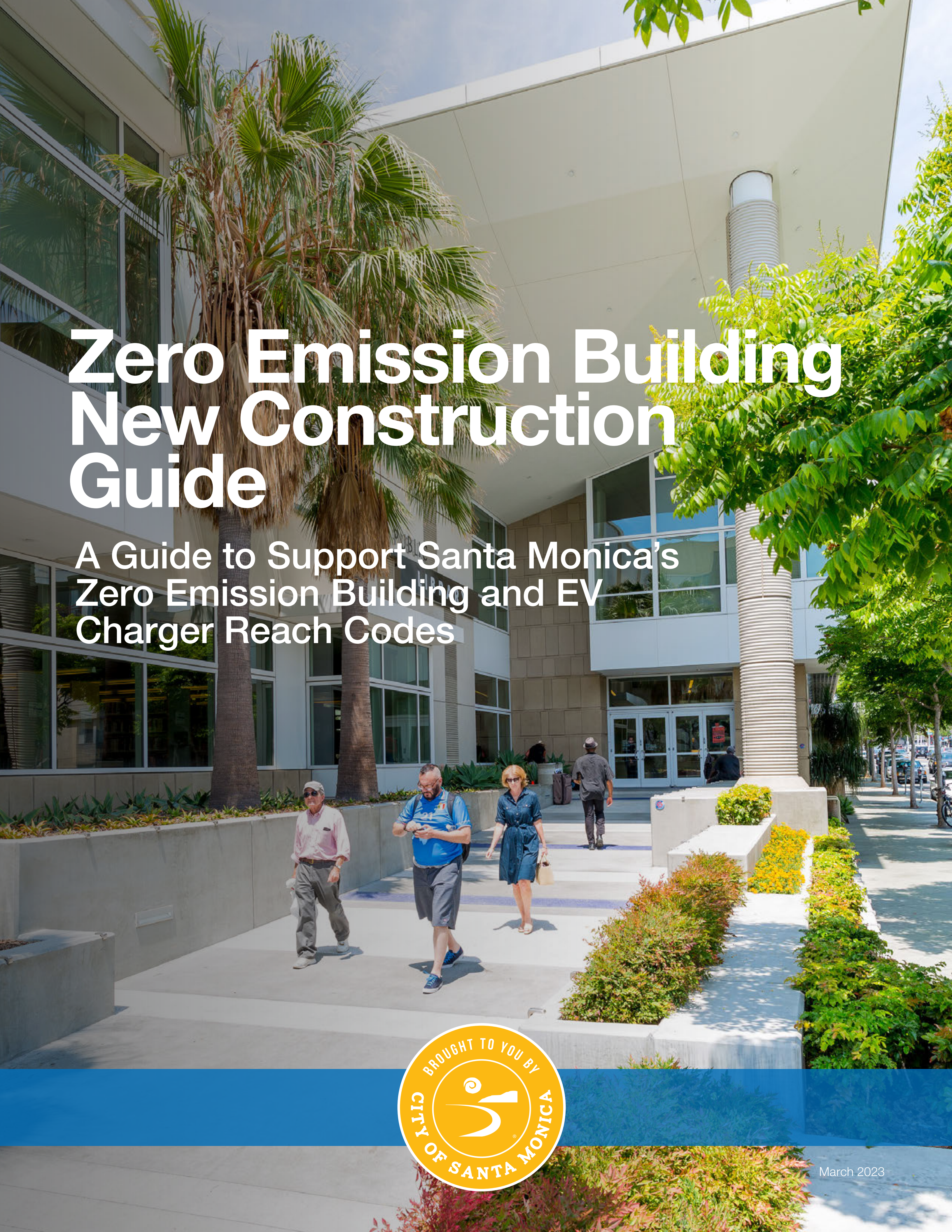

Zero Emission Building New Construction Guide

A Guide to Support Santa Monica's Zero Emission Building and EV Charger Reach Codes

BROUGHT TO YOU BY CITY OF SANTA MONICA

March 2023

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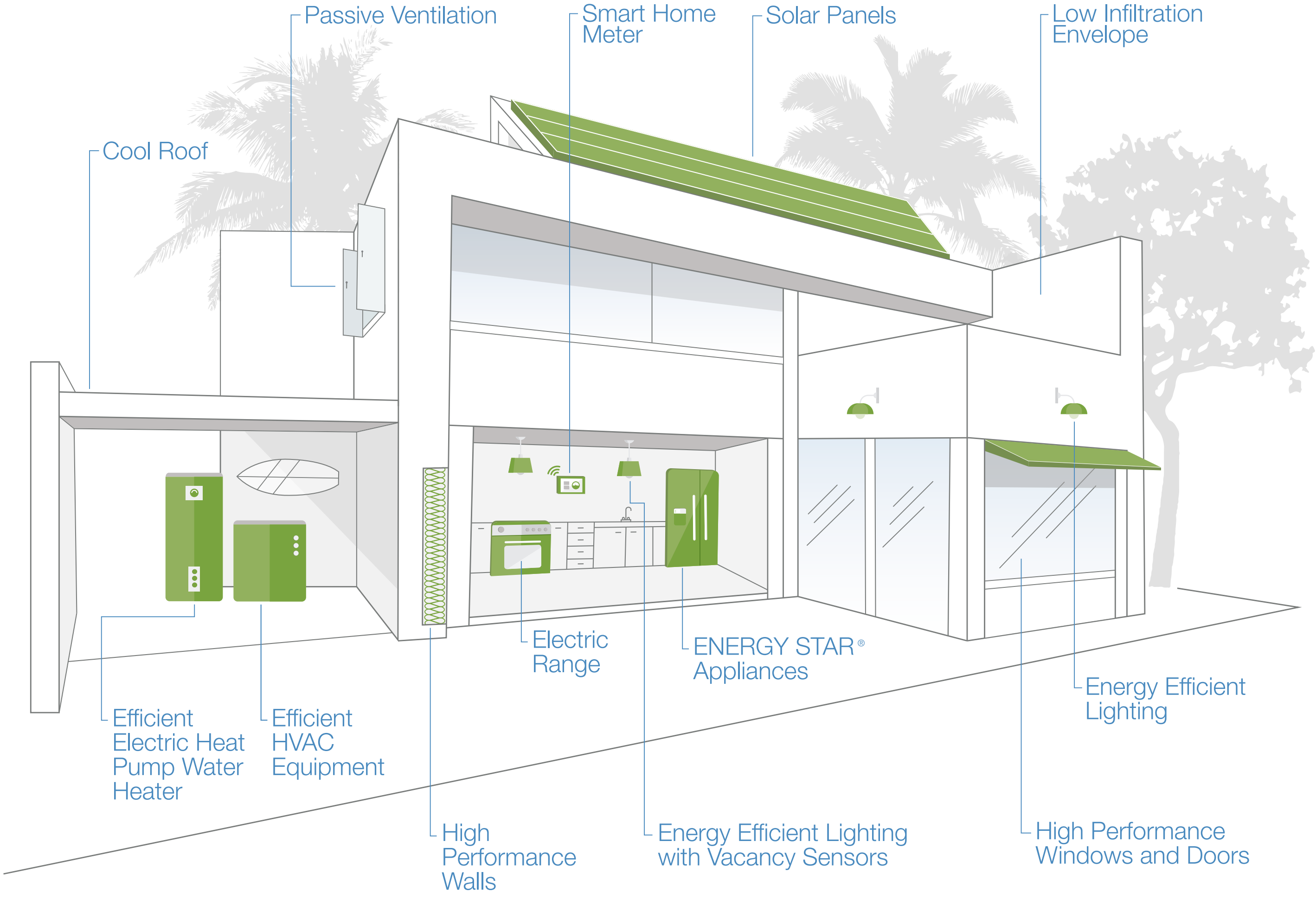


Figure 1. Zero net energy home energy efficiency and energy production features.

Main Library Santa Monica Blvd. Entrance with patrons.

Introduction

The City of Santa Monica has a long history of promoting high performance buildings that reduce energy use and carbon emissions. Most recently, in September 2022, the City Council adopted the Zero Emission Building (ZEB) Code and the Electric Vehicle (EV) Charger Reach Code. The ZEB Code amends the municipal code and drastically reduces operational carbon in new buildings by leveraging Santa Monica's decarbonized electricity supply and requiring the construction of all-electric buildings. The EV Charger Reach Code, on the other hand, amends the CALGreen EV charging requirements by increasing the percentage of required EV charging spaces.

Santa Monica's community choice aggregator, Clean Power Alliance (CPA), procures 100% carbon-free power for the community, delivered via Southern California Edison's existing electricity grid infrastructure. All-electric buildings that are powered by a combination of on-site solar and 100% renewable power from the CPA operate with zero emissions. Electric buildings reduce operational greenhouse gas (GHG) emissions in support of Santa Monica's goal to achieve an 80% reduction (below 1990 levels) in community carbon emissions by 2030. Existing all-electric buildings with energy supplied by CPA are supporting the City's goal for all buildings to be zero net carbon emissions (zero-emissions). The ZEB Code leverages this zero-emissions electricity to reduce the emissions of new buildings and major additions by requiring the construction of all-electric buildings (Figure 1).

This guide supports compliance with the Santa Monica ZEB Code and EV Charger Reach Code by providing guidance for meeting all of their requirements, including All-Electric Design, EV charging spaces, and tips to maximize energy efficiency. It also includes additional material on Grid Integration, which is not required by the ZEB Code, but which will become an increasingly important part of the decarbonization of buildings and the electrical grid. Finally, it includes a couple of case studies to help show what an all-electric building looks like.

Much of the guidance in this document applies to all building types; however, when information is presented that is specific to single-family, multifamily or non-residential buildings, those sections are highlighted with the following icons:

SF MF NR

zHome townhomes in Issaquah, WA

Santa Monica's 2022 Zero Emission Building (ZEB) Code

Santa Monica's ZEB Code applies to all building projects: new construction and renovation of single-family homes/ duplexes, low-rise multifamily (three stories or less), high-rise multifamily (four stories or more), hotels, and all other non-residential buildings.

The ZEB Code amends the Santa Monica Municipal Code and reduces emissions and on-site pollution by requiring that new buildings be all-electric. The ZEB Code prohibits gas infrastructure (commonly referred to as "natural gas piping") in new buildings.

ZEB Code Exemptions

The following buildings and appliances are exempted from the ZEB Code, and thus are not required to be all-electric:

1. Junior Accessory Dwelling Units.
2. Accessory Dwelling Units that are attached to an existing primary residential unit that has natural gas infrastructure.
3. City-Designated Historic Resources that were demolished in the course of rehabilitation, if compliance with the requirements would require the removal of more original finishes or features than proposed in the rehabilitation scope.
4. The use of portable propane appliances for outdoor cooking and heating.
5. Where the permitting authority has authorized fuel gas infrastructure in a new building after the applicant has established that it is not physically feasible to construct the building without fuel gas infrastructure.

WHAT IS TYPICALLY NOT CONSIDERED AN EXEMPTION?

Any of the following fuel gas connections/uses:

- Space heating (interior or exterior)
- Domestic water heating
- Residential pool or spa heating
- Fire pit, BBQ, or fireplace (interior or exterior)
- Residential cooking appliances or equipment
- Clothes dryer

Electric-Readiness Requirement

All new construction that is built with fossil fuel infrastructure due to meeting any of the exemptions above, including commercial kitchens, must have sufficient electric capacity, wiring, and conduit to achieve full building electrification in the future.

Find more details on the Zero Emission Building Code at: www.santamonica.gov/zero-emission-building-code

ACCESSORY DWELLING UNITS

Detached ADUs are treated as new single-family homes and must comply with all applicable requirements including all-electric and Title 24 solar PV requirements. ADUs that are completely within or are an addition to an existing building do not have to comply with the ZEB ordinance, unless the existing building meets the definition of new construction or meets the definition of demolition stated above. Similarly, attached ADUs, manufactured units, and garage conversions typically won't be required to install solar panels.

DEFINITIONS

EV Charger: Off-board charging equipment used to charge an electric vehicle.

Low Power Level 2 EV Ready: A 208/240-volt 20-ampere minimum branch circuit and a receptacle.

EV Capable: Electrical panel space and load capacity to support a branch circuit and necessary raceways to support EV charging.

Santa Monica's 2022 EV Charger Reach Code

In 2022, Santa Monica amended the CALGreen EV charging requirements in order to increase access to EV charging infrastructure in new buildings. Increasing the availability of EV charging infrastructure in new facilities is a critical component of EV adoption and supports the City's carbon emissions reduction goals outlined in the EV Action Plan and the Climate Action & Adaptation Plan.

The Santa Monica amendments requires a higher percentage of the parking spaces to be equipped with EV charging infrastructure compared to CALGreen. By requiring the conduit, panel capacity, and other components to be installed during new construction for EV capable and EV ready spaces, the cost of adding EV chargers in the future is significantly reduced. The Low Power Level 2 EV Ready requirement introduced in the 2022 CALGreen, and increased in Santa Monica's reach code for multi-family and workplace facilities, allows more EV chargers to be installed without requiring the full 40 amps of power previously required for all EV charging spaces.

Table 1: EV Charging Requirements for Residential New Construction
This table provides the EV charging requirements for new residential construction.

	EV Capable	Low Power Level 2 EV Ready	EV Chargers	Total Potential EV Spaces
Single-family, Duplex	1 per unit	--	--	1+
Multifamily, Hotel/ Motel	10%	60%	5%	75%

Table 2: Sample EV Charging Requirements for Multifamily & Hotel Buildings
This table provides a list of example multifamily and hotel buildings with differing numbers of total parking spaces and potential EV spaces.

Total Parking Spaces	EV Capable	EV Chargers	Low Power Level 2 EV Ready	Total Potential EV Spaces	% Total Potential EV Spaces	Power (Amps)
3	1	0	2	3	100%	80
10	1	1	6	8	80%	200
50	5	3	30	38	76%	920
100	10	5	60	75	75%	1800

EV charging at the Civic Center Parking Structure in Santa Monica (Courtesy of City of Santa Monica).

Table 3: EV Charging Requirements for Non-Residential New Construction

This table provides the EV charging requirements for non-residential buildings other than offices. Non-residential buildings are required to have a certain number of EV capable and EV charging spaces, but there are no requirements for EV ready spaces for non-residential buildings (other than office buildings, please see Table 5 for office-specific requirements).

Total Parking Spaces	EV Capable	EV Chargers[1, 2]
0-9	2	0
10-25	5	2
26-50	11	4
51-75	19	5
76-100	26	9
101-150	38	13
151-200	53	18
201 and over	30% of total	33% of EV capable spaces

1 Note: The number of EV chargers counts toward the required number of EV capable spaces.

2 Direct Current Fast Charge (DCFC) Option: 1 DC Fast Charger (480V; min 50 kW) may replace up to 5 required level 2 (240V) chargers; at least one level 2 charger must be provided per project.

Table 4: Sample Non-Residential EV Charging Requirements
This table provides an example of required EV charging for non-residential (non-office) buildings based on total parking spaces.

Total Parking Spaces	EV Capable	EV Chargers[1, 2]	Total EV Spaces	% Total Potential EV Spaces	Power (Amps)
5	2	0	2	40%	80
15	3	2	5	33%	200
35	7	4	11	31%	440
60	14	5	19	32%	760
85	17	9	26	31%	1040
125	25	13	38	30%	1520
175	35	18	53	30%	2120
250	75	25	100	40%	3990

1 Note: The number of EV chargers counts toward the required number of EV capable spaces.

2 DCFC Option: 1 DC Fast Charger (480V; min 50 kW) may replace up to 5 required level 2 (240V) chargers; at least one level 2 charger must be provided per project.

EV Charging Requirements for New Office Facilities

In addition to complying with the non-residential EV infrastructure requirements in Table 3, parking lots serving new offices must have Low Power Level 2 EV Ready spaces chargers in 20% of the parking spaces. Workplace charging is a convenient option for EV drivers that do not have home charging access, and helps balance demand on the electrical grid by drawing energy when there is typically excess solar power available during the day. Table 5 provides a sample of EV charging requirements for new offices with various parking spaces.

Find more information on the EV Charger Reach Code at: www.santamonica.gov/electric-vehiclecharger-requirements-for-new-construction

Table 5: Sample Office Facility EV Charging Requirements
This table provides an example of required EV charging for office buildings with different numbers of total parking spaces.

Total Parking Spaces	EV Capable	EV Chargers[1, 2]	Low Power Level 2 EV Ready (20%)	Total EV Spaces	% Total Potential EV Spaces	Power (Amps)
5	2	0	1	3	60%	100
15	3	2	3	8	53%	260
35	7	4	7	18	51%	580
60	14	5	12	31	52%	1000
85	17	9	17	43	51%	1380
125	25	13	25	63	50%	2020
175	35	18	35	88	50%	2820
250	75	25	50	150	60%	4990

1 Note: The number of EV chargers counts toward the required number of EV capable spaces.

2 DCFC Option: 1 DC Fast Charger (480V; min 50 kW) may replace up to 5 required level 2 (240V) chargers; at least one level 2 charger must be provided per project.

An outdoor unit for a residential heat pump space conditioning system.

Efficient, All-Electric Design

Nestled between the Pacific Ocean and the San Gabriel Mountains, projects in Santa Monica can take advantage of the warm, temperate climate and moderate wind to passively heat, cool, ventilate, and even illuminate buildings with the right site orientation and design. Combined with Santa Monica's carbon-free electricity, projects can reduce energy and rapidly decarbonize buildings in the City by utilizing highly efficient electric equipment.

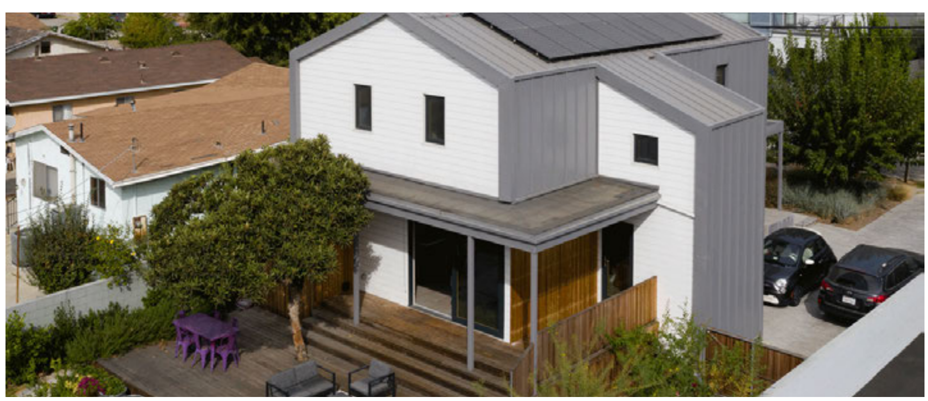
Energy efficiency is one of the foundations of zero-emissions buildings. Although there is no one-size-fits-all approach, best practices can help a project achieve an electric, zero net carbon project. Several opportunities exist in this section to support teams, including utilizing passive systems and selecting highly efficient, all-electric systems. Links to the Title 24 requirements are provided, including a resource on the Home Energy Rating System (HERS) verification.

Additionally, all-electric buildings offer several advantages over mixed-fuel buildings beyond just carbon reductions. Eliminating gas service to buildings comes with substantial cost savings for construction projects. Combined with the fact that the price difference between gas and electric equipment has been narrowed—and even eliminated in many cases—all-electric buildings generally cost less to construct than mixed-fuel buildings when thoughtfully designed. Eliminating gas combustion, especially from cooking, also benefits indoor air quality, cleanliness, and safety.

The following steps are recommended to achieve an efficient, net zero carbon building:

1. Set Goals
2. Reduce Energy Loads
3. Select Efficient Equipment
4. Add Renewable Energy
5. Integrate with the Grid

It is important to recognize that electric HVAC equipment includes both low-efficiency technology like resistance heating as well as higher-efficiency equipment such as heat pumps. While low-efficiency equipment generates heat through an electric resistance coil, heat pumps move and concentrate heat. It isn't easy to reach the levels of efficiency required by California's Title 24 with electric resistance-based equipment for larger loads, including water heating and space heating. All-electric buildings in Santa Monica will most likely utilize heat pumps for these end uses. In addition, passive ventilation, cooling, and lighting solutions can significantly minimize energy use but need to be incorporated early in the design process since they can have a significant impact on the design of the building.



Perlita Passive House in Los Angeles, CA designed by Arcolution LLC. (Image courtesy of Lawrence Anderson)

Planning and Goal Setting

There is no single recipe for energy efficiency in buildings; many efficiency measures and combinations of measures can be used to build an efficient all-electric building. Discussions with the project team and early energy modeling can help determine which approach or mix of energy efficiency measures is most appropriate for the project. With many paths available, it is important to understand the options and set goals around daily performance. For example, consider the trade-offs, like mechanical window controls to open and close windows at set hours, as opposed to manual windows, which come at a lower upfront cost, but require proper occupant education and use.

The following measures, in this order, lower energy consumption.

1. Building Orientation
2. Envelope Improvements
3. High-Efficiency Electric Equipment and Appliances
4. HERS Verifications (for residential projects)
5. Building-Grid Integrated Controls
6. Renewables

INTEGRATED DESIGN

Integrated design recognizes that a successful project begins at the schematic design phase and considers input from various key stakeholders, including the owner, occupants (when possible), architect, design engineers, energy consultants, contractors, and subcontractors (including HERS Raters and commissioning agents). Teams are encouraged to start early, set goals, make sure all parties are involved early in the integrated design process, and committed to the result.

Reducing the energy consumption of lighting, water heating, and space conditioning can reduce the equipment size and renewable energy resources needed to meet the needs of a building.

In Santa Monica, the largest energy consumers are typically water heating and space heating, although this does not mean that the other measures should be excluded from evaluating energy efficiency opportunities.

Several resources are available to help teams achieve a successful design. These include utility-sponsored programs and building certifications such as the Department of Energy's (DOE) Zero Energy Ready Home (ZERH), the ASHRAE Zero Energy Advanced Energy Design Guides, Passive House (PHIUS), Leadership in Energy and Environmental Design (LEED), and Living Building Challenge. Code-education and zero net energy (ZNE) best practices training resources include Energy Code Ace, California Association of Building Energy Consultants (CABEC), and the Zero Energy Project, among many others.

Perlita Passive House in Los Angeles, CA designed by Arcolution LLC. A blower door test is conducted to quantify the amount of air leakage and the effectiveness the air-sealing prior to finishing the house. (Image courtesy of Lawrence Anderson)

ENERGY MODELING

The California Energy Commission (CEC) provides free compliance software for modeling both residential and non-residential projects: CBECC-Res for low-rise residential projects and CBECC-Com for non-residential. Early and iterative energy modeling can be used during design to determine the benefits of various energy efficiency measures. For example, modeling can be used to determine if envelope measures—such as additional wall insulation, exterior shading or triple-glazed windows—allow space conditioning system sizes to be reduced enough to save construction costs while also reducing operating costs. An energy consultant will model the proposed building efficiency measures and inform the project team of ways to optimize the energy use in the building and meet low carbon and Title 24 requirements.

Title 24 requirements currently regulate energy use associated with space heating, space cooling, ventilation, other HVAC loads, domestic and service water heating, lighting and appliances. However, not all energy efficiency measures can currently be included in a Title 24 compliance model, such as plug load control, optimized daylighting, and passive cooling or ventilation. An energy consultant can further explain the software capabilities (and limitations) and Title 24 requirements during initial goal-setting meetings.

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HERS

Low-rise residential projects can use the Home Energy Rating System (HERS) standard in the design phase to identify energy efficiency measures. HERS is a nationally recognized system for inspecting and calculating a home's energy performance that has been adapted for California's energy code. Several of the residential measures—such as duct leakage and envelope tightness—require or have an option for HERS verification in order to show compliance and receive credit under Title 24, effectively requiring that a HERS Rater arrive on-site for almost every new construction, low-rise residential project. HERS verification can range from a visual inspection and confirmation to a test requiring specialized equipment.

Component	Single-Family
On-site visit ($/visit)	$270
Standard Measure verification ($/measure)	$55
Additional Measure verification ($/measure)	$125

Table 7: HERS costs for Single Family Homes.

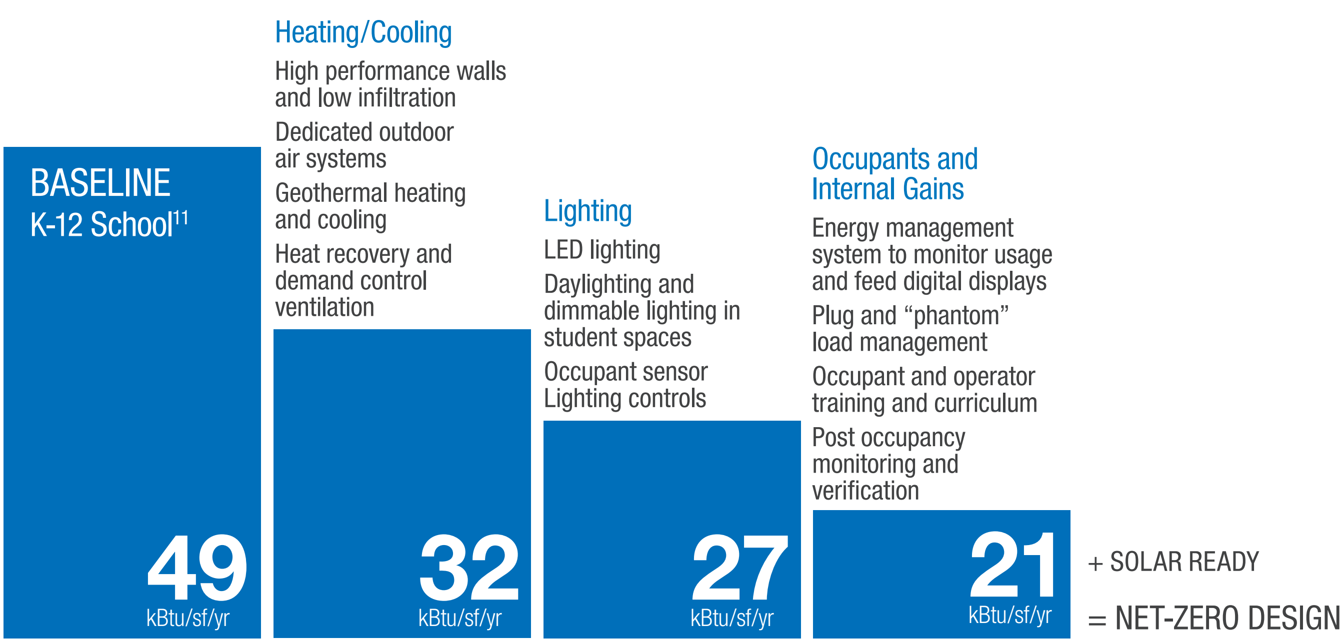
Component	Multi-family
Method 1: On-site visit ($/visit)	$300
Method 2: Per unit verification, no QII ($/unit)	$245
Method 2: Per unit cost of QII ($/unit)	$60

Table 8: HERS costs for Low-Rise Multifamily buildings.

HERS PRICING

HERS Raters typically charge a lump sum amount based on the location of a project, the number of site visits required, and the number of units and measures to be verified. It is not market practice to identify the cost for an individual HERS verification, as several factors affect the cost. HERS verification expenses include the cost for site visits and tests by a certified HERS Rater. HERS Raters typically price based on the number of site visits or by unit, then add-on for the number of features to be verified per visit. While general cost assumptions are explained below, for accurate pricing, contact a HERS Rater and include them in the integrated design process to develop a verification schedule. This will also avoid unnecessary site visits.

Typical single-family HERS verification pricing includes a set fee for each site visit and additional fees for each HERS measure to be verified during that visit. To estimate costs for each single-family HERS measure, project teams can use the following per-site and per-measure cost estimates shown in Table 7 as a guide. Standard measures include mandatory verifications and other common measures that may only require visual inspection, such as verified SEER/EER and refrigerant charge verification. Additional measures would include measures that require substantial field testing and equipment, such as



11 CBECS 2012 Data: https://portfoliomanager.energystar.gov/pdf/reference/US%20National%20Median%20Table.pdf

12 AEDG Guide NZE EUI Feasibility Targets for Vermont Climate Zone AEDG Targets: https://www.ashrae.org/technical-resources/aedgs/zero-energy-aedg-free-download

K-12 school energy use intensity (EUI) reduction steps used to achieve ZNE. Building system efficiencies provide the necessaries energy reductions to be able to produce all energy on site, over the course of a year.

Blinds can be used to improve fenestration performance through reducing solar heat gain and glare. (Image courtesy of City of Santa Monica).

low leakage ducts in conditioned spaces. These costs are 2017 estimates and actual costs can fluctuate based on the number of visits required, the number of measures, and the number of homes to be verified during each visit.

For multifamily buildings, HERS verification pricing differs by HERS company. Generally, HERS Rater pricing falls under two methods:

1. By the number of site visits, or
2. By the number of dwelling units (Table 8)

Method 1 is the price per site visit required, regardless of the number of measures or units. The total cost will scale appropriately based on the number of measures and units because this will impact the number of required site visits. The price-per-unit approach for Method 2 makes general assumptions on the standard number of visits per measure and averages costs among the number of units in a project. Quality Insulation Installation (QII) adds an additional $60 to each unit cost due to the multiple site visits required.

Envelope

An efficient building starts with a well-insulated and sealed building envelope (enclosure) to minimize heat transfer between the conditioned and unconditioned spaces. This reduces the energy needed to heat and cool a building. Attention must be paid to the details and joints during construction to ensure maximum energy performance and comfort for the occupants.

Project teams should discuss fenestration design and performance values with the consultant to optimize and balance project goals in regard to window area, orientation, and performance characteristics. Considering wall, floor, roof insulation, well-sealed air barrier, and other envelope measures early in the design process can reduce the size of the HVAC system, or even eliminate the need for mechanical heating and cooling. It is important that the entire project team, including subcontractors whose work may impact the building envelope, are aware of the project goals in order to successfully achieve the best envelope performance. This includes minimizing envelope penetrations which may jeopardize the integrity of thermal and air barriers.

Spray foam insulation can increase comfort by minimizing heat transfer, reducing HVAC loads (Courtesy of Dan Tapia).

INSULATION

Well-insulated walls, floors and roofs/ceilings reduce the amount of heat transfer through exterior walls and reducing HVAC loads. This can be accomplished through lower wall assembly U-factor via improved insulation, the use of a continuous insulation layer, and potentially increased stud thickness or a reduced framing factor. A building envelope U-factor represents the overall rate of heat transfer of an assembly—the lower the U-factor, the lower the rate of heat transfer. The wall assembly U-factor includes both the framing and insulation. Insulation is more resistant to heat transfer than metal or wood framing, so a wall assembly can greatly benefit from continuous exterior insulation over the framing which reduces heat transfer through the studs. It is important to discuss additional considerations with the framer and installer when implementing continuous exterior insulation greater than 2", typically around R-8.

Low-U-factor walls can be built with different envelope assemblies, and some can be more cost effective than others. For example, 2x6 studs carry a cost premium over 2x4 studs; however, 2x6 studs allow more space for a lower-density insulation which is cheaper than the high-density batt, spray foam, or other insulation types needed for 2x4 studs. Additionally, 2x6 studs more easily allow the framer to switch from 16" on center spacing to 24" on center, which can lead to a net first-cost reduction for lumber and limited thermal bridging.

R-38 Attic Insulation. Photo by Ryan McFarland. www.zieak.com

Assemblies and their resulting U-factors can be found in the 2022 Title 24 Joint Appendices JA4.3. Modeling guides are available through the California Advanced Homes Program (CAHP) Master Builder initiative for assistance in properly modeling High Performance Wall and High Performance Attic strategies in California Title 24 compliance software. Master Builder also has a product catalogue for a partial listing of product solutions available to the California market.

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QUALITY INSULATION INSTALLATION

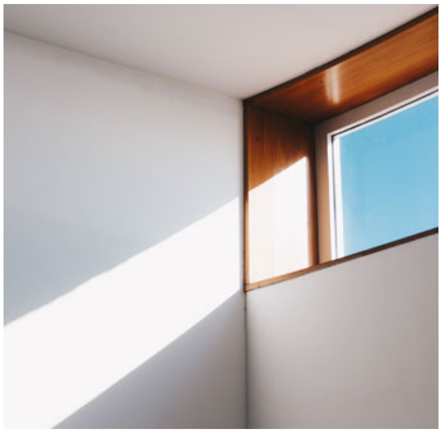
In residential construction, Quality Insulation Installation (QII) ensures that insulation is installed properly in floors, walls, and roofs/ceilings to maximize the thermal benefit of insulation. Depending on the type of insulation used, QII can be simple to implement for only the additional cost of HERS verification. Batt insulation may require an increase in installation time because the insulation needs to be cut to fit around penetrations and special joists, but this is standard practice for many insulation installers. Make sure that the insulation contractor is aware that QII is desired, and that the energy consultant indicates in the California Title 24 compliance software that this measure is being implemented, in order to receive the appropriate compliance credit.

There are costs associated with QII such as HERS verification, and potentially additional labor time, to install insulation to the highest standards. HERS verification requires at least two on-site visits for a single-family home and multiple visits for low-rise multifamily, depending on the number of units. The on-site visits can be coordinated with other HERS verifications to maximize each HERS Rater visit and reduce costs. For more information on HERS verifications and best practices to minimize costs associated with on-site verifications, see the HERS Section.

FENESTRATION

Design and construction efforts to achieve envelope energy efficiency can be lost through the selection and installation of poor performing windows, skylights, and doors or through large window areas. Santa Monica's temperate climate does not require triple-pane glazing but careful consideration for the amount of window-to-wall ratio and location of windows is important for thermal heat gain.

The National Fenestration Rating Council rates glazing performance by U-factor and solar heat gain coefficient (SHGC). U-factor is a measurement of the overall rate of heat transfer for the window assembly (including framing). SHGC describes how solar radiation is admitted through a window (specifically the glass) from sunlight exposure. The lower the value for each rating, the more



Clearstory window (image courtsey of Joao Jesus from Pexels).

resistant a window is to heat transfer and better at insulating. There are window components that, when adjusted or applied, improve fenestration performance, including coatings, tinting, and triple-pane windows.

Title 24 includes a maximum window-to-wall ratio of 40% for non-residential buildings and 20% for low-rise residential buildings in the prescriptive performance path. There are times when more window area may be desired to take advantage of a beautiful view or the need for ample daylight. These designs will require the building to utilize the modeled performance compliance path and the energy penalty of additional window area will need to be offset by additional efficiency elsewhere in the design. Effective design of building fenestration can allow the reduction of total window area—and energy use—while still providing views and daylight.

COOL ROOFS

Cool roofs reflect solar energy and release previously absorbed heat, generally through the use of a lighter color roofing material. A cool roof will reflect a larger portion of the sun's energy away from the roof, keeping the building cooler and requiring less mechanical cooling. Title 24 sets minimum solar reflectance requirements that vary by building type, roof slope and climate zone. The values can be met with almost any tile product at no additional cost or several non-white asphalt shingle and TPO (thermoplastic polyolefin) products from no cost increase to as little as $0.05 per square foot cost increase from non-cool roof products. To look up the performance values of roofing products, visit the Cool Roof Rating Council website at www.coolroofs.org.

Cool roof requirements in Title 24 are specific to roof slope and building type. Title 24 defines low-sloped roofs as having a roof pitch of 2:12. Low-sloped roofs are generally found on multifamily and commercial construction and can be built with a variety of roofing products. Steep-sloped roofs are more typical of low-rise residential construction in California, and are typically built with asphalt shingles, concrete, or clay tile.

INFILTRATION

An effective way to reduce unwanted heat exchange between conditioned and unconditioned space is to reduce leakage through the building envelope. This can be achieved by sealing all air barriers, chases, and penetrations, using materials with low air permeance levels, and minimizing penetrations through the envelope. This detailed exercise requires coordination among subcontractors in the field and verification through a third party such as a HERS Rater to confirm the final building envelope air leakage rate.

Reducing building envelope leakage can be difficult to achieve if subcontractors do not have prior experience with this design goal. It requires that all subcontractors whose work may bring them in contact with the envelope are cognizant of the goals and their role in achieving low leakage. There is no specific method to achieve low building envelope leakage during construction, but best practices include spreading awareness among the project team and testing envelope leakage at specific points during construction to check a project is on track. The ENERGY STAR® Thermal Bypass Checklist[1] is a helpful resource to understand the steps entailed in achieving low envelope leakage in single-family and low-rise multifamily buildings.

Following best practices described in this section and working with a trained and knowledgeable construction crew offer the best opportunity to achieve infiltration rates equal to or better than 3.0 ACH50 in residential and 0.40 CFM/sf in non-residential.

1 https://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/TBC_Guide_062507.pdf

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Title 24 modeling includes a credit for HERS-verified reduced envelope leakage (below 5.0 ACH50 for single-family homes and 7.0 ACH50 for multifamily). However, since verification occurs after construction is complete, relying on an aggressive air sealing target could complicate compliance.

Daylight fills the Perlita Passive House in Los Angeles, CA designed by Arcolution LLC (Image courtesy of Lawrence Anderson)

Lighting

Efficient lighting results from a combination of reducing the need for electric lighting by optimized daylighting, using efficient lighting technologies, and effectively controlling electric lights with manual and automatic controls. Daylighting provides access to natural light and a connection to the outdoors. As a "free" resource, daylight can be supplemented with visually pleasing, high efficacy light fixtures and lamps for task lighting a work surface or general illumination at night. Lighting controls also ensure lights are only on when they are needed.

DAYLIGHTING

Daylighting opportunities need to be considered early in design since they impact building design and space layout. Rooms that require ample lighting—such as desks or kitchens—should be located near windows to use daylight to its fullest effect. Windows can be placed high in large or deep rooms to more evenly daylight the space. Hallways require lower light levels than main rooms so they can be interior spaces or have shared light from other rooms. Skylights can provide even daylight to a centrally located room (although there are trade-offs with losing roof space for HVAC or solar photovoltaic equipment).

Direct daylight can cause discomfort from glare and heat gain, so shading strategies are needed. Interior material color and texture selection are important considerations for glare reduction. Daylight can also bring solar heat gains that can increase the building's cooling load. Therefore, designs should limit the east-west direct sun exposure of the building and make use of overhangs to shade south-facing windows since the orientation of these windows allows significant solar heat gain into the space and will have an impact on code compliance. Strategically placed north-facing windows can provide even and consistent levels of daylight throughout the year. It is critical to account for the impacts of glare and solar heat gain associated with added windows and skylights. Exterior shading elements and interior blinds and shades help reduce periods of direct sun exposure.

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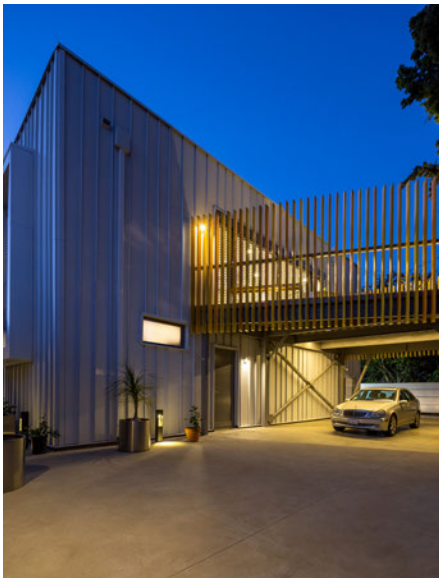
INTERIOR LIGHTING

In low-rise residential buildings, all permanently installed luminaires and lamps must be high efficacy. Efficacy is a ratio of light output to power used, rated in lumens (light output) per watt (power input). While code does not require plug-in lamps or other non-hardwired lighting to have high efficacy, following the same guidelines and selecting ENERGY STAR® products will result in lower energy use.

NR

In non-residential buildings, Title 24 sets limits for the amount of lighting power that is allowed per square foot of area (lighting power density); these lighting limits can be met through a combination of high efficacy light sources and good lighting design. A quality lighting design requires more than just the selection of high-efficiency light sources, it also requires the selection of luminaires that are appropriate and effective for the application and optimized placement of those luminaires. All-purpose lighting illuminates an entire room to a consistent lighting level while task lighting provides lighting to a specific area or surface, like a desk. All-purpose lighting has inherent energy inefficiencies if the lighting is designed for the highest intensity activity use in that space, as opposed to providing task lighting only where it is needed and lowering the intensity of the all-purpose lighting. For example, space navigation does not require the same



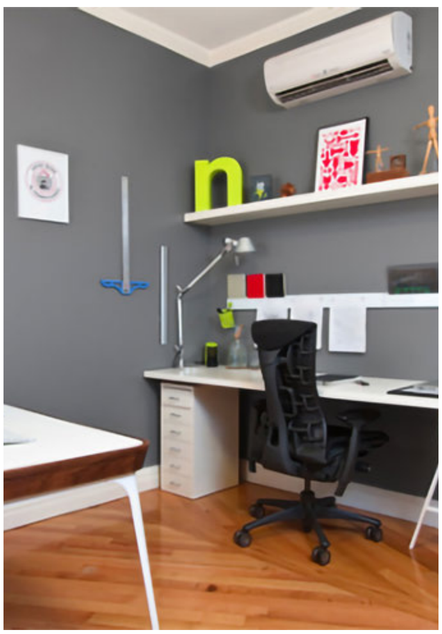
Exterior lighting at the Kienapfel Passive House in Culver City, CA designed by PARAVANT Architects. (Image courtesy of Fraser Almeida)

amount of light as reading nor does watching a movie require the same lighting as detail work like painting. It is important to identify horizontal work surfaces like kitchens and bathrooms where specific task lighting is necessary or where spot lighting for art will be located. Then, layer daylight and appropriate high efficacy light sources to illuminate the rest of the space as needed.

Energy use from lighting can also be reduced through the use of lighting controls such dimmable or bi-level switching devices, or a vacancy sensor as required by Title 24 in many spaces, especially in non-residential buildings. In residential buildings at least one luminaire in each of the following spaces must be controlled by a vacancy sensor: bathrooms, garages, laundry rooms, and utility rooms. While the use of vacancy sensors or daylight sensors may not be appropriate in all rooms, additional spaces like closets or basements can benefit from the use of vacancy sensors.

EXTERIOR LIGHTING

Similar to interior lighting, Title 24 requires high efficacy outdoor lighting. Most outdoor lighting used for area lighting must be controlled by a photocell, motion sensor, time switch control, or energy management system. Exterior lighting efficiency beyond code can be achieved through limiting the amount of exterior lighting, installing the highest efficacy lighting available, or all LED ENERGY STAR® Qualified Bulbs or lamps on the Design Lights Consortium's Qualified Product List.



Ductless Heat Pump (Courtesy of Nick Keppol).

Heating Ventilation and Air Conditioning

Heating, Ventilation, and Air Conditioning (HVAC) is the largest energy load in commercial buildings in Southern California and a significant load in residential buildings. Once the envelope design goals are established, identify heating, ventilation, and air conditioning needs and equipment in various spaces. Energy modeling can assist with the exercise of evaluating the energy performance and selecting high performance equipment. Also, consider duct design improvements such as locating ducts in the conditioned space to minimize heat transfer or eliminating ducts entirely with ductless heat pumps.

Installing the most efficient heating and cooling system is the second-best way to reduce energy use after reducing heating and cooling loads with an efficient envelope and passive strategies. The requirements for space conditioning equipment efficiency are set at the national level, so there is a significant opportunity to select equipment with much higher rated efficiencies than those required by the code. An efficient system is also one that has been sized correctly for the building heating and/or cooling loads. Avoid rules-of-thumb and ensure that the space conditioning equipment has been sized for the building's actual heating and cooling loads.

SPACE HEATING

The Title 24 incentivizes all-electric homes to have heat pumps for space and water heating. Heat pumps are three times more efficient than electric resistance technology, and they can serve both space heating and cooling with a single piece of equipment. Electric air-source heat pumps use the surrounding air to extract and reject heat and are by far the most common kind of heat pump equipment. Ground-source heat pumps use the ground to extract and reject heat. While they can achieve significantly higher levels of efficiency than air-source heat pumps in more extreme climates, they have comparable performance to air-source heat pumps in Santa Monica's temperate climate.

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In single-family homes and other low-rise residential buildings like apartments, as well as many smaller commercial buildings, heat pumps are an increasingly popular choice for space heating. In a mini-split heat pump system, a single indoor unit is connected directly to a single outdoor unit without the need for ducting. In multi-split systems, multiple indoor units are connected to a single outdoor unit. Variable refrigerant flow (VRF) systems are advanced multi-split systems that can allow some indoor units to heat while others cool.

NR

There are electric options for commercial buildings as well. Heat pump heating technologies are already widely used in mid- and high-rise buildings. Some mid-rise buildings can even use the same technologies and equipment preferred for low-rise buildings. For example, some multifamily buildings use split-system heat pumps where each unit has its own outdoor heat pump located on the roof. Many buildings can also use variable refrigerant flow (VRF) systems where multiple indoor units are connected to a single outdoor heat pump. There are limits on length of the refrigerant line that connects the indoor and outdoor units (these vary by equipment), so these are more common in mid-rise buildings. The through-the-wall packaged heat pumps that are common in hotels can be used in taller buildings, and only become less optimal in buildings that use curtain wall systems for the building envelope. However, these heat pumps are generally some of the least efficient heat pumps on the market and deliver lower levels of total performance than most other heat pump systems in the same application.

As buildings get taller, they have fewer system options in general, not just in all-electric buildings. Heat pumps and “reverse chillers” can also be used to provide heating in these systems. It is important to note that as buildings get taller, they become more dominated by cooling loads and less by heating loads. This means that a tall building sometimes provide cooling to the spaces even during the winter when people’s detached single-family homes would be providing heat. As a result, as buildings get taller, the cooling equipment becomes much more dominant, with the heating equipment getting smaller. This makes it easier to electrify the heating equipment in tall structures.

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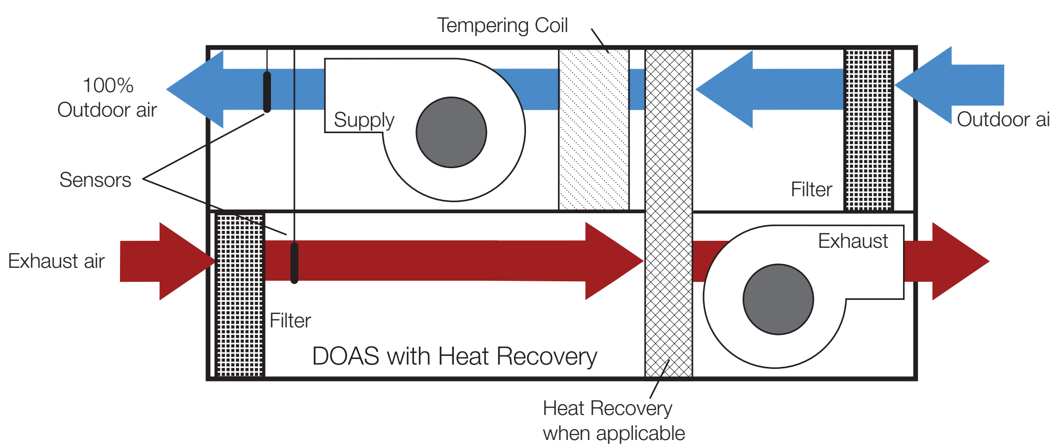
DEDICATED OUTDOOR AIR SYSTEMS



Components of a Dedicated Outside Air System with Energy Recovery (Courtesy NBI).

One effective way to reduce ventilation energy use is to decouple the space conditioning and ventilation systems. The fan requirements for ventilation are often very different than the fan requirements for space conditioning. Fan systems designed for space conditioning are typically not sized correctly for ventilation, which results in inefficient operation. Decoupling space conditioning from space ventilation requirements also effectively eliminates a common occurrence in buildings with variable air volume (VAV) systems—simultaneous

The outdoor unit for a commercial heat pump space conditioning system at the Santa Monica City Hall (Courtesy of City of Santa Monica).

heating and cooling. This inefficiency occurs when a zone with high cooling loads drives the supply air temperature down, causing most zones to receive air that has been cooled to a low temperature, then reheated. Simultaneous heating and cooling is not only one of the top energy problems in standard systems, but it also creates additional wear on hot-water pumps, chilled-water pumps, boilers, chillers, and auxiliaries.

Dedicated outdoor air systems (DOAS) gain their name from being 'dedicated' to bringing in outside air for ventilation and can be designed to meet 100% of the code ventilation requirements for all spaces. There are various DOAS configurations available as manufactured packaged units or built-up on-site, depending on the application. The DOAS configuration and features are driven largely by the latent and sensible loads of the application. Dehumidification, the use of pre-cooling (which may allow some downsizing of the space cooling system), and heat recovery are all system options to be considered based on the climate and building characteristics.

DUCT DESIGN AND CONSTRUCTION

Space conditioning and ventilation energy can be reduced through good duct design and construction. Duct designs that limit sharp turns, duct size transitions, and other air-flow constrictions reduce the amount of fan energy that is required to move conditioned air through the ductwork. Additionally, locating ducts in conditioned space can limit the energy losses from the ductwork. There are several strategies to locate ducts in conditioned space, including dropped ceiling chases and a conditioned plenum space. The cost to implement this strategy depends on the design and layout of the space so addressing ducts in conditioned space at schematic design is the best way to avoid higher costs and complications. Conditioned plenums and dropped ceiling chases are more cost-effective when the space layout allows for a single central plenum or chase. Dropped ceilings also require coordination with the HVAC, insulation, framing, and drywall subcontractors. Details of these designs and considerations are available in the Title 24 Residential Compliance Manual section 4.4.2.

When ductwork cannot be located in conditioned space, reducing duct leakage will reduce energy losses to the exterior. Tight ducts also improve the performance of ductwork located within conditioned space by ensuring that heating and cooling actually reaches the space for which it is intended. The CEC has established a testing protocol for this verification in the Title 24 Reference Appendices, along with all other HERS verification tests.

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REDUCE FAN WATTS

Upgrade the fans in air handlers from permanent split capacitor (PSC) motor to electronically commutated motors (ECM) that meets an efficacy of 0.3 watts/cfm or lower operating at full speed. Fan watt draw is a mandatory HERS verification measure, so the only additional cost is for the ECM, which is estimated to be around $100 to $150 per motor.

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REFRIGERANT CHARGE VERIFICATION

The leakage of refrigerant gas is a small but significant source of greenhouse gas emissions, because of the material's high Global Warming Potential (GWP). In residential buildings, a HERS Rater can verify that the amount of refrigerant in an air-cooled conditioner or air-source heat pump system is at an appropriate level. Having too much (overcharge) or too little (undercharge) can reduce the efficiency of a system and result in early failure. The correct refrigerant charge can improve the performance of a system and reduce energy wasted from an inefficient system. The cost for this measure is for HERS verification, which can be coordinated with other HERS verifications to reduce costs. In non-residential buildings, this function is a standard part of equipment installation.

Water Heating

Water heating is generally the largest single load in residential buildings in Santa Monica. There are three primary components to the performance of a water heating system: water conservation at the point of use, the efficiency of the water heating equipment and tank size, and the distribution system. High performance water heating requires careful consideration of all three of these components in the system design. The first step to reducing hot water energy consumption is to reduce the demand by specifying efficient, low-flow fixtures and water saving appliances in kitchens, bathrooms, lavatories, and laundry rooms. This will also decrease the overall water use. Once the hot water demand has been reduced, identify the most efficient way to heat, store, and distribute hot water.

Heat pump water heaters (HPWH) "pump" heat into the water, typically from the surrounding air. Since they move heat instead of generating it, HPWHs can achieve levels of efficiency three to four times higher than traditional electric resistance water heaters and four to six times higher than natural gas water heaters.

HPWHs have different design considerations than their electric resistance and natural gas counterparts. They generally do not heat water as quickly, and so require larger storage tanks to meet hot water demand. Most HPWHs extract heat from the surrounding air and need access to a volume of air that contains enough heat to meet the water heating needs. Therefore, they need to be located in space with a sufficient volume of air or need to be vented to provide enough air.

2500 Gallons of Well-Insulated Storage for Cyprus Apartments—230 Market Rate Units (Courtesy of Ecotope).

There are a handful of high-level technical considerations in the use of heat pump equipment for water heating described below.

STORAGE TANK SIZE

As discussed above, HPWHs are generally slower at heating water than electric resistance or gas water heaters, therefore they tend to require larger storage tanks to act as a buffer against demand. For example, a load that could be served by an electric resistance or gas water heater with a 40-gallon tank would generally require a 50-gallon tank with a heat pump water heater.

ACCESS TO HEAT

Since HPWHs move and concentrate heat instead of creating it, they need a source of heat. Most heat pump waters simply use ambient air, so generally, the source of heat is the air around the heat pump. The heat pump needs access to a large enough volume of air to provide the heat to "pump" into the water. Traditional water heater closet or boiler room-sized spaces pose a challenge for heat pumps because the HPWHs will quickly extract all of the heat from the air in the room. HPWHs located in smaller spaces will need to be vented to a larger space or the outdoors to provide adequate access to the requisite air from which to extract heat (not unlike the combustion air and exhaust that needs to be supplied to natural gas water heaters and boilers). Some HPWHs can also be connected to the ventilation exhaust or to the warm wastewater from a building to take advantage of waste heat from the building. Garages can provide an ideal location for HPWH equipment since they are protected from the elements, but still have a large volume of air from which HPWH equipment can draw heat.

Central HPWH equipment with 2500 gallons storage located in a parking garage in the Batik Apartments, Seattle, WA (Courtesy of Ecotope).

DEHUMIDIFICATION

Since HPWHs take heat from the surrounding air, they will cool and dehumidify the area where they are located. This can be advantageous in some circumstances, especially in buildings dominated by cooling loads. The dehumidification also means that HPWHs need to be provided with drains for the condensate. This is similar to a condensing gas water heater's need for a condensate drain, but an HPWH's condensate is not acidic like a condensing water heater. It therefore does not need to be treated before draining to the sewer.

ACOUSTICS

Heat pump water heaters generate some noise, similar to chillers, air-handlers, and other types of equipment. Noise can be an issue in some applications—such as apartments—but water heaters are often located where noise is not a significant issue, and newer models are much quieter than early generation models.

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Mid-rise and high-rise multifamily buildings often utilize centralized water heating equipment rather than a water heater for each dwelling unit. As buildings get taller, floor area becomes more valuable, and centralized systems allow for less square footage to be devoted to water heating systems. Centralized systems generally require a hot water loop with a recirculation pump to ensure that hot water is close to the points of use and that wait times for hot water are minimized.

CENTRAL SYSTEMS

Some HPWHs are far less efficient when reheating the warm water that returns from a recirculation loop than they are at heating cold inlet water. Therefore, central water heating systems with HPWHs will require special attention to the design to ensure efficient operation. When the recirculation loop is brought directly into the HPWH, special attention should be getting to select HPWH models that more effectively heat warm water. Another strategy is to separate the recirculation loop temperature maintenance load from the water heating load. An HPWH that is very efficient when heating cold water is selected to heat incoming cold water while an HPWH that is more effective at heating warm water is selected to reheat returning warm water from the recirculation loop. The latter appears to achieve higher levels of performance but is more complex to design.

Central HPWH systems also use larger storage tanks than their natural gas boiler counterparts. These larger storage tanks will need to be incorporated into space planning early in the design process.

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In single family homes and low-rise apartments, as well as non-residential buildings with limited water heating loads, heat pump water heaters can often be integrated into buildings with minimal modification to the building design.

A solar hot water system uses less energy than electric resistance or a heat pump to heat water. (Courtesy of U.S. Department of Energy)

SOLAR HOT WATER HEATING

Solar hot water heats, or preheats, water for use in the building. Typically, water is pumped from an insulated tank inside the building through conductive pipes to a heat-trapping solar collector box on the roof's south side (i.e. greenhouse effect). The water is heated by contact with the solar collector and then transferred to the insulated tank in the building. Solar hot water heaters convert 60%-70% of the sun's energy into heat and can provide 30-110 gallons of hot water daily.[2] This system uses less energy than an electric resistance water heater or heat pump because it uses the sun to heat the water. When the storage tank's temperature drops below a setpoint, a small heater can maintain the water temperature when the sun is not shining. The solar collector footprint on a residential roof ranges from two 3'x6' hot water solar panels to two 4'x10', hot water solar panels depending on hot water tank size. A solar hot water heater can cost between $7,000-$15,000, but may be eligible for federal renewable energy tax credits that recover up to 22% of their cost. In addition, solar hot water heaters can reduce household water heating bills by 75%.

Individual heat pump water heater. The heat pump is located above the storage tank (Courtesy Jeff Robbins).

DRAIN-WATER HEAT RECOVERY

Drain-water heat recovery recapture energy from wastewater before the hot water wash down the drain. Typical systems will include a small diameter metal pipe wrapped around a larger metal drain pipe. The heat energy from the drain pipe is transferred to the water in the smaller pipe, preheating the water. This process reduces the energy the water heater needs to heat cold water to hot water; instead, the water heater will use the preheated water, which could be 30 degrees warmer than the cold-water source. Drain-water heat recovery reduces the energy needed for household water heating by 25%. The average installed cost is $1,000.[3]

COMPACT WATER HEATER DISTRIBUTION

Compact HW distribution is a design strategy that reduces the length of pipe runs from an optimally located water heater to appliances and fixtures. Compact hot water distribution should be considered early in schematic design for successful implementation. Early consideration allows time to properly locate the water heater, hot water fixtures, and piping paths to minimize pipe lengths and also water, energy, and time waste. This measure can save project material and labor costs compared to a traditional hot water distribution design because less piping is used in the project.

Designing a project to meet Compact DHW Distribution requires forethought in floor plan and fixture placement, and/or moving the water heater to a location closer to fixtures (e.g., the attic or, an exterior or interior closet). Generally, compact distribution limits the hot water pipe length between the water heater and the fixtures, thus reducing distribution heat losses. A compact hot water distribution system has the added benefit of reducing occupant time waiting for hot water to arrive at the fixture, resulting in less wasted water.

2 Guidance for Architects, Engineers, and Builders; Zero Emission Building Code Prohibiting Fuel Gas Infrastructure in New Buildings. City of Santa Monica.

3 Santa Monica ZEB Code Summary

In low-rise residential buildings, Title 24 sets maximum allowed pipe lengths to qualify as a compact distribution system as outlined in Title 24 Residential Reference Appendices RA3.6.5.

The same principles can be applied to central systems with a hot water recirculation loop. In central water heating systems with high-efficiency equipment, heat loss from the distribution system can represent up to half of the energy use in the whole system. A recirculation loop is essentially a radiator. Minimizing the length of the recirculation loop reduces heat losses. Reducing the length of the recirculation loop may require grouping hot water end uses close together within the building. Placement of hot water uses can have a significant impact on the design of the building, which will need to be addressed early in the design process.

Insulating pipes reduces heat loss in pipes (Courtesy Wikipedia).

PIPE INSULATION

Pipe insulation reduces heat loss through the pipes and can help raise water temperatures at the appliance or fixture. The main benefit is that occupants will not need to wait long for hot water to run through the faucet. In some cases, the hot water temperature may be able to be lowered. Pipe insulation is especially important on hot water recirculation loops since they can be hot for significant portions of the day.

The 2022 Title 24 Standards include mandatory pipe insulation requirements in Table 120.3-A, which cover the majority of hot water pipes in both residential and non-residential buildings. The thickness of the pipe insulation requirements varies based on the size of the pipe and the temperature of the water the pipes carry. Combining pipe insulation and a compact distribution design will reduce costs since less pipe will require less insulation.

Equipment and Appliances

In highly efficient buildings, the energy demand from equipment and appliances can equate to 30-60%. New, highly efficient all-electric technologies are replacing gas equipment and are capable of achieving far higher levels of efficiency. Selecting energy efficient equipment and appliance and managing use will keep energy costs low and make zero net carbon or zero net zero goals achievable.

ENERGY STAR APPLIANCES

The ENERGY STAR® label is available for nearly all common appliances and equipment. It ranges from refrigerators, televisions, ceiling fans, computers, to pool pumps, and more. Look for higher tiered equipment for increased energy performance. CEE Tier 2, 3, 4, and CEE Advanced Tier are preferred over CEE Tier 1 products.

ELECTRIC COOKING

Electric equipment already exists for both residential and commercial kitchens. Portions of the United States do not use gas (for example, in parts of Florida where ground conditions preclude gas infrastructure), but rely primarily on electricity for their energy needs. Gas cooking is very inefficient, with only about 30% of the energy consumed actually being used to cook the food and the rest released as waste heat, while electric cooking equipment efficiency can approach 90%.[4]

Some consumers express a preference for natural gas for residential cooking since electric resistance stoves do not provide the same level of temperature

4 Frontier Energy. "Residential Cooktop Performance and Energy Comparison Study." Prepared for Sacramento Municipal Utility District, July 2019.

Electric kitchen at the Kienapfel Passive House in Culver City, CA designed by PARAVANT Architects. (Image courtesy of Fraser Almeida)

control and responsiveness of gas stoves. However, electric induction ranges offer a solution to this issue. These use an electromagnet field to “induce” heat in ferrous (steel and iron) cooking vessels like pots and pans. They allow the temperature to be changed as quickly and minutely as gas. Therefore, for cooking ranges, induction stoves offer an adequate alternative to gas.

The decision to use gas cooking in homes comes at a considerable cost. The infrastructure required for gas cooking is substantial, especially in multifamily buildings. Gas cooking also creates the need for more indoor ventilation, which increases the size and cost of the ventilation system. Perhaps most significantly, gas cooking has a tremendous impact on indoor air quality. Gas cooking can release levels of pollutants that, if they were measured outside, would violate the Clean Air Act.[5] As a result, households with gas cooking have nearly three times the rate of treatment for asthma.

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Like residential cooking, the electric equipment for commercial kitchens is readily available. National food restaurants, for example, have both gas and electric options for their restaurants depending on what utilities are available. Induction cooking is making inroads, even in commercial kitchens. Since it only heats the pots and pans and there is no open flame, induction cooking is safer for workers than gas or electric resistance cooking with reduced chance of a fire, smoke inhalation, and less risk of burns. Induction ranges also put less heat into the kitchen, making them more comfortable, more likely to meet the new OSHA indoor occupational heat standards, and reduce cooling loads in kitchens. Many of the commercial kitchens in Silicon Valley tech office buildings are all-electric, and some global tech firms are now working to transition all of their kitchens from gas to electric.

ELECTRIC CLOTHES DRYING

Electric dryers are widely available and heat pump dryers can be an effective alternative to electric resistance dryers. Often marketed as “condensing dryers,” these dryers have the additional benefit that they do not need an exhaust vent. They condense all of the water vapor that is drawn out of the clothes, eliminating the need to release the humid air to the exterior. The lack of an exhaust vent reduces building envelope penetrations and allows far more flexibility for laying out laundry spaces in a building.

5 Gillis, J. and Nilles, B. (2019). “Your Gas Stove Is Bad for You and the Planet” The New York Times. www.nytimes.com/2019/05/01/opinion/climate-change-gas-electricity.html

MF NR

Electric clothes dryers are widely available at the residential scale as are larger "commercial" electric dryers. However, as commercial dryers approach the very large sizes sometimes used in commercial laundries and hotels, availability of model choices becomes less common. All-electric buildings with very large laundry loads, such as hotels, will likely need to alter their designs to accommodate different equipment layouts that utilize different dryer models than gas-fired laundries.

PLUG LOADS

In very efficient buildings, plug loads are devices plugged into wall outlets and can represent 50% of total annual energy use. This energy use occurs when buildings are unoccupied, and devices are left plugged into the outlets. Selecting energy-efficient equipment and appliances is easier than ever with the popularity of the ENERGY STAR® label and the rise of plug controls. The reduction in plug loads will reduce energy demands and potentially allow for a smaller on-site renewable energy system.

PLUG CONTROLS

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Equipment, appliances, and other electronics that are not needed when the building is occupied—computers, monitors and televisions, lighting, fountains, chargers, etc.—can be plugged into a controlled circuit to be turned off during unoccupied hours. In non-residential buildings, Title 24 requires that 50% of receptacles in spaces such as offices and conference rooms be able to be automatically switched off at the circuit level. This is an effective way to reduce off-hour and vampire plug loads. Equipment that needs to operate at all hours—security systems, clocks, refrigerators, medical equipment, etc., can be plugged into an uncontrolled circuit. Products in both of these categories often have energy saving settings that can be applied to save energy whether the building is occupied or not.

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While these hard-wired approaches may not be appropriate for residential buildings, there are also plug-in options available. Plug strips are available that can control receptacles with an occupancy sensor, timer or even based on whether the device, such as a TV or computer, that is plugged into "master outlet" is powered on. There are also outlet switches that can be controlled by home automation switches or smart apps.

Renewable Energy

Once energy consumption has been minimized, on-site renewable energy systems and energy storage systems can be sized to optimize energy and financial savings. Santa Monica has an average of 281 days of sunshine a year, making it optimal for producing energy on-site with solar photovoltaic (PV) panels. The less energy the building uses, the fewer photovoltaic (PV) panels are required, and the lower the first costs. Additionally, the more the building is optimized with the grid, only limited battery storage is needed to store the energy generated on-site.

PV is the most cost-effective way for a building to create energy on-site. Panels are best located in areas with ample sunlight, preferably facing the south or west, often on the roof. Identify the amount of PV area required based in California Title 24 compliance software modeling and coordinate the necessary roof structure, space requirements, and minimize cast shadows with the design team and solar contractor early in design process.

Solar panels can be purchased, financed with a loan, or leased. Purchasing panels outright or with a loan allows owners to receive available incentives and/or tax credits. Loans and leasing reduce the upfront cost of the panels.

Tesla Power wall battery at the Kienapfel Passive House in Culver City, CA designed by PARAVANT Architects. (Image courtesy of Fraser Almeida)

Photovoltaic panels at NRDC Santa Monica Office (Courtesy of Tim Street-Porter).

Note however, the contract for leased panels generally gives away the "environmental benefit" of the solar panels. The company that owns the panels sells renewable energy credits (RECS) to others who want to buy the environmental benefit of clean power without installing a renewable energy system. The result is that the power from leased solar panels offsets someone else's carbon-intensive power supply and the environmental benefit is lost to the building where the systems is located.

Building-Grid Integration

As more of the grid is decarbonized and communities are able to take advantage of zero-emissions energy production, it becomes important to match building loads to the availability of renewable energy production. In order to pair renewable energy generation with increased demand and reduce GHG emissions, many projects are looking to design buildings that support better building-grid integration. Implementing grid integration in buildings will help enable the decarbonization of the electrical grid.

Grid integration provides multiple benefits including:

- Reducing the GHG impact of building operations by targeting reduced energy use in those periods when the generation of electricity is more carbon-intensive
- Increasing community resiliency with independent operating capabilities
- Incorporating flexible operating strategies that support evolving grid management
- Reducing the impact of building energy loads on grid ramps and peaks
- Reducing costs by reducing energy use during higher-cost time periods and reducing peak charges in commercial buildings

As more and more new renewable resources are added to the grid, older grid control systems make grid management more problematic for utilities. Yet everyone agrees that dependable grid operation is a critical priority. To maintain grid dependability, utilities must continue to manage and support peak generating capacity.

Rooftop solar with building-scale battery storage in Santa Monica (Courtesy RedCar)

Technologies that support grid-friendly buildings extend past energy efficiency and production and evaluate when buildings use energy. Energy efficiency, renewable energy, storage, peak load management, and smart controls are technologies that can be installed in buildings today. Buildings themselves must be able to more directly support grid operation by responding to fluctuations in grid load and contributing to broader efforts to manage more diverse grid resources. Buildings can incorporate peak energy load shifting, energy storage, and grid-responsive controls into their buildings to support a healthy electric grid.

LOAD SHIFTING

Conventional energy efficiency lowers overall building energy use and reduces the total peak building loads. Another essential strategy is to shift peak building load to a time of day that is not coincident with the utility peak, especially if that coincides with the availability of solar PV generation.

A range of building design and operating strategies can contribute to active building load management. Many of the passive design strategies discussed earlier in this guide can also be utilized to shift the time of day of a load. Thermal mass and night ventilation can pre-cool buildings to reduce and delay mid-day cooling loads, shifting the peak energy time. Fixed shading, electrochromic glass, and automated blinds can reduce and alter the daily pattern of solar gain into the building. Equipment schedules and setpoints can be altered to pre-heat or pre-cool a space to help it “coast” through all or part of peak periods.

If a pool is included in the building, it’s possible to use it as a heat sink for the air conditioner or use it to preheat or cool water for a radiant floor system.

STORAGE

Batteries are a critical tool to customize a building’s energy use profile to achieve beneficial grid integration. Buildings can be designed to routinely shift peak energy use and adjust loads to contribute to stable grid operations rather than to exacerbate grid shortages and oversupply.

Batteries can take advantage of short timescale fluctuations in grid carbon emissions in either direction. When grid carbon emissions are higher, a local battery can offset building energy use to reduce grid impact (discharge). When grid carbon emissions are lower, batteries can be used to stockpile low carbon energy for later use (charge).

Batteries can also be used to reduce or avoid peak demand charges, or to reduce ramp rate impacts during energy load increases. Finally, batteries can provide a mechanism for facilities to operate independently in the case of outages or other issues, contributing to building and community resiliency.

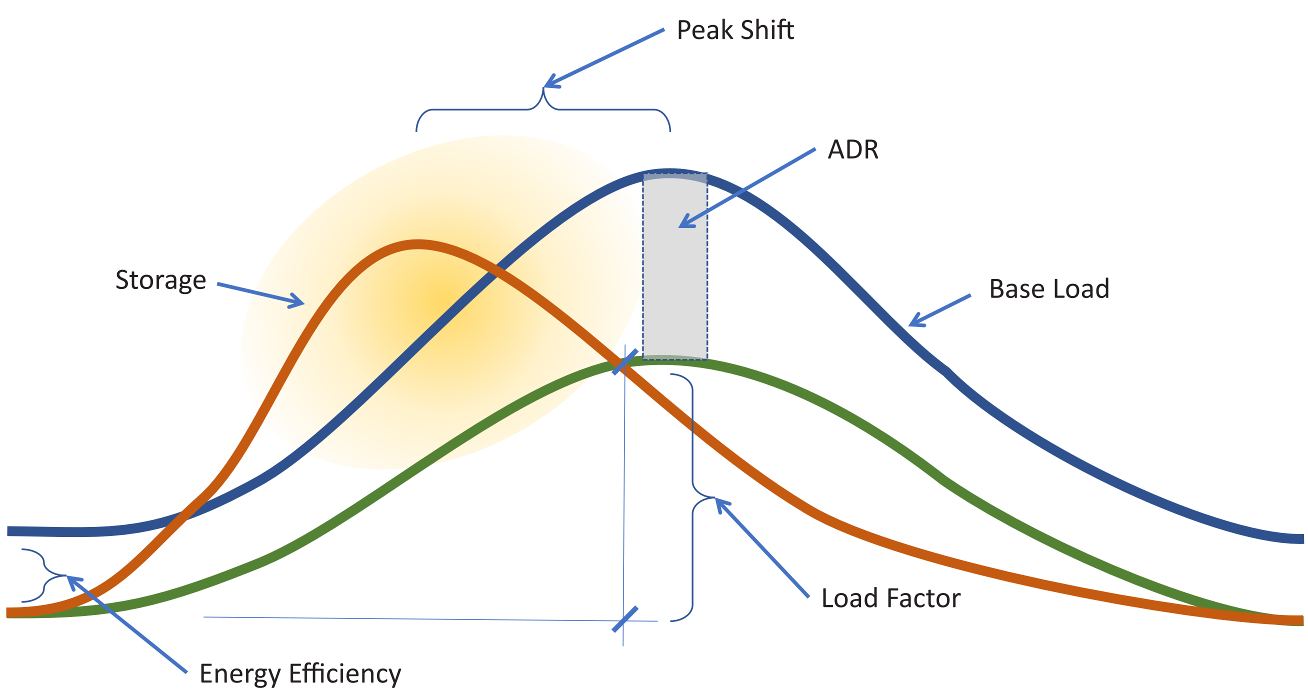
Storage is not only about batteries. Thermal energy can be stored as well. Water heater storage tanks can be used to store hot water. Some large air conditioning systems can make ice when lower-carbon or lower cost energy is more available and use the cold stored in that ice during other portions of the day.

Title 24 also provides efficiency credit for the integration of on-site storage in low-rise residential buildings, so this can be an effective strategy for code compliance as well.

GRID RESPONSIVE CONTROLS

Building energy controls play a key role in successfully shaping energy use in a manner consistent with energy efficiency, load shifting, and energy storage. Some building controls allow a short-term load response to the grid peak through demand management using smart thermostats in residences. However, commercial buildings need a more comprehensive approach to integrating building load management with grid operation. Intelligent, grid-integrated communication elements can automatically respond to grid signals. Smart systems and devices, from HVAC to lighting to EVs, can align building energy use with grid operation priorities and renewable energy availability.

Building system controls can address warm-up timing, temperature setbacks, "shut down" timing, and proactively pre-cool or pre-warm during opportune times. Occupancy sensors can reduce services to vacant spaces. Smart system controls that schedule hot water, and appliance loads to coincide with utility surplus instead of peak periods can all improve the interaction between buildings and the grid.



How different aspects of building response to grid conditions (Courtesy of New Buildings Institute).

If the building has active energy storage, building controls will also play a crucial role in optimizing the charging and discharging of the storage system to advance the building's energy efficiency and grid friendliness, lower cost and emissions, or any other goals. EVs also have the potential to act as battery storage for the building. A portion of the vehicle's battery capacity could be allocated to building or grid energy use during demand response calls or during peak demand times.

Water Efficiency

GREYWATER IRRIGATION

Greywater irrigation systems use wastewater from bathroom sinks, showers, bathtubs, and washing machines, excluding toilets or harsh chemicals, to irrigate outdoor landscaping. Separate pipes carry the greywater to a tank to collect greywater before an on-site filtration system cleans the water for reuse. Greywater can be used for irrigation or other non-potable uses. A greywater system can reduce household water consumption and water bills by over 50%. Simple laundry-to-landscape systems can cost as little as $100 to install, while a larger or more complex system can range from $1,000-$15,000.

WATER METERING

Water metering can be helpful when a building includes significant water demands, or multiple housing units share a single water meter. Meters measure the volume of water used by units. When a resource is measured, users are more likely to pay attention to their usage and reduce is. The owner should develop a monitoring plan to ensure consumption is within an acceptable range. In addition, monitoring the water flow can help identify leaks in the supply lines or within the building and allow for quick action to fix the leak. Water meters range from $200-$1000.

A greywater irrigation system is being installed in
Los Angeles, CA. (Courtesy of Greywater Corps)

Interior and exterior facades of the Pacific Landing Affordable Housing Development. (Courtesy of Walton Construction Inc.)

CASE STUDY

MF

Pacific Landing Affordable Housing Development

Santa Monica, CA

At the new all-electric Pacific Landing Affordable Housing Development, 37 affordable housing units stand on the site that once housed a gas station. The four-story, 42,000-square-foot mixed-use residential building includes EV infrastructure and a ground-floor coffee shop. The housing units include a mix of one, two, and three-bedroom units geared towards individuals and households making between 30% and 80% of the Area Median Income.

Developed by the nonprofit Community Corporation of Santa Monica, the efficient and all-electric facility generates energy on-site via rooftop PV panels. Working with the designer, Patrick Tighe Architecture, and contractor, Walton Construction, the overall energy was reduced through the careful selection of high efficiency split system heat pumps and heat pump water heaters, the design of passive cooling strategies, and the incorporation of ENERGY STAR equipment and appliances. For additional efficiency, the building has high performance windows and CRRC-1 Certified Roofing. Moreover, the EV charging infrastructure makes it easier for residents to switch to EVs.

Pacific Landing officially started operating in September 2022 and is awaiting LEED v4 BD+C Gold certification.

Chef Claude le Tohic and his staff cook in the electric kitchen at ONE65. (Courtesy of Rachelle Boucher)

CASE STUDY

NR

ONE65 Restaurant

San Francisco, CA

ONE65 is a 6-story, 20,000 square-foot recently renovated, nearly all-electric multi-concept French restaurant complex with three unique establishments. The building owner, Chef/Partner Claude le Tohic, led the three-year renovation, which opened to customers in 2019.

Chef le Tohic built on prior experience and advocated for an electric kitchen with the inclusion of induction stoves and space and water heating. The only gas hookup is for two gas burners for cooking with extra big pots, which they use only about 1-2 times a week, and the rest of the cooking is done with induction stoves and other electric appliances.

For most of his life, Chef le Tohic cooked with gas, but once he was introduced to electric cooking in his previous place of business, he did not want to return to gas. While the upfront cost of the electric induction stoves was greater than the gas counterparts, the induction stoves paid off within a year due to the staff time saved for cleaning and maintenance of the stoves, in addition to the energy savings. This highlights an important consideration when comparing costs for gas and electric equipment. Energy costs are only one part of the total cost of operating equipment, particularly in a commercial setting. It is important to consider other cost impacts such as maintenance and staff time for things like cleaning.

Le Tohic and his staff experienced many other benefits to induction stoves, including having a much cooler kitchen, safer environment, and equipment that is easier to clean. Nearly all of the heat generated by an induction stove goes directly into heating the food, unlike gas stoves, which emit a significant amount of heat into the surrounding air. In addition, while gas stoves stay on and heat the kitchen all day, induction stoves don't produce heat unless there is a pot or pan on the stove. This saves energy by reducing heat that must be cooled by the space cooling equipment. An additional benefit is that the staff is safer in the kitchen without open flames that could burn or catch items on fire. Furthermore, le Tohic noted that gas stoves tend to dirty the outside of pots and pans due to the open flame. Induction stoves do not dirty the outside of cookware nearly the same amount, so cleaning time is saved on both the cooking equipment and the pots and pans.

For anyone considering an electric kitchen, le Tohic recommends spending at least a day in an electric kitchen to see the clear benefits firsthand.

Terminology

All-Electric Building: A building whose only energy delivered to the site is electricity.

California Energy Compliance Software: CEC-approved simulation software used to show compliance with Title 24, Part 6. A list of approved residential and non-residential software is available on the CEC website: https://www.energy.ca.gov/rules-and-regulations/building-energy-efficiency.

Energy Consultant: In this context, an Energy Consultant is the professional hired to author Title 24 energy modeling calculations and to support Title 24 compliance documentation. The Certified Energy Analyst (CEA) designation, administered by the California Association of Building Energy Consultants (CABEC), is one who has demonstrated the necessary knowledge, ability, and experience to effectively apply Title 24, Part 6 requirements and modeling capability through a rigorous certification process. It distinguishes proficient energy consultants from their competition and helps assure building officials, plans examiners, incentive program administrators, and other stakeholders that they are receiving quality work.

Energy Design Rating (EDR): A scoring system that reflects a low-rise residential buildings' energy performance, as calculated in a CEC approved compliance software. A score of 100 is equal to that building's energy performance had it been constructed to the 2006 International Energy Conservation Code (IECC) standard. A score of zero reflects that a building's modeled annual energy use is entirely offset by the installed renewable generation on a TDV basis. The EDR calculation includes all end uses, including appliances and plug loads.

Electric Vehicle Service Equipment (EVSE): The technical name of an EV charger that connects an EV to the wiring in a building, either hardwired or by a plug and receptable.

EV Capable: Includes the conduit and electrical capacity, but no breaker, wiring or EV charger.

EV Charger Installed: Full circuit (208/240V 40-amp) with EV Charger (EVSE).

Low Power Level 2 EV Ready: Full-circuit (208/240V 20-amp) that is ready for an EV Charger containing the conduit, electrical capacity, and wiring; ready for the charger.

Home Energy Rating System (HERS) Verification: Third party verification that is used to confirm that contractors performed proper installation of home systems. Verifications range from visual inspection, to diagnostic analysis, to determined compliance with Title 24 specifications. HERS verifications and protocols are located in 2016 Title 24 Residential Appendices RA1, RA2, and RA3.

Integrated Design: An integrated design process includes the active and continuing participation of multiple stakeholders in the construction process. Bringing together the builder, architect, energy consultant, trade contractors, mechanical, structural, plumbing, and electrical engineers, and code officials at the beginning of the planning process leads to improved design cohesion, reduced costs, and the most effective energy efficiency strategy.

Mixed-fuel Building: A building that has both electricity and fossil fuel utilities delivered to the site.

Raceway/Conduit Equipped: The parking space is served by raceway or conduit to support a future EV charger; no additional panel capacity required.

Thermal Mass: Thermal mass is the ability of a material to absorb and store heat energy and slowly release it. High density materials like concrete, stone, brick, and tile require a lot of heat energy to warm the material. Low thermal mass materials include most wood, fabric, and other lightweight materials.

Time Dependent Valuation (TDV): An energy multiplier applied on an hourly basis to better reflect the value of electricity, gas, or propane savings based on when they occur. TDV is used in the EDR metric in Title 24 compliance software. The concept behind TDV is that energy efficiency measure savings should be valued differently depending on which hours of the day and year the savings occur, to better reflect the actual costs of energy to consumers, the utility system, and society. The TDV method encourages building designers to design buildings that perform better during periods of high energy costs.

Title 24, Part 6: California's Building Energy Efficiency Standards. The Standards have both mandatory minimum requirements as well as prescriptive requirements. The performance approach, in which an energy model is used to confirm that a home's installed measures will use the same amount of energy as the same building if constructed using the prescriptive requirements, is primarily used to demonstrate code compliance.

Zero Net Energy (ZNE) Building: An energy efficient building that produces as much energy as it consumes over the course of a year, usually by incorporating renewable energy generation on-site.

Zero-Emissions Building: An energy efficient building that only uses carbon free energy sources. In Santa Monica, electricity provided by the grid is procured from carbon-free generation, so all-electric buildings are also zero net carbon emissions buildings.

Resources

2022 Title 24 Documents:

- **Standards:** https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards
- **2022 Single-Family Residential Compliance Manual: for the 2022 Building Energy Efficiency Standards | California Energy Commission:** https://www.energy.ca.gov/publications/2022/2022-single-family-residential-compliance-manual-2022-building-energy-efficiency
- **2022 Non-residential and Multifamily Compliance Manual: for the 2022 Building Energy Efficiency Standards | California Energy Commission:** https://www.energy.ca.gov/publications/2022/2022-nonresidential-and-multifamily-compliance-manual-2022-building-energy
- **California Energy Code Stakeholders:** https://title24stakeholders.com

Advanced Energy Design Guides: https://www.energy.gov/eere/buildings/advanced-energy-design-guides

California Energy Wise Commercial Kitchen Resources: https://caenergywise.com

DOE Zero Energy Ready Homes: https://www.energy.gov/eere/buildings/zero-energy-ready-homes

Drain-Water Heat Recovery: https://www.energy.gov/energysaver/drain-water-heat-recovery

Energy Code Ace: https://energycodeace.com

ENERGY STAR® New Homes: https://www.energystar.gov/newhomes

ENERGY STAR® Certified Products: https://www.energystar.gov/products

Getting to Zero Resource Hub: http://gettingtozeroforum.org/resource-hub/

High Efficacy Residential Lighting Guide: https://cltc.ucdavis.edu/publication/high-efficacy-residential-lighting-guide

Design Lights Consortium's Qualified Product List—DesignLights: https://www.designlights.org/qpl/

LEED Rating Systems: https://www.usgbc.org/leed

Living Building Challenge: https://living-future.org/lbc/

NBI's Getting to Zero Buildings Database: https://newbuildings.org/resource/getting-to-zero-database/

Passive House Institute US: https://www.phius.org/

Residential Cooktop Performance and Energy Comparison Study: http://cao-94612.s3.amazonaws.com/documents/Induction-Range-Final-Report-July-2019.pdf

Santa Monica EV Charger Reach Code: https://santamonica.gov/electric-vehicle-charger-requirements-for-new-construction

Santa Monica Green Buildings: https://santamonica.gov/topic-explainers/green-building-in-santa-monica

The Home Energy Rating System (HERS) Index: https://www.resnet.us/

The Switch is On: https://switchison.org/

Washington State University's Guide to Energy Submetering: https://www.energy.wsu.edu/Portals/0/Documents/A_Short_Guide_to_Submetering-April2019-FINAL.pdf

Zero Energy Project: https://zeroenergyproject.com/

ZNE Communications Toolkit: http://gettingtozeroforum.org/zero-net-energy-communications-toolkit/

This guide was prepared by New Buildings Institute for the City of Santa Monica.

Learn more at: newbuildings.org

For more information on Santa Monica's Reach codes, visit **santamonica.gov/topic-explainers/green-building-in-santa-monica**

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