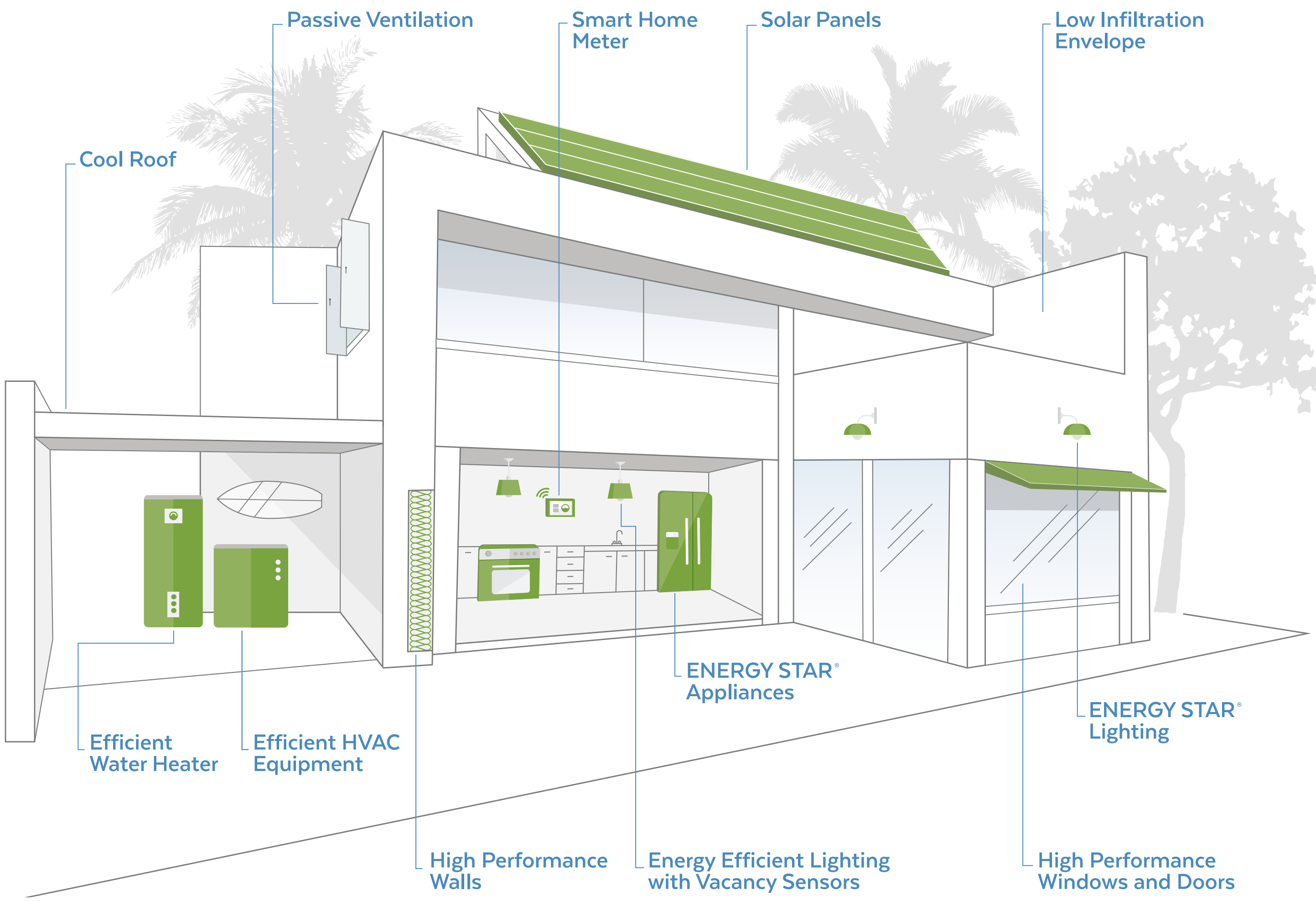
Santa Monica Residential Zero Net Energy Guide for New Construction



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ZNE homes save money and have a higher resale value as the top-tier option for home buyers. With significantly lower monthly utility costs, owners experience an improved net cash flow. California home owners generally pay high electricity rates, which leads to even more cost saving, making ZNE homes a good idea for homebuyers today. In California, incentives are high and may decline in the future.

Introduction

Zero net energy (ZNE) homes are utility grid connected homes that are designed and operated so efficiently that they are able to produce as much energy as they need to operate on an annual basis with clean, renewable energy. ZNE homes are more comfortable and healthier due to passive design strategies such as natural ventilation and daylighting. ZNE homes lower operational and maintenance costs and reduce emissions, while providing homeowners with greater peace of mind.

Although there is no one-size-fits-all approach—best practices can help your project achieve ZNE. This guide focuses on the general elements of ZNE homes and provides links to the specific details and requirements of Title 24 (energy code) and Home Energy Rating System (HERS) verification (field verified and tested).

The following steps are recommended:

1. **Set Goals**
2. **Reduce Energy Loads**
3. **Select Efficient Equipment**
4. **Add Renewable Energy**
5. **Verify Ordinance Compliance**

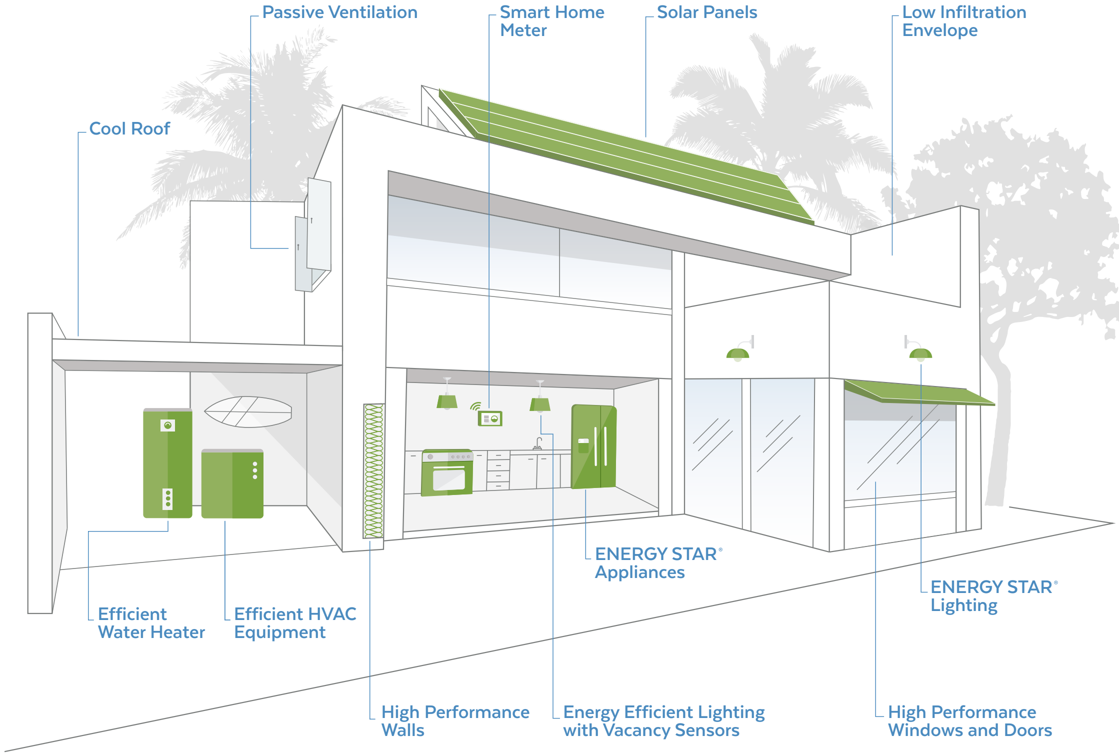
ZNE Code Building is one where the value of the energy produced by on-site renewable energy resources is equal to the value of the energy consumed annually by the building, as defined by the Integrated Energy Policy Report (IEPR)[1]

Santa Monica Zero Net Energy Ordinance

In December 2016, the Santa Monica City Council adopted a ZNE ordinance that requires low-rise residential new construction buildings to be 15% more efficient than 2016 Title 24 and achieve an Energy Design Rating (EDR) of zero, or less (EDR $\leq$ 0). The ordinance applies to single family homes, including townhomes, and low-rise multifamily residential projects less than or equal to three stories. The ZNE ordinance compliments Santa Monica's previously adopted solar ordinance. For more information, visit www.smgreen.org.

1 http://docketpublic.energy.ca.gov/PublicDocuments/15-IEPR-01/TN212017_20160629T154354_2015_Integrated_Energy_Policy_Report_Small_File_Size.pdf

Manna House in Glassell Park, CA. www.JeremyLevine.com, Photography by Tom Bonner



1. Set Goals

The end goal for ZNE homes is in the title—to produce as much energy as the home uses over the course of a year. However, a home owner may opt to just meet the code requirement. With the many paths for getting to zero, it's 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 use.

There is no single ZNE recipe; many efficiency measures and combinations of measures can help a home achieve ZNE. Discussions with your project team and simple energy models can help determine which ones are most appropriate for your home.

Integrated Design

Achieving ZNE begins with modifications to the traditional design and construction process. Homeowners and builders are encouraged to start early, set goals, make sure all parties are involved in the integrated design process and committed to the ZNE result.

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

The goal of a ZNE design is a comfortable home with lower annual utility bills than a traditional design. The Santa Monica ZNE ordinance encourages project teams

The Home Energy Rating System (HERS) is a nationally recognized system for inspecting and calculating a home's energy performance. The 2016 Title 24 has mandatory HERS measures. Several of the residential measures require or have an option for HERS verification to show compliance and receive credit under Title 24.

to implement measures that significantly reduce energy consumption on lighting, water heating, and space conditioning. This can then reduce the equipment size and renewable energy resources needed to meet the ZNE ordinance. Note that a ZNE building does not mean no energy bills—bill amounts are based on several factors including energy used, energy generated, and net energy metering policy from the local utility.

To reduce energy consumption, consider measures in the following order: building orientation, envelope improvements, systems and equipment improvements, HERS verifications, and finally, renewables. Consider including a Certified Energy Analyst (CEA) as the project's energy consultant, who can provide guidance on design opportunities, Title 24 energy modeling, and technical understanding of the Santa Monica ordinance. Home owners can locate a CEA through the California Association of Building Energy Consultants (CABEC) website: https://cabec.org/.

Several resources are available to help you achieve a successful ZNE design. These include utility-sponsored programs and building certifications such as the Department of Energy (DOE) Zero Energy Ready Home (ZERH), LEED, Living Building Challenge, Green Point Rated, and ENERGY STAR®. Code-education and ZNE best practices training resources include Energy Code Ace, CABEC, and the Zero Energy Project among many others.

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 your home with the right site and design. Attention to how the home is oriented and whether windows take advantage of natural light and breezes impact energy performance. These decisions about passive solutions and envelope early in the design process can significantly minimize energy use.

Many resources are available to designers to help analyze your 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.

Envelope

ZNE 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 house. Attention must be paid to the details and transitions during construction to ensure maximum comfort for the home owner.

Frank Lloyd Wright's Taliesin West in Scottsdale, AZ incorporates deep overhangs to shade the windows with passive ventilation, and thick thermal mass walls.

Project teams should discuss fenestration design and performance values with the consultant to optimize and balance project goals in regards to window area, orientation, and performance characteristics. Considering wall, floor, roof insulation, 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. 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. (CC) Dan Tapia

Title 24 residential requirements currently regulate energy use associated with space heating, space cooling, ventilation, other HVAC loads, and domestic water heating. Of course, there are other energy end uses in a home, 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.

Quality Insulation Installation

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 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 are 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 on-site 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.

High Performance Walls

High Performance Walls (HPW) increase the performance of the residential envelope, reducing 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 wall assembly 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.

Santa Monica's current prescriptive U-factor requirement is 0.065, which can be met with R-15 cavity insulation in a 2x4 wall at 16" on center with R-4 continuous exterior insulation. Examples to achieve a lower U-factor include:

- R-19 cavity insulation in 2x6 walls at 16" on center with R-5 continuous exterior insulation. This is the prescriptive requirement in many California climate zones in 2016 Title 24 Standards and achieves a U-factor of 0.051.
- R-15 cavity insulation in a 2x4 wall at 16" on center with R-8 continuous exterior insulation. This achieves a U-factor of 0.050.
- R-21 cavity insulation in 2x6 walls at 16" on center with R-4 continuous exterior insulation. This achieves a U-factor of 0.051.

Additional assemblies and their resulting U-factors can be found in the 2016 Title 24 Joint Appendices JA4.3. Modeling guides are available through the CAHP Master Builder initiative for assistance in properly modeling HPW 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.

Costs to consider when selecting a wall assembly are increasing stud depth and the type of insulation. 2x6 studs carry a cost premium over 2x4 studs; however, 2x6 studs allow more space for a lower density batt 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 lumber cost reduction. Discuss additional considerations with the framer and installer when implementing continuous exterior insulation greater than 2”, typically around R-8.

ZNE homes are higher performing, more resilient to the impacts of extreme weather events and less vulnerable to the instability of energy prices.

High Performance Attics

High Performance Attics (HPA) improve the building thermal envelope and reduce heating, ventilation, and air conditioning (HVAC) distribution losses in residential buildings when HVAC equipment and ductwork are located in the attic. HPA can be achieved several ways and depends on the attic construction (ventilated or sealed). The main components include insulating the barrier between conditioned and unconditioned space (typically the ceiling), insulation at the roof deck, and improving duct insulation and leakage if ductwork is in the attic space. Modeling guides are available through the CAHP Master Builder initiative for assistance in properly modeling HPA 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.

Current prescriptive requirements in Santa Monica are R-30 roof/ceiling insulation, a radiant barrier, R-6 duct insulation, and 5% total duct leakage when ducts are located in unconditioned space. A high performance ventilated attic may include:

- R-38 insulation at the ceiling below the attic
- Insulation at the roof deck with tile roofing:
  - R-13 below the roof deck (at rafter) spray in cellulose or fiberglass insulation secured with netting or spray foam insulation, or
  - R-6 continuous insulation above the roof deck
- Duct leakage target of 5% of the air handler airflow
- R-8 duct insulation if the ducts are located in unconditioned space
- Radiant barrier with above roof deck insulation. A radiant barrier is not practical to install, nor thermally effective, with insulation below the roof deck.

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

Variations on this design can be developed for asphalt shingles or a sealed attic. Additional HPA assemblies are described in the 2016 Title 24 Residential Compliance Manual section 3.6.2.1 and 3.6.3. An alternative to designing HPA is to locate all HVAC equipment and duct work in conditioned space and have it verified by a HERS Rater. For this design, see the Low Leakage Ducts in

Conditioned Spaces. Another alternative is to locate ducts in a sealed attic by moving the thermal envelope from the attic floor to the ceiling, including any gable ends. Finally, some above-deck insulation products, such as insulated ceiling tiles, or between-batten insulation blocks that are not strictly continuous, can be modeled as such for improved attic performance.

Cost considerations include increasing insulation depths and additional insulation at the roof deck. If using spray in cellulose or fiberglass insulation below the roof deck, netting is needed to secure the insulation directly against the roof deck. However, below deck insulation does not require a radiant barrier and can be done at the same time as ceiling insulation installation. Both forms of attic ceiling insulation also require careful attention to O'Hagin and soffit vents, and any other roof deck penetrations which may also add some cost. R-8 duct insulation is market standard and should have little to no cost increase on R-4.2 or R-6 insulation.

High Performance Fenestrations

zHomes in Issaquah, WA was the first ZNE townhouse project in the US.

A home's efforts at envelope energy efficiency can be lost through the selection and installation of poor performing windows, skylights, or doors. 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. Typically, a 10-30% window to wall ratio is acceptable, but there are times when more may be desired to take advantage of a beautiful view, or the need for ample daylight. These considerations are the trade-offs of energy performance to achieve ZNE.

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.

The 2016 Title 24 prescriptive values in Santa Monica are a U-factor of 0.32 and an SHGC of 0.25. There are window components that, when adjusted or applied, improve fenestration performance, including coatings, tinting, and triple-pane windows. An appropriate high performance window for Santa Monica has a U-factor of 0.30 and an SHGC of 0.23, with an incremental cost over the prescriptive window of about $0.15 per square foot of window (or less). This window is a dual-pane market standard and has a minimal cost increase compared to triple-pane and lower SHGC value windows, which can be heavily tinted based on currently available products.

In Title 24, a compliance penalty is applied if the west facing window area exceeds 5% of the total conditioned floor area and if the total glazing area exceeds 20% of the conditioned floor area. This should be considered during the integrated design process for buildings with a lot of windows. Low U-factor windows become especially necessary in designs with a high percentage of total or west facing windows.

Manna House in Glassell Park, CA has a light colored roof that doubles as a roof deck.
www.JeremyLevine.com
Photography by Tom Bonner

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. Cool roofs at the required values are widely available in California because it is a code requirement in many areas. The values can be met with almost any tile product at no additional cost or several non-white asphalt shingle products at 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, 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.

Santa Monica does not have cool roof requirements for low-sloped or steep-sloped roofs in 2016 Title 24. A recommended steep-sloped cool roof has an aged solar reflectance (ASR) of 0.20 and an aged thermal emittance of 0.85, which is the prescriptive requirement in several climate zones.

Building 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 HERS verification 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, 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 is a helpful resource to understand the steps entailed in achieving low envelope leakage in single family and low-rise multifamily buildings.

Title 24 modeling includes a credit for HERS verified reduced envelope leakage below 5.0 ACH50 for single family homes. By following QII frame-sealing, the other best practices mentioned in this section, and working with a trained and knowledgeable construction crew, 3.0 ACH50 should be easily achieved. However, since verification occurs after construction is complete, relying on an aggressive air sealing target could complicate compliance.

Passive Heating, Ventilation, Cooling, and Lighting

Consider designs that use passive ventilation to move air through the home. Use the house orientation to take advantage of cool morning or evenings winds. Deep roof overhangs, exterior window shades, and vegetation can block the sun during the hottest times of the day. Or, study if a thermal mass is right for the design.

While passive systems will not help contribute to meeting the Santa Monica ZNE ordinance, passive systems may reduce energy demands, require less energy, and potentially a smaller on-site renewable energy system. 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 in order to meet common temperature set points, air conditioning is used more frequently than heating. The first and primary step to reduce cooling is the design of a well-insulated and contiguous thermal envelope.

The Larch House in Ebbw Vale, Wales was built to PassivHaus standards and most energy needs a re met by heat from the sun, occupants, and appliances. (cc) Natural Building Technologies

There will be spaces and rooms with specific heating, cooling, or lighting requirements, such as kitchens, exercise or bed rooms. Instead of the entire home adopting these specifications and sacrificing energy efficiency, a primarily passively house can consider an independent efficient mechanical heating, cooling, and lighting systems in these spaces, just as you would use a bright desk light to illuminate a specific area. However, too many independent systems can actually increase energy use, so energy modeling is always encouraged.

Take advantage of daylighting during floor plan design. Locate rooms that require ample lighting, such as workshops or kitchens, near windows to use daylight to its fullest effect. Place high windows in large, 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 but there are trade-offs with losing roof space for HVAC or solar photovoltaic equipment.

The main shortfall of daylight is that it is not readily available at all hours of the day. Additionally, direct daylight can cause discomfort from glare and heat gain, so window and skylight blinds or exterior shading strategies are encouraged. Material color and texture selection is also an important consideration for glare reduction.

3. Select Efficient Equipment

Many efficiency measures and combinations of measures can achieve ZNE. Discussions with your project team and simple energy models can help determine which ones are most appropriate for your home.

Lighting

Daylighting can provide access to natural light and a connection to the outdoors for homeowners. As a free resource, daylight can be supplemented with visually pleasing, high efficacy light fixtures and lamps that can be used for task lighting a work surface or general illumination at night. Lighting controls can also ensure lights are only on when they are needed.

Daylighting

Decisions made early in the design phase can have a significant impact on a building's potential for using daylight as a primary light source and minimizing the need for electric light during daylight hours. In order to achieve adequate daylighting, homes need to be designed with the majority of frequently used spaces or rooms near exterior windows or under skylights or solar tubes in order to provide access to sufficient daylight.

Daylight fills the living room at the Three Trees House in Eagle Rock, CA, limiting electric light. www.JeremyLevine.com Photography by Tom Bonner

Homes should limit their East-West direct sun exposure and make use of overhangs to shade south facing windows. 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 can help reduce periods of direct sun exposure.

Lamps and Fixtures

Title 24 requires that all permanently installed luminaires and lamps be high efficacy. Efficacy is a ratio of light output to power used – lumens per watt. High-efficacy light sources generally provide brighter light levels with low wattage, similar to, but not limited to the characteristics of LEDs. 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 some spaces. 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 pantries or basements can benefit from the use of vacancy sensors.

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.

Exterior lighting is limited to the necessary locations at the Three Trees House in Eagle Rock, CA www.JeremyLevine.com Photography by Tom Bonner

Exterior Lighting

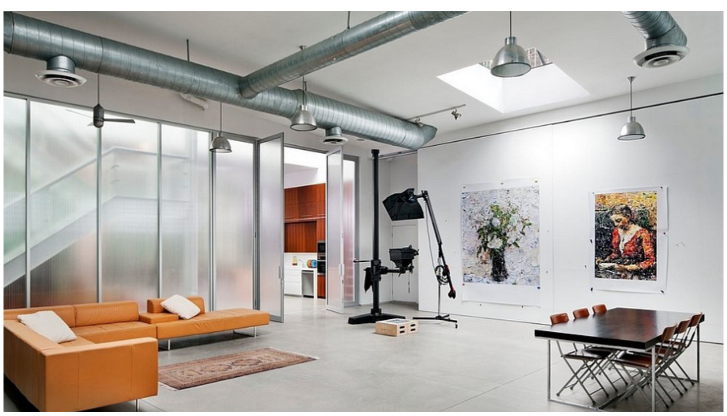
Similar to interior lighting, Title 24 requires outdoor lighting to be high efficacy. Outdoor lighting permanently mounted to a residential building must be controlled by a photocell, motion sensor, time switch control, or energy management system. Increasing exterior lighting efficiency beyond code can be challenging and passive strategies for exterior lighting are limited. Consider 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.

HVAC

Once the envelope design goals are established, identify home heating, ventilation, and air conditioning needs and equipment in various spaces. Energy modeling can assist with the exercise of selecting high performance equipment. Also, consider duct design improvements such as locating ducts in the conditioned space to minimize heat transfer.

Efficient HVAC System

Installing a heating and cooling system that is more efficient than the minimum efficiency set by the DOE is another way to reduce energy use associated with heating and cooling a space. Consider installing a certified ENERGY STAR® system with a high Annual Fuel Utilization Efficiency (AFUE) [or Heating Seasonal Performance Factor (HSPF)] in the case of heat pumps, and having a HERS Rater verify the Seasonal Energy Efficient Ratio (SEER) and Energy Efficient Ratio (EER) efficiency values of your installed system. A high AFUE can be achieved by purchasing a condensing furnace. The combination of verified high efficiency and HERS verified Refrigerant Charge Verification, will ensure that your HVAC system is operating at optimal efficiency, reducing the energy needed to heat and cool a home and lowering energy bills.



Locating ducts in the living space reduces air leakage and wasted HVAC energy. Design by BWARchitects

Low Leaking Ducts in Conditioned Space

This measure verifies that ducts and air handling equipment are located in conditioned space and meets CEC's definition that leakage to the outside cannot exceed 25 cubic feet per minute (cfm). This design is an alternative to High Performance Attics (See the HPA Section). This is achieved throughthree verifications:

- Duct leakage test (mandatory HERS verification)
- Envelope leakage test (i.e., blower door test)
- Verify low leakage air handling unit

CEC has established a testing protocol for this verification in the Title 24 Reference Appendices, along with all other HERS verification tests. To test the building leakage in low-rise multifamily buildings, some HERS Raters use a blower door test method by compartmentalizing individual dwelling units.

In a single family home, 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 home, including 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 home 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.

Typical multifamily construction practice is to locate ducts and HVAC equipment in conditioned space; therefore, the only additional cost is for the HERS verification to confirm that the system meets the specified leakage values.

A small efficient ductless heat pump can be installed in spaces that require specific temperature needs or only be used a few times a year. Photo by Nick Keppol

Reduced 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. New federal regulations that go 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.

Refrigerant Charge Verification

A HERS Rater will verify 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.

Domestic Hot Water

The best way to reduce hot water energy consumption is to reduce the demand by specifying efficient, low-flow fixtures in the kitchen, bath, and laundry rooms. This will also decrease overall water use. Once the hot water demand has been reduced, identify the most efficient way to heat, store, and distribute the hot water.

Efficient Water Heaters

Domestic water heating is one of the main energy uses for residential buildings in Santa Monica. Installing a water heater that is more efficient than the minimum efficiency set by the DOE reduces energy use associated with water heating. Consider installing an ENERGY STAR® certified water heater that is condensing or highly efficient. Condensing instantaneous (tankless) water heaters can achieve the highest energy factors on the market. The current DOE minimum energy factor for a gas instantaneous water heater is 0.80, whereas ENERGY STAR® certified gas instantaneous water heaters must have an energy factor of at least 0.90.

Compact Water Heater Distribution

Compact DHW distribution is a design strategy that reduces the length of pipe runs from an optimally located water heater to appliances and fixtures. To successfully implement compact hot water distribution, it should be considered early in schematic design so that the water heater, hot water fixtures, and piping paths are properly located 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 home.

Daylight and low-water use fixtures are on display at the Hutchins Residence in Eagle Rock, CA
www.JeremyLevine.com
Photography by Tom Bonner

Designing a project to meet Compact DHW Distribution requires forethought in floor plan and fixture placement, and/or moving a 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 to the fixture, resulting in less wasted water. The maximum allowed pipe lengths to qualify as a compact distribution system are outlined in Title 24 Residential Reference Appendices RA3.6.5.

Pipe Insulation

Pipe insulation reduces heat loss through your pipes and can help raise water temperatures at the appliance or fixture. The main benefit is that you will not need to wait long for hot water to run when you turn on a faucet. In some cases, you may be able to lower the temperature of your water heater too.

The 2016 Title 24 Standards include mandatory pipe insulation requirements in Table 120.3-A which cover the majority of hot water pipes. To receive credit for pipe insulation not covered under the mandatory requirement, all pipes between the water heater and fixtures must be insulated and verified by a HERS Rater. Beginning on January 1, 2017, the 2016 California Plumbing Code requires pipe insulation levels that are similar to that required if taking the non-HERS pipe insulation credit. Thus, the non-HERS credit is obsolete under the 2016 energy code. However, the HERS-Verified Pipe Insulation Credit will remain.

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

Pipe insulation requirements vary depending on the pipe diameter and the expected temperature of water being transported through the pipe. The majority of pipes that would be triggered under this requirement are 1/2” in diameter and are transporting water from a main branch to an end use fixture at lower temperatures. According to Table 120.3-A in 2016 Title 24, these pipes will need 1” of insulation. The cost for 1” pipe insulation on ½” in diameter is less than $4.00 per linear foot of pipe, plus the cost for HERS verification. The pipe length covered under this measure can be a small portion of the entire distribution piping, depending on the distribution design. Combining pipe insulation and a compact distribution design will reduce costs since there is less overall material needed.

Plug Loads

Even in very efficient homes, plug loads, which are devices plugged into wall outlets, can represent 50% of total annual energy use. Much of this energy use occurs when the home is 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.

Efficient equipment and appliances can help reduce home energy demand, reducing the size of the PV system needed to achieve ZNE.
Manna House in Glassell Park, CA
www.JeremyLevine.com
Photography by Tom Bonner

While plug load reduction will not help contribute to meeting the Santa Monica ZNE ordinance, the reduction in plug loads will reduce energy demands, require less energy, and potentially allow for a smaller on-site renewable energy system.

ENERGY STAR® Equipment and Appliances

The ENERGY STAR® label is available for nearly all home 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 house is unoccupied—computers, monitors and televisions, lighting, fountains, chargers, etc.—can be plugged into a controlled circuit to be turned off during unoccupied hours. 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 a resident is home or not.

Investment in ZNE practices and technologies creates local jobs that strengthen local economies and communities and helps us gain control of our energy future. By investing in a ZNE home, you can demonstrate leadership in clean energy in California.

Other Measures

This guide is not an exhaustive list of efficiency measures for achieving zero net energy. Review the resources section and spend some time gaining inspiration at the energy efficient Pico Branch Library.

Similar to passive systems and plug loads, other energy reductions will not help contribute to meeting the Santa Monica ZNE ordinance. However, further energy reduction can allow for a smaller on-site renewable energy system.

If a pool will be constructed, 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. If the home has an electric car, the car battery could be charged by the solar panels and the battery could later be used by the home during the evening when the solar panels are not producing energy. The combinations of efficiency measures needed to achieve ZNE are plentiful. Working with a creative, integrated team, you will find the best solutions for your home.

To maintain a ZNE home, energy management systems, or monthly bill review may be necessary to ensure that all systems are operating as intended.

4. Add Renewable Energy

Once energy consumption has been minimized, installing on-site renewable energy systems can be sized to meet the ZNE goal. 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 home uses, the fewer PV panels required, and the lower the price.

PV is the most cost effective way for homeowners to create energy on-site. Since the price of PV is dependent on the amount of energy generation needed, reduce the energy demand as much as possible to reduce the cost of PV. 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 on 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.

Solar panels can be purchased or leased. Purchasing panels allows the homeowner or builder to receive available incentives and/or tax credits. Leasing reduces the upfront cost of the panels and the maintenance. Either option offsets the energy used helping to meet your zero net energy goal.

5. Verify Ordinance Compliance

Energy modeling and HERS verification are two methods to ensure that your house is constructed as intended to meet Santa Monica's ZNE ordinance. Both tools can be more powerful in the design than after construction when using an integrated design process. Use the HERS standard in the design phase to identify energy efficiency measures for your home. Energy modeling can be used to test those measures' efficiency in an interactive away.

Ultimately, achieving ZNE depends on occupant behavior and understanding of ZNE features. Providing best practices and information on a ZNE home can help occupants take full advantage of their new home. Use energy modeling during design to determine the benefits of additional exterior wall insulation. Results may show that the added cost does not exceed the benefits or it may help to reduce the size of the HVAC system. You can further model the impacts of exterior shading or triple-glazed windows to determine if the HVAC system can be eliminated from the project, saving construction and operating costs though energy modeling.

The on-site photovoltaic panels at the zHome townhomes in Issaquah, WA assist in achieving the community's ZNE goal.

Energy Modeling

Residential projects can show compliance with the Santa Monica ZNE ordinance using CEC-approved energy simulation software. Energy consultants, especially CEAs, have extensive knowledge of energy simulation software and can produce the required Title 24 and Santa Monica ZNE Ordinance documentation. An energy consultant will model the proposed building and can inform the project team if the design meets the ordinance requirements.

Title 24 residential requirements currently regulate energy use associated with space heating, space cooling, ventilation, other HVAC loads, and domestic water heating. Of course, there are other energy end uses in a home, 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 a designer should consider selecting energy efficient appliances, as this will further reduce energy used in the home and annual energy bills, these appliances cannot earn Title 24 credit and will not help a project meet the 15% compliance margin or EDR ≤ 0. An energy consultant can further explain the software capabilities and Title 24 requirements during initial goal setting meetings.

Technische Universität Darmstadt's solar decathlon demonstration highlights the opportunities for shading glazing through overhands and exterior shutters.
(CC) Photo by Jeff Kubina

The following steps can be taken to confirm the project meets 15% improvement on 2016 Title 24 and an EDR ≤ 0:

Verifying 15% Improvement on 2016 Title 24:
Once the energy consultant performs the analysis on the proposed building design in an approved residential software, the Compliance Margin output must be greater than or equal to 15.0%. Using CBECC-Res. the Compliance Margin is located on the Energy Use Details tab of the analysis results or on the Title 24 Compliance Report, as shown in Figure 1 and Figure 2. The Compliance Margin calculation 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.

Figure 1. Compliance Margin output from CBECC-Res analysis results

SF_Pkg6_EDR0 - SF_Pkg1

Energy Use Details | Summary | Energy Design Rating

End Use	Standard Design Site (kWh)	Standard Design Site (therms)	Standard Design (kTDV/ft²-yr)	Proposed Design Site (kWh)	Proposed Design Site (therms)	Proposed Design (kTDV/ft²-yr)	Compliance Margin (kTDV/ft²-yr)
Space Heating	82	95.3	7.22	30	67.8	4.95	2.27
Space Cooling	60		2.58	33		1.39	1.19
IAQ Ventilation	141		1.11	141		1.11	0.00
Other HVAC			0.00			0.00	0.00
Water Heating		135.9	8.40		132.2	8.18	0.22
PV Credit						0.00	0.00
Compliance Total			19.31			15.63	3.68
Inside Lighting	616		4.99	616		4.99	19.1 %
Appl. & Cooking	1,046	45.2	11.25	1,046	45.2	11.24	Result:
Plug Loads	2,371		18.91	2,371		18.91	PASS
Exterior	152		1.14	152		1.14	(not current)
TOTAL	4,468	276.4	55.60	4,388	245.2	51.91	

Done

ENERGY USE SUMMARY				
04	05	06	07	08
Energy Use (kTDV/ft^2-yr)	Standard Design	Proposed Design	Compliance Margin	Percent Improvement
Space Heating	7.22	4.95	2.27	31.4%
Space Cooling	2.58	1.39	1.19	46.1%
IAQ Ventilation	1.11	1.11	0.00	0.0%
Water Heating	8.40	8.18	0.22	2.6%
Photovoltaic Offset	----	0.00	0.00	----
Compliance Energy Total	19.31	15.63	3.68	19.1%

Figure 2. Compliance margin output from Title 24 Compliance Report

Verifying EDR ≤ 0

Once the CEA performs the analysis on the proposed building design, the simulation software will display three (3) EDR values for the proposed building on the Energy Design Rating tab of the analysis results:

- EDR of Proposed Design
- EDR of Proposed PV
- Final Proposed EDR

To confirm the ZNE ordinance is met, the Final Proposed EDR must be equal to or less than 0.0, as shown in Figure 3, meaning that the EDR of the Proposed PV offsets the EDR of the Proposed Design. Energy consultants may need to go through an iterative process of adjusting the installed PV size until the Final Proposed EDR value is 0.0, or less. For reference, most 2016 code compliant single family homes in Santa Monica's climate zone (CZ6) will score between 50 and 54 without solar, and low-rise multifamily will score between 58 and 62 without solar.

Figure 3. Final Proposed EDR value from CBECC-Res analysis results

SF_Pkg6_EDR0 - SF_Pkg1

Energy Use Details | Summary | Energy Design Rating

EDR of Proposed Design: 48.7 EDR of Proposed PV: 49.5 Final Proposed EDR: -0.8 (not current)

EDR of Standard Design: 52.2

End Use	Reference Design Site (kWh)	Reference Design Site (therms)	Reference Design (kTDV/ft²-yr)	Proposed Design Site (kWh)	Proposed Design Site (therms)	Proposed Design (kTDV/ft²-yr)	Design Rating Margin (kTDV/ft²-yr)
Space Heating	209	174.1	13.51	30	67.8	4.95	8.56
Space Cooling	163		7.20	33		1.39	5.81
IAQ Ventilation	141		1.11	141		1.11	0.00
Other HVAC			0.00			0.00	0.00
Water Heating		189.6	11.72		132.2	8.18	3.54
Photovoltaics				-5,842		-52.81	52.81
Inside Lighting	2,615		21.36	616		4.99	16.37
Appl. & Cooking	989	73.4	12.31	1,046	45.2	11.24	1.07
Plug Loads	3,267		26.08	2,371		18.91	7.17
Exterior	328		2.35	152		1.14	1.21
TOTAL	7,712	437.1	95.64	-1,454	245.2	-0.90	96.54

Done

HERS

The Home Energy Rating System (HERS) is a nationally recognized system for inspecting and calculating a home's energy performance. The 2016 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 Raters typically provide 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 costs 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 can also avoid unnecessary site visits.

Single Family

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 below 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.

Figure 4. Single Family HERS Verification Costs Summary

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

Low-rise Multifamily

For multifamily buildings, HERS verification pricing differs by HERS company. Generally, HERS Rater pricing falls under two categories: 1) either price by the number of site visits (Figure 5), or 2) by the number of dwelling units (Figure 6).

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.

Figure 5. Multifamily HERS Verification Costs Summary—Method 1

Component	Multifamily
Method 1: On-site visit ($/visit)	$245

Method 2 is the price per unit. This method makes general assumptions on the standard number of visits per measure and averages costs amongst the number of units in a project. QII adds an additional $50 to each unit cost due to multiple site visits required.

Figure 6. Multifamily HERS Verification Costs Summary—Method 2

Component	Multifamily
Method 2: Per unit verification, no QII ($/unit)	$198
Method 2: Per unit cost of QII ($/unit)	$50

The Cottle Zero Energy Home | San Jose, CA

Recognized as the first net zero 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'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.

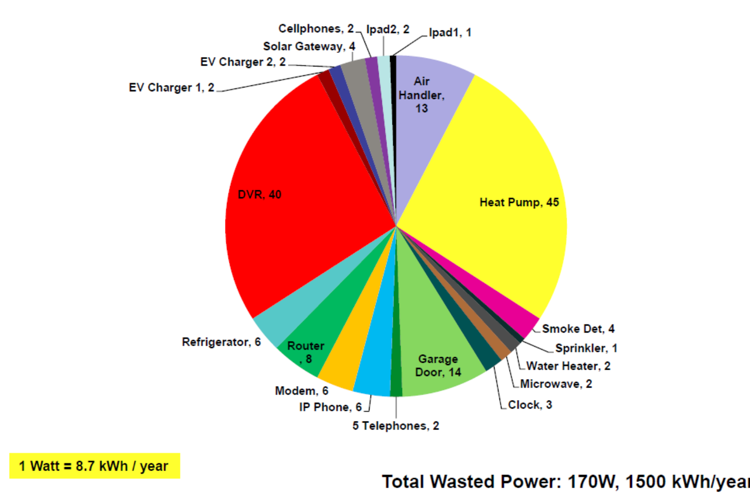
The home was built by Allen Gilliland, owner/founder of One Sky Homes. The incremental costs of building the home to the Passive House standard was $65,000, which is only 7% higher than that of a house built to code-minimum standards. With a HERS Rating of -1, the owners, Bill and Michelle Wong are able 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 28 cents per hour during peak demand times. This saves them approximately $2,900 a year compared to owners of a standard code compliant home.

The Energy+ Household Retrofit Zero Energy Home
Cupertino, CA

The 2,170-squart-foot, 4 bedroom/3 bathroom suburban home has achieved and maintained a net energy positive status since completing the major remodel in late 2011. The all-electric house in Cupertino, California is occupied by a working family of four. The family started by evaluating their current energy consumption including gas, natural gas, and electricity and found they used about 50,000 kWh/year. Second, they reduced energy use and increased efficiency into their home and lifestyles before eliminating natural gas use to become an all-electric home. Third, they electrified their automobiles to eliminate their gasoline use. Finally, they added a 10KW PV system to the south side of their roof to provide more energy than is necessary to run their home and their cars!

- Increased insulation in the attic, walls, and floors was expensive but provides comfort.
- 30% reduction by switching from conventional to efficient lights, appliances, and thermostat.
  - Replaced 50 CFLs with LEDs
  - Plug load cut-off remote saved 350 kWh/year.
- 66% energy savings by switching from gas to electric.
  - The electric heat pump water heater was selected over solar thermal due to it requiring less maintenance and fewer moving parts.
  - They moved from an 80% efficient gas furnace to a 300% air source heat pump and a 40% efficient gas cooktop to an 85% efficient induction cooktop.

A large part of the family's success is their attention and involvement. Developing a phased plan for energy use reduction can be beneficial for homeowners who occupy their home during a remodel or for those who do not have the capitol to complete the renovation in a short period of time. Regardless of the reason, ZNE is possible with any building and a good plan.



Energy and Household Plug analysis.

FAQ

Is it expensive to make my home ZNE? Custom home builders who are developing ZNE homes right now indicate that there are nominal additional costs, and that the key issue to achieve ZNE is design and quality construction. As the market continues to grow, the availability of trained developers and designers continues to increase, making ZNE homes more available and cost competitive.

Is there help to pay for a ZNE home? Incentives are available through utilities and state renewable energy programs to help offset ZNE design, planning, research, and construction costs. Programs such as California Advanced Homes and the New Solar Homes Partnership provide technical assistance and incentives for ZNE homes.

What is the difference between a ZNE home and a "ZNE-ready home?" A ZNE home includes a grid-tied renewable energy system that will produce at least as much energy as the home consumes over the course of a year. A ZNE-ready home is a high performance home that is designed and built with the same energy efficiency features as a ZNE home, but does not include a renewable energy system. In many cases, a renewable energy system can be added in the future to meet all of its annual energy consumption needs.

Manna House in Glassell Park, CA.
www.JeremyLevine.com
Photography by Tom Bonner

How do I know that a home is ZNE or ZNE ready? A ZNE or ZNE ready home is typically certified by a third party organization. Look for certifications like the Department of Energy's Zero Energy Ready Certification, the Living Building Challenge Zero Energy Certification, Passive House Certification, and Earth Advantage's Zero Energy and Zero Energy Ready Certifications. Independent energy consultants can also provide third-party verification of zero energy home performance.

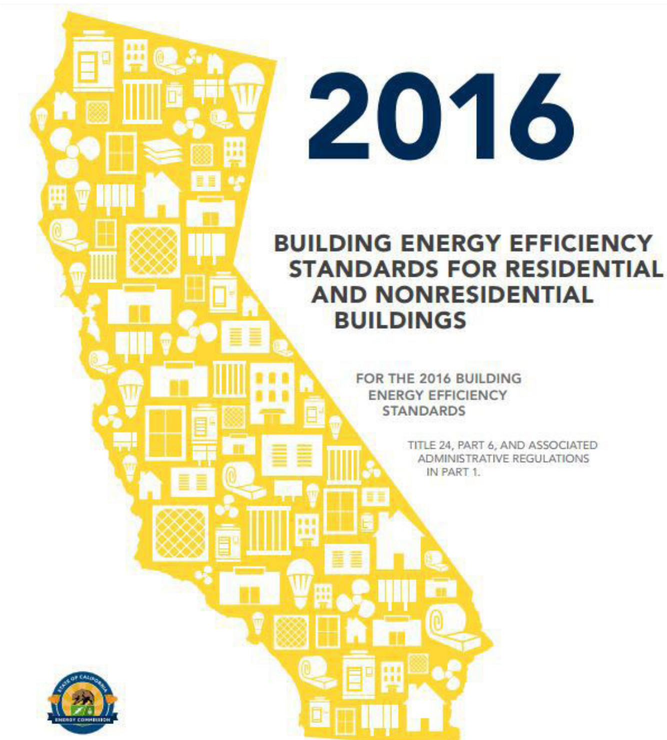
How can I make my home ZNE? Almost any home can be designed or renovated to become ZNE with the proper upgrades. To find a ZNE homebuilder, consult the Zero Energy Project Homebuilders List where you can find experts in the field available in your area. The Home Energy Rating System (HERS) Index evaluates the energy efficiency of your home and is a great way to get started towards ZNE. The targeted HERS Score can give you a better understanding of how energy efficient your home will be.

Why is it important to make homes ZNE? Energy efficiency improvements in building design and operations substantially reduce operating costs and the environmental impacts associated with buildings. The energy used in buildings is the second largest contributor to California's greenhouse gas (GHG) emissions. With rising energy costs, increasing climate-related impacts, and natural disasters, ZNE buildings help reduce our demand for energy and provide more resilient spaces to respond to climate impacts.

Terminology

A 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. The energy is measured in terms of Time Dependent Valuation (TDV).

California has set bold goals to achieve zero net energy for all new residential buildings by 2020 and all new commercial, as well as 50% of existing buildings, by 2030. For more information about ZNE definitions in California, see The Vocabulary of ZNE: A Guide to Zero Net Energy Terminology in California.



2016 Title 24

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. Santa Monica's ZNE Ordinance exceeds the energy requirements of the 2016 Title 24, Part 6.

Time Dependent Valuation (TDV)[2] – 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, to the utility system, and to society. The TDV method encourages building designers to design buildings that perform better during periods of high energy cost.

Energy Design Rating (EDR) – A scoring system that reflects a low-rise residential buildings' energy performance, as calculated in a California Energy Commission (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, http://www.energy.ca.gov/title24/2016standards/2016_computer_prog_list.html.

2 E3 (July 2014) Time Dependent Valuation of Energy for Developing Building Efficiency Standards: 2016 Time Dependent Valuation (TDV) Data Sources and Inputs. California Energy Commission. Available at: http://www.energy.ca.gov/title24/2016standards/prerulemaking/documents/2014-07-09_workshop/2017_TDV_Documents/

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.

Manna House in Glassell Park, CA.
www.JeremyLevine.com
Photography by Tom Bonner

Integrated Design – An integrated design process includes the active and continuing participation of multiple stakeholders to 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

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/wp-content/uploads/2016/09/CAHP-Master-Builder-Product-Catalogue.pdf

2016 Title 24 Documents:

Standards: energy.ca.gov/2015publications/CEC-400-2015-037/CEC-400-2015-037-CMF.pdf

Res Compliance Manual: energy.ca.gov/title24/2016standards/residential_manual.html

Reference Appendices (including HERS Verification Protocols): energy.ca.gov/015publications/CEC-400-2015-038/CEC-400-2015-038-CMF.pdf

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

ENERGY STAR® New Homes: energystar.gov/newhomes/?s=mega

ENERGY STAR® Certified Products: energystar.gov/products

DOE ZERH: energy.gov/eere/buildings/zero-energy-ready-home

LEED v4 for Homes and Multifamily Midrise:

usgbc.org/resources/leed-v4-homes-and-multifamily-midrise-current-version

Energy Code Ace: energycodeace.com/

Zero Energy Project: zeroenergyproject.org/

Green Point Rated: builditgreen.org/greenpoint-rated

Zero Energy Project – Resources for Zero Energy Homeowners, builders/renovators, buyers and sellers: zeroenergyproject.org/

The Home Energy Rating System (HERS) Index: resnet.us/hers-index

DOE Zero Energy Ready Home: energy.gov/eere/buildings/zero-energy-ready-home

California Residential ZNE Action Plan: californiaznehomes.com/

Savings by Design Incentives: savingsbydesign.com/zero-net-energy-zne-resources

Energy Design Resources: energydesignresources.com

ZNE Communications Toolkit: newbuildings.org/resource/ zero-net-energy-communications toolkit/

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

PassivHaus: phius.org/home-page

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

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