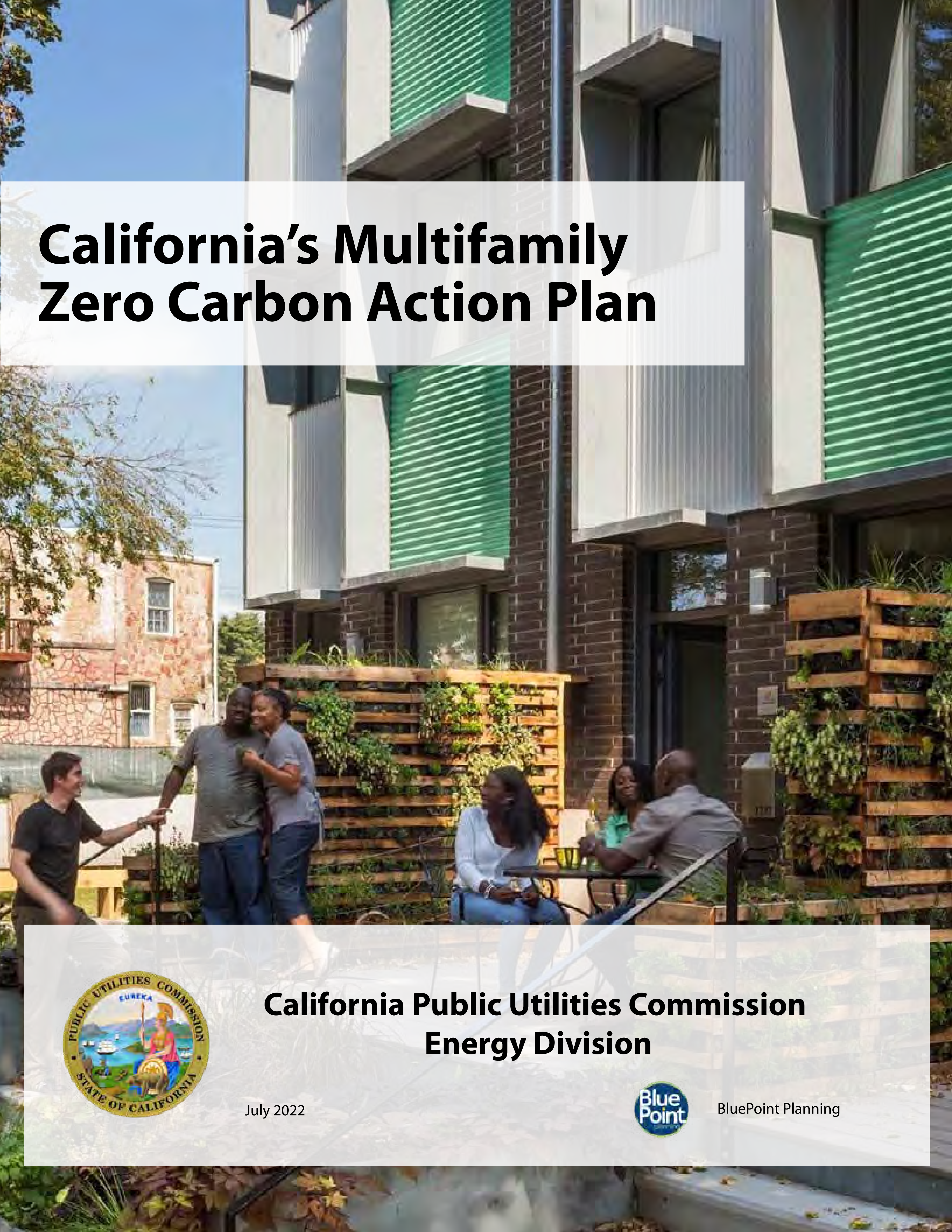


California's Multifamily Zero Carbon Action Plan

California Public Utilities Commission
Energy Division

July 2022

BluePoint Planning

Acknowledgments

The Multifamily Zero Carbon Action Plan is the culmination of discussions over two years with numerous stakeholders including industry experts, CPUC staff, and staff from RENs, CCAs, and equity-based on organizations. This Plan is meant to act as a guide for these groups and other relevant agencies and organizations to use to steer collective action towards zero carbon new construction and major renovations for multifamily buildings.

We thank the following partners, agency leads, and stakeholders who have been closely involved in shaping and reviewing the Plan throughout its development.

CPUC Staff

Rory Cox, CPUC
Abhilasha Wadhwa, CPUC
Christina Torok, CPUC
Jessica Allison, CPUC
Kevin Feizi, CPUC
Amanda Christenson, CPUC
Peter Franzese, CPUC
Travis Holtby, CPUC
Sarah Lerhaupt, CPUC
Audrey Neuman, CPUC
Jacob Rudolph, CPUC
Genesis Tang, CPUC
Jeorge Tagnipes, CPUC
Jessica Levine, CPUC
Nick Zanjani, CPUC
Nathaniel Kinsey, CPUC

CEC Staff

Mazi Shirakh, CEC
Tiffany Mateo, CEC
Will Vicent, CEC

Investor Owned Utilities

Conrad Asper, PG&E
Kelly Cunningham, PG&E
Pat Eilert, PG&E
Kathleen Ave, SMUD
Scott Blunk, SMUD
Michelle Thomas, SCE
Carlo Gavina, SoCal Gas

Multifamily Industry Stakeholders & Advisors

Sean Armstrong, Redwood Energy
Bronwyn Barry, North American Passive House Network and Passive House, BB Architects
Ann Edminster, Design AVEnues
Katie Ackerly, David Baker Architects
Steve Mann, Home Energy Services
Michael Kloefkorn, Van Meter Williams Pollack
Srinidhi Sampath, CHPC
Tanya Barham, Community Energy Labs
Abhijeet Pande, TRC
Tom White, Eden Housing
Jenny Berg, BayREN
Jordon Garbayo, 3CREN
Ralph DiNola New Buildings Institute (NBI)
Bruce Nilles, RMI
Jessica Grovesmith, Passive House Institute
Merrian Borgeson, NRDC
Panama Bartholomy, Building Decarbonization Coalition
Pierre Delforge, Building Decarbonization Coalition
Robert Nicely, Carmel Building and Design
Xavier Gaucher, Passive House California
Jay Murdoch, Owens Corning
Jennifer West, StopWaste
Debra Little, AjO
Bill Martin, California Geo

July 2022

Plan developed by:
BluePoint Planning
Mindy Craig
Bianca Hutner

Cover photo credits: 2022 Sam Oberter Photography

We also appreciate and thank representatives from the following organizations for their thoughtful input, time, and effort.

Air Resources Board
Arup
Asian Pacific Environmental Network
Bay Area Regional Energy Network
Build It Green
Building Decarbonization Coalition
Caliber Strategies
California Housing Partnership
Carmel Building and Design
Catalyst Group
City of San Francisco Water Power Sewer
Coachella Valley Association of Governments
Community Energy Labs
David Baker Architects
Design AVEnues, LLC
East Bay Community Energy
Eden Housing
Environmental Defense Fund
Frontier Energy
Greenlining Institute
Home Energy Services
Insight Resources Group
Ivy Energy
Los Angeles Department of Water and Power
Marin Clean Energy
Mendota Group
Natural Resource Defense Council
New Buildings Institute
North American Passive House Network
Opinion Dynamics
Pytok Architects
Passive House Institute
Redwood Energy
Reimagine Power
Rocky Mountain Institute
SCD Energy
Sonoma Clean Power
Southern California Regional Energy Network
Southwest Gas Corporation
StopWaste
The Utility Reform Network
TRC Companies
Tri-County Regional Energy Network
Van Meter Williams Pollack

And the many others who attended meetings and shared their insights.

Table of Contents

List of Figures & Charts

Acronyms

AB	Assembly Bill (California)
ADU	Accessory Dwelling Unit
BC	British Columbia
BUILD	Building Initiative for Low-Emissions Development
C&S	Codes & Standards
CAEESP	State of California Long-Term Energy Efficiency Strategic Plan
CalEPA	California Environmental Protection Agency
CALGreen	California Green Building Standards Code
CCA	Community Choice Aggregation
CEC	California Energy Commission
CPUC	California Public Utilities Commission
CSI	California Solar Initiative
CTCAC	California Tax Credit Allocation Committee
DAC	Disadvantaged Community
DG	Distributed Generation
DOE	US Department of Energy
DR	Demand Response
ED	Energy Division (CPUC)
EDR	Energy Design Rating
EE	Energy Efficiency
EPIC	Electric Program Investment Charge
ESJ	Environmental and Social Justice
ETCC	Emerging Technologies Coordinating Council
EUI	Energy Use Intensity
EV	Electric Vehicle
FEMA	Federal Emergency Management Agency
GHG	Greenhouse Gas
GWh	Gigawatt hour
HERS	Home Energy Rating System
HUD	US Department of Housing and Urban Development
HVAC	Heating, Ventilation, & Air Conditioning
ICC	International Code Council
IDP	Integrated Design Process
IOU	Investor-Owned Utility
LCA	Life Cycle Analysis
LEED	Leadership in Energy and Environmental Design Program
LIHTC	Low Income Housing Tax Credit
LGC	Local Government Commission
LGP	Local Government Partnership
MF	Multifamily
NBI	New Buildings Institute
NSHP	New Solar Homes Partnership
PG&E	Pacific Gas & Electric
PH	Passive House
PHFA	Pennsylvania Housing Authority
PHIUS	United States Passive House Institute
PIP	Program Implementation Plan
POU	Publicly Owned Utility
PSPS	Public Safety Power Shutoff
PA	Program Administrator
QAP	Qualified Allocation Plan
REN	Regional Energy Network
RD&D	Research, Development, and Demonstration
RNC	Residential New Construction
RFI	Request for Information
RPS	Renewable Portfolio Standards
SB	Senate Bill (California)
SCE	Southern California Edison
SMUD	Sacramento Municipal Utilities District
SoCal Gas	Southern California Gas
TECH	Technology and Equipment for Clean Heating
TDV	Time Dependent Valuation
TOU	Time of Use
USGBC	United States Green Building Council
WE&T	Workforce Education and Training
ZCFR	Zoning for Coastal Flood Resiliency
ZNE	Zero Net Energy

Executive Summary

Executive Summary

California has set an aggressive target to achieve carbon neutrality by 2045 at the latest. While our buildings are a significant contributor of carbon emissions, the technical capability to achieve zero carbon buildings exists. The Multifamily Zero Carbon Action Plan (MZCAP) endeavors to **push building energy efficiency levels to the highest level possible** for new and major renovations for multifamily buildings by incorporating cutting edge technologies and design approaches that achieve zero carbon emissions. The Plan focuses on creating a suitable environment and market for zero carbon buildings that will inform statewide energy code beginning in 2032 with and the adoption of zero carbon building reach codes in alignment with the State, stakeholders, and leading organizations such as the Building Decarbonization Coalition.

Under the auspices of the California Public Utilities Commission (CPUC), the MZCAP layers in **Passive House approaches** to drive energy efficiency improvements beyond current standards with electrification to achieve zero carbon emissions in building design, construction, and operation. Energy efficiency alone is not sufficient to meet the increased urgency of climate change, equity, and adaptation; multifamily development requires a substantial overhaul to a more holistic and integrated approach. The MZCAP encourages creating multifamily projects that are carbon neutral, climate resilient, affordable, and provide a durable sanctuary with healthy indoor air quality for residents during a loss of power or extreme weather event.

Zero Carbon Building Definition

A highly energy and water efficient building that uses no on-site fossil fuels and produces on-site or procures enough carbon-free renewable energy to meet building operations energy consumption annually. A zero carbon project prioritizes the use of recycled water and materials and is designed to reduce embodied carbon in the construction as much as possible.

(Based on Architecture 2030, Zero Code for California 2022)

California has led the country in the development of energy efficient buildings since the statewide 1974 enactment of building energy codes and

Major Renovations Definition

CalGreen building code defines major renovations as "additions, alterations or repairs where more than 50% of all existing wall of an existing structure is demolished or deconstructed," (more detailed definition listed in glossary). In practice, this means that major renovation projects generally occur in unoccupied housing.

standards. In 2008, the CPUC adopted the California Long-Term Energy Efficiency Strategic Plan (CAEESP), which included aggressive goals for deep energy efficiency and zero net energy (ZNE) residential and commercial buildings. Since then, the State of California legislature, former Governor Brown, and Governor Newsom have adopted legislation and plans to reduce carbon emissions (AB 32, SB 100), double the amount of renewable energy generation in the State (through a CPUC ruling), double energy efficiency in existing buildings (SB 350), promote electrification (through a CARB resolution[1]) and maintain California as a leader in addressing climate change. The State's goal of achieving carbon neutrality by 2045 has been a strong driver of far-reaching clean energy and energy efficiency policies in virtually all sectors. At the same time, California has seen rising economic and housing inequality, along with increasing impacts from climate change. Multifamily buildings sit at the intersection of these issues, and their construction can address these key challenges in the State.

As a leader in the nation, California is ready to provide a vision and action plan for all new and renovated multifamily projects to be zero carbon and climate resilient.

Dedicated Multifamily Building Code

"With the growing recognition of the relevance of multifamily buildings to California's affordable housing crisis...it is time to treat multifamily buildings as their own type, rather than as a combination of low-rise residential and nonresidential codes."[2]

The newest code cycle beginning in 2023 has several key changes for multifamily buildings. Historically, multifamily buildings have been characterized and regulated by the number of stories, regardless of building square feet or construction materials. Residential codes were applied to low-rise multifamily (three stories or less) and commercial codes and standards were applied to high-rise multifamily. This bifurcation created confusion and gaps in the application of innovative approaches to building efficiency. The new 2022 Energy Code has a new multifamily chapter to help streamline and highlight the important issues that are unique to multifamily buildings, while also establishing a single platform for residential and commercial modeling software.[3]

The MZCAP embraces the California Energy Commission (CEC) approach to considering multifamily buildings as a single category, and in most cases the goals and strategies in this Plan are applicable to multifamily buildings of any size.[4] (There may be some limitations for mixed-use or large high-rise buildings.) Further, the Plan is designed to drive more aggressive codes for the 2026 cycle. The MZCAP considers all new construction and major renovation multifamily building projects. It covers individual buildings as well as projects with multiple buildings and applies to affordable housing and market-rate projects.

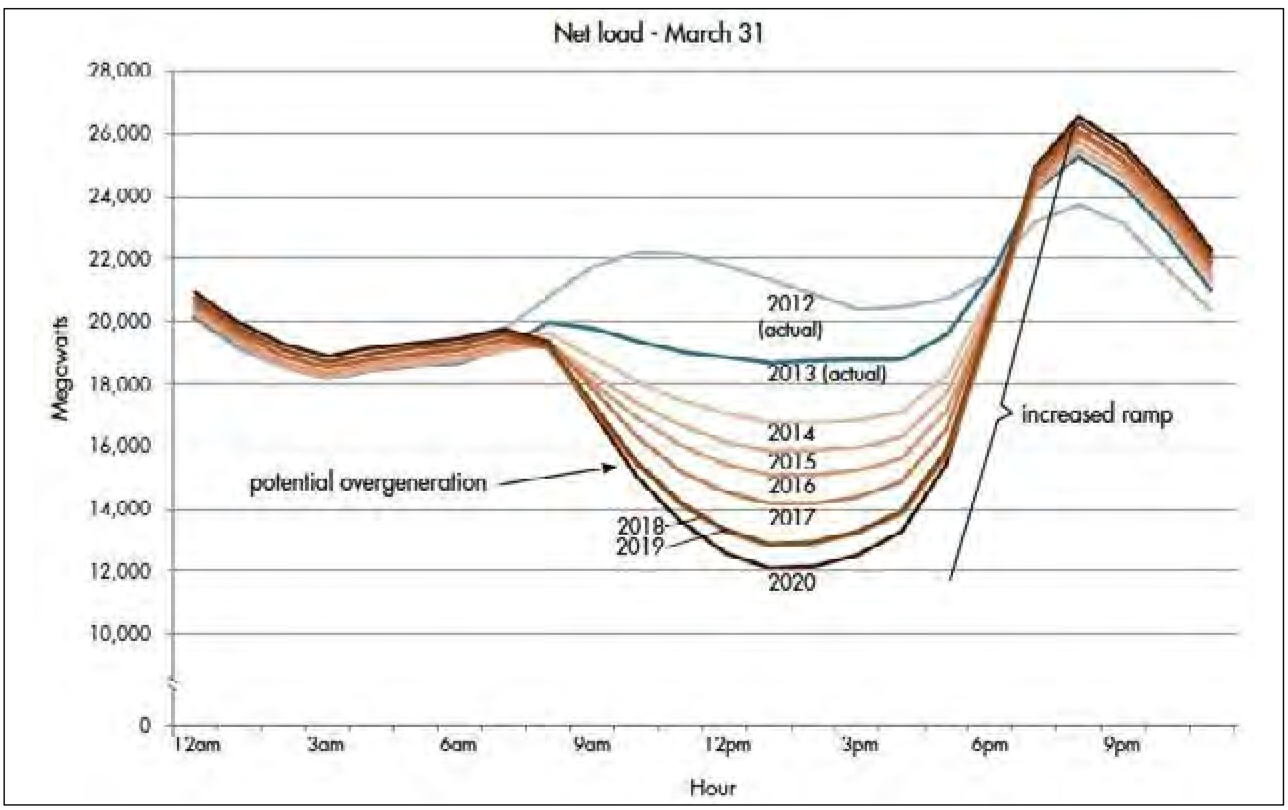
Building Decarbonization

"All-electric buildings are critical for curbing emissions. Buildings consume nearly 40 percent of energy in the United States... and a whopping 70 percent of electricity in California... The fossil fuel combustion in residential and commercial buildings accounts for 29 percent of U.S. emissions."[5]

As the State moves to a 100% renewable energy portfolio, all-electric buildings with low carbon emissions that support community resilience are the logical next step. Removing natural gas from multifamily buildings provides a range of benefits beyond the reduction in greenhouse gases (GHG), including better indoor air quality, reduction in costs from gas infrastructure, and improved safety. [6]

In recent years, electrification as a strategy to reduce emissions stemming from natural gas has picked up considerable steam. In 2019, the City of Berkeley became the first jurisdiction in California to ban natural gas in new construction buildings, signaling an aggressive push towards reducing building emissions and moving towards a fully electrified grid. Since then, over 50 other jurisdictions in California have adopted similar measures to require or highly incentivize all-electric new construction, especially as new electrified buildings are generally cheaper to construct than their mixed fuel counterparts.

Figure 1. Daily "Duck Curve" for energy use in California



Source" California Independent Systems Operator, 2016

CASE STUDY: Ice Box Challenge
Passive House Capability Demonstrated

Photo Courtesy of Passive House California, 2017 Oakland Frank Ogawa Plaza

The Ice Box Challenge is a public demonstration of the impact of Passive House building techniques on occupant comfort that has taken place in the summer months in cities across the world, such as Vancouver, Los Angeles, New York City, and recently, Glasgow as part of the 26th UN Climate Change Conference. In the Ice Box Challenge, two large boxes – one constructed following local building code, the other utilizing Passive House standards– were placed side by side in the summer heat, each housing a large block of ice, and opened weeks later to see how much ice remained.

In Los Angeles, the two boxes each originally held 500 lbs of ice and were opened after 7 days. Over 60 lbs of ice remained in the box built with Passive House standards, while the entire block of ice in the box built to standard code had melted on the 6th day. When the temperature in Los Angeles reached 88 degrees that week, the indoor of the standard code box had an internal temperature of 92 degrees, while the Passive House box had an internal temperature of 70. The Ice Box Challenge had similar results in other cities, with the box built to Passive House standards clearly outperforming the box built under State code. This demonstration highlights the ability of Passive House building standards to improve a building's envelope and reduce energy use while improving occupant comfort.

Figure 2: Multifamily Zero Carbon Action Plan Goals

Energy efficiency continues to play an important role in reducing and managing energy loads and support grid-friendly buildings. Solar production falls when the sun sets, while energy use peaks in the evening, creating the energy “Duck Curve,” as shown on the subsequent page. While off-shore wind turbines can fill the source of the energy gap later in the evening, the lack of short term battery storage and pervasive wind power in the interim causes fossil fuel sources to be used to meet these energy needs. It is important that new all-electric multifamily buildings are as efficient as possible and include resilience and grid stabilizing measures such as battery storage and advance energy controls to promote grid reliability and to ensure occupant comfort and safety in the case of extreme weather events and power outages.

Equity

Multifamily buildings, more than any other building type, serve low-income communities, typically renters. Affordable housing policies, complex financing, disproportionate climate impacts, utility bill burdens, and overall social vulnerability are some of the major concerns that are centered in the multifamily building space. While the majority of the buildings of concern are existing buildings, this Plan seeks to address equity in a variety of ways, including addressing climate resilience, lowering utility bills, exploring options to increase renovations of existing buildings, and ensuring that incentive funds are working to improve conditions with new multifamily projects. The recent CPUC decision to create a separate segment of the energy efficiency portfolio focused on equity ¬– for the IOUs and RENs– offers an important opportunity to break down persistent barriers.

A Holistic & Integrated Plan

The MZCAP’s vision is to ensure that all new multifamily buildings are constructed to be zero carbon by 2035, 10 years before the State’s current carbon neutrality goal. The Plan aims to take a phased approach to ensure that code requirements for zero carbon buildings are mandatory in 2035. Stakeholders and current practices indicate that 2035 is technically feasible, attainable and important. To reach this vision by 2035, the MZCAP has five goals that strive to establish a holistic approach to the multifamily sector. The Plan considers the building itself, the exterior environment and infrastructure, the professionals who develop them, as well as the long-term operational impacts and policy environment. Together, as illustrated in the adjacent diagram, the goals work together to create zero carbon resilient multifamily projects.

MZCAP Desired Outcomes

The implementation of the five goals illustrated on the previous page is designed to achieve the following outcomes:

- Integrate Passive House techniques to drive high levels of energy efficiency while enabling zero carbon buildings that integrate 100% renewable energy and, when possible, on-site generation and storage.
- Support and drive future code cycles by demonstrating the opportunity and feasibility of deeper efficiency through Passive House and performance-based approaches.
- Increase the availability and access to affordable, healthy, climate resilient multifamily housing for underserved and disadvantaged communities.
- Establish multifamily buildings that provide durable sanctuary for residents and that are resilient to increasing climate impacts.

- Build a robust zero carbon multifamily building and project market.
- Develop experience, knowledge, and capabilities for professional designers and architects to advocate, design, and build cost effective, all-electric high-performing building solutions.
- Mitigate the financial and development challenges to creating high-performing affordable multifamily buildings.
- Ensure equitable distribution of benefits from solar and prevent displacement of low-income tenants

1. Introduction

1. Introduction

"Achieving carbon neutrality by 2045 requires ambitious near-term actions around deployment of energy efficiency, transportation and building electrification, zero-carbon electricity, and reductions in non-energy, non-combustion greenhouse gas emissions. These least-regrets strategies are common across all deep decarbonization strategies."[7]

Background

The MZCAP aims to transform the multifamily new and major renovation market to become **zero carbon starting in 2035, and to be climate resilient, resulting in affordable, healthy, and comfortable homes for residents.** The Plan, created under the auspices of the CPUC, will inform the statewide new construction program, as well as help shape codes and standards in future cycles. Central to the MZCAP is the drive to identify and support deeper energy efficiency practices and to inspire and encourage market actors to go beyond code to zero carbon with the integration of Passive House approaches into the design and construction of new multifamily housing.

The MZCAP's strategies are designed to establish a strong foundation for a zero carbon future and to identify and empower actions that will drive building owners and decision makers to implement zero carbon multifamily buildings across markets and throughout the State. This Plan has built on the lessons learned to date, new market research, and substantial stakeholder input. To align with the State's goal to reach carbon neutrality by 2045 or sooner– as indicated by a directive from Governor Newsom for the CPUC and California Air Resources Board (CARB) to study pathways for a 2035 carbon neutrality goal– the process assessed major barriers and developed key market and policy strategies.

California has led the country in the development of energy efficient buildings since the statewide 1974 enactment of building energy codes and standards. In 2008, the CPUC adopted the California Long-Term Energy Efficiency Strategic Plan (CAEESP), which included aggressive goals for deep energy efficiency and ZNE residential and commercial buildings. Since then, the State of California legislature, former Governor Brown, and Governor Newsom have adopted legislation and plans to reduce carbon emissions (AB 32, SB 100), double the amount of renewable energy generation in the State (through a CPUC ruling), double energy efficiency in existing buildings (SB 350), and maintain California as a leader in addressing climate change. The State's goal of achieving carbon neutrality by 2045 has been a strong driver of far-reaching clean energy and energy efficiency policies in virtually all sectors. At the same time, California has seen rising economic and housing inequality, along with increasing impacts from climate change. Multi-family buildings sit at the intersection of these issues, and their construction can address these key challenges in the State.

As a leader in the nation, California is ready to provide a vision and action plan for all new and renovated multifamily projects to be zero carbon and climate resilient.

Plan Organization

The Plan is organized into the following four sections:

1. Introduction and Overview

This section provides an overview of changes to building code and changes in the building sector that have set the stage for the development of this Plan. It also lists decarbonization elements that are critical to the Plan's success and outlines the Plan purpose and desired outcomes.

2. Plan Context: Market and Policy

This section includes recent changes to the multi-family housing market and lists key drivers behind the push for equitable building decarbonization. This also outlines the technical and practical changes that ensure Plan feasibility, and includes Statewide policies and goals that support the goals of this Plan.

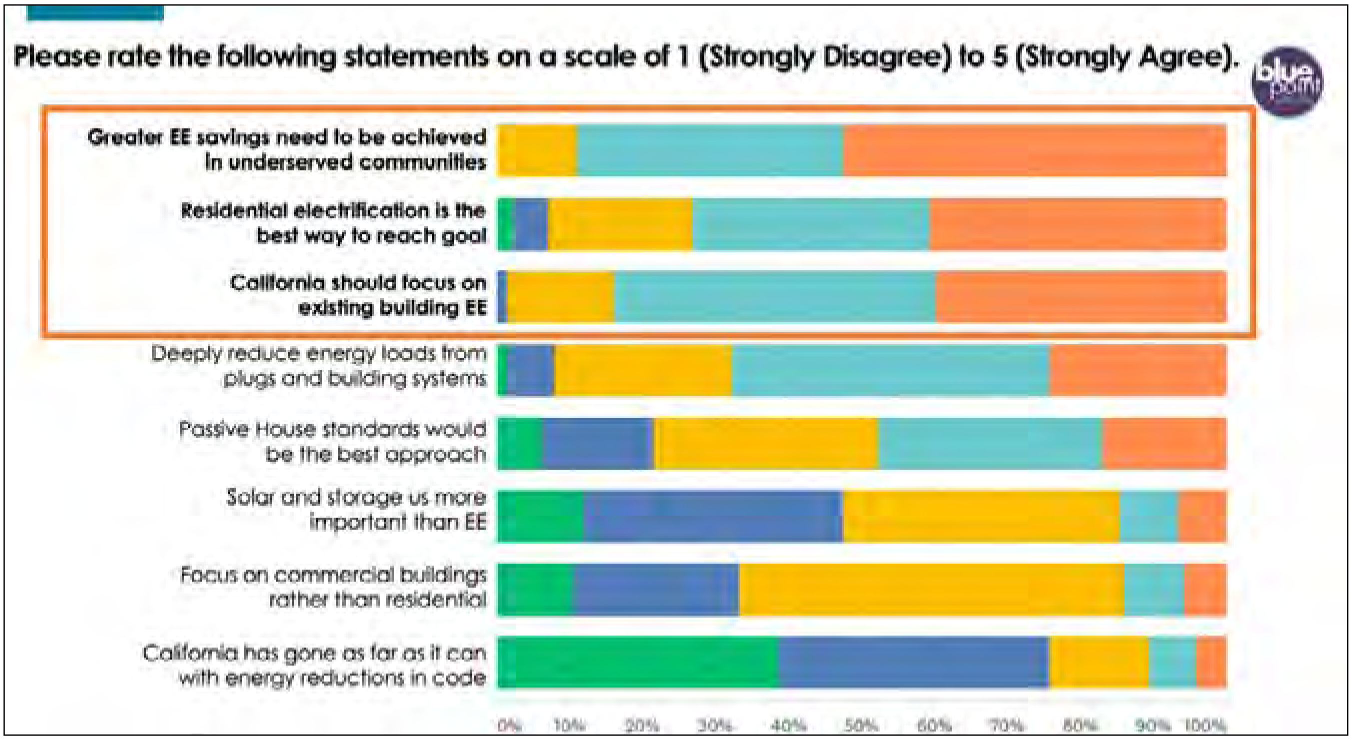
3. Strategic Framework

The strategic framework section is divided by Plan goals. Each section in the framework includes a goal description and strategies to achieve each of those goals. Each goal section also includes recommended leads and partners to implement each strategy and indicators of success.

4. Implementing the Plan

This section details the implementation efforts needed to align multifamily program efforts across sectors and the State, along with a timeline that includes major milestones to achieve all zero carbon multifamily construction beginning in 2035. This section also includes organizations that will need to play a part in advocating for this Plan's programs and practices.

Figure 3: Stakeholder Survey Results on Priorities for the New Residential Construction Program



Planning Process and Stakeholder Engagement

The MZCAP was developed with input from experts in multifamily housing, high-performing buildings, zero carbon industry leaders, and CPUC stakeholders throughout 2020 to 2022. The potential performance benefits of Passive House (PH) standards inspired the CPUC to study and consider how PH might be incorporated into the residential sector and future code. In 2019, Opinion Dynamics completed a white paper, "Barriers to Incorporating Passive House Concepts in Residential New Construction,"[8] which helped to inform this work. Many of the barriers identified related to developing a Passive House code for single family homes. Based on that insight and substantial input from stakeholders, it was decided that the most feasible application of a Passive House-like standard would be with multifamily projects. Further, stakeholders highlighted the opportunity to advance solutions for affordable housing¬– a critical segment for equity.

A survey was sent to stakeholders to assess the needs and opportunities for the future New Residential Construction Program. Figure 3 highlights some of the key findings that underscore the need for greater emphasis on underserved communities, electrification, existing buildings, plug loads, and Passive House standards. The project team held a stakeholder webinar about Passive House to share how PH designs could influence the new Multifamily Construction Program and to discuss options for incorporating PH techniques in California. An additional workshop was held to set goals and to develop the MZCAP strategic framework. The project team also convened small group working sessions to gather input on the specific goals and strategies from leaders in Passive House design, low carbon construction, and workforce development. Information from these sessions further informed and guided the development of draft goals and strategies of this Plan.

The project team then hosted a workshop for relevant stakeholders to provide feedback on draft goals and strategies and identify potential partners to help with plan implementation. Input from this workshop garnered information to fill gaps and provide new strategies of interest.

After the development of the preliminary draft of the MZCAP, CPUC staff reviewed the Plan and provided feedback. Stakeholders, including RENs, CCAs, and equity-based and affordable housing organizations, were provided an additional opportunity to review and comment on the final draft of the document, and this input was integrated into the final MZCAP.

Plan Purpose

"We estimate that making these [energy efficiency] improvements to the apartments and condominiums that fall in the top 25% of multifamily energy users has the potential to reduce multifamily residential energy use across the United States by approximately 17% and save residents $3 billion in energy costs."

[9]The multifamily sector is critical to address as it lies at the intersection of climate change, equity, and community development. As the State looks to become carbon neutral by 2045 or earlier, it is prioritizing land use changes and denser housing in cities. Emissions from the building sector represented 25% of California's emissions in 2016, with 12% coming from residential buildings (including emissions generated from electricity and emissions produced on site),[10] while 40% of the State's GHG emissions come from the transportation sector. The figures for residential emissions do not include methane leakage from natural gas transmission, which occurs at a rate of up to 4.3%[11]. Methane has a much higher Global Warming Potential (GWP) than carbon dioxide and breaks down more quickly in the atmosphere, posing an immediate threat to reaching carbon neutrality by 2045 or earlier. Reducing emissions and eliminating natural gas from the residential sector while prioritizing higher density development that encourages use of public transportation and active transportation, such as biking and walking, is essential to reducing Statewide emissions. Bills SB 9 and SB 10, which were signed into law in September 2021 by Governor Newsom, change zoning regulations to allow for greater density in all cities and enables the construction of duplexes, ADUs, and multistory buildings on land parcels previously zoned for single family use.

This Plan comes at a critical time for California, as low stock and high housing prices continue to fuel the housing and homelessness crisis. While single family housing prices dipped in 2020 during the pandemic lockdown, prices have surged again, and as of April 2021, the median home price in California was over $800,000. Unsurprisingly, housing prices in the State are among the highest in the nation, and on any given day there are 160,000 people experiencing homelessness in California.[12] There is a clear need for greater housing opportunities, especially for low-income populations. Currently, 1.3 million more affordable rental units need to be built to meet the State's housing needs.[13]

California's housing crisis has a wide range of complex issues which have led to the situation facing communities today. The MZCAP is focusing on one piece of the puzzle – helping to make sure that new multifamily housing and major renovations are climate-ready and able to achieve low carbon emissions. Other issues related to the difficulty of building housing in California, complexities of affordable housing financing, the vast number of existing buildings that need to be upgraded, and more are discussed but are not the focus of this effort.

Path to Decarbonization

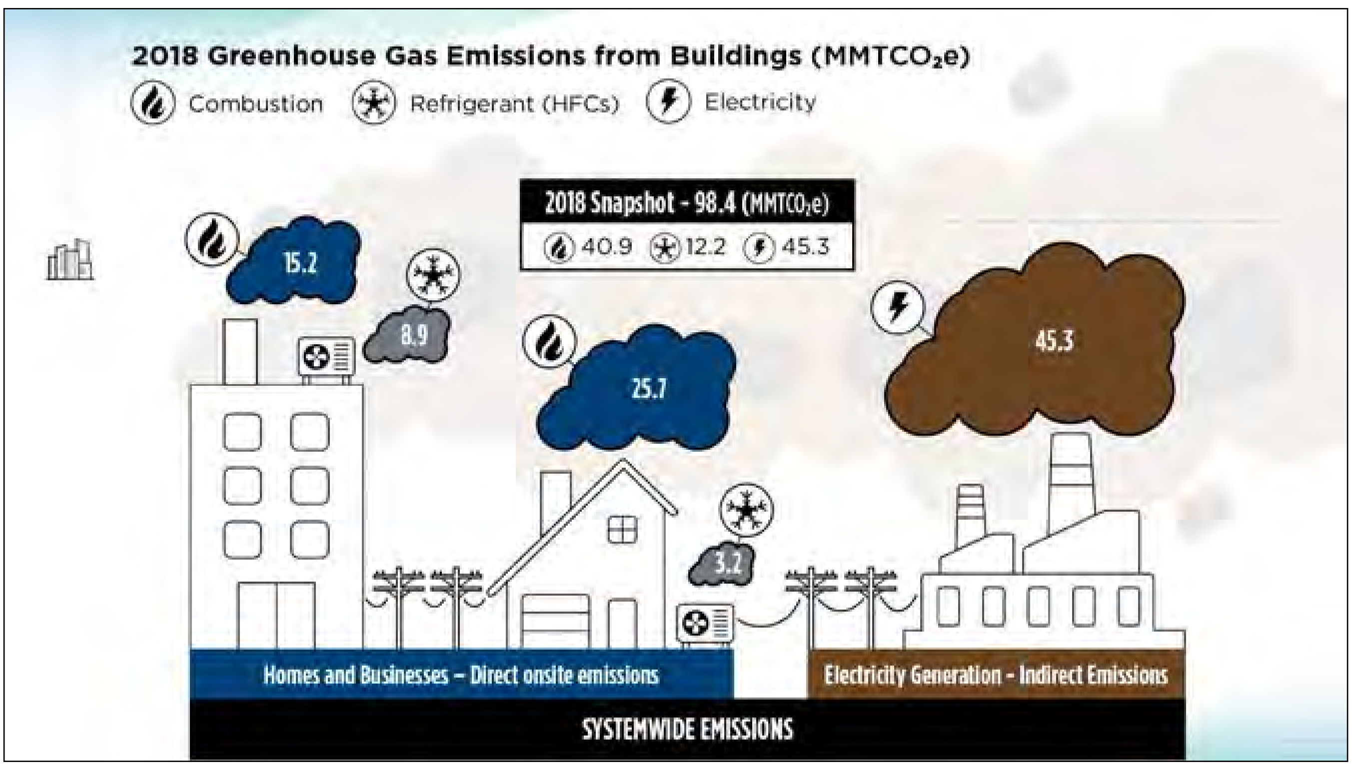
"To decarbonize a building is to remove greenhouse gas emissions from the building's energy use, achieved through making the building more efficient and integrating appliances powered by clean energy sources."[14]

As the State moves to a 100% renewable energy system, all-electric buildings with low carbon emissions that support community resilience are the logical next step. Importantly, the path to decarbonization must also be equitable. Equitable decarbonization requires community-buy in and decision-making around new projects and major renovations, and must include efforts to promote affordable housing and prevent displacement. These are discussed further in subsequent chapters and are an underlying consideration for a successful path to decarbonization.

Reaching zero carbon means tackling the major sources of emissions in buildings in California: natural gas, refrigerants, and embodied carbon in materials. Removing natural gas from multifamily buildings provides a range of benefits beyond the reduction in GHG, including better indoor air quality, reduction in costs from gas infrastructure, significant improvements in energy efficiency, and improved safety. [15] "Behind-the-meter gas leakage" is also a major source of GHG emissions and a problem for indoor air quality and occupant health.

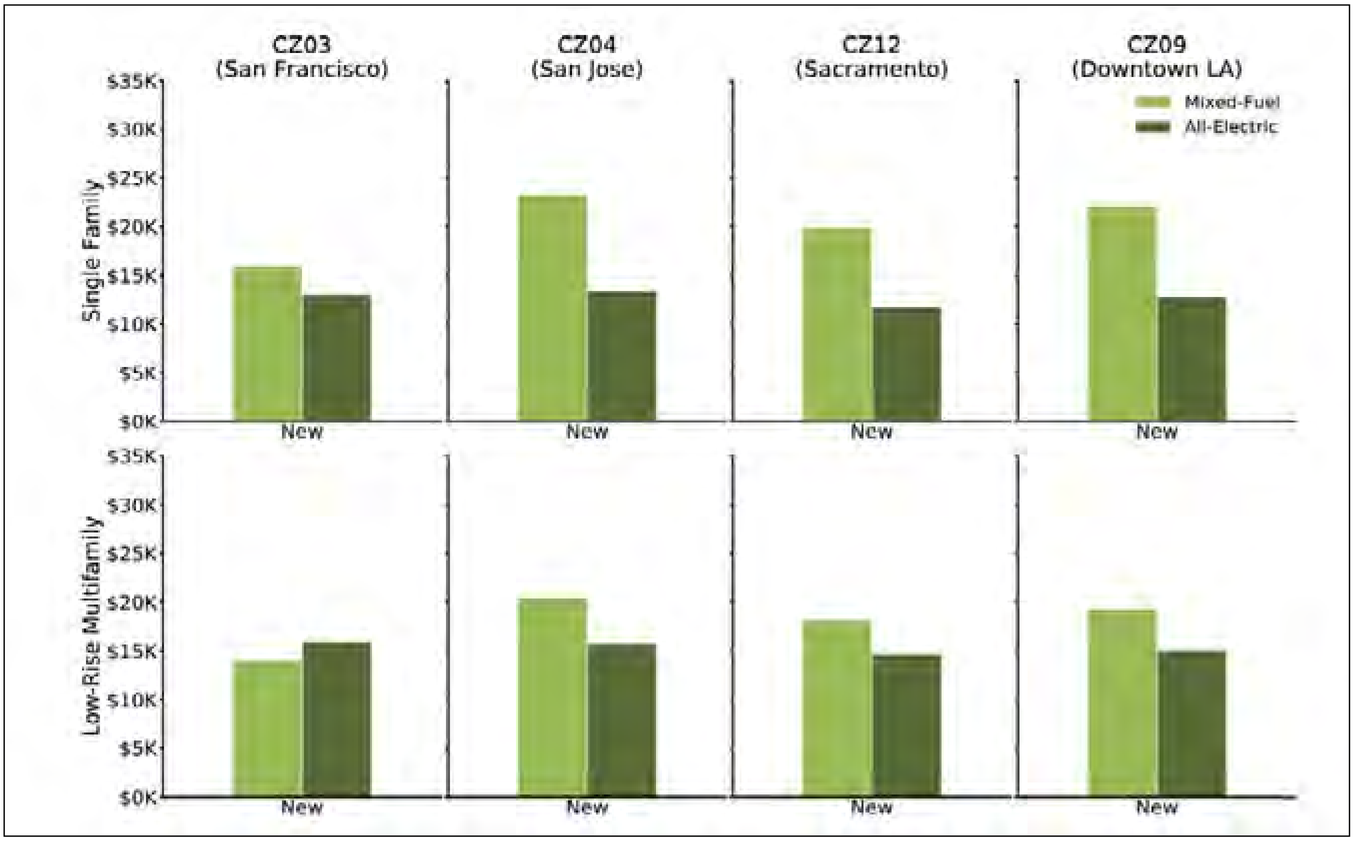
HFCs, or hydrofluorocarbons, are widely used in

Figure 4: Sources of GHG Emissions and Potential 2030 Emissions



Source: California Energy Commission, Building Decarbonization Assessment

Figure 5: Capital Costs Per Unit of Appliance and Infrastructure for New Construction



Source: Residential Building Electrification in California: Consumer economics, greenhouse gases and grid impacts, E3, 2019.

air conditioning, heat pump water heaters, and refrigerators and represent a growing source of emissions with the increase of heat pumps and electrification goals. New regulations and low emission alternatives are being studied to address HFCs, and current incentive programs administered by the CPUC are promoting the use of appliances that utilize refrigerants with a low global warming potential rating. [16]

To decarbonize buildings we need to simultaneously reduce energy demand with energy efficiency measures and remove natural gas through electrification. The following are the essential elements to help move towards decarbonization of new multifamily construction and major renovations.

Deep Energy Efficiency

A critical element to successful decarbonization is ensuring that new and major renovations for multifamily buildings substantially reduce energy demand through deep energy efficiency – much more than required by codes today. One approach to do this is to integrate Passive House strategies. PH building design "limits emissions by reducing the energy loads of a building through intentional, non-mechanical design strategies,"[17] such as building orientation, daylighting, natural ventilation, and more. This approach has been shown to be effective – PH buildings can use up to 80% less energy than existing standard construction counterparts.[18] Critically, PH buildings also promote comfort and resilience in the face of a disaster due to strong insulation and passive heating and cooling design elements that still function without power. The PH model has been around for over 40 years and can be applied to all building types – including multi-family residential, and mixed-use commercial and multifamily. The technique has become popular throughout Europe, while gaining ground in the United States as well, with the square footage of PH buildings more than doubling every two years in this past decade.[19] Today, there are more than 100 multifamily Passive House buildings in the United States equaling more than 2.7 million square feet.[20] This Plan aims to encourage utilization of PH design principles in new multifamily buildings, with an emphasis on securing a tight building envelope and reducing thermal bridging, and to offer a path for deeper energy efficiencies.

100% Electric

The second element is to remove natural gas in both new and existing multifamily buildings and develop all-electric buildings. All-electric buildings are more cost effective than their mixed fuel counterparts and can be achieved with today's technologies as illustrated by in Figure 5. Central to electrification is transformation from gas appliances such as heating, stoves, dryers, and hot water heaters, and amenities such as gas fireplaces and gas outdoor heaters, to electric appliances. Electric technologies, particularly for heat pumps and induction cooking, have progressed substantially and are at the center of enabling effective market transformation and social acceptance of these new appliances.

Heat pumps for hot water and HVAC systems are one of the most important technologies in the development of all-electric buildings. The systems use energy to transfer heat between outdoor and indoor air, instead of creating their own energy, enabling them to achieve up to 300% efficiency. These high efficiency systems address the largest emission sources in buildings – space heating and cooling and hot water heating.

Induction and electric cooktops are both good options for multifamily buildings. Cooking represents 1% of household emissions.[21] Induction cooktops are more efficient than traditional electric stoves, operating at 90% efficiency compared to 70% efficiency for electric stoves and 40% for gas stoves. [22] However, while induction stovetops are more efficient, they are (currently) significantly more expensive than standard electric cooktops for developers. Flat top electric stoves are already used in roughly half of all multifamily buildings in California, and are a cheaper option for multifamily units, especially for middle to low income housing.[23] Electric and induction stovetops also improve indoor air quality by reducing indoor air pollutants

Healthy, Green Affordable Housing - The Starling at Alameda Point generated from the combustion of natural gas in stoves. In early stages, the adoption of induction cooking was somewhat of a challenge as many people who cook prefer gas stoves. The market demand is growing substantially and being driven by homeowners interested in healthier, more efficient appliances.[24]

Electric dryers are already common. Electric resistance dryers use roughly the same energy as their gas counterparts[25], but they are a good alternative to gas when creating an all-electric home. Further, condensing dryers and heat pump dryers, which can reuse and dry excess humid heat pulled from clothing, further reduce energy use by 28% compared to standard dryers.[26]

Onsite Renewables and Battery Storage

While the MZCAP has a large focus on energy efficiency, on-site renewable generation and energy storage is a key component of building decarbonization as well. The integration of onsite solar and batteries is going to become a standard requirement for all multifamily buildings in the future and needs to be considered in the planning, design, and construction of multifamily projects.[27] Deep energy efficiency helps to reduce the requirements for additional generation and keep solar/battery systems at size that is more cost effective and feasible. For high-rise multi-family, generating sufficient onsite energy will be difficult without continued advances in vertical solar panels. Electric Vehicle to grid and EV to building technologies should also be considered as alternatives or additions to large energy battery storage. It is also important that tenants, especially low-income tenants, benefit from lower electricity rates due to on-site renewables such as rooftop solar.

Demand Response

Demand response programs and associated technologies enable customers to react to various market and utility cues to reduce or shift energy use at peak times to help grid operators balance loads. Demand response technologies leverage the various distributed energy resources needed for a building to be zero carbon – battery storage, renewables, electric vehicles, and appliances – and grid-friendly. Grid-responsive buildings can provide a valuable resource to grid operators to balance energy loads and help tenants benefit from time of use rates that incentivize non-peak energy use.

Embodied Carbon

Embodied carbon refers to the cumulative emissions that result from the production of building materials within a structure and represents a significant source of total building carbon. **Globally, embodied carbon represents 28% of all building-related emissions and 11% of total emissions.**[28] The environmental impact of concrete has also become more widely recognized in recent years. During the life cycle of a multi-story concrete-framed building, over 70% of emissions occur during construction, at least half of which is attributable to embodied emissions from concrete alone.[29][30] Business-as-usual projections estimate that embodied carbon and operational carbon will be equal by 2050 globally as energy efficiency improves.[31]

Concrete, which is used extensively in building projects, including for the foundation and framing of multistory apartment buildings, is an extremely carbon-intensive product. The introduction of less carbon-intensive building materials, particularly mass lumber, have the potential to drastically reduce embodied carbon emissions. Changing a multifamily building's structure from concrete to wood could cut its embodied carbon in half.[32]

The County of Marin and City of Berkeley have adopted embodied carbon reach codes that require developers to reduce the amount of cement used in projects by at least 25%. As one possible avenue, the new multifamily program could provide guidance to cities to help adopt these reach codes.

Other materials that have a carbon-intensive production process include aluminum, plastics, and foam insulation. While some use of these products is likely essential for building construction, their use should be minimized wherever possible.

2022 Code Changes

"The multifamily restructuring proposal eliminates the arbitrary split between three and four habitable story multifamily building requirements, and proposed requirements based on the type of construction and mechanical equipment used, regardless of the building height." [33]

The California Building Standards Code governs design requirements related to building occupant and structural safety and sustainability for all new buildings and major renovations in the State. The Code is updated every three years with new requirements, and the newest 2022 code cycle has several key changes for multifamily buildings. Historically, multifamily buildings have been characterized and regulated by the number of stories, regardless of building square feet or construction materials. Residential codes were applied to low-rise multifamily (three stories or less) and commercial codes and standards were applied to high-rise multifamily. This bifurcation created confusion and gaps in the application of innovative approaches to building efficiency. The new 2022 code unites the standards into a new multifamily chapter to help streamline and highlight the important issues that are unique to multifamily buildings.

The new code cycle will also ensure that new buildings achieve high efficiency standards. Multifamily buildings will need to either use electric heat pumps for space heating or meet stringent efficiency requirements without it, paving the way for electric heat pumps as a standard for new builds. The new code will also require solar and battery storage on multiple building types, including high-rise multifamily buildings of more than three stories, and will include battery-ready requirements for low-rise residential. Previously, residential buildings, which included multifamily buildings with three or fewer stories, could install batteries as part of their strategy to meet a required Energy Demand Rating (EDR), but it was not required, and there were no battery readiness requirements. To accompany battery storage requirements in the 2022 code, the State will mandate that all new residential buildings must be electric-ready, meaning there is enough electrical circuits and capacity to support the shift to all-electric housing, including with battery storage.

New code requirements for multifamily housing include changes to the following areas: roof assemblies, wall U-factor (a measure of heat flow), insulation standards, duct insulation, and duct leakage testing. The language also differentiates building envelope codes based on multifamily building type instead of number of stories.

In addition, recent changes to the multifamily building code in California have paved the way for reducing embodied carbon in buildings. In 2020, California adopted the International Building Code update, which differentiated code specifications based on building materials instead of the number of building stories. In particular, the code specifies different regulations for mass timber construction and permits timber construction up to 18 stories high.

2.Plan Context: Market & Policy

Photo Credit: Sam Oberter Photography

2. Plan Context: Market & Policy

The multifamily sector experiences significantly different issues, opportunities, and energy consumption patterns from single family homes. The critical elements that set multifamily buildings apart include **the size and complexity of buildings and systems, variability of ownership structure, split payment of utility costs between owners and tenants (split incentive), limited financing products, and varied tenant awareness, interest, and resources.** The construction of high-performing new buildings is substantially simpler than major renovations, particularly when an existing building has tenants. Overall, the MZCAP focuses on the development of new projects and those renovations that are driven by owners or developers and less impacted by tenants and the split incentive issues. Regardless, the complexity of the multifamily market, especially for affordable projects, makes it challenging to create a one-size-fits-all solution to creating high-performing buildings and zero carbon projects. The MZCAP strives to establish a performance approach that enables the range of actors to develop projects that can be based on the characteristics and needs of the project in question.

Multifamily Housing Types

Multifamily housing has many sub-types that make it more challenging to address as a single sector with new policies and building standards. The multifamily sector includes some of the following common configurations:

- Low- and high-rise apartments and condominiums
- Garden-style attached units
- Mixed-use buildings
- Senior housing and assisted living
- Special needs
- Single room occupancy
- Co-op housing
- Dormitories

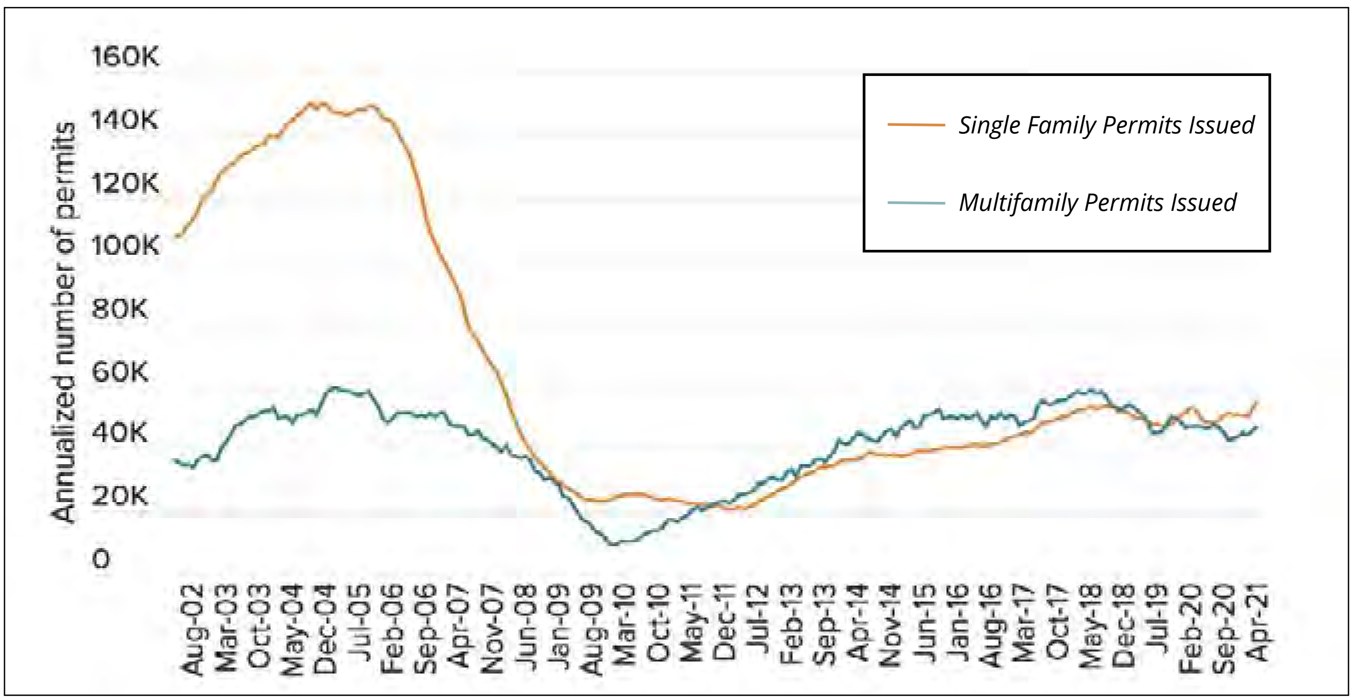
Each type has different occupancy and is nuanced with energy use intensities (EUIs) that are specific to the type and cannot always be generalized in a single category. In addition, over 50% of multifamily housing is in high-density urban areas with smaller rooftops and smaller units that create challenges for rooftop solar but may be simpler to achieve deeper efficiencies.

Multiple Market Actors

Another important consideration for the multifamily market sector is the multitude of market actors associated with the process of development and management of the projects. Below is a partial list of parties that could be involved with the development of a new multifamily building or complex:

- Decision Makers
  - Developers
  - Property Owners
  - Facility Managers/Property Managers
  - Local government Building Officials
- Financiers/Funders (Multiple funding sources are common in affordable housing.)
  - California Tax Credit Allocation Committee (TCAC)
  - U.S. Department of Housing and Urban Development (HUD)
  - United States Department of Agriculture's Rural Development Program
  - Community Development Financial Institutions
  - California State Treasurer's Department
  - Local Government loans and grants
  - Appraisers and Market Study Analysts
  - Design and Inspection Teams
  - Architects
  - Mechanical, Electrical, and Plumbing Engineers
  - Energy Consultants
  - HERS Raters - Group serves both single and multifamily
- Occupants (through input and as decision-makers)
  - Renters
  - Owners
  - Mixed-use building retail business owners

Figure 6: Multifamily vs Single family Permits Issued in California Between 2002-2021



Source: Blog post: "California's Housing Construction Picks Up Pace", Public Policy Institute of California, 2021.

Equity and Affordable Housing

"Policies that increase low-income adoption of energy efficiency measures and on-site renewable resources can help reduce the risk of a so-called "green divide," in which the benefits of these resources are not equally available to all."

[34]As detailed in the California Energy Commission's 2016 "Low Income Barriers Study", low-income customers face a range of procedural and structural barriers to equal access to energy efficiency resources in California. The multifamily sector houses approximately 31% of California's population, representing 43% of California's low-income population. Low-income households, with similar appliances in a smaller floor plan, have a higher per square foot utility cost, approximately 25% higher than non-low-income homes, and a higher likelihood of utility disconnection.[35] In fact, energy customers in California have collectively over $2 billion in utility debt even after the California Legislature's recent appropriation of $1 billion for utility debt relief, a number that highlights the potential for utility disconnection and energy burden for many in the State.[36]

The Low Income Barriers study highlights that low-income populations primarily rent and face the split incentive issue – a persistent barrier to reaching higher energy efficiency based on the different goals for property owners and renters who pay the utility bill. The study also describes how current programs and approaches to addressing multifamily, low-income energy efficiency is limited by a variety of market barriers, poor program integrations, lack of good data, and limited recognition of non-energy benefits that would increase the value and support for energy efficiency in buildings.

For the upcoming 2024 - 2034 Energy Efficiency portfolio business plan submissions, the CPUC has adopted new guidance on development of equity programs. Equity focused programs can represent up to 30% of IOU portfolios and more for Regional Energy Networks (RENs). Many of the needs and options to address low-income communities are in existing buildings – generally not covered by this Plan. However, raising the issue of equity for new buildings and major renovations is essential and should be central to how affordable housing development and the new construction program can work together to drastically improve equitable outcomes as buildings are renovated or developed.

Further, energy efficient, resilient buildings aimed to improve occupant comfort through a tight building envelope, passive heating and cooling strategies, good ventilation, and other methods, can reduce human health impacts of extreme heat, particulate matter from smoke and diesel, and more, while reducing housing and energy burdens for low-income occupants.

Programs that support new zero carbon construction and major renovations should also include specific considerations that address the impact on overall neighborhood affordability and potential displacement of residents. The development of these construction projects should include a robust engagement process for projects as well.

Figure 7: Home Ownership by Population (2016)

	Percent of California Moderate and High-Income Population	Percent of California Low-Income Population
Owned, Single Family Home	50%	26%
Rent, Single Family Home	11%	23%
Rent, Multifamily Housing	34%	47%
Other	6%	4%

Source: Low-Income Barriers Study, Table 10, Evergreen Economics, 2016

Housing Market Changes

The multifamily housing market in California has been growing as the State has prioritized denser transit-oriented development. In 2018, construction of multifamily units represented more than 31 percent of housing growth in the State, particularly in San Diego, Los Angeles, Irvine, Santa Clarita, and Sacramento. Reportedly, these units are cheaper to build and require less workers to complete.[37]

Recently passed zoning bills are set to pave the way towards denser development in California jurisdictions. SB 9 allows for two units per parcel of land previously zoned for single family use, making it easier to build duplexes and accessory dwelling units (ADUs). Additionally, SB 10 permits local governments to adopt an ordinance to zone any plot of land for up to 10 residential units if the parcel of land is in a transit-rich area or urban infill site.

Multifamily housing starts have been roughly on pace with single family housing starts over the past decade, a contrast to the prior decade when single family housing construction far outpaced that for multifamily housing. From January - June 2021, there were 25,400 multifamily housing starts, 5,300 more than the same period in 2020, an increase of 26%.[38]

Overall, the 2017 Annual Electric Power Industry Report indicates that multifamily housing represents 24% of all homes and 26% of the energy use from the residential sector.

Climate Change

Climate change is the driver behind decarbonization and will create increasingly substantial negative impacts to our communities with a disproportionate impact on low-income, frontline communities. These vulnerable communities are disproportionately likely to live in multifamily housing – and therefore this Plan provides an opportunity to set the stage for more equitable housing that is also climate-ready. The following is a summary of the key climate impacts for California and the multifamily sector, and in particular for low-income communities, who are disproportionately communities of color.

Drought

California is currently in one the worst droughts in over 100 years. [39] Many are suggesting that California change the language from "drought" which indicates a temporary situation, to something that highlights the long-term change that is now "normal." The combination of warmer temperatures and less precipitation is likely to decrease water from the Sierra Nevada snowpack, which acts as a natural reservoir by storing and distributing surface water across much of the State. Business-as-usual predictions estimate that the average Sierra Nevada snowpack could decline by 19% between 2025- 2050, and by 83% between 2075-2100,[40] threatening the natural water supply of many cities and resulting in widespread changes in the State's natural vegetative landscape.

Sea Level Rise

Sea level rise is expected to be at least six inches by 2030, and up to seven feet by the end of the century, a number that is further exacerbated by storm surges and El Niño events that produce significantly higher tides. Sea level rise poses a large threat to coastal cities; it is estimated that $8-10 billion worth of the State's existing property will be underwater by 2050, with up to $10 billion of existing property jeopardized during high tide.[41] Many of the most vulnerable areas are in disadvantaged communities, which will cause growing issues for safe and resilient siting of multifamily buildings.

Urban Heat Island

The urban heat island effect refers to the increased temperatures in urban spaces that result from concrete and hard surfaces, which absorb and retain the sun's heat. Urban areas, including multifamily developments, that lack trees and green space can be seven degrees hotter than greener outlying areas close by.[42] The Urban Heat Island impacts are particularly difficult for low-income communities and communities of color, who tend to have less tree canopy and green spaces.

Extreme Heat

Climate change is causing extreme temperatures and heat waves in California. In summer of 2021, a heat wave set record-breaking highs across California, as the weather reached 120°F in many cities in Southern California and hit an incredible high of 130°F in Death Valley, breaking the record for hottest temperature ever recorded on Earth. Increased extreme heat events are a public health issue, as they can cause heat exhaustion or heat stroke, which can lead to death. Additionally, increased use of air conditioning during heat waves threatens the State grid, often causing widespread brownouts and blackouts, and also contributes to higher energy burdens for renters.

Extreme Precipitation

While climate change has led to a long-standing drought in the State, it has also increased the amount of precipitation that occurs during a single rain event. This has led to flooding issues in many cities across the state, especially in industrialized jurisdictions with hardscapes and little green infrastructure.

Wildfires

2020 set the record for the most destructive wildfire season in United States history. In 2020, California lost 4.7 million acres to wildfires, which destroyed over 10,000 homes and killed over 30 people. Five of the six most destructive fires in California history also occurred in that year.

In response to increased wildfires, utilities have had to institute Public Safety Power Shutoffs (PSPS) to mitigate fire risk from live transmission lines running through forested areas. In PSPS events, large portions of the energy grid are shut off at once, causing significant disruptions to daily life as well as posing life-threatening risks to people who rely on electrically-powered life support devices in their homes. PSPS events have greatly underscored the need for reliable, grid-responsive power generation and storage in housing.

Technical Feasibility for Zero Carbon Multifamily Buildings

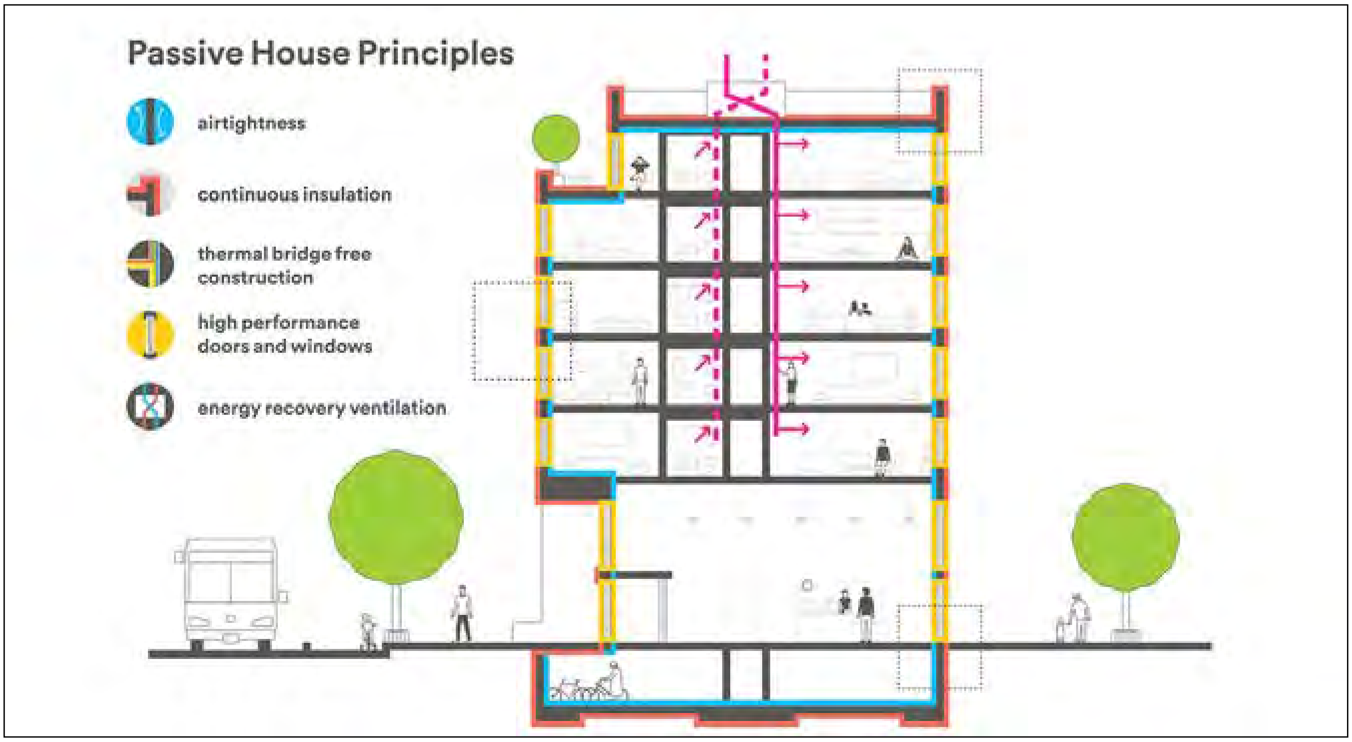
Constructing a multifamily zero carbon building that produces no operational emissions is technically achievable and, when designed to be zero carbon from the beginning, cost effective. A combination of a tightly sealed building envelope, all-electric appliances, low plug loads, and solar and storage can make zero carbon buildings a reality. Passive House building techniques that limit heat transfer between the building interior and exterior and take advantage of passive heating, cooling, and lighting techniques reduce a building's EUI and make it possible to utilize all the building's energy from on-site solar and storage.

Key elements to Zero Carbon Buildings

A well-insulated building envelope is critical to constructing an energy efficient building by reducing energy loss from heating and cooling systems and lowering energy use. **Passive House standards require an air tightness rating of below 0.6 air changes per hour at 50 pascals pressure (0.6ACH50)**. Passive house approaches as illustrated in Figure 8, are the foundation of this Plan and key to maximizing energy efficiency.

Thermal bridging refers to the transfer of heat between conductive building materials and can account for 30% of a building's energy loss.[43] Passive House buildings reduce thermal bridging by creating breaks between external walls and studs to stop heat transfer between the building interior and exterior. Zero carbon multifamily buildings should utilize these techniques and

Figure 8: Basic Elements of Passive House Design



Source: Building Energy Exchange

Figure 9: Multifamily Energy Use Intensity Targets by Global Climate Zone

Climate Zone	Multifamily Site EUI ($kBtu/ft^2 \cdot yr$)	Multifamily Source EUI ($kBtu/ft^2 \cdot yr$)	PV Area as Percent of Total Floor Area
0A	28	86	31%
0B	29	90	21%
1A	26	82	20%
1B	27	85	24%
2A	26	80	21%
2B	23	73	17%
3A	23	71	21%
3B	22	69	16%
3C	20	71	16%
4A	23	69	22%
4B	21	68	16%
4C	21	65	25%
5A	22	69	23%
5B	22	68	18%
5C	20	62	23%
6A	24	75	24%
6B	22	71	23%
7	24	75	26%
8	25	80	38%

Source: Transforming New Multifamily Construction to Zero: Strategies for Implementing Energy Targets and Design Pathways, National Renewable Energy Laboratory, 2020

eliminate thermal bridging wherever possible to reduce unwanted heat transfer.

Once the building envelope is well-insulated and heat transfer between the interior and exterior is reduced, the focus then shifts to reducing emissions associated with energy use. Zero carbon multifamily buildings **must be all-electric to eliminate emissions** from the combustion of natural gas. They should utilize electric heat pumps and electric heat pump water heaters to satisfy air heating and cooling and water heating needs. An alternative for larger projects is to integrate geothermal and waste heat recovery options for HVAC. Both these options work towards creating zero carbon buildings, and these systems can have added benefits at a larger, multi-building or district scale. This Plan will discuss geothermal and waste heat recovery systems in the subsequent chapter.

Multifamily buildings use a greater percentage of whole building energy on plug loads compared to single family buildings, as each unit has less space to be heated and cooled but still uses roughly the same number of appliances. **Plug loads consume 30 to 44% of whole building energy for multifamily buildings** (depending on climate zone) in the highest performing cases. Highly efficient appliances such as induction cooktops, heat pump clothes dryers, and ENERGY STAR rated or other third-party certified microwaves, dishwashers, clothes washers, and refrigerators should be utilized.

Once a building achieves ultra-low EUI targets, the next step to creating zero carbon buildings is adding **enough solar and storage to satisfy a building's energy needs**. An energy modeling analysis completed by NREL determined that low EUIs can be balanced with on-site renewable energy generation in all 19 climate zones in the United States. Considering that most of California is in climate zone 3 (with some in zone 4, and small portions in zones 2, 5, and 6), less solar panel coverage is required to offset building energy use, meaning taller buildings (4-6 stories) can still be offset with solar storage in most climate zones. Above is a table of the percentage of solar panel area compared to total floor area in a multifamily building, along with target EUIs for multifamily buildings based on the building's climate zone. Note that this study did not include the development of on-site battery storage from solar, which further underscores the potential of solar generation to offset energy use.

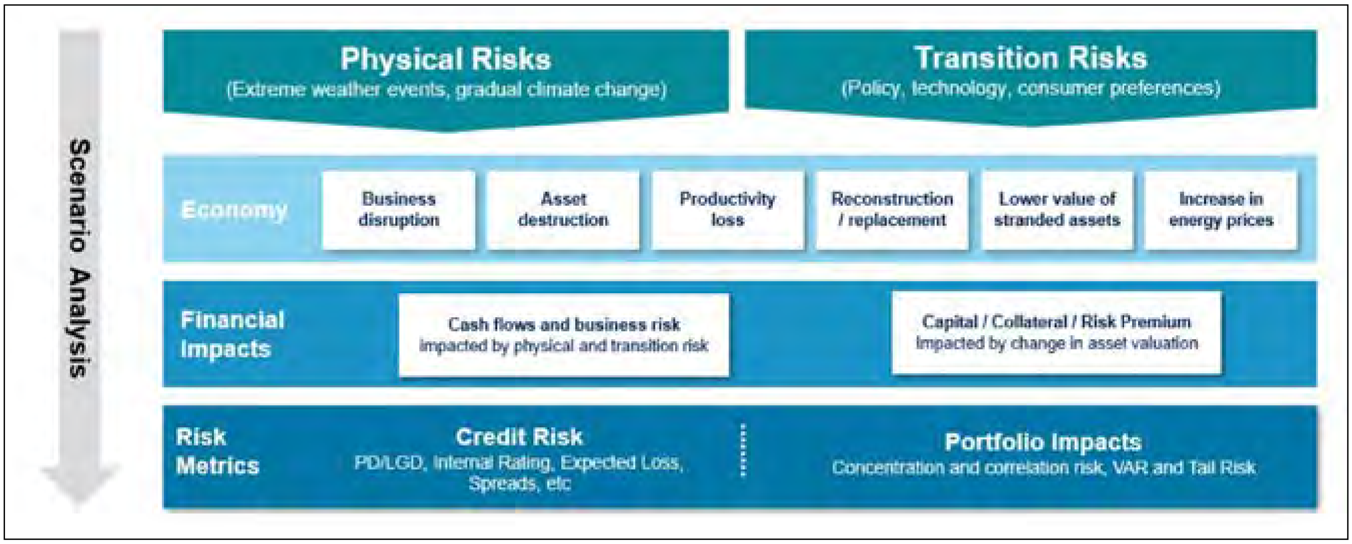
There are further opportunities for multifamily buildings and complexes to reduce energy use by installing waste heat recovery systems. These systems transfer heat energy from wastewater to water or space heating in the building, instead of creating new heat. This can greatly reduce energy use, particularly in colder climates where greater heating is necessary.

New Financial Realities

"Real estate owners can expect pension funds and investment managers to start asking not only for analysis of portfolio carbon emissions but also plans to reduce emissions over time. In the case of real estate, lenders, investors and building owners need to analyze specific buildings and portfolios to determine what energy efficiency measures actually need to be implemented to meet the targets, identify retrofit strategies, and create robust underwriting and performance assessments to inform lending and investment decision-making."[44]

Climate change is becoming a financial motivator to adopt and pursue resilience and climate reduction strategies for communities. With buildings as a major investment source in California, the potential benefits of creating resilient buildings are substantial, while the costs associated with climate related disasters and expected impacts to communities is staggering. A study by FEMA found that every $1 invested in preparing and planning effectively for disasters saves $6 in disaster recovery costs.[45] Likewise, in 2017 the bond rating firm Moody's Investor Services began to consider the threat of climate change, along with a community's preparedness and planning to address those threats, as part of the jurisdiction's bond rating, and in 2019, the firm made significant investments in climate-risk data to help assess cities' risks. Ongoing tools and resources from Moody's Analytics and similar firms are offering investors, real estate developers, and other decision makers mechanisms to understand and address the inherent risks of climate change to their financial well-being. The MZCAP sets the foundation for ensuring that zero carbon multifamily buildings are feasible and attainable, both technically and economically.

Figure 10: Moody's Analytics Climate-Adjusted Financial and Credit Impact Analysis Steps



Source: Edwards, J., Cui, R, and Mukherjee, A. Assessing the Credit Impact of Climate Risk for Corporates, Moody's Analytics. (2021).

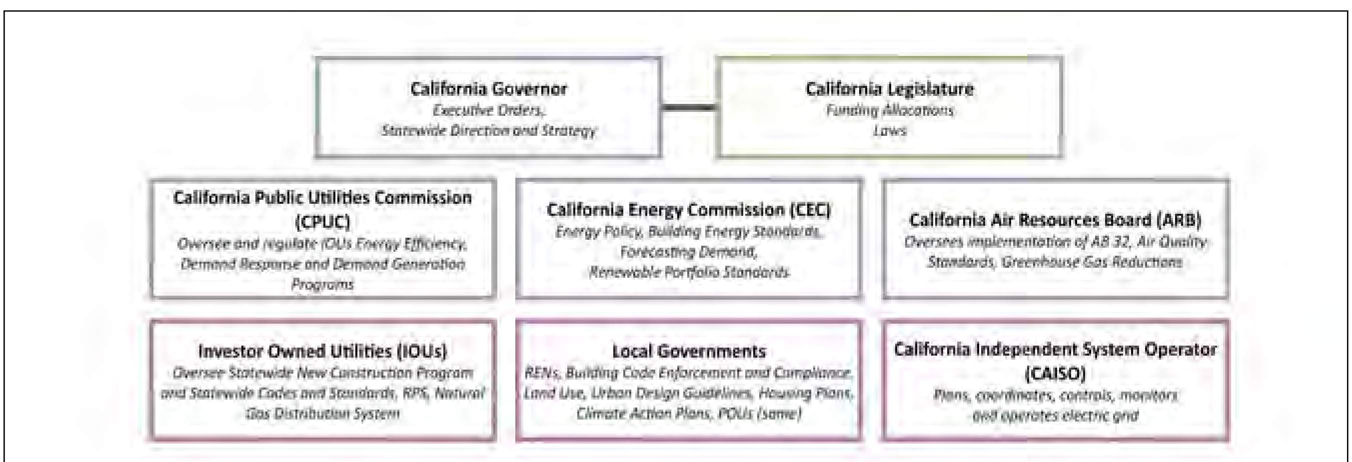
State Policy and Goals

The State of California has aggressively adopted legislation and funded initiatives and programs that will help to reduce California's carbon emissions and spur multifamily housing construction. Many of these drivers directly impact the MZCAP and its goals. The following is a summary of current climate and energy efficiency legislation that impact the State's ability to achieve new zero carbon multifamily buildings:

- **AB32, Global Warming Solutions Act of 2006**, and the legislation's renewal SB32 – Sets carbon emission reduction goals to 40% of 1990 levels by 2030. This will continue to be a critical policy in the future at the State level as well as the local level with the adoption of Climate Action Plans that incorporate solar, energy efficiency, and ZNE goals.
- **SB 350, Clean Energy and Pollution Reduction Act –** Requires the doubling of energy efficiency in buildings, a strong focus on disadvantaged communities, and the establishment of a renewable portfolio standard of 50% renewables by 2030.
- **SB 100, the 100 Percent Clean Energy Act of 2018 –** Requires that 100% of California's energy come from renewable energy sources in 2045 and sets an incremental goal of 60% renewable energy by 2030.
- **SB 1477 –** Creates the Building Initiative for Low Emissions Development (BUILD) and Technology and Equipment for Clean Heating (TECH) programs which will provide incentives for electrification of new and existing housing. The BUILD program focuses on promoting all-electric affordable housing, as 75% of the funding for the program is set aside to help fund all-electric appliances and technical assistance for low-income housing projects. BUILD includes incentives for heat pumps, energy efficiency, energy storage, and demand response. The TECH program provides upstream incentives to manufacturers, distributors, and vendors of heat pumps and heat pump water heaters.

Additionally, the CPUC recently approved the Wildfire and Natural Disaster Resiliency Rebuild Program (WNDRR) in November of 2021, which provides incentives for people who have lost their homes in natural disasters to rebuild all-electric homes. The WNDRR enables property owners to better utilize existing incentives including BUILD and TECH, with greater incentives for low-income housing.

Figure 11: Relevant Stakeholders in the Multifamily New Construction Program and Their Roles



- **SB 10** - Permits local governments to adopt an ordinance to zone any plot of land for up to 10 residential units if the parcel of land is in a transit-rich area or urban infill site.
- **SB 9** – Allows homeowners to create a duplex or subdivide an existing lot on their property into a maximum of four units
- **Executive Order EOB-55-18** - Established a statewide goal to achieve carbon neutrality by 2045 and to maintain negative emissions after beyond 2045.
- **SB 1383** - Set a target of achieving a 40 percent reduction in statewide methane emissions below 2013 levels by 2030.
- **AB197** - Assured that the State's implementation of its climate change policies is transparent and equitable, with the benefits reaching disadvantaged communities being fundamental to these efforts.
- **SB 867**- Requires local jurisdictions to create and adopt Adaptation Plans.

New Construction Multifamily Program

The New Construction program, currently operated by PG&E as a statewide program, has been an important tool to help test new concepts and incentivize builders to learn and adopt them in advance of code changes and other requirements. Typically, the New Construction program is a combination of technical assistance and incentives. The MZCAP focuses on how to leverage this program in the future to build a foundation for Zero Carbon Multifamily Buildings.

The current multifamily new construction program is part of the **California Energy-Smart Homes Program** administered by PG&E and managed by a third party - TRC. This program, includes funds for construction of new all-electric multifamily buildings and provides incentives to adopt advanced energy measures and transition to all-electric construction. To be eligible for the program, new construction buildings must achieve an Energy Design Rating (EDR) of ≥1.The program supports California's focus on building electrification to meet its climate objectives.

In total, the Energy-Smart Homes Program, which also covers single-family construction and alterations, provides $10 million per year to projects for its five year duration. The incentives for multifamily buildings decrease each year over the program's duration, and are listed below:

Year	2022	2023	2024	2025-26
Incentive	$2,200	$1,800	$1,500	$1,200

Plus there is an escalating incentive of $5.00 for each .01 EDR over 1.

Regulatory Agencies

The following regulatory agencies will be involved in the Plan implementation:

CPUC

The California Public Utilities Commission governs privately owned public utilities and manages infrastructure such as electricity, natural gas, telecommunications, and water. The CPUC should be involved in leading efforts to develop district scale energy infrastructure for multifamily building developments as well as providing guidance and potential incentives for building commissioning.

CEC

The California Energy Commission (CEC) is the state's primary energy policy and planning agency. The CEC offers a wide variety of energy programs geared towards distributing clean energy all throughout California. The CEC could help to align modeling tools to support zero carbon construction, as well as provide support to developing training programs and other relevant resources.

Energy Efficiency Portfolios

In 2022, the IOUs, RENs, and CCAs interested in Energy Efficiency (EE) programs filed updated 8-year business plans as dictated by the CPUC's Energy Efficiency Rolling Portfolio proceeding (R13-11-005) for 2024-2031. The Energy Efficiency Portfolio directs funding of approximately $500 million annually to fund energy efficiency programs. The Business Plans provide details of all planned priorities and spending for the coming years, including establishing a large number of decarbonization programs.

Critical to these new plans and future funding for energy efficiency programs is the change in how

Additional Multifamily Programs

Low Income Weatherization Program (LIWP) -Offers free photovoltaic systems and energy efficiency upgrades to low-income households

Low Income Home Energy Assistance Program (LHIEAP) - Offers low-income households financial support associated with home energy bills, energy crises, weatherization

Solar on Multifamily Affordable Housing (SOMAH) - Utilizes financial incentives to provide affordable photovoltaic energy system installations among multifamily buildings

Comprehensive Affordable Multifamily Retrofits (CAMR) Program - Collaborates with the Association for Energy Affordability, public housing authorities, and nonprofit affordable housing owners to finance efficient energy upgrades for existing properties

GoGreen Multifamily- Finances affordable energy efficiency upgrades and mitigates energy costs through financing options such as leases, equipment financing contracts, and energy service contracts

Building Initiative for Low-Emissions Development (BUILD) Program - Offers technical assistance and incentives associated with energy-efficient low-income multifamily buildings

TECH Initiative - Reduces GHG emissions associated with existing multifamily buildings through implementation of low-emission space and water technologies the CPUC considers cost effectiveness and the portfolios by segmenting work into three areas:

Resource – This is the majority of the funding for the IOUs and for programs designed to be cost effective that result in a minimum level of energy savings.

Market Support – Programs, tools, and services designed to bolster the market for energy efficiency. Programs in this segment include workforce training, financing, and technical assistance. RENs are encouraged to provide programs in this segment.

Equity – Dedicated programs focused on serving disadvantaged communities and addressing underserved segments of the populations. RENs are encouraged to provide programs in this segment.

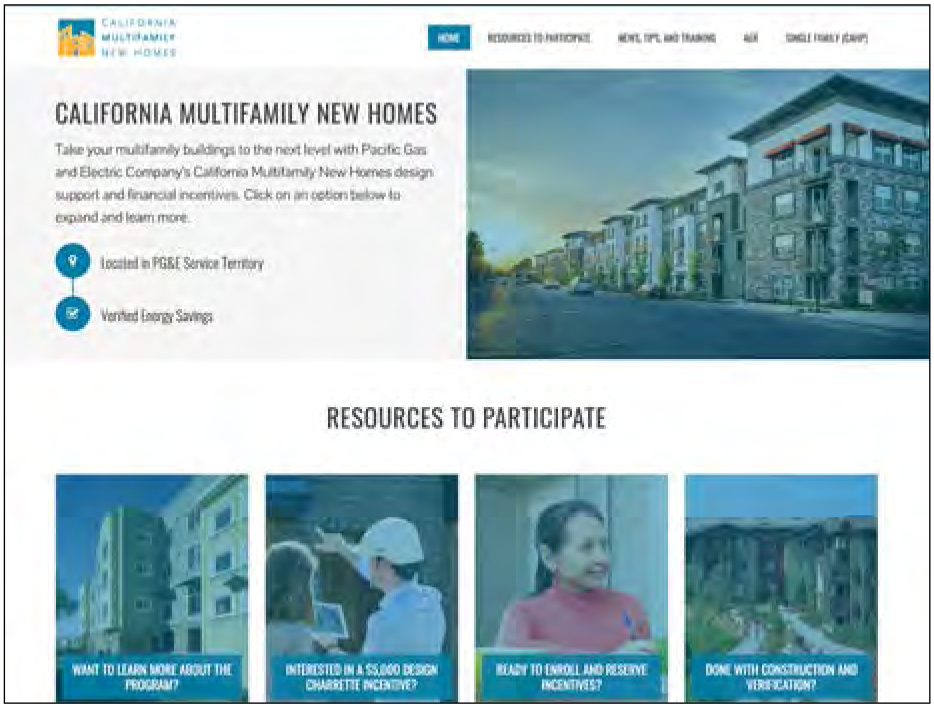
The addition of Equity and Market Support segments allows ratepayer funding to be dedicated to hard to capture energy savings, which may not have met historic cost effectiveness standards and which provide underserved communities more opportunities to improve their buildings, especially for the multifamily sector.

Program Administrators

The success of transitioning the Multifamily Program to become zero carbon is dependent on program administrators. Below are relevant administrators to help implement the program:

PG&E and IOUs

PG&E is an investor owned utility (IOU) company that currently administers the California Energy-Smart Program for new multifamily construction, with support from the other IOUs in the State. PG&E would be the main program administrator for the enhanced multifamily program recommended in this Plan. Additionally, utilities run Workforce Education and Training (WE&T) Programs and can play a role in administering training programs for the enhanced multifamily program.



California Multifamily New Homes Program Website

Regional Energy Networks

Two local government organization structures, the Regional Energy Network (REN) and the Community Choice Aggregator (CCA), both enabled by the CPUC, are California's most recent energy entities with the ability to interface directly with local government and CPUC initiatives. RENs are critical partners to large scale utilities, filling gaps and playing roles that are not as well suited to for-profit utilities. The multifamily sector, particularly for low-income communities, is an example of where RENs with CCAs can address broader issues than appropriate for an IOU. RENs also run WE&T Programs and can play a role in administering training programs for the enhanced multifamily program.

There are four approved RENs – one covering counties in Southern California (SoCalREN), one in the nine Bay Area counties (BayREN), one in the Central Coast (3C-REN), and the most recent, the Inland REN (I-REN) covering San Bernardino and Riverside Counties. Together, these RENs comprise more than two-thirds of the State's population.

Community Choice Aggregators

CCAs are designed primarily as a local entity empowered to purchase clean energy and offer and procure renewable and low-carbon power options that may not be available through IOUs. Marin Clean Energy, started in 2010, was the first active and operational CCA. Currently, there are 23 CCA programs in California that serve over 11 million customers.

CCAs have the authority to purchase and develop power generation, develop energy storage systems, and manage energy efficiency programs at the local level. This means that for more complex, local projects that are not historically attractive to IOUs, CCAs can become a leading entity.[46]

Other Key Actors

The following organizations and agencies also have a role in supporting the transition to zero new construction and major renovations in the multifamily sector:

Local Government

Local governments will play a significant role in moving the needle towards statewide zero carbon building codes by adopting reach codes and enabling planning and building departments to support zero carbon buildings with green infrastructure, and related efforts. In areas with municipally-owned utilities, local governments will also take on a larger role in coordinating multi-family programs efforts, not including specific incentive funds that are funded by IOU ratepayer programs.

California Department of Community Services

The California Department of Community Services and Development (CSD) uses innovative programs and financial assistance to empower low-income households and individuals. CSD's Low Income Weatherization Program (LIWP), is funded by California's State Climate Investments and allows a wide range of energy efficiency and solar incentives. In addition, CSD receives funding from the Federal Government to operate the Low Income Home Energy Assistance Program (LIHEAP), the U.S Department of Energy's Weatherization Assistance Program (WAP). CSD could build additional programs in line with this plan, including incentives for low-carbon refrigerants and solar plus battery.

California Energy Efficiency Coordinating Committee

The California Energy Efficiency Coordinating Committee (CAEECC) is a stakeholder forum connected to the CPUC Energy Efficiency Portfolio Business Planning process. The CAEECC reviews and discusses programs and needs for EE and could assist in developing metrics for the enhanced multifamily program and help develop an accelerator program that would increase the rate of major renovations for existing multifamily buildings.

Local Government Sustainable Energy Coalition (LGSEC)

LGSEC, a program of the non-profit CivicWell (formerly LGC), is a statewide membership organization representing local government members in the fields of clean energy and climate resilience in California. LGSEC as a coalition aims to cultivate local leadership to respond to climate change, and should be part of the effort to enable local governments to support zero carbon multifamily buildings.

California Building Standards Commission and CalGreen

The California Building Standards Commission (CBSC) decides on and administers CalGreen, the State's green building code. The enhanced multifamily program should work with CBSC to include specifications on embodied carbon materials in Statewide building code for multifamily buildings.

Air Quality Districts

Air Quality Districts are "responsible for regional air quality planning, monitoring, and stationary source and facility permitting,"[47] in California and can support local government planning and building departments to promote zero carbon buildings. Further, the Air Quality Districts are central to managing and evaluating climate and pollution mitigation regionally.

Professional Networks

The following organizations could all help to shape and develop an enhanced Multifamily New Construction Program and help guide program training offerings:

The **Passive House Network (PHN) and Passive House Institute (PHIUS)** provides comprehensive education to stakeholders about Passive House high performance building to stakeholders across the building industry.

The **American Institute of Architects (AIA**) is a national organization representing architects across the United States. The organization provides architects with a variety of tools and resources.

The **Urban Sustainability Directors Network (USDN)** is comprised of local government sustainability staff and practitioners in the United States and Canada.

The **Urban Land Institute (ULI)** is focused on the development community and is a important organization with builders and developers and architects involved in new construction.

3. Strategic Framework

3. Strategic Framework

The market for zero and low emissions buildings has changed significantly in the past few years. Local governments, states, and recently, the nation, have adopted goals of 100% carbon-free energy and are moving to adopt decarbonization policies for buildings and transportation. The need and appetite for zero carbon buildings is growing as climate change continues to wreak havoc in California and policymakers see advances in heat pump and electrification technologies, an increase in the renewable portfolio standard (RPS), and the reduction in costs for energy storage. Therefore, it is essential to set the foundation and capacity of the market and professionals to be able to design and build housing that works towards the State's 2045 carbon neutrality goal. Further, with the increasing threat of climate change, these buildings and projects must be built to be resilient to climate impacts and hazards and promote equity, and ensure the health and wellbeing of its occupants.

The Strategic Framework, illustrated in the following graphic and detailed in the following pages, first focus on **getting new construction programs right**, so that buildings are as energy and cost efficient as possible. The second provides a holistic set of strategies to make **buildings climate resilient** and more connected to the surrounding areas. The third goal focuses on prioritizing **education and training for industry and design professionals** to advocate and technically support zero carbon projects. The fourth area is on **maintaining sustainable low carbon operations** over the lifetime of the building. The final goal is to leverage State funding and a**ligning State and local policies to enable the construction of zero carbon multifamily buildings.**

Figure 12. Action Plan Framework

Goal 1. Optimize Building Performance, Reduce Carbon & Enhance Health

Optimize multifamily buildings as a system while reducing carbon emissions, and improving occupant health and comfort.

Objective

Enhance the Multifamily Residential New Construction Program to demonstrate and incentivize an integrated design and build approach that can move the market to achieve significantly lower greenhouse gas emissions and ultimately lead to revised codes and standards for zero carbon multifamily buildings.

This goal covers the overall design and construction of new and major renovations of multifamily buildings with a focus on the following strategies:

1.1 Integrate Passive House approaches into an enhanced Multifamily New Construction Program

1.2 Incentivize low-GWP refrigerants and the responsible maintenance and disposal of refrigerants

1.3 Drive down embodied carbon in the construction process

1.4 Establish uniform metrics to track and monitor project performance

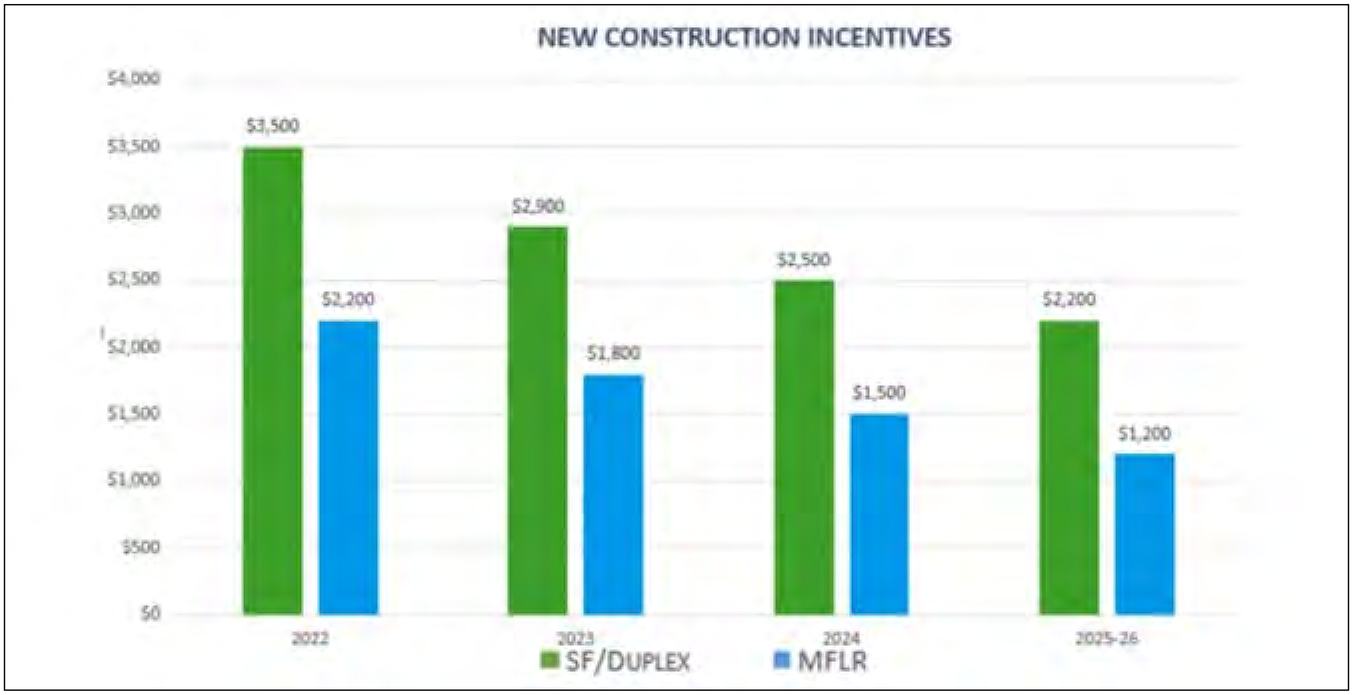
1.5 Develop incentives to encourage major renovations for existing multi-family buildings

Overview

"Beneficial electrification of housing – building tight, well-ventilated buildings with all-electric appliances and equipment –can improve health equity in low-income communities while achieving specific goals such as healthy indoor environments, emissions reductions, and cost savings."[48]

The development of new and renovated multi-family buildings is growing in California to support the housing crisis, offering an opportunity to transform how they are built to meet the changing needs of the climate and residents. Historically, multifamily buildings, particularly those built for affordable housing, have been inefficient and poor at integrating innovations above code related to new energy efficient building approaches and appliances.[49] The inclusion of natural gas appliances and heating and cooling has also contributed to health concerns, safety issues, and increased building emissions.

Figure 13: Baseline incentives for New Construction Program: single family and multifamily units



Source: TRC, (2021, September 27). Statewide Residential New Construction Program, California Energy-Smart Homes All Electric Residential Program Implementation Plan.

The current **Multifamily New Construction Measures of the State's Energy-Smart Homes All-Electric Residential Program** include a variety of incentives aimed at increasing energy efficiency and reducing emissions from low rise multifamily buildings (with three or fewer stories). The current Program provides incentives for new construction buildings that achieve an Energy Design Rating (EDR) of 1.0 or above, with additional incentives for each 0.1 delta efficiency EDR above 1.0. These base incentives decrease each year of the program. The Program is dedicating 20% of funding to Hard-to-Reach and Disadvantaged Communities. Further details on baseline incentives are included in Figure 13.

The current New Construction Program also provides incentives for alterations to existing multifamily buildings, which "changes design or technology or completes a replacement of the thermal components plus at least 75% of the distribution system [and] replaces gas meters."[50] This includes incentives for heat pump clothes dryers, ductless mini-split heat pumps, and heat pump water heaters that replace their gas counterparts.

The shift to all-electric housing in California is underway, a key trend that has the potential to virtually eliminate emissions from buildings. In **2019, 36% of the state's electricity was derived from renewable sources, and over 60% from carbon-free sources.**[51] This number is only expected to grow, as battery storage improves and California works to become carbon neutral by 2045, as outlined in SB 100. Building all-electric buildings that run on fully renewable energy, instead of using highly polluting natural gas, can work to eliminate emissions from the building sector.

The State has been incentivizing the development of new all-electric buildings, including through the creation of the **Building Initiative for Low**

Emissions Development (BUILD) program. The BUILD program has dedicated $60 million of its $80 million in funding to go towards incentives for new low-income development. BUILD provides baseline incentives for demonstrated avoided GHG emissions to developers and additional incentives for increased envelope and efficiency measures, beyond-code PV installation, and key technology installation.

Deep energy efficiency is a critical component of the shift to all-electric buildings and decarbonization to ensure energy demand is reduced and that the increased electricity loads can be managed effectively and be grid friendly. Establishing a new model for multifamily buildings that are zero carbon will require a refined approach to design and construction that drives energy usage to as low as possible by considering each major building system and harmonizing their operation to optimize the building energy use and emissions.

Goal 1. Strategies

1.1 Integrate Passive House approaches into an enhanced Multifamily New Construction Program

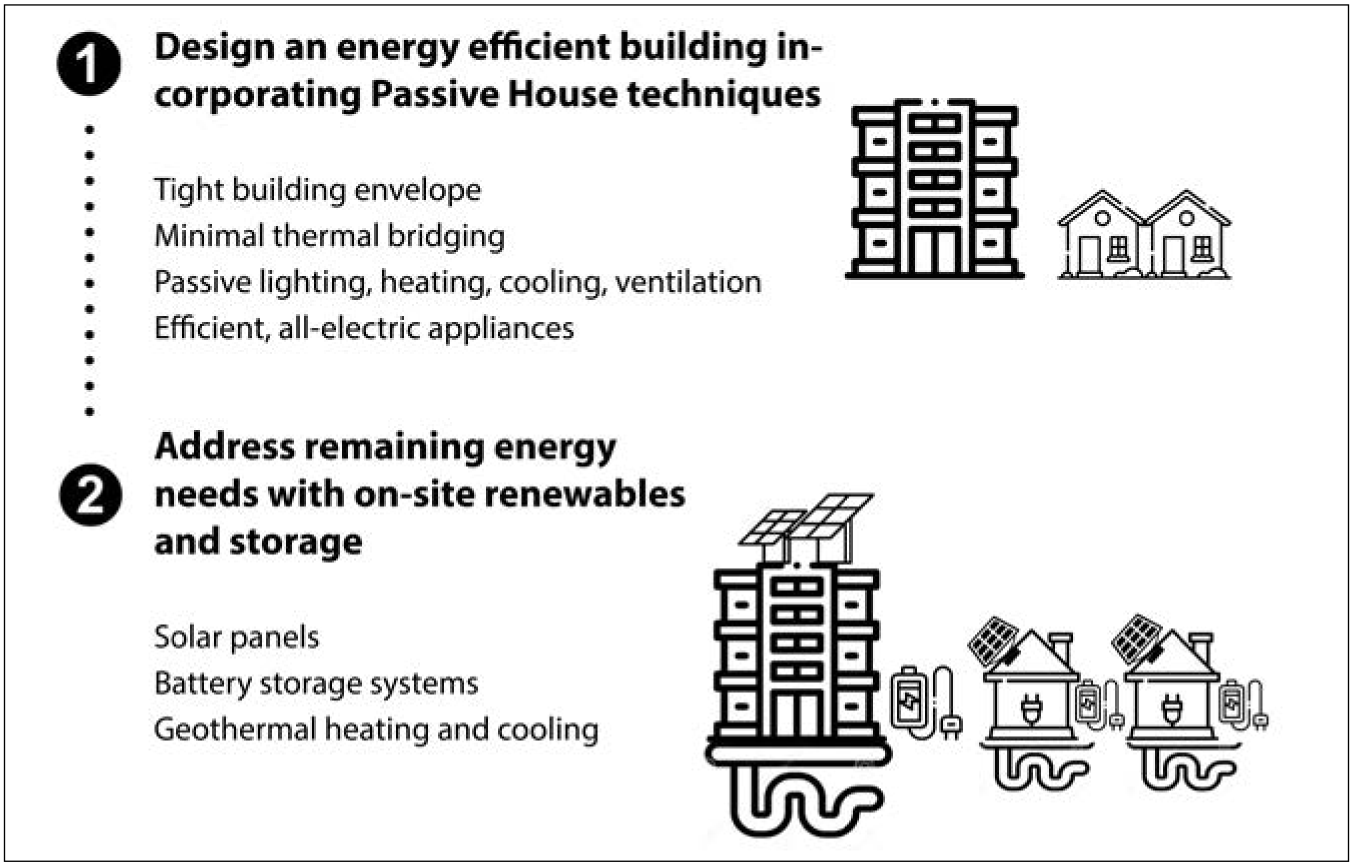
The New Construction Program has a deep history of helping the marketplace test, learn, and adopt new practices that inspire and reduce risk for forward-looking developers. The Program has also set the foundation for mainstream production builders to advance their energy efficiency practice, and ultimately codes and standards, as demonstrated by the success of the ZNE programs. An enhanced and more expansive statewide Multifamily New Construction Program (NCP) is needed by 2025 to assist developers and builders in achieving aggressive zero carbon multifamily buildings as a critical step to decarbonization for new buildings.

This revised NCP needs to identify and support systematic reduction of carbon emissions from multifamily buildings by providing modeling, design support, and technical assistance during project development and construction. There should be support in place to help integrate next generation high performance, high efficiency building practices such as Passive House techniques, with a focus on optimizing major building systems as discussed below.

Passive House Approaches

Passive House buildings are designed to achieve high energy efficiency standards and to require less energy use than their standard counterparts while providing year-round comfort to its occupants. Passive building design principles conceptualize energy use in the building as one connected system. Principles emphasize designing to manage solar gain and ensure an airtight building envelope to minimize the energy required to keep the building at a comfortable temperature with minimal energy inputs. These buildings also use ventilation systems that intentionally transfer heat between specific rooms (e.g., the heat generated from cooking in the kitchen might be transferred to another living space, like a living room). The layout and design of the house itself determines how energy is used throughout the building. The construction of Passive Houses (PH) is facilitated through an Integrated Design Process (IDP) in which developers, architects, energy consultants, contractors, and other members of the project team must

Figure 14: Zero Carbon Building Construction Process Overview



communicate to ensure the building meets PH standards (See Goal 3 for more).

PH buildings consider site geography and climate, and certification is performance-based, with different design standards for different climate zones. As a result of an IDP with a holistic, performance-based approach to energy use, Passive Houses have been able to demonstrate an 80-90% reduction in heating and cooling load compared to their standard existing counterparts.[52] Preliminary studies have also shown that PH buildings save up to 20% more energy than California's 2019 baseline code, can reduce heating demand by 50% and result in up to 59% reduction in carbon emissions (compared to mixed fuel buildings).[53]

The NCP could also consider providing additional incentives for project teams and developers that choose not only to integrate these Passive House techniques, but choose to verify their projects through a **Passive House certification.**

Important Passive House Elements

Building Envelope and Thermal Bridging

Thermal bridging refers to the transfer of heat between conductive building materials and can account for 30% of a building's energy loss. A well-insulated building envelope that minimizes thermal bridging is a key element to creating an ultra-energy efficient building and is critical to reducing energy loss from heating and cooling systems and lowering energy use. Double or triple pane windows are also a necessary part of the effort to ensure air-tightness.

Heating and Cooling

Heating and cooling systems should be all-electric. Electric heat pumps use less than half as much energy as traditional electric heating and are far more efficient than their natural gas counterparts.

Ventilation

Ventilation systems are critical to ensuring a continual supply of fresh air circulates through the building, especially when temperature and air conditions may not allow for opening windows. Ventilation systems with heat recovery are critical to saving energy and should be utilized in New Construction buildings. These systems can transfer the heat between incoming and exhaust air to warm or cool incoming air as desired.

Domestic Hot Water

Heat pump water heaters, which heat water by transferring energy between the air and water instead of creating new energy, are three times more efficient than traditional electric water heaters, and far more efficient than their gas counterparts.

Cooking

Stoves must be all-electric. Induction cook tops are more efficient than traditional electric stoves, operating at 90% efficiency compared to 70% efficiency for electric stoves and 40% for gas stoves,[54] and should be installed in new multi-family buildings when financially feasible. Electric and induction stovetops also improve indoor air quality by reducing indoor air pollutants generated from the combustion of natural gas.

Plug Loads

Plug loads consume 30 to 44% of whole building energy (depending on climate zone) in the most high-performing cases.[55] This percentage will only increase, as improvements to the building envelope that lower heating and cooling energy

Key Passive House Criteria[62]

Space Heating Demand: *not to exceed 15kWh annually OR 10W (peak demand) per square meter of usable living space*

Space Cooling Demand: *roughly matches the heat demand with an additional, climate-dependent allowance for dehumidification*

Primary Energy Renewables (PER) Structure: *The PER Structure has differing efficiency and renewable energy targets for separate classes of Passive House buildings (based on whether these buildings generate additional energy).*

Targets are set per square meter of usable living space per year, as shown below:

Passive House Class	Efficiency Requirement ***PER demand***	Renewable energy harvest ***PER Supply***
Classic	≤60 kWh/ (m2TFA yr)	No requirement
Plus	≤45 kWh/ (m2TFA yr)	≥ 60 kWh/ m2 footprint yr)
Premium	≤30 kWh/ (m2TFA yr)	≥120 kWh/ m2 footprint yr)

Airtightness: *maximum of 0.6 air changes per hour at 50 Pascals pressure (as verified with an on site pressure test in both pressurized and depressurized states)*

Thermal Comfort: *thermal comfort must be met for all living areas year-round with not more than 10% of the hours in any given year over 25°C*[63] use mean that plug loads comprise a larger portion of energy use. Plug loads are not part of the building system and are from residents' plug-in equipment such as computers, TVs, table lamps, etc. Installing energy-efficient appliances can help reduce this plug load. Additionally, utilizing smart outlets and other tools can reduce these "vampire" loads when not needed.

Demand Response

The Program should ensure that new buildings are grid-responsive with effective advanced building controls. Demand response is critical to grid management and load balancing, reducing grid operational costs and the likelihood of power outages.

Renewable and Battery Storage

Buildings should be designed to be solar and battery ready as well as provide electric vehicle charging. Program design should enable connections to other incentive programs and financing to cover these elements. Connections to renewable and battery systems may be more efficiently handled on a multi-building or community scale, as discussed in Strategy 2.2.

Design and Technical Assistance

The Program should provide comprehensive design and technical assistance to developers and the design/engineering/construction team to promote effective project coordination and holistically consider building energy use in the planning process.

Additionally, there could be specific design and technical assistance focused on helping developers engage with residents and community members around new construction and help them to ensure implementation of anti-displacement policies.

1.2 Incentivize low-GWP refrigerants and the responsible maintenance and disposal of refrigerants

Like standard air conditioning, most electric heat pump space and water heating technology relies on chemical refrigerants to circulate heat. Many refrigerants used in these products have a high global warming potential (GWP) – typically 1400-2000 times that of CO2[56] – can leak 10-40% of their content annually, a problem that is worsening as California gets hotter and more homes require cooling systems.[57] While low-GWP alternatives exist, a variety of barriers, such as high costs, lack of alternative equipment, and lack of trained technicians have slowed market adoption.[58] Furthermore, there has been little enforcement of the disposal of refrigerants,

Figure 15: Alternative Refrigerants for Heat Pump Technology with Low-GWP

Refrigerant	100-Year GWP	Common Uses
R-32, R-452B, R-454B, R-466A*	450-750	Replacement for R-410A. Not currently allowed in building codes for most types of HVAC applications. *R-466A is allowed per existing building codes but is not commercially viable.
R-1234yf	<1	Replacement for R-134A. Not currently allowed in building codes for most types of applications Permitted for use in chillers. Already widely used in vehicle air conditioners.
Propane (R-290)[136]	3	Replacement for some types of heat pumps. Not widely adopted in the United States and not currently allowed in building codes. Widely used in residential and commercial refrigeration elsewhere.
CO_2 (R-744)	1	Used in supermarket refrigeration, vehicle air conditioners, and heat pump water heaters. Not widely adopted in United States.

Source: California Building Decarbonization Assessment, 2021 as refrigerants are often released into the atmosphere at the product's end of life.

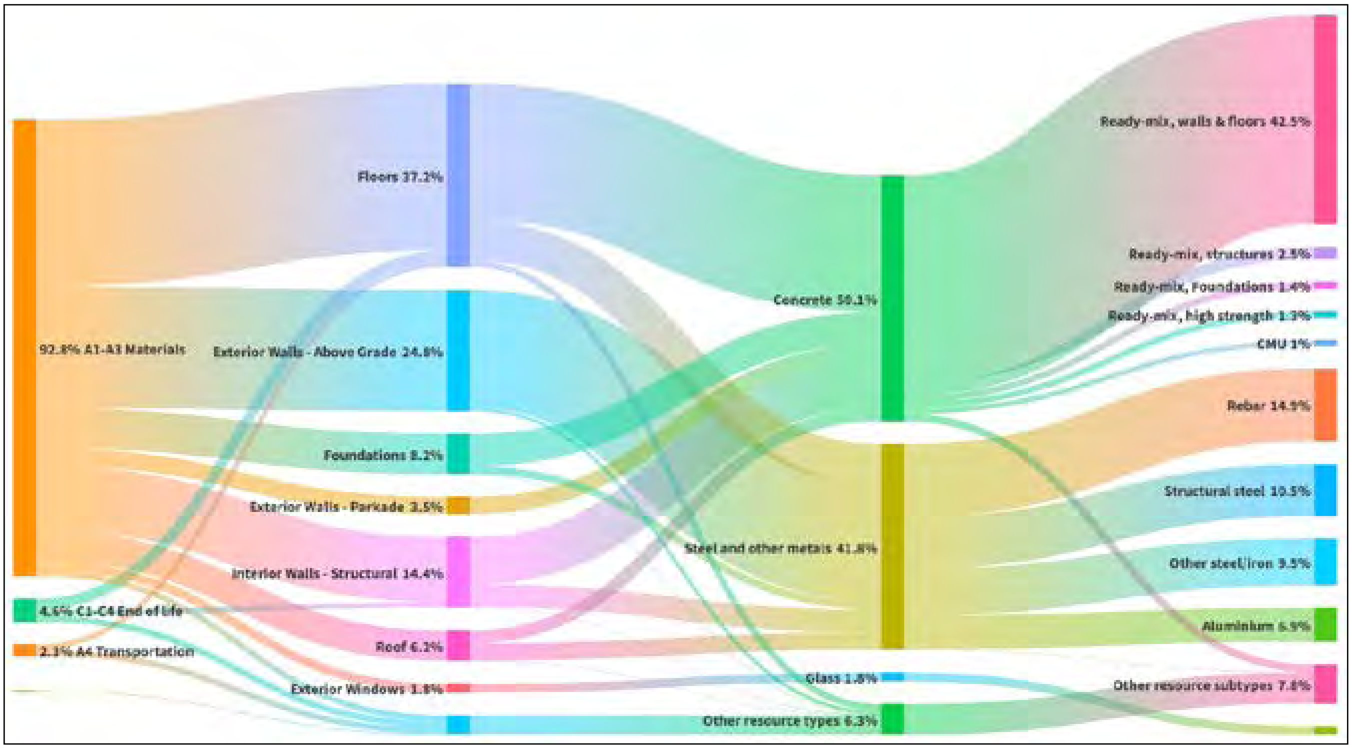
CARB, CPUC, and CEC have been working to change this, though, and are currently running programs and developing policies that require or incentivize the use of low-GWP refrigerants. CARB runs the State's Refrigerant Management program, which requires owners of refrigerant systems to inspect and report leaks, and in 2018 adopted regulations requiring reduced-GWP refrigerants with 750 GWP or lower in new HVAC systems by 2025. The CPUC's BUILD and TECH programs also include extra incentives for low-GWP refrigerant equipment. Additionally, CARB and CEC are currently funding research to develop alternatives to today's commonly used refrigerants.

The new Multifamily Program should streamline incentives for electric heat pump and heat pump water heater technology with low-GWP refrigerants and should consider layering incentives for this technology. A variety of low-GWP refrigerant alternatives are listed on the previous page. As the market for low-GWP refrigerants grows in the coming years, the Program should consider requiring all heat pump technology to have low-GWP refrigerants.

1.3 Drive down embodied carbon in the construction process

The NCP should require the use of low embodied carbon building materials to the greatest extent possible. **Concrete** - used for walls and floors; **steel** - used in rebar and for structural framing; and **aluminum** - used in interior walls and roofing are typically the most carbon intensive. Alternatives to these and other high carbon materials offers the greatest potential impacts

Figure 16: Life Cycle Assessment (LCA) of embodied carbon of building materials in a typical office building, as a percentage of total embodied carbon



Source: Priopta, Example Results- Whole Building LCA, 2020 to reduce carbon emissions. Projects targeting Passive House certification could use the newly released PHRibbon tool that allows the calculation of embodied carbon of materials. Additional incentives could be offered to teams that take this extra step. This project data could then be collected by program managers to help inform future code integration of embodied carbon calculation requirements.

Approaches to Reducing Embodied Carbon

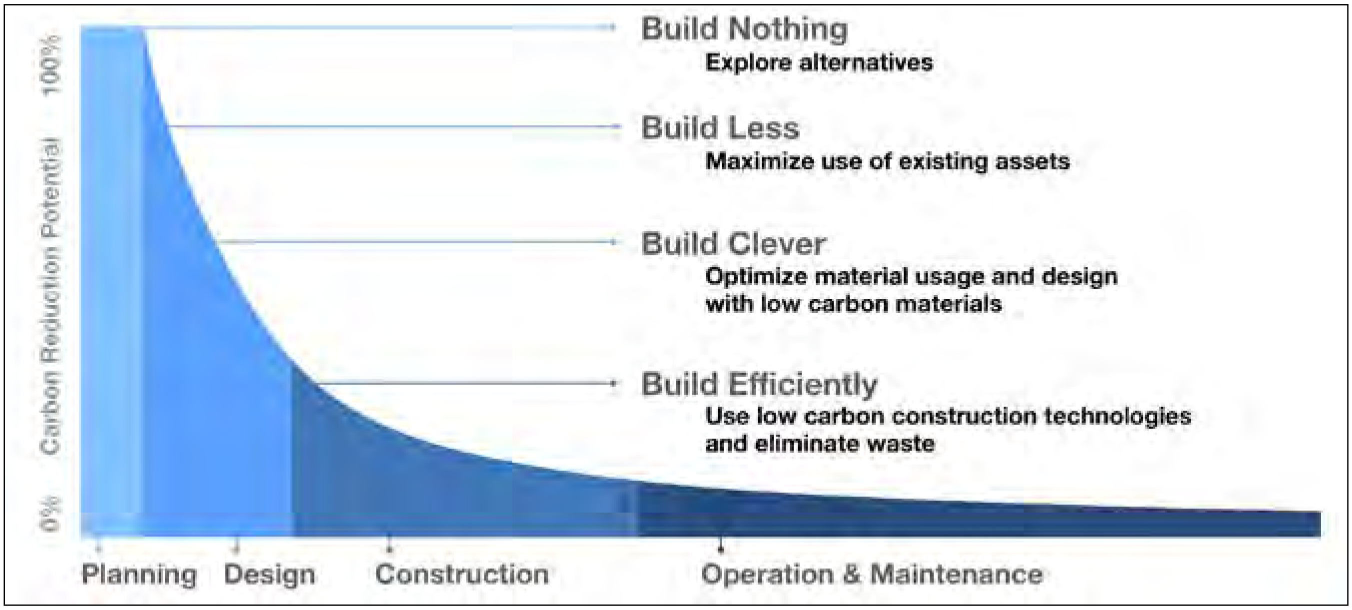
There are a number of ways that architects, engineers, and builders can reduce embodied carbon in buildings. The following are some key methods to reduce embodied carbon as outlined by the American Institute of Architects (AIA):

Reuse buildings and materials. Renovation and reuse projects reduce embodied carbon emissions by 50-75% compared to new construction. Most of this comes from the preservation from the foundation and structure, which are usually made from carbon intensive concrete and steel. When raw materials are required, utilizing salvaged materials virtually eliminates the embodied carbon associated with those products.

Use low carbon concrete mixes. Concrete mixes that use fly ash, slag, or calcined clays reduce cement content, which is the most carbon-intensive part of the concrete mix, without compromising structural integrity. If concrete is required for the project, using a lower cement content concrete can reduce embodied carbon emissions from concrete by 35-43%. [59]

Limit the use of carbon-intensive materials. Reducing use of aluminum, plastics, and foam insulation, which have a high carbon intensity, helps to reduce embodied carbon. Choosing products that have a high recycled content, such as steel, and lower carbon alternatives also achieves this goal. Reviewing a product's Environmental Product Declaration (EPD) provides information on embodied carbon and should guide decision-making.

Figure 17: Carbon Reduction Potential at Each Stage of Construction



Source: HM Treasury: Infrastructure Carbon Review via WGBC "Bringing Embedded Carbon Upfront" Report

Use carbon-sequestering materials. In addition to wood from responsibly managed forests, straw or hemp bales sequester carbon, and can be used as insulation. These materials are a clear renewable resource and are fire-safe.

Use unfinished materials. Leaving materials unfinished– such as using polished concrete as a floor without adding additional flooring– reduces materials use and associated embodied carbon.

Minimize waste. Designing in modules can minimize waste and designing buildings to be deconstructed forgoes embodied carbon associated with material disposal.

Purchase local materials when possible. Purchasing the above materials locally when possible further reduces embodied carbon, and contributes to the local economy as well.

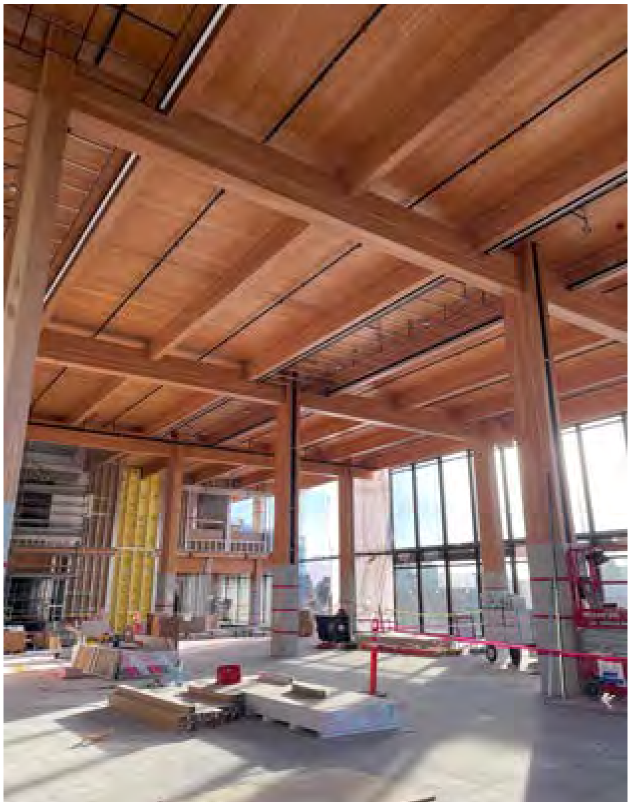
In addition, the use of **mass timber framing,** which uses laminated compressed layers of wood, has potential to drastically reduce embodied carbon and is already popular in many Nordic countries and continuing to gain traction in California. While most buildings 5 stories or lower may use general wood framing, taller buildings often rely on concrete framing. Changing a multi-story building's structure from concrete to mass timber could cut total embodied carbon emissions in half.[60] Timber framing is particularly beneficial when forests are responsibly managed, as wood can act as a renewable, carbon-sequestering building material.

1.4 Establish uniform metrics to track and monitor project performance

Building on existing rating and metrics systems, the Statewide New Construction program should adopt a consistent, equitable, and aligned performance metric system for the NCP.

The Statewide Team should work with stakeholders (such as the California Energy Efficiency Coordinating Committee - CAEECC) to explore the use of EUI targets or an absolute target as a measure of performance. (EUI is a measure of how much energy per square meter a building uses over the course of a year (kBTUs/sq ft/ year.))

A caution with using EUI as a metric is that use intensity is not absolute but varies by building type and size. Therefore, a large, single family home with two occupants could have a lower



New 6 story mass timber office building in Sunnyvale, CA

EUI than a small, three-bedroom apartment that houses a family while still using more energy overall, due to its large square footage. EUI measures vary even among multifamily projects based on density of units. Affordable housing, which is more likely to have studio or one-bedroom apartments, tends to have a higher density of units than luxury apartments, which may have three or more bedrooms. Therefore, it is important to set EUI targets for multifamily buildings by density. Program designers could work with low-income residents in multifamily buildings to help understand and set EUI goals. Setting an EUI or absolute target based on performance, alongside a target for modeling software, is an important step to creating a successful zero carbon multifamily building program.

1.5 Develop an industry accelerator program to increase the rate of major renovations for existing multifamily buildings

One of the greatest challenges in the multifamily sector is the large number of low-performing existing buildings, particularly those that serve low-income communities, and who are disproportionately people of color. The issue of a split incentive means that many property owners have little reason to update or renovate their buildings if they cannot directly recoup their investment. Other barriers based on the building condition, location, and owner absence, among others, decrease the likelihood of updating the existing stock. As a result, tenants of many multifamily buildings are not only forced to pay high energy prices but suffer from deferred maintenance and health and safety issues. The opportunities to reap the benefits of a major renovation program for existing buildings could vastly improve tenant safety and comfort, energy resilience, while securing energy savings.

Accelerator Program

A program that provides a bundled incentive/ financing/technical assistance package should be advanced by an IOU Program Administrator or a Regional Energy Network focused on existing buildings. The accelerator should drive major renovations and the installation of advanced heat pump heating and cooling, ventilation, water heating, and control technology within older multifamily housing occupied by low-income households in communities throughout California. The program would need to evaluate and support not only new technologies, but also utilize a new delivery method that connects building performance with ongoing incentives to link tenant and property owner benefits.

Developing a pathway to create direct benefits for low-income households can support the rapid advancement in scale that these new space and water heating technologies require. The pathway would define key product features, encourage manufacturer investment, build local supply chains, ensure quality installation practices, and reduce product costs for all consumers. The program also would create new local jobs, primarily in construction/ installation, to also benefit low-income communities and communities of color.

3. Strategic Framework

Scale and Speed

The program is presented as an accelerator because of the rapid pace of innovation and change required to move the industry. A central entity would define key components and technology elements so that scale can be developed to reduce prices and ensure quality and reliability. Multifamily and potential community-scale projects are likely to have a wide diversity of approaches and serve as demonstration projects. How the project operates locally would be flexible to allow for customization to the needs of communities. Linkages to other weatherization, housing rehabilitation, and related services would be provided through local coordination.

The accelerator should align with existing affordable housing requirements, weatherization, housing rehabilitation and provision, and community development efforts to add a level of advanced energy practice that changes how low-income residences are provided with energy services.

The process could open a **pathway to electrifying more multifamily buildings and supporting low-income tenants** in particular, by enabling the least efficient housing stock to benefit from the cleanest, most efficient, and carbon reducing technologies available today. Moreover, this accelerator program would support community resilience for low-income tenants, who would benefit from healthy indoor air and energy resilience. Updated buildings could further benefit from other electrification strategies, such as EV charging, bill reductions through variable rates, and energy storage. These outcomes also would directly serve the low-income housing occupants with increased reliability, more comfort, better safety, positive health impacts, and pathways to benefit from future electrification and the use of renewable energy.

Statewide Working Group

The Statewide Program team should establish or partner with an existing stakeholder working group including members from CAEECC, RENs,

Hollywood Palms, San Diego, CA - Retrofit to 100% Electric and Solar. Source: A Zero Emissions All-Electric Multifamily Construction Guide, Redwood Energy, 2019.

CCAs, local government policy makers, and other stakeholders to evaluate the opportunity to create an accelerator program to incentivize property owners to conduct a major renovation for multi-family buildings.[61] This working group could also be generally involved in streamlining funding related to high-performing affordable housing funding and financing, as expanded upon in Goal 5.

Partnerships

The Statewide Program team should seek to partner with and expand on the work of existing organizations who are running low-income home weatherization programs and explore how those organizations can participate in the new construction program. The Association for Energy Affordability (AEA) currently administers low-income weatherization upgrades in California and offers its services through RENs as well as the California Community Services and Development Agency (CSD). (The CPUC has previously indicated that the IOUs should work closely with CSD for low-income multifamily programs.) Partnering with CSD, AEA or a similar organization could expand existing programs to include larger building envelope changes and other energy-related upgrades that would promote community resilience and would build on existing program administration channels such as RENs or CCAs. Working with these organizations and involving CSD, RENs and CCAs as partners would be an efficient use of resources and would provide opportunities for localized on-the-ground efforts to provide these retrofits.

Focus on Electrification of HVAC

Multifamily buildings with central air conditioning and fossil fuel heating can be great candidates for heat pumps when either of the incumbent systems requires replacement. Expanding a central air conditioning system to a heat pump can be a relatively inexpensive.

In existing buildings, some efficiency elements may have already been established and may be difficult to alter, but opportunities exist to change central heating and cooling systems, water heating equipment, and some building envelope measures. Including building envelope efficiency investments at the same time as HVAC system changes can reduce heating system size and cost, reduce grid impacts, and sometimes enable more system choices (e.g., a single ductless system vs. a multi-head system). Coupling a heat pump retrofit with building shell efficiency upgrades in a single project can reduce transaction costs and improve the overall economics. The choices in system efficiency and building efficiency will impact long-term energy performance and should be comprehensively considered as part of electrification efforts.

Financing Affordable Housing

There is an opportunity to connect the construction of high-performance buildings to affordable housing financing, as affordable housing developers typically rely on funding through the state to finance their project. This could include incentivizing projects that will achieve an ultra-low EUI, including through Passive House construction. Good building energy performance will serve residents, property managers, grid managers, and more.

Program Administrators should evaluate creating a separate affordable housing incentive program in their Equity Portfolio that aligns with state and federal financing. This Program could align with funding from the California TCAC for affordable housing development and could include a mechanism in its program design that mitigates or removes the split incentive issue.

Goal 1. Recommended Roles and Responsibilities

Strategy	*Leads*	*Partners*
1.1 Integrate Passive House approaches into an enhanced Multifamily New Construction Program	PG&E - Statewide implementer	PHN/ PHCA/ PHI, CEC, CPUC
1.2 Incentivize low-GWP refrigerants and the responsible maintenance and disposal of refrigerants	PG&E - Statewide implementer	CEC, Industry market actors, CSD
1.3 Drive down embodied carbon in the construction process	PG&E - Statewide implementer	CalGREEN, CEC, Builders
1.4 Establish uniform metrics to track and monitor project performance	PG&E - Statewide implementer	CAEECC
1.5 Develop an industry accelerator program to increase the rate of major renovations for existing multifamily buildings	RENs	PG&E, CAEECC

Success Indicators

- **Multifamily buildings constructed through the NCP are all-electric and have significantly lower energy use and carbon emissions than their traditional counterparts.**
- **Buildings constructed through the NCP will be built based on EUI or absolute target energy efficiency metrics.**
- **Standardized metrics are developed and adopted to evaluate ultra-high efficiency building techniques in order to adopt and more widely utilize Passive House approaches.**
- **Incentives for achieving ultra-high efficiency buildings techniques, as listed above, will be integrated as a central part of the program.**
- **Percentage of buildings built to be zero carbon increase annually.**
- **Launch and support for an Accelerator program for existing buildings.**

Goal 2: Ensure Climate Resilient Multifamily Projects

Ensure multifamily buildings are designed and built to withstand changing climate conditions and support human wellbeing.

Objective

Incorporate resilience measures including energy resilience to reduce carbon emissions while increasing the ability of a multifamily building to function in and withstand a range of climate hazards and support human health.

This goal extends the application of zero carbon resilient consideration beyond the building envelope and includes the following strategies:

2.1 Design multifamily projects for climate resilience

2.2 Increase building resilience with the addition of solar plus energy storage systems

2.3 Support the development of resilient, green, and regenerative infrastructure

2.4 Support net zero water multifamily buildings

2.5 Incorporate the use of low temperature district energy systems that use alternative energy sources in multi-building projects

2.6 Enable layered program financing, incentives, and funding to help support resilient projects

Overview

Climate change is currently having and will continue to have substantial impacts on residents and buildings in California resulting from increased extreme weather, prolonged heat, sea level rise, direct threats from wildfires, and dangerous smoke levels. While the current building code has several standard safety measures for fire, indoor air quality, earthquake safety, and more, it is not designed with the projected climate threats in mind. Certainly, the vast majority of current buildings have not been designed to withstand more frequent extreme weather events like heat waves, wildfire smoke, and related Power Safety Power Shut Off (PSPS) events.

It is critical to ensure that new buildings are designed to function as a **durable sanctuary that keeps occupants safe, healthy, and comfortable over multiple days.** This is particularly important for multifamily buildings that often house disadvantaged populations who are more likely to have increased vulnerability to climate threats and are more likely to experience health complications from such an event. Further, lack of tree canopy and shade, inadequate stormwater management, and persistent droughts will have

Durable Sanctuary

A "durable sanctuary" refers to a home or building that ensures a safe and healthy living space for its occupants both every day and during extreme weather events and emergencies, including power outages for multiple days. A durable sanctuary should support the needs of the resident population (including communications, medical needs, and refrigeration). This includes ensuring safe temperatures, good air quality, and can provide electricity for key uses.

increasingly negative impact on multifamily and low-income residents. These elements are rarely considered in the building design. To achieve resilience, it is critical to incorporate **resilient infrastructure outside of the building envelope, including energy infrastructure and resilient landscaping, into the project design.**

The proposed new 2022 building code will require high-rise buildings (more than 3 stories) to install battery systems and require low-rise multifamily buildings to be battery-ready. While there is a statewide movement towards battery storage, the field is still somewhat nascent. AB 178 requires installation of solar panels on new residential units, but it only applies to buildings three stories or lower. There is a need for developers of multifamily buildings to holistically consider how other on-site elements can improve a building's resilience in the case of an extreme weather event or power outage. Integrated technologies such as vehicle to grid charging, solar and storage, and microgrids need to become common practice for multifamily buildings. Site-specific elements such as tree shading can be important to reducing a building's indoor air temperature, especially during an extreme heat event. Green infrastructure can reduce flooding risk by allowing rainwater to infiltrate the ground.

Reducing water usage and creating highly water efficient buildings is critical as well. According to The Future of California's Water-Energy Climate Nexus report by the nonprofit Next 10, "urban water is roughly twice as energy-intensive as agricultural water. If California fails to implement urban conservation measures and per-capita water demand is maintained at current levels, statewide urban water demand would increase 24 percent by 2035 with population growth, resulting in a 21 percent increase in annual water-related electricity use and a 25 percent increase in annual natural gas use."[64] It is critical to promote regional and building system resilience by significantly reducing water usage in buildings.

Goal 2. Strategies

2.1 Design multifamily projects for climate resilience

Buildings are designed for today's climate, not for the rapidly changing climate expected in 10, 20, or 50 years in the future. As extreme climate events become more frequent, it is important for designers and developers – who are making structures to last well over 50 years – to actively integrate climate resilience measures in their projects.

Resilience measures must be fully considered and incorporated into new construction. Passive House buildings, for example, can maintain a comfortable indoor temperature in the case of a power shut off in the extreme cold for over six days, compared to traditionally designed buildings, which only stay comfortable for about one day.[65] Similarly, the Ice Box Challenge showcased how PH homes can maintain comfortable temperatures in extreme heat.

In addition to incorporating climate resilience measures into building construction, new and major multifamily buildings should ensure community resilience to climate change on a neighborhood level. According to the U.S. Department of Health and Services, community resilience can be defined as the "sustained ability of communities to withstand, adapt to, and recover from adversity."[66] A key aspect of this is access to shelter and economic resources to respond to disaster. Notably, this includes ensuring the implementation of anti-displacement measures and that housing does not create high rent burdens for low-income tenants. In addition to relevant information listed below, there is more information on this and relevant strategies to achieve this in Goal 5.

Design Checklist for Resilient Projects

The New Construction Program, Codes and Standards, RENs, and other program administrator programs should adopt and require the use of a **Resilient Building Checklist** for new construction and major building renovations that are accepting incentives. Beyond that, local government building departments could require developers to fill out this same checklist as part of the project submittal package for multifamily developments, with modifications for their community.

A model for this effort is the City of Boston which has adopted a "Climate Resilience Checklist" (see case study on the next page) for developers of certain building types. Applicants are required

Case Study: Boston's Climate Resilience Checklist

In 2017, the City of Boston, MA, updated the Climate Change Review Policy for the construction or renovation of all large projects (20,000 sq feet and above), Planned Development Areas, and Institutional Master Plans in the City. Developers of these projects must submit a Climate Resilience Checklist with their project proposal. This checklist provides developers with information on future conditions in Boston through the end of the century and requires developers and other decision-makers to list the design (climate) conditions on which the building plans were based.

The Boston Climate Resilience Checklist, excerpt shown below, includes considerations for extreme heat, extreme precipitation, and sea level rise and flooding. Developers are required to provide a description of building features and considerations that address these future changes in climate.

C.1 – Extreme Heat - Design Conditions

Temperature Range - Low: Deg. | Temperature Range - High: Deg.

Annual Heating Degree Days: | Annual Cooling Degree Days

What Extreme Heat Event characteristics will be / have been used for project planning

Days - Above 90°: # | Days – Above 100°: #

Number of Heatwaves / Year: # | Average Duration of Heatwave (Days): #

Describe all building and site measures to reduce heat-island effect at the site and in the surrounding area:

C.2 - Extreme Heat – Adaptation Strategies

Describe how the building and its systems will be adapted to efficiently manage future higher average temperatures, higher extreme temperatures, additional annual heatwaves, and longer heatwaves:

Describe all mechanical and non-mechanical strategies that will support building functionality and use during extended interruptions of utility services and infrastructure including proposed and future adaptations:

D - Extreme Precipitation Events

From 1958 to 2010, there was a 70 percent increase in the amount of precipitation that fell on the days with the heaviest precipitation. Currently, the 10-Year, 24-Hour Design Storm precipitation level is 5.25". There is a significant probability that this will increase to at least 6" by the end of the century. Additionally, fewer, larger storms are likely to be accompanied by more frequent droughts.

D.1 – Extreme Precipitation - Design Conditions

10 Year, 24 Hour Design Storm: In.

Describe all building and site measures for reducing storm water run-off:

Source: Climate Resiliency Checklist, Boston Planning and Development Agency, 2021.

to submit a completed checklist prior to plan approval.

Working with stakeholders, PAs can help to develop an approach and method for utilizing this type of checklist. This checklist could also align with IOU Community Vulnerability Assessments and mitigation plans to address specific issues identified by community members in those plans.[67]

The proposed checklist should consider, at a minimum the following conditions:

- Firesafe: Building materials, location, and egress routes that consider potential fire risks, evacuation options, and offer a buffer to any wildlands urban interface (WUI).
- Air quality: Integrated air filtration systems and solutions to provide healthy indoor air quality during smoky periods.
- Smart location of equipment that leaves roofs available for solar and puts equipment out of any potential flood or other hazard areas.
- Water: Support water quality, water safety, and water efficiency, along with approaches to access water during a disaster.
- Support non-mechanical cooling approaches such as passive house building, cool roofs, and tree shading.
- Sea level rise and flooding: do not incentivize projects that are located in a FEMA or local jurisdiction flood zone.
- Multi-benefit energy and resilience measures including solar and storage enabling the building to operate off the grid during power outages and address the needs of residents (such as communications, medical needs, and refrigeration).
- Minimum temperature factor at doors, windows, and thermal bridges. This factor ensures and absence of condensation and prevents mold and mildew that can lead to long term building damage.
- Anti-displacement measures that will help to ensure the project does not displace low-income residents and residents of color from the neighborhood due to increased rental prices.

2.2 Increase building resilience with the addition of solar plus energy storage systems

Solar installations combined with battery storage systems are critical to a climate-friendly energy system and the development of reliable and effective distributed energy resources that complement a healthy, 100% renewable grid. Solar alone provides a generation source, but not necessarily at the right time of the day for the highest energy use. Connecting storage and solar along with energy demand response enables grid operators and utilities to better balance energy loads and reduce the demands for peak loads in the evenings. Further, the addition of storage creates the ability for the building to operate independent of the grid during a power outage – from extreme weather events to PSPS outages.[68]

The large-scale energy storage market in the United States totaled 1000MW in 2019 and is set to increase 10-fold to 10,000MW between 2021-2023. Additionally, of the 402MW of small-scale energy storage online in 2019, 83% of these systems were in California.[69] A strong market will help to drive prices down and create new innovations such as vertical solar and more efficient batteries that could make it easier for larger multifamily projects to generate and manage energy completely onsite.

California codes are continuing to push for greater integration and application of solar plus storage systems with the advent of the new code cycle. Beginning in 2023, all high-rise residential buildings with more than three stories will be required to install battery storage alongside solar systems, while low-rise residential buildings with three or fewer stories will be required to be battery-ready. Considering the trend towards battery storage requirements in CALGreen code, developers and designers should include solar and storage in all multifamily projects –

Philadelphia design-build architecture firm Onion Flats installed a 176-kW solar system with a rooftop canopy and wraps around the east-, west- and south-facing walls of its Front Flats apartment building. Source: Onion Flats including low-rise – to increase overall resilience and prepare the market to use these systems as routine practice. Increased availability of vertical solar systems and cheaper, more efficient batteries will make the practice more feasible in the coming years, while incentives in the short-term can bolster battery installation.

Installing solar plus storage systems may also be used at a community scale, especially when the ultimate development will include multiple buildings. Community scale solar in particular can increase design flexibility, provide for better project integration, and access funding outside of the normal development channels, potentially encouraging developer participation.

However, while battery storage is a fast-growing field within the energy industry, there is still a need to further understand and plan for achieving the proper scale of energy storage for multifamily (and other) buildings. This includes developing a better understanding of backup power options and how to address critical medical needs versus non-critical needs within a building.

EE + Renewable Incentives

It is important to connect incentives for the Multifamily Program to other IOU and Program Administrators' (PA) programs for reliable solar and storage systems at the local or community scale. Doing so will reduce impacts from power outages, enhance resilience from earthquakes or other disasters, and support a more resilient electric grid.

Electric Vehicle Integration

As another resilience measure, electric vehicle charging systems and vehicle-to-grid connection, which can transfer vehicle charge to a building's power source, should also be incorporated when appropriate. Vehicle charging that goes directly to the building's energy infrastructure could act as extra battery systems, helping to power the buildings' electricity after daylight hours, when solar goes offline, and can be a power source during a blackout.

Microgrids

If multifamily zero carbon projects are designed as part of a microgrid, they can further improve reliability and provide local resilience during major disruptive events or other emergencies. A better understanding of locational value can help IOUs assess and manage their distribution networks both when adding new loads and in areas that have distribution constraints.

2.3 Support the development of resilient, regenerative, and green infrastructure

Infrastructure outside of the building should be designed to be as resilient as possible and help to make residents safe by reducing impacts from extreme weather events, extreme heat, and drought. Impacts from and benefits of resilient measures to the external environment can be substantial. Further, many of the identified green infrastructure concepts have added benefits beyond the building project to mitigate issues at the neighborhood or city level.

To support and effectively administer a resilient and green project, PAs, particularly RENs who can work effectively with local building departments, should explore the adoption of or alignment with existing certification programs that can streamline compliance and help to support these third-party efforts. Examples of potential certification programs include the WELL Building and Community Standard, the Living Building Standard, ReSCAPE Rated Landscape, and LEED

Neighborhood Development (ND). The following are some of the areas a resilient program should incorporate:

Green Infrastructure

New multifamily projects should incorporate green infrastructure and stormwater management infrastructure, and regenerative, drought resistant landscaping throughout the project site. Consider integration of grey water systems to conserve water, as well as practices (listed below) to promote rainwater harvesting and stormwater management.

Rainwater Harvesting

Rainwater harvesting systems collect and store rainfall for later use. When designed appropriately, they slow and reduce runoff and provide a source of water. This practice could be particularly valuable in arid regions, where it could reduce demands on increasingly limited water supplies. The intended end use of the harvested rainwater will determine the type of treatment equipment that the system will need.

Rain Gardens

Rain gardens are versatile features that can be installed in almost any unpaved space. They are shallow, vegetated basins that collect and absorb runoff from rooftops, sidewalks, and streets. This practice mimics natural hydrology by infiltrating and evaporating and transpiring stormwater runoff.

Green Transportation and Parking

Parking spaces for multifamily buildings should be minimized whenever possible, while these projects should prioritize parking and use of low and zero carbon transit alternatives for their residents. This includes incorporating bike-shares on-site, while providing secure bike parking for bike owners.

Many green infrastructure elements can be seamlessly integrated into parking lot designs, when they are part of projects. Permeable pavements can be installed in sections of a parking lot and rain gardens and bioswales can be included in medians and along the parking lot perimeter. Benefits include mitigating the urban heat island and creating a more walkable built environment.

Green Roofs

Green roofs are covered with growing vegetation that enable rainfall infiltration and evapotranspiration of stored water. They are particularly cost-effective in dense urban areas where land values are high and on large industrial or office buildings where stormwater management costs are likely to be high.

Net Zero Water Strategies

Greywater Recycling systems lower a building's water use by capturing water from sinks, showers, and laundry machines, treating the water, and then circulating it back to be reused in those appliances or in toilets.

Blackwater Recycling systems lower a building's water use by capturing water from toilets, urinals, and irrigation, treating the water, and then circulating it back to be reused for those purposes.

2.4 Explore the creation of net zero water multifamily buildings

It is possible to create multifamily buildings that use net zero water over the course of a year through a combination of highly efficient appliances and water recycling.[70] In addition to greatly reducing water use, net zero water buildings also reduce energy use associated with water pumping and filtration. The new Multifamily Program should encourage buildings to reach net zero water use when possible. Net zero water multifamily buildings should meet LEED Zero Water Certification for indoor and outdoor sources, and design submittals should include intention to achieve this certification.

To achieve net zero water multifamily buildings, fixtures and appliances should be highly water efficient, and designers should specify the most efficient equipment possible, including those that can recycle water. Green infrastructure that reduces and captures rainwater, including downspout disconnection and rainwater harvesting as listed in the previous strategy, should also be installed on the property.

Net zero water projects should minimize the use of potable water and maximize the supply of alternative water derived from non-freshwater sources. This includes installing greywater systems that capture and reuse water from and for sinks, showers, and laundry machines. Projects should also explore opportunities to utilize blackwater recycling systems, which recycle water from urinals, toilets, and irrigation to be returned to their original source and reused for the same purposes. Buildings should not use potable water for irrigation. In general, net zero water projects should reduce sewer and stormwater discharge and treat wastewater on site.

To track and demonstrate net zero water operation, projects must establish annual water use and water balance by end-use.

2.5 Incorporate the use of low temperature district energy systems that use alternative energy sources in multi-building projects

Incentivize projects that renovate and/or enhance the energy infrastructure outside of the building structure to utilize other energy sources such as waste to energy as part of small scale district heating and cooling systems.

Waste Heat Recovery

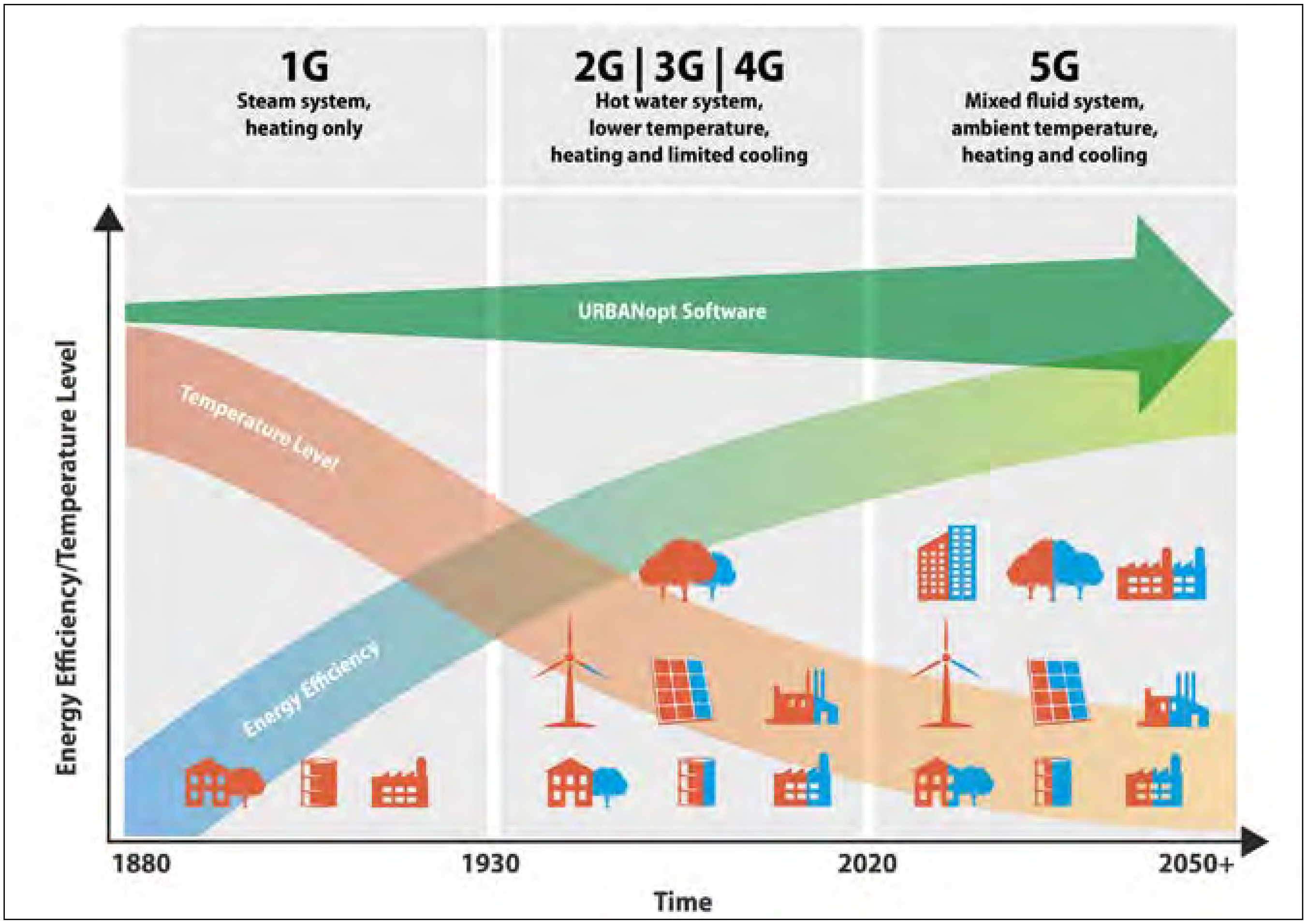
District heating systems can transfer heat energy from a range of existing heat sources, such as wastewater, to water or space heating in the building, and can greatly reduce a building's energy use and heating costs. For example, sewage heat recovery systems can recover low temperature heat from the process with a heat exchanger. These systems can be connected with heat pumps to increase water temperature, which can be transferred to multiple buildings in the vicinity. In a 60-unit apartment building in Vancouver, Canada, SHARC Energy Systems reported that their equipment reduced building energy use by 78%.

Scaled Energy Use

Moving to multi-building scale energy resolves pragmatic questions such as inadequate available roof space for solar, aesthetics, and shading by trees or other buildings. Greater scaled energy reduces the cost of renewables through economies of scale and makes financing alternative energy sources, such as geothermal energy or wastewater heat recovery, more feasible.

Geothermal energy is a consistent renewable energy source that can reduce energy demand for space and water heating and cooling by 50% or more, while also reducing emissions. Geothermal systems could be considered as a potential

Figure 18: Temperature of Heating Systems vs Energy Efficiency Over Time



Source: Simulation-Based Design and Optimization of Waste Heat Recovery Systems, NREL, 2019.

heating and cooling source for multi-building projects, which would be complemented by solar panels and battery storage to fully power plug loads and lighting.

5th Generation District Energy Systems

5th Generation District Energy Systems (DES) (see above) circulate ambient heat (via water) through buildings from sources such as wastewater or shallow geothermal exchange to different loads and operate at a multi-building or district scale. These systems rely on a combination of heat storage and water-source heat pumps to heat or cool water as needed. All energy exchange related to heating and cooling occurs within a closed loop system, and little energy is wasted.

These systems can contribute to a more stable energy grid, as more consistent operating temperatures of water means less spiked energy demand, especially during extreme cold or heat. The DES can incorporate heating and cooling opportunities at the same time, providing increased efficiency. The system also provides opportunities to use 100% renewable energy to meet electricity demand.

The cost of installing these energy systems and distribution piping falls on the district energy provider, reducing costs to developers, a key financial advantage, while providing low-cost, efficient heating and cooling to building occupants and users.

2.6 Enable layered program financing, incentives, and funding to help support resilient projects

Financing for multifamily projects, particularly for affordable housing, is extremely complex and is one of the greatest barriers to building more efficient multifamily projects. To achieve climate resilient design, projects must also be bolstered with mechanisms to enable finance layering from various local, regional, state, and federal sources. At the same time, resilient projects may also be better able to maintain insurance and lower risk that can better enable financing.

There is the opportunity to incorporate new construction projects into local government. Local Hazard Mitigation Plans (LHMP), Safety Elements, and climate adaptation planning open the potential to layer funding from FEMA, EPA, and other resilience funding sources which may otherwise not be available. Projects that clearly address and focus on climate resilience can be models to help local communities improve their resilience by utilizing larger scale solutions such as community microgrids, district energy, and community scale solar and storage.

Existing financial programs for residential buildings include the Self-Generation Incentive Program (SGIP), which provides rebates to homeowners for kWh generated with storage. The California Advanced Home Program (CAHP) also provides performance-based incentives for solar installation. The multifamily program should align with SGIP and CAHP to encourage battery storage technology on low-rise multifamily buildings that currently have no storage requirement.

Goal 2. Recommended Roles and Responsibilities

Strategy	*Leads*	*Partners*
2.1 Design multifamily projects for climate resilience	RENs, Local Government	CPUC, IOUs
2.2 Increase building resilience with the addition of solar plus energy storage systems	CCAs, RENs, IOUs	CPUC
2.3 Support the development of resilient, green, and regenerative infrastructure	Local Government, RENs	IOUs
2.4 Support net zero water multifamily buildings	Local Government, RENs	IOUs, CPUC
2.5 Incorporate the use of low temperature district heating systems that use alternative energy sources in multi-building projects	IOUs, CCAs, CPUC	Local Government
2.6 Enable layered program financing, incentives, and funding to help support resilient projects	IOUs, CCAs, RENs	CEC

Success Indicators

- **A Multifamily Climate Resilience Checklist is developed that also accounts for anti-displacement efforts, which is used by local government building departments and is standard practice.**
- **An increasing number of builders undergo building resilience certification programs (e.g. WELL Building and Community Standard, Living Building Standard, RESCAPE Rated Landscape, and LEED ND).**
- **An increasing number of new low-rise multifamily projects take advantage of existing solar and battery storage funding programs.**
- **An increasing number of new multifamily projects incorporate green infrastructure in the final built project.**
- **An increasing number of new multifamily projects achieve LEED Net Zero Water Certification in the final built project.**
- **An increasing number of large project integrate district energy systems supporting standard DERs.**

Goal 3: Establish Targeted Professional Training and Education

Establish targeted education and training to enable designers, architects, engineers, developers, and their agents to effectively advocate for and build zero carbon multifamily buildings.

Objective

Ensure that professionals involved in early decisions and design direction can effectively advocate and support the development of zero carbon and high-performing multifamily buildings adhering to advanced building standards while helping to eliminate perceived risks to high-performance construction.

This goal includes targeted strategies for professionals to be more effective in advocating and building zero carbon buildings:

3.1 Establish high-performing Integrated Design and Development Training

3.2 Align modeling tools to achieve low carbon goals

3.3 Utilize and encourage participation in high-performing buildings Energy Modeling Certificate Program training

3.4 Provide training and resources to advocate and encourage development of Zero Carbon Buildings

Overview

The technical capability to achieve zero carbon buildings exists but challenges to adoption at scale persist. Advances in technology, practices, and on-the-ground work allow for high-performing buildings and projects at unprecedented levels. Technical issues are rarely the reason a project under-performs or fails to achieve initial project goals, rather it is the processes needed to advocate and communicate about high-performing buildings that prevent their construction.

There are three major issues that the MZCAP considers that addresses this “people” challenge:

- Targeting education and training for design and engineering professionals
- Standardizing the practice of integrated design and build process
- Focusing on supporting effective advocacy and client engagement

The focus on design and engineering professionals does not mean that tradespeople and builders do not need training, but that it has been a long-term gap that needs to be addressed to push the industry forward.

Integrated Design and Building

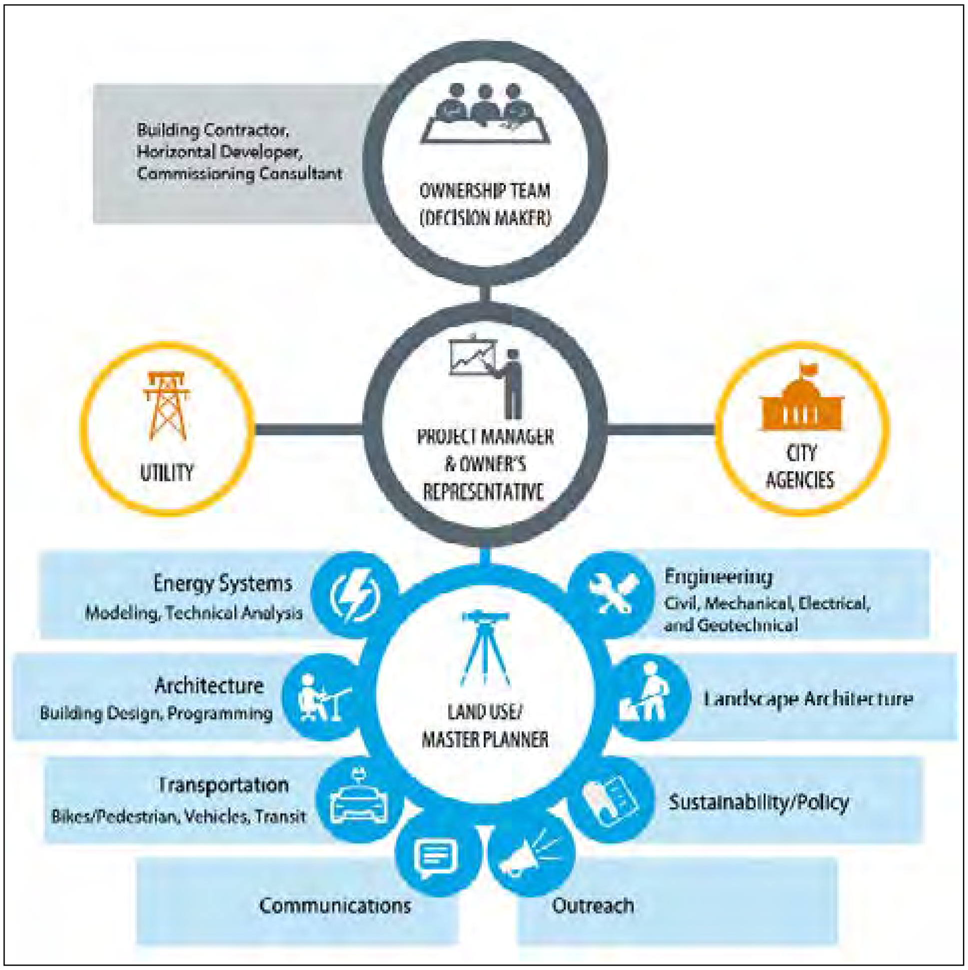
Traditionally, buildings are constructed using a linear design and construction process, in which designers and architects create building plans with minimal input from builders, energy engineers, and tradespeople, only involving them later in the process once the plans are already set. This piecemeal approach means that building components are designed in isolation with limited communication among the key players. This means that designers often fail to consider how mechanical elements, such as heating and cooling systems, are aligned with other building systems like the building envelope. This results in suboptimal performance, projects that abandon ambitious goals, and/or much higher costs due to late changes in scope and projects.

Zero Carbon Building Advocacy

An equal or even more critical issue is that designers and architects are generally beholden to clients' ideas of what a project should be, what it should cost, how it should operate, and what building features are marketable. Standard practices and conventional thinking drive many clients' requirements even when they may indicate a desire for a sustainable building. The reality of the complexities and the upfront costs of high-performing projects can be easily sidetracked if the design team is not prepared to offer solutions, solid advice, and approaches to achieve aggressive goals. It is important for designers to be able to provide the business-case for altering building design and explain other benefits to create zero carbon buildings.

Therefore, this goal and its strategies are focused on the early phases of a project and the practitioners responsible for developing multifamily buildings rather than the construction and the trades. Without addressing these early phase concerns, scaling high-performing zero carbon multifamily buildings will not be achieved.

Figure 19: Developing an Integrated Team for a High Performing Project



Source: A Guide to Energy Master Planning of High-Performing Districts and Communities, NREL, DOE, October 2020.

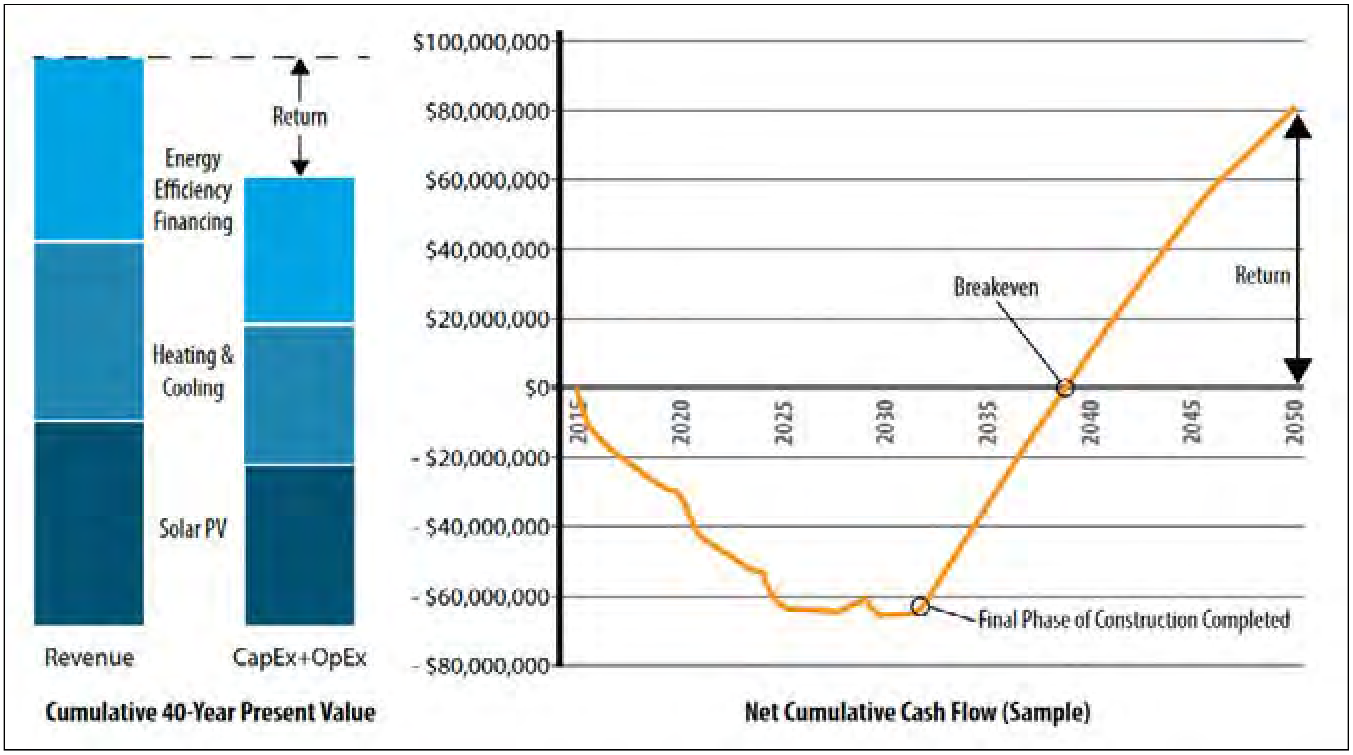
Goal 3. Strategies

3.1 Establish High-performing Integrated Design and Development Training

Development practices must change to create an integrated and holistic approach to building design and development that includes both technical and architectural considerations. It is necessary to help drive forward projects with an Integrated Design Process (IDP) by targeting training towards designers, architects, and to a lesser extent energy consultant, who are the professionals driving the projects. This approach differs from previous training programs that target construction workers and buildings. Establishing the right project team (see Figure 19 for components of a project team) at inception and ensuring all the players are actively involved is key to enable greater success for achieving high-performing projects.

The Statewide Workforce Education and Training (WE&T) program, in collaboration with PAs of the Statewide New Construction program, should provide an IDP training series to teach designers, engineers, energy analysts, energy consultants, and others how to achieve zero carbon building projects. Training would target architects, building designers, modelers, and similar professionals and allow them to have a deep understanding of building high-performing projects, a sense of agency and the knowledge to advocate effectively for aggressive operation and embodied carbon goals. This series of trainings should include education on reliable technical tools that help determine building carbon, how to establish and manage an integrated team, including invovement from community-based groups to help shape design based on the needs of residents, and how to ensure high-performing goals are met at each stage of project development from concept to construction. It should also include on-the-job training experience, as discussed in the following

Figure 20: Presenting the Long-Term Cost Benefit of High Performing Projects



Source: A Guide to Energy Master Planning of High-Performing Districts and Communities, NREL, DOE, October 2020.

paragraphs. Trainings should also help designers and architects advocate for zero carbon buildings with their clients. This would include how to present budgets, costs, and benefits in a way that aligns to developer needs and expectations as well as with other project sponsors.[71] Often designers do not have the ability to run economic models that support ROI analysis nor the expertise to present them in a confident manner. Training for designers and architects should include helping them to understand how to calculate as well as discuss total cost of ownership budgeting. Building this suite of knowledge will help to make projects more attractive and acceptable.

Hands On Expertise

A significant portion of training and education funding should go to on-the-job technical assistance and mentoring to give designers, architects, and consultants real-world experience on a zero carbon project. This is key to ensuring these groups are comfortable managing a project team as part of an integrated design process and building a zero carbon building. Typically, after the first hands-on experience, designers and architects are well-suited to use an integrated design process for future designs and run their own project teams.[72] The Program could also include incentives for doing a PH feasibility study and energy modeling for projects. Additional incentives could be added post-construction for high-performing units that achieve PH certification and save on energy use.

Link Training to Project Outcomes

There is also an opportunity to link training costs or subsidizes to project outcomes. Massachusetts offers developers rebates for high-performing projects and provides additional rebates for designers of these projects who attend PH trainings. California could explore a similar concept to encourage designers and architects to learn about the integrated design process and zero carbon buildings.

3.2 Align modeling tools to achieve zero carbon goals

The Program should support the use of robust design modeling and technical tools to ensure the optimization of multifamily buildings to be low to zero carbon and grid responsive.

The enhanced NCP should:

- Support new technologies and approaches to align modeled energy and emissions with real emissions and affordability needs.
- Provide opportunities for multiple pathways to achieve zero carbon goals, including a Passive House pathway.
- Offer technical assistance to developers to inform their decision making and help developers meet targets.
- Provide strong rationale for design and controls related decisions, to better inform value engineering processes.
- Allow PHPP software modeling to be used as part of the CEC CBEC- Res compliance pathway to achieve high performance buildings.

Live Blower Door/ Air Tightness Demonstration, Passive House Institute 2018

3.3 Utilize and encourage participation in high-performing buildings Energy Modeling Certificate Program training

Understanding the feasibility of a project and how to optimize, budget, and develop an effective energy system for it is a critical element to achieving a zero carbon goal. Competent energy modeling is essential to the design and construction of zero carbon buildings. A well-modeled building can optimize energy sources, building systems, incorporate advanced energy controls, and help to assess various scenarios to meet project goals and criteria.

Currently, most energy modeling software uses a piecemeal approach to estimate energy use, which makes it difficult to accurately measure building emissions and model more innovative or leading-edge technologies. Common modeling software such as REM/ Rate, REM/ Design, EnergyPlus, and BeOPT, predict energy use based on separate heating, cooling, ventilation, and systems, as well as lighting and plug and process loads.[73] A building's actual energy use can vary widely from the model for a variety of reasons such as building layout, the building envelope, and occupant behavior. New approaches are being regularly introduced such as the recently released Zero Code modeling tool from Architecture 2030 and PH Ribbon tool which helps to calculate embodied carbon in the design.

High-performing buildings trainings should utilize and offer existing energy modeling trainings using the latest technologies and tools. This should include much more than code compliance tools and should offer deep dives into products such as UrbanOpt which models at the community or district scale and ReOpt for building modeling developed by NREL and DOE to create high-performing projects and buildings. Creating an energy modeler certificate program would help to regulate and solidify the use of the best tools, as well as set ongoing learning objectives and advanced modeling pathways. This includes providing support to teams working on PH projects.

3.4 Provide training and resources to advocate and encourage development of zero carbon buildings

To help architects, engineers, planners, and other energy consultants effectively advocate for zero carbon buildings and projects, it is necessary to create a series of tools and resources focused on multifamily buildings. Communication materials and tools should be tailored to these groups to encourage the adoption the best practice business model for zero carbon, high-performing buildings. Resources, in the form of one-pagers or online webpages, should include information on, but not limited to, the following:

- Program requirements and incentives
- Multifamily Zero Carbon Business Case calculation methodologies and talking points for property owners and brokers
- Economics of upfront capital investments and operating costs, including potential financing, tax, and funding options
- Zero carbon, all-electric multifamily building opportunities and benefits
- Indoor air quality and the health benefits of induction cooking, all-electric buildings, and good ventilation systems
- Renewable energy system (rooftop, project scale, community scale) opportunities, tradeoffs, and requirements
- Resilience, energy assurance, and safety benefits
- Monitoring energy tools
- Building commissioning, operations, and maintenance requirements and potential for reduced long-term costs

These materials and training should be developed by the statewide New Construction Program and distributed and implemented through trade organizations such as American Institute of Architects (AIA), Urban Land Institute (ULI), American Planning Association (APA), Urban Sustainability Directors Network (USDN). This may also be a partnership arrangement and collaboration on all parts of the effort.

Goal 3. Recommended Roles and Responsibilities

Strategy	*Leads*	*Partners*
3.1 Establish High-Performing Integrated Design and Development Training	Statewide WE&T, RENs	PHIUS, PHN, AIA, USDN, et.al.
3.2 Align modeling tools to achieve zero carbon goals	CEC	PG&E- Statewide implementer, stakeholders
3.3 Utilize and encourage participation in high-performing buildings Energy Modeling Certificate Program training	WE&T	PHIUS, PHN, CEC
3.4 Provide training and resources to advocate and encourage development of zero carbon buildings	CPUC, CEC	PHIUS, PHN, AIA, USDN, et.al.

Success Indicators

- **The availability of design professional-focused zero carbon training across the state.**
- **The percentage of design professionals/architects who have completed zero carbon multifamily training increases annually.**
- **Modeling tools consistent and aligned to support zero carbon targets.**
- **An increasing number of energy consultants received a high-performing buildings certification.**
- **Range of partners offering complementary and supportive training.**

Goal 4. Foster Low Carbon Operations

Foster a long-term approach to project performance by incentivizing low carbon operations and supporting benefits of long-term operational savings.

Objective

Maintain energy savings and reduction in GHG emissions after the building is occupied by supporting effective maintenance practices and well-designed buildings that need limited behavior changes or interventions.

This goal has three main strategies that focus on building a standard practice for planning complex buildings with a long-term perspective, inclusive of ongoing operations.

4.1 Employ total cost of ownership budgeting

4.2 Monitor building energy use

4.3 Ensure long-term building energy optimization through building commissioning from design through operation

Overview

Typically, developers and designers focus on the capital investment for projects and do not effectively consider the operation of the building or tenant's costs. This results in most discussions, funding, and considerations going into design and construction and not into how a building will operate over its 50 year plus lifetime. To ensure a truly sustainable building, it is critical to consider and address ongoing emissions from operations and ensure that energy costs for tenants are low and equitable. While California Title 24, part 6, requires non-residential, mixed-use multifamily buildings to conduct building commissioning, it does not apply to strictly residential buildings.

Zero carbon multifamily buildings should be built so that occupants do not need to "behave" in a particular way; rather, **the buildings will automatically, through their design, construction, and advanced controls, create a comfortable, healthy, and easy to live space.** This approach will greatly alleviate the tenant's responsibility of having to properly control energy use in the homes, and instead places responsibility on the designers to create buildings that do not require extensive interventions to meet goals. Program administrators should require some level of monitoring and regular energy commissioning on large multi-building projects to ensure that systems are functioning as intended and maintained over the building's lifetime. In addition to ensuring low energy use, building commissioners should also monitor heat pumps and other appliances to make sure that refrigerants from these appliances are not leaking.

Incentives for energy efficiency could be designed to maintain operational savings year after year and could be based on performance instead of based on modeling assumptions. This would help address the split incentive issue and result in:

- Lower energy use and lower energy burdens
- Improved equipment function
- Reduced building operation and maintenance
- Extended life of equipment
- Reduction in building carbon emissions

Total Cost of Ownership

Total cost of ownership is the cost of designing and constructing a building combined with the cost of operating the building. A building's design and construction cost is only 10 percent of the cost over the life of a building. The operation cost, which includes regular service and preventive maintenance for building systems, ongoing repairs, consumables and energy consumption, is 90 percent.

Source: DPR, /www.dpr.com/media/review/spring-summer-2014/qa-the-total-cost-of-ownership

Goal 4. Strategies

4.1 Employ total cost of ownership budgeting

Typical project budgeting that relies on a simple payback calculation does not consider the long-term costs and impacts of operating a building for 50 plus years. It is important to establish guidelines and tools for building developers and project teams to adopt a total cost of ownership budgeting approach, offering value to higher capital cost improvements that will enable long-term operational savings.

The total cost of ownership (TCO) represents the cumulative cost of owning or using an asset throughout its duration of use, and can consider the costs of maintenance, installation, upgrades, energy use, disposal, and more. This stands in contrast to the payback method of economic analysis, which measures how quickly project funders can receive a return on investment and ignores any additional savings that occur after the return on investment is reached.

A Life Cycle Cost Analysis (LCCA) is the method used to find an asset's TCO and is utilized in the asset procurement selection process. By considering all inputs that go into installing, maintaining, properly using, and disposing of an asset, an LCCA provides a more accurate representation of long-term economic performance.[74] The lifetime of various appliances and materials is calculated as well, providing greater context for decision-making. It also considers how inflation may affect investments moving forward, as money invested in building improvements now is more cost effective than the same amount required for upgrades in the future.

4.2 Monitor building energy use

It is important to continually monitor building energy use to ensure energy systems are functioning and being used properly. This allows building owners to detect and correct equipment malfunctions or failures or identify tenants that are using their HVAC systems incorrectly or inefficiently. The new Multifamily Program, especially in the early phase, should require monitoring and provide subsidies to cover a period of that monitoring. Collecting accurate building energy data from high efficiency buildings helps to quantify savings and can be used to inform future subsidies and incentives provided as part of this program. Monitoring can also help transform how baseline codes and reach codes are developed and provide targets for these codes.

4.3 Ensure long-term building energy optimization through building commissioning from design through operation

To streamline administration and ensure compliance, the new Multifamily Program should require LEED fundamental or enhanced commissioning (for LEED certified buildings), or equivalent for all new participating multifamily buildings. Commissioning plus routine retro commissioning ensures that a building performs as intended.

In the design phase, designers should identify commissioning needs and select a commissioning provider for the project, who advocates on behalf of the building owner to achieve energy standards. The commissioning agent should help identify target energy requirements, set strategies to achieve them, and then incorporate these standards into the proper documentation to ensure effective implementation. Once construction is completed, the commissioning provider should then assess and confirm that minimum energy performance targets were achieved and provide direction on how to efficiently operate the building in the future.

Continual energy monitoring in buildings is a keystone of commissioning. A commissioning agent should revisit a project every 2 to 5 years to assess the operation of systems and how well they are functioning with occupant use. This would also include assessment of utility metering information and other systems data. Any changes or adjustments can be made to address problems and ensure effective ongoing operation.

Commissioning Defined

Building commissioning *is when a building is initially commissioned and undergoes an intensive quality assurance process that begins during design and continues through construction, occupancy, and operations. Commissioning ensures that the new building operates initially as the owner intended and that building staff are prepared to operate and maintain its systems and equipment.*

Retrocommissioning *is the application of the commissioning process to existing buildings and seeks to improve how building equipment and systems function together. Depending on the age of the building, retrocommissioning can often resolve problems that occurred during design or construction, or address problems that have developed throughout the building's life. In all, retrocommissioning improves a building's operations and maintenance (O&M) procedures to enhance overall building performance.*

Recommissioning *is another type of commissioning that occurs when a building that has already been commissioned undergoes another commissioning process. The decision to recommission may be triggered by a change in building use or ownership, the onset of operational problems, or some other need. Ideally, a plan for recommissioning is established as part of a new building's original commissioning process or an existing building's retrocommissioning process.*[75]

Goal 4. Recommended Roles and Responsibilities

Strategy	*Leads*	*Partners*
4.1 Employ total cost of ownership budgeting	Development Community and Builders	Local Government, RENs
4.2 Monitor building energy use	PG&E Statewide implementer	Building owners and developers
4.3 Ensure long-term building energy optimization through building commissioning from design through operation	CEC, CPUC, RENs	Local Government

Success Indicators

- **Total Cost of Ownership is common practice and part of the New Construction Program's technical assistance.**
- **All completed projects are monitored for energy use.**
- **All New Construction program projects are required to utilize LEED Enhanced Commissioning or an equivalent commissioning process.**

Goal 5: Mitigate the Financial and Policy Challenges to Development

Support enhanced and streamlined financing and enable policies that provide a supportive path forward to affordable zero carbon multifamily buildings.

Objective

Provide financial incentives to encourage zero carbon multifamily developments while reducing conflicting local land zoning, planning policies, and regulations and mitigating impacts on housing affordability.

Policy can act as a barrier to the implementation of high-performing buildings, particularly for complex affordable housing and multifamily projects. Effective financing and streamlined local government policy is necessary to enable the development of these buildings. This Goal includes the following three enabling strategies to address the most critical policy areas:

5.1 Coordinate and streamline funding policies, mechanisms, and programs

5.2 Establish a path to zero carbon codes for multifamily buildings

5.3 Support local government planning and building departments to implement zero carbon buildings

Overview

Government regulations and policies are fundamental to driving green building and zero carbon development and are therefore essential to reach the MZCAP goals. **State government** dictates housing laws, oversees the Regional Housing Needs Assessment (RHNA), which guides the amount of housing required in a jurisdiction, sets Codes and Standards, and is a key player in affordable housing financing. There is an need and opportunity to connect the construction of high-performance buildings to state policies, especially affordable housing financing, as affordable housing developers typically rely on funding through the state. This includes coordinating efforts and policy among the **CPUC, CEC, IOUs,** the state **California Tax Credit Allocation Committee (CTCAC),** which administers the federal and state Low-Income Housing Tax Credit Programs**.**

Local government planning departments direct land use planning through a range of policies in General Plans and Specific Plans, zoning policy, transportation plans, and climate plans. These policies in turn set the stage for where and how new buildings and district or community projects can be developed. Local government **building departments** enforce building codes and are key players that can either hinder or help in the development of high-performing multifamily buildings. Often short-handed, building officials have limited time to learn all of the details of these new high performing standards. Further, Local Governments are in charge of pursuing and enforcing local **Reach Codes** that can push to higher performance levels. Local governments need to be supported, encouraged, and recognized as leaders in enabling innovation and making sure there are the right conditions to pursue zero carbon projects. Maximizing the potential of local governments includes leveraging RENs, CCAs, and state and regional government efforts. It is essential to coordinate efforts that allow and encourage local governments to enact enabling policies for this construction.

Goal 5. Strategies

5.1 Coordinate and streamline funding policies, mechanisms, and programs

Multifamily housing plays an important role in providing affordable housing options to Californians. However, changes in federal affordable housing policies and increases in market demand for transit-friendly, high-density housing is reducing the availability of those units. Availability of viable financing tools and resources will be critical to increase and maintain an appropriate level of affordable multifamily units.

It is important to encourage and enable collaboration across State agencies to leverage funding opportunities that support zero carbon multifamily construction. Notably, this includes ongoing coordination and streamlining efforts with the CPUC, CEC, IOUs, and the CTCAC. As mentioned in Goal 1, a stakeholder working group of low-income housing and electrification-related organizations should be formed to align and streamline high-performing affordable housing financing and funding mechanisms.

The policies, mechanisms, and programs listed in this section present opportunities for this coordination to make financing and development of affordable high performance multifamily housing more attainable.

Consistent Energy Data

Lenders, appraisers, and financiers of affordable and market rate housing need market comparison data along with utility cost data to appropriately value energy efficiency and on-site renewable generation. For projects with market-rate units, market comparison studies and asset ratings that include energy use data associated with energy efficiency features and solar will allow for factoring in the higher rent potential of a property and positively impact the level of financing available.

Additionally, a separate renter-targeted rating could serve as a mechanism to provide return on investment made by the landlords towards improved energy efficiency and on-site generation in the form of higher rents and less turnover. The renter-targeted rating based on reduced energy costs and higher comfort could attract renters and make the properties higher value rentals. It also has the potential for lowering renter turnover due to higher level of satisfaction, which in turn avoids operating costs for landlords associated with each turnover.

Affordable Housing Incentive Program

Program Administrators should evaluate creating a separate affordable housing incentive program that aligns with state and federal financing, including reducing first-cost based on long-term performance. This Program could align with funding from the California TCAC for affordable housing development. Such a program should also include a mechanism in its program design that mitigates or removes the split incentive issue.

This could include incentivizing projects that will achieve an ultra-low EUI, including through Passive House construction. Good building energy performance will serve residents, property managers, grid managers, and more.

Low Income Housing Tax Credit

Program administrators should work with the California TCAC to create and align incentives for zero carbon affordable housing construction. The Low-Income Housing Tax Credit (LIHTC) Program is an indirect Federal subsidy used to finance the development of affordable rental housing for low-income households. The LIHTC Program was created to provide the private market with an incentive to invest in affordable rental housing. Housing tax credits are awarded to developers of qualified projects. Developers then sell these credits to investors to raise capital (or equity) for their projects, which reduces the debt that the developer would otherwise have to borrow. Because the debt is lower, a tax credit property can in turn offer lower, more affordable rents. California should consider altering how low-income housing tax credits are distributed by incentivizing zero carbon, high-performing projects. Through a point-based system called the Qualified Allocation Plan (QAP), the California Housing Authority (CHA) sets its own criteria and priorities for deciding who receives the tax credits. CHA could include points for high-performing projects and projects that integrated Passive House design principles.

Energy Efficiency Tax Credits

In California, the CTCAC allows for the use of the California Utility Allowance Calculator 44 to calculate project-specific utility allowances for low-income housing projects that include high levels of energy efficiency (at least 15% above base code) and on-site solar generation. This allows developers to invest in energy efficiency and solar as well as earn tax credits to offset the initial costs. Additionally, it aligns the utility allowance in rent calculation due to potentially lowered utility bills for low-income residents. Multifamily program financing should make sure to leverage this tool.

Bay Area Housing Finance Authority

Established in 2019, BAHFA is a shared initiative between ABAG and MTC. BAHFA aims to promote preservation and production of affordable housing in the San Francisco Bay Area, which struggles acutely with lack of housing and homelessness. The regional authority has the ability to raise revenue for affordable housing through a ballot measure and is considering placement of a 2024 ballot measure that would allocate $10 billion in general funds dedicated to affordable housing in the Bay Area. If passed, there is a key opportunity to align with this potential ballot measure and incorporate high energy efficiency standards into requirements for this buildings.

BUILD Program

As mentioned previously in the Plan, the BUILD program is aimed at growing the market for electric space and water heating appliances to increase the number of all-electric homes in the State. The BUILD program focuses on promoting all-electric affordable housing, as 75% of the funding for the program is set aside to help fund all-electric appliances and technical assistance for low-income housing projects. BUILD includes incentives for heat pumps, energy efficiency,

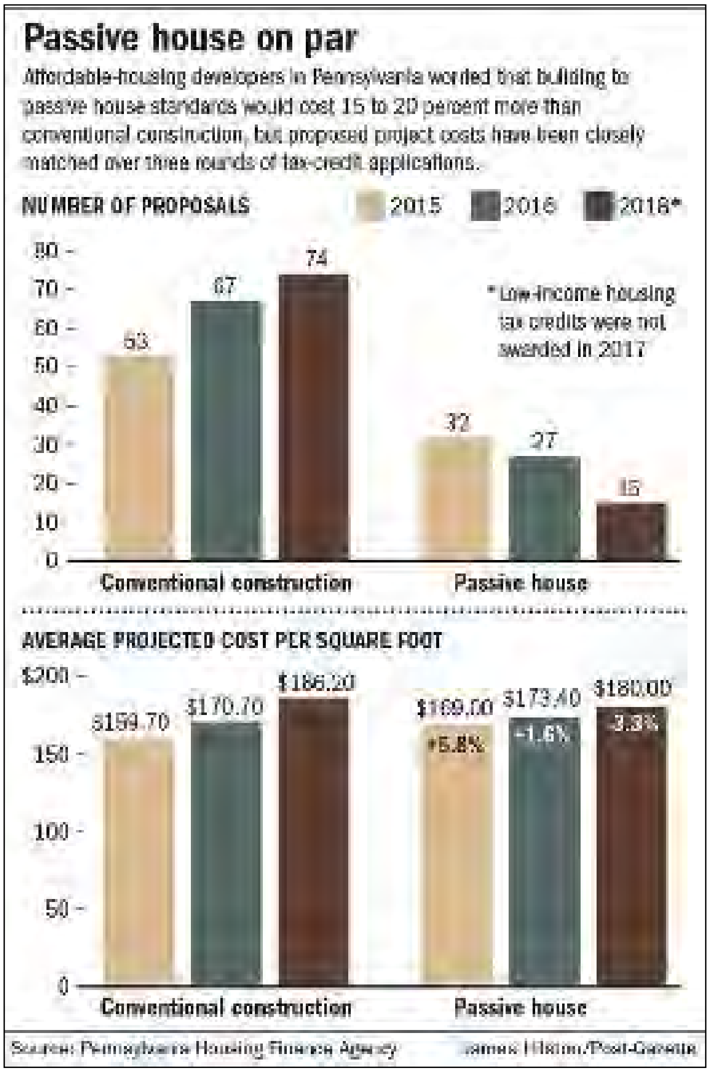
Case Study: Passive House in Pennsylvania

Some states have incentivized Passive House design through their affordable housing financing process. Pennsylvania has the most Passive House buildings out of any state in the country because the State has included PH design as a building characteristic that garners points in the bids for affordable housing development. Winning affordable housing tax credits from the United States Department of Housing and Urban Development (US HUD) which subsidizes up to 70% of building cost, is a highly competitive process. Through a point-based system called the Qualified Allocation Plan (QAP), each state agency sets its own criteria and priorities—such as project location, target resident demographics, project sponsor types—to decide who receives the tax credits.

The Pennsylvania Housing Finance Authority (PHFA) started offering 10 points out of 130 in the QAP for PH projects. This increased the number of developers who included PH certification in development submittal, and the number of submittals for PH designs that were awarded tax credits increased. In the first year, eight of 32 PH projects were approved, in the second year, 10 out of 27 were approved. By the third year of the process, PH multifamily housing actually cost less to build than standard housing.

This method took advantage of existing processes that developers already use, as opposed to creating a separate incentive or program. By heavily weighing PH designs in the QAP in a highly competitive bid process, PHFA created a fruitful Passive House market. The total number of multifamily projects certified by the United States Passive House Institute (PHIUS) in the state is now 56.

Other states have adopted a similar approach. Connecticut also added four out of a possible 102 points for PH certification for developers, and Massachusetts added five out of 82 additional "special characteristics" points that are awarded after a project has achieved a baseline qualification. As of August 2021, the number of multifamily PH projects in the two states is 24 and 20, respectively.



Source: Post Gazette, 2018

energy storage, and demand response. The set of multifamily efforts for this Plan should consider streamlining with BUILD.

EPIC Grant Solicitations

The CEC currently administers the Electric Program Investment Charge (EPIC) Program, which invests in technological research and demonstration projects that will enable the transformation of the electricity sector to meet California's climate and energy goals. These goals include expanding the use of renewables, decentralizing the energy grid while promoting a resilient energy system, and shifting the state towards electrification of all buildings. In past years, the program has invested $160 million into projects to move the state towards these outcomes. Administrators of the Multifamily Zero Carbon Program should collaborate with the CEC to solicit grants that will fund opportunities to advance technology that supports the construction of zero carbon multifamily homes.

5.2 Establish a path to zero carbon codes for multifamily buildings

The California Energy Commission, with Title 24, part 6, has consistently increased the energy efficiency requirements through the tri-annual codes and standards cycle. The new 2022 Code will provide a major update for multifamily buildings starting in 2023. The update, as mentioned earlier in this Plan, creates a single chapter for all multifamily buildings and a range of critical improvements.

Performance Approach

Part of the focus of the Plan is to create an environment for multifamily buildings that focus on an end result rather than on the way a project reaches that outcome. This performance approach recognizes the dynamic character of the market and the need to support innovation while protecting the critical infrastructure and safety of the grid.

The industry and local government agencies involved in enforcing the codes need to be prepared for and open to managing the evolution to new approaches to building energy performance. Appliance standards also need to be updated and aligned with the zero carbon goals, as allowed under Federal preemption rules.

Building standards and code provide a baseline for what buildings should achieve, not necessarily the ideal goal of a zero carbon building. Therefore, while establishing zero carbon-level performance codes is important, **code may inherently limit some innovative performance-based approaches.**

Reach Codes and Setting a Path Forward

To establish a zero carbon multifamily building standard by 2035, technical feasibility and cost effectiveness related to Passive House integrated building processes, project scale-renewables, changing technologies, and maintenance and behavior impacts for all of the different multi-family building types, as well as other elements outlined in previous strategies, must be piloted, and integrated into Reach Codes and the overall codes development process as soon as possible.

The New Construction Program can help to chart a path with **incentives and technical assistance** to zero carbon multifamily standard with Passive House-style, performance approaches. The effort should build on demonstrated success with the integration of Passive House elements, as well as align with fire and safety codes to create a more streamlined process.

In addition, local government, supported by the **RENs and other key partners, could work together to create an effective Reach Code for Multifamily building.** A potential approach to explore may be a tiered reach code similar to British Columbia's, detailed on page 81, with increasing levels of energy requirements and decreased energy use. Cities could adopt the appropriate level of the reach code for their jurisdiction, working towards an eventual statewide mandatory zero carbon multifamily building code. A tiered reach code can allow some cities to become early adopters of high-performing or Passive House standards, helping to create a knowledgeable base of designers familiar with the construction of high-performing buildings while building the zero carbon multifamily market in the State.

5.3 Support local government planning and building departments to implement zero carbon buildings and related efforts.

Enabling policies, particularly around land use planning, governance, and zoning, should be adopted to smooth the path to zero carbon buildings at a community level and allow for more innovation and success in pursuing zero carbon projects. Policies can align with state level actions to support a robust market that can be self-sustaining.

Climate Action Planning

Based on AB 32/SB 32, local governments have developed local climate action plans for most of the jurisdictions in California. Over forty counties have developed Local Hazard Mitigation Plans following FEMA and California OES guidelines that help to mitigate against disasters and build community resilience. Many of these plans will be updated in the coming years. This provides an opportunity to integrate zero carbon goals and multiple approaches to energy related carbon emission reduction into the plans.

Land Use Planning

Land use planners are one of the most important actors not actively involved in green building or zero carbon construction currently. Typically, planners are in charge of long-term development of a city or town through a General Plan or Specific Plan (typically a neighborhood scale) and by setting zoning rules, developing urban design guidelines and transportation networks, and dictating the mix and location of building types and uses. Historically, planners have rarely consider energy or the potential for renewables in these plans. The State Office of Planning and Research (OPR) tracks the various elements in General Plans and has identified approximately

Case Study: British Columbia Step Code

In 2017 British Columbia (BC), Canada, adopted the BC Energy Step Code to provide incremental steps towards achieving energy efficient buildings and prepare the market for the goal of all net zero energy ready buildings by 2032. This Step Code surpasses the requirements of the current Code and allows communities to tailor more stringent energy efficiency measures to their communities' needs within the 2032 timeline.

There are three main levels of the BC Energy Step Code, and each requires different energy efficiency standards. The different metrics used to measure energy efficiency are EUI, TEDI, and Air Leakage Rate. Each level can have one or more steps attached, depending on the building type. Broadly, the different levels of the Step Code are illustrated in the graphic and listed below:

Step 1: The purpose of step 1 is to **familiarize builders with a new way of measuring energy efficiency**, with the actual construction remaining the same as conventional construction. This step requires builders to use a whole-building energy model to calculate the energy use and conduct an airtightness test.

Lower Steps (2, 3): Steps 2 and 3 builds on Step 1 by requiring modest gains in energy efficiency by using **conventional building designs that have careful air-sealing practices**. Designers and builders incrementally incorporate some key elements in the design, building envelope, and equipment and systems, but the building and design process stays the same. Builders and designers are advised to collaborate with the energy modeler to select the most cost-effective way to meet the requirements.

Upper Steps (3, 4, 5): These steps require increasingly more stringent energy efficiency measures. To achieve the Upper Steps, builders and designers need to adopt a more **integrated approach to building design** and may need to incorporate more substantial changes in building design, layout, framing techniques, system selection, and materials.

Source: BC Energy Step Code: A Best Practices Guide for Local Governments, British Columbia Energy Step Code Council and Building and Safety Standards Branch, 2017

11 California cities and counties with some level of energy element – mostly dedicated to energy efficiency for buildings. The lack of engagement makes it difficult to consider and integrate infrastructure improvements, from sewer and water to transportation networks, that may facilitate the development of a distributed energy resource network. There is an opportunity to incorporate guidelines for energy and DER within the State of California's General Plan and Specific Plan Guidance through OPR.

It is important for local governments to understand how a new multifamily program aligns with their current plans and policies. The Program should establish support resources for local governments to understand potential building code implications, to ensure alignment of other plans and policies, and to inform urban design and zoning guidelines for considerations such as parking, infrastructure, and community scale renewables or District Energy Systems.

There is also great opportunity to leverage SB 35 by having cities put in place objective design standards that align with the development of multifamily zero carbon buildings. If cities were able to do this, they would greatly increase the number of zero carbon multifamily buildings approved and built within their jurisdiction on a swift timeline.

Anti-Displacement

As new zero carbon buildings are being developed, it is important that these new buildings do not cause displacement of local low-income communities and communities of color– either in existing buildings undergoing renovations or in surrounding areas of new construction. The new multifamily construction program should include guidance for local governments to put in place anti-displacement policies. Additionally, the new multifamily program should consider earmarking funding for implementing relevant anti-displacement policies. See case study for more information.

Role of RENs and CCAs

RENs can work effectively with local jurisdictions and building departments to align codes and encourage building of zero carbon multifamily buildings. There is room to consider how RENs could fund programs or provide technical assistance to city staff on how to align city policies and State regulatory measures to promote construction of this housing.

Cities could then alter and adopt this policy template to fit their jurisdiction and facilitate the construction of zero carbon multifamily housing. Communications with local government staff should emphasize how this program aligns with local climate action plan goals.

For larger developments, CCAs could move elements of renewable energy infrastructure and possibly elements of advanced heap pump systems, such as ground loops or waste heat from sewers, off of developer budgets and into the costs of energy in the future, lowering development costs and improving affordability.

Case Study: Transformative Climate Communities Anti-Displacement Policies

The Transformative Climate Communities (TCC) Program, administered by the California Strategic Growth Council, "funds development and infrastructure projects that achieve major environmental, health, and economic benefits in California's most disadvantaged communities." Projects funded by TCC must include a Displacement Avoidance Plan detailing how applicants will avoid displacement of existing households and small businesses in project areas and conduct community engagement as part of that plan development. The Displacement Avoidance Plan must describe existing vulnerability among residents in the project area and choose from a list of short-term and long-term displacement policies. These can include:

Long term policies for production of affordable housing:

- Incentives for inclusionary zoning
- Density bonus ordinance
- Community land trusts
- Fee on new commercial or residential development that is dedicated to affordable housing
- Land banking programs
- Development of new accessory dwelling units (ADU)
- Neighborhood preference legislation that gives existing residents within a certain circumference preference for newly built affordable units
- Dedication of a certain percentage of a housing bond to building housing in the TCC Project Area
- Site acquisition and fee deferrals to develop 100% affordable housing
- Production of family-sized rental and ownership affordable units
- Allow affordable housing on a limited number of underutilized Production, Distribution and Repair (PDR) parcels with a ground floor requirement for PDR
- Housing bond to fund affordable unit development

Short term policies for preservation of existing affordable housing:

- Rent control, stabilization ordinances, and rent review boards
- No-net loss of affordable housing units / net gain of affordable units
- Preservation of existing affordable housing in the Project Area through the one-for-one redevelopment of distressed public housing; right-to-return policies for existing residents in good standing in redeveloped public housing; and commitment not to raise rents above pre-redevelopment levels for existing residents in redeveloped buildings
- Policies to preserve single-room occupancy and/or mobile home parks and to allow current residents in good standing to remain or return in the case of redevelopment*
- Condominium conversion restrictions
- Demonstration of application to local, state, and federal programs to fund preservation of affordable housing
- Preservation of affordable housing via acquisition and rehabilitation programs
- Covenants to maintain affordability in perpetuity
- Community land trusts
- Restrictions on short-term rentals and non-primary residences

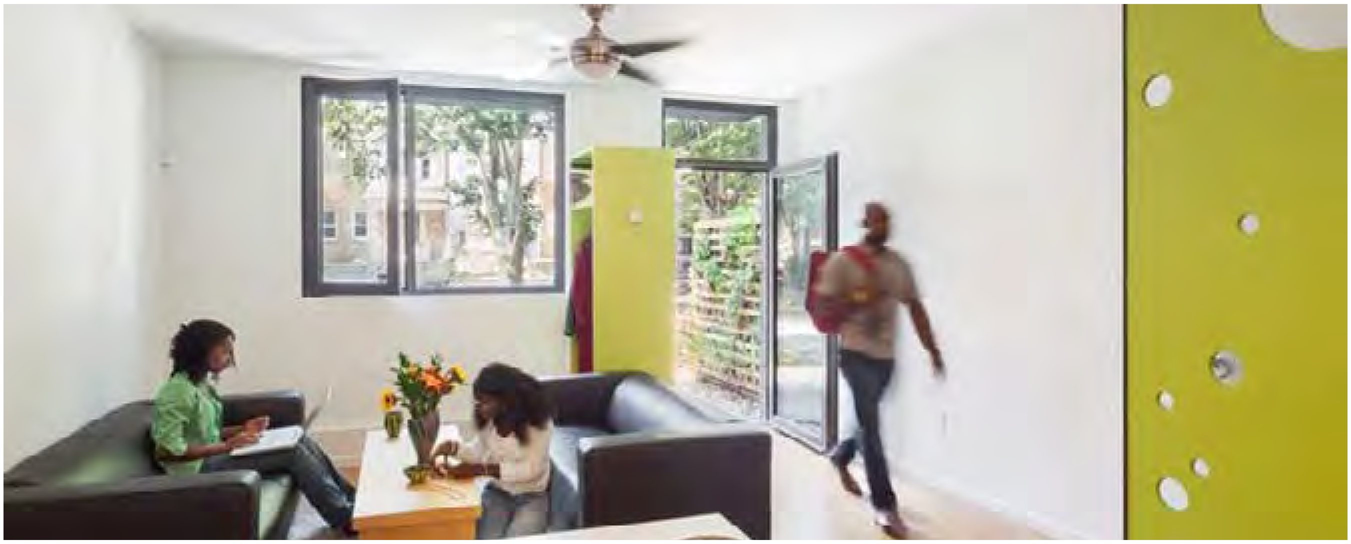
Goal 5. Recommended Roles and Responsibilities

Strategy	*Leads*	*Partners*
5.1 Coordiante and streamline funding policies, mechanisms, and programs	Local government, State	IOUs, RENs
5.2 Establish a path to zero carbon codes for multifamily buildings	RENs, Statewide C&S	Local Government Reach Codes
5.3 Enable local government planning and building departments to support zero carbon buildings and related efforts.	Local Govern-ment,RENs, CCAs	Air Quality Districts, LGC

Success Indicators

- **A statewide working group is created to help coordinate and align affordable housing financing and policy.**
- **An increasing number of local governments adopt reach codes that require increasingly stringent levels of energy efficiency requirements, aligned with zero carbon goals.**
- **Guidance documents and resources are created for local governments and building departments.**
- **Cities adopt best practices guidelines for planning, zoning, and codes and standards.**
- **RENs and participating CCAs expand multifamily programs to support zero carbon multi-family buildings - new and major renovations.**

4. Implementation



4. Implementation

Overview

The MZCAP provides a holistic set of ideas, strategies, and priorities to enable stakeholders, agencies and local jurisdictions to move forward to a common goal to establish a **Zero Carbon Multifamily market**. While ideally this effort is aligned and coordinated at local, regional, and state levels, it can also be a tool for individual and organizational action and advocacy. The success of the MZCAP depends upon the efforts and advocacy of a variety of key actors. A combination of state and regional agencies, organizations, and local government actors should help to advocate for, support and align the implementation of the Plan.

As in most new concepts, it is anticipated that there will be a phased adoption of the strategies presented in this Plan, with early adoption by developers and owners who are dedicated to the highest level of green building and spurred by requirements of all-electric ordinances. Those early adopters, similar to the adoption of Zero Net Energy Single Family homes in California (which led to the 2020 Code adoption of solar for all new homes), will demonstrate the feasibility of Zero Carbon buildings, illustrate best practices, and encourage new technologies to support a broader market. Ultimately, supporting these early adopters will help to move the market and capture broad engagement by the majority of builders and developers (see Figure 2 New Technologies Adoption Curve). It is critical that this stepwise process occur in a logical and well supported fashion to help **prove the concept on the ground and reduce real and perceived risks by the market.**

While the Plan was initiated by CPUC Energy Division staff, there is a recognition that they can only influence a portion of the actions required to implement the plan. Engagement by the full range of actors detailed in the Plan is required to achieve its aggressive goals.

Milestones

The following page provides an initial set of milestones that will lead to an ultimate target of a **zero carbon energy code in 2034** and is a guide for stakeholders to help implement the plan. The numbers adjacent to the action align to the Plan goal.

MZCAP Path to Code & Implementation

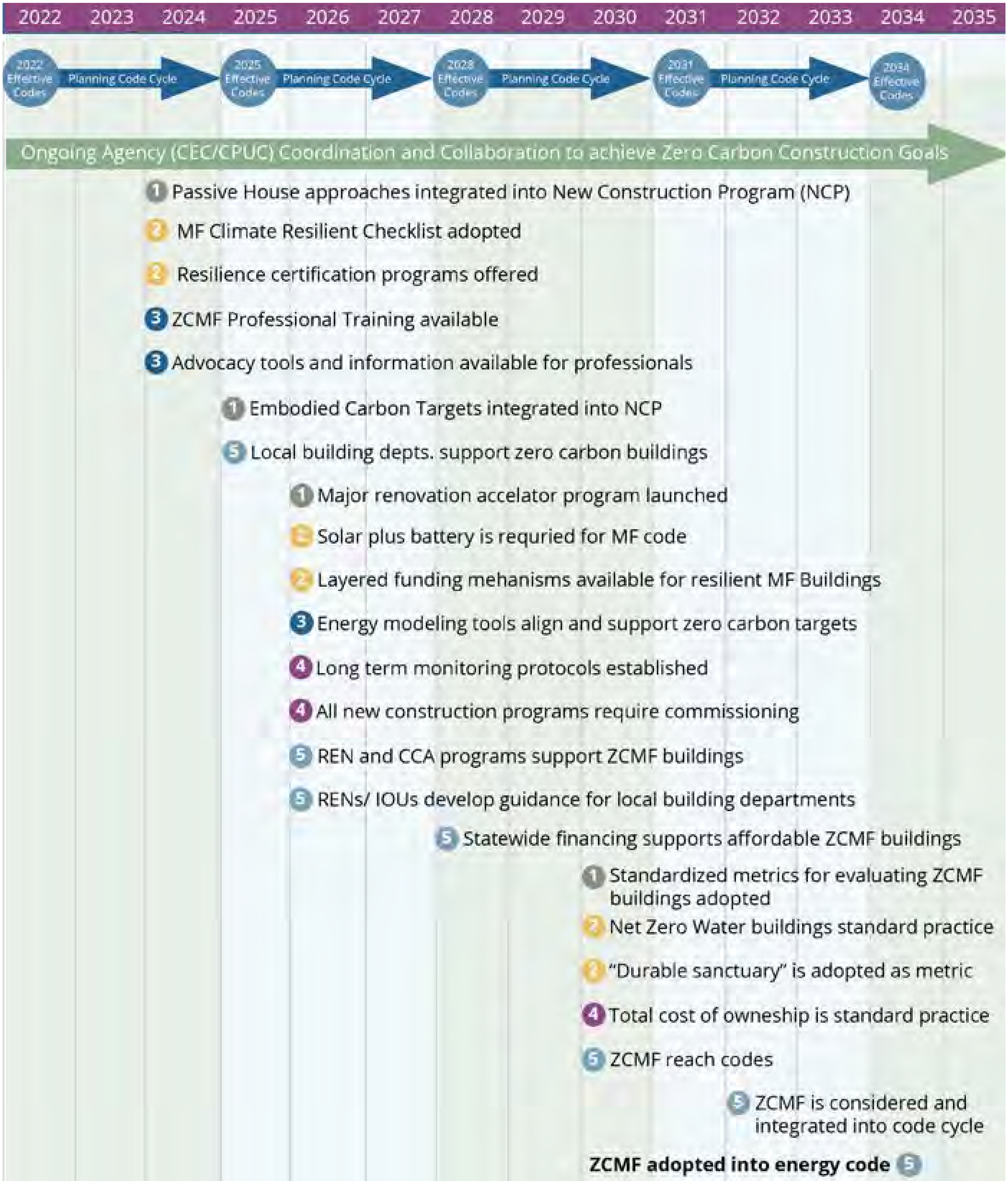
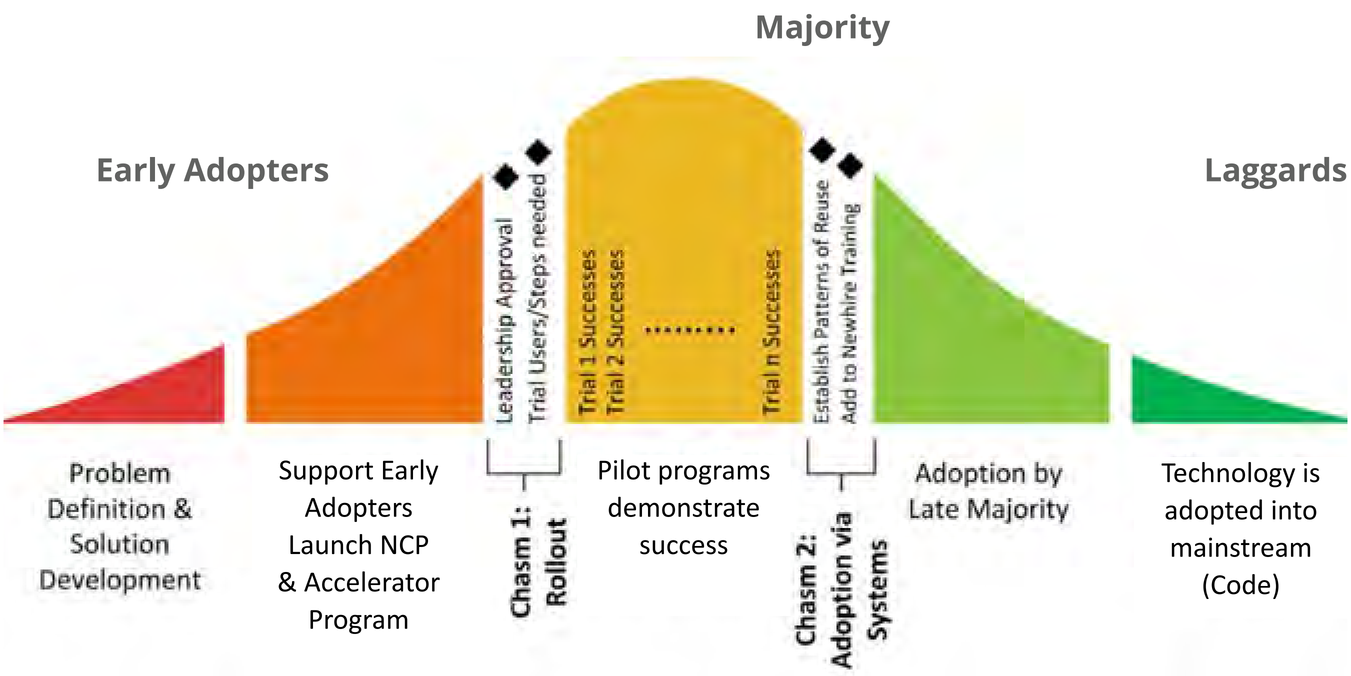


Figure 21. New Technologies Adoption Curve



Source: Adapted from Chris Harden, 2019, https://chrisharden.com/index.php/2019/10/11/the-initiative-adoption-curve/

Near Term Activities

Highlighted below are near-term efforts – from 2024-2027– needed to lay critical groundwork for the transition to zero carbon multifamily construction.

New Construction Program

Many of the Plan strategies encourage the New Construction Program to integrate new approaches, requirements, and technical assistance to assist these early adopters. The CPUC, along with RENs, CCAs, and the CAEECC, can help move this plan forward by working with PG & E and future third party providers to reshape the program to meet Zero Carbon goals.

Major Renovation Accelerator Program

The Major Renovation Accelerator Program will require significant efforts to develop and launch, and there are multiple stakeholders that can aid in this effort. There is room for CCAs and RENs to work closely with the Statewide program team to help design and advocate for it. Additionally, the Association for Energy Affordability, which administers low-income weatherization upgrades in California, can use this Plan as a guide for designing and potentially expanding their low-income programs to align with the Goals of the Plan.

Energy Modeling Tools

Energy Modeling Tools will need to align with zero carbon goals to enable this Plan's success. Architects and their organizations (AIA, APA, PHIUS) can advocate and work with the CEC to align energy modeling tools to support zero carbon compliance pathways.

Training and Education

One of the largest areas for early engagement and action is in the training and education area - Goal 3. The IOU WE&T program, as well as the RENs will play an important role in this effort to reach developers and designers with zero carbon design trainings. Further, the professional organizations such as AIA, APA, ULI can help to take their members to a higher level of understanding by developing and providing this training.

Resilient Buildings

Ensuring that multifamily buildings are resilient is a critical piece of this Plan, and developers and designers have a large role to play in preparing and moving the market towards resilient construction. Developers and designers can use this Plan as a guide in their decision to install battery storage to all multifamily projects, including low-rise multifamily buildings, which currently does not have battery storage requirements. Additionally, they can utilize the principles in the Climate Resilience Checklist when designing their projects and ensure their buildings meet the criteria of building resilience certification programs (WELL Building and Community Standard, Living Building Standard, RESCAPE Rated Landscape, and LEED ND). Notably, these actors can also advocate within their organizations (AIA, APA, etc.) to use these standards.

Funding

One of the largest barriers discussed to achieve affordable housing goals is the difficulty in layering affordable housing funding mechanisms together. The challenge of developing even more complex projects is somewhat daunting. Stakeholders should look at developing a statewide working group that can help to understand synergies in the many funding mechanisms and identify areas for streamlining them (Goal 5). Further, this working group can help to identify and secure new funding as it becomes available from the federal government and state for climate related infrastructure and housing investments.

Glossary

Building Envelope: The building envelope refers to the separation between the interior and exterior of a building. Key components of the building envelope include windows, doors, foundation, roof, siding, and insulation.

Demand response: Energy loads capable of being reduced, deferred, or curtailed in response to signals regarding such conditions as energy prices or system constraints.

Disadvantaged Community (DAC): CalEPA has defined disadvantaged communities as the populations that comprise the top 25% scoring areas from CalEnviroScreen, which measures pollution burden and social vulnerability.

Durable Sanctuary: A home or building that ensures a safe and healthy living space for its occupants both every day and during extreme weather events and emergencies.

Embodied Carbon: The cumulative emissions that result from the production of building materials.

Energy Use Intensity (EUI): EUI provides a standard measurement for the amount of energy that is used on a per square footage basis. This “energy intensity” changes with the number and kind of building users –or intensity of use. EUI is calculated by dividing the total energy consumed by a building in one year (measured in kBtu) by the total gross floor area of the building.

Grid-friendly: The term refers to a project that enhances and is an asset to the operation of the electrical grid.

Integrated Design Process (IDP): An Integrated Design Process refers to a holistic approach to building design in which designers collaborate with contractors throughout the entire design phase, and heavily consult them through the construction phase. With this process, different design elements, which are usually treated separately, are thought of holistically to optimize energy use.

Loading Order: The order in which utilities must prioritize electricity sources to meet customer demand. The current loading order requires utilities to first employ energy efficiency and conservation measures, then use renewables, and lastly, fossil fuels.

Major Renovations: The following major renovation construction practices, as listed in the California Green Building Code, are treated as new construction in the Code and should be subject to the requirements of the New Construction Program: “additions, alterations or repairs where more than 50% of all existing wall of an existing structure, measured in lineal feet, are demolished or deconstructed or where there are additions exceeding 50% of the existing floor area, or any combination of the two cumulatively exceeding 50%, building additions of 1,000 square feet or greater, and/or building alterations with a permit valuation of $200,00 or above, it is considered new construction and shall comply with Tier 1 level requirements.”

Microgrid: A small energy system capable of balancing captive supply and demand resources to maintain stable service within a defined boundary. There is no universally accepted minimum or maximum size for a microgrid.

Glossary

Operational Carbon: Carbon resulting from energy use throughout the lifecycle of the building.

Passive House - “Passive House is a building standard that relies on a combination of energy efficiency with passive solar and internal heat gains to dramatically reduce space heating demands and allow for simplified methods of providing needed heat. The concept is implemented through stringent performance standards for airtightness and energy consumption” (New York Passive House).

Program Administrator (PA): Refers to companies or organizations who receive ratepayer funding for energy efficiency programs via the CPUC, including the four investor-owned utilities (IOUs), regional energy network (REN), or community choice aggregation (CCA).

Resilience: “Resilience of the energy sector refers to the capacity of the energy system or its components to cope with a hazardous event or trend, responding in ways that maintain their essential function, identity, and structure while also maintaining the capacity for adaptation, learning and transformation.” (International Energy Association (IEA))

Thermal Bridging - The transfer of heat between conductive building materials such as studs and beams.

Endnotes

1 California Air Resources Board. (2020, November 19). California Indoor Air Quality Program Update [Resolution 20-32]. https://ww2.arb.ca.gov/sites/default/files/barcu/board/res/2020/res20-32.pdf

2 TRC, "Multifamily Restructuring," 2022 Title 24, Part 6 Final CASE Report.

3 S. Armstrong (personal communication, April 2022)

4 The California Green Building Code's (CALGreen) current definition for major renovations is "50 percent or more of the exterior weight bearing walls are removed or demolished."

5 Golden, S. (2021, August 13). California just took a huge step towards building electrification. Greenbiz. Retrieved September 20, 2021, from https://www.greenbiz.com/article/california-just-took-huge-step-towards-building-electrification.

6 Redwood Energy, et. al, A Zero Emissions All-Electric Multifamily Construction Guide, 2019.

7 "Achieving Carbon Neutrality in California", PATHWAYS Scenarios Developed for the California Air Resources Board, October 2020, page 8.

8 Rick Winch, Ellen Steiner, Ph.D., and Jen Loomis, Ph.D., Opinion Dynamics, "Barriers to Incorporating Passive House Concepts in Residential New Construction," December 11, 2019.

9 ACEEE Topic Brief, "Understanding Multifamily Home Energy Efficiency Potential", October 2020.

10 Hopkins, A. S. (2018, October 16). Decarbonization of heating energy use in California buildings - new report! Decarbonization of Heating Energy Use in California Buildings - New Report! Synapse Energy. Retrieved September 2, 2021, from https://www.synapse-energy.com/about-us/blog/decarbonization-heating-energy-use-california-buildings-new-report

11 Naomi W. July 2018. Natural Gas Methane Leakage and the Potential of Renewable Natural Gas [PowerPoint slides] Redwood Energy's ZNE Conference https://www.youtube.com/watch?v=3tcBhaoL7U-o&t=736s

12 US Interagency Council on Homelessness California Homelessness Statistics. USICH. (n.d.). https://www.usich.gov/homelessness-statistics/ca.

13 Mazzella, Danielle and Lindsay Rosenfeld. California Housing Partnership. (2020). California Affordable Housing Needs Report. https://chpc.net/resources/2020-statewide-housing-needs-report/.

14 Building Decarbonization Coalition, "A Roadmap to decarbonize California Buildings," December 12, 2019, Page 3.

15 Redwood Energy, et. al, A Zero Emissions All-Electric Multifamily Construction Guide, 2019.

16 CEC, "California Building Decarbonization Assessment," August 13, 2021, page 36-37.

17 Greenbuild. (2021). Carbon in Buildings: Material Embodied vs. Operations Generated [white-paper].

18 [Schnieders/Feist 2001] Schnieders, Jürgen; Feist, Wolfgang; Pfluger, Rainer; Kah, Oliver: CEPHEUS - Scientific Analysis, Final Report, Project Information Nr. 22, 1. edition, Passive House Institute, 2001.

19 PHIUS. (n.d.). Phius+ certification overview. Project Certification Overview: Passive House Institute U.S. Retrieved September 15, 2021, from https://www.phius.org/phius-certification-for-buildings-products/project-certification/overview.

20 PHIUS. https://www.phius.org/about/mission-history, Accessed September 29, 2021.

21 U.S. EIA (2021) Annual Energy Outlook 2021.

22 Micah Sweeney, Jeff Dols, Brian Fortenbery, and Frank Sharp. 2014. Induction Cooking Technology Design and Assessment. Electric Power Research Institute. https://www.aceee.org/files/proceedings/2014/data/papers/9-702.pdf.

Endnotes

23 Palmgren, Claire, et al. California Energy Commission. “2019 California Residential Appliance Saturation Study.” (2019) https://www.energy.ca.gov/sites/default/files/2021-08/CEC-200-2021-005-PO.pdf.

24 https://www.alliedmarketresearch.com/household-induction-cooktops-market, Accessed 10/16/2021.

25 Bendt, Paul. (2010.) ACEEE. “Are we Missing Energy Savings in Clothes Dryers?” https://www.aceee.org/files/proceedings/2010/data/papers/2206.pdf

26 Energy Star, (n.d.) “Heat Pump Dryers.” https://www.energystar.gov/products/heat_pump_dryer.

27 Current CPUC budgeting and policy requirements that bifurcate energy efficiency and DERs needs to be eliminated so that buildings can be incentivized appropriately to meet State goals.

28 Greenbuild (2021) Carbon in Buildings: Material Embodied vs. Operations Generated [whitepaper].

29 Leigh, G. (2021, July 30). Wooden Buildings Reach for the Sky. New York Times. https://www.nytimes.com/2021/07/30/todaysinyt/wooden-buildings-reach-for-the-sky-in-vaxjo-sweden.html?referringSource=articleShare.

30 Priopta Innovations Inc. (n.d.). Example Results- Whole Building LCA. Priopta. Retrieved September 24, 2021, from https://www.priopta.com/

31 Greenbuild (2021) Carbon in Buildings: Material Embodied vs. Operations Generated [whitepaper].

32 Leigh, G. (2021, July 30). Wooden Buildings Reach for the Sky. New York Times. https://www.nytimes.com/2021/07/30/todaysinyt/wooden-buildings-reach-for-the-sky-in-vaxjo-sweden.html?referringSource=articleShare.

33 TRC, “Multifamily Restructuring,” 2022 Title 24, Part 6 Final CASE Report.

34 California Energy Commission, “SB 350 Low-Income Barriers Study, Part A - Commission Final Report,” 12/15/2016, page 13.

35 California Energy Commission, “SB 350 Low-Income Barriers Study, Part A - Commission Final Report,” December 16, 2016, pages A-1-A6.

36 Yerrapotu, Amulya. “California Families Need More Utility Debt Relief.” (2022). Cal Matters. https://calmatters.org/commentary/2022/02/california-families-need-more-utility-debt-relief/

37 CEC, “2019 Integrated Energy Policy Report,” June, 2020, page 207.

38 First Tuesday Editorial Staff. (2020, August 12). The slowing trend in California construction starts. First Tuesday Journal. https://journal.firsttuesday.us/the-rising-trend-in-california-construction-starts/17939/

39 https://www.cnn.com/2021/10/14/us/california-summer-drought-worst-on-record/index.html, Accessed 10/16/2021.

40 University of California, Berkeley. California’s Fourth Climate Change Assessment. (2018), page 7.

41 Petek, G. (2020, August 10). What threat does sea-level rise pose to California? Retrieved October 5, 2021, from https://lao.ca.gov/Publications/Report/4261.

42 EPA. (n.d.) Heat Island Effect. Retrieved October 5, 2021 from https://www.epa.gov/heatislands

43 Whale, L. (2016). (rep.). Thermal Bridging Guide. Zero Carbon Hub/ C4Ci. Retrieved September 15, 2021, from https://www.zerocarbonhub.org/sites/default/files/resources/reports/ZCH-ThermalBridging-Guide-Screen_0.pdf.

44 Moody’s, “Implementing Net Zero In Commercial Real Estate,” September 2021, page 4.

45 National Institute of Building Sciences. 2017. Natural Hazard Mitigation Saves: 2017 Interim Report. https://www.fema.gov/sites/default/files/2020-07/fema_ms2_interim_report_2017.pdf.

46 California Community Choice Association. (2021). CalCCA. https://cal-cca.org/

47 California Air Resources Board, “California Air Districts,” 2022, State of California https://ww2.arb.ca.gov/california-air-districts.

48 RMI, "Decarbonizing Homes: Improving Health in Low-Income Communities through Beneficial Electrification," October 2021, page 7.

49 Sokol, M. (2016). SB 350 Low-Income Barriers Study Draft Recommendations. California Energy Commission.

50 TRC, (2021, September 27). Statewide Residential New Construction Program, California Energy-Smart Homes All Electric Residential Program Implementation Plan [PowerPoint slides]

51 California Energy Commission, "New data shows nearly two-thirds of California's electricity came from carbon-free sources in 2019." July 16, 2020. https://www.energy.ca.gov/news/2020-07/new-data-shows-nearly-two-thirds-californias-electricity-came-carbon-free

52 Passive House Institute. Passive House Standard- A Proven Energy Saver

53 Mann, Steve (2021). "Reaching for a Passive House Code: California's Nascent Adoption Journey." Passive House Accelerator. https://passivehouseaccelerator.com/articles/reaching-for-a-passive-house-code-californias-nascent-adoption-journey

54 Flax, Brian. Thermal Bridging: What It Is and Why You Should Avoid It. Kore. 2016. https://www.kore-system.com/thermal-bridging-what-it-is-why-you-should-avoid-it/

55 Micah Sweeney, Jeff Dols, Brian Fortenbery, and Frank Sharp. 2014. Induction Cooking Technology Design and Assessment. Electric Power Research Institute. https://www.aceee.org/files/proceedings/2014/data/papers/9-702.pdf

56 Langner, Rois, Paul A. Torcellini, Matt Dahlhausen, David Goldwasser, Joe Robertson, and Sarah B. Zaleski. 2020. Transforming New Multifamily Construction to Zero: Strategies for Implementing Energy Targets and Design Pathways: Preprint. Golden, CO: National Renewable Energy Laboratory. NREL/CP-5500-77013. https://www.nrel.gov/docs/fy20osti/77013.pdf

57 California Energy Commission. (2021). California Building Decarbonization Assessment. https://www.energy.ca.gov/publications/2021/california-building-decarbonization-assessment

58 van Gerwen R.J.M., Verwoerd M. (2000) Emission reduction of non-CO2 greenhouse gases used as refrigerant. In: van Ham J., Baede A.P.M., Meyer L.A., Ybema R. (eds) Non-CO2 Greenhouse Gases: Scientific Understanding, Control and Implementation. Springer, Dordrecht. https://doi.org/10.1007/978-94-015-9343-4_60

59 Nath, P., Sarker, P. K., & Biswas, W. K. (2018). Effect of fly ash on the service life, carbon footprint and embodied energy of high strength concrete in the marine environment. Energy and Buildings, 158, 1694–1702. https://doi.org/https://doi.org/10.1016/j.enbuild.2017.12.011

60 Leigh, G. (2021, July 30). Wooden Buildings Reach for the Sky. New York Times. https://www.nytimes.com/2021/07/30/todaysinyt/wooden-buildings-reach-for-the-sky-in-vaxjo-sweden.html?referringSource=articleShare.

61 A good starting point may be the new report released by Stopwaste and AEA laying out the steps to effectively electrify existing buildings. ("Accelerating Electrification of California's Multifamily Buildings: Policy Considerations and Technical Guidelines," May 2021)

62 The most current certification criteria can be found at passivehouseinternational.org.

63 International Passive House Association. (n.d.) "Passive House certification criteria." Passivehouse international, https://passivehouse-international.org/index.php?page_id=150

64 Perry, F. Noel, Colleen Kredell, Marcia E. Perry, and Stephanie Leonard. 2021. The Future of California's Water-Energy Climate Nexus. Next 10. https://www.next10.org/sites/default/files/2021-09/Next10-Water-Energy-Report_v2.pdf

Endnotes

65 Ayyagari, Sneha, Michael Gartman and Jacob Corvidae. 2020. Hours of Safety in Cold Weather: A Framework for Considering Resilience in Building Envelope Design and Construction. Rocky Mountain Institute. https://rmi.org/wp-content/uploads/2020/02/Hours-of-Safety-insight-brief.pdf

66 U.S. Department of Health and Human Services. “Community Resilience” (2015). https://www.phe.gov/Preparedness/planning/abc/Pages/community-resilience.aspx

67 CPUC decision 20-08-046, directs IOUs to complete a Community Vulnerability Assessment focused on the climate risks to IOU operations, services, and assets, including leading a community engagement process with underserved and disadvantaged communities to inform the plans about the lived-experience of the communities and their particular needs.

68 Note that policy needs to catch up to this opportunity and enable these systems and controls to more easily operate independent of the grid. Rulings around “Rule 21” and smart invertors are moving forward and will ultimately create a workable framework to allow cost-effective integration of DERs and grid-connected renewables and storage.

69 Battery Storage in the United States: An Update on Market Trends. EIA. (2021, August 16). Retrieved September 24, 2021, from https://www.eia.gov/analysis/studies/electricity/batterystorage/

70 Office Energy Efficiency & Renewable Energy, U.S. Department of Energy. (n.d.). Net Zero Water Building Strategies. https://www.energy.gov/eere/femp/net-zero-water-building-strategies

71 Poel, Bart. 2014. Integrated Design with a Focus on Energy Aspects. https://www.aceee.org/files/proceedings/2004/data/papers/SS04_Panel9_Paper11.pdf.

72 Barry, Bronwyn, NAPHN. (personal communication March 2022)

73 Architecture 2030 has just created the new Zero Code energy calculator to help design via a prescriptive or performance approach to Zero Carbon buildings