Codes and Standards Enhancement (CASE) Initiative

2022 California Building Energy Efficiency Standards

Scoping Report

Multifamily Code Options

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Background

When the California Energy Commission (CEC) first created Title 24 Building Energy Efficiency Standards (Standards) in 1977, the focus was on single family homes. At the time, multifamily dwellings represented about a third of new residential units. Since that time, efficiency standards developed primarily for single-family homes have been applied to low-rise multifamily residential units. Likewise, nonresidential building equipment and envelope characteristics have been applied to high-rise multifamily buildings. Throughout the 1990s, building codes focused on multifamily housing never emerged due to a decline in multifamily new construction from 1985 to 1993 and little growth for the following ten years (Figure 1). Likewise, the first utility-sponsored multifamily new construction program was not launched until 1999 two decades after single-family new construction programs. From then until now, interest in multifamily-specific standards has greatly increased. In early 2018, the CEC made a public commitment[1] to appropriately address multifamily in the 2022 Standards.

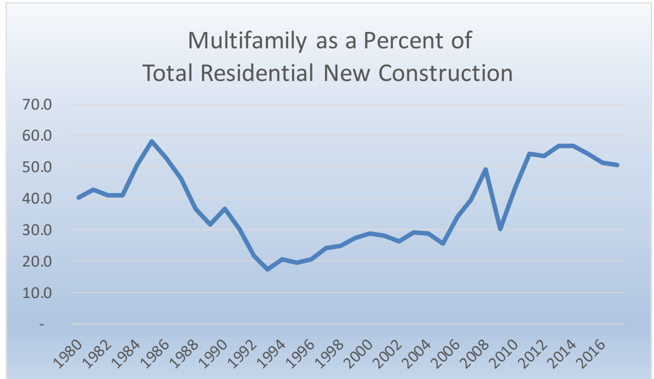

Figure 1: Based on Data from the California Department of Finance

Over the past twenty years, multifamily construction of four stories or more has increased from less than 10 percent to over 50 percent of all new multifamily units. Because much of the multifamily new construction is designed as urban infill, there is also a trend toward more mixed-use. (Hidey) Utility energy efficiency program administrators report a trend toward greater use of heat pumps and away from gas-fired space conditioning and water heating equipment. Energy consultants widely recognize that the software used for building energy modeling does not adequately deal with high-rise multifamily buildings, mixed use buildings, nor the types of heat pumps commonly used in multifamily buildings. For these, and other reasons, it is important to address multifamily buildings as a specific building type in the Standards. This report presents recommendations to develop a robust and practicable set of standards.

Project Purpose/Approach

This report draws upon the expertise of several parties involved in multifamily energy efficiency from various perspectives. That expertise, combined with a review of relevant literature and the author's personal experience, was used to develop recommendations to guide the multifamily code development process for the 2022 Standards update.

Thirteen experts were interviewed. Their backgrounds include program administrators, multifamily zero net energy (ZNE) analysts, building science professionals, a multifamily solar expert, the CEC's lead consultant on residential standards, and two national multifamily energy efficiency experts. Their input was summarized and included as Appendix A in this document.

The literature review comprised over forty sources, the most relevant of which are listed in Appendix B. According to experts interviewed, indoor air quality and its relationship to both energy use and occupant

[1] "So next round. . . we're going to focus on multifamily, larger multifamily and commercial." Commissioner McAllister at the May 9, 2018 CEC Business Meeting when the 2019 Standards were adopted.

health is one of the areas most in need of attention in multifamily new construction. As a result, a large portion of the resources reviewed focused on air-tightness and ventilation.

This project was particularly informed by on-going work of other consultants to the Codes and Standards team. In particular, Energy Solutions provided a list of measures already under consideration and TRC provided an invaluable Multifamily Market Characterization report. One other influential source was a summary of an informal session at the 2018 ACEEE Summer Study, that brought together dozens of interested parties from all over the country to discuss priorities for multifamily codes.

This report is organized into four primary sections: the structure of a multifamily code section, software for implementing the multifamily code requirements, multifamily code measures, and required research. These sections are followed by a recommendations summary. Within each topic, the report includes, where possible, relevant details from the interviews and references to the reviewed literature. Portions of the recommendations and supporting analysis are based on the author's experience and do not include references.

Code Structure

Currently, low-rise multifamily requirements are found in the "Low-Rise Residential" (residential) chapters of Title 24 Part 6. High-rise multifamily envelope and mechanical requirements are in the Nonresidential and High-Rise Residential (nonresidential) chapters, while lighting and water heating requirements are in the residential chapters. The compliance manuals follow the same divisions. This requires design teams and enforcement personnel to access both residential and nonresidential code sections and manuals for high-rise multifamily projects. Further confusion results when a multifamily project includes both three-story and four-story buildings of ostensibly the same design that, due to the code split, have very different requirements.

Table 1: Mandatory Minimums in 2019 Title 24 Part 6.

Comparison of Mandatory Maximum U-factors								
Roof		**Wall**			**Floor**			
LR	*HR*	*Framing*	*LR*	*HR*	*type*	*LR*	*HR*
0.043	0.075	2X4	0.102	0.11	Framed	0.037	0.071
		2X6	0.071		Mass	NR	0.269
		Metal	0.102	0.151			
		Mass	0.125*	0.690			

* Except CZ16 at 0.07

The recommendation, supported by all those interviewed, is to have a code section for multifamily, separate from the residential (single-family) chapters and the nonresidential chapters. Reasons given include:

- The space conditioning and water heating equipment used are often different from what is used in either single family homes or commercial buildings.
- Usage schedules are different from commercial buildings.
- Low-rise multifamily, construction materials and techniques are often different than in single-family new construction.
- The industries focused on designing and building multifamily are generally not the same as those focused on single-family or commercial buildings (mixed use is an exception).
- It makes little sense to evaluate fenestration for high-rise multifamily as a percentage of wall area while evaluating low-rise fenestration as a percentage of floor area.
- "Multifamily" includes a range of building types that could be better addressed in a chapter focused on multifamily.

- Multifamily projects often consist of multiple buildings, some subject to the high-rise regulations and some to the low-rise. When designs are essentially the same except for building height, this creates confusion and cynicism among design teams and building departments.

One consultant argued that the structure of the multifamily chapters might be more logical if it were structured more like the nonresidential code, since the rest of the California Building Code generally treats them as commercial buildings. This aspect seems to be less important than the main goal of unifying all the multifamily requirements into one section. Further, it may not be the most effective approach. For example, multifamily lighting does not warrant a whole chapter (as commercial lighting does), and fenestration should be treated more like low-rise residential than commercial buildings. It is the recommendation of this report that the multifamily section be structured more like the low-rise residential section. If the multifamily section follows the format of the low-rise residential section, it will have three chapters – mandatory measures, prescriptive and performance approaches, and additions and alterations. The CEC has already taken steps in that direction by creating a multifamily prescriptive measures table in the 2019 Standards.

One similarity to the nonresidential sections is the range of building types. There aren't as many different multifamily building types (as compared to nonresidential), yet there are variations that may need differing code requirements. For example, some multifamily buildings have a significant amount of common area (meeting rooms, gym, laundry facilities, etc.) while others (known as "garden style") lack common corridors. Some have large apartments while others have single-room occupancies (SROs) with or without common kitchen facilities. Mixed use buildings may also need to have distinct requirements.

The interviewees generally agreed that designated senior housing and designated student housing should be treated differently; these are known, fixed occupancies, and have usage patterns distinguishable from other multifamily buildings. If the 2022 update requires paring down objectives, this particular effort could be put on hold until the 2025 update. This would also simplify the public outreach process during the adoption cycle.

In addition to separating multifamily into its own section of the Standards, this report recommends a Multifamily Compliance Manual separate from the other compliance manuals. Plans examiners would rather have another manual available to use than have to consult both the Residential Manual and the Nonresidential Manual when reviewing multifamily plans. Likewise, designers' and energy consultants' work would be facilitated by having a single manual for multifamily buildings.

These steps are highly important **even if** resource constraints dictate that no actual measures should change for multifamily in this next cycle. Stone Energy Associates worked with the New Buildings Institute (NBI) on a parallel effort to accomplish this in the International Energy Conservation Code (IECC).[2] We made a strong attempt to keep the requirements relatively static while collecting all requirements into one multifamily chapter. It was not possible to keep some measures unchanged since the two code sections (nonresidential and residential) deal with certain measures using very different metrics. The effort did not succeed in the 2018 IECC process, but NBI did create a design guide with a purpose similar to California's compliance manuals. NBI will again attempt to convince the IECC to unite multifamily requirements in one chapter.

Software

It is not uncommon for multifamily new construction projects to include both two to three story buildings, and one or more taller buildings. In those cases, as well as mixed use buildings, the design team currently

[2] See "NBI Factsheet MF Code."

needs to use two different software packages (CBECC-Res and CBECC-Com, or their vendor supported parallels) and the plans examiner needs to be familiar with both. Some common areas in multifamily buildings need to be modeled with the nonresidential software. Neither software package was designed for multifamily and neither software package is "right" for a significant number of multifamily projects.

Confusion can occur when the results of the modeling indicate, that the energy use *per square foot* of the four-story building is nearly double that of the same building in a three-story configuration, as shown in Table 2.[3] Clearly both results cannot be correct. This confusion may breed mistrust of the software and the Standards on which they are based. A high level of attention to enforcement may be unrealistic when the approved software supporting the code provides such anomalous results.

Table 2: Comparative Results Using Low-Rise and High-Rise Software

End Use	Standard Design		Proposed Design	
	HR	LR	HR	LR
Space Heating	21.61	21.55	19.25	18.38
Space Cooling	51.35	30.15	37.24	28.80
Fans	62.93	8.24	70.63	9.14
DHW	33.93	31.88	30.90	29.34
Pumps	0.00	0.00	2.59	0.00
Totals	**169.82**	**91.82**	**160.61**	**85.66**
		% Better than Standard	**5.4%**	**6.7%**
TDV Energy Use shown as kBtu/ft2yr of Conditioned Floor Area				

Until recently, uniting all multifamily analyses under one software package meant having to choose between building the new software based on either the CBECC-Res or CBECC-Com platform. Bruce Wilcox, one of the interviewees, reported that he is now leading a team whose mission it is to unite the two software packages, creating *modules* that reference the appropriate algorithms regardless of the building type. The software will allow the user to model the residential portions, the common areas, and the retail and office spaces in a mixed-use building.

It will still be important to ensure that the software is designed to model all multifamily buildings appropriately, preserving consistency and allowing for difference when necessary. For example, ventilation rates and fenestration area per floor area ratio should be consistent regardless of the number of stories, but framing assumptions and fenestration type may need to be different for taller buildings.

As mentioned earlier, a wide range of multifamily building types exists. Many of the differences between the types will require different assumptions and/or routines within the software. For example, single-room occupancy units (SROs) often do not have kitchens and sometimes share a bathroom between two to four units. Another example is the difference between garden style ("walk-up") apartment buildings and those with central loaded corridors. At some point after the 2022 Standards, it may make sense to create separate requirements for occupancy types that are known and fixed, such as senior housing and student housing, since they have different usage patterns from the rest of multifamily occupants.

Several articles and reports have noted that low-income multifamily buildings and occupancies differ significantly from other multifamily buildings, perhaps warranting a different set of requirements. While we do recommend research leading to a better understanding of those differences, we do not recommend creating low-income as a separate and distinct building type in the Standards, at least until extensive research has been completed; creating standards prematurely may have the unintended consequence of further disadvantaging low-income households.[4]

Additionally, software changes regarding occupant assumptions specific to multifamily buildings should be explored. Recent data from several multifamily projects shows that the best indicator of energy use intensity is the number of occupants,[5] not square footage or number of bedrooms. Code requirements

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[3] The table shows results from analysis using CEC-approved software for a four story high-rise residential and a three story low-rise residential building with no other design features changed.

[4] For example, if it is found that low-income households use less space conditioning and water heating energy, basing Standards on that data could increase utility costs or decrease comfort level among disadvantaged residents.

[5] Billing analysis and end use analysis performed on several hundred apartments by Redwood Energy (2015-2018).

cannot be based directly on number of occupants; that quantity is unknown at the time the energy analysis is performed, as well as once construction is complete. However, it is likely that occupant density can be correlated to a new metric which combines conditioned floor area (CFA) and number of bedrooms—rather than just one or the other. Creation and use of such a metric should make the analysis of measure impacts more accurate. This may be particularly true for water heating energy and plug loads; the two largest end uses in relatively efficient multifamily buildings.

Code Measures

Some measures warrant inclusion in both multifamily code and single-family codes; others may be unique to multifamily. Even for the measures that should also be advanced in the single-family code, the analytical framework will often need to change to correctly understand the impact in multifamily buildings. This may be true for air-tightness and ventilation more than any other aspect of the code.

Air Tightness

Testing of air tightness in residences began as an energy efficiency measure in response to the energy crises of the 1970s.[6] As the code ratcheted up insulation requirements and fenestration performance, air leakage became one of the major sources of wasted energy. It was no longer appropriate to count on intrusion of unconditioned air through leaks as the source of "fresh" air. Blower door testing became the norm to establish that the envelope did not leak more than a minimal amount.

For multifamily buildings, only one or two walls out of four represent potential leaks to and from the exterior. The other walls (and often floor and ceiling) are adjacent to other dwelling units. Intrusion of smoke, cooking odors, and other noxious fumes are as serious a concern as the energy waste through exterior leaks.[7] Testing protocols developed for single-family homes that don't account for infiltration of neighboring unit odors have not translated well to the needs of multifamily buildings.

Much research has examined methods to seal multifamily walls (interior and exterior), and potential testing protocols for air-tightness. However, whole building air leakage testing is impractical in many multifamily buildings. Furthermore, testing of individual units, while addressing the potential of contaminated air intrusion from neighbors, does not adequately answer the energy-related issue of leakage to and from the exterior. The 2019 Standards specify the method of testing for air tightness for multifamily dwelling units, but this method should be revisited. Additional research needs to include specific testing of alternate blower door protocols and development of an accurate way to translate testing of a sample of compartmentalized dwelling units into an overall *exterior* leakage rate. This should be done in preparation for the 2022 Standards update. Numerous resources provide recent research as a starting point; several are listed in the References section of this report.

Ventilation

Ventilation in a multifamily building is often more complicated than in single-family. Contributing factors include connecting spaces (e.g., corridors, equipment chases, etc.), aesthetics of urban buildings (disdain for protrusions from the side walls), and the time it takes new tenants to learn to control ventilation. One of the ideas discussed in the interviews was demand ventilation—controlled based on sensed humidity, CO, CO2, VOCs, and PM2.5. Some experts favored it, but the general consensus indicated significant concern that the sensors or controls could fail. One member of the ASHRAE Indoor Air Quality (IAQ) committee stated that a high proportion of sensors and controls would almost certainly

[6] See the *Air Infiltration and Ventilation Centre* website: https://www.aivc.org
[7] Several studies and papers make this case. See the Appendix B: References.

fail within five to fifteen years, and that the occupants might then be in a worse situation than if the builder had followed the prescriptive requirements of ASHRAE 62.2.

Bath fans are often used to also provide whole house (WH) exhaust-only ventilation. A controller steps up the bath fan from the level needed for WH ventilation to a higher speed when it senses moisture in the bathroom. These controls rely on humidistats. Recent review (by Build It Green staff) of the operation of several installations indicates that this configuration can result in significant problems.[8] Humidistats are often not connected correctly to the rest of the controls. In some cases, they are connected but not functioning, either due to faulty installation or gradual impaction with dust or debris. One measure that would solve *some* of these problems is a requirement for acceptance testing of controls on bath fans. Another option is to **require** separate WH ventilation fans, rather than allowing the use of bath fans for whole home ventilation.

Some multifamily buildings have central exhaust ventilation shafts which currently may not be modeled accurately. Further field research is needed to align modeling assumptions and algorithms with the actual effects for actual configurations of central shafts. These details may include tightness of the shaft and connections, types of balancing vanes or dampers used, exhaust fan motor, and impact of operable windows.[9]

Heating and Cooling

Because the issues with mini-splits are covered extensively in analyses by parties better versed in the design and/or installation of these systems, this report does not explore this topic in depth. However, it is worth noting that improving the requirements and energy performance analyses for mini-splits was high on almost all of the interviewees' lists of needs for a multifamily code.

It has long been required by code that space heating equipment be able to maintain at least 68°F (20° C) three feet above the floor throughout the habitable spaces. However according to the National Weather Service, almost every year, more people die in the U.S. from heat waves than from cold snaps or any other weather event (National Weather Service).[10] As the climate warms, it will become increasingly important to ensure that buildings allow occupants to remain relatively cool during heat waves. In single-family homes, where over 80 percent of households are owners, occupants can choose to add air conditioning, change out windows, and add insulation to cope with the changing climate. In multifamily dwellings, where approximately 88 percent of households are renters, occupants do not have that same capability. [11] Therefore, it is important that the code ensures that new multifamily dwellings can stay cool enough to be safe in an extended heat wave. It may be time to consider a requirement that multifamily dwellings can maintain temperatures at or below 79° (26° C) in the summer.[12]

[8] In the Build It Green research, several apartments were found to have peeling paint and/or mold in the bathrooms because the humidistats were not functioning.

[9] This is not meant to imply that a ventilation strategy should depend on operable windows, but rather the effect of occupants opening windows in one or more of the connected apartments can affect ventilation elsewhere in the building.

[10] A majority of the fatalities are in multifamily buildings inhabited by low income households and the elderly (Margolis, et al. 2008).

[11] HUD 2011. Also, according to U.S. Census Bureau data, out of approximately 30.5M apartment households, roughly 27.5M are renters.

[12] In a study by TRC wherein they interviewed hundreds of multifamily residents about their satisfaction with indoor summer temperatures, "two-thirds (67%) of those who gave a definitive response (n=401) said that they wished it were cooler in the summer. Only 27% said that they were satisfied with summer temperatures." Berkland, et al. 2018.

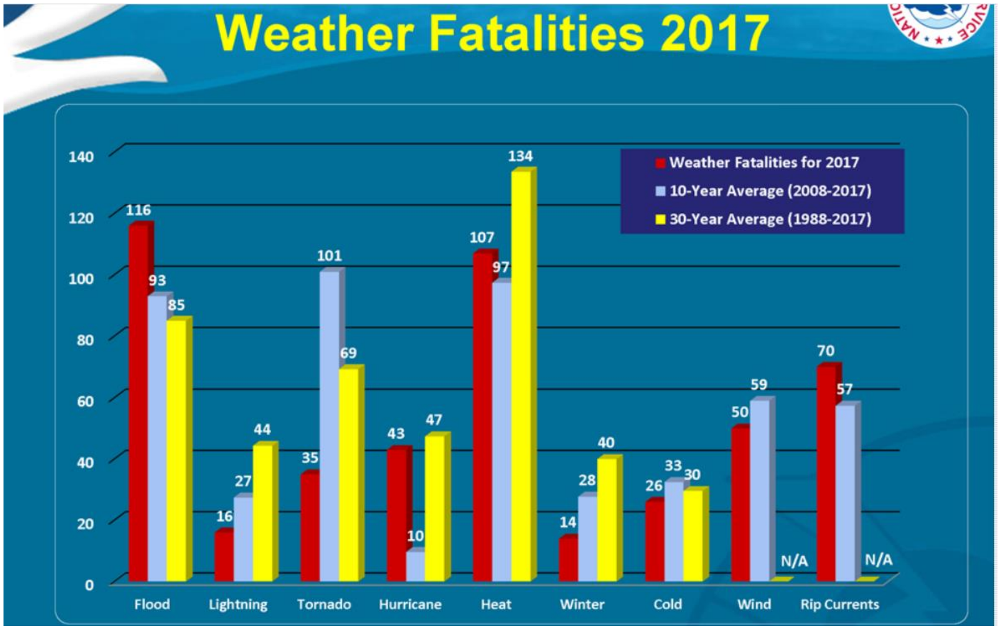

Figure 2: National Weather Service Data on Weather-Related Deaths

In uniting the high-rise and low-rise requirements within one code section and creating the ability to model both within one software program, it will be important to ensure that the software can address all of the relatively typical kinds of HVAC equipment, including heat recovery ventilation (HRV) and enthalpy recovery ventilation (ERV). TRC's 2018 Multifamily Market Characterization report provides a good first look at the range of equipment being installed. However, the document reported a shortage of available information about HVAC equipment in high-rise multifamily buildings; the data on high-rise multifamily and on retrofits in low-rise buildings came from participants in PG&E's multifamily incentive program. Experienced energy consultants report having to "trick" the software in order to more accurately represent HVAC equipment in many of their projects. Accuracy and confidence will both be increased when the software can actually model the equipment types being installed.

Domestic Hot Water (DHW), Including Central Systems (CDHW)

Advances were made for the 2019 code in modeling heat pump (HP) water heating systems, and current work is intended to add capabilities for heat pump central water heating (HP CDHW). But the performance of some new equipment coming on the market may not be captured even with the updates, according to feedback from energy consultants. The accuracy of the new algorithms should be evaluated against real installations across a range of equipment configurations. Additionally, some large systems that combine DHW and space conditioning utilize chillers. There is currently no method to correctly model those systems, even in the revised 2019 version of the software.

One of the more promising strategies of making highly-efficient buildings support efficient grid operation is to equip DHW HP equipment (individual or central DHW) with demand response (DR) controls. This can be as simple as controls that raise tank temperatures 10°-20° (F) during the solar peak (using onsite PV energy), and shut off the equipment during the grid peak. This strategy is being tested under an EPIC research contract managed by Build It Green.[13]

[13] All-Electric ZNE MF Research under CEC GFO-15-308.

Another method is to use grid connected HP water heaters that the serving utility or ISO can cycle as needed to balance the grid. This type of control requires slightly more complexity in order to ensure that occupants have hot water when needed. Midwest rural cooperatives have been using this strategy for years, albeit with electric resistance water heaters. (Lazar 2016)

The current water heating algorithms for compact hot water delivery systems (CHWDS) apply to single-family projects and low-rise multifamily units with individual water heaters. It appears that the exclusion of low-rise multifamily with central DHW and all high-rise multifamily is due to a lack of data on the potential savings in those cases. Logically, there is no reason to believe that high-rise apartments with individual DHW systems should benefit less from CHWDS than similar apartments in low-rise buildings. Also, it is likely that apartments with central DHW systems could still benefit from CHWDS, although the savings potential would certainly be different than for individual water heaters.[14]

Plug Loads

"*Single-family and multifamily units can be very different physically and can have very different energy usage characteristics. For example, according to the RASS microdata there are differences between single-family and multi-family in the average CFA for a given NBr* [number of bedrooms], *the average demographics of occupants, and the average number of products and their frequency of use*." (Rubin 2016)

There is too little data on differences between single-family ("residential") and multifamily plug load energy use. Much of the current data that *is* available is specific to low-income housing which, on average, may have very different characteristics (e.g., demographics, ratio of CFA to number of bedrooms, etc.) than other multifamily housing.[15] As California moves toward true zero net energy dwelling design and construction, plugs loads are becoming more and more important.

Load	South Coast		Desert	
	as built	w/o Laundry	as built	w/o Laundry
Laundry	15%	n.a.	13%	n.a.
Plug Loads	25%	29%	20%	24%
DHW	23%	27%	19%	22%
Cooking	13%	15%	11%	13%
Cooling	0%	0%	11%	13%
Lighting	9%	11%	7%	8%
Refrigerator	8%	9%	6%	7%
Heating	6%	7%	12%	14%
Dishwasher	1%	1%	1%	1%

Figure 3: Courtesy of Redwood Energy

Figure 3 shows the percentage of actual energy used for all end uses in two all-electric apartments of essentially the same design, but in different Climate Zones. In both southern California locations, the data show that plug loads are the largest loads (between 20 percent and 29 percent of the total) in efficient multifamily dwellings, whether they have an in-unit laundry or not, due to the relatively lower heating and cooling loads.[16]

Appliances

As the state moves closer to its decarbonization goals, removing natural gas from residences may be resisted by those who favor their gas stoves and dislike cooking with electric resistance. Induction stoves may be the answer to this dilemma. The relative cost of induction cooking seems to be falling fairly rapidly, and those who have adopted induction cooking (in particular almost all TV chefs) prefer them

[14] Based on personal communication with Gary Klein, November 2018.
[15] This is not an argument that there ought to be different requirements and modeling assumptions for affordable housing, but rather that more must be learned about multifamily miscellaneous electric loads across all types of multifamily housing.
[16] Data provided by Redwood Energy from projects on which they did the analysis and monitoring.

over gas stoves.[17] The Standards should account for the energy savings of induction cooking. This will require standard research typical for a CASE measure.

There has been significant research in recent years on the use and effectiveness of range hoods: cubic feet per minute (CFM) draw, ability to withdraw various pollutants, size of the canopy, as well as sone ratings[18] and usage patterns. It may now be appropriate to collect all that research and determine whether minimum requirements for installed systems need to be expanded or updated. Even with clean induction cooking, volatile oils and particulate matter from cooking still can impact indoor air quality. [19]

Laundry

There are two issues with laundry equipment that should be included in the multifamily standards. First, the incumbent energy for in-unit laundry hook-ups should be a part of the *standard* regulated budget. When the hook-ups are there, the *proposed* budget should assume minimum efficient washers and dryers if (a) the builder installs basic equipment, or (b) doesn't install any washers and dryers. The software should allow a user-input for higher efficiency/lower energy use in the proposed budget when Energy Star equipment is specified to be installed. Laundry energy is accounted for in this way for the Tax Credit Allocation Committee for low-income housing.

Secondly, if no in-unit hook-ups are installed and central laundry facilities are provided instead, (a) that energy use should be captured as part of the common area load, and (b) a much lower amount of energy should be assumed in the proposed budget for the dwelling units. Research has shown that occupants with in-unit laundry hook-ups complete approximately 40 percent more loads than those with central laundry facilities (NRC 2002). Although laundry energy use is a relatively small portion of older multifamily buildings' energy use, in a highly efficient multifamily building, laundry can easily account for more energy use than for heating or cooling.

Lighting

Residential lighting baselines were produced for single-family homes through the California Residential Lighting Survey completed by HMG for the CEC in the 1990s and updated a few years ago. The code has assumed that the lighting density and usage patterns in multifamily dwellings is the same as in single-family dwellings. There is no basis for this assumption since it has not been tested. In all of the studies to date, multifamily buildings either were not included or their data were combined with the single-family homes. This report proposes a research project to determine what the typical number of lamps are (by room type), their wattages, and their hours of operation. With the market transition to LEDs, lighting energy use may be low enough that a full study is unwarranted. However, a scoping exercise to determine the potential savings effect is appropriate.

[17] Research done by Redwood Energy. 2018.

[18] Sone ratings indicate how loud the fan is when operating.

[19] Eliminating a natural gas range eliminates the formaldehyde from burning of natural gas but does not eliminate pollutants from cooking itself. Based on personal communication with Tom Philips of Healthy Building Research in Davis, CA. 2018.

Energy Use Feedback Devices

Preliminary research by Redwood Energy has shown the potential for reducing energy use in all-electric apartments by 5 percent to 15 percent through simple devices that inform occupants of the intensity of their energy use. There exists a significant range of such devices that use different mechanisms for determining energy use, allocating it to various end uses, and informing occupants of the results.[20] The one used by Redwood Energy (the Nexi) connects to circuits in the panel and has a device that mounts on the wall (about the same size and shape as a typical thermostat). The wall device uses colors, from green through orange to deep red, to inform occupants of (a) instantaneous use intensity and (b) daily cumulative use relative to a baseline (budget). Other kinds of devices employ signal recognition algorithms to indicate how much energy has been used by various end-uses. All are intending to provide occupants with the information they need to modify behaviors and control their energy usage.

Figure 4: Example of Energy Feedback Device - Nexi by Canary Systems

Envelope

Envelope construction details might be the place where real world differences between high-rise and low-rise multifamily buildings are the greatest. However, these differences are not directly related to the number of stories, but rather construction techniques. While it is true that it would be nearly impossible to design a ten-story wood-framed apartment building, the code does allow six-story wood framed buildings. Likewise, two- and three-story buildings are sometimes steel framed. Therefore, any differences in envelope requirements should be based on the construction type and details, not number of stories.

Methodologies for establishing fenestration area will need to be addressed for unification of low-rise and high-rise multifamily requirements. Window to wall ratio may be the appropriate metric for commercial buildings, but multifamily buildings (and multifamily spaces in mixed-use buildings) should use the same metric as other residential buildings: window to conditioned floor area. However, it is also appropriate to set a lower ceiling on *standard* window area than what is used for single-family buildings. A CEC-sponsored study about ten years ago found that the average fenestration area in multifamily buildings was about 14 percent of conditioned floor area (CFA).[21] It may be appropriate to set the amount at which the Standard Budget is capped at 15 percent, instead of 20 percent as with single-family dwellings. The same study found that except in climate zones (CZs) 1, 3, and 5, an SHGC of 0.23 was cost effective. A U-factor of 0.30 was cost effective in all CZs.

Solar

Photovoltaics (PV) is generally more complicated for multifamily buildings than single-family homes. Because of the ownership/occupant split that applies to over 80 percent of multifamily dwellings, virtual net metering (VNM) is required to make it cost effective. Without VNM, each apartment would have to have its own panels and inverter, at a significantly greater cost than one central PV system.[22] Last decade, the California Public Utilities Commission (CPUC) directed all the electric IOUs to develop VNM tariffs. However, not all publicly owned utilities (POUs) have followed suit. Since neither the

[20] See https://www.energysage.com/energy-products/energy-monitors

[21] https://www.energy.ca.gov/2015publications/CEC-500-2015-045/CEC-500-2015-045.pdf

[22] Virtual net metering is primarily a billing activity. The MF building's solar output is metered and allocated to tenants' bills based on a prescribed formula.

CPUC nor the building standards can force POUs to do so, cost-effective analysis for multifamily PV is somewhat challenging.

Additionally, as the 2019 Standards recognize, there may not be sufficient roof space to accommodate proportionately the same amount of PV as with single-family homes. These two confounding issues imply that several alternatives need to be available to multifamily developers. It is worth exploring whether the current alternatives are sufficient and suit the industry.

One attractive option is thermal storage. A current research project (the Build It Green EPIC project mentioned above) is examining the viability of using over-sized HP water heaters to shift the heating and water heating loads away from peak hours to periods with lower time dependent valued (TDV) energy. The tanks are heated to approximately 140°F in the afternoon while the PV is generating energy and essentially shut off from 4 p.m. to 9 p.m. HP water heater manufacturers are currently developing controls to allow this same strategy to be used without external controllers. This is a promising control strategy that should be considered for the 2022 code cycle.

Batteries may also be a good strategy for multifamily buildings. A larger battery array can be more cost effective than several smaller ones. By storing solar energy in the afternoon and sending it into the grid during peak periods when rates are higher, owners can maximize the value of their PV systems. Additionally, with the advent of electric vehicles (EV) the potential exists to use EV batteries to augment the site battery.

Electric Vehicles

Half of the EVs sold in the U.S. are bought in California, as shown in Figure 5. EVs represent more than 5 percent of the new vehicle market in California, with a much higher average in most urban areas.[23] In eleven Bay Area communities they represent more than 15 percent of sales, and the percentages are rising fairly rapidly. It will be important to make sure that multifamily buildings built to the 2022 Standards are EV-Ready. What exactly that means should emerge from a CASE study, but at a minimum there may need to be one charging station for each apartment. The market is growing too rapidly to delay this requirement until the 2025 update cycle.

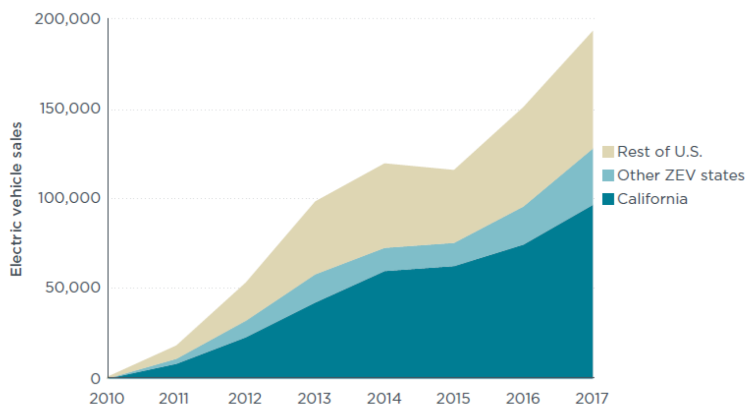

Figure 5:California EV Sales - international Council on Clean Transportation 2018

[23] These data and the graph that follows are courtesy of a May 2018 briefing paper by the International Council on Clean Transportation. See references

Further, vehicle to grid (V2G) and vehicle to home (3H) connections and controls should also be evaluated. Several manufacturers and researchers are exploring controls to allow electric vehicles to power homes and send excess power back to the grid at peak times. In a multifamily setting, the arrangement of the equipment and metering of energy in and out would be more complex than in the single-family example shown. The graphic to the left, which shows a potential configuration is courtesy of the National Renewable Energy Lab's (NREL's) Energy Systems Integration Facility. These systems are being tested now by NREL and others.

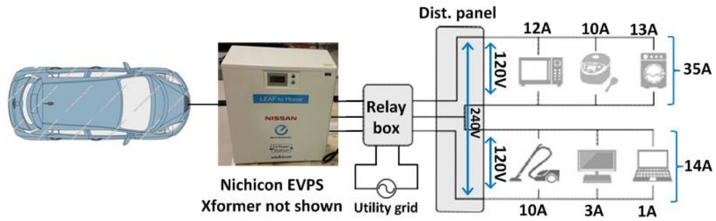

Figure 6: Vehicle to Home Example - NREL

Required Research

The range of issues that need to be addressed to ensure the code fosters energy efficiency and reduced carbon emissions in multifamily buildings necessitates a significant amount of supporting research. In some cases, the research is mostly done or underway and simply needs to be collected, reviewed, and summarized. For other issues, the Statewide CASE Team will need to begin new research or supplement research that has not completely or adequately addressed unique multifamily specifics.

Multifamily Prototypes

The TRC 2018Multifamily Market Characterization report provided information on multifamily building details that are common among projects represented in the Home Energy Rating System (HERS) registry and existing multifamily projects involved in retrofit programs. We need to expand the survey and analysis to include high-rise multifamily construction and the non-participant market. The research should provide solid details on the numbers of multifamily new construction projects across several categories. These include, at a minimum: garden style, low-rise central loaded corridor buildings, mid-rise, high-rise, single room occupancies, and mixed-use buildings. The data collected should include number of floors, number of units, common area floor space, common area use designations, envelope materials/details, fenestration area, HVAC equipment used, DHW equipment, and available roof area (including parking facilities). The study should focus on very recent construction, projects underway, and projects planned.

Multifamily Occupancy Metric

One of the more important research questions is creation of a metric that better calibrates energy use in multifamily dwellings. This report recommends creating a metric that is a function of both conditioned floor area (CFA) and number of bedrooms. This has the best chance of representing what is likely the most accurate metric—the number of occupants (which the code obviously cannot accommodate). The research should focus on finding the best correlation between energy usage, number of occupants, CFA, and number of bedrooms. See more on this in the following two sections.

Air Tightness Testing

Research is needed to develop or establish a cost-effective means for accurately and reliably determining dwelling unit and building-level air tightness. Testing every apartment and the building as a whole is not generally practical, especially for multifamily buildings with several floors or a large number of dwelling units.

Testing a sufficient sample of units for compartmentalization is appropriate for determining if the project will adequately protect occupants from inter-unit transfer of smoke and other pollutants. However, since such tests cannot separate how much air leakage is from the exterior versus the adiabatic surfaces, they do not directly translate to a building air leakage number. This is especially true for buildings with central corridors, common area laundry rooms, and other shared spaces. Similarly, a whole building blower door test, where it can be done, provides no insight into the degree of compartmentalization achieved.

A protocol is needed for testing a reasonable sample of spaces (apartments and common areas) and a procedure for turning the results into meaningful estimates on whole-building. A significant amount of work on this issue has been conducted across the country, so the research effort may only involve a literature review and subsequent analysis. However, any recommended procedures should also be validated against real world projects and vetted by industry practitioners.

Ventilation

Several areas of research are warranted for multifamily ventilation.

First, we should explore making a requirement that each unit be provided with dedicated whole house (whole apartment) ventilation. Whole house ventilation (WHV) needs to be compared against current typical practice of using a two-stage bath fan for required ventilation, particularly as to meeting actual needs for IAQ. The research should include an assessment of the effectiveness and persistence of humidistats, the marginal costs for WHV, and the potential for HRVs/ERVs to cost-effectively meet demands.

- What is the prevalence of heat recovery ventilation or energy recovery ventilation?
    - Is it cost effective? Is it market ready?
    - Should it be prescriptive or a compliance option?
- Are humidistats controlling bath fans typically installed correctly and functioning properly?

Second, a study on the availability and reliability of multi-facet ventilation demand controls is needed. Several models are on the market, but they vary significantly by pollutants sense and by price. Of primary concern is any data on persistence and operational effectiveness.

Third, research is needed regarding the details of central ventilation shaft construction practices to account for relevant details in the compliance software. The Western Cooling Efficiency Center (WCEC), the Association for Energy Affordability (AEA), the Benningfield Group and LBNL have all done research in this area, as have several organizations in the Midwest and East Coast. A greater understanding of the effects of various flow regulators, connections, and other details of the systems is still needed. The research should also lead to an understanding of how operable window usage affects ventilation efficiency.

Lastly, additional research is needed to determine if further requirements are appropriate for range hoods to better ensure proper indoor air quality. A significant amount of research exists on the relationship between important parameters (e.g., hood dimensions, fan CFM, ducting, and fan noise) and effectiveness of removing critical pollutants from cooking. New research should focus on determining if range hood criteria needs to be different for gas ranges versus electric ranges (including induction ranges).

Heating and Cooling

There is still much research need on the types of HVAC equipment and controls installed in multifamily dwelling units and buildings. We need to conduct a survey, field work, and analyses that will answer the following questions:

- What is the full range of HVAC equipment types that are used in multifamily buildings?
    - How prevalent is each type in new construction?
    - The study should place a stronger (though not exclusive) emphasis on mid- to high-rise multifamily.
    - The study should include a significant sample from non-participant multifamily properties, since TRC's analysis focused primarily on program participant properties.
- What are the predominant controls and control strategies used in multifamily buildings?
- Should the heating and cooling set points in multifamily be the same as assumed for single-family homes and as represented in the ACM?
- Is a minimum cooling capacity requirement justified?

DHW Use Schedules

Currently, the water heating calculations rely on conditioned floor area. Since the average square footage of a California apartment is less than half the size of a California home (834sf. vs. 2388sf.) and the number of occupants per household is roughly equal (approximately 2.37 vs. 2.55, estimated from U.S. Census data), an equation based on conditioned floor area should not be used to estimate of hot water energy or water use. To develop the relative importance (factors) for square footage and number of bedrooms, we will need to analyze multiple apartment buildings for energy use, water use, apartment size, number of bedrooms, and occupants.

Additionally, the compact hot water delivery system (CHWDS) design criteria eliminating low-rise multifamily with central systems and all high-rise multifamily buildings needs to be reevaluated. Installation details and performance metrics need to be developed to potentially expand CHWDS credits to multifamily projects that are currently excluded.

Plug Loads and Appliances

The revised occupancy metrics described above should also apply to plug loads. Currently, plug loads are calculated as a function of the number of bedrooms, regardless of the conditioned floor area. As shown in a CASE Report (Rubin et al, 2016) the three sources of data currently relied on (RESNET 2013, RASS 2009, and Building America 2014) do not closely align with each other. Further, those data sources are either wholly or primarily developed from single-family homes. However, the current algorithms for single family homes and multifamily homes are very closely aligned. "*The plug load and lighting rulesets have some limitations. The rulesets generally do not account for differences in energy use patterns between single-family and multifamily housing*."[24]

One example that can illustrate the problem with differences in plug loads is refrigerators. Regardless of any difference between the average number or size of refrigerators installed in single-family homes versus those in apartments,[25] the same refrigeration energy is currently assumed for a two-bedroom house and a two-bedroom apartment. Likewise, it may not be reasonable to assume that an 1800 square foot two-bedroom aprtment will have the same number of television sets as an 850 square foot two-bedroom apartment. In both examples, this may be the case, but no statistical data is available to answer the question.

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[24] Rubin et al. Note also, that the CASE Report recommends separate studies and algorithms for multifamily and single-family homes in Section 8.1.1.

[25] "Apartment size" refrigerators are little more than half the size of "standard" refrigerators and the TRC report shows that there are approximately 20% more refrigerators/home in single family homes. Conversely, LBNL found that home owners are twice as likely to install Energy Star refrigerators than multifamily building owners.

We need to conduct a survey and analyses that will answer the following questions:

- What is the average total annual energy use (AEC) for apartments?
  - How does it vary by number of bedrooms (Nbr)?
  - How does it vary by CFA?
  - How does it vary by number of occupants?
- Can we identify a function of Nbr and CFA that better represents the number of occupants?
  - How well would that function represent variance in energy use in apartments, compared to the current method?
- What is the average size of a refrigerator in California apartments?
  - Does this vary by number of bedrooms?
  - Does it vary by square footage of the apartment?
  - How different is it from the average size refrigerator in single-family homes?
- Is the number of televisions relatively uniform across apartments of differing sizes (CFA) that contain the same number of bedrooms?
- What is the difference in energy use for an induction stove versus gas or electric resistance?
  - Is induction cooking cost effective?
  - If not, can a compliance option be developed?
- What other plug loads are significant?
- Are the other plug loads significantly different in single-family homes versus multifamily?
  - Is their impact adequately represented by a function based on Nbr?
  - If not, would it be adequately represented by a function that relies on both CFA and Nbr?

Laundry

There have only been two studies on the comparison of central laundry facilities to in-unit laundry hook-ups in multifamily buildings. The widely cited study by the National Research Center (2001) indicates that there can be significant water and energy savings from central laundry facilities. This study necessitates replication to determine the current savings potential and develop means for giving central facilities credit in the compliance software.

Lighting

Lighting installed wattage and usage patterns may by significantly different in multifamily buildings than assumed in the ACM. However, with the widespread use of LED lighting, there may not be enough energy use to justify a deep research project. We recommend a high-level analysis to determine if further research is warranted.

Energy Use Feedback and Controls

As the internet of things (IoT) grows, it expands the potential for reducing gas and electrical loads and moving loads to a more favorable time of day. Research is needed into the development, reliability, and improvement of a range of controls, such as:

- Home energy management systems
- Other controls for plug loads (time of use and shut-off during periods of non-use),
- Energy use feedback devices, like the Nexi from Canary Systems,
- Controlling heat pump water heaters to balance the needs of the household with time of use tariffs (grid harmonization), and
- Controlling EV charging and discharging (vehicle to grid and vehicle to home) in a way that harmonizes with the needs of the grid.

Recommendations Summary

Multifamily buildings have been getting an increasing amount of attention from researchers, energy consultants, non-profits, and government agencies. This is likely due to three factors:

1. Multifamily construction has gained greater importance—over 50 percent of new residential units in California have been multifamily for eight years in a row.
2. Multifamily has been largely overlooked for decades—the first time Title 24 had a requirement that was specifically developed for multifamily was 2005.
3. The majority of cost-effective energy efficiency measures that can currently be included for single-family homes have already been addressed.

It is time to create a set of building energy efficiency regulations for multifamily buildings that are developed based on research specific to multifamily, and to bring all the requirements for both high-rise and low-rise multifamily into one set of chapters. Of almost equal importance are 1) the need to ensure that the compliance programs correctly represent the important elements of multifamily construction, and 2) the need to create a compliance manual specifically for multifamily buildings, as an aid to design teams and the enforcement community. The greatest opportunities for energy savings in multifamily buildings may flow from the decrease in confusion that these changes will bring about.

Other significant savings can result from the exploration and adoption of new measures listed in this report; from expanding the applicability of existing measures to multifamily buildings or to more types of multifamily building; and from creating new protocols and calculations specific to how multifamily buildings perform and are used. Obviously, some of the recommendations in this report cannot be accomplished in time for adoption within the 2022 Standards, but all should be explored. This process can lay the groundwork for achieving truly zero net energy and very low-carbon multifamily buildings in 2025.

Stone Energy Associates (SEA) produced this report for PG&E, representing the Statewide CASE Team. Stone Energy Associates is a three-year old consulting firm whose principal, Nehemiah Stone, has over forty years of relevant experience. Nehemiah Stone was a licensed contractor, chief building official, staff in the CEC's Building Standards Office, advisor to the Chairman of the CEC, and energy consultant. He designed and managed the state's first multifamily new construction program in 1999, has been the technical advisor to the California Tax Credit Allocation Committee for multifamily energy matters since 2009, and has been involved with building standards for multifamily projects since 2002.

Appendix A: Summary of Expert Interviews

The first task in the SEA current project for PG&E (through Energy Solutions) was to interview several experts with relevant information about what multifamily-relevant issues should be addressed in the 2022 updates to Title 24 Part 6. SEA concluded those interviews and with this report, provides a summary of the results.

SEA conducted nine interviews including 13 people. Both the Association for Energy Affordability (AEA) and TRC had multiple people on the call. SEA interviewed:

- Gina Rodda (Gable Associates)
- Wayne Waite (low-income solar consultant)
- Amy Dryden (Build It Green)
- Andy Brooks, John Neal, Nick Dirr (Association for Energy Affordability)
- Sean Armstrong (Redwood Energy)
- Bruce Wilcox (lead consultant to CEC on energy efficiency building standards)
- Sophia Hartkopf, Elizabeth McCullum, Nick Dunfee (TRC)
- Sean Denniston (New Buildings Institute)
- Paul Torcellini (National Renewable Energy Lab)

I questioned them about their thoughts and experiences across four broad topics (software, technologies, documentation, and code structure), and several specific measures or issues within each broad topic. There was general agreement on most issues, with a few significant exceptions.

Software

On the question of whether there ought to be a single multifamily (multifamily) chapter that addresses multifamily buildings of all types, everyone who answered this question agreed that it would help clarify and simplify the requirements for multifamily construction. However, there were a range of views about whether there ought to be a separate software package for multifamily. Some (four firms of the nine) supported the idea while three others felt that it would be better to simply modify the current residential software and have a multifamily path within it. One consultant felt that the size of the dwelling should dictate what software to use. There was also general agreement that all of the common area spaces should be able to be modeled in the same package, rather than switching back and forth. Some even felt that this should include nonresidential spaces in a predominantly multifamily building.

When asked, “What are the main measures that are not currently addressed properly by the software?” almost everyone pointed out variable refrigerant flow (VRF) equipment, mini-splits, and central heat pump (HP) water heating technologies. Additionally, some felt that some ventilation technologies are too hard to model *correctly*, especially ERVs and HRVs.

Three other comments about the software were noteworthy.

- One consultant felt that the fan energy data in the software is “out of whack.” It doesn’t seem to represent actual fan energy.
- Another consultant felt that energy use estimates in “tiny houses” (500 square feet or less) is too high in the software. He suggested field analysis of actual energy use in order to realign the baseline with reality. As tiny houses become more popular, this issue will increase in importance.

- Another pointed out that the equipment mapping protocols need to be fixed. For example, in HR multifamily, HVAC equipment in the proposed design is compared to 4-pipe fan coil systems in the standard design, even though those systems are rarely ever used in multifamily construction.

Some of the data points needed in order to model multifamily buildings correctly include understanding of occupancy and equipment schedules as specific to these buildings. None of the interviewees offered any sources of data on multifamily schedules, but they generally felt more research is needed. One said, "It's a crime that no one is spending any money on this." Another indicated that mechanical engineers with whom she works tell her the schedules aren't right, but again, they have no research on which to rely.

Most interviewees felt that senior housing is different enough and discernable enough (permanently dedicated) that it ought to have different schedules within the software. There were more mixed responses on the same question related to student housing. Dormitories could be modeled similarly to other single room occupancies (SROs) but with their own schedules. However, regarding student apartments, some interviewees felt they should be modeled as other apartments without student-specific schedules.

NREL is beginning the process of developing a set of multifamily prototypes for modeling. They are planning to launch the project at the end of October and have draft models for review by approximately April of 2019. Their first step is to get a sense of what kinds of designs are going to be built over the next five to ten years. For that effort they are interviewing active design teams across the country. SEA will be staying in contact with Paul Torcellini of NREL to keep apace of their efforts and to coordinate so that California's prototypes can be consistent to the extent that that makes sense.

There were numerous other "*tweaking*" suggestions for the software. Those will be discussed further in the final report.

Technologies

The top issues that interviewees felt need to be addressed in multifamily standards are similar to those they felt the software is lacking in: accurate representation of ventilation technologies and ventilation effectiveness, central DHW, and mini-splits. But several other measures also surfaced.

Multiple parties felt that we need to address electric vehicle (EV) charging in the multifamily code (as well as the SF code). One person stated that we need to address EVs as a battery source, not just a load on the system.

Other suggestions included (number of mentions):

- Home energy management systems (1)
- Demand response controls (4)
- Removing solar thermal requirements in multifamily (2)
- HRV and ERV as compliance options (1)
- A wider range of equipment choices (1)
- A more "forward looking" code using future weather (2)
- Be consistent in representing HR and LR multifamily envelope details,
    - such as window area (2)
    - wall U-factors (1)

- Consider exterior sheet insulation for all climate zones (1)

There was a significant range of opinions on whether the alternatives to full PV when roof area is limited are appropriate or adequate. Some objected to trading between energy efficiency measures and renewable energy, feeling that it sends the wrong message to builders and occupants. Others pointed out that high-end multifamily generally includes Energy Star appliances and wifi T-stats anyway, and low-income multifamily generally cannot afford them. Therefore, it is a free ride for the former and a non-alternative for the latter.

One consultant suggested canopy solar (placing the panels 6 to 8 feet above the roof plane), not so much as an alternative, but rather as one way of meeting the actual goal. Another recommended allowing for a reduction in the "with solar" EDR if the "without solar" EDR is significantly better than the minimum. Virtually all stated that they are waiting to see what the CEC's community solar criteria will be.

Some of the other suggestions included:

- Place a higher emphasis on control systems to help occupants respond to TOU tariffs
- Require cross-over-proof faucets
- Require commissioning of more systems
- Require balanced ventilation
- Create ways to convert compartmentalization air leakage values to exterior leakage
- Consider Passive House as a one-for-one alternative to standard code compliance

One option discussed was demand controlled ventilation, where the demand is sensitive to temperature, relative humidity, PM2.5, CO2, and VOCs. Two interviewees did not support the idea. The others felt it would be helpful but were concerned about the persistence. In general, those supporting felt that more research, adequate warranties, and very tight criteria would be needed.

Additionally, two consulting firms recommended another look at the assumptions made in calculating internal gains and occupant density in multifamily. They do not feel that the analysis of cost effectiveness is based on the right assumptions.

Documentation

This was the area about which the interviewees had the least to say. Only one interviewee addressed the question of what measures the forms do not adequately deal with in multifamily buildings. Her response: "All of them. The forms are not helpful for multifamily." For example, in low-rise multifamily, she states that you have to call your common areas "garage or something similar." Some systems serving two story apartments cannot be represented without making two spaces out of the apartments. Elevators are not dealt with. In essence, she claimed documenting (as well as modeling) much of multifamily requires consultants to use a series of "work arounds." She also suggested linking final planning department approvals to compliance with the energy code

A couple consultants also decried the fact that there are no registries for high rise multifamily, though until the CF-1R and modeling are fixed so that they work for multifamily, there is not much that can be done about the registries.

Code Structure

All but one consultant supported the idea of having a separate, comprehensive chapter for all multifamily requirements. The one who was not supportive wondered whether it would really help or not. It is worth noting that this one consultant does not work with individual projects and has no interaction with building departments.

There was general agreement that there should be a stronger all-electric option in the code, with one consultant declaring that there should *only* be an all-electric option. Most did not see a need for challenging the federal preemption issue since modeling is the standard approach to multifamily design and the required trade-offs can be dealt with that way. One consultant suggested that to align the all-electric and mixed-fuel alternatives, the CEC should include the full cost of gas infrastructure in the cost/benefit analysis.[26]

One consultant suggested differentiating multifamily types as much as possible, such as creating categories for SROs and assisted living facilities. Another suggested having factors included for regions of the state where the grid is almost 100 percent clean energy already. Another suggested aligning requirements with R-1 and R-2 dwelling categories. Yet another wants to see all requirements aligned with future weather, and creation of future-focused TDV values.

There were several comments about specific types of multifamily, or *potentially* multifamily buildings, as well as mixed use buildings and nonresidential spaces in predominantly multifamily buildings. The final report will provide more detail on those comments.

The following are final suggestions from the interviewees on the structure of the code as it pertains to multifamily buildings.

- Laundry use should be better represented, so that design teams can see the impact of choosing either in-unit laundry or common laundry facilities.
- There should be a map (set of questions) that help the design team determine what category a building should fit (e.g., townhomes, assisted living).
- Swimming pools should be included in the modeling, both as a demand and as a possible thermal storage measure.
- The multifamily chapter should be structured more similar to the nonresidential chapter since the rest of the building codes treat them primarily as commercial buildings.
- Provide an alternative path, such as Living Building Challenge or Passive House (Note: this suggestion was made by a different consultant than the one who made a similar comment above).

Lastly, there were many suggestions for additional research needed to deal with all of the issues raised in the questions and interviewees' responses. The final report will provide a comprehensive discussion of those research suggestions.

The next phase of this work is an in-depth literature review. SEA already reviewed the measure list developed by the Statewide CASE Team, provided to SEA by Energy Solutions. SEA will also review what other states are doing and have done, what research and recommendations are being developed for the IECC, and other sources. That review will be followed by a summary of the findings.

Thank you for the opportunity to support this very important effort.

[26] Note that this is a recommendation SEA made during the 2019 Standards update process, along with submission of data on the costs as part of the docket.

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