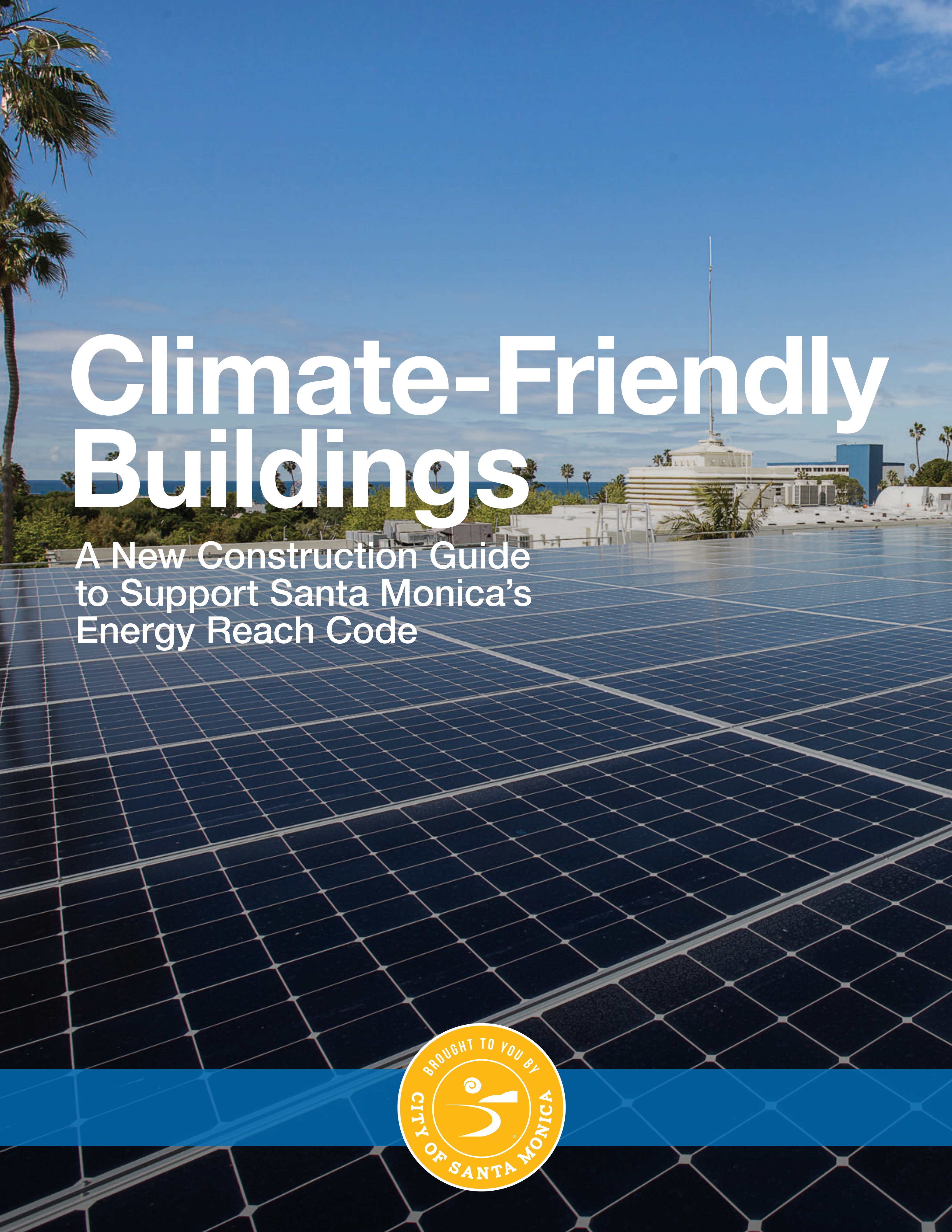

Climate-Friendly Buildings

A New Construction Guide to Support Santa Monica's Energy Reach Code

BROUGHT TO YOU BY CITY OF SANTA MONICA

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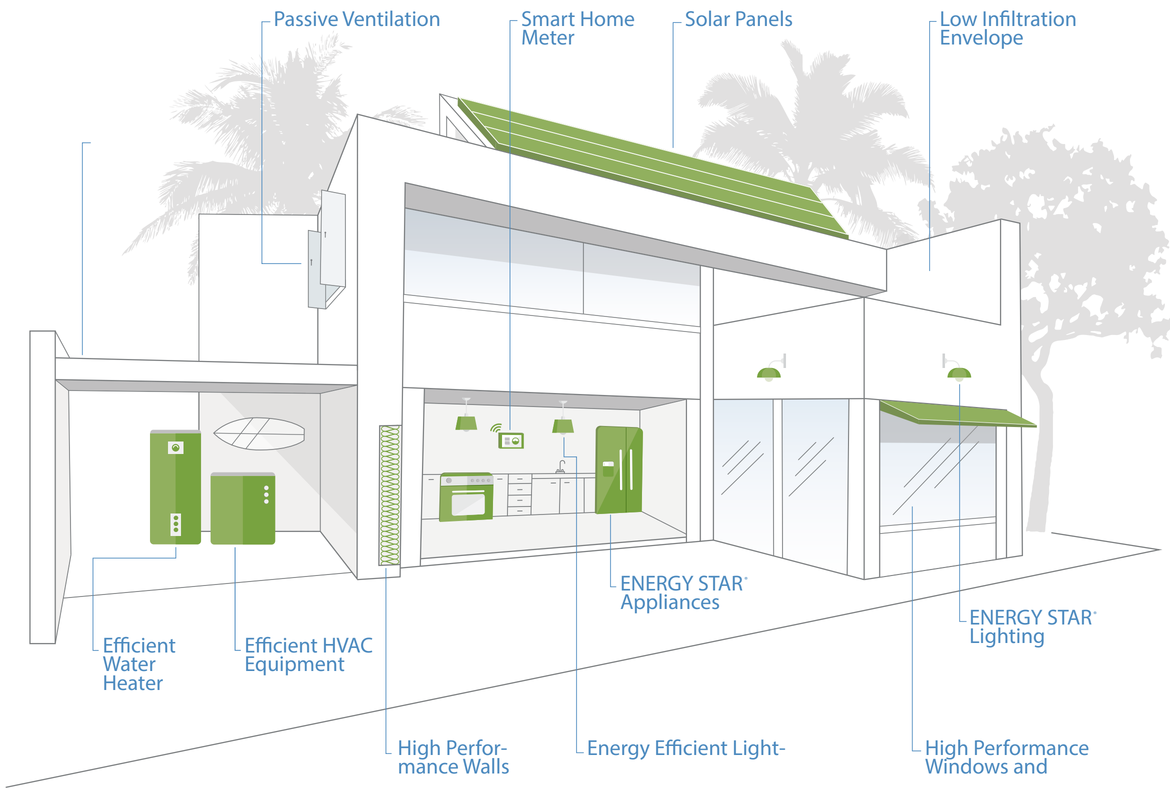
ICONS

Much of the guidance in this guide applies to all building types; however, when information is presented that is specific to single-family (SF), multifamily (MF) or non-residential (NR) buildings, those sections are highlighted with these icons.

NR MF SF



Zero net energy home energy efficiency and energy production features.

Introduction

The Santa Monica City Council, in December 2016, was one of the first cities to adopt a zero net energy (ZNE) ordinance for low-rise residential new construction. In September 2019, City Council built on that ordinance in order to promote the transition to all-electric requirements for new construction and adopted the **2019 Building Energy Efficiency Standards—Standards for Residential and Nonresidential Buildings.**

The 2020 Energy Reach Code, as the standard is known, reduces operational carbon in new buildings by leveraging Santa Monica's decarbonized electricity supply and encouraging the construction of all-electric buildings. It also requires greater efficiency from buildings that burn natural gas.

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 are effectively zero-emissions buildings. Electric buildings that 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 from CPA are supporting the City's goal for all buildings to be zero net carbon emissions (zero-emissions). The Energy Reach Code leverages this zero-emissions electricity to reduce the emissions of new buildings and major additions by encouraging the construction of all-electric buildings (Figure 1).

This guide supports compliance with the Santa Monica Energy Reach Code by providing guidance for meeting all of the Reach Code requirements, including All-Electric Design, Energy Efficiency and Renewable Energy. It also includes additional material on Grid Integration, which is not required by the Reach Code, but which will become an increasingly important part of the decarbonization of buildings and the electrical grid. Finally, it includes a handful of case studies to help show what a zero-emissions building looks like.

Effective January 1, 2020 **Santa Monica New Construction** Energy & Green Building Reach Codes See SMMC 8.36 & SMMC 8.106	**Code Compliance Pathways***	
	All-Electric	**Mixed-Fuel (Electric & Natural Gas)**
Single-Family & Multi-Family (3 stories or less)	**Efficiency + Solar:** Meet State Code (no local reach code)	**Efficiency + Solar:** Must meet CalGreen Tier 1 1. Achieve a Total Energy Design Rating of ≤ 10 2. Complete Quality Insulation Installation (QII) 3. Plus one of the following: • Roof deck insulation or ducts in conditioned space; or • High-Performance Walls; or • HERS-Verified Compact Hot Water Distribution with Drain Water Heat Recovery
Multi-Family (4+ stories) & Hotel	**Efficiency:** Meet State Code **Minimum Solar:** 2 watts/sq. ft. of bldg. footprint	**Efficiency:** 5% better than State code **Minimum Solar:** 2 watts/sq. ft. of bldg. footprint
All Other Non-Residential	**Efficiency:** Meet State Code **Minimum Solar:** 2 watts/sq. ft. of bldg. footprint	**Efficiency:** 10% better than State code **Minimum Solar:** 2 watts/sq. ft. of bldg. footprint
New Heated Pools	Heat-pump and/or Solar	N/A, Gas Pool Heating Prohibited
Major Additions	**Solar for Single Family/Duplexes:** 1.5 watts/sq. ft. of addition **Solar for all others:** 2 watts/sq. ft. of addition's footprint	

*** All Projects:** Title 24 Certificate of Compliance must be authored by a Certified Energy Analyst (CEA).

Figure 1: Santa Monica Reach Code Requirements.

zHome townhomes in Issaquah, WA

Santa Monica's 2020 Energy Reach Code

Santa Monica's Energy Reach Code applies to all buildings: single family homes, low-rise multifamily (three stories or less), high-rise multifamily (four stories or more), hotels, and all other non-residential buildings, as well as new heated pools, and single family/duplexes major additions.

The Reach Code has two components: carbon emissions reductions and on-site renewable energy production, such as solar power.

The Reach Code reduces emissions by requiring that buildings in Santa Monica either be all-electric buildings or achieve higher levels of efficiency if they include natural gas. Under the Energy Reach Code:

- All-electric buildings may be built to Title 24, California's statewide energy code.
- Projects supplied with natural gas (mixed-fuel buildings), are required to design to a higher standard for efficiency.
- Residential and low-rise multifamily projects must achieve CalGreen Tier 1 efficiency requirements resulting in a total energy design rating (EDR) of 10 or less.
- High-rise multifamily projects and hotels must improve efficiency by 5%.
- All other non-residential projects that include natural gas must demonstrate a 10% improvement over Title 24.
- The Reach Code also reduces emissions by prohibiting natural gas for pool water heating.

The Reach Code also then requires 2 watts of on-site photovoltaic production per square foot of the building footprint for all non-residential buildings (offices, retail, high-rise multifamily, hotels, etc.).

Documenting Compliance

Energy-modeled projects must show compliance with the Santa Monica 2020 Energy Reach Code using CEC-approved energy simulation software. Energy consultants, especially Certified Energy Analysts (CEA), have extensive knowledge of energy simulation software, and can produce the required Title 24 documentation. CEAs can provide guidance on design opportunities, Title 24 energy modeling, and technical understanding of the Santa Monica Energy Reach Code. Santa Monica's Reach Code requires that all projects incorporate a Certified Energy Analyst (CEA) as the project's energy consultant. Owners can locate a CEA through the California Association of Building Energy Consultants (CABEC) website: https://cabec.org/.

Verifying All-Electric Design. Project teams must prepare building plans and a Title 24 Certificate of Compliance that is signed by a CEA and does not include natural gas infrastructure or equipment. City Plan Check staff will confirm the all-electric design during the plan review.

Verifying Mixed-Fuel Buildings Improvement on 2019 Title 24. Low-rise residential compliance for mixed-fuel buildings: Using CBECC-Res, project teams must prepare building plans and a Title 24 Certificate of Compliance that is signed by a CEA and meets CalGreen Tier 1 under the 2019 California Green Building Standards Code.[1] The CalGreen Tier 1 box must be checked and the total Energy Design Rating (EDR) must be 10 or less.

1 Title 24, Part 11, Appendix A4 Residential Voluntary Measures Division A4.203–Performance Approach for Newly Constructed Buildings.

High-rise residential (4+ stories), hotels, and non-residential mixed-fuel buildings. Using CBECC-Comm, the project teams must prepare building plans and a Title 24 Certificate of Compliance that meets the Compliance Margin requirements of the Santa Monica Energy Reach Code. The Compliance Margin is located on the Energy Use Details tab of the analysis results or on the Title 24 Certificate of Compliance, as shown in Figure 2 and Figure 3.

The Compliance Margin calculation compares the proposed design versus a standard design and only considers end uses that are regulated under Title 24, including space heating, space cooling, ventilation, fans and pumps, and domestic water heating. The calculation does not include indoor or outdoor lighting, appliances, or plug loads. In Santa Monica, the largest energy consumers are typically water heating and space heating. This does not mean that the other measures should be excluded from evaluating energy efficiency opportunities.

ENERGY DESIGN RATING

	Energy Design Ratings		Compliance Margins	
	Efficiency[1] (EDR)	Total[2] (EDR)	Efficiency[1] (EDR)	Total[2] (EDR)
Standard Design	59	32.		
Proposed Design	51	10	8	22.2

RESULT:[3] COMPLIES

1: Efficiency EDR includes improvements to the building envelope and more efficient equipment
2: Total EDR includes efficiency and demand response measures such as photovoltaic (PV) systems and batteries
3: Building complies when efficiency and total compliance margins are greater than or equal to zero

- Standard Design PV Capacity: 3.09 kWdc
- Proposed PV system downsized to 5.29 kWdc (a factor of 0.882) due to cap of 1 x proposed design electricity use

ENERGY USE SUMMARY

Energy Use (kTDV/ft^2-yr)	Standard Design	Proposed Design	Compliance Margin	Percent Improvement
Space Heating	16.75	8.7	8.05	48.1
Space Cooling	5.2	2.39	2.81	54
IAQ Ventilation	6.07	6.07	0	0
Water Heating	13.77	10.17	3.6	26.1
Self Utilization Credit	n/a	0	0	n/a
Compliance Energy Total	**41.79**	**27.33**	**14.46**	**34.6**

REQUIRED PV SYSTEMS - SIMPLIFIED

01	02	03	04	05	06	07	08	09	10	11	12
DC System Size (kWdc)	Exception	Module Type	Array Type	Power Electronics	CFI	Azimuth (deg)	Tilt Input	Array Angle (deg)	Tilt: (x in 12)	Inverter Eff. (%)	Annual Solar Access (%)
5.29	NA	Standard	Fixed (roof mount)	Microinverters	false	180	Degre es	3	0.63	96	100

Figure 2: Residential Compliance Report.

C1. COMPLIANCE RESULTS FOR PERFORMANCE COMPONENTS (Annual TDV Energy Use, kBtu/ft^2-yr)

COMPLIES

Energy Component	Standard Design (TDV)	Proposed Design (TDV)	Compliance Margin (TDV)[1]
Space Heating	1.67	1.88	-0.21
Space Cooling	17.42	17.03	0.39
Indoor Fans	15.17	15.91	-0.74
Heat Rejection	--	--	--
Pumps & Misc.	--	--	--
Domestic Hot Water	31.88	24.29	7.59
Indoor Lighting	--	--	--
ENERGY STANDARDS COMPLIANCE TOTAL	**66.14**	**59.11**	**7.03 (10.6%)**

Figure 3: Non-Residential Compliance Form.

Santa Monica's 2020 EV Charging Reach Code

In 2020, Santa Monica adopted amendments to the CalGreen electric vehicle (EV) charging requirements in order to promote greater access to EV charging infrastructure in new buildings.

Requiring the conduit, panel capacity, and other components to be installed during new construction significantly reduces the cost to add EV chargers in the future. The amendments also require a percentage of the parking spaces to be equipped with EV chargers, rather than only requiring the electrical infrastructure.

Increasing the availability of electric vehicle (EV) charging infrastructure at 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.

EV Charging Requirements for New Construction
(pending CBSC approval)

	State: EV Capable	EV Chargers Installed	EV Ready	Raceway/ Conduit Equipped	Total Potential EV Spaces
Single Family, Duplex	1 per unit	--	1 per unit	--	1+
Multifamily	10%	10%	20%	70%	100%
Hotel/Motel*	6% avg	10%	--	30%	40%
Office*	6% avg	10%	20%	30%	60%
All other nonresidential*	6% avg	10%	--	30%	40%

TERMINOLOGY

EV Charger Installed: Full circuit (208/240V 40-amp) electric vehicle supply equipment (EVSE) per CAL-Green+ EV Charger

EV Ready: Full-circuit EVSE; ready for the charger

EV Capable: Full-circuit without charger or breaker (required by CALGreen, not included in Santa Monica's reach code categories)

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

***DCFC Option:** 1 DC Fast Charger (480V; min 50 kW) may replace up to 5 required level 2 (240V) chargers


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

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

All-Electric Design

Santa Monica's carbon-free electrical supply creates an opportunity to rapidly decarbonize buildings in the City by utilizing electric equipment instead of natural gas-fired equipment for end-uses like water heating, space heating, and cooking.

Therefore, while the Reach Code requires mixed-fuel buildings to achieve efficiency levels beyond Title 24, all-electric buildings only need to meet Title 24 requirements.

All-electric buildings offer several advantages over mixed-fuel buildings beyond just carbon reductions. The elimination of the gas service to the building comes with substantial cost savings to 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. The elimination of gas combustion, especially from cooking, also has benefits for indoor air quality and safety.

It is important to recognize that efficient electric HVAC equipment includes both low-efficiency technology like resistance heating as well as higher-efficiency equipment such as heat pumps. While electric resistance equipment generates heat through the use of an electric resistance coil, heat pumps move heat from one substance to another and concentrate it. It is difficult 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.

Electric Space Heating

Most ventilation and cooling equipment used in buildings is already electric, and space heating can be supplied by high-efficiency heat pumps. Santa Monica's temperate climate is ideally suited to heat pumps, without some of the concerns about effectiveness and efficiency that can be found in especially cold climates. With gas heating, separate pieces of equipment are required to provide heating and cooling, while heat pumps 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.

MF SF

In single-family homes and other low-rise residential buildings like apartments, as well as many smaller commercial buildings, heat pumps are already widely used 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

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

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.

As buildings get taller, they have fewer system options in general, not just in all-electric buildings. Mixed-fuel, high-rise buildings generally use a chiller and boiler to provide cooling and heating, respectively, to the building. 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 can be providing cooling to the spaces even during the winter when people’s 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.

Electric Water Heating

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.

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.

2500 Gallons of Well-Insulated Storage for Cyprus Apartments – 230 Market Rate Units (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.

NR MF

- **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.

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.

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.

MF SF

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.

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

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 used to cook the food and the rest released as waste heat, while electric cooking equipment efficiency can approach 90%.[2]

MF SF

Some consumers express a preference for natural gas for residential cooking since electric resistance stoves do not provide the same level of temperature 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.[3] As a result, households with gas cooking have nearly three times the rate of treatment for asthma.[4]

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

3 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

4 Jarvis et al. (1996) "Evaluation of asthma prescription measures and health system performance based on emergency department utilization." https://www.ncbi.nlm.nih.gov/pubmed/8618483

Electric kitchen at zHome townhomes in Issaquah, WA.

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

NR

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.[5] 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.

NR MF

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.

5 Kostuch Media Ltd. (2017). Why Induction Cooking is the Hottest Trend to Hit Restaurant Kitchens. Food Service and Hospitality. www.foodserviceandhospitality.com/why-induction-cooking-is-the-hottest-trend-to-hit-restaurant-kitchens/

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

Energy Efficiency

Energy efficiency is one of the foundations of low- and zero-emissions buildings. Although there is no one-size-fits-all approach, best practices can help a project achieve an electric zero net energy building.

This section focuses on the general elements of energy-efficient buildings and provides links to the specific details and requirements of Title 24, including Home Energy Rating System (HERS) verification.

THE FOLLOWING STEPS ARE RECOMMENDED:

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

1. Set Goals

Under Santa Monica's Energy Reach Code, the efficiency goal is different for all-electric and mixed-fuel buildings. All-electric buildings will only need to meet the requirements of 2019 Title 24, while mixed-fuel buildings will need to meet a higher level of efficiency (Figure 1). While this section will be useful for all-electric buildings working to meet California's new, more efficient energy code, it will be vital for mixed-fuel projects.

There is no single recipe for energy efficiency in buildings; many efficiency measures and combinations of measures can be used to meet the Reach Code requirements. 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 the 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.

Integrated Design

Achieving the standards in the 2020 Energy Reach Code begins with modifications to the traditional design and construction process. 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.

Integrated design recognizes that a successful project begins at the schematic design phase and considers input from various key stakeholders, including the owner, architect, design engineers, energy consultants, contractors, and subcontractors (including HERS Raters and commissioning agents). Everyone should be aware of the goals, understand their contribution, and help make crucial design decisions to start the project on the right track to minimize costly redesigns later.

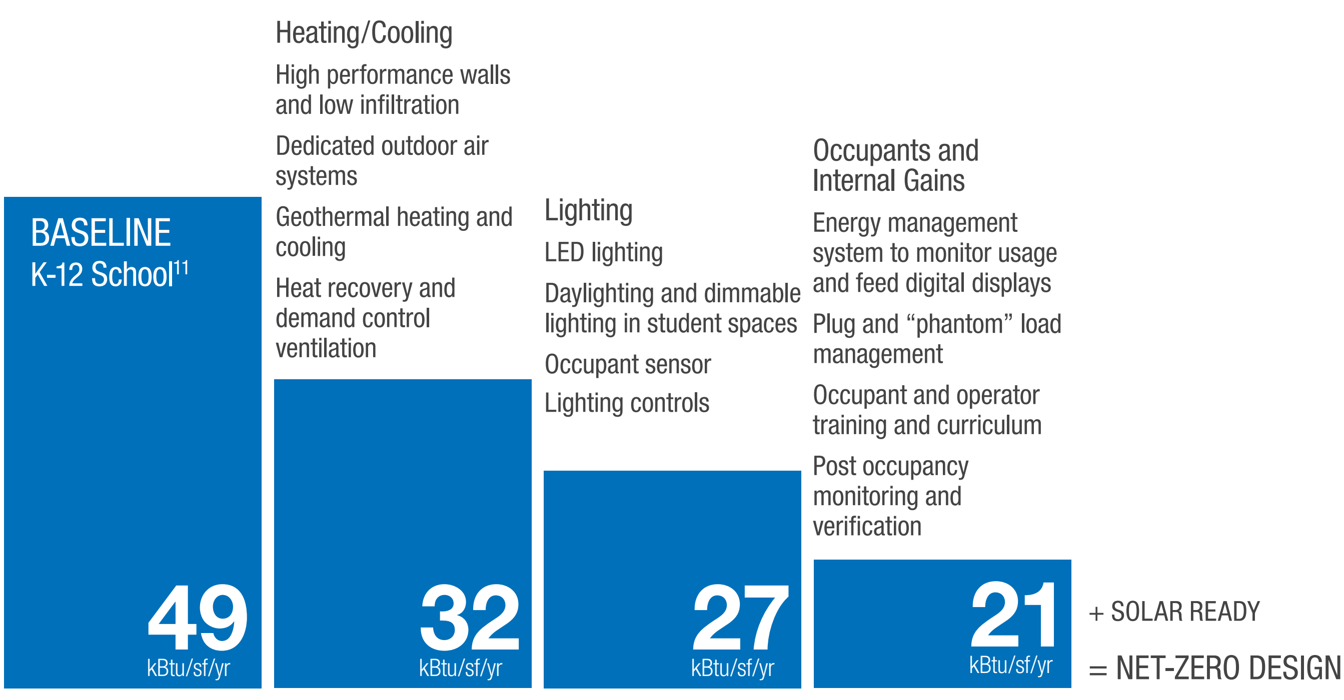
The Santa Monica Energy Reach Code encourages project teams to implement measures that significantly reduce the energy consumption of lighting, water heating, and space conditioning. This can then reduce the equipment size and renewable energy resources needed to meet the Reach Code.

To lower energy consumption, consider measures in the following order:

- Building orientation,
- Envelope improvements,
- Hers verifications (for residential projects),
- Building-grid integrated controls
- Renewables

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. Santa Monica's Energy Reach Code requires that all projects incorporate a Certified Energy Analyst (CEA) as the project's energy consultant. A CEA will model the proposed building and can inform the project team if the design meets the Energy Reach Code requirements.

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 (PHI or PHIUS), Leadership in Energy and Environmental Design (LEED) and Living Building Challenge. Code-education and ZNE best practices training resources include Energy Code Ace, California Association of Building Energy Consultants (CABEC), and the Zero Energy Project, among many others.



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.

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 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 may show that the added cost of a measure like additional wall insulation does not exceed the energy and cost savings or it may help to reduce the size of the HVAC system. Likewise, modeling can be used to determine if measures—such as exterior shading or triple-glazed windows—allow space conditioning system sizes to be reduced, saving construction and operating costs. Energy consultants, especially CEAs, have extensive knowledge of energy simulation software and can produce the required Title 24 and Santa Monica Energy Reach Code documentation. An energy consultant will model the proposed building and can inform the project team if the design meets the ordinance requirements.

Title 24 requirements currently regulate energy use associated with space heating, space cooling, ventilation, other HVAC loads, and domestic and service water heating. Of course, there are other energy end uses in a building, including lighting and appliances. However, not all energy efficiency measures can currently be included in a Title 24 compliance model, such as plug load control, improved lighting, and passive cooling or ventilation. Although designers should consider selecting energy-efficient appliances, as this will further reduce energy used and monthly energy bills - especially in homes—these appliances cannot earn Title 24 credit and will not help a project meet code requirements. An energy consultant can further explain the software capabilities and Title 24 requirements during initial goal-setting meetings.

MF SF

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. The 2019 Title 24 has mandatory HERS measures, effectively requiring that homes be built to the standard and that a HERS Rater arrive on-site for almost every new construction, low-rise residential project. Several of the residential measures require or have an option for HERS verification in order to show compliance and receive credit under Title 24. HERS verification can range from a visual inspection and confirmation to a test requiring specialized equipment.

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 by site visit 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 Figure 4 as a guide. Standard measures include the 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 low leakage ducts in conditioned space. These costs are 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) either price by the number of site visits (Figure 4), or 2) by the number of dwelling units (Figure 5). 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 $50 to each unit cost due to multiple site visits required.

Component	Single Family
On-site visit ($/visit)	$220
Standard Measure verification ($/measure)	$45
Additional Measure verification ($/measure)	$100

Figure 4: HERS costs for Single-Family Homes.

Component	Multifamily
Method 1: On-site visit ($/visit)	$245
Method 2: Per unit verification, no QII ($/unit)	$198
Method 2: Per unit cost of QII ($/unit)	$50

Figure 5: HERS costs for Low-Rise Multifamily buildings.

2. Reduce Energy Loads

Santa Monica's warm, temperate climate with moderate wind provides opportunities for nature to passively heat, cool, ventilate, and even light buildings with the right site orientation and design. Attention to how the building is oriented allows for passive design opportunities such as daylighting, natural ventilation, and even passive cooling. Careful design of the building—especially the fenestration—can minimize solar heat gains in the summer while still providing daylighting and even passive heating in the winter. These decisions about passive 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.

Many resources are available to designers to help analyze the micro-climate and building configuration. Early design analysis software and other evaluation tools can be used to analyze site characteristics and compare design alternatives without significant investment in energy modeling. Without these tools, some simple rules can be followed to meet similar results.

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

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.

Insulation

Well-insulated walls, floors and roofs/ceilings reduce the amount of heat transfer through exterior walls and reducing HVAC loads. This measure requires 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.

The insulation requirements 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 lower in cost than the high-density batt, spray foam, or other insulation type needed in 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.

Assemblies and their resulting U-factors can be found in the 2019 Title 24 Joint Appendices JA4.3. Modeling guides are available through the 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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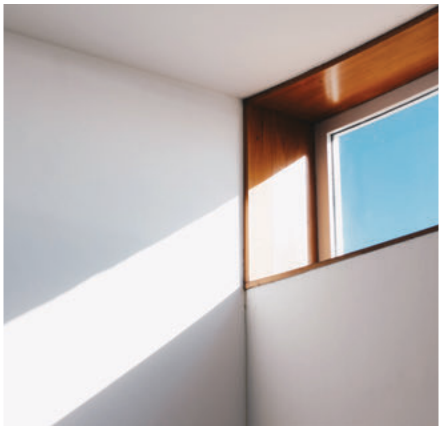
Quality Insulation Installation

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. 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

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



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

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 under Verify Construction.

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 resistive 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 the 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 refer to the color of the roofing material and its ability to reflect solar energy and release previously absorbed heat. A lighter color 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[6] 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.

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

Three Trees House in Eagle Rock, CA. www.JeremyLevine.com Photography by Tom Bonner.

3. Select Efficient Equipment

Once the building has an efficient envelope, the next step is to select efficient equipment and size it correctly. The major climatic variables that impact the energy performance of buildings include temperature, wind, solar energy, and moisture. Santa Monica is cooling-dominated, meaning that to meet common temperature set points, air conditioning is used more frequently than heating.

An important part of this aspect is utilizing passive strategies to limit or even eliminate the need for mechanical equipment. Passive strategies for ventilating, heating, cooling and lighting a building reduce the building's energy consumption by limiting the amount of time that mechanical systems need to run. Passive ventilation moves air through the building and provides outdoor air to meet ventilation needs. The building can be orientated to take advantage of cool morning or evening winds. Deep roof overhangs, exterior window shades, and vegetation can block the sun during the hottest times of the day. Thermal mass can be used to absorb excess heat during hotter portions of the day and release it during colder times of the day thus reducing heating loads in the winter and cooling loads in the summer. Daylighting can lower the operating hours of electric lighting (daylighting is discussed in greater detail in the Lighting section below).

Lighting

Efficient lighting is 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.

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

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

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 is an important consideration 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 be high efficacy, following the same guidelines and selecting ENERGY STAR® products will result in lower energy use.

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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 core element of quality lighting design is proper high efficacy luminaire selection and placement. 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 amount of light as reading nor does watching a movie require the same lighting as detail work like painting. 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 at the Kienapfel Passive House in Culver City, CA designed by PARAVANT Architects. (Image courtesy of Fraser Almeida)

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. Increasing exterior

Ductless Heat Pump (Courtesy of Nick Keppol).

lighting efficiency beyond code can be challenging. Consider limiting the amount of exterior lighting, installing the highest efficacy lighting available, or all light emitting diode (LED) ENERGY STAR® Qualified Bulbs or lamps on the Design Lights Consortium's Qualified Product List.

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.

Efficient HVAC System

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. Electric space conditioning equipment is generally capable of achieving much higher levels of efficiency than their natural gas counterparts; see All-Electric Design on page 7 for more information about designing with electric equipment.

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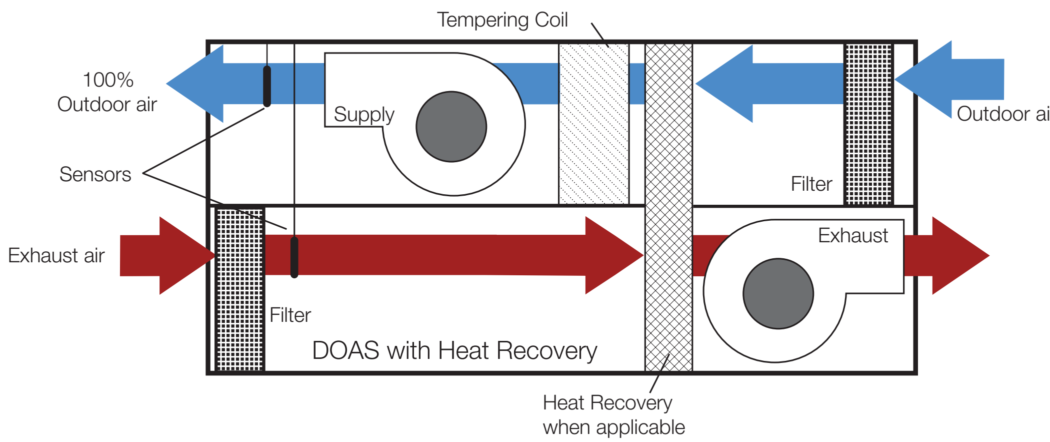
Dedicated Outdoor Air Systems

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 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.



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

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 radiant 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. 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 fan in the furnace or air handler from one using permanent split capacitor (PSC) motor to one with an electronically commutated motor (ECM) that meets an efficacy of 0.3 watts/cfm or lower operating at full speed. Federal regulations that went into effect July 3, 2019, are expected to result in equivalent performance for all newly manufactured furnaces, provided that the ducts are sized properly. 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.

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

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 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.

Efficient Water Heaters

Code requirements for water heating equipment significantly lag behind the performance levels available on the market, so it is easy to specify high performance equipment. Installing a water heater that is more efficient than the minimum efficiency set by the energy code reduces energy use associated with water heating.

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.

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 2019 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.

Plug Loads

In very efficient buildings, plug loads, which are devices plugged into wall outlets, can represent 50% of total annual energy use. Much of 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. While plug load reduction will not help contribute to meeting the Santa Monica Energy Reach Code, the reduction in plug loads will reduce energy demands and potentially allow for a smaller on-site renewable energy system.

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.

Plug Controls

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% 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.

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.

4. Add Renewable Energy

Once energy consumption has been minimized, on-site renewable energy systems and energy storage systems can be sized to meet Reach Code requirements. Excluding low-rise residential projects, the City of Santa Monica requires all new buildings to install a minimum of 2 watts of solar per square foot of the building’s footprint. 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 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 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 with at least a 5 degree tilt. 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. 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 is offsetting someone else’s carbon-intensive power supply and the environmental benefit is lost to the building where the systems is located.

Photovoltaic panels at Santa Monica City Hall (Courtesy of City of Santa Monica).

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

5. Integrate with the Grid

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. To meet the growing challenges of increasing renewable energy generation and reducing GHG emissions on the electric grid, many projects are looking to design buildings that support better building-grid integration. The Santa Monica Energy Reach Code does not require any grid integration beyond what is already in Title 24, but 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 operation 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

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.

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. But 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.

If a pool is included in the building, it's possible to use the pool as a heat-sink for the air conditioner or use it to pre-heat 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 up, a local battery can offset building energy use to reduce grid impact (discharge). When emissions are down, 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 renewable energy is more available and use the cold stored in that ice during other portions of the day.

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The 2019 edition of 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 electric vehicles, 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

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

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. Electric vehicles 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.

How Buildings Can Integrate with the Electric Grid

The diagram shows the different aspects of building response to grid conditions. Conventional **energy efficiency** typically lowers a building's energy **base load** as well as its **peak load.** Often, this increases the load factor. In regions with **automated demand response (ADR)** already deployed as part of utility grid operation, buildings are incentivized to shed some load during peak demand events (as defined by the utility).

Another important strategy is to **shift peak** building load, using **energy storage** as well as operational strategies, outside of the utility's peak time, especially if that coincides with the availability of solar photovoltaic generation. Grid integrated buildings can significantly expand the scale and variety of building responses to grid conditions.

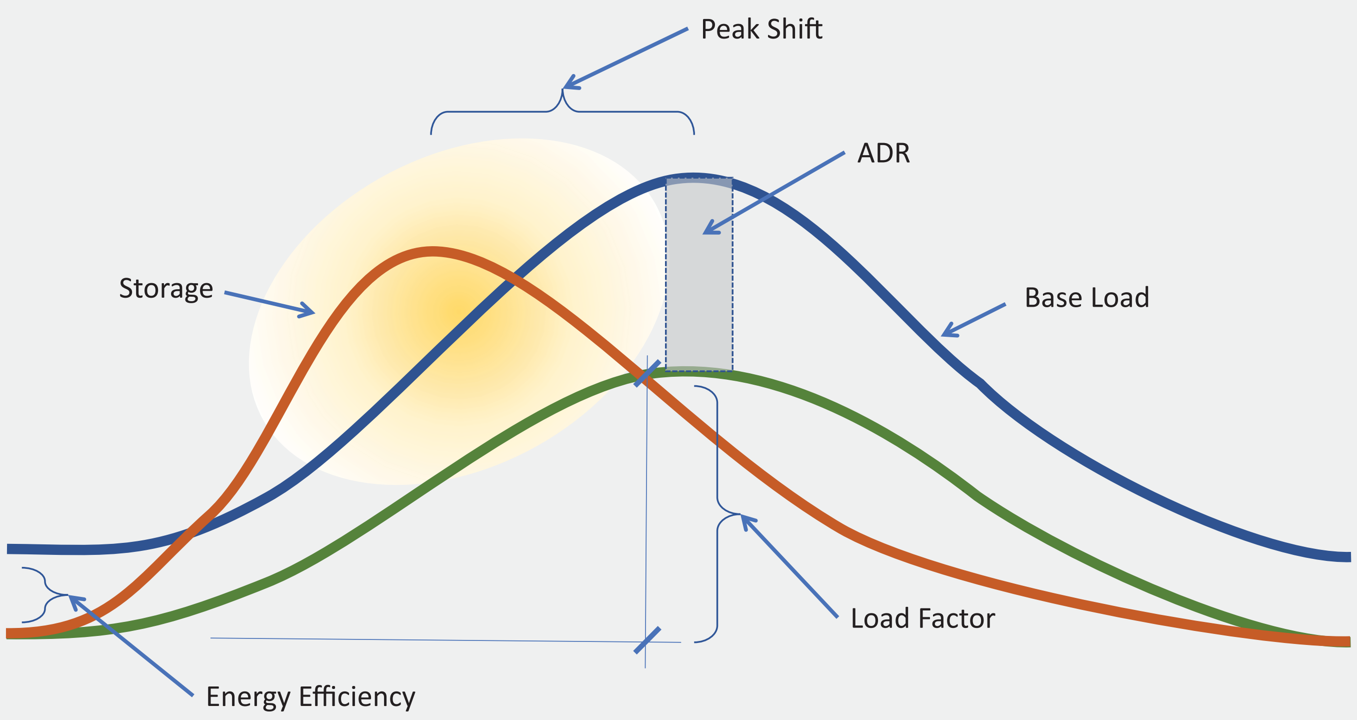

Figure 6: How different aspects of building response to grid conditions (Courtesy of New Buildings Institute).

Cottle Zero Energy home (Courtesy of One Sky Homes).

CASE STUDY

The Cottle Zero Energy Home

San Jose, CA

Recognized as the first zero net energy home in California, the Cottle Home is a two-story, 3,200 square-foot, 4-bedroom, 3.5-bathroom new construction project. This traditional-style home features cut veneer stone and reclaimed timber front porch columns.

The home was built by Allen Gilliland, owner and founder of One Sky Homes. The incremental costs of building the home to the Passive House standard was $65,000, which is only 7% higher than that of a house built to code-minimum standards. With a HERS Rating of -1, the owners are able to supply all of their own energy needs (including charging their electric vehicle). The house generates enough energy to power itself for free as well as exports 2,000 kWh back to the utility at $0.28 per hour during peak demand times. This saves them approximately $2,900 a year compared to owners of a standard code compliant home.

THE HOME'S ENERGY-SAVING DESIGN FEATURES INCLUDE:

- Triple-pane glass on all windows to prevent heat loss in the winter.
- A sensor-controlled ventilation system that uses night ventilation cooling to cool and flush out hot air in the warmer months.
- A 6.4-kW, 30-panel, roof- mounted PV system and a three-panel solar thermal system for heating water.
- Water conserving plumbing features and a grey water recycling system that supplies 80% of the home's irrigation needs.

NRDC Office (Courtesy of Tim Street-Porter).

Internal light well (Courtesy of Tim Street-Porter).

CASE STUDY

NR

Natural Resources Defense Council Office

Santa Monica, CA

NRDC's office in Southern California is at the forefront of green building design in the United States earning a Platinum rating from the U.S. Green Building Council's LEED (Leadership in Energy and Environmental Design) program.

NRDC's office emphasizes the use of passive strategies to reduce energy consumption. Electric lighting is reduced through a design that provides ample daylight and daylighting controls that automatically turn off lighting when there is enough daylight. Light-colored roofs reduce solar heat gains through the envelope while simultaneously reducing heat island effect. Natural ventilation reduces ventilation fan energy, and the cooling system makes use of Santa Monica's temperate outdoor air to reducing space conditioning energy. Fans create air movement that helps keep occupants comfortable at higher temperatures.

THE REHABILITATION OF THE 1920S STRUCTURE INCLUDED:

- Daylighting through the multiple stories with three internal light wells
- High efficiency luminaires that make effective use of 90% of the light produced (as opposed to 50% which is typical of many luminaires)
- Automatic daylighting and occupancy controls for electric lighting
- EnergyStar rated appliances
- Natural Ventilation that also provides all of the space cooling in some of the spaces
- High efficiency heating and cooling equipment
- High efficiency water heating
- Light-colored cool roof
- On-site renewable energy production

Terminology

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 carbon emissions buildings.

ALL-ELECTRIC BUILDING: A building whose only energy delivered to the site is electricity.

MIXED-FUEL BUILDING: A building that has both electricity and fossil fuel utilities delivered to the site.

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.

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.

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 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.

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.

CALIFORNIA ENERGY COMPLIANCE SOFTWARE: CEC-approved simulation software used to show compliance with Title 24, Part 6. A list of approved residential and nonresidential software is available on the CEC website: https://www.energy.ca.gov/rules-and-regulations/building-energy-efficiency.

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.

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.

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.

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 wood, fabric, and other lightweight materials.

Resources

2019 Title 24 Documents:

- Standards: energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards
- Reference Appendices (including HERS Verification Protocols): energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2019-building-energy-efficiency-0
- Residential Compliance Manual: ww2.energy.ca.gov/2018publications/CEC-400-2018-017/Compliance_Manual-Complete_without_forms.pdf

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

California ZNE Action Plans: capath2zne.org

California Energy Wise Commercial Kitchen Resources: caenergywise.com

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

Energy Code Ace: energycodeace.com

ENERGY STAR® New Homes: energystar.gov/newhomes

ENERGY STAR® Certified Products: energystar.gov/products

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

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

Home Performance Attics (HPA) and High Performance Walls (HPW) Modeling Guides: cahp-pge.com/wp-content/uploads/2016/08/2013-Title-24-CAHP-Master-Builder-Modeling-Guidebook-V5-Formatted.pdf

HPA and HPW Product Catalogue: cahp-pge.com/MasterBuilder_WISE_TRC_ProductCatalog.pdf

LEED Rating Systems: usgbc.org/leed

Living Building Challenge: living-future.org/lbc

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

Passive House Institute US: phius.org

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

Savings by Design Incentives: savingsbydesign.com

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

Zero Energy Project: zeroenergyproject.org

ZNE Communications Toolkit: 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