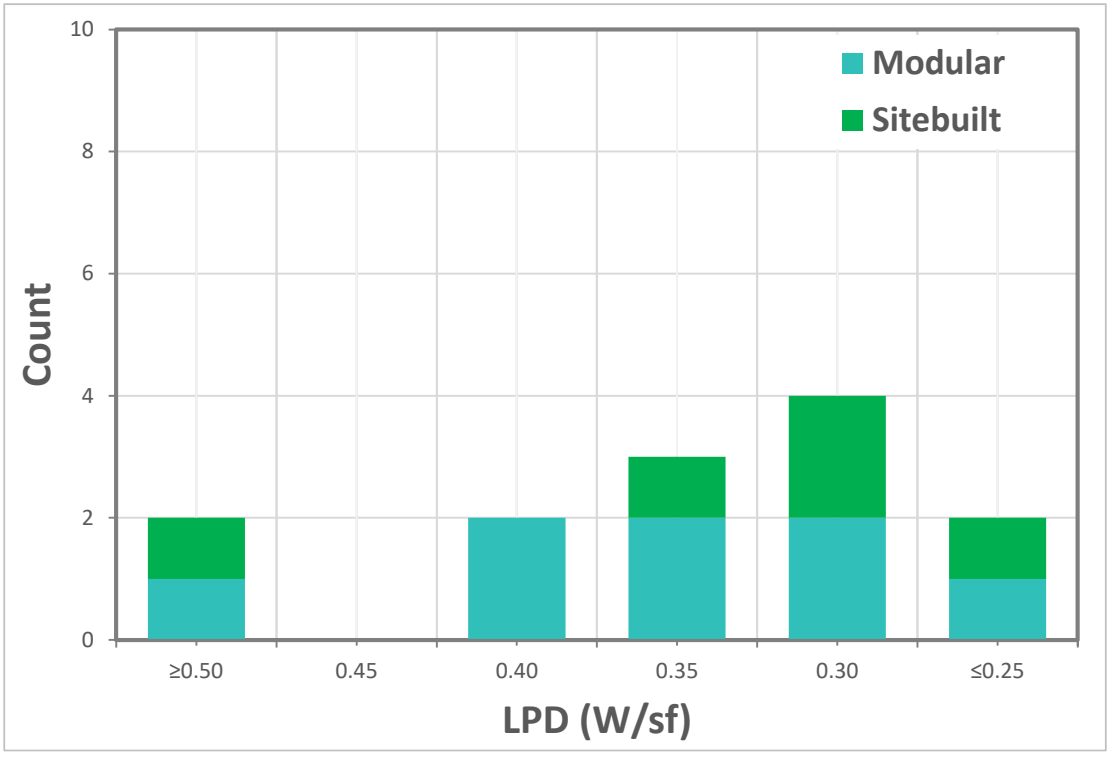


Figure 40. Modular and site-built building dwelling unit lighting power density (CZ4).

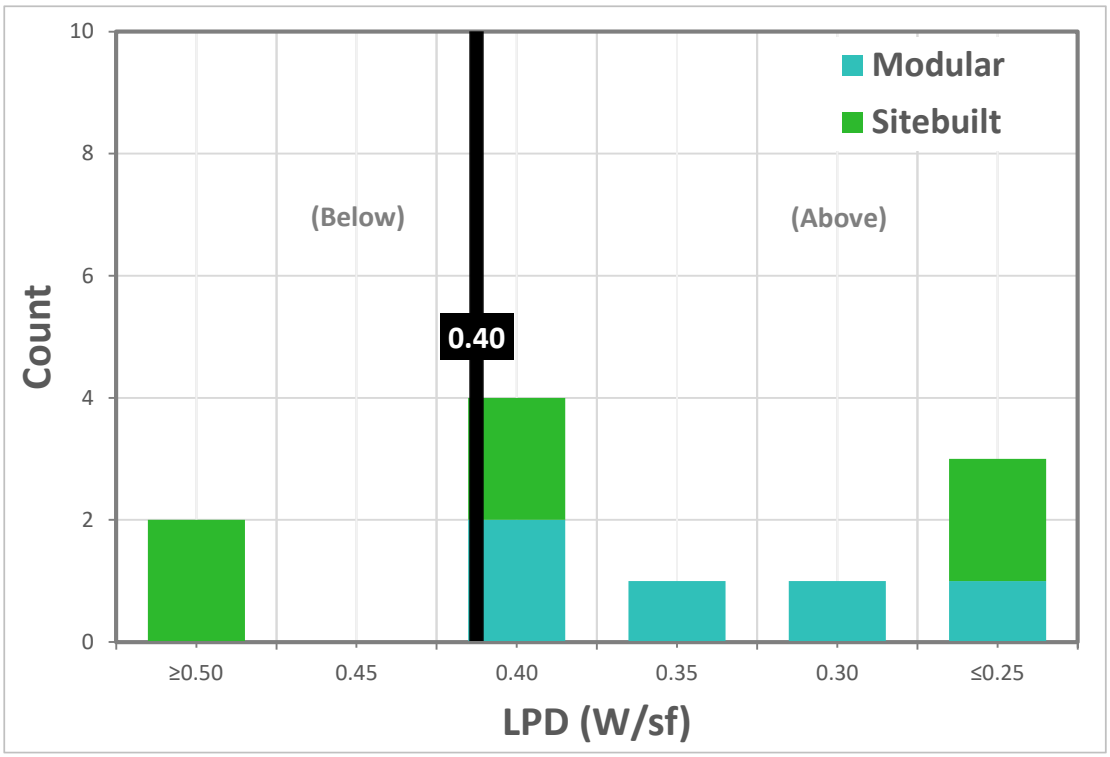


Figure 41. Modular and site-built building residential commons lighting power density (CZ3).

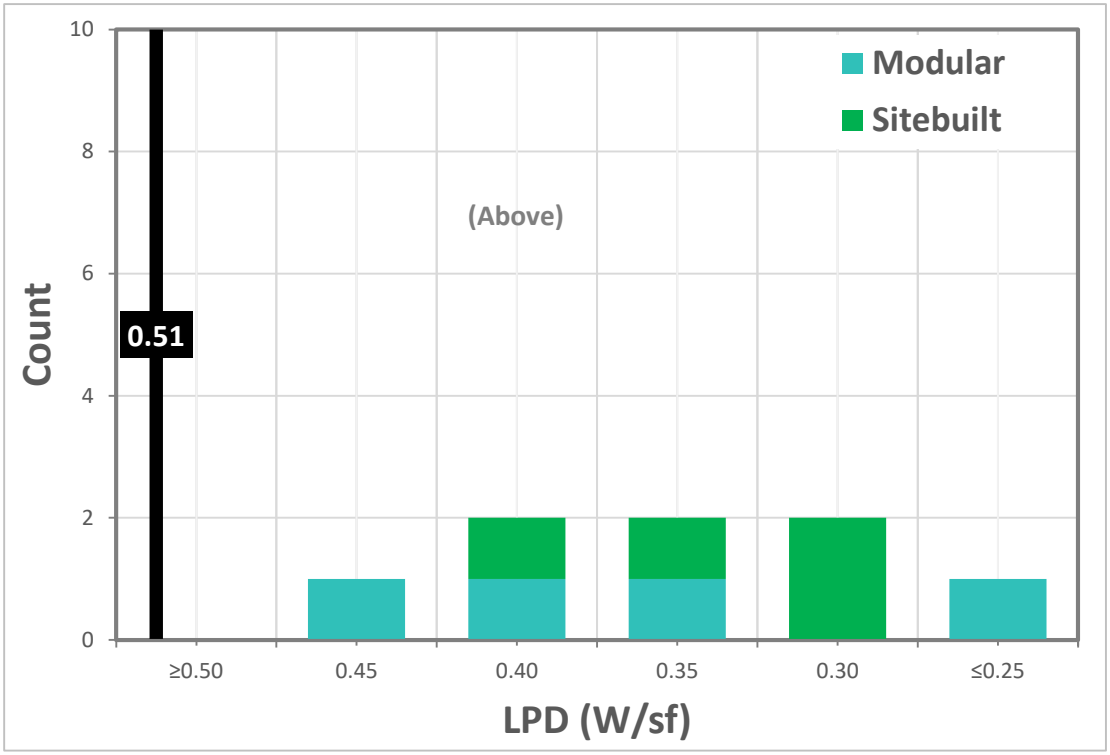


Figure 42. Modular and site-built building residential commons lighting power density (CZ4).

Results (Table 6 and Figures 43-46) suggest that the average efficiency of key energy conservation measures (ECMs) in modular multifamily construction slightly exceeds the average efficiency of key energy measures in site-built multifamily construction in climate zone 3 whereas the average efficiency of ECMs in site-built multifamily construction slightly exceeds the average efficiency of key energy measures in modular multifamily construction in climate zone 4. While the prescriptive code compliance rates of individual measures were not used to compare the energy code compliance rate of modular multifamily buildings to site-built buildings, most key measures for most buildings nevertheless met or were often better than the prescriptive energy code requirements for each climate zone. Notable exceptions include wall U-factor in climate zone 3. Other exceptions include window-to-wall-ratio (WWR) for a modular multifamily building in climate zone 4 using envelope trade-off and, HVAC SEER value for a site-built building in climate zone 3 using performance path. Other exceptions include lighting power density for two modular projects in climate zone 3 using residential exclusions and (or) space type methods.

Table 6. Modular and site-built building energy performance by measure.

	Climate Zone 3				**Climate Zone 4**			
ECMs	Modular	*n*	Site-built	*n*	Modular	*n*	Site-built	*n*
Roof (U)	**0.027**	9	0.031	13	**0.023**	8	0.025	8
Wall (U)	**0.065**	9	0.066	16	**0.057**	8	0.059	9
Window (U)	**0.27**	9	0.31	15	0.28	10	0.28	13
Window (SHGC)	0.23	9	**0.22**	15	0.29	9	**0.28**	13
WWR	**0.17**	9	0.24	7	0.27	8	**0.23**	6
HVAC (SEER)	**16.8**	9	15.2	6	13.8	5	**14.0**	6
HVAC (HSPF)	**10.5**	9	9.1	6	9.8	5	**10.1**	4
DHW (UEF)	**1.19**	11	0.90	7	2.20	7	**2.24**	6
LPD (W/sf)	0.29	7	**0.23**	6	0.33	8	**0.32**	5

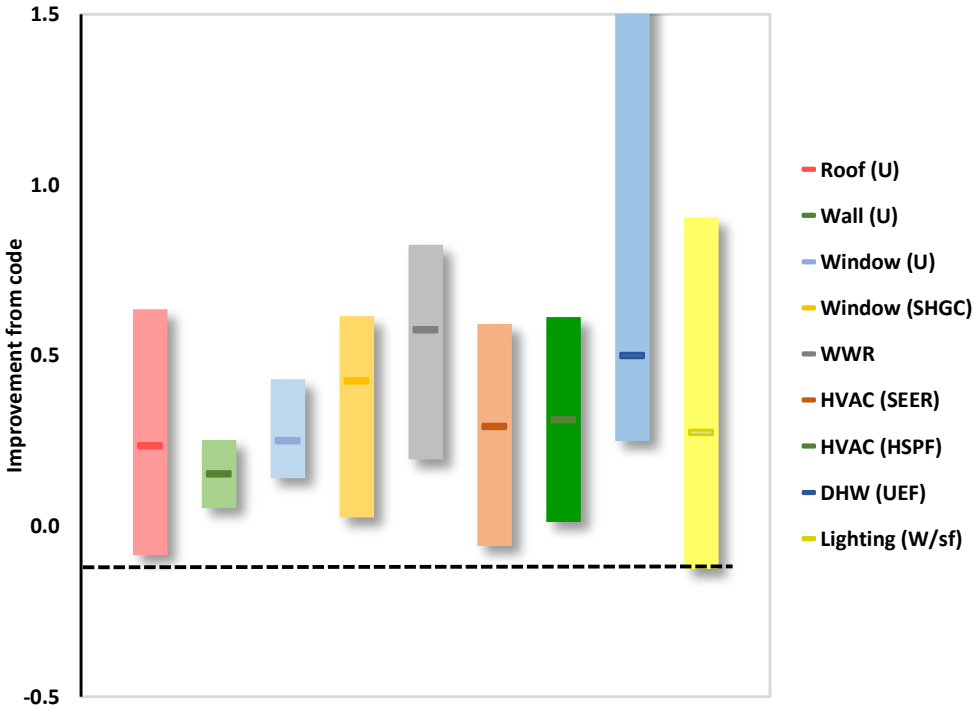


Figure 43. Modular ECM improvement from code (CZ3).

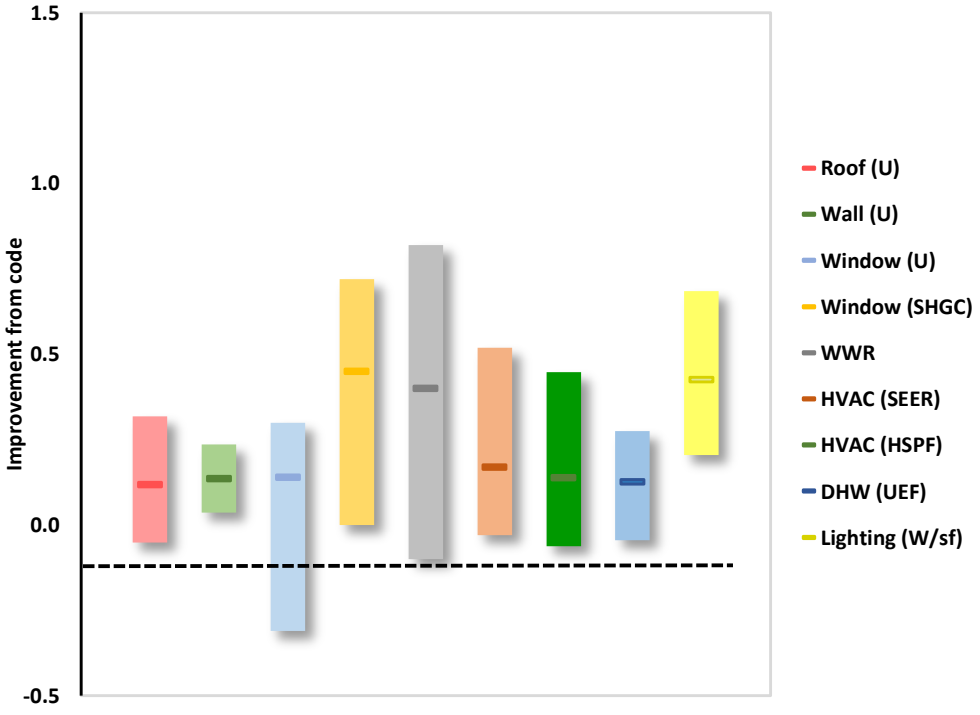


Figure 44. Site-built ECM improvement from code (CZ3).

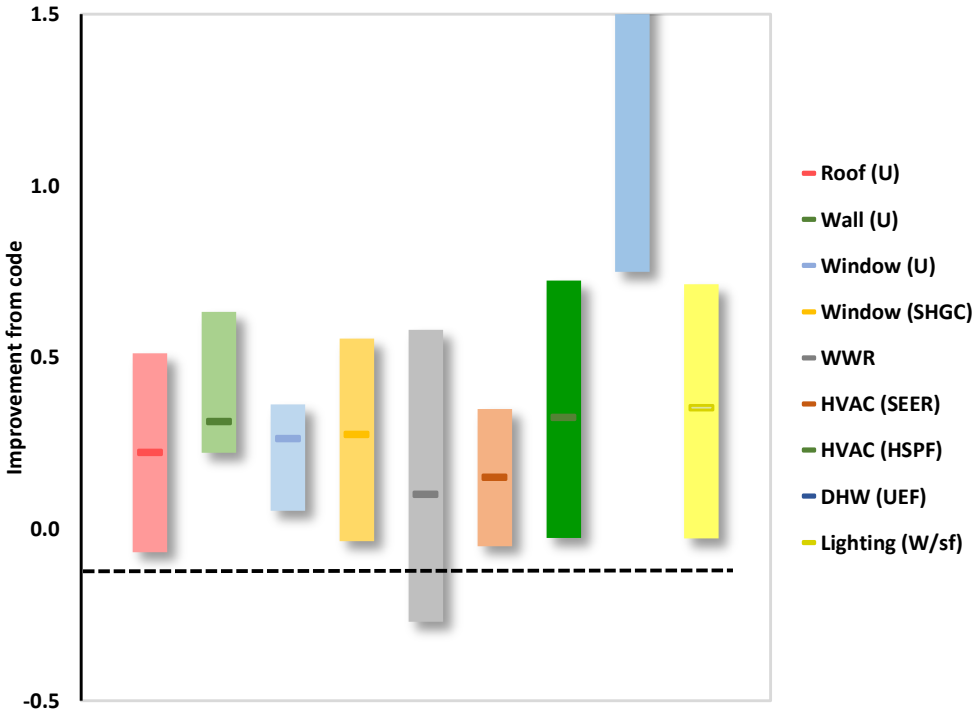


Figure 45. Modular ECM improvement from code (CZ4).

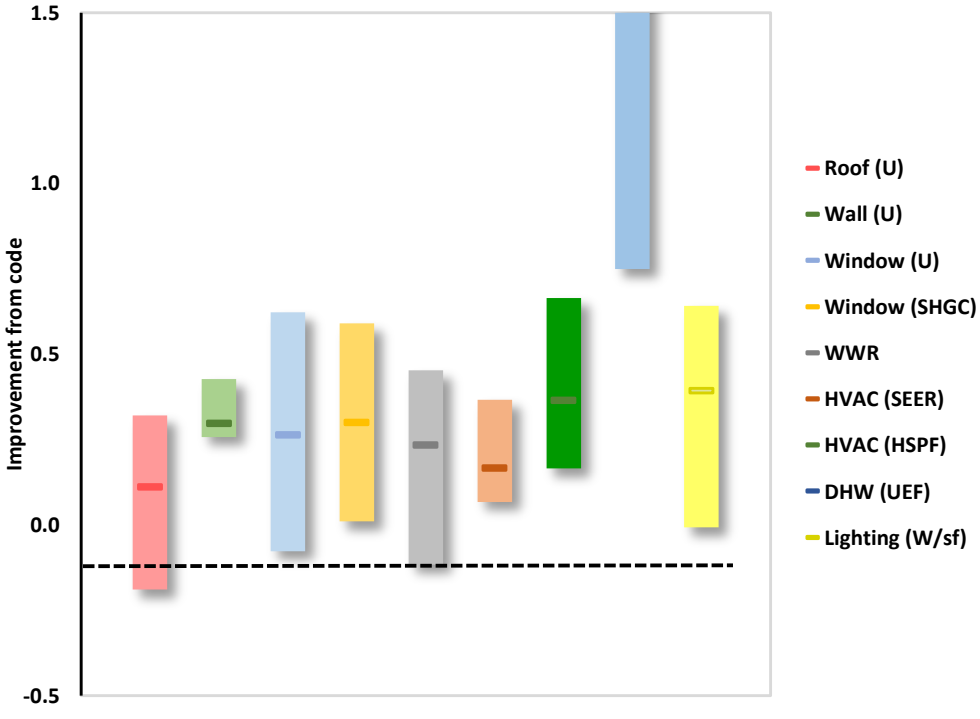


Figure 46. Site-built ECM improvement from code (CZ4).

High Reflectance Roofs

Low-sloped roofs in CZ3 are required to meet roof solar reflectance or thermal emittance requirements. For modular buildings, the roof material was only visible on site and not in the factory. If the installed roof was a white roof a value of "0.55" was recorded. Of 7 modular and site-built buildings in CZ3 (and not in T24 CZ 1-8, 12 or 16), 7 (100%) were found to have met the T24 code requirement with aged thermal reflectance values ranging from 0.63-0.70 and thermal emittance values ranging from 0.75-0.85.

Continuous Air Barrier

Materials deemed to comply with air barrier requirements were found on all (100%) of modular and site-built buildings. Materials include plywood or oriented strand board (3/8" min. thickness) and gypsum board (½" min. thickness). Three buildings were found to also have extruded polystyrene or foil-back polyisocyanurate insulation board (½" min thickness) installed on the outside of the wall sheathing. For modular buildings, the air barrier was observed in the factory and again on site to verify that field connections and penetrations were properly sealed. Inspections verified that the air barrier was continuous between wall and roof assemblies and between wall and floor assemblies. Inspections also verified that insulation was in contact with an air barrier to prevent air from passing through the insulation. Blower door testing was conducted on 7 units in a modular building and 11 units in a site-built building. Although not required by T24, IECC or ASHRAE 90.1, average air leakage at 50Pa through the modular envelope (0.22 cfm/sf) was slightly less than average air leakage through the site-built envelope (0.23 cfm/sf).

Vestibules

Buildings designed to T24 do not require a vestibule. For IECC/SEC/WSEC buildings, vestibules were observed in the field for 4 modular and 2 site-built buildings. None of these IECC/SEC/WSEC buildings, whether having or not having a vestibule, were required to have an entrance vestibule given that residential entrances were either service entrances, shared with public access to mixed-use commercial spaces, had revolving doors or opened into a lobby space less than 3,000sf.

Thermostat Dead-band and Setback

Thermostats in all spaces including common spaces and dwelling units must have at least a 5°F dead-band. A dead-band is a temperature range in which neither heating nor cooling system is activated to prevent the thermostat from alternating between heating and cooling mode in rapid succession. Thermostats were identified and assigned to all HVAC systems serving dwelling units and residential common spaces from the mechanical schedule. For each thermostat, the make, model and control type were recorded. For modular buildings, thermostats were installed in the factory and were not powered

at time of inspection. Of 18 modular and site-built buildings having thermostats installed within the residential sample spaces, 18 (100%) had a minimum 5°F dead-band factory setting. Thermostats must also have automatic or programable setbacks. Programmable thermostats allow setback settings to lower the temperature in the winter and raise the temperature in the summer during periods when the conditioned space is unoccupied. All thermostats observed had factory default setbacks ranging from 62°F (heating mode) to 80°F (cooling mode) or approximately 6°F setback from the default occupied setpoints. For buildings in CZ3c and CZ4c with DOAS systems and electric heat, dead-band and setback settings were not observed.

Night Fan Controls

Fans that control ventilation related to HVAC systems are required to be off during unoccupied periods. This measure applies to ventilation systems whether they are stand alone or within heating and cooling systems. This measure is not applicable to dwelling units. For 11 of 11 (100%) modular and site-built buildings having sequence of operations (SOO) data, residential corridors and commons were provided with continuous OA ventilation. Five additional modular buildings had open-air corridors. One other site-built building was a condominium and did not have corridors or common spaces separate from dwelling units. Except for leasing and property management offices, few other residential spaces had scheduled periods of inoccupancy requiring night fan controls. Spaces having scheduled periods of inoccupancy comprised a very small proportion (<5%) of the overall residential floor area and approximately one-third were provided demand control ventilation (DCV).

Duct Leakage

Duct joints, seams, and connections must be fastened and sealed. All ductwork located outside the building envelope must be tested. For modular buildings, ducts in dwelling units were observed in the factory, whereas ducts in common spaces were observed in the field. For 13 modular and site-built buildings, the primary residential space heating and cooling systems were ductless mini-split or multi-split systems. For all remaining buildings, ducts in dwelling units were located within the thermal envelope, usually in a duct chase below the finished ceiling, especially for buildings using dimensional wood framing. For all buildings, interior corridors were ventilated by rooftop DOAS equipment via vertical supply and exhaust air shafts. None of the code applicable energy reports (T24, COMCheck, etc.) provided data on duct leakage testing.

Storage Tank Heat Traps

Buildings with storage tank-type water heaters or hot water storage tanks with vertical water pipes must have either integral heat traps or heat traps installed on both the inlet and outlet of the tank. For 17 modular and site-built buildings using solar water heating systems that require thermosiphoning, tankless systems or ASHRAE 90.1/SEC recirculating systems, heat traps are not required. Of the 14 remaining modular and site-built buildings using in-unit storage tank-type water heaters or central DHW storage tanks, all were equipped with integral heat traps or, had dielectric union heat traps installed on both the inlet and outlet of the tank. External heat traps on storage tank water heaters were often observed in the factory whereas heat traps on central DWH storage tanks were only observed in the field.

Pipe Insulation

For buildings with automatic circulating and heat-traced water heating systems, hot water piping must be insulated with not less than 1 inch of insulation ($U \leq 0.27$ or $R \geq 3.7$). For modular buildings, pipe insulation was observed in the factory. Of 25 modular and site-built buildings requiring insulation on recirculating hot water piping, 17 (70%) were found to have met the code requirement. For the remaining buildings, pipe insulation could not be verified at time of inspection (e.g. not yet installed or covered by interior finishes).

Temperature Maintenance Systems and Demand Recirculation Controls

DHW circulation systems must be equipped with automatic time switches or controls that can deactivate the pump when the water in the circulation is at the desired temperature and when there is not a demand for hot water. For modular and site-built buildings that comply with Title 24, controls for hot water temperature maintenance systems are not required. For buildings that comply with the SEC, hot water demand recirculation systems are not permitted. For buildings that do not have circulating central water heating systems, neither temperature maintenance systems or demand recirculation controls are applicable. Of 13 modular and site-built buildings requiring demand recirculation controls, only 5 (39%) could be verified. For the remaining buildings, recirculation controls could not be accessed on site or verification found in the construction documents.

Interior Lighting Controls

Occupancy sensors are required in certain specific space types, varying by code. Occupancy sensors must turn lights off automatically within a certain period of time after occupants leave the space. If occupants enter the space, these controls are required to turn lights on automatically or manually, depending on space type. For dwelling units that comply with Title 24, at least one luminaire in bathrooms, laundry

rooms and utility rooms must be controlled by an occupancy sensor. Of these, 9 (53%) had occupancy sensors installed at time of inspection. For dwelling units that comply with the IECC/SEC/WSEC, all permanently installed luminaires must be controlled by an occupancy sensors. Of these, 3 (21%) had occupancy sensors installed at time of inspection. For modular buildings, occupancy sensors were often observed in the factory and again on site but generally were not powered at time of inspection. For the remaining site-built buildings, occupancy sensors could not be verified at time of inspection (e.g. not yet installed). Dwelling units are generally exempt from daylighting controls. The requirements for daylighting controls generally do not apply to interior corridors and most common spaces.

Exterior Power Allowance and Lighting Controls

Exterior lighting must be automatically controlled by an astronomical time switch or a photocell. Power allowances and controls for exterior lighting associated with residential use of the building such as resident entries, walkways, driveways, parking, pool areas and other outside residential commons areas are included. Power allowances and controls for exterior lighting associated with commercial use of the building or shared with commercial use of the building are excluded. For buildings that comply with the IECC, exterior lighting controlled from within a dwelling unit is exempt. For both CZ3 and CZ4, the average exterior power allowance of modular buildings was 0.09W/sf compared to 0.13W/sf for site-built buildings. Since most modular and site-built buildings were mixed-use, it was often difficult to differentiate between shared commercial and residential use of exterior spaces. As a result, data collection and analysis for exterior power allowance and lighting controls is incomplete.

Onsite Renewable Energy

Renewable energy systems may be required to meet code requirements based on peak rated output per square foot of building area, or as a percentage of the mechanical, water heating, and lighting energy use. Onsite renewable energy is a requirement of IECC for buildings that have applied for energy credits under C406 (0.50W/sf) and, for all SEC buildings under C411. Of 6 modular and site-built buildings under the SEC, 5 (83%) were found to have solar photovoltaic (PV) systems meeting the code requirement of 0.25W/sf. Seven buildings (4 modular and 3 site-built) under T24 were found to have installed solar water heating or PV systems. None of the IECC buildings were observed as having applied for renewable energy credits or having installed renewable energy systems.

In summary, data was obtained on 25 modular and 30 site-built commercial multifamily buildings (Appendix B). Of 38 measures selected for code compliance study, roughly 30% were not required by code in one or more study regions or were not applicable to all buildings, space uses and equipment systems. Examples include high reflectance roofs, entrance vestibules, night fan controls, duct leakage, DHW heat traps, temperature maintenance systems, demand recirculation controls, exterior lighting controls and interior daylighting controls (Table 7). Data collection for these measures was limited.

Table 7. Energy conservation measures (ECMs) selected for code compliance study.

Category	Energy Efficiency Measures	
Envelope	● Roof insulation ● Wall insulation ● Window U-factor ● Continuous air barrier	● High reflectance ('cool') roofs ● Window-to-wall ratio ● Window SHGC ● Entrance vestibules
HVAC – Space Cooling Equipment	● Split AC efficiency ● PTAC/VTAC efficiency ● Mini/multi-split efficiency	● Split HP efficiency ● PTHP/VTHP efficiency
HVAC – Space Heating Equipment	● Split HP efficiency ● Mini/multi-split efficiency ● Central boiler efficiency	● PTHP/VTHP efficiency ● Gas furnace efficiency
HVAC – Controls	● Thermostat dead-band ● Ventilation night fan control	● Thermostat setback ● Duct leakage
DHW – Equipment	● Central boiler (DHW) efficiency ● In-unit electric storage efficiency ● Storage unit heat traps	● In-unit gas storage efficiency ● In-unit tankless/instant efficiency ● Pipe insulation, recirculation
DHW - Controls	● Central temperature maintenance	● Central recirculation controls
Lighting Systems and Controls	● Interior power allowance/LPD ● Manual control ● Occupancy sensor control ● Exterior lighting control	● Exterior power allowance/LPD ● Automatic time switch control ● Daylighting control
Onsite Renewables	● Solar photovoltaics and water heat-	

● ECM highly applicable to building type(s), code(s) and climate zone(s); <10% of sample excluded or unverifiable
● ECM marginally applicable to building type(s), code(s) and climate zone(s); ≥50% of sample excluded or unverifiable
● ECM not applicable to building type(s), code(s) and climate zone(s); >90% of sample excluded or unverifiable

ENERGY PERFORMANCE STUDY

The goal of the **energy performance study** was to compare the energy use intensity (EUI) of 25 completed modular multifamily buildings to a baseline of site-built multifamily buildings using post-occupancy energy use data. Post-occupancy data EUI data was obtained on 14 completed modular multifamily buildings. Building energy modeling (BEM) was used to obtain EUI data on an additional 9 completed modular multifamily buildings that did not yet have sufficient post-occupancy energy data. Post occupancy EUI data from modular multifamily buildings was then compared to a baseline of 128 comparable site-built multifamily buildings in the same sample area and climate zone.

Methods

Since permanent modular construction is regulated by the state in each sample area, the 23 projects recruited for participation in the energy performance study were identified through a permit search of modular multifamily dwelling units listed in the California HCD, Pennsylvania DCED and Washington L&I databases.

Beginning in 2015, energy benchmarking became required for commercial and multifamily buildings in Seattle, WA. By 2019, energy benchmarking using the ENERGY STAR Portfolio Manager™ was required for all commercial and multifamily buildings over 50,000sf in all study regions (Table 8). Benchmarking data, including site energy-use intensity (kBtu/sf/yr), ENERGY STAR™ score, energy use by source, greenhouse gas emissions (GHGE) and other post-occupancy energy use data was obtained for 14 modular multifamily buildings. Site EUI and ENERGY STAR™ scores for each modular building were averaged for the years energy benchmarking data was available (e.g. data range). These values were then compared to benchmarking data over the same data range from a sample of site-built multifamily buildings of similar size built in the same year and metro area (city, county, etc.) as the modular multifamily buildings.

To be eligible for ENERGY STAR™ certification, a building must earn a score of 75 or higher on the U.S. Environmental Protection Agency (EPA) 1-100 scale, indicating that the building performs better than at least 75% of similar buildings nationwide. Scores are calculated using at least 12-months of actual utility billing data using the ENERGY STAR Portfolio Manager™ tool and considers important energy use factors including year built, number of buildings, gross floor area, conditioned floor area, weather (e.g. heating and cooling degree days), occupancy type and percentage of occupancy, number of residential units, total number of bedrooms, number of laundry hookups, and other considerations. Gross floor area includes all fully enclosed spaces including both residential and non-residential spaces such as management offices, utility spaces, corridors, fitness rooms, small retail spaces, community rooms and other common spaces <5,000sf.

Table 8. Annual energy benchmarking requirements.

State of California	2019	All commercial and multifamily residential buildings >50,000sf.	Building Energy Benchmarking Program
Los Angeles, CA	2017	All commercial and residential >100,000sf (2017); >50,000sf (2018); >20,000sf (2019).	The Existing Buildings Energy and Water Efficiency (EBEWE) Program
San Francisco, CA	2019	All commercial buildings >10,000sf and multifamily residential buildings >50,000sf.	Existing Buildings Energy Performance Program
Philadelphia, PA	2014	All commercial and multifamily residential buildings >50,000sf.	Philadelphia Energy Benchmarking
Seattle, WA	2015	All commercial and multifamily residential buildings >20,000sf.	Seattle Energy Benchmarking

Next, the EUI of and additional 9 modular buildings that did not yet have sufficient post-occupancy energy data were evaluated using ASHRAE 140 compliant building energy modeling (BEM). Each of these projects were approved as having complied with the energy efficiency requirements of the T24 or IECC performance path method. Unlike prescriptive code compliance which requires that each element of a building meet a minimum acceptable standard, performance path requires the use of energy modeling to evaluate the energy performance of all elements of a building together as an integrated system. An output of the BEM process is a 'site' EUI, or the predicted energy use of the building per unit floor area per year (Btu/sf/yr) and considers the energy efficiency of building elements, building orientation and geometry, space use, occupancy patterns, climate, shading and other factors. An estimate of 'source' EUI and greenhouse gas emissions (GHGE) can also be determined based on available fuel types (electric, gas, etc.) and subsequent energy generation and transmission efficiencies.

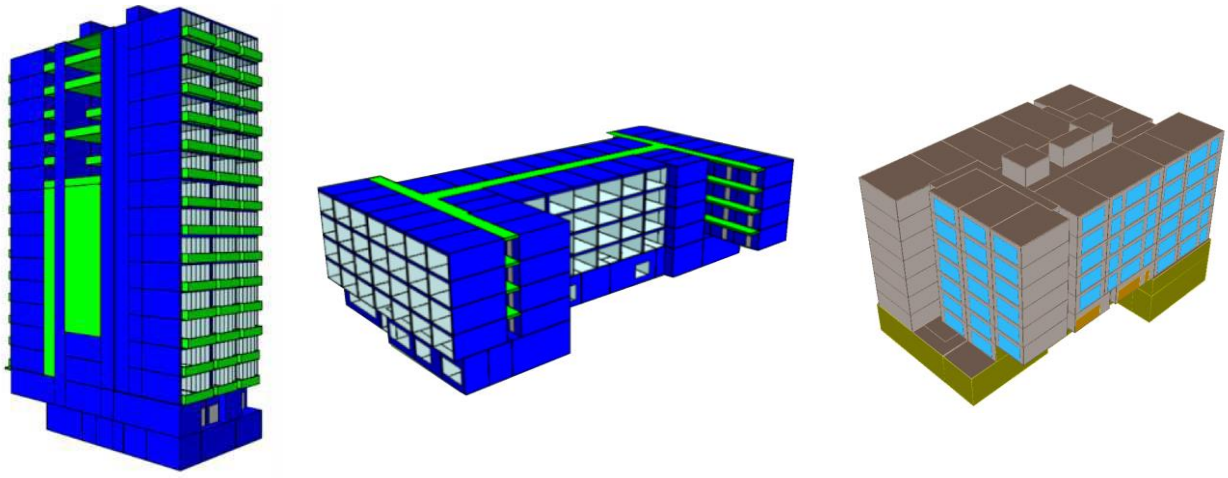


Figure 47. Building energy modeling (BEM).

BEM software tools provide hour-by-hour whole building energy simulation that incorporates detailed calculations of sun angles, shading, direct solar gain, solar influenced exterior surface temperatures, diversified occupancy schedules, thermal mass, HVAC thermostat schedules, building HVAC controls, ventilation, fan energy and fan heat. Input to the model includes hourly weather data using actual weather records in each study location.[4]

[4] EnergyPlus.net/weather-location

Results

Similar to the code compliance study, results suggest that the average post-occupancy energy performance of modular multifamily construction (36.0 kBtu/sf/yr) is similar to the average post-occupancy energy performance of site-built multifamily construction (35.8 kBtu/sf/yr) among buildings of similar age and typology (Table 9). However, ENERGY STAR™ scores for modular multifamily construction (86) are somewhat higher on average compared to site-built multifamily construction (81), suggesting that when normalized for occupant density and other energy use factors, the actual energy performance of modular multifamily construction may exceed the energy performance of site-built construction. In fact, the average floor area of modular multifamily buildings used in the performance study (115,235sf) was 20% less than the average floor area of site-built multifamily buildings (147,436sf). Yet, the average number of residential units in modular multifamily buildings was greater than the average number of units in site-built buildings. As a result, the occupant density for modular multifamily buildings may be more than 30% greater than the occupant density for site-built multifamily buildings. In summary, EUI data was obtained on 23 modular and 128 site-built commercial multifamily buildings (Appendix C).

Table 9. Modular and site-built building energy performance by building.

			Modular				Site-built			
Project	CZ	Year Built	Data Range	GSF	Site EUI	E-Star Score	No. Bldgs.	GSF	Site EUI	E-Star Score
Mod 1[1]	3B	2013	2017-21	69,111	44.9	58	13	72,694	32.4	73
Mod 2[1]	3B	2017	2020-21	386,000	41.7	58	12	265,887	34.7	80
Mod 3[2]	3B	2020	-	37,651	44.6	-	-	-	-	-
Mod 4[2]	3B	2021	-	36,273	41.3	-	-	-	-	-
Mod 5[2]	3B	2022	-	51,967	31.0	-	-	-	-	-
Mod 6[2]	3B	2023	-	55,224	29.9	-	-	-	-	-
Mod 7[1]	3C	2014	2019-21	500,000	30.2	95	13	171,017	34.7	82
Mod 8[1]	3C	2016	2019-21	198,258	21.2	100	10	241,582	37.6	80
Mod 9[1]	3C	2016	2019	66,813	57.1	93	8	96,620	29.5	89
Mod 10[1]	3C	2017	2019-21	162,575	27.5	96	9	169,546	23.0	90
Mod 11[1]	3C	2017	2019-21	107,521	53.5	82	9	169,546	23.0	90
Mod 12[1]	3C	2019	2019-21	50,406	58.2	75	12	260,796	30.6	91
Mod 13[1]	3C	2020	2021	72,776	46.0	95	3	98,462	52.4	82
Mod 14[2]	3C	2021	-	39,752	27.6	-	-	-	-	-
Mod 15[2]	3C	2021	-	58,000	28.1	-	-	-	-	-
Mod 16[1]	4A	2012	2016-21	129,330	52.1	83	7	155,494	46.9	68
Mod 17[1]	4A	2015	2017-21	65,864	32.1	80	6	89,904	56.2	45
Mod 18[1]	4A	2020	2020-21	277,542	22.0	98	6	151,682	35.9	77
Mod 19[1]	4C	2014	2015-20	47,343	30.2	98	10	59,481	35.8	90
Mod 20[1]	4C	2017	2018-20	41,132	25.7	-	10	45,150	28.2	96
Mod 21[2]	4C	2023	-	63,518	25.1	-	-	-	-	-
Mod 22[2]	4C	2023	-	49,760	38.0	-	-	-	-	-
Mod 23[2]	4C	-	-	83,585	21.1	-	-	-	-	-
Average				**115,235**	**36.0**	**86**	**128**	**147,436**	**35.8**	**81**

[1] Benchmarking data.
[2] Building energy modeling (BEM) data.

Table 10. Modular and site-built building energy performance by climate zone.

	Modular			**Site-built**		
Climate Zone	Number of Buildings	EUI (kBtu/sf/yr)	Energy Star Score	Number of Buildings	EUI (kBtu/sf/yr)	Energy Star Score
3B	6	38.9	58	25	**35.5**	76
3C	9	38.8	91	64	**33.0**	86
4A	3	**35.4**	87	19	46.3	63
4C	5	**28.0**	98	20	32.0	93
	23	**36.0**	**86**	**128**	**35.8**	**81**

AIR LEAKAGE STUDY

The air leakage rates of 7 modular dwelling units were compared to the air leakage rates of 11 site-built dwelling units used in the **code compliance study**. For all tests, the air leakage rate (cfm) and air change rate per hour (ACH) was observed at a pressure of 50 Pa. For modular unit tests, air leakage rates were further observed at multipoint pressures between 20 and 60 Pa. Results indicate that modular units had a higher air change rate (6.0) on average than site-built project units (4.7). Modular units, however, were smaller than the site-built units, so the envelope area of modular units was greater relative to unit floor area and interior volume. When normalized for this difference, the average air leakage rate of modular unit envelope area (0.22 cfm/sf) was slightly less than the air leakage rate of site-built unit envelope area (0.23 cfm/sf).

Although few differences were observed between the types of materials and equipment used in either modular or site-built multifamily construction, the installation quality of envelopes in modular multifamily construction appeared to be better when compared to site-built construction. Damage to the modular envelope, however, was often observed following transport to the building site. Also observed were several field modifications to the envelope of modular units to accommodate structural and mechanical connections. Together with extensive use of through-wall HVAC systems, the transport, placement, and rework of modular units likely compromised the higher quality of envelope installation and airtightness observed in the factory.

Methods

To determine the extent of degradation in envelope airtightness associated with the transport and placement of modular multifamily dwelling units, an NREL study, *Energy Efficiency in Permanent Modular Construction*, was commissioned in 2021 to compare the factory airtightness to the post-transport airtightness of 7 modular dwelling units. Units consisted of 5 one-bedroom dwellings units and 2 studio dwelling units. These units were part of a 400-unit commercial multifamily development located in Philadelphia, PA and permitted under the IECC 2015 energy code. Beginning in May 2021, two rounds of testing were performed in the factory including ANSI/RESNET/ICC 380-2019 envelope leakage tests on units in a (1) pre-sealed and (2) sealed condition. Pre-sealed testing was first performed following the installation of windows, doors, and interior finishes. Sealed testing was then performed following the sealing of ductwork; HVAC cabinets; and mechanical, electrical, and plumbing penetrations. Sealed testing also included the use of a self-sealing aerosol designed to seal fine air leaks in the unit envelope.

Results

Results (Table 11) show none of the pre-sealed units would have met the 2015 IECC air change rate (≤ 3.0 ACH) requirement for residential and low-rise multifamily buildings. Once sealed, however, 6 of 7 units would have exceeded the 2015 IECC air change rate requirement.

Table 11. Pre-set modular air leakage test results.

Unit	Unit Type	Unit Volume (cf)	Factory ACH_{50} (Pre-sealed)	Factory ACH_{50} (Sealed)	Site Staging Area ACH_{50}
1	1-Bedroom	4,333	9.0	1.8	6.0
2	Studio	3,193	5.9	1.0	7.7
3	1-Bedroom	4,333	10.8	3.1	3.7
4	Studio	3,193	6.9	1.8	6.0
5	1-Bedroom	4,400	5.7	1.7	6.2
6	1-Bedroom	4,400	7.4	2.4	-
7	1-Bedroom	4,400	6.4	1.1	6.3
	Average		**7.4**	**1.8**	**6.0**

In December 2021, following transport approximately 500 miles from the factory to the project site, the same 7 units were again tested in a staging area prior to placement. These units, however, were tested with transportation wrap still installed. In addition, HVAC cabinets were unsealed, bath fans and lighting fixtures were not installed, and in one case, a window was missing. Also observed was cracking of drywall interiors. As a result, air leakage following transport was comparable to the pre-sealed condition observed in the factory (Table 11). To determine if any further degradation in envelope airtightness occurred during crane placement and post-set rework, the same 7 units were tested a fourth time in May 2022 (Figure 48). The air leakage rates of installed modular units were further compared to a baseline of 11 site-built multifamily dwelling units of similar size and construction, located in the same area and permitted under the same energy code. All modular and site-built dwelling units were tested within 30 days of certificate of occupancy.

Figure 48. ANSI/RESNET/ICC 380-2019 envelope leakage test setup.

The average air change rate for the 7 modular units tested following placement was 6.0 ACH (Table 12).

The average enclosure air leakage rate for the 7 modular units tested was 0.22 cfm/sf.

Table 12. Post-set modular air leakage test results.

Unit	Unit floor Area (sf)	Unit Volume (cf)	Enclosure Area (sf)	Unit Air Leakage (cfm)	Unit Air Leakage (ACH)	Enclosure Air Leakage (cfm/sf)
1	490	4,333	1,700	369	5.1	0.21
2	375	3,193	1,390	406	7.6	0.29
3	490	4,333	1,760	362	5.0	0.21
4	375	3,193	1,390	422	7.9	0.30
5	500	4,400	1,780	367	5.0	0.21
6	500	4,400	1,780	418	5.7	0.23
7	500	4,400	1,780	436	5.9	0.24
				Average	**6.0**	**0.22**

The average air change rate for the 11 site-built units tested following placement was 4.7 ACH (Table 13). The average enclosure air leakage rate for the 11 site-built units tested was 0.23 cfm/sf.

Table 13. Site-built air leakage test results.

Unit	Unit floor Area (sf)	Unit Volume (cf)	Enclosure Area (sf)	Unit Air Leakage (cfm)	Unit Air Leakage (ACH)	Enclosure Air Leakage (cfm/sf)
1	750	7,875	2,717	610	4.6	0.22
2	950	9,975	3,207	670	4.0	0.21
3	723	7,592	2,596	463	3.7	0.18
4	723	7,592	2,596	596	4.7	0.23
5	823	8,642	2,924	797	5.5	0.27
6	750	7,875	2,717	638	4.9	0.23
7	950	9,975	3,207	774	4.7	0.24
8	723	7,592	2,596	676	5.3	0.26
9	823	8,642	2,924	599	4.2	0.20
10	750	7,875	2,717	630	4.8	0.23
11	950	9,975	3,207	875	5.3	0.27
				Average	**4.7**	**0.23**

Damage to the modular envelope, however, was often observed following transport to the building site. Damage consisted of cracks in the drywall, which had mostly been repaired prior to testing. Also observed were several field modifications to the envelope of modular units to accommodate mechanical connections. In several units, field rework was noted in ceilings to relocate fire protection or other mechanical, electrical, and plumbing systems. In addition, access panels were cut beneath the HVAC system in test units to relocate or connect condensate piping (Figure 49). In other cases, supply duct chases from the HVAC system appeared to be unsealed. Together with the use of through-wall vertical terminal heat pump systems, which are inherently less airtight than comparable spilt HVAC systems used in the site-built units, considerable air leakage was traced to the mechanical closet.

Figure 49. Unsealed condensate access (note relocated drain hole filled with batt insulation).

To determine the air leakage through the HVAC closet, the closet in one of the modular tests units was sealed and the blower door test repeated. The unit air leakage rate was reduced roughly 20% from 422 CFM_{50} to 337 CFM_{50} (7.9 ACH_{50} to 6.3 ACH_{50}). Results of multipoint airtightness tests further suggest that modular air leakage was likely caused by a smaller number of larger openings in the modular unit enclosure such as those found in the HVAC closet. On average, the slope of the trend line showing unit air leakage (cfm) in relation to unit air pressure (Pa) for modular dwelling units is 0.52 (Figure 50). A slope approaching 0.50 suggests air leakage caused by a smaller number of larger openings in the unit enclosure. A slope approaching 1.0 suggests air leakage caused by a larger number of smaller openings in the unit enclosure.

Opportunities exist for air leakage improvement in modular dwelling units, including minimizing and pre-cutting penetrations at the factory where possible, proper sealing of field modifications, and use of split systems in place of through-wall packaged systems. In addition to improved airtightness, mini-split and multi-split systems typically have higher efficiency compared to packaged systems and wall or ceiling mounted split systems can maximize available dwelling unit floor space.

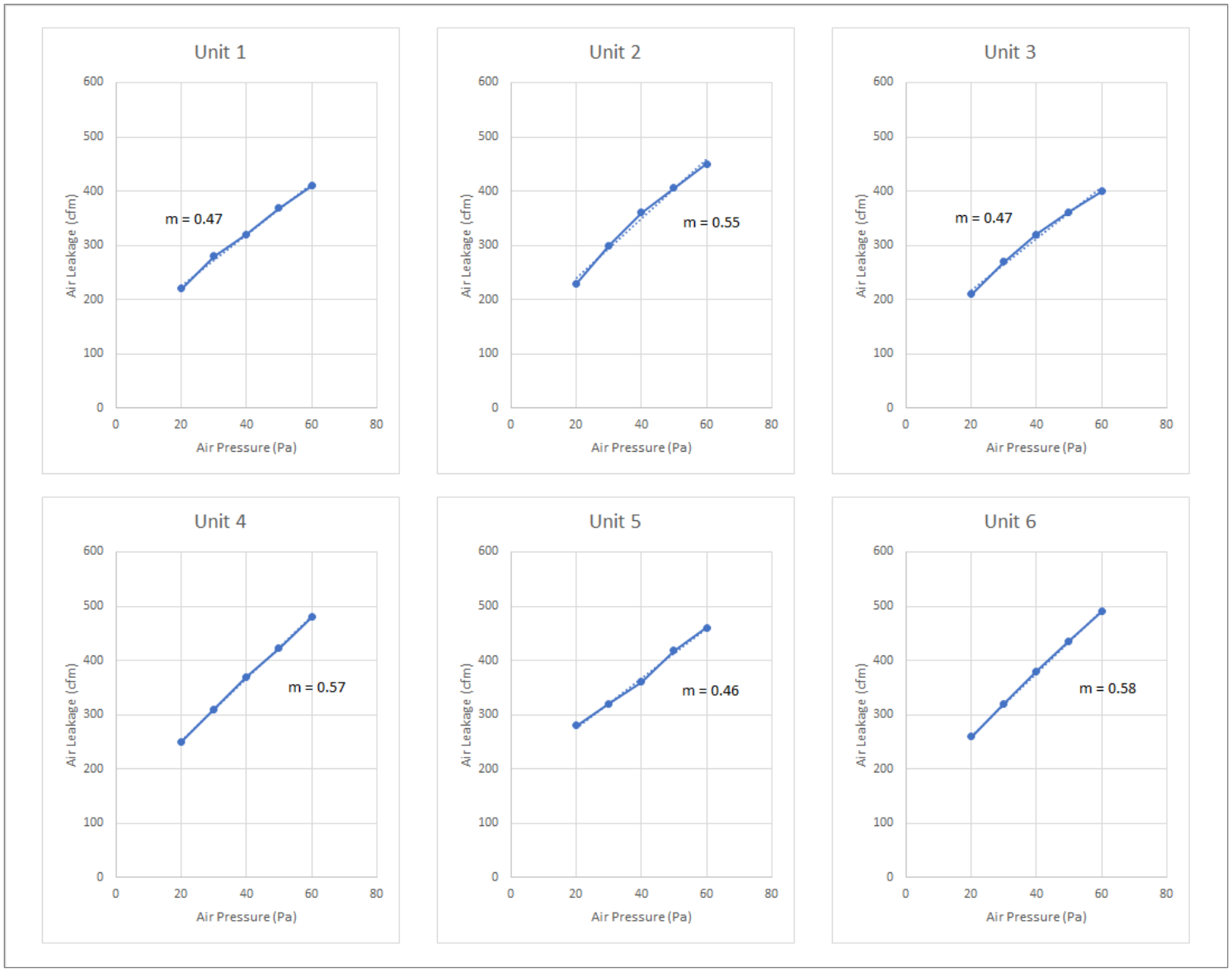


Figure 50. Modular multipoint blower door tests.

MARKET RESEARCH STUDY

Interviews were conducted with project stakeholders during factory and construction site visits to identify key market benefits and barriers to modular construction including schedule savings, construction cost, transportation and site logistics, facility investments, financing and project delivery methods. Other factors such as materials and waste, permitting and inspections, safety and productivity, and design flexibility were also discussed. Findings suggest that the most significant advantage of modular construction is schedule savings. Completion of above-grade modular structures and curtain wall assemblies was achieved in roughly half the time required for comparable site-built construction. Overall, modular buildings in this study were completed 25% faster on average when compared to site-built buildings. Modular construction was found to be cost-competitive with site-built construction when considering shortened construction schedules and faster income generation, particularly for mid-rise and high-rise multifamily buildings in areas with stringent codes and high construction costs.

Differences in production efficiency, however, were observed between volumetric and non-volumetric modular construction. Transportation of non-volumetric assemblies (e.g. panels and components) was generally more efficient than transportation of volumetric modules and required less jobsite staging area and logistics. Unlike volumetric modular construction, non-volumetric modular components were sourced and assembled from a decentralized supply chain of vendors and fabricators, increasing reliability while distributing risk and reducing cost. While both benefit from the safety and productivity of climate-controlled manufacturing facilities, non-volumetric modular production was achieved in smaller, less asset-intensive factories with fewer workers.

Perhaps the greatest potential benefit of non-volumetric construction is greater product-centric standardization, repeatability and market diversification. Unlike volumetric modular manufacturers that must absorb the cost and inefficiency of designing and manufacturing a new product for each project, non-volumetric modular manufacturers can provide standardized products for multiple projects and project types. As a result, panelized manufacturers may be better able to sustain production between project cycles, maintain cash flow and retain a more stable workforce.

Methods

To assess production efficiency, interviews were conducted with project stakeholders during factory and construction site visits to identify key market performance and production efficiency factors. Project stakeholders included project executives, design professionals and construction field supervision staff. Key market performance and production efficiency factors surveyed included:

- Schedule
- Cost
- Transportation and Site Logistics
- Facilities
- Financing
- Delivery Models
- Materials and Waste
- Permitting and Inspections
- Quality
- Flexibility
- Safety and Productivity
- Labor

Results

Results from stakeholder interviews suggest that barriers to modular uptake include a building industry that is unfamiliar with modular construction or is unwilling to change from traditional site-built methods. Other barriers include consideration too late in the design process, transportation cost, lack of uniform standards, permitting delays, and the risks associated with modular builders as a 'super-subs' in the design-bid-build delivery process. Volumetric modular construction is capital intensive and often requires large up-front deposits as well as frequent progress payments to maintain cash-flow. Along with offsite progress verification and a track record of financial distress, many commercial lenders will not fund volumetric modular projects. Permitting and inspection delays on volumetric modular projects were also found to increase costs and erode schedule savings.

In contrast, non-volumetric modular construction appears more amenable to the conventional financing, surety, permitting and inspections process. The design flexibility of panelized components may also allow greater repeatability and diversification between projects and project types. As a result, non-volumetric modular manufacturers may be better able to scale the production of standardized panels rather than absorb the cost and inefficiency of manufacturing customized volumetric modules for individual projects.

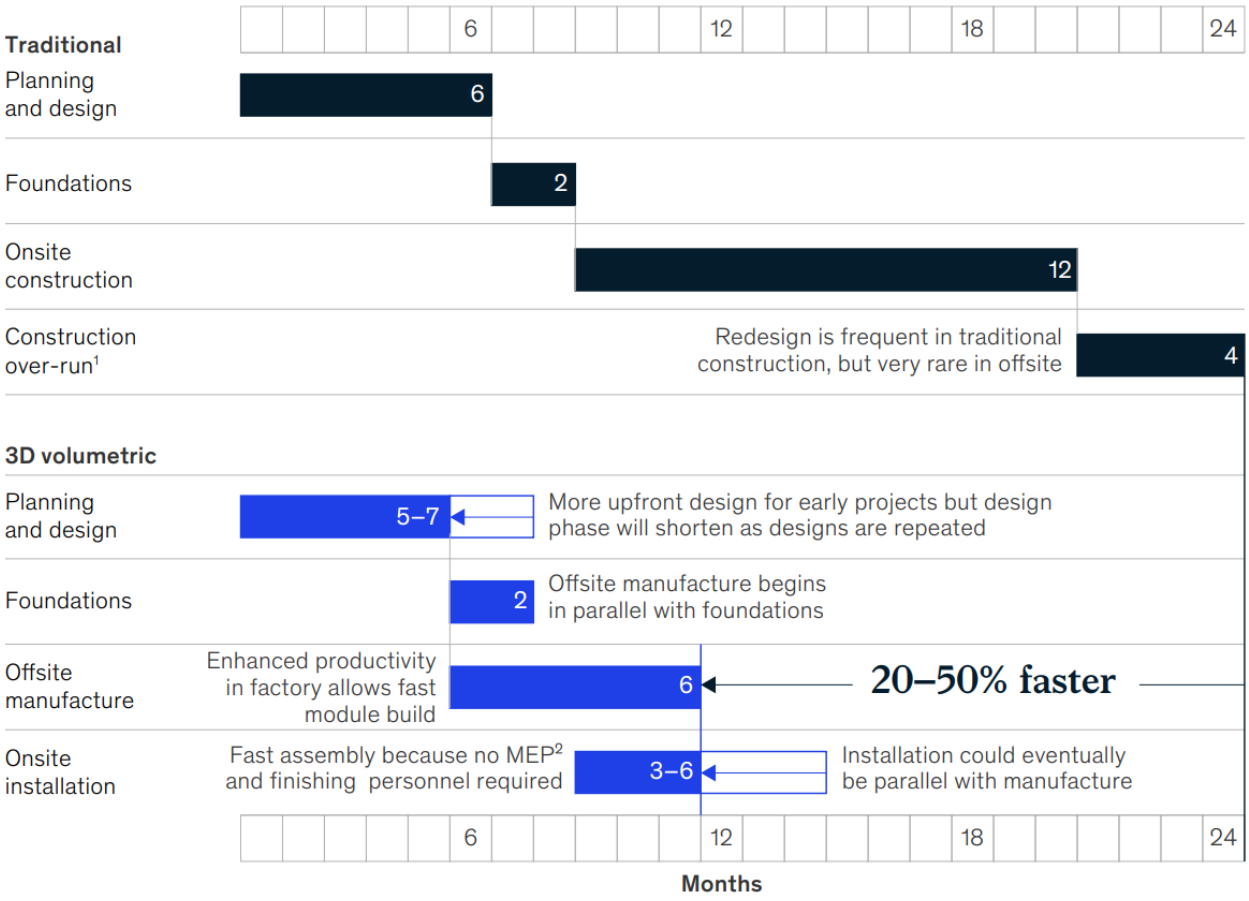
Construction Schedule

For occupancy-driven projects having standardized building units such as apartments and hotels, offsite prefabrication of repetitive building components can proceed simultaneously with onsite construction, reducing time, project overhead and the impact of weather (Figure 51). By placing 6-10 modules per day, the above grade structure on a modular building can be completed in 45-65% less time on average than the time required for comparable site-built construction.

For example, a non-volumetric modular project achieved 45% overall schedule savings when compared to a similar site-built project (Figure 52). As shown, the above-podium structure and envelope for the 60,000sf modular project consisting of more than 1,000 floor, load-bearing wall and ceiling panels, was erected in approximately 90 days. The modular project achieved enclosure and MEP rough-in before the adjacent site-built project completed framing. This project was completed in <12 months, roughly half the time required to complete the site-built project. Unlike traditional modular manufacturers acting as suppliers or subcontractors, the fabricators on this project were the design-manufacture-construct prime contractor with far more control over the project design and build. Combined with greater permitting and inspection familiarity, non-volumetric construction experienced fewer conflicts and schedule delays despite needing more onsite time and labor compared to volumetric modular construction.

Schedule savings was also found to be dependent on the extent of offsite production as a percentage of the total project. Offsite requires site-built foundations, exterior WRB and finish systems, MEP connections, and some interior finish work. For low-rise, slab-on-grade buildings where site-work is minimized and offsite is a greater percentage of the overall project, greater schedule savings can be achieved. For larger projects requiring deep foundations, elevator shafts and stair towers (Figure 53), offsite is a lesser percentage of the total project and overall schedule savings may be reduced. For most modular projects, corridors were unfinished so that MEP connections could be made between units and the building. Similarly, modular roofing and exterior finishes are installed onsite (Figure 54). Together, onsite activities can account for more than 60% of the budget and >80% of the construction schedule on modular projects. Delays in onsite construction combined with delays in permitting and offsite inspections can quickly negate modular time savings.

Using 3D volumetric modules can deliver 20–50 percent schedule compression. Example multifamily project construction duration, traditional vs offsite 3D volumetric, months.



[1] Over-runs of 25–50% of projected construction duration are common.
[2] Mechanical, electrical, plumbing.

Figure. 51. Modular and site-built construction schedule.
Source: Modular Construction - from Projects to Products, McKinsey (2019).

Figure 52. 6-month progress comparing non-volumetric modular construction and site-built construction. Modular project (left in each photo) achieves enclosure, insulation and MEP rough-in before the site-built project (right in each photo) completes framing (Month 6).

Figure 53. Onsite modular foundation construction.

Figure 54. Onsite modular exterior finishes.

Construction Cost

Construction costs for site-built projects in this study averaged $251/sf. The cost for modular projects averaged $243/sf, approximately 4% less than site-built construction. Site-built construction contracts, including firm, fixed-price contracts, usually have change orders and a contingency for unforeseen conditions. By comparison, modular contracts, which are typically 40% or more of the project, are 'locked in' prior to construction with greatly reduced (or eliminated) change orders and contingency. The modular manufacturer can also consolidate the mark-ups and contingencies of several subcontractors. Schedule savings from modular construction can reduce project overheads and interest carry on construction financing while accelerating income generation.

There is an opportunity for 20 percent savings—but at a risk of up to 10 percent cost increases if labor savings are outweighed by logistics or materials costs. Average 5-10% savings.

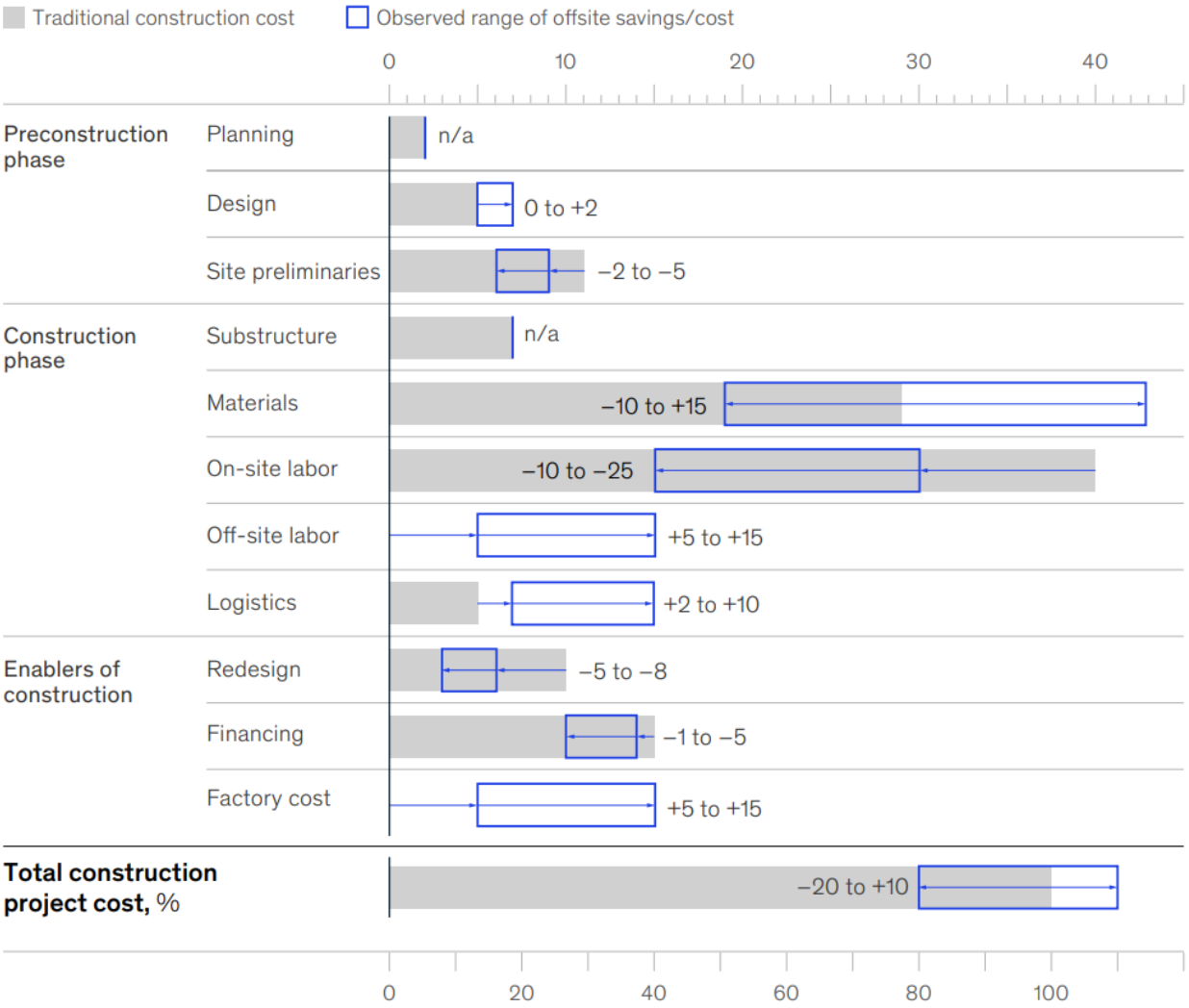


Figure 55. Modular and site-built construction cost.
Source: Modular Construction - from Projects to Products, McKinsey (2019).

Transportation and Site Logistics

Although offsite construction requires transportation of building assemblies from factory to site, transportation of non-volumetric modular construction was significantly more efficient than transportation of volumetric modules, reducing cost and the limitations of distance between factory and jobsite. Damage to non-volumetric components during transport and placement was significantly less than transport and placement of volumetric modules, resulting in less onsite rework and repair. Non-volumetric modular construction also required less jobsite storage and staging area than either volumetric modular or site-built construction (Figure 56). Perhaps the greatest benefit of transportation efficiency was the reduction in time that building components were exposed to weather. Volumetric modules for large multifamily projects are often produced over a period of several months and then stored at the production site or staging area near the job site until placement. Volumetric modular materials such as drywall and insulation are vulnerable to moisture during storage, transport and placement. In contrast, non-volumetric modular construction does not use moisture vulnerable materials and interior finishes are not installed until the building envelope is enclosed.

Facility Investments

While offsite construction benefits from the productivity of climate-controlled manufacturing facilities, volumetric modular construction requires significantly greater factory floor space. Volumetric modules are roughly 14-16ft wide and 65-75ft long (900-1,200sf) depending on the project and manufacturer. Factories can generally accommodate 20-30 modules at various stages of completion in each production line. Larger factories with multiple production lines may exceed 500,000sf. Completed modular units are stored at the factory before transportation to the jobsite or near-jobsite staging area. Given that few differences exist between the types of materials and assembly methods used in volumetric modular and site-built multifamily construction, volumetric modular is also labor intensive and factories must accommodate a large workforce. By comparison, non-volumetric modular production was achieved in much smaller, less asset-intensive factories. Components required less space to produce and store. Having no wet-wall components, non-volumetric manufacturing was also faster and required less equipment. Overall, fixed factory overhead for non-volumetric manufacturers was on average <20% of the fixed overhead for volumetric modular manufacturers.

Figure 56. Offsite storage and staging area required for modular construction.

Financing

One of the most significant institutional barriers to offsite construction has been access to commercial financing. For volumetric modular construction, materials must be purchased and production lines reconfigured for each project weeks or even months ahead of fabrication. Materials alone can be 60% or more of the total cost of production. As a result, volumetric manufacturers often require large upfront deposits 30%-50% of the modular contract. In addition, the capital intensive nature of volumetric modular construction often requires frequent progress payments in order for manufacturers to maintain cash-flow. Combined with offsite progress verification and a track record of financial distress within the modular industry, many commercial lenders will not fund volumetric modular projects.

For those lenders willing to fund modular projects, most require the developer to share more of the risk. This often includes the developer paying for line reservation fees and material deposits 3-6 months prior to production. As an unsecured loan, interest rates are often higher and loan-cost (LTC) ratio lower. As suppliers, modular manufacturers discourage retainage. Together, these and other factors contribute to higher equity requirements for the developer, particularly at the beginning of the project. Data from interviews with several project manufacturers and lenders is provided (Table 14).

Table 14. Modular finance, cash-flow and production metrics.

Delivery method	Supplier only (4); Supplier-GC (3); Developer-Supplier-GC (2)
Product type	Volumetric (6); Non-volumetric-panel (1)
Project type	Affordable (49%); Market rate (26%); Hospitality (21%); Other (4%)
Automation	Fully automated (0); Semi-automated (1); Manual, machine-assisted (6)
Productivity	2-5 module completions per day
Module cost	$100-180/sf ($130 avg); +$5,000-10,000/module for transport and crane set
Site schedule	7-15 months (11 average)
Cap rates	4%-6% (4.5 average)
Financing	0.65-0.70 LTC; interest-only; 12-18 month typ. with 6-month lease-up
Equity	20-30%; spent first (land acquisition, design, permitting, modular deposits)
Interest rates	≥9% blended; unsecured offsite work underwritten against developer credit
Draw schedule	LOI (5%); material (25%); online (30%); offline (35%); set (5%)
Retention	None (supplier not subcontractor)
Biling cycle	Every 15-30 days
Contract	Fixed price; 3-6 months prior to production

A letter-of-intent (LOI) and non-refundable deposit of *5%* of the modular contract is usually required 6 months ahead of production. A *25%* (or greater) material deposit is usually required 3 months ahead of production. Often, both line reservation and material deposits are paid by the developer before project financing is available. Once modular production begins, usually in parallel with on-site earthwork and foundations, volumetric modules progress through 2-3 factory work stations per day and are completed from start to finish in approximately 10-15 days. Most manufacturers using machine-assisted manual assembly produce 2-3 finished modules per day or 40 modules per month on average. An 'online' fee of 30-35% is charged for each module start and an 'offline' fee of 30-35% is charged for each module completion. The final 5-10% of the modular contract is usually billed following module transport and placement on site.

A cash flow schedule compares site-built construction to volumetric modular construction from the perspective of the project developer. The site-built case study is a 200-unit multifamily building consisting of 6 stories of Type-III residential over 1 story of Type-I commercial. The construction cost is $45M and the construction duration is 21 months. The modular case study is a 200-unit multifamily building consisting of 5 stories of modular over 1 story of Type-I commercial. The construction cost is approximately $45M and the construction duration is 15 months. The developer's monthly and cumulative cash-flow requirements for the site-built project are shown (Figure 57). The developer's equity requirement for construction is approximately $13.7M. $4.8M of this equity is deferred until the end of the project in the form of released retainage. Total interest carry during the project is $2.3M.

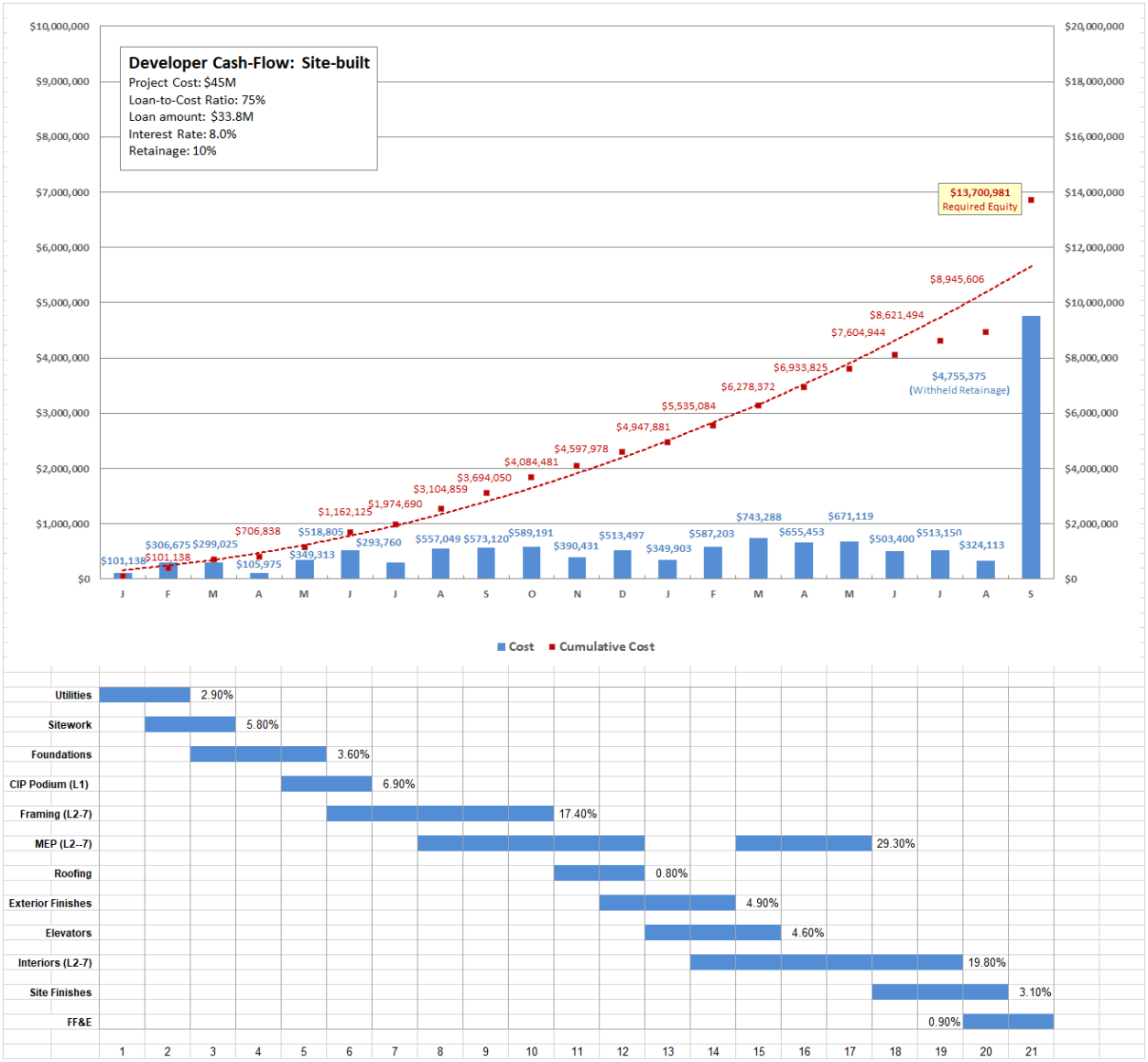


Figure 57. Site-built project cash deployment schedule.

The developer's monthly and cumulative cash-flow requirements for the modular project are also shown (Figure 58). The developer's equity requirement for construction is approximately $18.1M. $8.1M of this equity is required 3-6 prior to construction for line reservation fees and material deposits. Total interest carry during the project is $2.4M, roughly the same as the site-built project despite a 6-month shorter construction schedule. In contrast to the site-built project having more evenly distributed construction costs over a longer period of time, the modular project requires significantly more cash early in the project to the cover the cost of both onsite and offsite work occurring simultaneously.

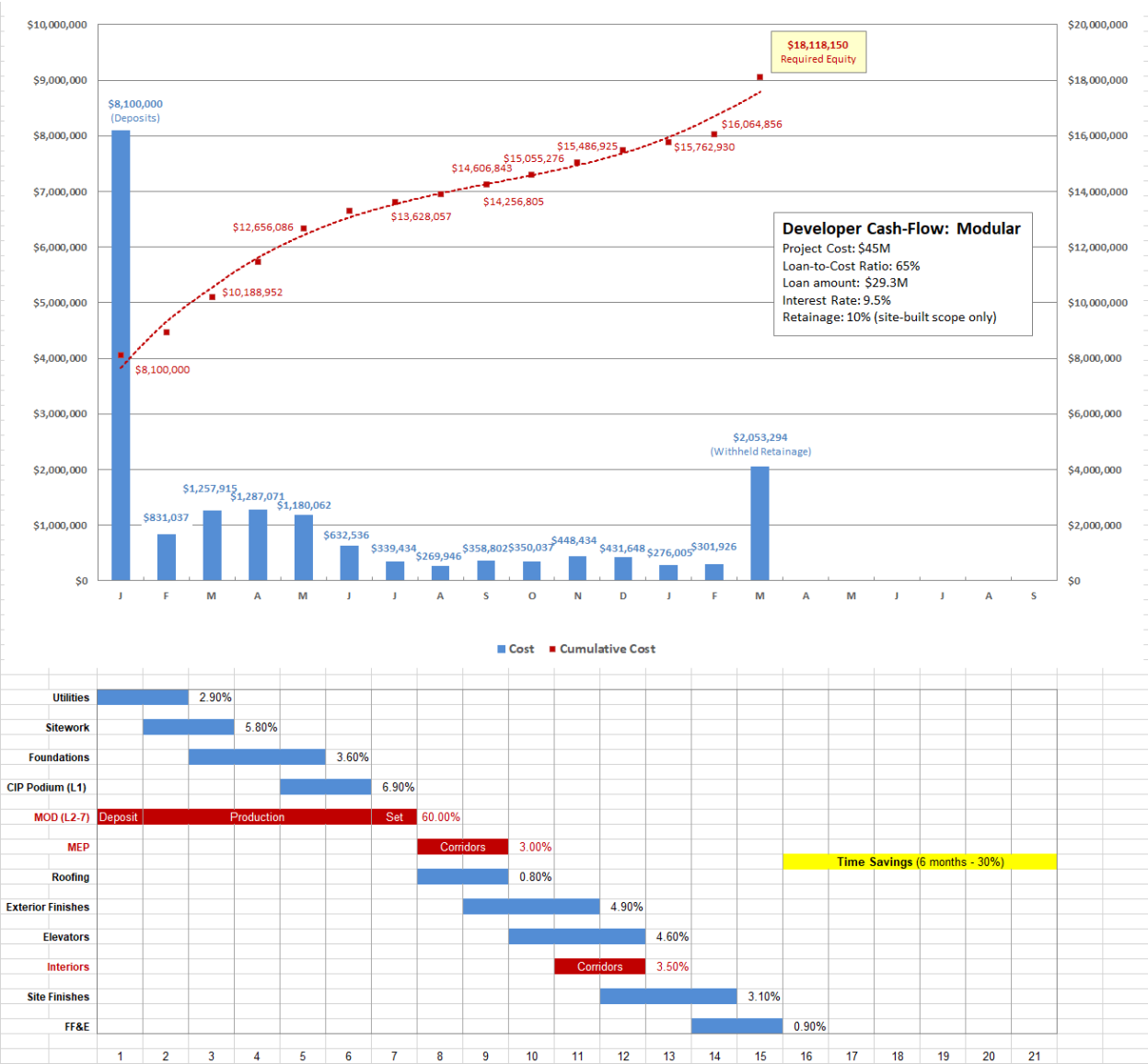


Figure 58. Modular developer cash deployment schedule.

Delivery Model

For the non-volumetric modular projects studied, the manufacturer was an integral part of a project development team. As a result, a commitment to offsite was made at the beginning of the project and buildings were designed for optimal component configurations. In contrast, volumetric modular construction is often considered too late in the design process. Sub-optimal module configurations are incorporated into site-built designs resulting in inefficient fabrication and added transportation costs. Non-standard, project specific module configurations do not allow for production to be maintained between project cycles resulting in downtime and difficulty maintaining a stable workforce. Volumetric modular construction also requires a large workforce and significant factory floor space. Consequently, most modular manufacturers can only produce one or two projects at a time, limiting the backlog of work required to maintain stable production. As a result, many volumetric modular manufacturers have difficulty servicing debt between project cycles. Unlike the project-centric business model of volumetric modular construction, non-volumetric modular construction has greater potential for product-centric standardization and diversification across multiple projects and project types. As a result, manufacturers of non-volumetric panels and components may be better able to manage production between project cycles, service debt and retain a stable workforce.

Labor Productivity and Safety

Offsite projects can not only reduce the number of workers onsite, but may also reduce many of the safety risks common on site-built projects, particularly fall hazards. Fewer workers and shortened construction schedules result in less noise, traffic and other disruptions to the surrounding community. In contrast to a transient workforce under the control of multiple trade contractors, offsite construction relies on a stable, permanent workforce under a central point of control. The repetitive, less specialized nature of prefabrication in a controlled factory setting also allows fabricators to better utilize a diverse workforce. As a result, offsite manufacturers can access a larger labor pool and potentially lower labor costs. The offsite manufacturer can further provide a work environment free of disruptions from other trades and unpredictable site and weather conditions. As data from project manufacturers shows (Table 15), offsite productivity rates for various types of modular construction are generally better than site-built construction. Modular construction appears to moderately reduce labor hours and dependence on skilled labor availability when compared to site-built construction. Combined with offsite and onsite production occurring simultaneously, overall construction schedules can be reduced up to 50% and construction costs up to 10%.

Compared to site-built construction, offsite construction requires fewer workers and pays lower wages by utilizing a greater share of lower skilled, non-traditional workers. In fact, most offsite activity can be found in areas with limited skilled labor availability and limited affordable housing. Modular manufacturing may also provide an opportunity for older workers or those with disabilities to extend their careers given a more comfortable work environment and lesser physical demands. In a controlled factory setting, lower-skilled workers under the close supervision of experienced trades-persons can maintain levels of quality and consistency that often exceed that observed in site-built construction.

Table 15. Modular and site-built labor productivity.

	Non-Volumetric Modular (Panelized)	Volumetric Modular (Semi-Automated)	Volumetric Modular (Manual)	Site-built
Labor hours (per module/1,100sf)	500	400-500	600-800	800-1,000
Labor hours (per sf)	0.45	0.35-0.45	0.55-0.75	0.75-0.90

The workforce for typical modular factories ranges from approximately 50-200 workers. Non-volumetric modular (panelized) manufacturers typically have the fewest workers and smallest offsite facilities, but require more onsite labor compared to volumetric modular manufacturers. The average age of workers among modular manufacturers surveyed is 35 although several workers were >60 years of age. Women comprised 15-20% of the offsite workforce. Compared to site-built construction, the higher proportion of women and older workers may be attributed to a less physically challenging work environment. Related, worker retention rates among modular manufacturers averaged 65% annually with higher retention rates observed among manufacturers using automation (90%). 'Skilled' workers, or those having some form of credentialling and experience, averaged 20% of the workforce with higher skill rates observed among manufacturers using automation or self-performing MEP and specialty finishes. Offsite worker safety (0.91) was found to be better than onsite worker safety (1.00) as determined by Workers' Compensation EMR. All manufacturers surveyed utilized a non-union workforce. Roughly half of manufacturers surveyed subcontracted MEP installation at the factory site. A few others subcontracted specialty finishes and general labor. Nearly all of manufacturers surveyed subcontracted module transportation and placement or deferred to the site general contractor for set services.

Materials and Waste

In addition to energy, materials and waste are important performance factors, particularly for comparing embodied carbon among construction alternatives. For site-built projects, little or no effort to reuse or recycle cutoff waste was observed among trades. Most often, waste disposal was provided by the general contractor and billed to the project owner as a project overhead expense. As a result, subcontractors had little incentive to reduce, reuse or recycle jobsite waste. In contrast, modular manufacturers designed modules to make efficient use of dimensional materials and minimize cutoff waste. Waste from one production process was generally reused in another or recycled. However, since each volumetric module required a complete structural envelope or 'cube', floors, ceilings and walls between adjacent units were unavoidably doubled.

Table 16 provides a summary of these and other key performance factors for volumetric modular, non-volumetric modular and site-built multifamily construction.

Table 16. Observation of key performance factors.

	Volumetric Modular	Non-Volumetric Modular	Site Built
Building Types	Low-rise and mid-rise multifamily, hospitality, education, office, healthcare.	Mid-rise and high-rise multifamily. Diversification to other markets likely.	All sectors.
Schedule	≥40% shorter construction schedule. Moderate risk of delays.	≥40% shorter construction schedule. Low risk of delays.	Unpredictable site conditions. Moderate risk of delays.
Cost	5-15% lower construction cost. Moderate risk of delay costs.	High construction cost. Low ownership cost.	Low construction cost. Moderate risk of change orders and contingency.
Transportation - Site Logistics	High transportation costs and distance limitations. High site-staging area storage.	Moderate transportation costs and distance limitations. Minimal site storage.	Moderate site storage and staging area.
Facilities	Extensive facility investment.	Moderate facility investment.	Minimal facility investment except MEP and specialty trades.
Financing	≥30% upfront deposits. Weekly production draws. Offsite verification. High cash-flow risk. Strict liquidity, insurance and bonding requirements.	Favorable cap rates and LTVR (≥75%). Lower equity requirements. Moderate risk.	Traditional financing process.
Delivery	Centralized. ≥40% of project risk allocated to manufacturer. Manufacturer is 'super sub' contractor in design-bid-build delivery.	Decentralized. Risk shared among several component manufacturers and vendors. Manufacturer is prime in turn-key design-build delivery.	Decentralized. Risk shared among several sub-contractors and suppliers.
Business Model	High fixed costs. Stable flow of production required. Project specific modules cannot be manufactured and stored between project cycles.	Moderate fixed costs. Stable flow of production required. Standard panel types can be manufactured and stored between project cycles.	Low fixed costs. Production can be quickly scaled to meet demand.
Materials - Waste	Doubling of floor, wall and ceiling framing. Significant reuse of cut-off waste.	Use of renewable, recycled and recyclable materials.	Significant cut-off waste. Little or no recycling.
Permitting - Inspections	Permitting delays common. Require offsite inspections.	Require offsite inspections.	Standard permitting and inspection process.
Quality	High factory QA/QC. Moderate transportation and placement damage. Rework.	High factory QA/QC. Minimal transportation and placement damage.	Moderate QA/QC. Weather-related moisture problems common.
Flexibility	Minimal flexibility to design changes. Must be incorporated at onset of design.	Moderate flexibility to design changes.	Flexible to design changes.
Safety - Productivity	Centralized, climate-controlled production. Minimal onsite workers exposed to risk.	Centralized, climate-controlled production. Minimal onsite workers exposed to risk.	Decentralized production exposed to weather and onsite hazards.
Labor	High level of union resistance to modules manufactured using non-union labor.	More onsite trade work than modular. Less union resistance.	Favorable labor union support for union trades and wages.

CONCLUSIONS

Prefabrication in a controlled factory setting has the potential to improve the energy code compliance and energy performance of modular buildings compared to traditional site-built buildings. Results suggest that the performance of key energy conservation measures (ECMs) in modular multifamily construction slightly exceeds the performance of key measures in site-built construction, particularly in climate zones 3B and 3C. Although few differences were observed between the types of materials and equipment used in either modular or site-built multifamily construction, the installation quality of envelope measures (e.g. insulation, air barrier, etc.) in modular multifamily construction appeared to be better when compared to site-built construction. Supporting this conclusion are air leakage test results conducted on 7 modular multifamily units and 11 site-built multifamily units. The air leakage rate of modular unit envelopes (0.22 cfm/sf) was slightly better compared to the air leakage rate of site-built unit envelopes (0.23 cfm/sf). While no project used the prescriptive path for energy code compliance, most ECMs for most buildings sampled met or exceeded the prescriptive energy code requirements for each code and climate zone.

Similarly, there appeared to be little difference in the post-occupancy energy performance of modular multifamily construction (36.0 kBtu/sf/yr) and site-built construction (35.8 kBtu/sf/yr) among buildings of similar age and typology. However, ENERGY STAR™ scores for modular multifamily construction (86) were higher on average compared to site-built multifamily construction (81), suggesting that when normalized for occupant density and other energy use factors, the post-occupancy energy performance of modular multifamily construction may exceed the energy performance of site-built construction.

Interviews conducted with project stakeholders during factory and construction site visits identified key market benefits and barriers including schedule savings, construction cost, transportation and site logistics, facility investments, financing and project delivery methods. Other factors such as materials and waste, permitting and inspections, safety and productivity, and design flexibility were also addressed. Findings suggest that the most significant advantage of modular construction is schedule savings. For multifamily projects, offsite prefabrication of repetitive dwelling units can proceed simultaneously with onsite construction, reducing time, project overhead and the impact of weather. Overall, modular buildings in this study were completed 25% faster on average when compared to site-built buildings. Modular construction was found to be cost-competitive with site-built construction especially when considering shortened construction schedules and faster income generation. Costs for modular projects ($243/sf) in this study averaged 4% less than site-built construction ($251/sf).

Modular construction requires transportation of building assemblies, often limiting the distance between factory and site. Transportation of non-volumetric or 'panelized' components was found to be significantly more efficient than transportation of volumetric modules. Panelized components also sustained less transportation-related damage and required less jobsite storage and staging area. Placement of volumetric modules, however, was faster and required fewer workers. While modular construction benefits from the productivity of climate-controlled manufacturing facilities, volumetric modular construction requires a larger factory and workforce compared to non-volumetric modular construction. Materials for modular construction must be purchased up to three months ahead of production and often require project developers to pay large, upfront deposits exceeding one-third of the modular contract. Many commercial lenders are reluctant to release financing for 'unsecured' offsite work and for those that do, loan terms are generally less favorable than traditional site-built financing.

The most successful projects studied were those having the manufacturer as an integral part of the project development team from the onset of planning and design. Unlike the project-centric 'super-sub' delivery model where manufacturers must absorb the cost and inefficiency of designing and producing a new product for each project, integrated manufacturers were better able scale production of standardized modules and components for multiple projects and project types. As a result, manufacturers that were an integral part of the project development team were better able to sustain production between project cycles, service debt and retain a more stable workforce.

In summary, the permanent modular construction (PMC) industry in North America has nearly tripled in volume since 2015, generating $12B in revenue in 2022, or roughly 6% of all new commercial construction starts. Successful modular projects are generally those that incorporate modular construction early in design and have repetitive space use types such as the multifamily market. Significant growth for modular multifamily construction is being realized on the West Coast and in the Northeast U.S. where housing affordability is forcing many residents to transition from single to multifamily housing. As a result, the use of volumetric and non-volumetric modular construction is expected to increase to over 50% of projects by 2025.

Limitations and Lessons Learned

The performance period of this project was August 1, 2020 – July 31, 2023. Data collection during the first half of this project was adversely affected by the *COVID-19* pandemic. The small size of this project also precluded the subcontracting of data collection partners in study areas. Consequently, travel costs were likely a higher proportion of the overall project cost than may be typical of other commercial field studies. To manage travel costs, visits to multiple project sites were necessary during each trip, limiting the amount of data that could be collected at each site.

The most limiting factor, however, was the apparent adoption of data collection protocols from previous field studies. Specifically, several energy measures included in the protocol from previous office and retail studies either did not apply or substantially contribute to energy use in multifamily buildings. These measures, however, were often the most difficult and time-consuming to observe in the field. Examples include night fan controls, duct leakage, DHW heat traps, temperature maintenance systems and demand recirculation controls. Night fan controls were rarely observed given multifamily buildings are continuously occupied and use mainly 100% OA for conditioning of corridors and similar spaces in the climate zones of study. Roughly one-third of the residential HVAC systems were ductless and most of the remaining had ductwork installed inside the conditioned space, precluding the requirement for duct leakage testing. Several projects utilized solar DHW, precluding the use of heat traps and some code jurisdictions did not require use of heat traps.

Temperature maintenance systems were not required by code for several projects and did not apply to another third of projects having tankless or in-unit storage tank systems. Demand recirculation similarly did not apply to tankless or in-unit storage tank systems and was not allowed in some code jurisdictions. Commercial spaces in mixed-use buildings comprised <15% of the total conditioned floor area on average. Commercial spaces associated with residential use were <5% of the of the total floor area. The time required for data collection in these spaces was disproportionately high relative to their contribution to overall building energy use. Related, isolating residential and commercial spaces associated with residential use from other commercial spaces became difficult for some measures such as outdoor lighting. Often, building entrances and ground floor common areas were shared, were service entrances or were well below the floor area threshold necessitating vestibules.

Recruitment methods included in the protocol were largely ineffective, particularly for site-built projects. The most (only) effective method for site-built project recruitment was the 'walk-up' method. Face-to-face contact with project personnel was key to developing the relationship necessary to gain access to the construction site and to obtain construction documents (CDs). Nearly all of the site-built projects included in the study were recruited in this manner. A review of both the CDs and COMcheck (or equivalent) was done for all projects. CDs were used to verify the COMcheck data. This process was very time intensive and few discrepancies were found. Most (all) of the relevant data could have been reliably obtained from only the COMcheck report. For future studies, the protocol development process could be streamlined to improve the effectiveness of the tool while minimizing the time and cost of its development especially since the protocol developed for this study appeared to be materially the same as was used by the subcontractor in previous studies.

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GLOSSARY OF TERMS AND ACRONYMS

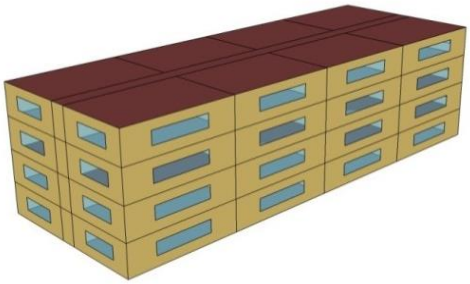
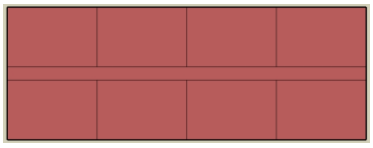
AC	air conditioning
ACH	air change rate per hour
ACH50	air change rate at 50 Pa
AFUE	annual fuel utilization efficiency
AHJ	authority having jurisdiction
AHRI	Air Conditioning, Heating, and Refrigeration Institute
AHU	air handling unit
ANSI	American National Standards Institute
ASHP	air source heat pump
ASHRAE	American Society of Heating, Refrigeration and Air-Conditioning Engineers
AWHP	air (to) water heat pump
BEM	building energy modeling
BTUH	British thermal unit per hour
CDs	construction documents
CF	cubic feet
CFM	cubic feet per minute
COP	coefficient of performance
CZ	climate zone
DCV	demand control ventilation
DCED	Pennsylvania Department of Community and Economic Development
DHW	domestic hot water
DOAS	direct outdoor air system
DOE	U.S. Department of Energy
ECM	energy conservation measure
EER	energy efficiency ratio
EIA	Energy Information Administration
EMR	experience modifier rating
EPA	U.S. Environmental Protection Agency
ERV	energy recovery ventilation
EUI	energy use intensity
F	Fahrenheit

FCU	fan coil unit
FEMP	Federal Energy Management Program
FT	feet
GC	general contractor
GHGE	greenhouse gas emissions
GSF	gross square feet
HCD	California Housing and Community Development
HP	heat pump
HSPF	heating seasonal performance factor
HUD	U.S. Department of Housing and Urban Development
HVAC	heating, ventilating, and air conditioning
IBC	International Building Code
IC	industrialized construction
ICC	International Code Council
IECC	International Energy Conservation Code
KBTU	thousand British thermal units
KW	kilowatts
L&I	Washington Labor and Industries
LoE	low emissivity
LOI	letter of intent
LPD	lighting power density
LTC	loan to cost ratio
LTV	loan to value ratio
MBH	thousand British thermal units per hour
MBI	Modular Building Institute
MEP	mechanical, electrical and plumbing
MOD	modular
NFRC	National Fenestration Rating Council
NREL	National Renewable Energy Laboratory
OA	outdoor air
OC	on center
OS	occupancy sensor

OST	On Screen Takeoff
PA	Pascals
PMC	permanent modular construction
PNL	panelized
PNNL	Pacific Northwest National Laboratory
PTAC	packaged terminal air conditioning
PTHP	package terminal heat pump
PV	photovoltaic
QA/QC	quality assurance / quality control
RESNET	Residential Energy Systems Network
R	thermal resistance
SEC	Seattle Energy Code
SEER	seasonal energy efficiency ratio
SF	square feet
SHGC	solar heat gain coefficient
SOO	sequence of operations
T24	California Title 24 Energy Code
U	thermal transmittance
UEF	uniform energy factor
UPV	uniform present value
VRF	variable refrigerant flow
VTAC	vertical terminal air conditioning
VTHP	vertical terminal heat pump
W	Watt
WRB	weather resistant barrier
WSEC	Washington State Energy Code
WSHP	water source heat pump
WWR	window-to-wall ratio
YR	year

APPENDIX A

PNNL Building Energy Modeling (BEM) Prototype Specifications.

	Item	Descriptions			Data Source
Program					
	Vintage	NEW CONSTRUCTION			
	Location (Representing 8 Climate Zones)	Zone 1A: Honolulu, Hawaii (very hot, humid) Zone 1B: New Delhi, India (very hot, dry) Zone 2A: Tampa, Florida (hot, humid) Zone 2B: Tucson, Arizona (hot, dry) Zone 3A: Atlanta, Georgia (warm, humid) Zone 3B: El Paso, Texas (warm, dry) Zone 3C: San Diego, California (warm, marine)	Zone 4A: New York, New York (mixed, humid) Zone 4B: Albuquerque, New Mexico (mixed, dry) Zone 4C: Seattle, Washington (mixed, marine) Zone 5A: Buffalo, NY (cool, humid) Zone 5B: Denver, Colorado (cool, dry) Zone 5C: Port Angeles, Washington (cool, marine)	Zone 6A: Rochester, Minnesota (cold, humid) Zone 6B: Great Falls, Montana (cold, dry) Zone 7: International Falls, Minnesota (very cold) Zone 8: Fairbanks, Alaska (subarctic	Selection of representative climates based on ASHRAE Standard 169-2013
	Available fuel types	Gas, electricity			
	Building Type (Principal Building Function)	**Multifamily**			
	Building Prototype	**Mid-Rise Apartment**			
Form					
	Total Floor Area (sq feet)	33,700 (152 ft x 55.5 ft)			
	Building shape				Reference: PNNL-16770: *Analysis of Energy Saving Impacts of ASHRAE 90.1-2004 for the State of New York*
	Aspect Ratio	2.74			
	Number of Floors	4			90.1 Envelope Subcommittee
	Window Fraction (Window-to-Wall Ratio)	South: 20.0%, East: 20.0%, North: 20.0%, West: 20.0% Average Total: 20.0%			Reference: Based on feedback from the National Multi-family Housing Council (NMHC)
	Window Locations	See image			
	Shading Geometry	None			
	Azimuth	Non-directional			
	Thermal Zoning	Each floor has 8 apartments except ground floor (7 apartments and 1 office with equivalent apartment area) Total 8 apartments per floor with corridor in center. Zone depth is 25 ft for each apartment from side walls and each apt is 25' x 38' (950 ft²). 			Reference: PNNL-16770: *Analysis of Energy Saving Impacts of ASHRAE 90.1-2004 for the State of New York*
	Floor to floor height (ft)	10			
	Floor to ceiling height (ft)	10 (No drop-in ceiling plenum is modeled)			
	Glazing sill height (ft)	3 ft (4 ft high windows)			

Architecture			
Exterior walls			
Construction	Steel-frame walls (2X4 16IN o.c.) 0.4 in. stucco+5/8 in. gypsum board + wall Insulation+5/8 in. gypsum board		Reference: PNNL-16770: *Analysis of Energy Saving Impacts of ASHRAE 90.1-2004 for the State of New York* . Base Assembly from 90.1 Appendix A.
U-factor (Btu / h * ft^2 * °F) and/or R-value (h * ft^2 * °F / Btu)	Requirements in codes or standards		Applicable codes or standards
Dimensions	Based on floor area and aspect ratio		
Tilts and orientations	Vertical		
Roof			
Construction	Built-up roof: roof membrane+roof insulation+metal decking		Reference: PNNL-16770: Analysis of Energy Saving Impacts of ASHRAE 90.1-2004 for the State of New York Base Assembly from 90.1 Appendix A.
U-factor (Btu / h * ft^2 * °F) and/or R-value (h * ft^2 * °F / Btu)	Requirements in codes or standards Residential; roofs, insulation entirely above deck		Applicable codes or standards
Dimensions	Based on floor area and aspect ratio		
Tilts and orientations	Horizontal		
Window			
Dimensions	Based on window fraction, location, glazing sill height, floor area and aspect ratio		
Glass-Type and frame	Hypothetical window with a weighted U-factor and SHGC		
U-factor (Btu / h * ft^2 * °F)	Requirements in codes or standards		Applicable codes or standards
SHGC (all)	Residential; vertical glazing		
Visible transmittance			
Operable area	100%		
Skylight			
Dimensions	Not Modeled		
Glass-Type and frame	NA		
U-factor (Btu / h * ft^2 * °F)			
SHGC (all)			
Visible transmittance			
Foundation			
Foundation Type	Slab-on-grade floors (unheated)		
Construction	8" concrete slab poured directly on to the earth		
Slab on grade floor insulation level	Requirements in codes or standards		Applicable codes or standards
Dimensions	Based on floor area and aspect ratio		
Interior Partitions			
Construction	2 x 4 uninsulated stud wall		
Dimensions	Based on floor plan and floor-to-floor height		
Internal Mass	8 lbs/ft2 of floor area		Reference: Building America Research Benchmark
Air Barrier System			
Infiltration (ACH)	Peak infiltration: 0.2016 cfm/sf of above grade exterior wall surface area, adjusted by wind Additional infiltration through building entrance		Reference: PNNL-18898. *Infiltration Modeling Guidelines for Commercial Building Energy Analysis* .

HVAC			
	System Type		
	Heating type	Gas furnace	90.1 Mechanical Subcommittee
	Cooling type	Split system DX (1 per apt)	
	Distribution and terminal units	Constant volume	
	HVAC Sizing		
	Air Conditioning	Autosized to design day	
	Heating	Autosized to design day	
	HVAC Efficiency		
	Air Conditioning	Requirements in codes or standards Minimum equipment efficiency for electrically operated unitary and applied heat pumps	Applicable codes or standards
	Heating		
	HVAC Control		
	Thermostat Setpoint	75°F Cooling/70°F Heating	
	Thermostat Setback	No setback for apartments	
	Supply air temperature	Maximum 113F, Minimum 55F	
	Economizers	Requirements in codes or standards	Applicable codes or standards
	Ventilation	ASHRAE Standard 62.1 or International Mechanical Code See under **Outdoor Air**	Applicable codes or standards
	Demand Control Ventilation	Requirements in codes or standards	Applicable codes or standards
	Energy Recovery	Requirements in codes or standards	Applicable codes or standards
	Supply Fan		
	Fan schedules	See under **Schedules**	
	Supply Fan Total Efficiency (%)	Depending on the fan motor size	Requirements in applicable codes or standards for motor efficiency
	Supply Fan Pressure Drop	Depending on the fan supply air cfm	
	Service Water Heating		
	SWH type	Individual residential water heater with storage tank	
	Fuel type	Electricity	Reference: RECS 2005
	Thermal efficiency (%)	Requirements in codes or standards	Applicable codes or standards
	Tank Volume (gal)	50	Reference: *PNNL-23269 Enhancements to ASHRAE Standard 90.1 Prototype Building Models*
	Water temperature setpoint	140 F	
	Water consumption	See under **Schedules**	Reference: Building America Research Benchmark
Internal Loads & Schedules			
	Lighting		
	Average power density (W/ft^2)	Apartment units: See under **Lighting Load** for the detailed calculations. Corridor: 0.5 W/ft^2. When applicable, the power density is based on requirements in codes or standards.	Apartment: Building America Research Benchmark and applicable codes or standards
	Schedule	See under **Schedules**	Reference: Building America Research Benchmark
	Daylighting Controls	Requirements in codes or standards	Applicable codes or standards
	Occupancy Sensors	Requirements in codes or standards	Applicable codes or standards
	Plug load		
	Average power density (W/ft^2)	0.62 W/ft^2 daily peak per apartment, including all the home appliances See under **Plug Load** for the detailed calculations	Reference: Building America Research Benchmark
	Schedule	See under **Schedules**	
	Occupancy		
	Average people	See under **Zone Summary**	Reference: Building America Research Benchmark
	Schedule	See under **Schedules**	
Misc.			
	Elevator		
	Quantity	1	Reference: DOE Commercial Reference Building Models of the National Building Stock
	Motor type	hydraulic	
	Peak Motor Power (watts/elevator)	16,055	
	Heat Gain to Building	Interior	
	Peak Fan/lights Power (watts/elevator)	161.9	90.1 Mechanical Subcommittee, Elevator Working Group
	Motor and fan/lights Schedules	See under **Schedules**	Reference: DOE Commercial Reference Building Models of the National
	Exterior Lighting		
	Peak Power (W)	Based on design assumptions for façade, parking lot, entrance, etc. and requirements in codes or standards	Applicable codes or standards
	Schedule	See under **Schedules** and control requirements in codes or standards	Applicable codes or standards

APPENDIX B

Code Compliance Projects.

Table B-1. Code compliance data set of modular and site-built multifamily buildings.

	Modular		**Site-built**	
Location	Full Data	Partial Data	Full Data	Partial Data
LA	3	4	2	7
SF	4	1	4	3
PHL	3	5	2	8
SEA	2	3	0	4
	25		**30**	

Modular Volumetric	Affordable	T24 2019	Performance Path
64,636GSF	64,636CSF	56,853RSF	71 Units
Roof (U) 0.026	Wall (U) 0.048	Window (U) 0.29	(SHGC) 0.17
WWR 22%	Cooling M/M-Split HP	Cooling 18.0 SEER	Heating M/M-Split HP
Heating 10.3 HSPF	DHW Gas	DHW 0.95 UEF	Interior LPD 0.42W/sf
4 Stories	CZ3B		

- Status – COMPLETE ☑ Plan Review ☑ Factory/Site 1 ☑ Site 2

Modular Volumetric	Affordable	T24 2019	Performance Path
38,245GSF	34,242CSF	29,956RSF	51 Units
Roof (U) 0.026	Wall (U) 0.052	Window (U) 0.30	(SHGC) 0.22
WWR 19%	Cooling PTHP	Cooling 16.0 SEER	Heating PTHP
Heating 10.3 HSPF	DHW Gas	DHW 0.99 UEF	Interior LPD 0.11W/sf
5 Stories	CZ3B		

- Status – COMPLETE ☑ Plan Review ☑ Factory/Site 1 ☑ Site 2

Modular Volumetric	Affordable	T24 2019	Performance Path
55,244GSF	52,149CSF	46,689RSF	94 Units
Roof (U) 0.024	Wall (U) 0.052	Window (U) 0.26	(SHGC) 0.20
WWR 12%	Cooling Split HP	Cooling 16.0 SEER	Heating Split HP
Heating 10.0 HSPF	DHW Gas	DHW 0.87 UEF	Interior LPD 0.39W/sf
6 Stories	CZ3B		
• Solar DHW			
• Status – COMPLETE	☑ Plan Review	☑ Factory/Site 1	☑ Site 2

Modular Volumetric	Affordable	T24 2019	Performance Path
165,466GSF	162,460CSF	162,460RSF	0 Units
Roof (U) 0.026	Wall (U) 0.052	Window (U) 0.28	(SHGC) 0.36
WWR 13%	Cooling Mini-split HP	Cooling 14.0 SEER	Heating Mini-split HP
Heating 9.0 HSPF	DHW Gas	DHW 0.96 UEF	Interior LPD 0.24W/sf
4 Stories	CZ3C		
• Solar DHW			
• Status – COMPLETE	☑ Plan Review	☑ Factory/Site 1	☑ Site 2

Modular Volumetric	Market	T24 2016	Performance Path
191,800GSF	151,646CSF	151,646RSF	156 Units
Roof (U) 0.033	Wall (U) 0.052	Window (U) 0.26	(SHGC) 0.17
WWR 13%	Cooling M/M Split HP	Cooling 16.0 SEER	Heating M/M Split HP
Heating 8.5 HSPF	DHW Gas	DHW 0.98 UEF	Interior LPD 0.27W/sf
6 Stories	CZ3C		

- Status – COMPLETE ☑ Plan Review ☑ Factory/Site 1 ☑ Site 2

Modular Volumetric	Market	T24 2016	Performance Path
160,839GSF	116,807CSF	89,057RSF	105 Units
Roof (U) 0.022	Wall (U) 0.048	Window (U) 0.29	(SHGC) 0.17
WWR 22%	Cooling DOAS/ERV	Cooling n/a	Heating Electric
Heating n/a	DHW Gas	DHW 0.95 UEF	Interior LPD 0.22W/sf
7 Stories	CZ3C		
• Solar DHW			
• Status – COMPLETE	☑ Plan Review	☑ Factory/Site 1	☑ Site 2

Modular Volumetric	Affordable	T24 2016	Performance Path
36,234GSF	29,401CSF	29,401RSF	36 Units
Roof (U) 0.015	Wall (U) 0.052	Window (U) 0.18	(SHGC) 0.21
WWR 14%	Cooling DOAS/ERV	Cooling n/a	Heating Electric
Heating n/a	DHW AWHP	DHW 3.7 COP	Interior LPD 0.42W/sf
4 Stories	CZ3C		

- Status – COMPLETE ☑ Plan Review ☑ Factory/Site 1 ☑ Site 2

Modular Volumetric	Market	IECC 2015	Trade-off
535,778GSF	400,323CSF	264,869RSF	410 Units
Roof (U) 0.027	Wall (U) 0.048	Window (U) 0.29	(SHGC) 0.25
WWR 30%	Cooling VTHP	Cooling 13.0 SEER	Heating VTHP
Heating 11.9	DHW Electric	DHW 0.92	Interior LPD 0.48W/sf
9 Stories	CZ4A		

- Status – COMPLETE ☑ Plan Review ☑ Factory/Site 1 ☑ Site 2

Modular Volumetric	Affordable	IECC 2015	Trade-off
36,147GSF	36,147CSF	34,510RSF	47 Units
Roof (U) 0.019	Wall (U) 0.048	Window (U) 0.28	(SHGC) 0.33
WWR 14%	Cooling PTAC	Cooling 12.0 SEER	Heating Electric
Heating n/a	DHW Electric	DHW 0.93	Interior LPD 0.32W/sf
4 Stories	CZ4A		

- Status – COMPLETE ☑ Plan Review ☑ Factory/Site 1 ☑ Site 2

Modular Volumetric	Affordable	IECC 2018	Performance Path
103,945GSF	94,459CSF	85,378RSF	78 Units
Roof (U) 0.019	Wall (U) 0.048	Window (U) 0.27	(SHGC) 0.29
WWR 33%	Cooling VTAC	Cooling 12.0 SEER	Heating Electric
Heating n/a	DHW Electric	DHW 0.95	Interior LPD 0.31W/sf
7 Stories	CZ4A		

- Status – COMPLETE ☑ Plan Review ☑ Factory/Site 1 ☑ Site 2

Modular N-Volumetric	Market Rate	SEC 2018	Performance Path
86,808GSF	61,677CSF	52,882RSF	112 Units
Roof (U) 0.015	Wall (U) 0.030	Window (U) 0.35	(SHGC) 0.21
WWR 20%	Cooling AWHP	Cooling 3.5 COP	Heating AWHP
Heating 4.8 COP	DHW AWHP	DHW 4.8 COP	Interior LPD 0.36W/sf
14 Stories	CZ4C		

- Wastewater heat recovery, open-air corridors, 229kW PV
- Status – COMPLETE ☑ Plan Review ☑ Factory/Site 1 ☑ Site 2

Modular N-Volumetric	Affordable	SEC 2018	Performance Path
62,265GSF	45,889CSF	39,620RSF	124 Units
Roof (U) 0.020	Wall (U) 0.040	Window (U) 0.26	(SHGC) 0.32
WWR 26%	Cooling AWHP	Cooling 3.5 COP	Heating AWHP
Heating 4.8 COP	DHW AWHP	DHW 4.8 COP	Interior LPD 0.28W/sf
5 Stories	CZ4C		

- Wastewater heat recovery, open-air corridors, 106kW PV
- Status – COMPLETE ☑ Plan Review ☑ Factory/Site 1 ☑ Site 2

Modular Volumetric	Affordable	T24 2016	Performance Path
- GSF	29,140CSF	29,140RSF	80 Units
Roof (U) 0.033	Wall (U) 0.052	Window (U) 0.29	(SHGC) 0.29
WWR 14%	Cooling PTHP	Cooling 13.0 SEER	Heating PTHP
Heating 11.0 HSPF	DHW Gas	DHW 0.98 UEF	Interior LPD - W/sf
6 Stories	CZ3B		
• Solar DHW			
• Status – INCOMPLETE ☑ Plan Review ☐ Factory/Site 1 ☑ Site 2			

Modular Volumetric	Affordable	T24 2016	Performance Path
- GSF	37,651CSF	37,651RSF	111 Units
Roof (U) 0.033	Wall (U) 0.048	Window (U) 0.32	(SHGC) 0.25
WWR 24%	Cooling PTHP	Cooling 13.0 SEER	Heating PTHP
Heating 11.0 HSPF	DHW Gas	DHW 0.98 UEF	Interior LPD - W/sf
4 Stories	CZ3B		
• Status – INCOMPLETE ☑ Plan Review ☐ Factory/Site 1 ☑ Site 2			

Modular Volumetric	Market	- Code	- Path
386,000GSF	- CSF	- RSF	389 Units
Roof (U) -	Wall (U) -	Window (U) -	(SHGC) -
WWR -	Cooling Split HP	Cooling - SEER	Heating Split HP
Heating - HSPF	DHW - Type	DHW - EF	Interior LPD - W/sf
5 Stories	CZ3B		

• Status – INCOMPLETE ☐ Plan Review ☐ Factory/Site 1 ☑ Site 2

Modular Volumetric	Market	- Code	- Path
- GSF	- CSF	- RSF	357 Units
Roof (U) -	Wall (U) -	Window (U) -	(SHGC) -
WWR -	Cooling Split HP	Cooling 14.0 SEER	Heating Split HP
Heating 8.2 HSPF	DHW Gas	DHW 0.97 UEF	Interior LPD - W/sf
5 Stories	CZ3B		

• Status – INCOMPLETE ☐ Plan Review ☐ Factory/Site 1 ☑ Site 2

Modular Volumetric	Asst Living	- Code	- Path
- GSF	- CSF	- RSF	- 324 Units
Roof (U) -	Wall (U) -	Window (U) -	(SHGC) -
WWR -	Cooling Split HP	Cooling 13.0 SEER	Heating Split HP
Heating 11.2 HSPF	DHW Electric	DHW - EF	Interior LPD - W/sf
5 Stories	CZ3C		

- Status – INCOMPLETE ☐ Plan Review ☑ Factory/Site 1 ☐ Site 2

Modular Volumetric	Affordable	- Code	- Path
133,794 GSF	- CSF	- RSF	281 Units
Roof (U) -	Wall (U) -	Window (U) 0.29	(SHGC) 0.25
WWR -	Cooling VTHP	Cooling 14.0 SEER	Heating VTHP
Heating 8.2 HSPF	DHW Electric	DHW - EF	Interior LPD - W/sf
7 Stories	CZ4A		

- Status – INCOMPLETE ☐ Plan Review ☐ Factory/Site 1 ☑ Site 2

Modular Volumetric	Market	- Code	- Path
- GSF	- CSF	- RSF	- Units
Roof (U) -	Wall (U) -	Window (U) 0.29	(SHGC) 0.25
WWR -	Cooling Split HP	Cooling - SEER	Heating Split HP
Heating - HSPF	DHW Electric	DHW - EF	Interior LPD - W/sf
5 Stories	CZ4A		

• Status – INCOMPLETE ☐ Plan Review ☐ Factory/Site 1 ☑ Site 2

Modular Volumetric	Affordable	- Code	- Path
55,000 GSF	- CSF	- RSF	111 Units
Roof (U) -	Wall (U) -	Window (U) -	(SHGC) -
WWR -	Cooling - Type	Cooling - SEER	Heating - Type
Heating - HSPF	DHW Electric	DHW - EF	Interior LPD - W/sf
6 Stories	CZ4A		

• Status – INCOMPLETE ☐ Plan Review ☐ Factory/Site 1 ☑ Site 2

Modular Volumetric	Market	- Code	- Path
- GSF	- CSF	- RSF	201 Units
Roof (U) -	Wall (U) -	Window (U) -	(SHGC) -
WWR -	Cooling Split HP	Cooling - SEER	Heating Split HP
Heating - HSPF	DHW Electric	DHW - EF	Interior LPD - W/sf
5 Stories	CZ4A		

• Status – INCOMPLETE ☐ Plan Review ☐ Factory/Site 1 ☑ Site 2

Modular Volumetric	Market	- Code	- Path
218,277 GSF	- CSF	- RSF	120 Units
Roof (U) -	Wall (U) -	Window (U) -	(SHGC) -
WWR -	Cooling Split HP	Cooling - SEER	Heating Split HP
Heating - HSPF	DHW Electric	DHW - EF	Interior LPD - W/sf
6 Stories	CZ4A		

• Status – INCOMPLETE ☐ Plan Review ☐ Factory/Site 1 ☑ Site 2

Modular N. Volumetric	Market Rate	SEC 2018	Performance Path
83,585GSF	67,681CSF	58,115RSF	98 Units
Roof (U) 0.020	Wall (U) 0.048	Window (U) 0.26	(SHGC) 0.38
WWR 32%	Cooling PTHP	Cooling 16.0 SEER	Heating PTHP
Heating 11.5 HSPF	DHW AWHP	DHW 3.8 COP	Interior LPD 0.37 W/sf
8 Stories	CZ4C		
• Status – INCOMPLETE ☑ Plan Review ☐ Factory/Site 1 ☐ Site 2			

Modular Volumetric	Market Rate	IECC 2018	Trade-off
287,856GSF	203,305CSF	203,305RSF	241 Units
Roof (U) 0.020	Wall (U) 0.048	Window (U) 0.26	(SHGC) 0.35
WWR 32%	Cooling DOAS/ERV	Cooling n/a	Heating Electric
Heating n/a	DHW Gas	DHW 0.97 UEF	Interior LPD 0.21 W/sf
7 Stories	CZ4C		
• Status – INCOMPLETE ☑ Plan Review ☐ Factory/Site 1 ☐ Site 2			

Modular Volumetric	Market Rate	IECC 2018	- Path
71,681GSF	59,918CSF	47,320RSF	100 Units
Roof (U) 0.026	Wall (U) 0.040	Window (U) 0.30	(SHGC) -
WWR 18%	Cooling DOAS/ERV	Cooling n/a	Heating Electric
Heating n/a	DHW - Type	DHW - EF	Interior LPD 0.29 W/sf
5 Stories	CZ4C		

- Status – INCOMPLETE ☑ Plan Review ☐ Factory/Site 1 ☐ Site 2

Site-built	Market	T24 2016	-
21,035GSF	14,110CSF	13,460RSF	14 Units
Roof (U) 0.033	Wall (U) 0.052	Window (U) 0.35	(SHGC) 0.24
WWR 14%	Cooling Split HP	Cooling 14.0 SEER	Heating Split HP
Heating 8.2 HSPF	DHW Gas (tankless)	DHW 0.81 UEF	Interior LPD 0.26W/sf
5 Stories	CZ3B		

- Status – COMPLETE ☑ Plan Review ☑ Factory/Site 1 ☑ Site 2

Site-built	Market	T24 2016	-
688,165GSF	405,645CSF	318,860RSF	363 Units
Roof (U) 0.033	Wall (U) 0.052	Window (U) 0.28	(SHGC) 0.22
WWR 41%	Cooling Split HP	Cooling 14.0 SEER	Heating Split HP
Heating 8.2 HSPF	DHW Gas	DHW 0.82 UEF	Interior LPD 0.18W/sf
9 Stories	CZ3B		

- Status – COMPLETE ☑ Plan Review ☑ Factory/Site 1 ☑ Site 2

Site-built	Market	T24 2016	-
69,000GSF	67,300CSF	55,820RSF	68 Units
Roof (U) 0.025	Wall (U) 0.052	Window (U) 0.34	(SHGC) 0.22
WWR 17%	Cooling M/M Split HP	Cooling 13.0 SEER	Heating M/M Split HP
Heating 12.0 HSPF	DHW Gas	DHW 0.97 UEF	Interior LPD 0.24W/sf
6 Stories	CZ3C		
• Status – COMPLETE ☑ Plan Review ☑ Factory/Site 1 ☑ Site 2			

Site-built	Market	T24 2016	Performance Path
127,172GSF	123,187CSF	114,430RSF	142 Units
Roof (U) 0.026	Wall (U) 0.048	Window (U) 0.35	(SHGC) 0.24
WWR 27%	Cooling DOAS/ERV	Cooling n/a	Heating Electric
Heating n/a	DHW Gas	DHW 0.95 UEF	Interior LPD 0.28W/sf
6 Stories	CZ3C		
• Solar DHW			
• Status – COMPLETE ☑ Plan Review ☑ Factory/Site 1 ☑ Site 2			

Site-built	Market	T24 2016	-
61,452GSF	61,452CSF	53,046RSF	66 Units
Roof (U) 0.026	Wall (U) 0.052	Window (U) 0.30	(SHGC) 0.24
WWR 19%	Cooling M/M Split HP	Cooling 20.0 SEER	Heating M/M Split HP
Heating 10.0 HSPF	DHW Gas	DHW 0.96 UEF	Interior LPD -
7 Stories	CZ3C		
• Status – COMPLETE ☑ Plan Review ☑ Factory/Site 1 ☑ Site 2			

Site-built	Market (condo)	T24 2016	Performance Path
329,025GSF	195,946CSF	195,946RSF	165 Units
Roof (U) 0.026	Wall (U) 0.048	Window (U) 0.26	(SHGC) 0.18
WWR 28%	Cooling Split HP	Cooling 14.0 SEER	Heating Split HP
Heating 8.2	DHW Gas	DHW 0.95 UEF	Interior LPD 0.17W/sf
5 Stories	CZ3C		
• Solar DHW			
• Status – COMPLETE ☑ Plan Review ☑ Factory/Site 1 ☑ Site 2			

Site-built	Market	IECC 2015	-
86,503GSF	86,503CSF	60,420RSF	45 Units
Roof (U) 0.033	Wall (U) 0.048	Window (U) 0.33	(SHGC) 0.31
WWR 28%	Cooling Split HP	Cooling 14.0 SEER	Heating Gas
Heating 92 AFUE	DHW Electric	DHW 0.98	Interior LPD -
6 Stories	CZ4A		

- Status – COMPLETE ☑ Plan Review ☑ Factory/Site 1 ☑ Site 2

Site-built	Market (condo)	IECC 2015	-
236,080GSF	197,860CSF	197,860RSF	104 Units
Roof (U) 0.026	Wall (U) 0.048	Window (U) 0.28	(SHGC) 0.28
WWR 19%	Cooling Split AC	Cooling 14.0 SEER	Heating Gas
Heating 92 AFUE	DHW Electric	DHW 0.92	Interior LPD 0.47W/sf
4 Stories	CZ4A		

- Status – COMPLETE ☑ Plan Review ☑ Factory/Site 1 ☑ Site 2

Site Built	Market	T24 2016	- Path
47,665 GSF	32,045 CSF	32,045 RSF	28 Units
Roof (U) 0.033	Wall (U) 0.052	Window (U) 0.32	(SHGC) 0.25
WWR 25%	Cooling Split HP	Cooling -14.0 SEER	Heating Split HP
Heating 8.0 HSPF	DHW Gas (tankless)	DHW 0.81 UEF	Interior LPD 0.24 W/sf
6 Stories	CZ3B		

• Status – INCOMPLETE ☑ Plan Review ☑ Factory/Site 1 ☐ Site 2

Site Built	Market	- Code	- Path
- GSF	- CSF	- RSF	77 Units
Roof (U) -	Wall (U) 0.052	Window (U) 0.26	(SHGC) 0.18
WWR -	Cooling Split AC/HP	Cooling - SEER	Heating Split AC/HP
Heating - HSPF	DHW - Type	DHW - EF	Interior LPD - W/sf
6 Stories	CZ3B		

• Status – INCOMPLETE ☐ Plan Review ☑ Factory/Site 1 ☐ Site 2

Site Built	Market	- Code	- Path
- GSF	- CSF	- RSF	79 Units
Roof (U) 0.033	Wall (U) 0.052	Window (U) 0.35	(SHGC) 0.25
WWR -	Cooling Split AC/HP	Cooling - SEER	Heating Split AC/HP
Heating - HSPF	DHW - Type	DHW - EF	Interior LPD - W/sf
8 Stories	CZ3B		

• Status – INCOMPLETE ☐ Plan Review ☑ Factory/Site 1 ☐ Site 2

Site Built	Market	- Code	- Path
- GSF	- CSF	- RSF	252 Units
Roof (U) 0.033	Wall (U) 0.052	Window (U) -	(SHGC) -
WWR -	Cooling Split AC/HP	Cooling - SEER	Heating Split AC/HP
Heating - HSPF	DHW - Type	DHW - EF	Interior LPD - W/sf
7 Stories	CZ3B		

• Status – INCOMPLETE ☐ Plan Review ☑ Factory/Site 1 ☐ Site 2

Site Built	Market	- Code	- Path
- GSF	- CSF	- RSF	- Units
Roof (U) -	Wall (U) 0.052	Window (U) 0.27	(SHGC) 0.20
WWR -	Cooling - Type	Cooling - SEER	Heating - Type
Heating - HSPF	DHW - Type	DHW - EF	Interior LPD - W/sf
6 Stories	CZ3B		

• Status – INCOMPLETE ☐ Plan Review ☑ Factory/Site 1 ☐ Site 2

Site Built	Market	- Code	- Path
148,588 GSF	- CSF	- RSF	154 Units
Roof (U) -	Wall (U) 0.052	Window (U) 0.26	(SHGC) 0.20
WWR -	Cooling Split AC/HP	Cooling - SEER	Heating Split AC/HP
Heating - HSPF	DHW - Type	DHW - EF	Interior LPD - W/sf
8 Stories	CZ3B		

• Status – INCOMPLETE ☐ Plan Review ☑ Factory/Site 1 ☐ Site 2

Site Built	Market	- Code	- Path
- GSF	- CSF	- RSF	- Units
Roof (U) 0.033	Wall (U) 0.048	Window (U) 0.27	(SHGC) 0.20
WWR -	Cooling Split AC/HP	Cooling - SEER	Heating Split AC/HP
Heating - HSPF	DHW - Type	DHW - EF	Interior LPD - W/sf
7 Stories	CZ3B		

• Status – INCOMPLETE ☐ Plan Review ☑ Factory/Site 1 ☐ Site 2

Site Built	Market	- Code	- Path
- GSF	- CSF	- RSF	- Units
Roof (U) 0.033	Wall (U) 0.048	Window (U) 0.28	(SHGC) 0.32
WWR -	Cooling Split AC/HP	Cooling - SEER	Heating Split AC/HP
Heating - HSPF	DHW - Type	DHW - EF	Interior LPD - W/sf
4 Stories	CZ3C		

• Status – INCOMPLETE ☐ Plan Review ☑ Factory/Site 1 ☐ Site 2

Site Built	Market	- Code	- Path
- GSF	- CSF	- RSF	- Units
Roof (U) 0.026	Wall (U) 0.048	Window (U) 0.28	(SHGC) 0.22
WWR -	Cooling - Type	Cooling - SEER	Heating - Type
Heating - HSPF	DHW - Type	DHW - EF	Interior LPD - W/sf
6 Stories	CZ3C		
• Status – INCOMPLETE ☐ Plan Review ☑ Factory/Site 1 ☐ Site 2			

Site Built	Market	- Code	- Path
- GSF	- CSF	- RSF	- Units
Roof (U) 0.026	Wall (U) 0.048	Window (U) 0.28	(SHGC) 0.22
WWR -	Cooling Split HP	Cooling - SEER	Heating Split HP
Heating - HSPF	DHW - Type	DHW - EF	Interior LPD - W/sf
6 Stories	CZ3C		
• Status – INCOMPLETE ☐ Plan Review ☑ Factory/Site 1 ☐ Site 2			

Site Built	Affordable	IECC 2018	- Path
146,242GSF	130,535CSF	112,626RSF	142 Units
Roof (U) 0.026	Wall (U) 0.048	Window (U) 0.38	(SHGC) 0.36
WWR 32%	Cooling Split HP	Cooling 13.0 SEER	Heating Split HP
Heating 8.9 HSPF	DHW Electric	DHW 0.98	Interior LPD 0.24 W/sf
5 Stories	CZ4A		
• Status – INCOMPLETE ☑ Plan Review ☑ Factory/Site 1 ☐ Site 2			

Site Built	Market	- Code	- Path
- GSF	- CSF	- RSF	- Units
Roof (U) -	Wall (U) -	Window (U) 0.28	(SHGC) 0.25
WWR -	Cooling Split AC	Cooling - SEER	Heating Gas
Heating - HSPF	DHW Gas	DHW - EF	Interior LPD - W/sf
5 Stories	CZ4A		
• Status – INCOMPLETE ☐ Plan Review ☐ Factory/Site 1 ☑ Site 2			

Site Built	Market	- Code	- Path
- GSF	- CSF	- RSF	- Units
Roof (U) -	Wall (U) -	Window (U) 0.30	(SHGC) 0.32
WWR -	Cooling Split AC	Cooling 11.0 EER	Heating Gas
Heating 0.80 EF	DHW Electric	DHW - EF	Interior LPD - W/sf
- Stories	CZ4A		
• Status – INCOMPLETE ☐ Plan Review ☐ Factory/Site 1 ☑ Site 2			

Site Built	Market	- Code	- Path
- GSF	- CSF	- RSF	- Units
Roof (U) -	Wall (U) -	Window (U) 0.27	(SHGC) 0.32
WWR -	Cooling M/M Split HP	Cooling 13.0 SEER	Heating M/M Split HP
Heating 10.8 HSPF	DHW Electric	DHW - EF	Interior LPD - W/sf
5 Stories	CZ4A		
• Status – INCOMPLETE ☐ Plan Review ☑ Factory/Site 1 ☐ Site 2			

Site Built	Market	- Code	- Path
- GSF	- CSF	- RSF	- Units
Roof (U) -	Wall (U) 0.048	Window (U) -	(SHGC) -
WWR -	Cooling Split AC	Cooling - SEER	Heating Gas
Heating - HSPF	DHW Gas	DHW - EF	Interior LPD - W/sf
5 Stories	CZ4A		

• Status – INCOMPLETE ☐ Plan Review ☑ Factory/Site 1 ☐ Site 2

Site Built	Market	- Code	- Path
- GSF	- CSF	- RSF	- Units
Roof (U) 0.026 (spray)	Wall (U) -	Window (U) 0.27	(SHGC) 0.30
WWR -	Cooling - Type	Cooling - SEER	Heating - Type
Heating - HSPF	DHW - Type	DHW - EF	Interior LPD - W/sf
5 Stories	CZ4A		

• Status – INCOMPLETE ☐ Plan Review ☑ Factory/Site 1 ☐ Site 2

Site Built	Market	- Code	- Path
- GSF	- CSF	- RSF	- Units
Roof (U) -	Wall (U) -	Window (U) 0.28	(SHGC) 0.25
WWR -	Cooling M/M Split HP	Cooling 16.0 SEER	Heating M/M Split HP
Heating 12.5 HSPF	DHW Electric	DHW - EF	Interior LPD - W/sf
4 Stories	CZ4A		
• Status – INCOMPLETE ☐ Plan Review ☑ Factory/Site 1 ☐ Site 2			

Site Built	Market	- Code	- Path
- GSF	- CSF	- RSF	- Units
Roof (U) -	Wall (U) 0.048	Window (U) 0.28	(SHGC) 0.28
WWR -	Cooling - Type	Cooling - SEER	Heating - Type
Heating - HSPF	DHW - Type	DHW - EF	Interior LPD - W/sf
6 Stories	CZ4A		
• Status – INCOMPLETE ☐ Plan Review ☑ Factory/Site 1 ☐ Site 2			

Site-built	Affordable	SEC 2015	Performance Path
186,460GSF	160,084CSF	126,948RSF	200 Units
Roof (U) 0.026	Wall (U) 0.040	Window (U) 0.26	(SHGC) 0.20
WWR 18%	Cooling DOAS/ERV	Cooling n/a	Heating Electric
Heating n/a	DHW AWHP	DHW 3.8 COP	Interior LPD 0.26W/sf
7 Stories	CZ4C		
• 50kW PV			
• Status – INCOMPLETE ☑ Plan Review ☑ Factory/Site 1 ☐ Site 2			

Site-built	Affordable	SEC 2015	Prescriptive Path
88,026GSF	73,326CSF	59,476RSF	90 Units
Roof (U) 0.026	Wall (U) 0.040	Window (U) 0.24	(SHGC) 0.20
WWR 20%	Cooling DOAS/ERV	Cooling n/a	Heating Electric
Heating n/a	DHW AWHP (CO_2)	DHW 5.0 COP	Interior LPD 0.31W/sf
5 Stories	CZ4C		
• CO_2 AWHP, 20kW PV			
• Status – INCOMPLETE ☑ Plan Review ☐ Factory/Site 1 ☑ Site 2			

Site-built	Affordable	SEC 2015	Performance Path
76,793SF	76,450CSF	65,697RSF	118 Units
Roof (U) 0.026	Wall (U) 0.040	Window (U) 0.18	(SHGC) 0.24
WWR 19%	Cooling DOAS/ERV	Cooling n/a	Heating Electric
Heating n/a	DHW AWHP (CO_2)	DHW 5.0 COP	Interior LPD 0.32W/sf
8 Stories	CZ4C		
• CO_2 AWHP, 20kW PV			
• Status – INCOMPLETE ☑ Plan Review ☑ Factory/Site 1 ☐ Site 2			

Site-built	-	SEC 2015	-
43,789GSF	41,549CSF	37,099RSF	92 Units
Roof (U) 0.019	Wall (U) 0.048	Window (U) 0.27	(SHGC) 0.35
WWR -	Cooling -	Cooling -	Heating -
Heating -	DHW -	DHW -	Interior LPD -
8 Stories	CZ4C		
• Status – INCOMPLETE ☑ Plan Review ☐ Factory/Site 1 ☐ Site 2			

APPENDIX C

Energy Performance EUI Benchmarking Data.

	GSF	Site EUI	EStar	
2017	69,111	48.0	48	
2018	69,111	46.9	50	
2019	69,111	45.2	61	
2020	69,111	40.8	73	
2021	69,111	43.8	58	
		44.9	58	

Site Built Baseline (2013) Same Buildings

	GSF	Site EUI	EStar	n
2019	72,398	31.4	72	12
2020	72,694	31.1	76	13
2021	72,694	34.7	72	13
		32.4	73	13

Site Built Baseline (2013) All Buildings

	GSF	Site EUI	EStar	n
2019	156,058	35.2	74	26
2020	185,342	40.1	67	26
2021	164,494	35.1	76	25
	168,631	36.8	72	26

2019

2014	13218 Avalon Blvd	Multifamily Housing	78	53,517	34	LOS ANGELES	Los Angeles	Avalon Apartments (JSCO)
2013	4201 Via Marina	Multifamily Housing	93	654,862	35.3	MARINA DEL REY	Los Angeles	Shores - Shores LLC
2013	639 N Broadway	Multifamily Housing	100	382,200	27.1	LOS ANGELES	Los Angeles	Jia - 29221
2013	9400 Corbin Avenue	Multifamily Housing	35	375,573	48.6	NORTHRIDGE	Los Angeles	Terrena (61009)
2013	18179 W Terra Verde PL	Multifamily Housing		302,165		CANYON COUNTR	Los Angeles	Townhomes at Lost Canyon
2013	6701 Eton Ave	Multifamily Housing	88	269,608	47.4	CANOGA PARK	Los Angeles	Alta Warner
2013	13488 Maxella Ave	Multifamily Housing		236,775		MARINA DEL REY	Los Angeles	Stella
2013	1234 N La Brea Ave	Multifamily Housing	97	207,769	33.5	WEST HOLLYWOO	Los Angeles	The Huxley - Essex
2013	527 W Regent St	Multifamily Housing	60	172,452	41.7	INGLEWOOD	Los Angeles	527 W Regent St
2013	133 South Kenwood Street	Multifamily Housing		143,802		GLENDALE	Los Angeles	Casa de la Paloma: CDP
2013	200 East Broadway	Multifamily Housing	96	137,037	56.6	GLENDALE	Los Angeles	Eleve - 24300
2013	1717 Garfield Place	Multifamily Housing	15	110,087	63.4	LOS ANGELES	Los Angeles	The Metro at Hollywood: 5555 Hollywood
2013	12223 Atlantic Ave.	Multifamily Housing	76	89,601	43.9	LYNWOOD	Los Angeles	Park Place Apartments (JSCO)
2013	345 S Gramercy Pl.	Multifamily Housing		87,889	4.5	LOS ANGELES	Los Angeles	ANGELS DREAM CASTLE LLC
2013	7238 Canby Avenue	Multifamily Housing	67	82,475	33.8	LOS ANGELES	Los Angeles	Canby Woods: Canby Woods
2013	3023 South Western Avenue	Multifamily Housing	78	81,502	34.7	LOS ANGELES	Los Angeles	Jefferson Park Terrace
2013	1168 S Barrington Avenue	Multifamily Housing	1	78,000	64.3	LOS ANGELES	Los Angeles	The BW
2013	2401 West Jefferson Blvd.	Multifamily Housing	80	72,204	25	LOS ANGELES	Los Angeles	Jefferson Square: Jefferson Square
2013	1230 S. Menlo Avenue	Multifamily Housing	69	72,201	35.2	LOS ANGELES	Los Angeles	Little Tokyo - Menlo Family Housing
2013	240 East 6th Street	Multifamily Housing	61	69,111	45.2	LOS ANGELES	Los Angeles	The Star: 240 East 6th Street
2013	2250 Parkside Ave	Multifamily Housing	88	68,948	27.2	LOS ANGELES	Los Angeles	Mission Plaza
2013	15301 Lanark Street	Multifamily Housing	70	68,345	37	LOS ANGELES	Los Angeles	La Coruna Senior Apartments, LP
2013	14925 W Magnolia Blvd.	Multifamily Housing	81	65,877	26.1	SHERMAN OAKS	Los Angeles	Magnolia
2013	14925 W Magnolia Blvd.	Multifamily Housing	81	65,877	26.1	SHERMAN OAKS	Los Angeles	Magnolia
2013	4900 Vineland Av.	Multifamily Housing	92	64,652	28.6	LOS ANGELES	Los Angeles	Vineland Avenue Senior Housing
2013	12035 W Osborne St	Multifamily Housing	86	59,463	27.1	SYLMAR	Los Angeles	Vista Crest
2013	210 Santa Monica Blvd.	Multifamily Housing	100	54,876	14.2	SANTA MONICA	Los Angeles	Mayfair Residences
2013	5845 Carlton	Multifamily Housing	80	53,275	29.4	LOS ANGELES	Los Angeles	5845 Carlton
			72	72,398	31.4			
			74	156,058	35.2			

2020

5306 N Sepulveda Blvd	5306 N Sepulveda Blvd	SHERMAN OAsS	51540	Multifamily Housing	Multifamily Housing	36	95	2014	Los Angeles
Shores (sr67)	4201 Via Marina	MARINA DEL REY	654862	Multifamily Housing	Heated Swimming Pool	28.9	100	2013	Los Angeles
6201 Hollywood Blvd	6201 Hollywood Blvd	LOS ANGELES	413000	Multifamily Housing	Multifamily Housing	67.9	1	2013	Los Angeles
Jia - 29221	639 N Broadway	LOS ANGELES	382200	Multifamily Housing	Heated Swimming Pool	13.1	100	2013	Los Angeles
Terrena (61009)	9400 Corbin Avenue	NORTHRIDGE	375573	Multifamily Housing	Multifamily Housing, O	51.2	43	2013	Los Angeles
Terrena (61009)	9400 Corbin Avenue	NORTHRIDGE	375573	Multifamily Housing	Multifamily Housing, O	51.2	43	2013	Los Angeles
Townhomes at Lost Car	18179 W Terra Verde Pl	CANYON COUNTRY	302165	Multifamily Housing	Heated Swimming Pool	89.8	1	2013	Los Angeles
Eton Warner Center (lw	6701 Eton Ave	CANOGA PARs	269608	Multifamily Housing	Heated Swimming Pool	49.7	91	2013	Los Angeles
Stella	13488 Maxella Ave	MARINA DEL REY	236775	Multifamily Housing	Multifamily Housing	54.5	37	2013	Los Angeles
Stella	13488 Maxella Ave	MARINA DEL REY	236775	Multifamily Housing	Multifamily Housing	54.5	37	2013	Los Angeles
The Huxley - Essex	1234 N La Brea Ave	WEST HOLLYWOOD	207769	Multifamily Housing	Heated Swimming Pool	45.7	77	2013	Los Angeles
527 W Regent St	527 W Regent St	INGLEWOOD	172452	Multifamily Housing	Multifamily Housing	39.9	61	2013	Los Angeles
Eleve - 24300	200 East Broadway	GLENDALE	137037	Multifamily Housing	Fast Food Restaurant, M	56.8	93	2013	Los Angeles
The Metro at Hollywoo	1717 Garfield Place	LOS ANGELES	110087	Multifamily Housing	Multifamily Housing	36.3	90	2013	Los Angeles
Pars Place Apartments	12223 Atlantic Ave.	LYNWOOD	89601	Multifamily Housing	Multifamily Housing, Pa	48.6	62	2013	Los Angeles
ANGELS DREAM CASTLE	345 S Gramercy Pl.	LOS ANGELES	87889	Multifamily Housing	Multifamily Housing	3.8		2013	Los Angeles
Canby Woods: Canby W	7238 Canby Avenue	LOS ANGELES	82475	Multifamily Housing	Multifamily Housing	34.5	78	2013	Los Angeles
Jefferson Pars Terrace	3023 South Western Av	LOS ANGELES	81502	Multifamily Housing	Multifamily Housing, Pa	31.8	89	2013	Los Angeles
The BW	1168 S Barrington Aven	LOS ANGELES	78000	Multifamily Housing	Multifamily Housing	52.1	6	2013	Los Angeles
Pars Encino Apartment:	4940 Paso Robles Ave	ENCINO	76248	Multifamily Housing	Multifamily Housing, Pa	25.6	85	2013	Los Angeles
Jefferson Square: Jeffe	2401 West Jefferson Bl	LOS ANGELES	72204	Multifamily Housing	Multifamily Housing	25.4	84	2013	Los Angeles
MENLO FAMILY HOUSIN	1230 S. Menlo Avenue	LOS ANGELES	72201	Multifamily Housing	Multifamily Housing	34.2	97	2013	Los Angeles
The Star: 240 East 6th St	240 East 6th Street	LOS ANGELES	69111	Multifamily Housing	Multifamily Housing	40.8	73	2013	Los Angeles
Mission Plaza - ms89	2250 Parsside Ave	LOS ANGELES	68948	Multifamily Housing	Multifamily Housing, Pa	34.7	72	2013	Los Angeles
La Coruna Senior Apart	15301 Lanars Street	LOS ANGELES	68345	Multifamily Housing	Multifamily Housing	38.3	76	2013	Los Angeles
Vista Crest	12035 W Osborne St	SYLMAR	59463	Multifamily Housing	Multifamily Housing, Pa	28.4	88	2013	Los Angeles
Mayfair Residences	210 Santa Monica Blvd.	SANTA MONICA	54876	Multifamily Housing	Multifamily Housing, Pa	14.4	100	2013	Los Angeles
5845 Carlton	5845 Carlton	LOS ANGELES	53275	Multifamily Housing	Multifamily Housing	32.3	72	2013	Los Angeles
			72,694			31.1	76		
			185,342			40.1	67		

2021

5306 N Sepulveda Blvd	5306 N Sepulveda Blvd	SHERMAN OAKS	51540	Multifamily Housing	36.7	90	2014	Los Angeles
Shores (sr67)	4201 Via Marina	MARINA DEL REY	654862	Multifamily Housing	28	100	2013	Los Angeles
Jia - 29221	639 N Broadway	LOS ANGELES	382200	Multifamily Housing	23.7	100	2013	Los Angeles
Terrena (61009)	9400 Corbin Avenue	NORTHRIDGE	375573	Multifamily Housing	50.4	33	2013	Los Angeles
Townhomes at Lost Canyon - CO (rh68)	18179 W Terra Verde PL	CANYON COUNTRY	302165	Multifamily Housing	14.7	99	2013	Los Angeles
Eton Warner Center (lw77)	6701 Eton Ave	CANOGA PARK	269608	Multifamily Housing	47	92	2013	Los Angeles
Stella	13488 Maxella Ave	MARINA DEL REY	236775	Multifamily Housing	51.3	48	2013	Los Angeles
The Huxley - Essex (hx003)	1234 N La Brea Ave	WEST HOLLYWOOD	207769	Multifamily Housing		80	2013	Los Angeles
527 W Regent St	527 W Regent St	INGLEWOOD	172452	Multifamily Housing	33.9	74	2013	Los Angeles
Brio Apartment Homes & Villas (nx006)	546 W Colorado St	GLENDALE	163703	Multifamily Housing			2013	Los Angeles
Casa de la Paloma: CDP	133 South Kenwood Street	GLENDALE	143802	Multifamily Housing	40.8	65	2013	Los Angeles
Eleve - 24300	200 East Broadway	GLENDALE	137037	Multifamily Housing	35.3	100	2013	Los Angeles
The Metro at Hollywood: 5555 Hollywood	1717 Garfield Place	LOS ANGELES	121379	Multifamily Housing	31.4	100	2013	Los Angeles
Park Place Apartments (JSCO)	12223 Atlantic Ave.	LYNWOOD	89601	Multifamily Housing	46	68	2013	Los Angeles
ANGELS DREAM CASTLE LLC	345 S Gramercy Pl.	LOS ANGELES	87889	Multifamily Housing			2013	Los Angeles
Canby Woods: Canby Woods	7238 Canby Avenue	LOS ANGELES	82475	Multifamily Housing	32.7	76	2013	Los Angeles
Jefferson Park	3023 South Western Avenue	LOS ANGELES	81502	Multifamily Housing	34.1	72	2013	Los Angeles
The BW	1168 S Barrington Avenue	LOS ANGELES	78000	Multifamily Housing	50	7	2013	Los Angeles
Park Encino (pr411)	4940 Paso Robles Ave	ENCINO	76248	Multifamily Housing	24	97	2013	Los Angeles
Jefferson Square: Jefferson Square	2401 West Jefferson Blvd.	LOS ANGELES	72204	Multifamily Housing	20.9	94	2013	Los Angeles
MENLO FAMILY HOUSING	1230 S. Menlo Avenue	LOS ANGELES	72201	Multifamily Housing	32.5	98	2013	Los Angeles
Mission Plaza (ms89)	2250 Parkside Ave	LOS ANGELES	68948	Multifamily Housing	69.1	16	2013	Los Angeles
La Coruna Senior Apartments, LP: La Coruna Senior A	15301 Lanark Street	LOS ANGELES	68345	Multifamily Housing	35.7	77	2013	Los Angeles
Vista Crest	12035 W Osborne St	SYLMAR	59463	Multifamily Housing	26.1	90	2013	Los Angeles
Mayfair Residences	210 Santa Monica Blvd.	SANTA MONICA	54876	Multifamily Housing	14	100	2013	Los Angeles
5845 Carlton	5845 Carlton	LOS ANGELES	53275	Multifamily Housing	30.9	71	2013	Los Angeles
			72,694		34.7	72		
			164,494		35.1	76		

	GSF	Site EUI	EStar	
2020	386,000	40.7	65	
2021	386,000	42.7	51	
	386,000	41.7	58	

Site Built Baseline (2017) Same Buildings

	GSF	Site EUI	EStar	n
2020	265,887	34.6	81	12
2021	265,887	34.7	78	12
	265,887	34.7	80	12

Site Built Baseline (2017) All Buildings

	GSF	Site EUI	EStar	n
2020	187,223	31.0	87	26
2021	189,699	31.9	83	26
	188,461	31.5	85	26

2020

Oascrest Heights	22737 Oascrest Circle	YORBA LINDA	55291	Multifamily Housing	Multifamily Housing	29.1	96	2018	Orange
Aspect (lp63)	251 Orangefair Ave	FULLERTON	436892	Multifamily Housing	Heated Swimming Pool	14.4	100	2017	Orange
CA590_Avalon Huntingt	7400 Center Ave.	HUNTINGTON BEACH	391267	Multifamily Housing	Multifamily Housing	33.1	92	2017	Orange
PARALLEL - GREYSTAR	1105 E sATELLA AVE	ANAHEIM	386000	Multifamily Housing	Multifamily Housing	40.7	65	2017	Orange
AMLI Uptown Orange	385 S. Manchester Ave.	ORANGE	355172	Multifamily Housing	Multifamily Housing, Pa	43.5	61	2017	Orange
Valentia (11329)	951 S. Beach Blvd	LA HABRA	328225	Multifamily Housing	Multifamily Housing	39.5	75	2017	Orange
Westview I Apartment	21100 Spectrum	IRVINE	299843	Multifamily Housing	Multifamily Housing	22.9	98	2017	Orange
Broadstone Cavora	26033 Cape Drive	LAGUNA NIGUEL	296418	Multifamily Housing	Multifamily Housing	20.9	95	2017	Orange
Eleven10 (lv011)	1110 W Town and Coun	ORANGE	286025	Multifamily Housing	Heated Swimming Pool	38.4	97	2017	Orange
Westview II Apartment	23107 Spectrum	IRVINE	227408	Multifamily Housing	Multifamily Housing	33.2	55	2017	Orange
Fusion (fs85)	17321 Murphy Ave	IRVINE	223218	Multifamily Housing	Heated Swimming Pool	41.2	86	2017	Orange
Broadstone Cavora (bv:	26033 Cape Dr	LAGUNA NIGUEL	209758	Multifamily Housing	Heated Swimming Pool	66.5	10	2017	Orange
JOULE LA FLORESTA - SI	420 LA CRESCENTA DR	BREA	204000	Multifamily Housing	Multifamily Housing	40.7	87	2017	Orange
Vivere Flats (vf28)	1725 S Auburn Way	ANAHEIM	199898	Multifamily Housing	Heated Swimming Pool	45.9	84	2017	Orange
Westview II Apartment	25111 Spectrum	IRVINE	166987	Multifamily Housing	Multifamily Housing	24.8	95	2017	Orange
Villas Fashion Island #0	4102 San Joaquin Plaza	NEWPORT BEACH	159643	Multifamily Housing	Multifamily Housing	24.8	95	2017	Orange
Villas Fashion Island #0	2201 San Joaquin Plaza	NEWPORT BEACH	133486	Multifamily Housing	Multifamily Housing	30.3	73	2017	Orange
Villas Fashion Island #0	6100 San Joaquin Plaza	NEWPORT BEACH	116949	Multifamily Housing	Multifamily Housing	24.3	96	2017	Orange
Villas Fashion Island #0	1200 San Joaquin Plaza	NEWPORT BEACH	111510	Multifamily Housing	Multifamily Housing	25.2	96	2017	Orange
Paramount Family Irvin	2117 Hamal	IRVINE	111451	Multifamily Housing	Heated Swimming Pool	28.3	97	2017	Orange
Villas Fashion Island #0	5100 San Joaquin Plaza	NEWPORT BEACH	110904	Multifamily Housing	Multifamily Housing	22.8	98	2017	Orange
Lemon Grove	1148 N. Lemon St,	ORANGE	110622	Multifamily Housing	Multifamily Housing, Pa	18.5	100	2017	Orange
Luminaira- Cadence Fa	1158 Hamal	IRVINE	109082	Multifamily Housing	Heated Swimming Pool	28.5	87	2017	Orange
Villas Fashion Island #0	3206 San Joaquin Plaza	NEWPORT BEACH	89569	Multifamily Housing	Multifamily Housing	25.1	97	2017	Orange
Oascrest Terrace: Oascr	22754 Eastpars Drive	YORBA LINDA	82986	Multifamily Housing	Multifamily Housing	31.4	90	2017	Orange
Villas Fashion Island #0	7101 San Joaquin Plaza	NEWPORT BEACH	82171	Multifamily Housing	Multifamily Housing	25.9	91	2017	Orange
Andalucia	816 N. Figueroa St	SANTA ANA	76785	Multifamily Housing	Multifamily Housing, Pa	20.3	100	2017	Orange
Rocswood (Lincoln Apa	1270 E. Lincoln Ave.	ANAHEIM	67711	Multifamily Housing	Multifamily Housing		82	2017	Orange
Casa Ramon	840 W Walnut Ave	ORANGE	67028	Multifamily Housing	Multifamily Housing, Pa	35	100	2017	Orange
			265,887			34.6	81		
			187,223			31.0	87		

2021

Aspect (lp63)	251 Orangefair Ave	FULLERTON	436892	Multifamily Housing	14.8	100	2017	Orange
CA590_Avalon Huntington Beach (cv85)	7400 Center Ave.	HUNTINGTON BEACH	391267	Multifamily Housing	30.5	94	2017	Orange
PARALLEL - GREYSTAR	1105 E KATELLA AVE	ANAHEIM	386000	Multifamily Housing	42.7	51	2017	Orange
AMLI Uptown Orange	385 S. Manchester Ave.	ORANGE	355172	Multifamily Housing	42	60	2017	Orange
The George (ht87)	2211 E Orangewood Ave	ANAHEIM	310617	Multifamily Housing	51.9	42	2017	Orange
Westview I Apartment Homes I 03	21100 Spectrum	IRVINE	299843	Multifamily Housing	24	97	2017	Orange
Broadstone Cavora	26033 Cape Drive	LAGUNA NIGUEL	296418	Multifamily Housing	20.7	95	2017	Orange
Eleven10 (lv011)	1110 W Town and Country Rd	ORANGE	286025	Multifamily Housing	38.8	96	2017	Orange
Westview II Apartment Homes #02	23107 Spectrum	IRVINE	227408	Multifamily Housing	32.9	57	2017	Orange
Fusion (fs85)	17321 Murphy Ave	IRVINE	223218	Multifamily Housing	49.6	66	2017	Orange
Broadstone Cavora (bv71)	26033 Cape Dr	LAGUNA NIGUEL	209758	Multifamily Housing	67.7	7	2017	Orange
JOULE LA FLORESTA - SIMPSON PROPERTY	420 LA CRESCENTA DR	BREA	204000	Multifamily Housing	34.9	68	2017	Orange
Vivere Flats (vf28)	1725 S Auburn Way	ANAHEIM	199898	Multifamily Housing	44.2	83	2017	Orange
Westview II Apartment Homes #01	25111 Spectrum	IRVINE	166987	Multifamily Housing	25.1	94	2017	Orange
Villas Fashion Island #04	4102 San Joaquin Plaza	NEWPORT BEACH	159643	Multifamily Housing	25.3	94	2017	Orange
Luxaira (lz001)	1105 Hamal	IRVINE	152179	Multifamily Housing	25	91	2017	Orange
Villas Fashion Island #02	2201 San Joaquin Plaza	NEWPORT BEACH	133486	Multifamily Housing	29.3	76	2017	Orange
Villas Fashion Island #06	6100 San Joaquin Plaza	NEWPORT BEACH	116949	Multifamily Housing	25.4	94	2017	Orange
Villas Fashion Island #01	1200 San Joaquin Plaza	NEWPORT BEACH	111510	Multifamily Housing	24.3	97	2017	Orange
Paramount Family Irvine Housing Partners, L.P. (Esp	2117 Hamal	IRVINE	111451	Multifamily Housing	26.7	94	2017	Orange
Villas Fashion Island #05	5100 San Joaquin Plaza	NEWPORT BEACH	110904	Multifamily Housing	23.4	98	2017	Orange
Lemon Grove	1148 N. Lemon St,	ORANGE	110622	Multifamily Housing	29.3	88	2017	Orange
Luminaira- Cadence Family Irvine Housing Partners,	1158 Hamal	IRVINE	109082	Multifamily Housing	28	85	2017	Orange
Villas Fashion Island #03	3206 San Joaquin Plaza	NEWPORT BEACH	89569	Multifamily Housing	23.3	98	2017	Orange
Oakcrest Terrace: Oakcrest Terrace	22754 Eastpark Drive	YORBA LINDA	82986	Multifamily Housing	31	89	2017	Orange
Villas Fashion Island #07	7101 San Joaquin Plaza	NEWPORT BEACH	82171	Multifamily Housing	24.7	92	2017	Orange
Andalucia	816 N. Figueroa St	SANTA ANA	76785	Multifamily Housing	26.8	100	2017	Orange
Casa Ramon	840 W Walnut Ave	ORANGE	67028	Multifamily Housing	41.8	92	2017	Orange
			265,887		34.7	78		
			189,699		31.9	83		

	GSF	Site EUI	EStar	
2019	500,000	31.4	95	
2020	500,000	30.3	95	
2021	500,000	28.8	96	
	500,000	30.2	95	

Site Built Baseline (2014) Same Buildings

	GSF	Site EUI	EStar	n
2019	171,017	36.7	80	13
2020	171,017	33.8	83	13
2021	171,017	33.6	83	13
	171,017	34.7	82	13

Site Built Baseline (2014) All Buildings

	GSF	Site EUI	EStar	n
2019	157,163	38.5	76	15
2020	190,555	34.0	80	16
2021	190,555	34.4	81	16
	179,424	35.6	79	16

2019

2015	685 N. 6th Street	Multifamily Housing	100	80,835	15.7	SAN JOSE	Santa Clara	Japantown Senior Apartrments
2014	1 Vista Montana	Multifamily Housing	95	500,000	31.4	SAN JOSE	Santa Clara	Domain-Prime Group
2014	1102 S Abel St	Multifamily Housing	91	380,453	39.3	MILPITAS	Santa Clara	Apex- Essex
2014	3401 Iron Point Dr	Multifamily Housing	99	324,610	29.9	SAN JOSE	Santa Clara	AIRE-River Oaks (rk11)
2014	2870 KAISER DR	Multifamily Housing	72	269,740	32.8	SANTA CLARA	Santa Clara	Hearth (22674)
2014	250 Brandon Street	Multifamily Housing	54	236,048	53.3	SAN JOSE	Santa Clara	River View V
2014	175 Baypointe PKWY	Multifamily Housing	76	201,600	44.1	SAN JOSE	Santa Clara	Enso - Essex
2014	3477 Lily Way	Multifamily Housing	55	153,782	58	SAN JOSE	Santa Clara	River View VI
2014	299 W Washington Ave	Multifamily Housing	68	143,310	38	SUNNYVALE	Santa Clara	Solstice 299 - Essex
2014	515 Barrett Avenue	Multifamily Housing	99	133,738	17.8	MORGAN HILL	Santa Clara	The Lodge: The Lodge
2014	3229 El Camino Real	Multifamily Housing		111,735		SANTA CLARA	Santa Clara	Tuscany Apartments
2014	215, 221, & 229 Ford Road	Multifamily Housing	99	100,805	21	SAN JOSE	Santa Clara	Ford Road Plaza - Total
2014	383 Stockton	Multifamily Housing	90	68,180	26.9	SAN JOSE	Santa Clara	CA102_Building 1
2014	15675 Milan Lane	Multifamily Housing	25	66,046	71.2	MORGAN HILL	Santa Clara	Diamond Creek Villa: 15675 Milan Lane
2014	1535 W. San Carlos Street	Multifamily Housing	63	58,940	38.9	SAN JOSE	Santa Clara	Buena Vista Midtown - Total
2014	5 Comstock Cir	Multifamily Housing	89	54,227	33.6	PALO ALTO	Santa Clara	Escondido Village, Lieberman
2014	6 Comstock Cir	Multifamily Housing	90	54,227	33.8	PALO ALTO	Santa Clara	Escondido Village, Miller
			80	171,017	36.7			
			76	157,163	38.5			

2020

Japantown Senior Apar	685 N. 6th Street	SAN JOSE	80835	Multifamily Housing	Multifamily Housing	16.2	100	2015	Santa Clara
Domain-Prime Group	1 Vista Montana	SAN JOSE	500000	Multifamily Housing	Heated Swimming Pool	30.3	95	2014	Santa Clara
Apex- Essex	1102 S Abel St	MILPITAS	380453	Multifamily Housing	Heated Swimming Pool	38.3	92	2014	Santa Clara
CA102_Avalon Morriso	899 Morrison Pars Drive	SAN JOSE	340880	Multifamily Housing	Multifamily Housing	44.4	41	2014	Santa Clara
AIRE-River Oass (rs11)	3401 Iron Point Dr	SAN JOSE	324610	Multifamily Housing	Heated Swimming Pool	29.5	100	2014	Santa Clara
Hearth: 2870 saiser Driv	2870 saiser Drive	SANTA CLARA	269740	Multifamily Housing	Multifamily Housing	40.8	38	2014	Santa Clara
Hearth South: Hearth S	2900 Hearth Place	SANTA CLARA	243344	Multifamily Housing	Multifamily Housing		63	2014	Santa Clara
Misora (ms081)	388 Santana Row	SAN JOSE	241446	Multifamily Housing	Heated Swimming Pool	26.8	100	2014	Santa Clara
River View V	250 Brandon Street	SAN JOSE	236048	Multifamily Housing	Heated Swimming Pool	51.7	81	2014	Santa Clara
Enso - Essex	175 Baypointe PsWY	SAN JOSE	201600	Multifamily Housing	Heated Swimming Pool	43.6	77	2014	Santa Clara
River View VI	3477 Lily Way	SAN JOSE	153782	Multifamily Housing	Heated Swimming Pool	47.8	91	2014	Santa Clara
Solstice 299 - Essex	299 W Washington Ave	SUNNYVALE	143310	Multifamily Housing	Heated Swimming Pool	33.6	76	2014	Santa Clara
The Lodge (ld064)	515 Barrett Avenue	MORGAN HILL	133738	Multifamily Housing	Multifamily Housing	18.6	99	2014	Santa Clara
Tuscany Apartments	3229 El Camino Real	SANTA CLARA	111735	Multifamily Housing	Multifamily Housing	37	70	2014	Santa Clara
Ford Road Plaza - Total	215, 221, & 229 Ford Ro	SAN JOSE	100805	Multifamily Housing	Multifamily Housing	24	96	2014	Santa Clara
Buena Vista Midtown -	1535 W. San Carlos Stre	SAN JOSE	58940	Multifamily Housing	Multifamily Housing	42.6	58	2014	Santa Clara
Escondido Village, Lieb	5 Comstocs Cir	PALO ALTO	54227	Multifamily Housing	Multifamily Housing	16.1	98	2014	Santa Clara
Escondido Village, Mill	6 Comstocs Cir	PALO ALTO	54227	Multifamily Housing	Multifamily Housing	15.3	99	2014	Santa Clara
			171,017			33.8	83		
			190,555			34.0	80		

2021

Domain-Prime Group	1 Vista Montana	SAN JOSE	500000	Multifamily Housing	28.8	96	2014	Santa Clara
Apex- (px010) Essex	1102 S Abel St	MILPITAS	380453	Multifamily Housing	35.9	95	2014	Santa Clara
CA102_Avalon Morrison Park (ck70)	899 Morrison Park Drive	SAN JOSE	340880	Multifamily Housing	45.7	42	2014	Santa Clara
AIRE-River Oaks (rk11)	3401 Iron Point Dr	SAN JOSE	324610	Multifamily Housing	28.3	100	2014	Santa Clara
Hearth: 2870 Kaiser Drive	2870 Kaiser Drive	SANTA CLARA	269740	Multifamily Housing	38.6	43	2014	Santa Clara
Hearth South: Hearth South	2900 Hearth Place	SANTA CLARA	243344	Multifamily Housing	32.6	85	2014	Santa Clara
Misora (ms081)	388 Santana Row	SAN JOSE	241446	Multifamily Housing		100	2014	Santa Clara
River View V	250 Brandon Street	SAN JOSE	236048	Multifamily Housing	52.5	77	2014	Santa Clara
Enso - Essex (ns008)	175 Baypointe PKWY	SAN JOSE	201600	Multifamily Housing	39.8	84	2014	Santa Clara
River View VI	3477 Lily Way	SAN JOSE	153782	Multifamily Housing	53.1	81	2014	Santa Clara
Solstice 299 - (sl58) Essex	299 W Washington Ave	SUNNYVALE	143310	Multifamily Housing	35.1	76	2014	Santa Clara
The Lodge (ld064)	515 Barrett Avenue	MORGAN HILL	133738	Multifamily Housing	10.9	100	2014	Santa Clara
Tuscany Apartments	3229 El Camino Real	SANTA CLARA	111735	Multifamily Housing	37.3	66	2014	Santa Clara
Ford Road Plaza - Total	215, 221, & 229 Ford Road	SAN JOSE	100805	Multifamily Housing		96	2014	Santa Clara
Buena Vista Midtown - Total	1535 W. San Carlos Street	SAN JOSE	58940	Multifamily Housing	41.2	60	2014	Santa Clara
Escondido Village, Lieberman	5 Comstock Cir	PALO ALTO	54227	Multifamily Housing	15.3	98	2014	Santa Clara
Escondido Village, Miller	6 Comstock Cir	PALO ALTO	54227	Multifamily Housing	15.2	98	2014	Santa Clara
			171,017		33.6	83		
			190,555		34.4	81		

	GSF	Site EUI	EStar	
2019	198,258	21.3	100	
2020	198,258	23.0	100	
2021	198,258	19.4	100	
	198,258	21.2	100	

Site Built Baseline (2016) Same Buildings

	GSF	Site EUI	EStar	n
2019	222,535	33.1	74	10
2020	265,168	40.1	84	9
2021	237,043	39.5	82	10
	241,582	37.6	80	10

Site Built Baseline (2016) All Buildings

	GSF	Site EUI	EStar	n
2019	253,040	37.7	79	17
2020	247,031	41.1	77	18
2021	227,157	39.2	77	19
	242,409	39.3	78	18

2019

2016	33 8th Street	Multifamily Housing	100	526,442	19.8	SAN FRANCISCO	San Francisco	33-8th at Trinity Place
2016	399 Fremont Street	Multifamily Housing	43	509,885	56.5	SAN FRANCISCO	San Francisco	399 Fremont
2016	299 Fremont St	Multifamily Housing	100	503,972	16.8	SAN FRANCISCO	San Francisco	Solaire
2016	1010 16th St.	Multifamily Housing	88	472,881	33.6	SAN FRANCISCO	San Francisco	Potrero 1010 - 29911
2016	Fremont St. and Harrison St.	Multifamily Housing	84	436,149	34.6	SAN FRANCISCO	San Francisco	340 Fremont - 29921
2016	1222 Harrison Street	Multifamily Housing	57	391,541	44.8	SAN FRANCISCO	San Francisco	L Seven (11312)
2016	1688 Pine Street	Multifamily Housing	98	351,860	27.7	SAN FRANCISCO	San Francisco	Rockwell Owners Association
2016	200 Buchanan Street	Multifamily Housing	73	300,000	41.7	SAN FRANCISCO	San Francisco	Alchemy
2016	1 Henry Adams	Multifamily Housing	51	250,597	52.2	SAN FRANCISCO	San Francisco	One Henry Adams - 29940
2016	655, 795, 895 Pacific Ave	Multifamily Housing	76	210,438	56.7	SAN FRANCISCO	San Francisco	Ping Yuen
2016	5880 3rd Street	Multifamily Housing	100	198,258	21.3	SAN FRANCISCO	San Francisco	Waterbend
2016	101 Polk Street	Multifamily Housing	77	155,218	46.3	SAN FRANCISCO	San Francisco	101 Polk
2016	1401 Mission St	Multifamily Housing	93	138,512	28.3	SAN FRANCISCO	San Francisco	Olume_CO (lm59)
2016	360 Berry Street	Multifamily Housing	96	133,989	29.5	SAN FRANCISCO	San Francisco	Mission Bay by Windsor
2016	848 Fairfax Ave	Multifamily Housing	59	130,565	36.3	SAN FRANCISCO	San Francisco	Hunters View Phase II A
2016	838 Pacific Ave.	Multifamily Housing	99	123,322	49	SAN FRANCISCO	San Francisco	Ping Yuen North
2016	1239 Turk Street	Multifamily Housing	89	74,376	42.2	SAN FRANCISCO	San Francisco	Willie B Kennedy: Willie B Kennedy
2016	5050 Mission Street	Multifamily Housing		61,367	20.1	SAN FRANCISCO	San Francisco	ChesHill On Mission
2016	800 Presidio Ave	Multifamily Housing	76	57,000	23.9	SAN FRANCISCO	San Francisco	John Burton Housing
			74	222,535	33.1			
			79	253,040	37.7			

2020

The Duboce (db015)	181 Sanchez St	SAN FRANCISCO	65285	Multifamily Housing	Multifamily Housing	46.5	59	2017	San Francisco
33-8th at Trinity Place	33 8th Street	SAN FRANCISCO	526442	Multifamily Housing	Multifamily Housing, Pa	19.9	100	2016	San Francisco
399 Fremont	399 Fremont Street	SAN FRANCISCO	509885	Multifamily Housing	Heated Swimming Pool	45.1	63	2016	San Francisco
Solaire	299 Fremont St	SAN FRANCISCO	503972	Multifamily Housing	Multifamily Housing, Pa	23.3	100	2016	San Francisco
Potrero 1010 - 29911	1010 16th St.	SAN FRANCISCO	472881	Multifamily Housing	College/University, Fitr	34.7	84	2016	San Francisco
340 Fremont - 29921	Fremont St. and Harrisc	SAN FRANCISCO	436149	Multifamily Housing	Multifamily Housing, Pa	33.2	85	2016	San Francisco
Rocswell Owners Assoc	1688 Pine Street	SAN FRANCISCO	351860	Multifamily Housing	Multifamily Housing, Pa	29.5	98	2016	San Francisco
Alchemy	200 Buchanan Street	SAN FRANCISCO	300000	Multifamily Housing	Multifamily Housing, Pa	41.5	75	2016	San Francisco
One Henry Adams - 299	1 Henry Adams	SAN FRANCISCO	250597	Multifamily Housing	Multifamily Housing, Pa	49.6	54	2016	San Francisco
Waterbend (wb30)	5880 3rd Street	SAN FRANCISCO	198258	Multifamily Housing	Multifamily Housing, Pa	23	100	2016	San Francisco
101 Pols	101 Pols Street	SAN FRANCISCO	155218	Multifamily Housing	Multifamily Housing, Pa	46.9	73	2016	San Francisco
Olume_CO (lm59)	1401 Mission St	SAN FRANCISCO	138512	Multifamily Housing	Multifamily Housing, Pe	27.4	94	2016	San Francisco
Mission Bay by Windso	360 Berry Street	SAN FRANCISCO	133989	Multifamily Housing	Multifamily Housing, Pa	30.6	94	2016	San Francisco
Ping Yuen Central: 795	795 Pacific Ave	SAN FRANCISCO	123751	Multifamily Housing	Multifamily Housing	53.8	52	2016	San Francisco
Ping Yuen North	838 Pacific Ave.	SAN FRANCISCO	123322	Multifamily Housing	Multifamily Housing	73.1	88	2016	San Francisco
OLUME Apartments	1401 Mission St	SAN FRANCISCO	117869	Multifamily Housing	Multifamily Housing, Pe	32.2	84	2016	San Francisco
Duboce Apartments	181 Sanchez St.	SAN FRANCISCO	111985	Multifamily Housing	Multifamily Housing, Re	36	50	2016	San Francisco
Willie B sennedy: Willi	1239 Turs Street	SAN FRANCISCO	74376	Multifamily Housing	Multifamily Housing	40.7	93	2016	San Francisco
Ping Yuen West: 895 Pa	895 Pacific Ave.	SAN FRANCISCO	59256	Multifamily Housing	Multifamily Housing	62.1	54	2016	San Francisco
Ping Yuen East: 655 Pac	655 Pacific Ave.	SAN FRANCISCO	56490	Multifamily Housing	Multifamily Housing	60.8	51	2016	San Francisco
			265,168			40.1	84		
			247,031			41.1	77		

2021

The Duboce (db015)	181 Sanchez St	SAN FRANCISCO	65285	Multifamily Housing	49.8	46	2017	San Francisco
33-8th at Trinity Place	33 8th Street	SAN FRANCISCO	526442	Multifamily Housing	20.1	100	2016	San Francisco
399 Fremont	399 Fremont Street	SAN FRANCISCO	509885	Multifamily Housing	43.7	69	2016	San Francisco
Potrero 1010 - 29911	1010 16th St.	SAN FRANCISCO	472881	Multifamily Housing	31.6	92	2016	San Francisco
340 Fremont - 29921	340 Fremont St.	SAN FRANCISCO	436149	Multifamily Housing	36	79	2016	San Francisco
Solaire (sl008)	299 Fremont St	SAN FRANCISCO	426521	Multifamily Housing	27.6	100	2016	San Francisco
Rockwell Owners Association	1688 Pine Street	SAN FRANCISCO	351860	Multifamily Housing	28	98	2016	San Francisco
Alchemy	200 Buchanan Street	SAN FRANCISCO	300000	Multifamily Housing	41.2	74	2016	San Francisco
One Henry Adams - 29940	1 Henry Adams	SAN FRANCISCO	250597	Multifamily Housing	52.4	49	2016	San Francisco
Waterbend (wb30)	5880 3rd Street	SAN FRANCISCO	198258	Multifamily Housing	19.4	100	2016	San Francisco
Olume_CO (lm59)	1401 Mission St	SAN FRANCISCO	138512	Multifamily Housing	22.3	99	2016	San Francisco
Mission Bay by Windsor	360 Berry Street	SAN FRANCISCO	133989	Multifamily Housing	28.4	96	2016	San Francisco
Ping Yuen Central: 795 Pacific	795 Pacific Ave	SAN FRANCISCO	123751	Multifamily Housing	52	53	2016	San Francisco
Ping Yuen North	838 Pacific Ave.	SAN FRANCISCO	123322	Multifamily Housing	87.4	63	2016	San Francisco
Duboce Apartments	181 Sanchez St.	SAN FRANCISCO	111985	Multifamily Housing	33.5	64	2016	San Francisco
Pacific Point (cf53)	350 Friedell St	SAN FRANCISCO	82000	Multifamily Housing	27.4	91	2016	San Francisco
480 Potrero	480 Potrero Ave	SAN FRANCISCO	76600	Multifamily Housing	29.6	95	2016	San Francisco
Willie B Kennedy: Willie B Kennedy	1239 Turk Street	SAN FRANCISCO	74376	Multifamily Housing	43	86	2016	San Francisco
ChesHill On Mission	5050 Mission Street	SAN FRANCISCO	61367	Multifamily Housing	21.3		2016	San Francisco
Ping Yuen West: 895 Pacific Ave	895 Pacific Ave.	SAN FRANCISCO	59256	Multifamily Housing	63.1	36	2016	San Francisco
Ping Yuen East: 655 Pacific	655 Pacific Ave.	SAN FRANCISCO	56490	Multifamily Housing	57	40	2016	San Francisco
			237,043		39.5	82		
			227,157		39.2	77		

	GSF	Site EUI	EStar	
2019	66,813	57.1	93	
		57.1	93	

Site Built Baseline (2016) Same Buildings

	GSF	Site EUI	EStar	n
2019	96,620	29.5	89	8
		29.5	89	8

Site Built Baseline (2016) All Buildings

	GSF	Site EUI	EStar	n
2019	181,461	31.3	86	13
	181,461	31.3	86	13

2019

2016	4863 Willow Rd, Pleasanton	Multifamily Housing	87	475,362	35.5	PLEASANTON	Alameda	The Galloway at Pleasanton - Essex
2016	50 Vintage Circle	Multifamily Housing	75	351,127	34.4	PLEASANTON	Alameda	Vintage - Greystar
2016	5211 Demarcus Blvd	Multifamily Housing	100	309,878	22.6	DUBLIN	Alameda	CA110_Avalon Dublin Station II
2016	39800 Fremont Boulevard	Multifamily Housing	89	235,820	38	FREMONT	Alameda	Pathfinder Village
2016	1605 Lexington Lane	Multifamily Housing	59	213,850	40.8	PLEASANTON	Alameda	The Mason Flats at Township Square
2016	460 Grand Ave	Multifamily Housing	100	163,000	13	OAKLAND	Alameda	AveVista
2016	3921 Telegraph Ave	Multifamily Housing	94	130,738	22.5	OAKLAND	Alameda	Mural Apartments
2016	188 11th Street	Multifamily Housing	100	112,174	24.2	OAKLAND	Alameda	Prosperity Place: 188 11th Street
2016	1089 Bluebell Drive	Multifamily Housing	72	94,522	50.9	LIVERMORE	Alameda	Heritage Park Livermore Senior Community
2016	15888 Hesperian BLVD	Multifamily Housing	66	76,759	31.8	SAN LORENZO	Alameda	Arbor at Hesperian
2016	1935 Addison Street	Multifamily Housing	100	70,306	22.2	BERKELEY	Alameda	Addison Arts Apartments
2016	2201 Dwight Way	Multifamily Housing	93	66,813	57.1	BERKELEY	Alameda	Garden Village
2016	41152 Fremont Boulevard	Multifamily Housing	89	65,153	24	FREMONT	Alameda	Laguna Commons: 2988 Laguna Commons
2016	2038 Parker St	Multifamily Housing	92	60,304	47.1	BERKELEY	Alameda	Parker Place 2038 - Greystar
2015	5723 W. Las Positas Blvd	Multifamily Housing	84	249,537		PLEASANTON	Alameda	Anton Hacienda
			89	96,620	29.5			
			86	181,461	31.3			

	GSF	Site EUI	EStar	
2019	162,575	27.6	96	
2020	162,575	28.2	96	
2021	162,575	26.8	97	
	162,575	27.5	96	

Site Built Baseline (2017-18) Same Buildings

	GSF	Site EUI	EStar	n
2019	169,886	27.7	86	9
2020	169,515	21.5	92	9
2021	169,237	19.9	93	9
	169,546	23.0	90	9

Site Built Baseline (2017-18) All Buildings

	GSF	Site EUI	EStar	n
2019	185,401	27.6	87	10
2020	158,155	22.9	86	14
2021	149,634	19.5	95	18
	164,397	23.3	89	14

2019

2019	459 23rd St.	Multifamily Housing	82	53,843	30	OAKLAND	Alameda	Rasa
2018	150 4th Street	Multifamily Housing	100	300,642	26.2	OAKLAND	Alameda	Fourth Street East - Greystar
2018	4901 Broadway	Multifamily Housing	100	203,245	10.2	OAKLAND	Alameda	Baxter on Broadway
2018	528 W. Juana Ave.	Multifamily Housing	98	68,943	21.2	SAN LEANDRO	Alameda	La Vereda
2018	24200 Silva Avenue	Multifamily Housing	100	64,000	41.1	HAYWARD	Alameda	Park Manor Townhomes
2017	6775 Golden Gate Dr Ste 100	Multifamily Housing	100	557,290	22.4	DUBLIN	Alameda	Aster
2017	3888 Artist Walk	Multifamily Housing	57	254,603	34.6	FREMONT	Alameda	Artist Walk
2017	3888 Artist Walk Commons	Multifamily Housing		209,789		FREMONT	Alameda	Artist Walk - Residential
2017	1400 San Leandro Blvd	Multifamily Housing	96	162,575	27.6	SAN LEANDRO	Alameda	Marea Alta
2017	240 Kottinger Drive	Multifamily Housing	99	116,194	19.4	PLEASANTON	Alameda	Kottinger Gardens Phase 1
2017	34588 11th St	Multifamily Housing	93	107,521	49.1	UNION CITY	Alameda	The Union Flats
2017	2121 Dwight Way	Multifamily Housing	96	93,215	27.7	BERKELEY	Alameda	The Dwight
2017	2010 Milvia St	Multifamily Housing	21	88,850	46.4	BERKELEY	Alameda	Stonefire Berkeley
2017	1801 Jefferson Street	Multifamily Housing	99	82,636	26.3	OAKLAND	Alameda	Uptown District
			86	169,886	27.7			
			87	185,401	27.6			

2020

Rasa (rs253)	459 23rd St.	OAsLAND	53843	Multifamily Housing	Multifamily Housing	38.5	55	2019	Alameda
Baxter on Broadway (b	4901 Broadway	OAsLAND	199903	Multifamily Housing	Multifamily Housing, P	13.5	100	2018	Alameda
Pauline Weaver Senior	47003 Mission Falls Cou	FREMONT	80557	Multifamily Housing	Multifamily Housing, O	25.6		2018	Alameda
La Vereda	528 W. Juana Ave.	SAN LEANDRO	68943	Multifamily Housing	Multifamily Housing, P	29.2	84	2018	Alameda
Pars Manor Townhome	24200 Silva Avenue	HAYWARD	64000	Multifamily Housing	Multifamily Housing	4.4	100	2018	Alameda
Aster (sz41)	6775 Golden Gate Dr St	DUBLIN	557290	Multifamily Housing	Heated Swimming Pool	22.3	100	2017	Alameda
MacArthur Commons -	539 39th St	OAsLAND	500249	Multifamily Housing	Heated Swimming Pool	28.2	100	2017	Alameda
Artist Wals (ts99)	3888 Artist Wals	FREMONT	254603	Multifamily Housing	Heated Swimming Pool	32.6	58	2017	Alameda
Marea Alta	1400 San Leandro Blvd	SAN LEANDRO	162575	Multifamily Housing	Multifamily Housing, P	28.2	96	2017	Alameda
Parser Apartments - CO	2038 Parser St	BERsELEY	146924	Multifamily Housing	Multifamily Housing, O	15.4		2017	Alameda
sottinger Gardens Phas	240 sottinger Drive	PLEASANTON	116194	Multifamily Housing	Multifamily Housing	20.5	99	2017	Alameda
The Union Flats - CO (th	34588 11th St	UNION CITY	107521	Multifamily Housing	Heated Swimming Pool	54.2	80	2017	Alameda
The Dwight - CO (hd33)	2121 Dwight Way	BERsELEY	93215	Multifamily Housing	Fitness Center/Health (	21.9	100	2017	Alameda
Stonefire Berseley - CO	2010 Milvia St	BERsELEY	88850	Multifamily Housing	Multifamily Housing			2017	Alameda
Uptown District	1801 Jefferson Street	OAsLAND	82636	Multifamily Housing	Multifamily Housing, P	27.2	98	2017	Alameda
Valor Crossing	7500 Saint Patrics Way	DUBLIN	61712	Multifamily Housing	Multifamily Housing, P	36.9	100	2017	Alameda
Faith Manor Apartment	27601 Tyrrell Ave	HAYWARD	57250	Multifamily Housing	Multifamily Housing	42.8	97	2017	Alameda
			169,515			21.5	92		
			158,155			22.9	86		

2021

Baxter on Broadway (bx010)	4901 Broadway	OAKLAND	199903	Multifamily Housing	13.2	100	2018	Alameda
Paseo Estero: Paseo Estero	255 8th Avenue	OAKLAND	110865	Multifamily Housing	4.6	100	2018	Alameda
Vista Estero: Vista Estero	285 8th Avenue	OAKLAND	88112	Multifamily Housing	6.6	100	2018	Alameda
St Marks: St Marks	394 12th Street	OAKLAND	75862	Multifamily Housing			2018	Alameda
La Vereda	528 W. Juana Ave.	SAN LEANDRO	68943	Multifamily Housing	29.8	86	2018	Alameda
Park Manor Townhomes: Park Manor Townhomes	24200 Silva Avenue	HAYWARD	64000	Multifamily Housing	3.4	100	2018	Alameda
37433 Willow St	37433 Willow St	NEWARK	52993	Multifamily Housing	23.2	100	2018	Alameda
Aster (sz41)	6775 Golden Gate Dr Ste 100	DUBLIN	557290	Multifamily Housing	20.8	100	2017	Alameda
MacArthur Commons - CO (mc023)	539 39th St	OAKLAND	500249	Multifamily Housing	24.2	100	2017	Alameda
Artist Walk (tk99)	3888 Artist Walk	FREMONT	254603	Multifamily Housing	34	51	2017	Alameda
Marea Alta	1400 San Leandro Blvd	SAN LEANDRO	162575	Multifamily Housing	26.8	97	2017	Alameda
Parker Apartments	2038 Parker St.	BERKELEY	149261	Multifamily Housing	20.4	100	2017	Alameda
Kottinger Gardens Phase 1: 2803 Kottinger Gardens I	240 Kottinger Drive	PLEASANTON	116194	Multifamily Housing	19.9	99	2017	Alameda
The Union Flats - CO (th128)	34588 11th St	UNION CITY	107521	Multifamily Housing	57.1	74	2017	Alameda
The Dwight - CO (hd33)	2121 Dwight Way	BERKELEY	90717	Multifamily Housing	24.3	100	2017	Alameda
Stonefire Berkeley - CO (nf15)	2010 Milvia St	BERKELEY	88850	Multifamily Housing	9.4	100	2017	Alameda
Uptown District	1801 Jefferson Street	OAKLAND	82636	Multifamily Housing	24	100	2017	Alameda
Stevenson Terrace: Stevenson Terrace	39605 Stevenson Place	FREMONT	77624	Multifamily Housing	11.9	100	2017	Alameda
Chestnut Square Senior: Chestnut Square Senior	1651 Chestnut Street	LIVERMORE	58052	Multifamily Housing	11.1	100	2017	Alameda
Faith Manor Apartments - Total	27601 Tyrrell Ave	HAYWARD	57250	Multifamily Housing	51.3	85	2017	Alameda
			169,237		19.9	93		
			149,634		19.5	95		

	GSF	Site EUI	EStar	
2019	107,521	49.1	93	
2020	107,521	54.2	80	
2021	107,521	57.1	74	
	107,521	53.5	82	

Site Built Baseline (2017-18) Same Buildings

	GSF	Site EUI	EStar	n
2019	169,886	27.7	86	9
2020	169,515	21.5	92	9
2021	169,237	19.9	93	9
	169,546	23.0	90	9

Site Built Baseline (2017-18) All Buildings

	GSF	Site EUI	EStar	n
2019	185,401	27.6	87	10
2020	158,155	22.9	86	14
2021	149,634	19.5	95	18
	164,397	23.3	89	14

2019

2019	459 23rd St.	Multifamily Housing	82	53,843	30	OAKLAND	Alameda	Rasa
2018	150 4th Street	Multifamily Housing	100	300,642	26.2	OAKLAND	Alameda	Fourth Street East - Greystar
2018	4901 Broadway	Multifamily Housing	100	203,245	10.2	OAKLAND	Alameda	Baxter on Broadway
2018	528 W. Juana Ave.	Multifamily Housing	98	68,943	21.2	SAN LEANDRO	Alameda	La Vereda
2018	24200 Silva Avenue	Multifamily Housing	100	64,000	41.1	HAYWARD	Alameda	Park Manor Townhomes
2017	6775 Golden Gate Dr Ste 100	Multifamily Housing	100	557,290	22.4	DUBLIN	Alameda	Aster
2017	3888 Artist Walk	Multifamily Housing	57	254,603	34.6	FREMONT	Alameda	Artist Walk
2017	3888 Artist Walk Commons	Multifamily Housing		209,789		FREMONT	Alameda	Artist Walk - Residential
2017	1400 San Leandro Blvd	Multifamily Housing	96	162,575	27.6	SAN LEANDRO	Alameda	Marea Alta
2017	240 Kottinger Drive	Multifamily Housing	99	116,194	19.4	PLEASANTON	Alameda	Kottinger Gardens Phase 1
2017	34588 11th St	Multifamily Housing	93	107,521	49.1	UNION CITY	Alameda	The Union Flats
2017	2121 Dwight Way	Multifamily Housing	96	93,215	27.7	BERKELEY	Alameda	The Dwight
2017	2010 Milvia St	Multifamily Housing	21	88,850	46.4	BERKELEY	Alameda	Stonefire Berkeley
2017	1801 Jefferson Street	Multifamily Housing	99	82,636	26.3	OAKLAND	Alameda	Uptown District
			86	169,886	27.7			
			87	185,401	27.6			

2020

Rasa (rs253)	459 23rd St.	OAsLAND	53843	Multifamily Housing	Multifamily Housing	38.5	55	2019	Alameda
Baxter on Broadway (b	4901 Broadway	OAsLAND	199903	Multifamily Housing	Multifamily Housing, P	13.5	100	2018	Alameda
Pauline Weaver Senior	47003 Mission Falls Cou	FREMONT	80557	Multifamily Housing	Multifamily Housing, O	25.6		2018	Alameda
La Vereda	528 W. Juana Ave.	SAN LEANDRO	68943	Multifamily Housing	Multifamily Housing, P	29.2	84	2018	Alameda
Pars Manor Townhome	24200 Silva Avenue	HAYWARD	64000	Multifamily Housing	Multifamily Housing	4.4	100	2018	Alameda
Aster (sz41)	6775 Golden Gate Dr St	DUBLIN	557290	Multifamily Housing	Heated Swimming Pool	22.3	100	2017	Alameda
MacArthur Commons -	539 39th St	OAsLAND	500249	Multifamily Housing	Heated Swimming Pool	28.2	100	2017	Alameda
Artist Wals (ts99)	3888 Artist Wals	FREMONT	254603	Multifamily Housing	Heated Swimming Pool	32.6	58	2017	Alameda
Marea Alta	1400 San Leandro Blvd	SAN LEANDRO	162575	Multifamily Housing	Multifamily Housing, P	28.2	96	2017	Alameda
Parser Apartments - CO	2038 Parser St	BERsELEY	146924	Multifamily Housing	Multifamily Housing, O	15.4		2017	Alameda
sottinger Gardens Phas	240 sottinger Drive	PLEASANTON	116194	Multifamily Housing	Multifamily Housing	20.5	99	2017	Alameda
The Union Flats - CO (th	34588 11th St	UNION CITY	107521	Multifamily Housing	Heated Swimming Pool	54.2	80	2017	Alameda
The Dwight - CO (hd33)	2121 Dwight Way	BERsELEY	93215	Multifamily Housing	Fitness Center/Health C	21.9	100	2017	Alameda
Stonefire Berseley - CO	2010 Milvia St	BERsELEY	88850	Multifamily Housing	Multifamily Housing			2017	Alameda
Uptown District	1801 Jefferson Street	OAsLAND	82636	Multifamily Housing	Multifamily Housing, P	27.2	98	2017	Alameda
Valor Crossing	7500 Saint Patrics Way	DUBLIN	61712	Multifamily Housing	Multifamily Housing, P	36.9	100	2017	Alameda
Faith Manor Apartment	27601 Tyrrell Ave	HAYWARD	57250	Multifamily Housing	Multifamily Housing	42.8	97	2017	Alameda
			169,515			21.5	92		
			158,155			22.9	86		

2021

Baxter on Broadway (bx010)	4901 Broadway	OAKLAND	199903	Multifamily Housing	13.2	100	2018	Alameda
Paseo Estero: Paseo Estero	255 8th Avenue	OAKLAND	110865	Multifamily Housing	4.6	100	2018	Alameda
Vista Estero: Vista Estero	285 8th Avenue	OAKLAND	88112	Multifamily Housing	6.6	100	2018	Alameda
St Marks: St Marks	394 12th Street	OAKLAND	75862	Multifamily Housing			2018	Alameda
La Vereda	528 W. Juana Ave.	SAN LEANDRO	68943	Multifamily Housing	29.8	86	2018	Alameda
Park Manor Townhomes: Park Manor Townhomes	24200 Silva Avenue	HAYWARD	64000	Multifamily Housing	3.4	100	2018	Alameda
37433 Willow St	37433 Willow St	NEWARK	52993	Multifamily Housing	23.2	100	2018	Alameda
Aster (sz41)	6775 Golden Gate Dr Ste 100	DUBLIN	557290	Multifamily Housing	20.8	100	2017	Alameda
MacArthur Commons - CO (mc023)	539 39th St	OAKLAND	500249	Multifamily Housing	24.2	100	2017	Alameda
Artist Walk (tk99)	3888 Artist Walk	FREMONT	254603	Multifamily Housing	34	51	2017	Alameda
Marea Alta	1400 San Leandro Blvd	SAN LEANDRO	162575	Multifamily Housing	26.8	97	2017	Alameda
Parker Apartments	2038 Parker St.	BERKELEY	149261	Multifamily Housing	20.4	100	2017	Alameda
Kottinger Gardens Phase 1: 2803 Kottinger Gardens I	240 Kottinger Drive	PLEASANTON	116194	Multifamily Housing	19.9	99	2017	Alameda
The Union Flats - CO (th128)	34588 11th St	UNION CITY	107521	Multifamily Housing	57.1	74	2017	Alameda
The Dwight - CO (hd33)	2121 Dwight Way	BERKELEY	90717	Multifamily Housing	24.3	100	2017	Alameda
Stonefire Berkeley - CO (nf15)	2010 Milvia St	BERKELEY	88850	Multifamily Housing	9.4	100	2017	Alameda
Uptown District	1801 Jefferson Street	OAKLAND	82636	Multifamily Housing	24	100	2017	Alameda
Stevenson Terrace: Stevenson Terrace	39605 Stevenson Place	FREMONT	77624	Multifamily Housing	11.9	100	2017	Alameda
Chestnut Square Senior: Chestnut Square Senior	1651 Chestnut Street	LIVERMORE	58052	Multifamily Housing	11.1	100	2017	Alameda
Faith Manor Apartments - Total	27601 Tyrrell Ave	HAYWARD	57250	Multifamily Housing	51.3	85	2017	Alameda
			169,237		19.9	93		
			149,634		19.5	95		

	GSF	Site EUI	EStar	
2019	50,406	45.1	96	
2020	50,406	67.5	62	
2021	50,406	62.0	68	
	50,406	58.2	75	

Site Built Baseline (2018-19) Same Buildings

	GSF	Site EUI	EStar	n
2019	264,251	27.3	95	12
2020	251,419	35.2	87	12
2021	266,721	29.4	92	11
	260,797	30.6	91	12

Site Built Baseline (2018-19) All Buildings

	GSF	Site EUI	EStar	n
2019	251,095	27.8	94	13
2020	222,770	30.6	85	21
2021	258,673	27.8	87	28
	244,179	28.7	89	21

2019

2019	200 Infinity Way	Multifamily Housing		227,324	12.7	MOUNTAIN VIEW	Santa Clara	Revela
2019	111 Lewis Street	Multifamily Housing		141,157		GILROY	Santa Clara	The Cannery: 111 Lewis Street
2019	1144 South Second Street	Multifamily Housing	96	50,406	45.1	SAN JOSE	Santa Clara	Second Street Studios
2018	415 E. Taylor Street	Multifamily Housing	100	445,687	21.1	SAN JOSE	Santa Clara	Cannery Park by Windsor
2018	753 Montague Expressway	Multifamily Housing	100	428,295	22.5	MILPITAS	Santa Clara	The Edge Apartments
2018	1315 McCandless Dr	Multifamily Housing	74	349,349	41.2	MILPITAS	Santa Clara	Turing
2018	808 West San Carlos	Multifamily Housing		337,456	33.7	SAN JOSE	Santa Clara	808 West (11177)
2018	650 E. Capitol Ave	Multifamily Housing	94	332,318	34.5	650 E. CAPITOL AV	Santa Clara	Capitol 650-LMC
2018	787 The Alameda	Multifamily Housing	100	249,988	22.7	SAN JOSE	Santa Clara	Modera The Alameda
2018	300 W Washington Ave	Multifamily Housing	95	234,488	33	SUNNYVALE	Santa Clara	The Flats at Cityline
2018	678 North King Road	Multifamily Housing	98	171,399	20	SAN JOSE	Santa Clara	Kings Crossing: Kings Crossing
2018	787 The Alameda	Multifamily Housing	96	162,856	31.7	SAN JOSE	Santa Clara	Modera The Alameda
2018	Laurel Grove Lane	Multifamily Housing	80	93,218	32.2	SAN JOSE	Santa Clara	Laurel Grove: Laurel Grove
2018	300 Railway Avenue	Multifamily Housing	100	90,697		CAMPBELL	Santa Clara	300 Railway
			95	264,251	27.3			
			94	251,095	27.8			

2020

The James (11176)	98 North First Street	SAN JOSE	407640	Multifamily Housing	Multifamily Housing	32.7	46	2019	Santa Clara
1501 Berryessa Rd	1501 Berryessa Rd	SAN JOSE	300000	Multifamily Housing	Multifamily Housing	14.1	100	2019	Santa Clara
NOVO - LMC	2260 W EL Camino Real	MOUNTAIN VIEW	296188	Multifamily Housing	Multifamily Housing, Pa	28.9	76	2019	Santa Clara
Revela (rv060)	200 Infinity Way	MOUNTAIN VIEW	227324	Multifamily Housing	Heated Swimming Pool	28.1		2019	Santa Clara
The Cannery: 111 Lewis	111 Lewis Street	GILROY	141157	Multifamily Housing	Multifamily Housing	27.6	93	2019	Santa Clara
One38 (rp009)	138 Balbach St	SAN JOSE	133092	Multifamily Housing	Multifamily Housing, Pa	21.4	97	2019	Santa Clara
Evelyn Family Apartme	779 East Evelyn Avenue	MOUNTAIN VIEW	110400	Multifamily Housing	Multifamily Housing	26.5	90	2019	Santa Clara
Second Street Studios	1144 South Second Stre	SAN JOSE	50406	Multifamily Housing	Multifamily Housing	67.5	62	2019	Santa Clara
Cannery Pars by Winds	415 E. Taylor Street	SAN JOSE	445687	Multifamily Housing	Multifamily Housing, Pa	23.1	99	2018	Santa Clara
The Edge Apartments	753 Montague Expressv	MILPITAS	428295	Multifamily Housing	Heated Swimming Pool	28.4	100	2018	Santa Clara
Turing - tr003	1315 McCandless Dr	MILPITAS	349349	Multifamily Housing	Multifamily Housing	49.5	52	2018	Santa Clara
808 West (61069)	808 West San Carlos	SAN JOSE	337456	Multifamily Housing	Multifamily Housing, Re	43.1	80	2018	Santa Clara
Capitol 650-LMC	650 E. Capitol Ave	650 E. CAPITOL AVE	332318	Multifamily Housing	Heated Swimming Pool	43	74	2018	Santa Clara
The Flats at Cityline	300 W Washington Ave	SUNNYVALE	234488	Multifamily Housing	Multifamily Housing, Pa	34.5	91	2018	Santa Clara
ELAN MOUNTAIN VIEW	1030 CASTRO ST STE 211	MOUNTAIN VIEW	164000	Multifamily Housing	Multifamily Housing	29.7	70	2018	Santa Clara
Modera The Alameda	787 The Alameda	SAN JOSE	162902	Multifamily Housing	Heated Swimming Pool	36.6	89	2018	Santa Clara
Modera Alameda (md0	787 The Alameda	SAN JOSE	162856	Multifamily Housing	Heated Swimming Pool	32.6	95	2018	Santa Clara
sings Crossing: sings Cr	678 North sing Road	SAN JOSE	104495	Multifamily Housing	Multifamily Housing	34.1	83	2018	Santa Clara
Latitude 37 Phase II	1277 Babb Ct	SAN JOSE	99971	Multifamily Housing	Heated Swimming Pool	15.1	100	2018	Santa Clara
Laurel Grove: Laurel Gr	Laurel Grove Lane	SAN JOSE	93218	Multifamily Housing	Multifamily Housing	34.7	66	2018	Santa Clara
300 Railway	300 Railway Avenue	CAMPBELL	90697	Multifamily Housing	Heated Swimming Pool	41.5	98	2018	Santa Clara
Edwina Benner Plaza	460 Persian Drive	SUNNYVALE	56628	Multifamily Housing	Multifamily Housing, Pa	16.7	100	2018	Santa Clara
			251,419			35.2	87		
			222,770			30.6	85		

2021

Mylo Santa Clara - Essex (my022)	3710 El Camino Real	SANTA CLARA	670596	Multifamily Housing	23.7	80	2019	Santa Clara
Lynhaven Apartments (ly035)	919 S Winchester Blvd	SAN JOSE	551565	Multifamily Housing	42.7	41	2019	Santa Clara
The James (11176)	98 North First Street	SAN JOSE	407640	Multifamily Housing	13.3	100	2019	Santa Clara
Santa Clara Square V	3315 Montgomery Dr	SANTA CLARA	400935	Multifamily Housing	26.2	100	2019	Santa Clara
Revela Phase 2 (rv155)	100 Infinity Way	MOUNTAIN VIEW	312168	Multifamily Housing			2019	Santa Clara
1501 Berryessa Rd, San Jose, CA 95133	1501 Berryessa Rd	SAN JOSE	300000	Multifamily Housing	35.3	90	2019	Santa Clara
NOVO - LMC	2260 W EL Camino Real	MOUNTAIN VIEW	296188	Multifamily Housing	20.3	100	2019	Santa Clara
Revela (rv060)	200 Infinity Way	MOUNTAIN VIEW	227324	Multifamily Housing	28.7		2019	Santa Clara
Santa Clara Square II	3320 Montgomery Drive	SANTA CLARA	223458	Multifamily Housing	33.4	96	2019	Santa Clara
Modera San Pedro Square (md147)	28 N Almaden Ave	SAN JOSE	208131	Multifamily Housing	21.1	83	2019	Santa Clara
Santa Clara Square I	3410 Montgomery Drive	SANTA CLARA	184320	Multifamily Housing	36.9	89	2019	Santa Clara
The Cannery: 111 Lewis Street	111 Lewis Street	GILROY	141157	Multifamily Housing	23.5	99	2019	Santa Clara
One38 (rp009)	138 Balbach St	SAN JOSE	133092	Multifamily Housing	9.6		2019	Santa Clara
Evelyn Family Apartments: Evelyn Family Apartmen	779 East Evelyn Avenue	MOUNTAIN VIEW	110400	Multifamily Housing	26.6	89	2019	Santa Clara
Renascent Place	2450 Senter Road	SAN JOSE	103212	Multifamily Housing	27.5	96	2019	Santa Clara
Villas on the Park	290 North 2nd Street	SAN JOSE	62400	Multifamily Housing	40.9	65	2019	Santa Clara
Second Street Studios	1144 South Second Street	SAN JOSE	50406	Multifamily Housing	62	68	2019	Santa Clara
Cannery Park by Windsor	415 E. Taylor Street	SAN JOSE	445687	Multifamily Housing	21.1	99	2018	Santa Clara
The Edge Apartments	753 Montague Expressway	MILPITAS	428295	Multifamily Housing	27	100	2018	Santa Clara
Turing (tr003)	1315 McCandless Dr	MILPITAS	349349	Multifamily Housing	47.8	49	2018	Santa Clara
808 West (61069)	808 West San Carlos	SAN JOSE	337456	Multifamily Housing	32.7	98	2018	Santa Clara
Capitol 650-LMC	650 E. Capitol Ave	650 E. CAPITOL AVE	332318	Multifamily Housing	18.5	100	2018	Santa Clara
Flats at Cityline (fl016)	300 W Washington Ave	SUNNYVALE	289259	Multifamily Housing	28.7	88	2018	Santa Clara
Elan Mountain View (ln250)	1030 Castro St # 2110	MOUNTAIN VIEW	188197	Multifamily Housing	25.6	44	2018	Santa Clara
Modera Alameda (md018)	787 The Alameda	SAN JOSE	187894	Multifamily Housing	26.5	100	2018	Santa Clara
Kings Crossing: Kings Crossing	678 North King Road	SAN JOSE	104495	Multifamily Housing	29.8	90	2018	Santa Clara
Latitude 37 Phase II	1277 Babb Ct	SAN JOSE	99971	Multifamily Housing			2018	Santa Clara
300 Railway	300 Railway Avenue	CAMPBELL	90697	Multifamily Housing	39.5	99	2018	Santa Clara
Edwina Benner Plaza	460 Persian Drive	SUNNYVALE	56628	Multifamily Housing	15.1	100	2018	Santa Clara
			266,721		29.4	92		
			258,673		27.8	87		

	GSF	Site EUI	EStar	
2021	72,776	46.0	95	
	72,776	46.0	95	

Site Built Baseline (2017-20) Same Buildings

	GSF	Site EUI	EStar	n
2021	98,462	52.4	82	3
	98,462	52.4	82	3

Site Built Baseline (2017-20) All Buildings

	GSF	Site EUI	EStar	n
2021	98,462	52.4	82	3
	98,462	52.4	82	3

2021

Residence Inn Vacaville	360 Orange Drive	VACAVILLE	56483	Hotel	46.9	93	2000	Solano
Montage Healdsburg	100 Montage Way	HEALDSBURG	151847	Hotel	39.4	90	2020	Sonoma
AC Hotel Santa Rosa	300 Davis Street	SANTA ROSA	72776	Hotel	46.0	95	2020	Sonoma
Healdsburg CA TRIO	110 Dry Creek Rd	HEALDSBURG	82628	Hotel	74.2	71	2018	Sonoma
8755 Old Redwood Highway	8755 Old Redwood Highway	WINDSOR	61000	Hotel	43.7	84	2017	Sonoma
			98,492		52.4	82		

	GSF	Site EUI	EStar	
2017	129,330	56.3	73	
2018	129,330	58.8	77	
2019	129,330	52.9	83	
2020	129,330	42.5	95	
2021	129,330	46.4	92	
		52.1	83	

Site Built Baseline (2011-13) Same Buildings

	GSF	Site EUI	EStar	n
2017	155,494	45.8	64	7
2018	149,845	51.7	58	7
2019	149,845	51.2	63	7
2020	149,845	43.2	79	7
2021	155,494	43.8	77	7
		46.9	68	7

Site Built Baseline (2011-13) All Buildings

	GSF	Site EUI	EStar	n
2017	153,922	45.9	66	13
2018	153,626	49.7	58	12
2019	142,488	45.4	62	11
2020	129,029	43.8	64	13
2021	142,081	46.6	64	13
	147,130	46.5	64	13

2016

319 W CHELTEN AVE	Delmar	2014	Multifamily Hous	53900	48	38.9
2116 CHESTNUT ST	2116 Chestnut	2013	Multifamily Hous	410780	47	51.2
3200L CHESTNUT ST # A	381-Chestnut Square	2013	Multifamily Housi	368221	76	66.9
1901-39 CALLOWHILL ST	The Granary	2013	Multifamily Housi	310417	35	51.4
1900 N 9TH ST	Paseo Verde North and Soutl	2013	Multifamily Housi	180882	95	34.4
1605-27 SANSOM ST	The Sansom	2013	Multifamily Hous	85032		46.5
921-31 ELLSWORTH ST	921 Ellsworth, LP	2013	Multifamily Hous	80400	91	23.5
1415 FAIRMOUNT AVE	JBJ Soul Homes (Fairmount G	2013	Multifamily Hous	75000	70	55.7
249-57 S 13TH ST	John C. Anderson Apartment	2013	Multifamily Housi	62925	36	36.3
221 W JOHNSON ST	Nugent Senior Apartments	2013	Multifamily Housi	54015	86	25.8
1 BROWN ST	1 Brown Street Associates	2012	Multifamily Hous	260100	75	45.8
1000 DIAMOND ST	Diamond Green	2012	Multifamily Housi	129330	77	55.8
1440 MOUNT VERNON ST	600 North Broad Association	2012	Multifamily Hous	101442		72.3
6025 E ROOSEVELT BLVD	Oakland Terrace 2012 LP	2012	Multifamily Housi	72840	78	59.4
2101 W VENANGO ST	Ray Homes	2011	Multifamily Housi	39155	45	46.9
4700 CITY AVE	Mansion at Bala	2010	Multifamily Hous	444073	47	31
				155,494	64	45.9
				161,631	67	47.4

2017

3200L CHESTNUT ST # A	381-Chestnut Squ	2013	Multifamily Housi	368221	76	61.9
2116 CHESTNUT ST	2116 Chestnut	2013	Multifamily Housi	315660	35	54.7
1901-39 CALLOWHILL ST	The Granary	2013	Multifamily Housi	310417	27	54
1900 N 9TH ST	Paseo Verde Nort	2013	Multifamily Housi	180882	89	31
1605-27 SANSOM ST	The Sansom	2013	Multifamily Housi	85032		44.8
1415 FAIRMOUNT AVE	JBJ Soul Homes (F	2013	Multifamily Housi	75000		
921-31 ELLSWORTH ST	921 Ellsworth, LP	2013	Multifamily Housi	71400	84	25
249-57 S 13TH ST	John C. Anderson	2013	Multifamily Housi	62925	65	36.2
221 W JOHNSON ST	Nugent Senior Ap	2013	Multifamily Housi	54015	54	32.3
1 BROWN ST	1 Brown Street As	2012	Multifamily Housi	264000	88	33.3
1000 DIAMOND ST	Diamond Green	2012	Multifamily Housi	129330	73	56.3
1440 MOUNT VERNON ST	600 North Broad A	2012	Multifamily Housi	101442		72.4
6025 E ROOSEVELT BLVD	Oakland Terrace 2	2012	Multifamily Housi	72840	75	59.6
2101 W VENANGO ST	Ray Homes	2011	Multifamily Housi	39155		45.4
4700 CITY AVE	Mansion at Bala	2010	Multifamily Housi	444073	41	30.6
				155,494	64	45.8
				153,922	66	45.9

2018

1000 Diamond St	Diamond Green	2012	Mixed Use Property	129,330	77	58.8
3200 Chestnut Square	381 - Chestnut Square	2013	Multifamily Housing	368,221	48	76.4
2116 Chestnut St.	2116 Chestnut	2013	Multifamily Housing	315,660	48	54.5
1901-39 Callowhill St.	The Granary	2013	Multifamily Housing	270,880	44	52.1
1900 North 9th Street	Paseo Verde North and South	2013	Multifamily Housing	180,882		47.1
4428-4470 & 4413-4451 Germantown Ave	Nicetown Court I & II	2013	Multifamily Housing	128,788	96	35.8
1605 Sansom St	The Sansom	2013	Multifamily Housing	85,032		45.3
249-57 S. 13th Street	John C. Anderson Apartments	2013	Multifamily Housing	62,925	74	36.9
221 W. Johnson Street	Nugent Senior Apartments	2013	Multifamily Housing	54,015	50	36
921 Ellsworth St	Birchwood at Cedars Village-Ingerman	2013	Multifamily Housing	53,300	69	34.4
1 Brown St	Penn Treaty Village-1 Brown St	2012	Multifamily Housing	264,000	78	41.6
1440 Mt. Vernon St.	600 North Broad Association	2012	Multifamily Housing	101,442	2	72.8
6063 Roosevelt Blvd.	Oakland Terrace 2012 LP	2012	Multifamily Housing	72,840	73	61.9
2101 W. Venango St	Ray Homes	2011	Other	39,155		51.3
				149,845	58	51.7
				153,626	58	49.7

2019

3200L CHESTNUT ST #A	381-Chestnut Square	2013	Multifamily Housing	368221	56	79.3
2116 CHESTNUT ST	2116 Chestnut	2013	Multifamily Housing	315660	51	53
1901-39 CALLOWHILL ST	The Granary	2013	Multifamily Housing	270880	60	46.7
1900 N 9TH ST	Paseo Verde North and Soutl	2013	Multifamily Housing	180882		47.4
1415 FAIRMOUNT AVENUE	JBJ Soul Homes (Fairmount G	2013	Multifamily Housing	75000		15.9
1601 SANSOM ST	The Sansom - Panco Manager	2013	Multifamily Housing	74492	66	37
249-57 S 13TH ST	John C. Anderson Apartment	2013	Multifamily Housing	62925	73	37.3
221 W JOHNSON ST	Nugent Senior Apartments	2013	Multifamily Housing	54015	51	35
921-31 ELLSWORTH ST	Birchwood at Cedars Village-	2013	Multifamily Housing	53300	64	34.8
1000 DIAMOND ST	Diamond Green	2012	Multifamily Housing	129330	83	52.9
6025 E ROOSEVELT BLVD	Oakland Terrace 2012 LP	2012	Multifamily Housing	72840	73	60.2
2101 W VENANGO ST	Ray Homes	2011	Multifamily Housing	39155		52.3
4700 CITY AVE	Mansion at Bala	2010	Multifamily Housing	444073	42	32.8
				149,845	63	51.2
				142,488	62	45.4

2020

381-Chestnut Square	3200L CHESTNUT ST #A	Multifamily	368221	2013	93	48.7
2116 Chestnut	2116 CHESTNUT ST	Multifamily	315660	2013	58	49.1
The Granary	1901-39 CALLOWHILL ST	Multifamily	270880	2013	73	40.7
Paseo Verde North and South	1900 N 9TH ST	Multifamily	180882	2013	91	40.8
JBJ Soul Homes (Fairmount Garden	1415 FAIRMOUNT AVENUE	Multifamily	75000	2013		19.2
The Sansom - Panco Management	1601 SANSOM ST	Multifamily	74492	2013	18	50
Nicetown Court II	4428-4470 & 4413-4451 Germa	Multifamily	65232	2013	69	60.6
John C. Anderson Apartments	249-57 S 13TH ST	Multifamily	62925	2013	88	31.6
Nugent Senior Apartments	221 W JOHNSON ST	Multifamily	54015	2013	52	33.5
Birchwood at Cedars Village-Ingerr	921-31 ELLSWORTH ST	Multifamily	53300	2013	56	35.5
Diamond Green	1000 DIAMOND ST	Multifamily	129330	2012	95	42.5
Oakland Terrace 2012 LP	6025 E ROOSEVELT BLVD	Multifamily	72840	2012	74	56.6
Nicetown Court I	4340 Germantown Ave	Multifamily	44781	2011	36	52.2
Ray Homes	2101 W VENANGO ST	Multifamily	39155	2011		50.3
Mansion at Bala	4700 CITY AVE	Multifamily	444073	2010	51	29.6
			149,845		79	43.2
			129,029		64	43.8

2021

2116 Chestnut Street	2116 Chestnut Apartments	2013	Multifamily Housing	410780	50	49.9
3200 Chestnut Square	381 - Chestnut Square	2013	Multifamily Housing	368221	91	48.7
1901-39 Callowhill St.	The Granary	2013	Multifamily Housing	310417	74	40.0
1900 North 9th Street	Paseo Verde North and	2013	Multifamily Housing	180882	89	43.3
1601 SANSOM ST	The Sansom - Panco	2013	Multifamily Housing	74492	32	45.3
4428-4470 & 4413-	Nicetown Court II	2013	Multifamily Housing	65232	68	61.1
249-57 S. 13th Street	John C. Anderson	2013	Multifamily Housing	62925	91	30.6
221 W. Johnson	Nugent Senior Apartments	2013	Multifamily Housing	54015	39	36.5
921 Ellsworth St	Birchwood at Cedars	2013	Multifamily Housing	53300	72	31.8
1000 Diamond St	Diamond Green	2012	Multifamily Housing	129330	92	46.4
6063 Roosevelt Blvd.	Oakland Terrace 2012 LP	2012	Multifamily Housing	72840	75	57.3
4340 Germantown	Nicetown Court I and II	2011	Multifamily Housing	110013	53	57.9
4340 Germantown	Nicetown Court I	2011	Multifamily Housing	44781	33	53.2
2101 W. Venango St	Ray Homes	2011	Multifamily Housing	39155		50.3
4700 City Avenue	Mansion at Bala	2010	Multifamily Housing	444073	49	30.3
				155,494	77	43.8
				142,081	64	46.6

	GSF	Site EUI	EStar	
2017	53,000	35.4	-	
2018	53,000	36.5	72	
2019	53,000	35.5	73	
2020	65,864	26.2	88	
2021	65,864	26.8	87	
		32.1	80	

Site Built Baseline (2014-16) Same Buildings

	GSF	Site EUI	EStar	n
2017	89,076	56.2	37	6
2018	89,076	53.5	44	6
2019	89,071	57.7	46	6
2020	89,071	57.0	47	6
2021	89,904	56.9	49	6
		56.3	45	6

Site Built Baseline (2014-16) All Buildings

	GSF	Site EUI	EStar	n
2017	235,760	46.1	57	22
2018	205,660	48.3	58	28
2019	270,602	50.6	54	22
2020	260,131	45.6	59	18
2021	304,504	52.6	53	20
	255,331	48.6	56	22

2017

1221-31 S BROAD ST	Armory Lofts	2017	Multifamily Housi	32198	94	33.6
500 N 21ST ST	Dalian on the Parl	2016	Multifamily Housi	450000	90	33
1363 N 31ST ST	The Fairmount at	2016	Multifamily Housi	272255	47	32.3
1338-48 CHESTNUT ST	435110 - Avenue c	2016	Multifamily Housi	235115		54.9
250 N CHRISTOPHER COLUMBUS BL	One Water Street	2016	Multifamily Housi	210222	69	39.3
1900 W ALLEGHENY AVE	Allegheny Apts Ph	2016	Multifamily Housi	102485		23.2
910 CHERRY ST	910 Cherry Street	2016	Multifamily Housi	64000	93	27.8
3100 W THOMPSON ST	CS Brewerytown A	2016	Multifamily Housi	53000		35.4
2560 BELMONT AVE	Inglis Gardens at I	2016	Multifamily Housi	50439	80	35.6
2564 BELMONT AVE	Inglis Gardens at I	2016	Multifamily Housi	49447	63	40.9
3900 CITY AVE	PC - 4 Towers	2015	Multifamily Housi	806870	86	41.4
3400L LANCASTER AVE	382-The Summit a	2015	Multifamily Housi	546793	3	87.5
3737 CHESTNUT ST	3737 Chestnut	2015	Multifamily Housi	506548	87	28.3
3601 MARKET ST	3601 Market Stree	2015	Multifamily Housi	354372	44	56.9
2017-23 CHESTNUT ST	AQ Rittenhouse	2015	Multifamily Housi	92109	57	50.4
410 S FRONT ST	(PA2497) - 410 Sou	2015	Multifamily Housi	85498	28	48.1
3939-41 CHESTNUT ST	3939 Chestnut Str	2015	Multifamily Housi	52789		
1221 MOUNT VERNON ST	The Residences at	2015	Multifamily Housi	51000	99	20.8
810 ARCH ST	Francis House of F	2015	Multifamily Housi	50000	1	122.8
600 HARVEY ST	Rittenhouse Hill	2014	Multifamily Housi	520280	50	54.4
1900-24 ARCH ST	1912-20 Arch St. A	2014	Multifamily Housi	332245	75	34.6
800 N DELAWARE AVE	800 North Delawa	2014	Multifamily Housi	160000	64	31
315-23 N 12TH ST	Goldtex	2014	Multifamily Housi	140363	4	64.9
319 W CHELTEN AVE	Delmar	2014	Multifamily Housi	53900	40	39.6
				89,076	37	56.2
				235,760	57	46.1

2018

1221-31 South Broad Street	Armory Lofts	2017	Multifamily Housing	32,198	73	45.9
500 North 21st Street	Dalian on the Park	2016	Multifamily Housing	450,000	86	37.6
1363 N. 31st Street	The Fairmount at Brewerytown	2016	Multifamily Housing	272,255	64	32.1
1338-1348 Chestnut Street	435110 - Avenue of the Arts (The Griffin)	2016	Multifamily Housing	235,115		58.9
777 S Broad St	777 South Broad	2016	Multifamily Housing	218,753	50	36.8
250 N. Christopher Columbus Blvd.	One Water Street Associates	2016	Multifamily Housing	210,222	66	42.3
1125 Sansom St.	The Collins	2016	Multifamily Housing	195,399	20	47.4
521 S Broad St	SouthStar Lofts	2016	Multifamily Housing	118,616	1	87.7
1900 W Allegheny Ave	Allegheny Apts Phase 1 & 2	2016	Multifamily Housing	102,485		28.8
910 Cherry Street	910 Cherry Street	2016	Multifamily Housing	64,000	95	28.8
3100 West Thompson Street	CS Brewerytown Associates LP	2016	Multifamily Housing	53,000	72	36.5
2560 Belmont Avenue	BELMONT SPECIALTY HOUSING II	2016	Multifamily Housing	50,970	85	35.7
2560 Belmont Avenue	Inglis Gardens at Belmont II	2016	Multifamily Housing	50,439	100	20
2564 Belmont Avenue	Inglis Gardens at Belmont I	2016	Multifamily Housing	49,447	63	43.3
2564 Belmont Ave	BELMONT SPECIALTY HOUSING I	2016	Multifamily Housing	48,083	70	41.9
3900 City Avenue	PC - 4 Towers	2015	Multifamily Housing	806,870	74	50.3
3400 Lancaster Ave	382 - The Summit at University City	2015	Multifamily Housing	546,793	5	83.9
3737 Chestnut Street	3737 Chestnut	2015	Multifamily Housing	506,548	83	32.3
2021 Chestnut St	AQ Rittenhouse	2015	Multifamily Housing	92,109	59	51.2
2017-23 Chestnut St.	AQ Rittenhouse	2015	Multifamily Housing	92,077	68	50.7
410 South Front Street	(PA2497) - 410 South Hill Condominium	2015	Multifamily Housing	85,498	20	61.2
1221 Mt Vernon Street	The Residences at 1221	2015	Multifamily Housing	51,000	97	23.7
810 Arch St	Francis House of Peace	2015	Multifamily Housing	50,000	38	82.4
600 Harvey Street	Rittenhouse Hill	2014	Multifamily Housing	520,280	55	57.2
1900-24 Arch St.	1912-20 Arch St. Associates	2014	Multifamily Housing	332,245	77	38
100 West Oxford St	Oxford Mills	2014	Multifamily Housing	180,000		49.7
800 N. Delaware Ave.	Penn Treaty Village-800 N. Delaware Ave	2014	Multifamily Housing	160,000	70	33.5
315-23 N. 12th Street	Goldtex	2014	Multifamily Housing	140,363	6	68.3
1415 Fairmount Avenue	JBJ Soul Homes	2014	Multifamily Housing	75,000		88.1
319 W Chelten Ave.	Delmar	2014	Multifamily Housing	53,900	47	41.3
				89,076	44	53.5
				205,660	58	48.3

2019

2413-29 N BROAD ST	Ruth Williams House	2017	Multifamily Housing	50248		40.1
500 N 21ST ST	Dalian on the Park	2016	Multifamily Housing	450000	82	38.3
3601L MARKET ST	Arrive University City - Trinity	2016	Multifamily Housing	278163	29	63.4
3000 MASTER ST #A	The Fairmount at Brewerytov	2016	Multifamily Housing	272255	65	34.4
1338-48 CHESTNUT ST	435110 - Avenue of the Arts (	2016	Multifamily Housing	235115		61.8
777 S BROAD ST	777 South Broad	2016	Multifamily Housing	218753	38	38.5
250 N CHRIS COLUMBUS BLVD	One Water Street Associates	2016	Multifamily Housing	210222	70	40.1
232-52 S 24TH ST	Locust on the Park	2016	Multifamily Housing	198064	40	43.9
106-14 S 11TH ST	The Collins	2016	Multifamily Housing	195399	22	44.8
521-31 S BROAD ST	SouthStar Lofts	2016	Multifamily Housing	118616		72.1
1900 W ALLEGHENY AVE	Allegheny Apts Phase 1 & 2	2016	Multifamily Housing	102485		61.2
910-14 CHERRY ST	910 Cherry Street	2016	Multifamily Housing	64000	96	27.2
3100 W THOMPSON ST	CS Brewerytown Associates L	2016	Multifamily Housing	53000	73	35.5
3950 CITY AVE	PC - 4 Towers	2015	Multifamily Housing	806870	76	48.6
3400L LANCASTER AVE	382-The Summit at University	2015	Multifamily Housing	546793	44	79.6
3723-39 CHESTNUT ST	3737 Chestnut	2015	Multifamily Housing	506548	80	32.9
2017-23 CHESTNUT ST	AQ Rittenhouse	2015	Multifamily Housing	92077	69	47
410 S FRONT ST	(PA2497) - 410 South Hill Con	2015	Multifamily Housing	85498	18	59.6
1221 MOUNT VERNON ST	The Residences at 1221	2015	Multifamily Housing	51000	97	23.6
810 ARCH ST	Francis House of Peace	2015	Multifamily Housing	50000	41	79.8
600 HARVEY ST	Rittenhouse Hill	2014	Multifamily Housing	520280	37	61.6
2930 CHESTNUT ST	evo at Cira Centre South	2014	Multifamily Housing	478494		43.9
1900-24 ARCH ST	1912-20 Arch St. Associates	2014	Multifamily Housing	332245	70	39.1
315-23 N 12TH ST	Goldtex	2014	Multifamily Housing	140363	4	71.5
				89,071	46	57.7
				270,602	54	50.6

2020

Ruth Williams House	2413-29 N BROAD ST	Multifamily	50248	2017		52.5
Dalian on the Park	500 N 21ST ST	Multifamily	450000	2016	86	34.5
777 South Broad	777 S BROAD ST	Multifamily	218753	2016	38	37.1
(PA2632) - One Riverside Condo	210 S 25th St	Multifamily	203017	2016	77	32.1
Locust on the Park	232-52 S 24TH ST	Multifamily	198064	2016	49	38.1
SouthStar Lofts	521-31 S BROAD ST	Multifamily	118616	2016	3	56.9
Allegheny Apts Phase 1 & 2	1900 W ALLEGHENY AVE	Multifamily	102485	2016		65.3
910 Cherry Street	910-14 CHERRY ST	Multifamily	64000	2016	97	25.7
3018 W Thompson	3018 W Thompson Street	Multifamily	49500	2016	100	12.3
PC - 4 Towers	3950 CITY AVE	Multifamily	806870	2015	73	47.9
382-The Summit at University City	3400L LANCASTER AVE	Multifamily	546793	2015	68	62.7
3737 Chestnut	3723-39 CHESTNUT ST	Multifamily	506548	2015	86	29.9
AQ Rittenhouse	2017-23 CHESTNUT ST	Multifamily	92077	2015	72	48.4
(PA2497) - 410 South Hill Condomir	410 S FRONT ST	Multifamily	85498	2015	21	55.2
3100 W Thompson St	3100 W Thompson St	Multifamily	65864	2015	88	26.2
The Residences at 1221	1221 MOUNT VERNON ST	Multifamily	51000	2015	89	27.2
Francis House of Peace	810 ARCH ST	Multifamily	50000	2015	37	81.6
Rittenhouse Hill	600 HARVEY ST	Multifamily	520280	2014	45	57.2
evo at Cira Centre South	2930 CHESTNUT ST	Multifamily	478494	2014		42.3
Goldtex	315-23 N 12TH ST	Multifamily	140363	2014	6	65.6
			89,071		47	57.0
			260,131		59	45.6

2021

2415 N. Broad Street	Ruth Williams House	2017	Multifamily Housing	51248		50.8
500 North 21st Street	Dalian on the Park	2016	Multifamily Housing	536000	87	35.4
1919 Market Street	1919 Market St (mk51)	2016	Multifamily Housing	456519	61	52.6
3601 Market St	Arrive University City	2016	Multifamily Housing	403920	53	49.6
777 S Broad St	777 South Broad (st031)	2016	Multifamily Housing	218753	1	74.4
201 S 25th St	Locust on the Park (lc003)	2016	Multifamily Housing	198064	44	40.3
210 S 25th St	(PA2632) - One Riverside	2016	Multifamily Housing	131081	8	70.8
521 S Broad St	SouthStar Lofts (st032)	2016	Multifamily Housing	118616	7	46.8
3018 W Thompson	3018 W Thompson	2016	Multifamily Housing	115365	100	12.4
1900 W Allegheny	Allegheny Apts Phase 1 & 2	2016	Multifamily Housing	102485		65.6
910 Cherry Street	910 Cherry Street	2016	Multifamily Housing	64000	95	27.5
3900 City Avenue	PC - 4 Towers	2015	Multifamily Housing	806870	70	49.0
3400 Lancaster Ave	382 - The Summit at	2015	Multifamily Housing	582682	51	72.2
3737 Chestnut Street	3737 Chestnut	2015	Multifamily Housing	521869	83	31.5
220 South 17th Street	Warwick Hotel	2015	Multifamily Housing	460000	57	67.6
2017-23 Chestnut St.	AQ Rittenhouse - CO (qr04)	2015	Multifamily Housing	92077	67	48.8
410 South Front	(PA2497) - 410 South Hill	2015	Multifamily Housing	85498	49	45.5
3100 W Thompson St	3100 W Thompson St	2015	Multifamily Housing	65864	87	26.8
810 Arch St	Francis House of Peace	2015	Multifamily Housing	55000	32	84.1
600 Harvey Street	Rittenhouse Hill	2014	Multifamily Housing	520280	49	55.6
2930 Chestnut St	Evo at Cira Centre South	2014	Multifamily Housing	480644	84	53.1
315-23 N. 12th Street	Goldtex	2014	Multifamily Housing	140363	4	69.6
				89,904	49	56.9
				304,504	53	52.6

	GSF	Site EUI	EStar	
2020	218,277	15.0	100	
2021	277,542	28.9	96	
		22.0	98	
Site Built Baseline (2018-20) Same Buildings				
	GSF	Site EUI	EStar	n
2020	150,157	32.3	81	6
2021	151,682	39.4	72	6
		35.9	77	6
Site Built Baseline (2018-20) All Buildings				
	GSF	Site EUI	EStar	n
2020	151,141	46.2	65	21
2021	163,005	43.3	67	27
	157,073	44.8	66	24

2020

Dwell at 2nd St.	1300 N. 2nd St.	Multifamily	218277	2020	100	15.0
Atlantic	1401 Spruce St	Multifamily	368991	2019	17	66.7
Crane Chinatown	1001 Vine Street	Multifamily	159485	2019	92	33.8
Link University City	3600 Lancaster Ave	Multifamily	146403	2019	99	25.5
The Irvine Apartments (rv059)	780 S 52nd St	Multifamily	128453	2019	100	12.5
The View at Manayunk	4136 Mitchell St.	Multifamily	62300	2019	99	25.2
Blumberg Senior Apartments	1515 N 24th Street	Multifamily	61498	2019	62	44.1
Gloria Cazerez Residence	1315 N. 8th St	Multifamily	35308	2019		30.1
The Alexander	1601 VINE ST	Multifamily	547684	2018	74	39.1
Lincoln Square	1000 S BROAD ST	Multifamily	339779	2018		68.3
1102 Market	1102-48 MARKET ST	Multifamily	275068	2018	20	72.5
1150 Market	1100 MARKET ST LP	Multifamily	214097	2018	1	126.5
Cornerstone Village II (Larimer II) -	185 Larimer Ave	Multifamily	170808	2018		
The Hamilton I (hm066)	1520 Hamilton St	Multifamily	163563	2018	41	75.6
Liberty Square Building 1	1203 Germantown Avenue	Multifamily	82858	2018	98	21.6
1600 Callowhill	352 N 16TH ST	Multifamily	81726	2018	23	66.7
700 Somerset LP	700 Somerset	Multifamily	67500	2018	67	43.6
Witherspoon Senior Apartments	2050 S 58TH ST	Multifamily	64677	2018	88	27
Liberty Square Building 2	236 W THOMPSON ST	Multifamily	59707	2018	96	26.8
The Stable Lofts	631 N Broad Street	Multifamily	58000	2018	93	28.4
Roberto Clemente Homes	3921-61 N 5th Street	Multifamily	56893	2018	56	36
The Willows at Mount Vernon-Inge	1702 Mt Vernon St	Multifamily	29170	2018	42	54.2
			150,157		81	32.3
			151,141		65	46.2

2021

219-229 Vine St.	Mariner's Court	2021	Multifamily Housing	56416	82	25.9
3720 Chestnut St.	The Chestnut	2020	Multifamily Housing	412428	93	35.5
1300 N. 2nd St.	Dwell at 2nd St.	2020	Multifamily Housing	277542	96	28.9
4460 Fairmount	MMS - Philly - 4460	2020	Multifamily Housing	62222	53	39.0
1011 N Hancock St.	Carriage Wheel Lofts	2020	Multifamily Housing	52260	83	24.7
1920 East Orleans	Maguire Residence	2020	Multifamily Housing	50902	36	37.5
1401 Spruce St	Atlantic	2019	Multifamily Housing	368991	7	77.1
112 S. 19th Street	The Harper	2019	Multifamily Housing	260172	68	38.1
1001 Vine Street	Crane Chinatown	2019	Multifamily Housing	159485	68	44.9
3600 Lancaster Ave	Link University City (ln060)	2019	Multifamily Housing	147135	100	20.6
780 S 52nd St	The Irvine Apartments	2019	Multifamily Housing	136871	87	35.0
1201 Jackson St	Jackson	2019	Multifamily Housing	117263	78	38.3
4136 Mitchell St.	The View at Manayunk	2019	Multifamily Housing	62300	96	29.0
1315 N. 8th St	Gloria Cazerez Residence	2019	Multifamily Housing	35308		29.9
1601 Vine Street	The Alexander	2018	Multifamily Housing	547684	67	46.4
1000 S Broad St	Lincoln Square	2018	Multifamily Housing	443064		69.0
1199 Ludlow St	1150 Market	2018	Multifamily Housing	290594	5	91.7
121 N 2nd St	The National	2018	Multifamily Housing	232352	92	36.5
401 RACE ST	View At Old City -	2018	Multifamily Housing	216000	85	38.3
1520 Hamilton St	The Hamilton I (hm066)	2018	Multifamily Housing	163563	3	105.7
2103 W Godfrey	MMS - Philly - 2103 W	2018	Multifamily Housing	106640	96	39.7
352 N. 16th St.	1600 Callowhill	2018	Multifamily Housing	89863	22	63.9
1203 Germantown	Liberty Square Building 1	2018	Multifamily Housing	82858	69	33.7
700 Somerset	700 Somerset LP	2018	Multifamily Housing	67500	70	43.3
2050 S. 58th Street	Witherspoon Senior	2018	Multifamily Housing	64677	88	26.9
236 W Thompson	Liberty Square Building 2	2018	Multifamily Housing	59707	93	29.2
631 N Broad Street	The Stable Lofts	2018	Multifamily Housing	58000	85	30.8
3921-61 N 5th Street	Roberto Clemente Homes	2018	Multifamily Housing	56893	51	37.7
322 N BROAD ST	322 on North Broad	2017	Multifamily Housing	519504		38.5
				151,682	72	39.4
				163,005	67	43.3

	GSF	Site EUI	EStar	
2016	47,343	30.2	98	
2017	47,343	34.9	-	
2018	47,343	40.6	95	
2019	47,343	30.6	99	
2020	47,343	16.5	100	
	47,343	30.2	98	
Site Built Baseline (2014) Same Buildings				
	GSF	Site EUI	EStar	n
2016	59,481	35.8	91	10
2017	59,481	37.5	87	10
2018	59,481	37.3	92	10
2019	59,481	34.8	92	10
2020	59,481	33.7	93	10
	59,481	35.8	90	10
Site Built Baseline (2014) All Buildings				
	GSF	Site EUI	EStar	n
2016	146,758	36.9	87	37
2017	148,223	37.8	89	40
2018	148,845	38.2	89	40
2019	147,238	37.5	89	41
2020	132,084	34.9	90	51
	146,651	36.3	89	40

2015

2015	Multifamily MR (5-9)	ARRAY APARTMENTS	14027 LAKE CITY WAY NE	2014	447,915	100	26.8
2015	Multifamily MR (5-9)	URBANA APARTMENTS	1501 NW 56TH ST	2014	439,262	99	32.8
2015	Multifamily MR (5-9)	AMLI MARK 24 APTS	2428 NW MARKET ST	2014	418,285	100	18.3
2015	Multifamily MR (5-9)	525 AT THE ENCLAVE	525 NE NORTHGATE WAY	2014	313,595	93	40.7
2015	Multifamily MR (5-9)	TRUE NORTH APARTMENTS	801 DEXTER AVE N	2014	305,537	98	35.2
2015	Multifamily MR (5-9)	GREEN LAKE VILLAGE APTS	427 NE 72ND ST	2014	292,376	100	18.2
2015	Multifamily MR (5-9)	THE TOWNE APTS	1920 QUEEN ANNE AVE N	2014	233,528	100	22.3
2015	Multifamily MR (5-9)	SLATE APARTMENTS	3040 17TH AVE W	2014	209,583	95	20.8
2015	Multifamily MR (5-9)	RIVET APARTMENTS	1201 MERCER ST	2014	145,716	97	30.5
2015	Multifamily MR (5-9)	OREGON 42 APARTMENTS	4502 42ND AVE SW	2014	137,068	99	42.8
2015	Multifamily MR (5-9)	ARTHOUSE APARTMENTS	2334 ELLIOTT AVE	2014	135,643	99	27.8
2015	Multifamily MR (5-9)	VIVA APARTMENTS	1111 E UNION ST	2014	123,075	95	33.6
2015	Multifamily MR (5-9)	CANVAS APARTMENTS	600 ELLIOTT AVE W	2014	118,344	98	20.2
2015	Multifamily MR (5-9)	4730 CALIFORNIA APARTMENTS	4724 CALIFORNIA AVE SW	2014	113,204	81	38.6
2015	Multifamily MR (5-9)	SUNSET ELECTRIC APARTMENTS	1111 E PINE ST	2014	97,104	58	45
2015	Multifamily MR (5-9)	APERTURE ON FIFTH	206 5TH AVE N	2014	94,909	99	32.6
2015	Multifamily MR (5-9)	SQUARE ONE APARTMENTS	1020 NE 63RD ST	2014	84,891	100	24.1
2015	Multifamily MR (5-9)	COLLINS ON PINE APTS	1601 13TH AVE	2014	84,389	89	32.1
2015	Multifamily MR (5-9)	LIGHTBOX APTS	4545 8TH AVE NE	2014	82,087	100	19.9
2015	Multifamily MR (5-9)	COMPASS ON DEXTER APTS	756 JOHN ST	2014	81,993	85	36.6
2015	Multifamily MR (5-9)	ARTSPACE MT BAKER LOFTS	2915 RAINIER AVE S	2014	78,756	84	26.9
2015	Multifamily MR (5-9)	THE BLAKE APTS (Built Green 3 Star Certified)	5020 CALIFORNIA AVE SW	2014	72,356	95	36.9
2015	Multifamily MR (5-9)	LEXICON APTS	120 HARVARD AVE E	2014	62,049	19	56.6
2015	Multifamily MR (5-9)	STREAM BELMONT APTS	500 BELMONT AVE E	2014	55,113	100	26.9
2015	Multifamily MR (5-9)	EMMONS ON 3RD	2217 3RD AVE	2014	47,343	99	28.5
2015	Multifamily MR (5-9)	THE DENNING APARTMENTS	2721 17TH AVE S	2014	45,167	97	25.6
2015	Multifamily MR (5-9)	IDENTITY APTS 4106	4106 12TH AVE NE	2014	42,905	96	50.5
2015	Multifamily MR (5-9)	IDENTITY APTS 4123	4123 12TH AVE NE	2014	42,393	98	48.6
2015	Multifamily MR (5-9)	306 QUEENE ANNE APTS	306 QUEEN ANNE AVE N	2014	31,990	99	30.6
2015	NonResidential	AMAZON - PHASE VI	500 9TH AVE N	2014	427,181	99	39.2
					59,481	87	35.9
					156,758	92	32.2

2016

2016	Multifamily MR (5-9)	The Array	14027 LAKE CITY WAY NE	2014	447,915	100	27.0
2016	Multifamily MR (5-9)	Urbana	1501 NW 56th St.	2014	439,262	99	32.0
2016	Multifamily MR (5-9)	AMLI Mark24	2428 NW Market St	2014	418,285	100	20.0
2016	Multifamily MR (5-9)	Odin	5402 20th Ave. NW	2014	318,835	100	30.4
2016	Multifamily MR (5-9)	525 at the Enclave	525 NE Northgate Way	2014	313,595	87	44.8
2016	Multifamily MR (5-9)	801 Dexter-True North	801 Dexter Avenue North	2014	305,537	96	38.9
2016	Multifamily MR (5-9)	Green Lake Village	427 NE 72nd St	2014	292,376	100	36.3
2016	Multifamily MR (5-9)	Broadstone Infinity	1414 10th Ave	2014	278,554	100	22.8
2016	Multifamily MR (5-9)	Towne Apartments (McKinstry)	1920 Queen Anne Ave N	2014	233,528	100	23.3
2016	Multifamily MR (5-9)	Slate Apartments	3040 17th Ave. W.	2014	209,583	96	20.4
2016	Multifamily MR (5-9)	Rivet	1201 Mercer St	2014	145,716	98	28.7
2016	Multifamily MR (5-9)	Oregon 42	4502 42ND AVE SW	2014	137,068	98	43.2
2016	Multifamily MR (5-9)	Arthouse Apartments	2334 Elliott Ave	2014	135,643	98	30.2
2016	Multifamily MR (5-9)	Viva	1111 E Union St	2014	123,075	95	33.4
2016	Multifamily MR (5-9)	Canvas	600 Elliott Ave. W	2014	118,344	91	23.4
2016	Multifamily MR (5-9)	4730 California	4730 California Ave SW	2014	113,204	57	51.6
2016	Multifamily MR (5-9)	AMLI South Lake Union 2	528 Pontius Ave N	2014	110,964	98	30.9
2016	Multifamily MR (5-9)	Sunset Electric	1111 E Pine Street	2014	103,100	76	50.1
2016	Multifamily MR (5-9)	Aperture on Fifth	206 5th Ave N	2014	94,909	97	36.7
2016	Multifamily MR (5-9)	Zephyr Apts	200 Belmont Ave E	2014	85,647	7	57.0
2016	Multifamily MR (5-9)	Square One	1020 NE 63rd St.	2014	84,891	100	24.7
2016	Multifamily MR (5-9)	Collins on Pine	1601 13th Avenue	2014	84,389	91	29.9
2016	Multifamily MR (5-9)	Lightbox Apartments	4545 8th Ave NE	2014	82,087	100	21.3
2016	Multifamily MR (5-9)	Compass on Dexter	756 John St	2014	81,993	84	36.2
2016	Multifamily MR (5-9)	Artspace Mt. Baker	2915 Rainier Avenue South	2014	78,756	63	32.0
2016	Multifamily MR (5-9)	Nine and Pine	1601 9th Ave	2014	74,509	20	78.4
2016	Multifamily MR (5-9)	The Blake	5020 California Ave SW	2014	72,356	91	39.6
2016	Multifamily MR (5-9)	Latitude Apartments	500 3rd Ave W	2014	70,191	98	30.7
2016	Multifamily MR (5-9)	Lexicon Apartments	120 HARVARD AVE E	2014	62,049	91	35.0
2016	Multifamily MR (5-9)	Stream Belmont	500 Belmont Ave E	2014	55,113	99	28.5
2016	Multifamily MR (5-9)	Emmons on 3rd	2217 3rd Ave	2014	47,343	98	30.2
2016	Multifamily MR (5-9)	The Denning	1636 S McClellan Street	2014	45,167	93	29.3
2016	Multifamily MR (5-9)	129610 - Identity Seattle Building I	Bldg I: 4106 12th Ave NE	2014	42,905	95	51.6
2016	Multifamily MR (5-9)	129610 - Identity Seattle Building D	4123 12th Ave NE	2014	42,393	96	51.2
2016	Multifamily MR (5-9)	Cheryl Chow Court	2014 NW 57th St	2014	39,286	14	57.1
2016	Multifamily MR (5-9)	306 QA	306 QUEEN ANNE AVE N	2014	31,990	98	33.5
2016	Multifamily MR (5-9)	Studio 7 Apartments	4029 7th Ave NE	2014	30,649	100	42.3
2016	Multifamily MR (5-9)	Sedona 80 LLC	8520 20TH AVE NE	2014	26,198	100	64.1
2016	Multifamily MR (5-9)	WA023_AVA Ballard	5555 14th AVE NW	2013	317,814	97	29.9
					59,481	91	35.8
					146,758	87	36.9

2017

2017	Multifamily MR (5-9)	The Array	14027 LAKE CITY WAY NE	2014	447,915	99	29.8
2017	Multifamily MR (5-9)	Urbana	1501 NW 56th St.	2014	439,262	100	32.5
2017	Multifamily MR (5-9)	AMLI Mark24	2428 NW Market St	2014	418,285	100	20.4
2017	Multifamily MR (5-9)	Odin	5402 20th Ave. NW	2014	318,835	100	31.2
2017	Multifamily MR (5-9)	525 at the Enclave	525 NE Northgate Way	2014	313,595	89	44.7
2017	Multifamily MR (5-9)	801 Dexter-True North	801 Dexter Avenue North	2014	305,537	91	44.3
2017	Multifamily MR (5-9)	Green Lake Village	427 NE 72nd St	2014	292,376	100	36
2017	Multifamily MR (5-9)	Infinity	1414 10th Ave	2014	278,554	99	25.9
2017	Multifamily MR (5-9)	Radius	400 Boren Ave N	2014	253,015	97	42.8
2017	Multifamily MR (5-9)	Towne Apartments	1920 Queen Anne Ave N	2014	233,528	100	25.6
2017	Multifamily MR (5-9)	Slate Apartments	3040 17th Ave. W.	2014	209,583	100	22.8
2017	Multifamily MR (5-9)	Rivet	1201 Mercer St	2014	145,716	100	26.9
2017	Multifamily MR (5-9)	Oregon 42	4502 42ND AVE SW	2014	137,068	98	46.3
2017	Multifamily MR (5-9)	Arthouse Apartments	2334 Elliott Ave	2014	135,643	99	32.5
2017	Multifamily MR (5-9)	Marq West Seattle	3261 SW Avalon Way Ste	2014	129,280	98	23.1
2017	Multifamily MR (5-9)	Viva	1111 E Union St	2014	123,075	99	32.6
2017	Multifamily MR (5-9)	Canvas	600 Elliott Ave. W	2014	118,344	95	23.4
2017	Multifamily MR (5-9)	Anthem on 12th	103 12th Ave	2014	116,576	100	25.7
2017	Multifamily MR (5-9)	4730 California	4730 California Ave SW	2014	113,204	72	46.1
2017	Multifamily MR (5-9)	AMLI South Lake Union 2	528 Pontius Ave N	2014	110,964	97	32.8
2017	Multifamily MR (5-9)	Sunset Electric	1111 E Pine Street	2014	103,100	78	52.5
2017	Multifamily MR (5-9)	Aperture on Fifth	206 5th Ave N	2014	94,909		38.3
2017	Multifamily MR (5-9)	Zephyr Apts	200 Belmont Ave E	2014	85,647	10	63.9
2017	Multifamily MR (5-9)	Square One	1020 NE 63rd St.	2014	84,891	100	26.7
2017	Multifamily MR (5-9)	Collins on Pine	1601 13th Avenue	2014	84,389	95	30.9
2017	Multifamily MR (5-9)	Lightbox Apartments	4545 8th Ave NE	2014	82,087		22.2
2017	Multifamily MR (5-9)	Compass on Dexter	756 John St	2014	81,993	73	41.8
2017	Multifamily MR (5-9)	Artspace Mt. Baker	2915 Rainier Avenue South	2014	78,756	65	34.3
2017	Multifamily MR (5-9)	Nine and Pine	1601 9th Ave	2014	74,509	40	77.5
2017	Multifamily MR (5-9)	The Blake	5020 California Ave SW	2014	72,356		34.9
2017	Multifamily MR (5-9)	Latitude Apartments	500 3rd Ave W	2014	70,191	100	30
2017	Multifamily MR (5-9)	Lexicon Apartments	120 HARVARD AVE E	2014	62,049	86	38.8
2017	Multifamily MR (5-9)	Stream Belmont	500 Belmont Ave E	2014	55,113	100	28
2017	Multifamily MR (5-9)	Emmons on 3rd	2217 3rd Ave	2014	47,343		34.9
2017	Multifamily MR (5-9)	The Denning	1636 S McClellan Street	2014	45,167		31.5
2017	Multifamily MR (5-9)	129610 - Identity Seattle Building I	Bldg I: 4106 12th Ave NE	2014	42,905	93	54.9
2017	Multifamily MR (5-9)	129610 - Identity Seattle Building D	4123 12th Ave NE	2014	42,393	94	55.6
2017	Multifamily MR (5-9)	Cheryl Chow Court	2014 NW 57th St	2014	39,286	23	55.6
2017	Multifamily MR (5-9)	306 QA	306 QUEEN ANNE AVE N	2014	31,990	99	32.5
2017	Multifamily MR (5-9)	Studio 7 Apartments	4029 7th Ave NE	2014	30,649	100	48.2
2017	Multifamily MR (5-9)	Sedona 80 LLC	8520 20TH AVE NE	2014	26,198	100	69.8
2017	Multifamily MR (5-9)	WA023_AVA Ballard	5555 14th AVE NW	2013	317,814	97	32.8
					59,481	87	37.5
					148,223	89	37.8

2018

2018	ARRAY APARTMENTS	Multifamily MR (5-9)	14027 LAKE CITY WAY NE	2014	448,303	100	27.5
2018	URBANA APARTMENTS	Multifamily MR (5-9)	1501 NW 56TH ST	2014	439,262	98	34
2018	AMLI MARK 24 APTS	Multifamily MR (5-9)	2428 NW MARKET ST	2014	418,285	100	28.9
2018	ODIN APARTMENTS	Multifamily MR (5-9)	5343 TALLMAN AVE NW	2014	318,835	100	30.1
2018	525 AT THE ENCLAVE	Multifamily MR (5-9)	525 NE NORTHGATE WAY	2014	313,595	90	43.5
2018	RIVET APARTMENTS	Multifamily MR (5-9)	1201 MERCER ST	2014	145,727	100	27.6
2018	OREGON 42 APARTMENTS	Multifamily MR (5-9)	4502 42ND AVE SW	2014	137,068	99	44.5
2018	ARTHOUSE APARTMENTS	Multifamily MR (5-9)	2334 ELLIOTT AVE	2014	135,643	100	28.2
2018	THE MARQ WEST SEATTLE	Multifamily MR (5-9)	3261 SW AVALON WAY	2014	129,280	99	21.8
2018	VIVA APARTMENTS	Multifamily MR (5-9)	1111 E UNION ST	2014	123,075	99	34.1
2018	CANVAS APARTMENTS	Multifamily MR (5-9)	600 ELLIOTT AVE W	2014	118,344	97	22.1
2018	ANTHEM ON 12TH	Multifamily MR (5-9)	103 12TH AVE	2014	116,576	99	26
2018	4730 CALIFORNIA APARTMENTS	Multifamily MR (5-9)	4730 CALIFORNIA AVE SW	2014	113,204	71	45.9
2018	AMLI 528 PONTIUS	Multifamily MR (5-9)	528 PONTIUS AVE N	2014	110,964	99	28.7
2018	SQUARE ONE APARTMENTS	Multifamily MR (5-9)	1020 NE 63RD ST	2014	109,355	100	29.9
2018	SUNSET ELECTRIC APARTMENTS	Multifamily MR (5-9)	1111 E PINE ST	2014	103,100	97	41.4
2018	APERTURE ON FIFTH	Multifamily MR (5-9)	206 5TH AVE N	2014	94,909		38.1
2018	ZEPHYR APTS	Multifamily MR (5-9)	200 BELMONT AVE E	2014	85,647	12	58.8
2018	COLLINS ON PINE APTS	Multifamily MR (5-9)	1601 13TH AVE	2014	84,389	79	43.7
2018	LIGHTBOX APTS	Multifamily MR (5-9)	4545 8TH AVE NE	2014	82,087	100	41.6
2018	COMPASS ON DEXTER APTS	Multifamily MR (5-9)	756 JOHN ST	2014	81,993	76	40.5
2018	ARTSPACE MT BAKER LOFTS	Multifamily MR (5-9)	2915 RAINIER AVE S	2014	78,756	74	32.1
2018	NINE & PINE APARTMENTS	Multifamily MR (5-9)	1601 9TH AVE	2014	74,509	32	77.2
2018	THE BLAKE APTS (Built Green 3 Star Certi	Multifamily MR (5-9)	5020 CALIFORNIA AVE SW	2014	72,356		39.7
2018	LATITUDE QUEEN ANNE	Multifamily MR (5-9)	500 3RD AVE W	2014	70,191	100	28.4
2018	LEXICON APTS	Multifamily MR (5-9)	120 HARVARD AVE E	2014	62,049	89	37.9
2018	STREAM BELMONT APTS	Multifamily MR (5-9)	500 BELMONT AVE E	2014	55,113	100	21.5
2018	EMMONS ON 3RD	Multifamily MR (5-9)	2217 3RD AVE	2014	47,343	95	40.6
2018	THE DENNING APARTMENTS	Multifamily MR (5-9)	2721 17TH AVE S	2014	45,167		28.4
2018	IDENTITY APTS 4106	Multifamily MR (5-9)	4106 12TH AVE NE	2014	42,905	98	48.4
2018	IDENTITY APTS 4123	Multifamily MR (5-9)	4123 12TH AVE NE	2014	42,393	99	45.8
2018	CHERYL CHOW COURT	Multifamily MR (5-9)	2014 NW 57TH ST	2014	39,286	25	55.2
2018	306 QUEENE ANNE APTS	Multifamily MR (5-9)	306 QUEEN ANNE AVE N	2014	31,990	96	37.5
2018	STUDIO 7 APTS	Multifamily MR (5-9)	4029 7TH AVE NE	2014	30,649	100	48.4
2018	SEDONA	Multifamily MR (5-9)	8520 20TH AVE NE	2014	26,198	100	50.5
					59,481	92	37.3
					148,845	89	38.2

2019

2019	ARRAY APARTMENTS	Multifamily MR (5-9)	14027 LAKE CITY WAY NE	2014	448,303	99	31.4	31.3
2019	URBANA APARTMENTS	Multifamily MR (5-9)	1501 NW 56TH ST	2014	439,262	99	32.6	32.6
2019	AMLI MARK 24 APTS	Multifamily MR (5-9)	2428 NW MARKET ST	2014	418,285	100	30.2	30.3
2019	ODIN APARTMENTS	Multifamily MR (5-9)	5343 TALLMAN AVE NW	2014	318,835	100	30.5	30.4
2019	525 AT THE ENCLAVE	Multifamily MR (5-9)	525 NE NORTHGATE WAY	2014	313,595	87	47.8	47.5
2019	TRUE NORTH APARTMENTS	Multifamily MR (5-9)	801 DEXTER AVE N	2014	305,537	99	34	33.8
2019	GREEN LAKE VILLAGE APTS	Multifamily MR (5-9)	427 NE 72ND ST	2014	292,376	NA	44.8	44.8
2019	VIVA APARTMENTS	Multifamily MR (5-9)	1111 E UNION ST	2014	123,075	93	35.6	35.4
2019	CANVAS APARTMENTS	Multifamily MR (5-9)	600 ELLIOTT AVE W	2014	118,344	97	21.8	21.8
2019	ANTHEM ON 12TH	Multifamily MR (5-9)	103 12TH AVE	2014	116,576	98	32.4	32.2
2019	4730 CALIFORNIA APARTMENTS	Multifamily MR (5-9)	4730 CALIFORNIA AVE SW	2014	113,204	67	47.2	47.2
2019	AMLI 528 PONTIUS	Multifamily MR (5-9)	528 PONTIUS AVE N	2014	110,964	99	30.4	30.2
2019	SQUARE ONE APARTMENTS	Multifamily MR (5-9)	1020 NE 63RD ST	2014	109,355	100	31.2	31
2019	SUNSET ELECTRIC APARTMENTS	Multifamily MR (5-9)	1111 E PINE ST	2014	103,100	95	39.6	39.2
2019	APERTURE ON FIFTH	Multifamily MR (5-9)	206 5TH AVE N	2014	94,909	NA	39.1	39
2019	ZEPHYR APTS	Multifamily MR (5-9)	200 BELMONT AVE E	2014	85,647	10	61.9	61.8
2019	COLLINS ON PINE APTS	Multifamily MR (5-9)	1601 13TH AVE	2014	84,389	77	45.3	45.4
2019	BROADWAY ESTATES LLC	Multifamily MR (5-9)	515 HARVARD AVE E	2014	82,960	96	31.4	31.4
2019	LIGHTBOX APTS	Multifamily MR (5-9)	4545 8TH AVE NE	2014	82,087	100	39.4	39.3
2019	COMPASS ON DEXTER APTS	Multifamily MR (5-9)	756 JOHN ST	2014	81,993	78	39.3	39.2
2019	ARTSPACE MT BAKER LOFTS	Multifamily MR (5-9)	2915 RAINIER AVE S	2014	78,756	73	32.8	32.7
2019	NINE & PINE APARTMENTS	Multifamily MR (5-9)	1601 9TH AVE	2014	74,509	32	75.5	75.1
2019	THE BLAKE APTS (Built Green 3 Star	Multifamily MR (5-9)	5020 CALIFORNIA AVE SW	2014	72,356	NA	39	39
2019	LATITUDE QUEEN ANNE	Multifamily MR (5-9)	500 3RD AVE W	2014	70,191	100	28.5	28.4
2019	LEXICON APTS	Multifamily MR (5-9)	120 HARVARD AVE E	2014	62,049	85	39.2	39.5
2019	STREAM BELMONT APTS	Multifamily MR (5-9)	500 BELMONT AVE E	2014	55,113	100	26.9	26.9
2019	EMMONS ON 3RD	Multifamily MR (5-9)	2217 3RD AVE	2014	47,343	99	30.6	30.6
2019	THE DENNING APARTMENTS	Multifamily MR (5-9)	2721 17TH AVE S	2014	45,167	NA	31.2	31.2
2019	IDENTITY APTS 4106	Multifamily MR (5-9)	4106 12TH AVE NE	2014	42,905	100	33.7	33.3
2019	IDENTITY APTS 4123	Multifamily MR (5-9)	4123 12TH AVE NE	2014	42,393	100	33.2	33
2019	CHERYL CHOW COURT	Multifamily MR (5-9)	2014 NW 57TH ST	2014	39,286	26	55	54.9
2019	306 QUEENE ANNE APTS	Multifamily MR (5-9)	306 QUEEN ANNE AVE N	2014	31,990	99	34.7	34.3
2019	STUDIO 7 APTS	Multifamily MR (5-9)	4029 7TH AVE NE	2014	30,649	100	47.8	47.2
2019	SEDONA	Multifamily MR (5-9)	8520 20TH AVE NE	2014	26,198	100	48	47.4
					59,481	92	34.9	34.8
					147,238	89	37.6	37.5

2020

2020	ARRAY APARTMENTS	Multifamily (1-9)	2014	6	448,303	98	34.5	33.8
2020	URBANA APARTMENTS	Multifamily (1-9)	2014	8	439,262	100	30.3	30.3
2020	AMLI MARK 24 APTS	Multifamily (1-9)	2014	7	418,285	100	26.3	26.3
2020	ODIN APARTMENTS	Multifamily (1-9)	2014	7	318,835	100	31.4	31.1
2020	525 AT THE ENCLAVE	Multifamily (1-9)	2014	5	313,595	83	49.5	49.1
2020	TRUE NORTH APARTMENTS	Multifamily (1-9)	2014	6	305,537	100	20.1	19.6
2020	GREEN LAKE VILLAGE APTS	Multifamily (1-9)	2014	6	292,376	NA	45.2	45.1
2020	BROADSTONE INFINITY APAR	Multifamily (1-9)	2014	7	278,554	100	27	26.6
2020	ZEPHYR APTS	Multifamily (1-9)	2014	7	85,647	15	56.5	56.2
2020	COLLINS ON PINE APTS	Multifamily (1-9)	2014	6	84,389	82	40.6	40.3
2020	BROADWAY ESTATES LLC	Multifamily (1-9)	2014	7	82,960	97	30.9	30.4
2020	LIGHTBOX APTS	Multifamily (1-9)	2014	7	82,087	100	39.9	39.5
2020	COMPASS ON DEXTER APTS	Multifamily (1-9)	2014	6	81,993	87	42.5	41.7
2020	ARTSPACE MT BAKER LOFTS	Multifamily (1-9)	2014	5	78,756	77	28.6	28
2020	NINE & PINE APARTMENTS	Multifamily (1-9)	2014	7	74,509	76	51.8	51
2020	THE BLAKE APTS (Built Green	Multifamily (1-9)	2014	7	72,356	98	35.9	35.3
2020	LATITUDE QUEEN ANNE	Multifamily (1-9)	2014	5	70,191	99	31	30.8
2020	LEXICON APTS	Multifamily (1-9)	2014	7	62,049	79	41.9	40.9
2020	STREAM BELMONT APTS	Multifamily (1-9)	2014	6	55,113	98	32	32
2020	EMMONS ON 3RD	Multifamily (1-9)	2014	7	47,343	100	16.5	16.5
2020	COLUMBIA GARDENS AT RAIN	Multifamily (1-9)	2014	4	45,892	78	28.8	28.2
2020	THE DENNING APARTMENTS	Multifamily (1-9)	2014	6	45,167	NA	31.2	30.9
2020	WEATHERFORD APTS	Multifamily (1-9)	2014	4	43,566	92	22.3	21.9
2020	IDENTITY APTS 4106	Multifamily (1-9)	2014	7	42,905	100	26.2	25.4
2020	IDENTITY APTS 4123	Multifamily (1-9)	2014	7	42,393	100	33.5	32.6
2020	CHERYL CHOW COURT	Multifamily (1-9)	2014	6	39,286	28	55	53.9
2020	PATRICK PLACE APARTMENTS	Multifamily (1-9)	2014	4	34,723	50	54.6	53.5
2020	306 QUEENE ANNE APTS	Multifamily (1-9)	2014	8	31,990	100	31	30.4
2020	LAVITA APARTMENTS	Multifamily (1-9)	2014	4	21,267	100	33.4	32.6
2020	1806 23rd Ave Microhousing	Multifamily (1-9)	2014	4	20,246	94	38.6	37.8
					59,481	93	34.3	33.7
					132,084	90	35.4	34.9

	GSF	Site EUI	EStar	
2018	41,132	20.8	-	
2019	41,132	27.6	-	
2020	41,132	28.8	-	
	41,132	25.7	-	

Site Built Baseline (2017) Same Buildings

	GSF	Site EUI	EStar	n
2018	43,687	22.8	97	8
2019	45,150	28.9	96	10
2020	45,150	33.0	94	10
	44,662	28.2	96	10

Site Built Baseline (2017) All Buildings

	GSF	Site EUI	EStar	n
2018	45,590	35.1	76	21
2019	48,447	35.4	77	21
2020	98,440	33.9	91	28
	64,159	34.8	81	23

2018

2018	CITY LINE II APARTMENTS	Multifamily LR (1-4)	4730 32ND AVE S	2017	192,257	100	20.3
2018	BLUESTONE APTS	Multifamily LR (1-4)	9051 20TH AVE SW	2017	51,521	87	21.8
2018	NOVO SEATTLE	Multifamily LR (1-4)	6105 ROOSEVELT WAY NE	2017	39,272	100	23.2
2018	MIO APTS	Multifamily LR (1-4)	1319 NE 65TH ST	2017	30,820	90	29.3
2018	EAST UNION APARTMENTS	Multifamily MR (5-9)	2220 E UNION ST	2017	184,974	100	41.9
2018	SPRINGLINE APARTMENTS	Multifamily MR (5-9)	3220 CALIFORNIA AVE SW	2017	161,999	94	39.4
2018	TWENTY 20 MAD APARTMENTS	Multifamily MR (5-9)	2020 E MADISON ST	2017	151,166		
2018	550 BROADWAY APARTMENTS (ZIG)	Multifamily MR (5-9)	550 BROADWAY	2017	138,434	100	30.3
2018	ICON APARTMENTS	Multifamily MR (5-9)	400 S JACKSON ST	2017	137,771	86	40.7
2018	MERCY OTHELLO PLAZA	Multifamily MR (5-9)	6940 M L KING JR WAY S	2017	125,565	100	26.2
2018	The Hub - U District Seattle	Multifamily MR (5-9)	5000 UNIVERSITY WAY NE	2017	125,070		38.8
2018	19 WEST HARRISON CORA APTS	Multifamily MR (5-9)	350 1ST AVE W	2017	96,529	100	28.4
2018	REVERB APARTMENTS	Multifamily MR (5-9)	1023 E ALDER ST	2017	77,757		
2018	FOX & FINCH APARTMENTS	Multifamily MR (5-9)	525 BOREN AVE N	2017	41,600	96	28.5
2018	STREAM 403	Multifamily MR (5-9)	403 BELMONT AVE E	2017	38,408		
2018	ORI APARTMENTS	Multifamily MR (5-9)	5260 UNIVERSITY WAY NE	2017	36,356		
2018	101 BROADWAY APARTMENTS	Multifamily MR (5-9)	101 BROADWAY E	2017	35,990	100	27.1
2018	HAMILTON APARTMENTS	Multifamily MR (5-9)	2305 E MADISON ST	2017	33,889		
2018	VIVID	Multifamily MR (5-9)	219 1ST AVE N	2017	33,114	100	13.6
2018	ISOLA SW ALASKA	Multifamily MR (5-9)	4400 SW ALASKA ST	2017	29,317		34.5
2018	VEGA APARTMENTS	Multifamily MR (5-9)	4528 44TH AVE SW	2017	23,090		
2018	THE WHITTAKER	Multifamily MR (5-9)	4755 FAUNTLEROY WAY SW	2016	649,605	100	34.3
					43,687	97	22.8
					45,590	76	35.1

2019

2019	CITY LINE II APARTMENTS	Multifamily LR (1-4)	4730 32ND AVE S	2017	192,257	98	29.9	29.9
2019	BLUESTONE APTS	Multifamily LR (1-4)	9051 20TH AVE SW	2017	51,521	75	24.4	24.5
2019	JEFFERSON STATION APARTMENT	Multifamily LR (1-4)	2902 BEACON AVE S	2017	47,499	NA	26.6	26.6
2019	NOVO SEATTLE	Multifamily LR (1-4)	6105 ROOSEVELT WAY NE	2017	39,272	100	47.4	47.2
2019	CHROMA APARTMENTS	Multifamily MR (5-9)	1212 HARRISON ST	2017	200,823	100	21.1	21.1
2019	SPRINGLINE APARTMENTS	Multifamily MR (5-9)	3220 CALIFORNIA AVE SW	2017	161,999	93	40.9	40.7
2019	TWENTY 20 MAD APARTMENTS	Multifamily MR (5-9)	2020 E MADISON ST	2017	151,166	NA	29.8	29.7
2019	550 BROADWAY APARTMENTS (ZIG	Multifamily MR (5-9)	550 BROADWAY	2017	138,434	57		54.1
2019	ICON APARTMENTS	Multifamily MR (5-9)	400 S JACKSON ST	2017	137,771	82	42.6	42.5
2019	MERCY OTHELLO PLAZA	Multifamily MR (5-9)	6940 M L KING JR WAY S	2017	125,565	55	46.6	46.5
2019	19 WEST HARRISON CORA APTS	Multifamily MR (5-9)	350 1ST AVE W	2017	96,529	100	27.4	27.3
2019	REVERB APARTMENTS	Multifamily MR (5-9)	1023 E ALDER ST	2017	77,757	100		22.9
2019	PARSONAGE APARTMENTS	Multifamily MR (5-9)	4138 BROOKLYN AVE NE	2017	54,502	100	29	28.6
2019	FOX & FINCH APARTMENTS	Multifamily MR (5-9)	525 BOREN AVE N	2017	41,600	97	28.5	28.3
2019	STREAM 403	Multifamily MR (5-9)	403 BELMONT AVE E	2017	38,408	NA		
2019	ORI APARTMENTS	Multifamily MR (5-9)	5260 UNIVERSITY WAY NE	2017	36,356	99	34.2	34.2
2019	101 BROADWAY APARTMENTS	Multifamily MR (5-9)	101 BROADWAY E	2017	35,990	93	33.6	33.5
2019	HAMILTON APARTMENTS	Multifamily MR (5-9)	2305 E MADISON ST	2017	33,889	100	16.5	16.4
2019	VIVID	Multifamily MR (5-9)	219 1ST AVE N	2017	33,114	100	27.2	27.1
2019	ISOLA SW ALASKA	Multifamily MR (5-9)	4400 SW ALASKA ST	2017	29,317	NA	27.3	27.1
2019	VEGA APARTMENTS	Multifamily MR (5-9)	4528 44TH AVE SW	2017	23,090	NA		
2019	CASCADE I & II COMBINED	Multifamily MR (5-9)	221 MINOR AVE N	2016	550,889	99	31.3	31.3
					45,150	96	29.7	28.9
					48,447	77	35.7	35.4

2020

2020	Broadstone Lexington South	Multifamily (1-9)	2017	8	390,855	99	29.6	29.3
2020	CHROMA APARTMENTS	Multifamily (1-9)	2017	7	200,823	100	18.8	18.4
2020	CITY LINE II APARTMENTS	Multifamily (1-9)	2017	4	192,257	100	28.1	27.6
2020	Modera Jackson	Multifamily (1-9)	2017	5	187,832	NA	24	23.8
2020	SPRINGLINE APARTMENTS	Multifamily (1-9)	2017	5	161,999	88	42.9	42.3
2020	Orion	Multifamily (1-9)	2017	7	156,327	93	32.7	32.7
2020	TWENTY 20 MAD APARTMEN	Multifamily (1-9)	2017	6	151,166	100	24.4	24.3
2020	550 BROADWAY APARTMENT	Multifamily (1-9)	2017	6	138,434	36	59.7	59.6
2020	ICON APARTMENTS	Multifamily (1-9)	2017	7	137,771	84	41.6	41.5
2020	Arbora Court	Multifamily (1-9)	2017	7	135,492	100	32.4	31.6
2020	MERCY OTHELLO PLAZA	Multifamily (1-9)	2017	6	125,565	55	47.9	46.9
2020	19 WEST HARRISON CORA AP	Multifamily (1-9)	2017	6	96,529	100	29	28.7
2020	BROADCAST APARTMENTS	Multifamily (1-9)	2017	6	80,674	89	48.6	48.3
2020	REVERB APARTMENTS	Multifamily (1-9)	2017	8	77,757	100	25.9	25.7
2020	PARSONAGE APARTMENTS	Multifamily (1-9)	2017	7	54,502	100	26.7	25.8
2020	BLUESTONE APTS	Multifamily (1-9)	2017	4	51,521	70	25.7	25.2
2020	JEFFERSON STATION APARTM	Multifamily (1-9)	2017	4	47,499	NA	28.7	28.5
2020	FOX & FINCH APARTMENTS	Multifamily (1-9)	2017	7	41,600	NA	32.4	32
2020	PARKSTONE APARTMENTS	Multifamily (1-9)	2017	4	41,132	NA		
2020	NOVO SEATTLE	Multifamily (1-9)	2017	4	39,272	100	54.1	53.7
2020	STREAM 403	Multifamily (1-9)	2017	7	38,408	97	33.6	33.1
2020	ORI APARTMENTS	Multifamily (1-9)	2017	7	36,356	99	35	34.5
2020	101 BROADWAY APARTMENT	Multifamily (1-9)	2017	6	35,990	88	35.7	35.4
2020	HAMILTON APARTMENTS	Multifamily (1-9)	2017	5	33,889	97	43.4	42.6
2020	WALLINGFORD 45 CONDOMII	Multifamily (1-9)	2017	4	33,272	NA		
2020	VIVID	Multifamily (1-9)	2017	6	33,114	100	26.5	26.3
2020	ISOLA SW ALASKA	Multifamily (1-9)	2017	5	29,317	NA	28	27.3
2020	1210 REPUBLICAN EFFICIENCI	Multifamily (1-9)	2017	7	25,000	100	26	25.2
2020	VEGA APARTMENTS	Multifamily (1-9)	2017	6	23,090	98	45.2	44.3
2020	CASCADE I & II COMBINED	Multifamily (1-9)	2016	7	550,889	95	34.8	34.7
					45,150	94	33.4	33.0
					98,440	91	34.3	33.9

LIST OF FIGURES

LIST OF TABLES