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MEMORANDUM

To: California Energy Commission
From: NORESCO
Date: July 21, 2025

Subject: Proposed 2028 Energy Code Cycle Building Prototype Updates

INTRODUCTION

The California Energy Commission's (CEC) building prototypes represent typical building types within the state and incorporate minimum energy efficiency and load management requirements from California's Energy Code (California Code of Regulations, Title 24, Part 6). The impact of proposed code-change measures is evaluated in energy models of these prototype buildings, and the statewide impacts of measures are estimated based on the statewide distribution of each building type by climate zone.

The CEC receives feedback from the public and other stakeholders throughout the code-development process. Recent stakeholder feedback suggested that the representativeness of school, assembly and hotel prototypes used in the 2025 Energy Code cycle could be improved. In response to these concerns, the CEC is proposing to update the school, assembly and hotel building prototypes for the 2028 Energy code cycle.

DISCUSSION

Stakeholders, CEC staff, and the CEC's analytical team identified areas to improve the representativeness of the current school, assembly and hotel building prototypes. Proposed changes are outlined below.

Schools

The Division of the State Architect (DSA) communicated that the existing Small and Large School prototypes did not represent typical kindergarten through 12th grade public schools as they are currently built in California in two primary aspects:

- The schedule of the existing school prototypes did not reflect a summer break and therefore over-estimated energy use for schools.
- The layout of the existing school prototypes did not accurately represent typical schools in California and therefore cost estimates for implementing proposed measures were inaccurate.

To address these issues, the CEC proposes two new school prototypes for kindergarten through 8th grade, and for 9th through 12th grade.

Kindergarten through 8th Grade

Occupancy Schedules

In collaboration with DSA staff, occupancy levels and schedules for spaces in kindergarten through 8th grade (K-8) schools were developed using DSA data sources and experience, and interviews of school staff and other relevant entities including California Department of Education staff.

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The proposed schedules for K-8 schools include a summer break, a revised set of holidays, student half days and early-out days, summer school, and finally, the diverse activities in a multipurpose room (cafeteria, gymnasium, and performance), including weekend use. None of these activities had been represented in the existing Small School prototype which had been previously used to represent these grade levels.

Discussions with DSA also revealed that different spaces in school buildings have different occupancy schedules. For example, a multipurpose room (MPR) in a school administrative building may open early for breakfast and stay open late for sports activities, while the offices in the building follow a more typical school schedule. Accurately representing the usage of these spaces requires a change from current practice where a single schedule is determined by a floor's dominant space type and that schedule is applied to all spaces on that floor.

Weighting was also considered in the schedules to capture the relative impact of elementary school schedules versus those of middle schools. Research into the statewide floor area and counts of school types indicated that there were approximately 4 elementary schools to every middle school[1]. The weighting strategy affected the frequency, time of day, or level of occupancy for sports, performances, and other school activities in the multipurpose room, and the classroom occupancy during summer school.

The resulting schedules were diverse and numerous. A sample of the most frequent occupancy schedules are illustrated in Figure 1 through Figure 3.

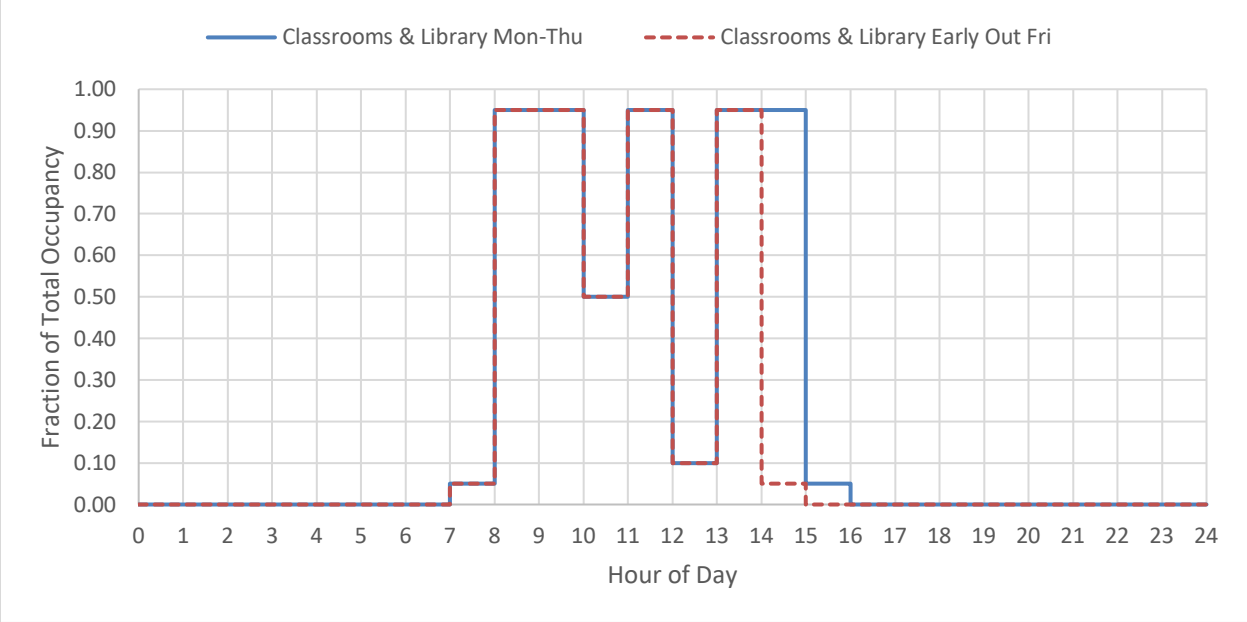

Figure 1: Proposed Typical Classroom Occupancy Schedule

[1] The ratio of floor area of elementary to middle schools in the Dodge construction starts database (Dodge Construction Network, 2023) for 2016 through 2023 was 4.13 to 1. The ratio of counts of elementary to middle schools provided by the Department of Education was 3.15 to 1 (Email from: Department of the State Architect, 2025).

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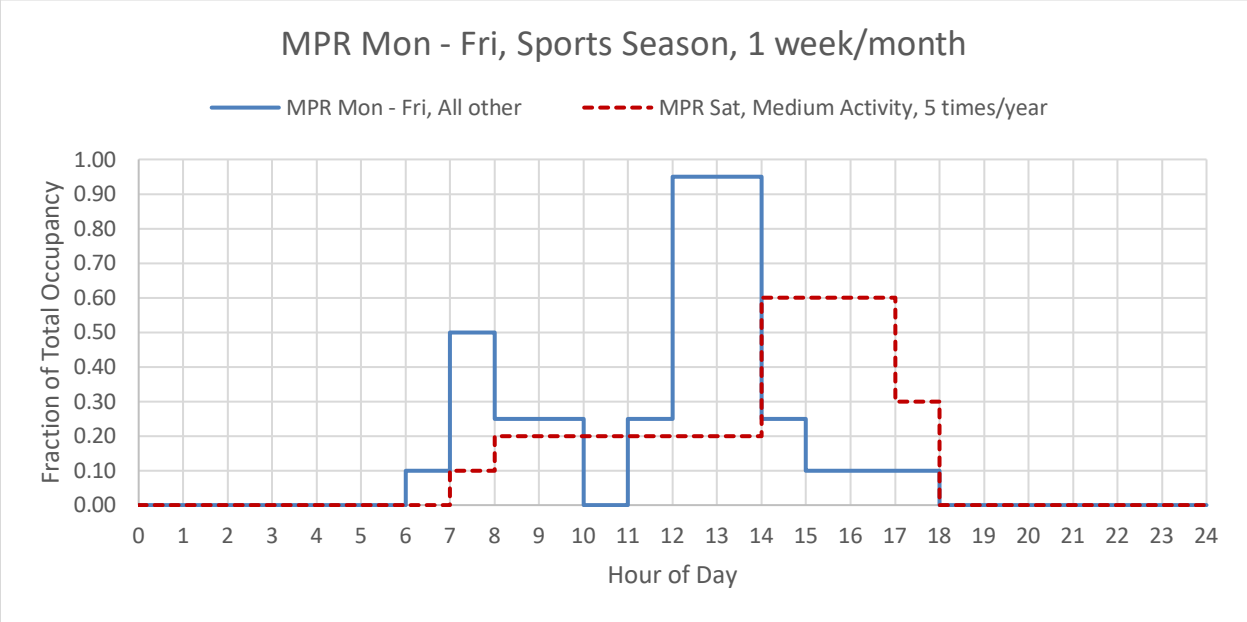

Figure 2: Proposed Typical MPR Occupancy Schedule

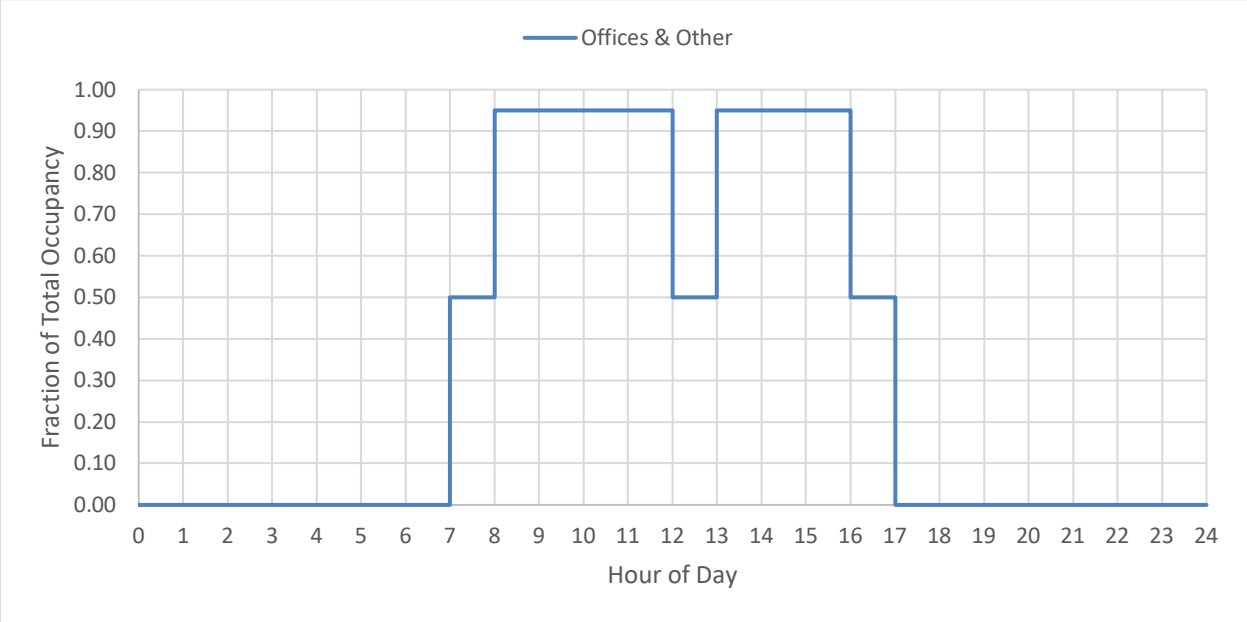

Figure 3: Proposed Offices and Other Spaces Occupancy Schedule

Geometry

To improve the representativeness of the layout and geometry of the K-8 school prototype, the CEC reviewed design drawings provided by DSA staff of what they considered a typical campus, along with supplemental example drawings to show the diversity of window geometries observed in classrooms and main lobbies. The layout is illustrated in Figure 4.

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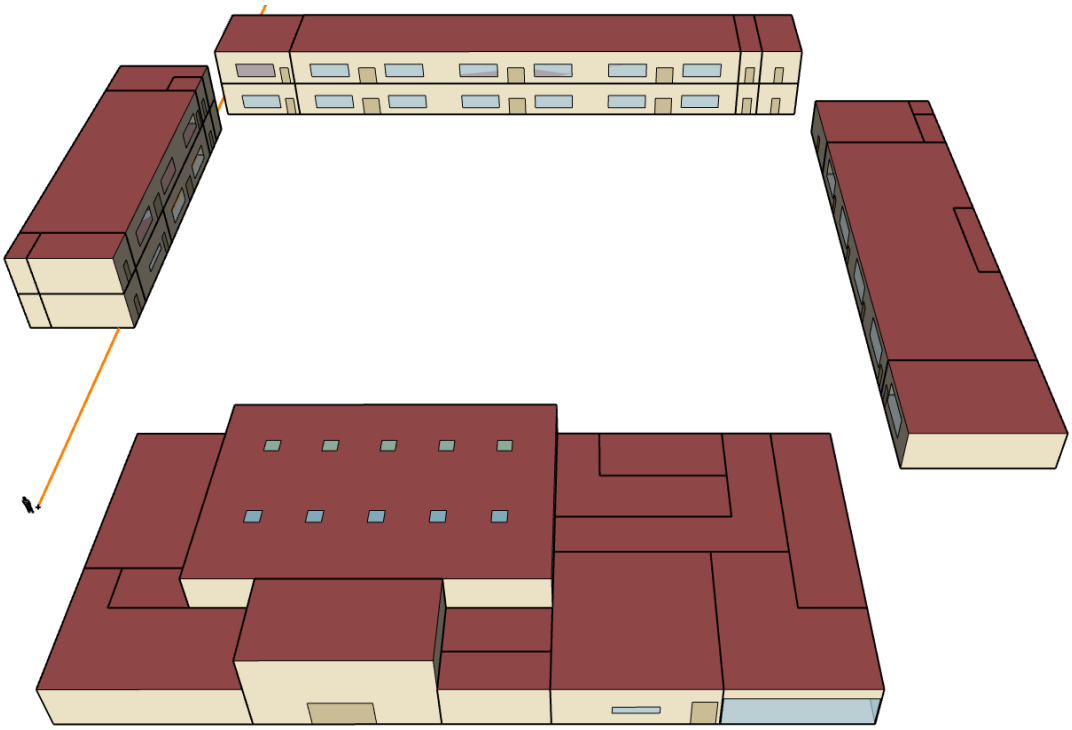

Figure 4: Proposed Kindergarten through 8th Grade School Prototype Layout

The proposed geometry for K-8 schools comprises four buildings surrounding a central courtyard. The west, north, and east buildings are classroom buildings, and there is an administrative and multipurpose room building on the south. To improve model run time and simplify the implementation of future measures on the prototype, the geometry was simplified in these ways:

- Spaces with similar functions were combined into a single space
- The number of walls for each space was minimized
- Groups of windows were merged into a single window[2]

To minimize the energy impact from the simplification of the geometry, the following parameters were held within a 1% difference between the original design drawings and the final prototype geometry:

- Total campus floor area
- Ratio of space type floor area to total campus floor area (e.g., ratio of classroom floor area to total campus floor area)

[2] Windows on a façade of a particular space were grouped if they were less than two feet apart.

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- Window-to-floor area ratio by space type and orientation (e.g., west-facing windows in classrooms)[3]
- Daylit area-to-floor area ratio by space type

Exterior wall area by space type and orientation was not tracked, but a concerted effort was made to maintain this aspect between the design drawings and the new prototype.

HVAC Systems

Single-zone systems were shown in the design drawings shared by DSA, which is consistent with the Alternative Calculation Method (ACM) Manual Standard Design. So, the ACM Standard Design, single-zone heat pumps, is proposed as the K-8 school prototype's HVAC system.

High Schools

To align the High School prototype with typical high schools in California, the team proposes to modify the K-8 school prototype by applying multipliers to the area of spaces that are included in both prototypes, adding space types, and modifying schedules, as needed.

Occupancy Schedules

DSA staff provided information on occupancy, which led to revisions of the K-8 school schedule for use in the High School prototype. Notable revisions are that high schools have a zero period[4] for classrooms, much more activity for sports and theater, and a longer summer school session.

Geometry

DSA staff provided design drawings of a high school campus. From these drawings, the total floor area for each of the space types on the campus was calculated. These floor areas were used to create multipliers that could be applied to the K-8 school prototype to approximate the high school floor areas. For example, in the K-8 school prototype, classrooms made up 26,300 square feet, whereas in the high school drawings they made up 51,800 square feet. So, an overall multiplier of 51,800 ÷ 26,300 ≈ 2 was used for the classrooms[5].

The high school design drawings also included space types that are not in the K-8 school prototype. These spaces were added to the high school prototype. Examples include a gymnasium, performance building, and cafeteria.

HVAC Systems

Single-zone systems were shown in the high school design drawings shared by DSA staff, which is consistent with the ACM Standard Design. So, the ACM Standard Design, single-zone heat pumps, is proposed as the high school prototype's HVAC system. [6]

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[3] CEC's analytical team reviewed examples of classroom window geometry for several campuses. Statistics were used to arrive at a representative window.
[4] Zero period is an early-morning class period before first period.
[5] Only integers can be used as multipliers in the energy modeling software, EnergyPlus.
[6] Very large schools often use centralized HVAC systems, regardless of number of stories. Thus, the existing prototype, the Large School, which was historically used for this grade level used a VAV system.

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Future work

In future code cycles, CEC staff may propose a revised High School prototype based more directly on the DSA design drawings and further refine schedules based on additional discussions with DSA staff. A new prototype to represent colleges and universities may also be proposed in future code cycles.

Assembly Spaces

There was concern that the current occupancy schedule for the assembly building prototypes did not represent key features of many of the assembly building types used in the Energy Code. Figure 5 illustrates the current occupancy schedule for assembly spaces. This schedule applies to all assembly spaces, regardless of the specific building type.

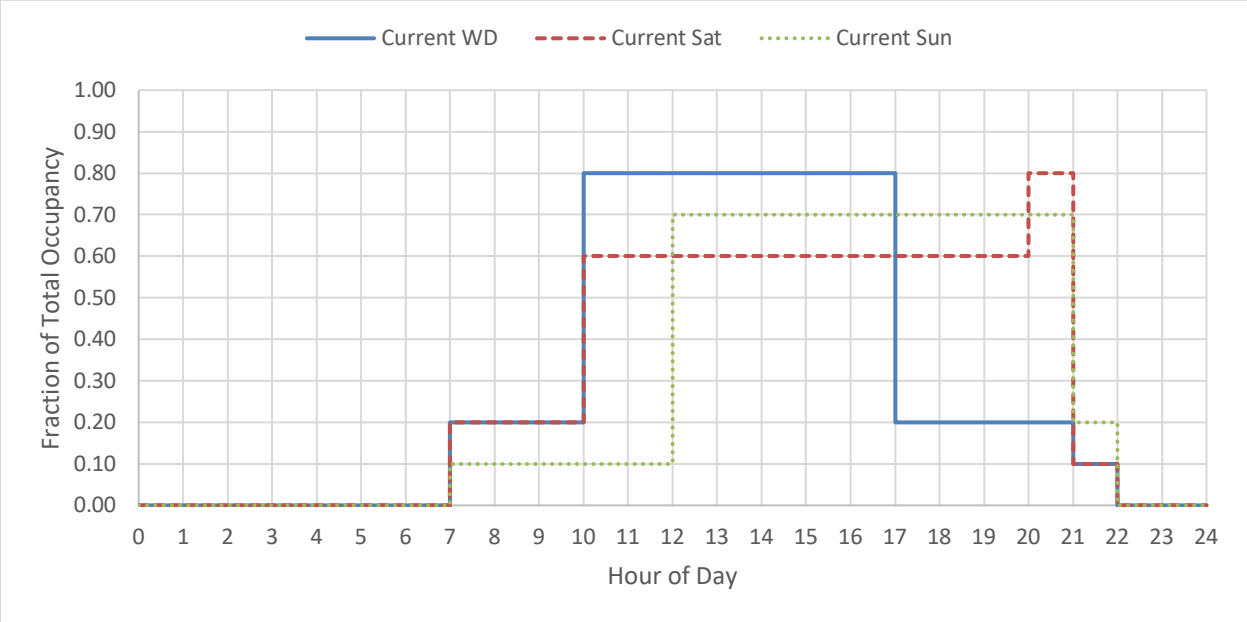

Figure 5: Current Assembly Schedule

To improve representativeness, CEC staff propose to update the schedules for the following building types.

Theaters: Motion pictures and live performances

This space type is expected to have low occupancy during the day on weekdays and higher occupancy on weekends, except for afternoons and evenings on Sundays, which were assumed to be more like weekday evenings. These conclusions are based on a review theater showtimes and ticket availability (Fandango, 2025). The proposed schedule is illustrated in Figure 6.

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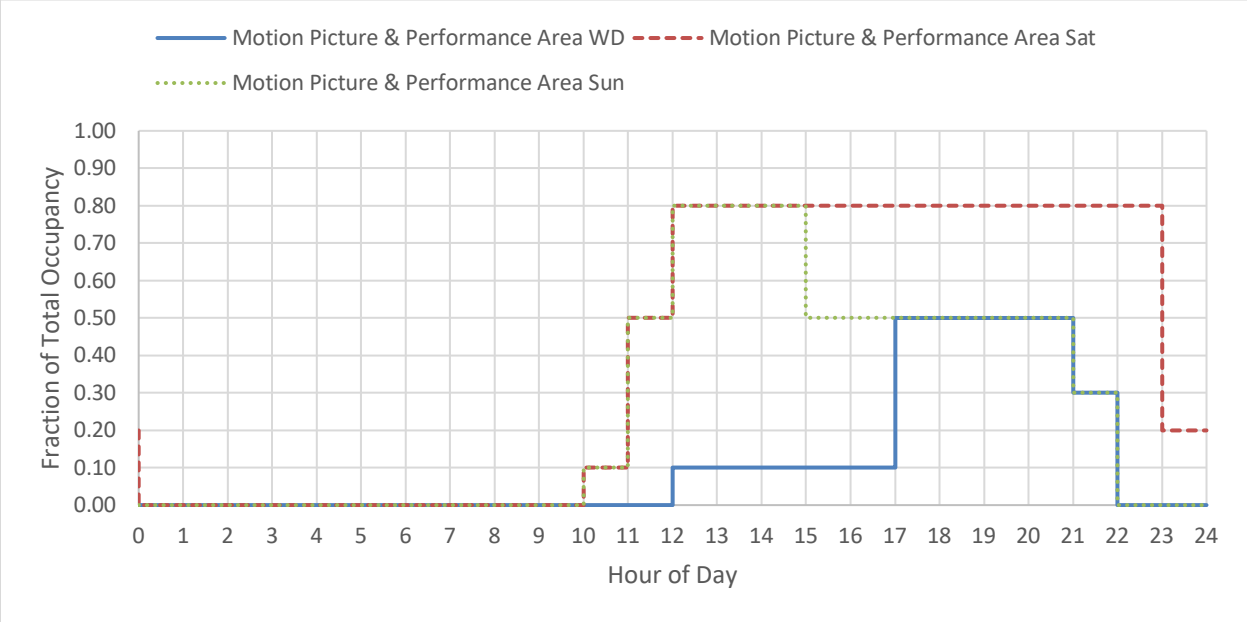

Figure 6: Proposed Motion Picture & Live Performance Occupancy Schedules

Museums and Libraries[7]

A sampling of published schedules of operation for these space types indicated closing in the early evening. It was assumed that peak occupancy occurred on weekends, and that weekday daytime occupancy was low but not insignificant, with occupancy increasing in the afternoon. The proposed schedule is illustrated in Figure 7.

[7] School libraries will use their own library schedule that is specific to schools.

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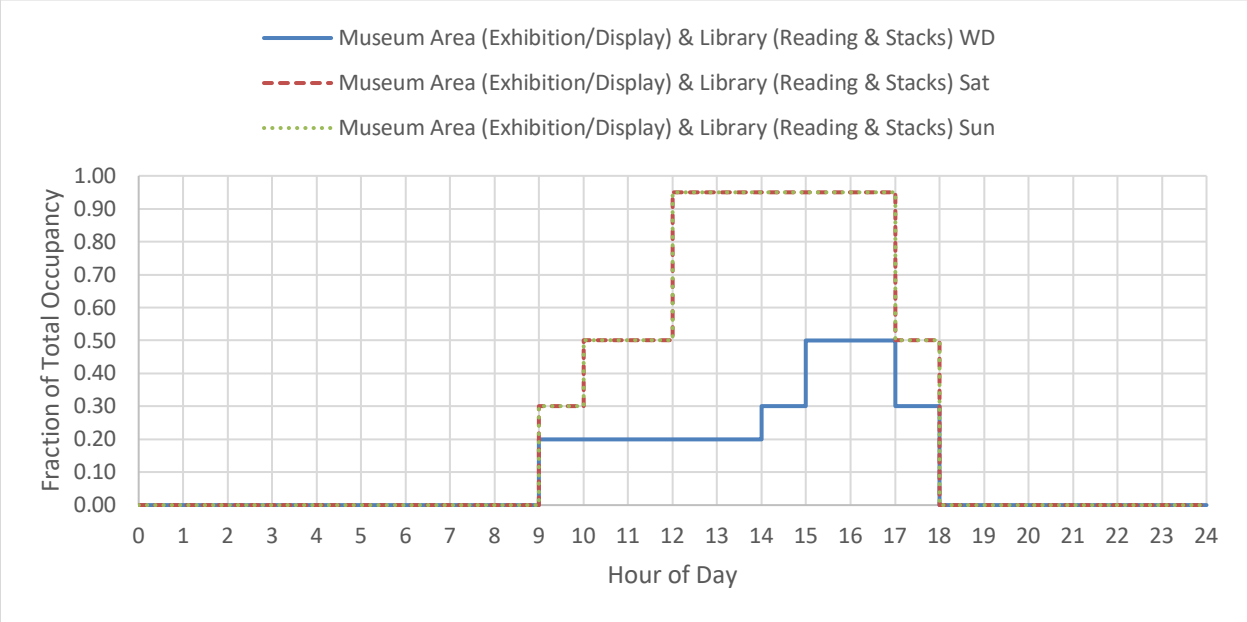

Figure 7: Proposed Museum and Library Occupancy Schedules

Religious worship spaces

The worship areas of religious worship buildings were found to have much fewer hours than the current assembly schedule. Research revealed that religions with the highest percentage of California's population (Wikipedia, 2025) typically had the highest number of worship services on Sundays, with Saturdays being the next highest, and weekdays having some morning and evening attendance. The proposed worship area schedule is illustrated in Figure 8.

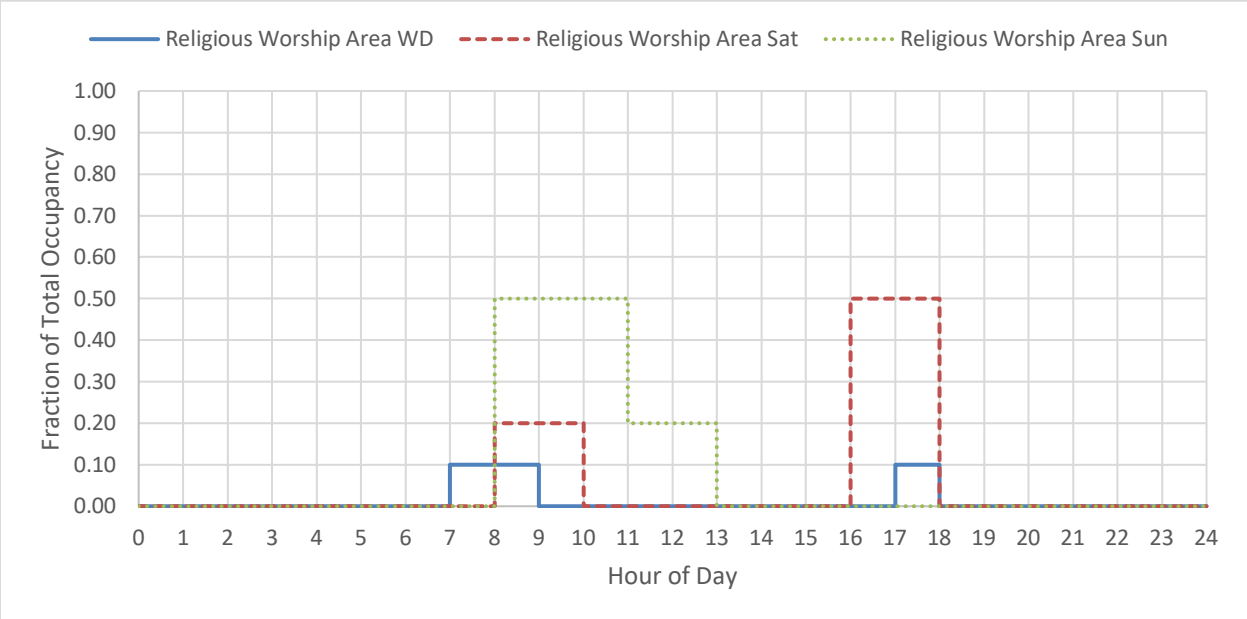

Figure 8: Proposed Religious Worship Buildings Occupancy Schedule for the Worship Area Only

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Convention centers

Sampling of event schedules in convention centers (Moscone Center, 2025) (Los Angeles Convention Center, 2025)revealed that convention centers typically operate on a business-hour schedule except that occupancy extended to weekends, and was limited to operation for a couple of weekdays and one weekend day. The proposed schedule assumes these buildings operate on Thursdays, Fridays, and Saturdays and is illustrated in Figure 9.

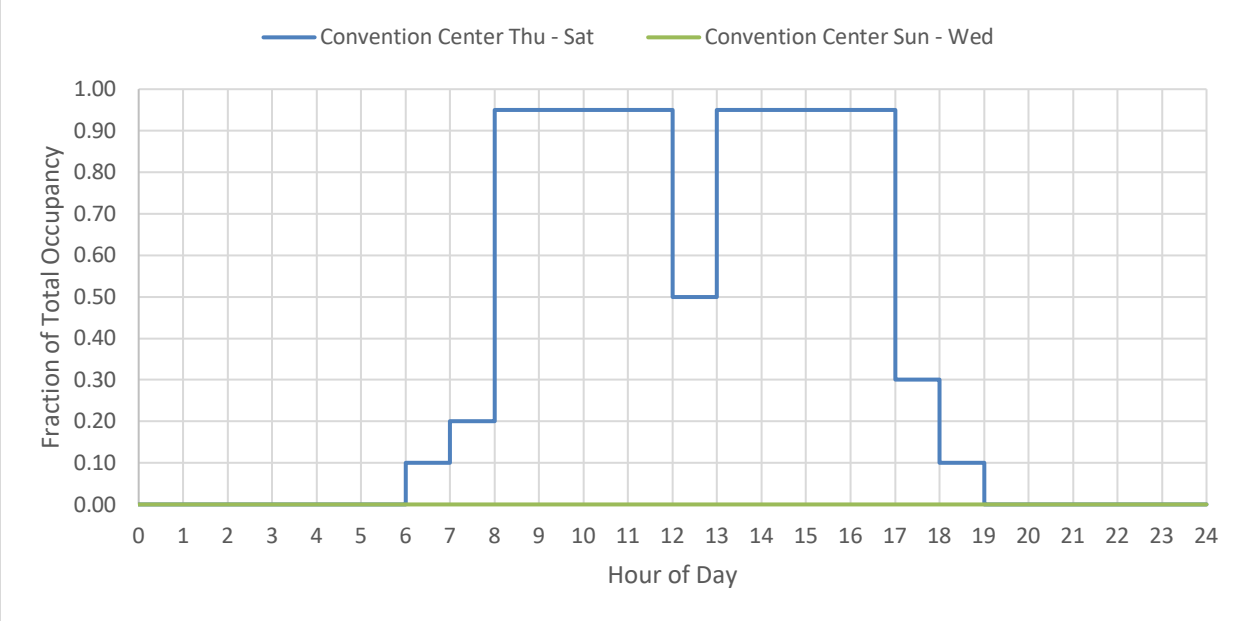

Figure 9: Proposed Convention Center Occupancy Schedule

Exercise, fitness, and gymnasiums

Staff propose to use the Pacific Northwest National Laboratory (PNNL) schedules (Pacific Northwest National Laboratory, 2025) for this occupancy type. The PNNL schedule has steady occupancy throughout the day that lasts from early morning until late evening, with some breaks in occupancy during the day on weekdays. The proposed schedule is illustrated in Figure 10.

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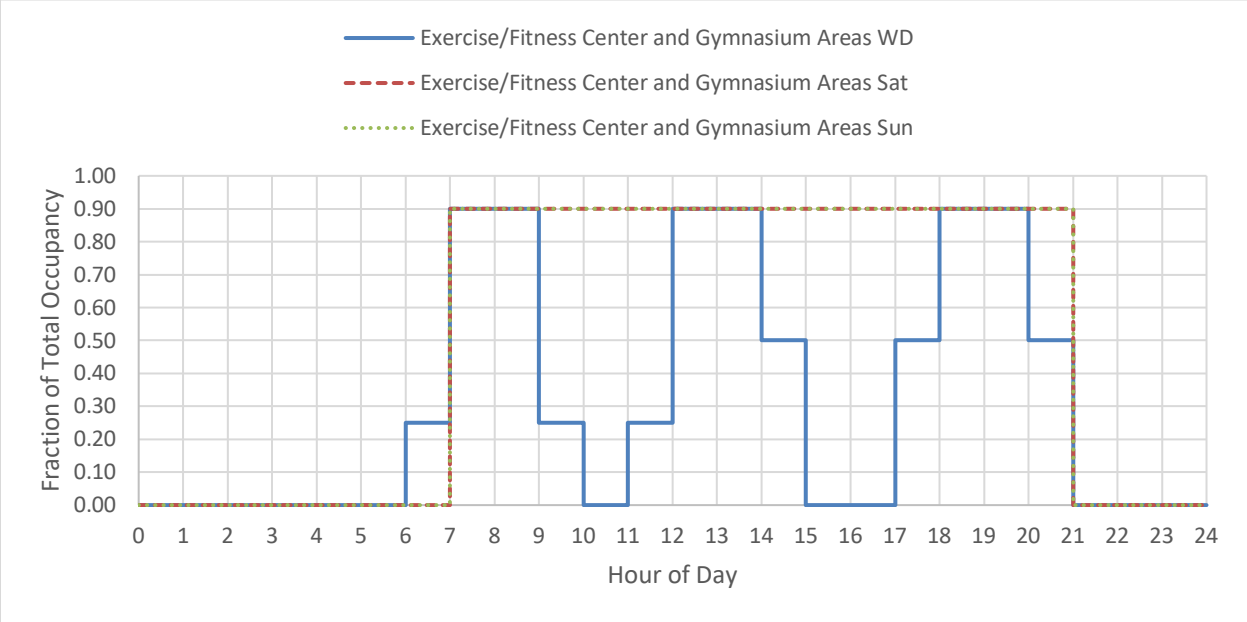

Figure 10: Proposed Exercise, Fitness, and Gymnasium Occupancy Schedule

Hotels & Motels

The proposed revisions address the following concerns regarding the existing prototype for hotels:

- The existing thermostat setpoints for hotel guestrooms are not typical of hotels in California
- The existing prototype's geometry may not accurately reflect the distribution of hotel sizes in California

Thermostat Setpoints

The current setpoints for hotel guest rooms are based on the Residential ACM thermostat setpoints, which use an algorithm based on historical weather[8]. This algorithm is not considered accurate for a hotel room where guests are likely not staying for longer time periods and has setpoint temperatures that are not considered typical of hotels in California.

The proposed setpoints are based on the setpoints used in the Department of Energy's hotel prototypes (Department of Energy, 2025). The setpoint schedule is illustrated in Figure 11. Note that the heating and cooling setpoints are the same and constant throughout the day reflecting that occupants do not typically change their preferences for temperature when they are guests at a hotel.

[8] The Residential ACM setpoints differ in that they operate in cooling or heating modes, based on the outside air temperature over the previous 8 days.

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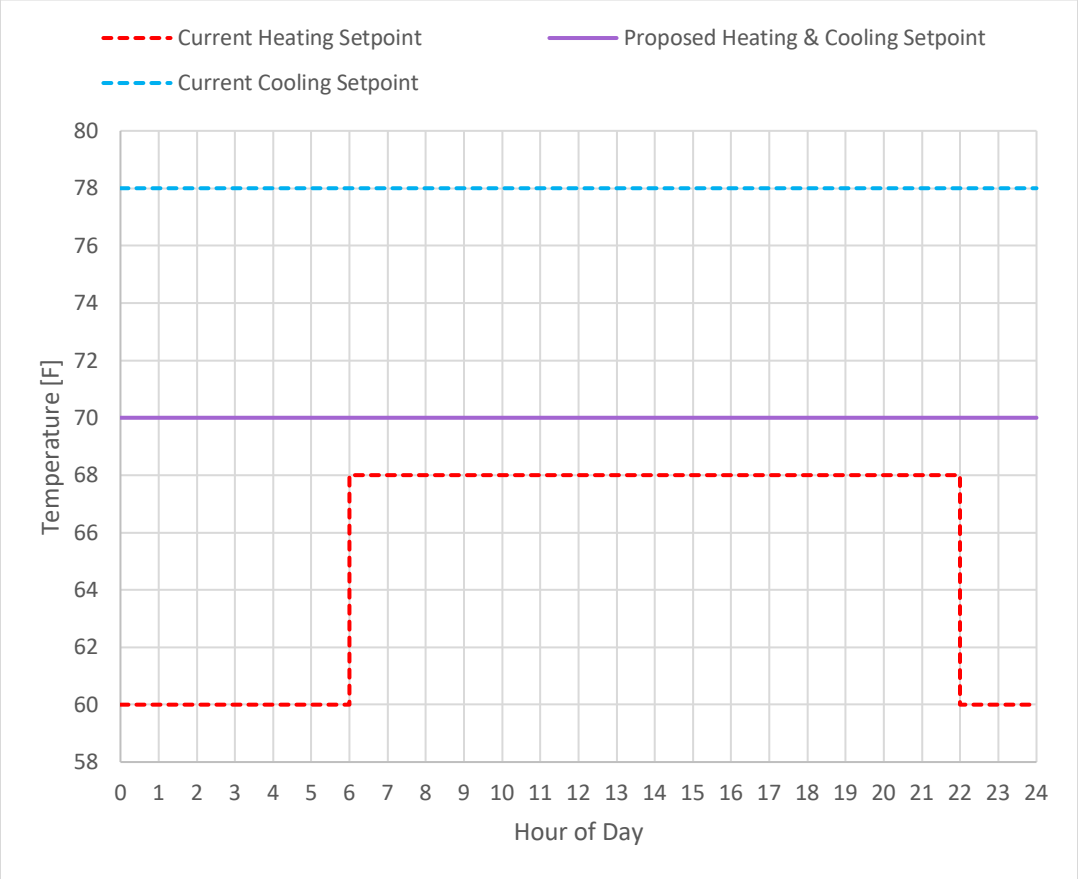

Figure 11: Current and Proposed Hotel Guestroom Thermostat Setpoints

Hotel Sizes

The existing hotel prototype is based on Department of Energy's Small Hotel prototype (Department of Energy, 2025). For PNNL's studies, this prototype is meant to represent hotels that are less than 60,000 square feet (Xuechen, Butzbaugh, Chen, Zhang, & Rosenberg, 2020). An investigation was carried out to determine if this prototype was adequate to represent the typical hotel in California.

Geometry

The Dodge construction-starts database (CAS) (Dodge Construction Network, 2023) was used to gather data for hotels in California. Evaluation of this data showed that if hotels were split between those less than 60,000 square feet and those greater than 60,000 square feet, the existing prototype was a good representation of buildings less than 60,000 square feet as presented in Table 1.

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Table 1: Existing Hotel Correlation to California Hotels Less Than 60,000 Square Feet

Data Source	Number of stories	Footprint [thousand sf]
Existing CEC Hotel Prototype	4	10.6
Dodge CAS[9]	2.8	14.2

However, the Dodge CAS data also showed that 74% of the hotel statewide floor area is represented by buildings larger than 60,000 square feet and that the characteristics of those buildings vary somewhat from the characteristics of the existing hotel prototype. For this reason, a new Large Hotel prototype was proposed.

PNNL also has a Large Hotel prototype meant to represent hotels larger than 60,000 square feet. The number of stories and footprint of this prototype corresponded well to the characteristics of hotels in California that are larger than 60,000 square feet as presented in Table 2. CEC staff propose to use the Large Hotel prototype from PNNL for California.

Table 2: Proposed Large Hotel Correlation to California Hotels Greater Than 60,000 Square Feet

Data Source	Number of stories	Footprint [thousand sf]
PNNL Large Hotel	6	20.4
Dodge CAS[9]	8.7	25.2

HVAC Systems

Investigations of the California End-use Survey (CEUS) (Barioant, Mort, Alereza, & Dohrm, 2024) database uncovered that hotels of this size typically use a central gas boiler and chiller that serve four-pipe fan coil systems in guestrooms. So, this design was chosen as the HVAC system for guestrooms in the new Large Hotel prototype.

CONCLUSION

To improve representativeness of the school and hotel building prototypes, K-8 School, High School, and Large Hotel prototypes are proposed. The K-8 school prototype is based on discussions with, and design drawings from, DSA staff. The High School prototype is also based on DSA staff input and was adapted from the K-8 school prototype. The Large Hotel prototype is based on the PNNL Large Hotel prototype which was found to correlate well with California hotels larger than 60,000 square feet. Table 3 summarizes the features of the proposed prototypes.

[9] The number of stories and footprint for the Dodge CAS data are floor-area weighted averages for all the data in the state.

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Table 3: General Prototype Specifications

Proposed Prototype	Floor Area [square feet]	Number of Stories	HVAC System
K-8 School	41,500	Classroom Building: 2 Kindergarten: 1 Administrative/MPR: 1	Single-zone heat pumps
High School	190,000	Classroom Buildings: 2 Administrative/Cafeteria: 1 Gym: 1 Theater: 1	Single-zone heat pumps
Large Hotel	122,100	6	Four-pipe fan coils with central gas boiler and chiller

Assembly building schedules were also modified to improve representativeness. Specifically, updated schedules are proposed for theaters, museums, libraries, religious worship, convention centers, and fitness centers and gymnasiums.

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