Multifamily Zero Carbon Action Plan

CPUC

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Developed by: BluePoint Planning

Table of Contents

List of Acronyms ... iii

List of Figures and Charts ... iv

EXECUTIVE SUMMARY ... 1

Building Decarbonization ... 2

Dedicated Multifamily Building Code ... 2

Equity ... 3

MZCAP Desired Outcomes ... 3

A Holistic & Integrated Plan ... 4

1. INTRODUCTION AND OVERVIEW ... 6

Background ... 6

Planning Process and Stakeholder Engagement ... 7

Plan Purpose ... 8

Path to Decarbonization ... 9

2022 Code Changes ... 13

2. PLAN CONTEXT: MARKET & POLICY ... 14

Types of Multifamily Housing ... 14

Multiple Market Actors ... 15

Housing Market Changes ... 15

Equity and Affordable Housing ... 17

Climate change ... 18

New Financial Realities ... 19

Technical Feasibility for Zero Carbon Multifamily Buildings ... 20

State Policy and Goals ... 22

3. STRATEGIC FRAMEWORK ... 24

Goal 1. Optimize Multifamily Buildings as a System ... 26

Goal 2: Ensure Climate Resilient Multifamily Projects ... 37

Goal 3: Establish Targeted Professional Training and Education ... 48

Goal 4. Foster Low Carbon Operations ... 55

Goal 5: Support Financing, Planning, and Policies ... 59

GLOSSARY ... 68

ENDNOTES ... 70

List of 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
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)
TCAC	Tax Credit Allocation Committee
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

List of Figures and Charts

Figure 1. Multifamily Zero Carbon Action Plan Vision and Goals 4
Figure 2: Stakeholder Survey Results on Priorities for the New Residential Construction Program 7
Figure 3: Sources of GHG Emissions and Potential 2030 Emissions 9
Figure 4. Shares of Residential Gas Use by End Use 10
Figure 5: Capital Costs per Unit of Appliance and Infrastructure for New Construction. 11
Figure 6: Multifamily vs Single family Permits Issued in California Between 2002-2021 16
Figure 7: Home Ownership by Population (2016) 17
Figure 8: Moody's Analytics Climate-Adjusted Financial and Credit Impact Analysis Steps 19
Figure 9: Basic Elements of Passive House Design 20
Figure 10: Multifamily Energy Use Intensity Targets by Climate Zone 21
Figure 11: Relevant Stakeholders in the Multifamily New Construction Program and Their Roles 22
Figure 12. Multifamily Zero Carbon Action Plan Framework 25
Figure 13: Zero Carbon Building Construction Process Overview 28
Figure 14: Alternative Refrigerants for Heat Pump Technology with Low-GWP. 30
Figure 15: Life Cycle Assessment (LCA) of Embodied Carbon of Building Materials in a Typical Office Building, as a Percentage of Total Embodied Carbon 32
Figure 16: EUI Targets for High--, Medium-, and Low-Density Buildings Based on Global Climate Zones 33
Figure 17: Sample from Boston Resilience Checklist 40
Figure 18: 5th Generation DES Heat Flow Diagram 45
Figure 19: Temperature of Heating Systems vs Energy Efficiency Over Time 45
Figure 20: Developing an Integrated Team for a High-Performing Project 49
Figure 21: Presenting the Long-Term Cost Benefit of High-Performing Projects 50
Figure 22: Passive House Affordable Housing Proposals and Costs 62
Figure 23: BC Energy Code Levels for Building Type 64

Executive Summary

The Multifamily Zero Carbon Action Plan (MZCAP) endeavors to push building energy efficiency levels to the lowest level possible for new and renovated multifamily buildings by incorporating cutting edge technologies and techniques that achieve zero carbon. It is focused on informing the 2025 code cycle and the adoption of zero carbon building codes in alignment with the State, stakeholders, and leading organizations such as the Building Decarbonization Coalition. The MZCAP focuses on Passive House approaches to drive energy efficiency and electrification to achieve zero carbon emissions in multifamily building design, construction, and operation. The MZCAP encourages creating multifamily projects that are climate resilient, affordable, and provide a durable sanctuary for residents during a loss of power or extreme weather event. Energy efficiency alone is not sufficient to meet the increased urgency of climate change, equity, and adaptation; multifamily developments require a substantial overhaul to a holistic and integrated design approach.

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.[1] 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 standards. In 2008, the California Public Utilities Commission (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), 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.

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."[1]

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. 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.[2]

In the past two 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.

As California phases out natural gas and brings more solar-powered electricity onto the energy grid, energy efficiency is becoming a more salient part of energy planning and a tool to manage 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." This inconsistency in loads can shock the energy grid as power sources go offline and other fossil fuel sources need to come online quickly. 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 in the case of extreme weather events and power outages.

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." [3]

The newest code cycle beginning in 2023 has a number of 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 2023 code unites the standards into a new multifamily chapter to help streamline and highlight the important issues that are unique to multifamily buildings.[4]

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[5]. (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 2025 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 as well as market-rate projects.

Equity

Multifamily buildings, more than any other building type, serves low-income communities, typically renters. Affordable housing policies, disproportionate climate impacts, utility bill burden, 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, 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 have a clear segment of the energy efficiency portfolio focused on equity is critical and an opportunity to break down persistent barriers.

MZCAP Desired Outcomes

The implementation of the five goals 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, onsite generation and storage.
- Support and drive future code cycles by demonstrating the opportunity and feasibility of deeper efficiency through Passive House and integrated approaches.
- Increase the availability and access to affordable, 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.

A Holistic & Integrated Plan

The MZCAP's vision is to have all multifamily buildings be zero carbon by 2035, 10 years before the State's overall carbon neutrality goal. Stakeholders and current practices indicate that 2035 is technically feasible and attainable. 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.

Figure 1. Multifamily Zero Carbon Action Plan Vision and Goals

Case Study

Ice Box Challenge: Passive House Capabilities Demonstrated

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 Melbourne. In the Ice Box Challenge, two large boxes – one constructed following the State's 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 held similar findings 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.

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

1. Introduction and Overview

"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."[6]

Background

The MZCAP aims to transform the multifamily new and major renovation market to be **zero carbon by 2035, and to be climate resilient, resulting in affordable, healthy, and comfortable homes for residents.** The Plan 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 over the past year. The planning process assessed the major continuing barriers and developed a set of key market and policy strategies to ensure the multifamily building sector is aligned with the State's goal of achieving carbon neutrality by 2045.

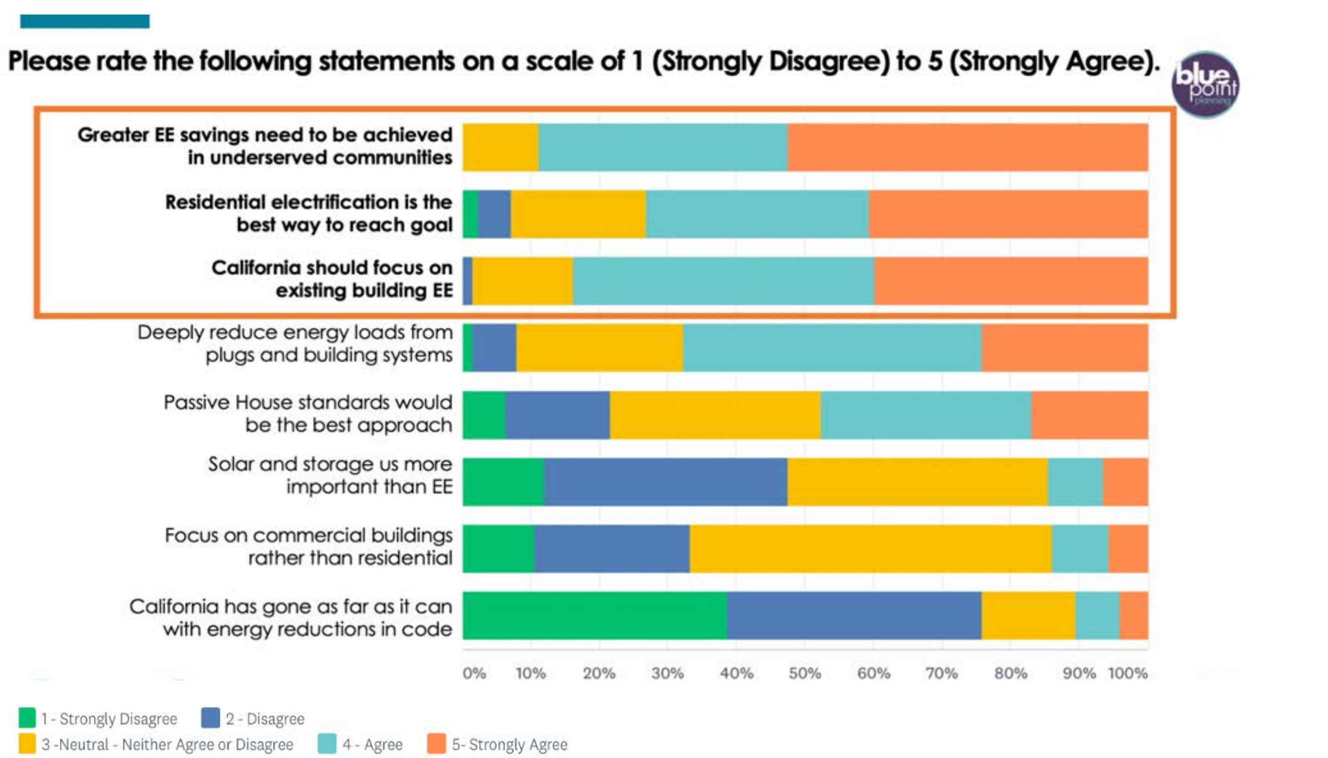
California has led the country in the development of energy efficient buildings since the statewide 1974 enactment of building energy codes and standards. In 2008, the CPUC adopted the California Long-Term Energy Efficiency Strategic Plan (CAEESP), which included aggressive goals for deep energy efficiency 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. 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.

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 2021. In 2019, Opinion Dynamics completed a white paper, "Barriers to Incorporating Passive House Concepts in Residential New Construction,"[7] which helped to inform this work and focus the Plan on multifamily buildings. Many of the barriers identified focused on developing a Passive House code for single family homes. Based on those barriers and substantial input from stakeholders, the MZCAP focuses on multifamily buildings, which have demonstrated stronger feasibility to incorporate Passive House approaches and represent a substantial solution to help address the housing crisis.

Figure 2: Stakeholder Survey Results on Priorities for the New Residential Construction Program



A survey was sent to stakeholders to assess the needs and opportunities for the future New Residential Construction Program. Figure 2 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 (PH) 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 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."

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, it is prioritizing denser housing in cities. Emissions from the building sector represented 25% of California's emissions in 2016, with 12% coming from residential buildings (includes emissions generated from electricity and emissions produced on site), [8] while 40% of the State's GHG emissions come from the transportation sector. Reducing emissions from the residential sector while prioritizing higher density development that encourages use of public transportation and active transportation 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.[9] 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.[10]

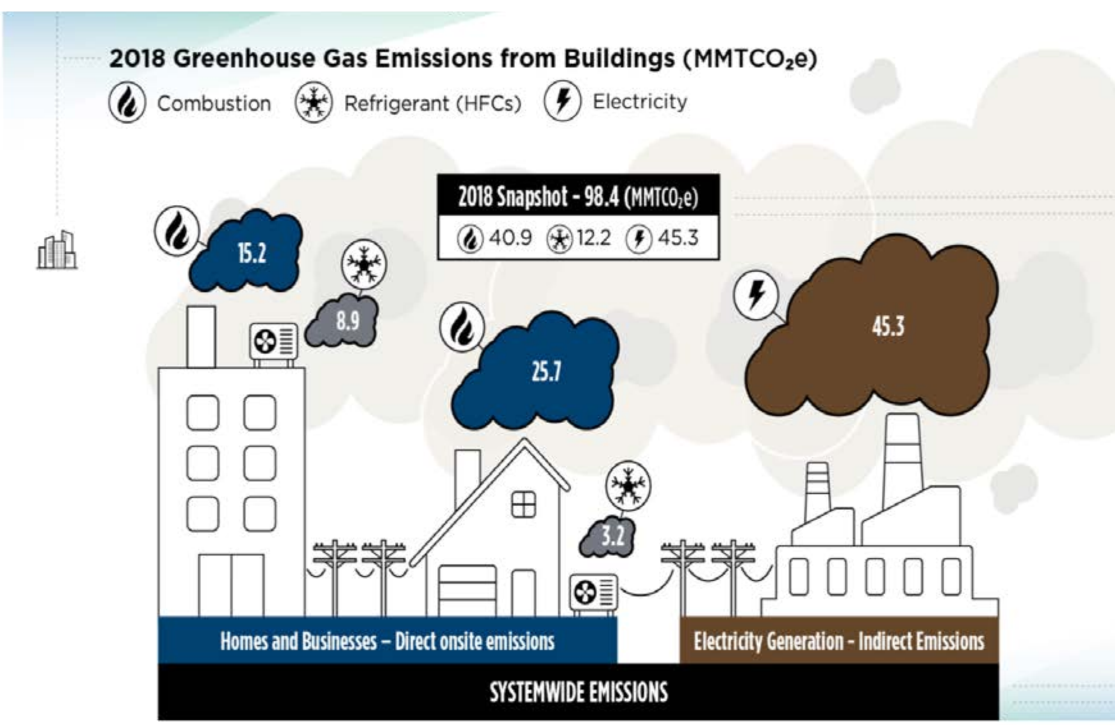
California's housing crisis has a wide range of complex issues which have led to the situation facing communities today. The MZCAP is focusing on one piece of the puzzle – helping to make sure that new multifamily housing is climate-ready and able to achieve low carbon emissions. Other issues related 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.[11]"

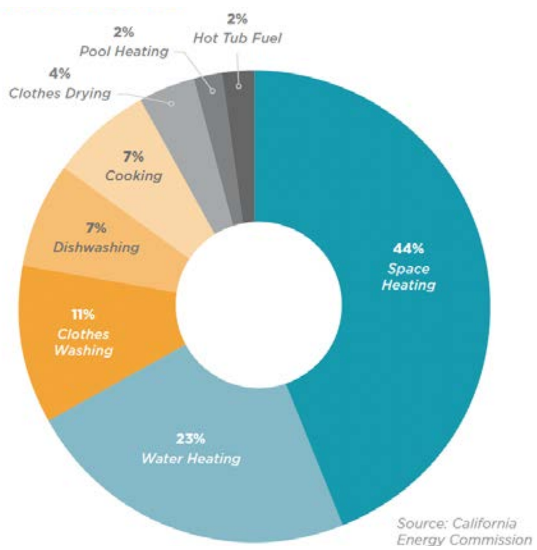
As the State moves to a 100% renewable energy system, all-electric buildings with low carbon emissions that support community resilience are the logical next step. Reaching zero carbon means tackling the major sources of emissions in buildings in California: natural gas, refrigerants, and embodied carbon 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, and improved safety.[12]

Figure 3: Sources of GHG Emissions and Potential 2030 Emissions



Source: California Energy Commission, Building Decarbonization Assessment

Figure 4. Shares of Residential Gas Use by End Use



Source: Roadmap to Decarbonize California Buildings

In California, multifamily buildings emissions are typically higher from water heating than space heating with a large percentage of energy use derived from plug loads. "Behind-the-meter gas leakage" is also a major source of GHG emissions and a problem for indoor air quality and occupant health. HFC or hydrofluorocarbon are widely used in air conditioning, heat pump water heaters, and refrigerators and represent a major 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.[13]

The following are the essential elements to help move towards decarbonization of the multifamily sector.

Deep Energy Efficiency

The first element is ensuring that new and renovated multifamily buildings substantially reduce demand for energy through deep energy efficiency – much more than required by codes today. One approach to do this is to integrate PH strategies. PH building design "limits emissions by reducing the energy loads of a building through intentional, non-mechanical design strategies,"[14] 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 standard construction counterparts. The Passive House model has been around for over 40 years and can be applied to all building types – including multifamily 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.[15] Today, there are more than 100 multifamily Passive House buildings in the United States equaling more than 2.7 million square feet.[16] 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 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.

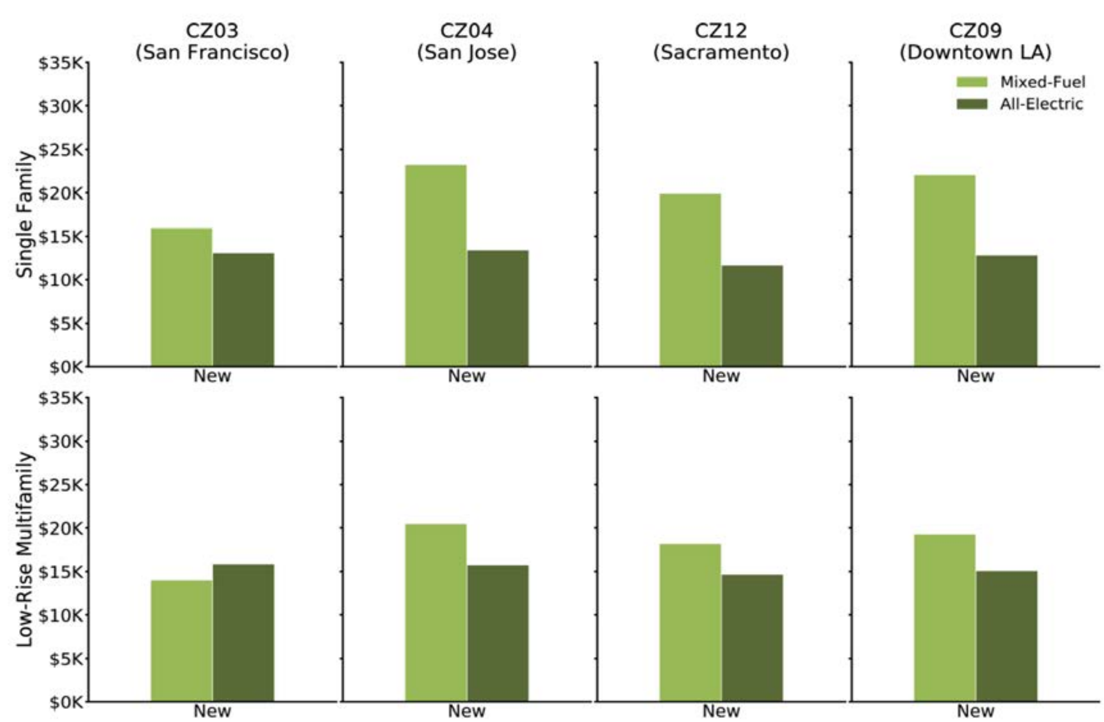
Induction cooktops are more efficient than traditional electric stoves, operating at 90% efficiency compared to 70% efficiency for electric stoves and 40% for gas stoves.[17] Electric and induction stovetops also improve indoor air quality by reducing indoor air pollutants generated from the combustion 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.[18]

Electric washers and dryers are already common. Electric washers and dryers are not more energy efficient than their gas counterparts, but they are a good alternative to gas when creating an all-electric home.

Onsite Renewables and Battery Storage

The MZCAP is primarily designed to address building energy efficiency and not renewable generation and energy storage. However, 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.[19] Deep energy efficiency helps to reduce the requirements for additional generation and keep solar/battery systems at size that is more cost

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.

effective and feasible. For high-rise multifamily, 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.

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 particular times to assist grid operators balance loads at peak use times. 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.[20] 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.[21] [22] Business-as-usual projections estimate that embodied carbon and operational carbon will be equal by 2050 globally as energy efficiency improves.[23]

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.[24] The practice is popular in many Nordic countries and continuing to gain traction in the U.S. Timber framing is particularly beneficial when forests are responsibly managed, as wood can act as a renewable, carbon-sequestering building material.

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.

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." [25]

The newest code cycle beginning in 2023 has a number of 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 2023 code unites the standards into a new multifamily chapter to help streamline and highlight the important issues that are unique to multifamily buildings.[26]

The new code cycle will also require solar and battery storage on multiple building types, including high-rise multifamily buildings of more than three stories. It will also 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.

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.

Types of Multifamily Housing

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
  - 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
  - Renters
  - Owners
  - Retail business owners for mixed-use buildings

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.[27]

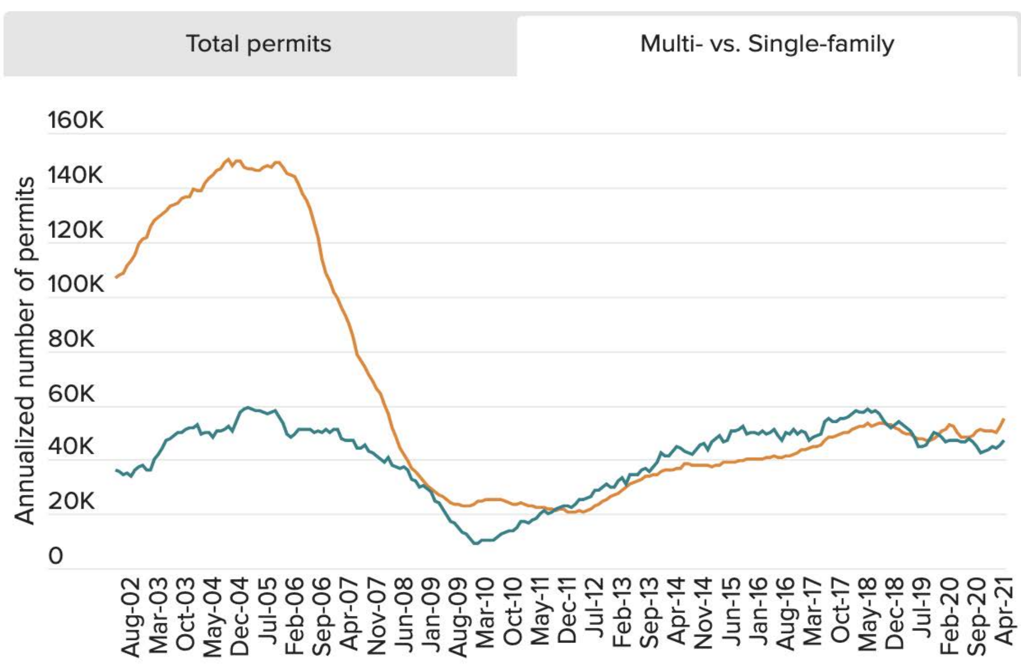
Recently passed zoning bills are set to pave the way towards denser development in California jurisdictions. SB 9 allows for two units per parcel of land previously zoned for single family use, making it easier to build duplexes and accessory dwelling units (ADUs). Additionally, SB 10 permits local governments 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. While the COVID-19 pandemic has affected the number of housing construction starts in 2020, multifamily construction starts have picked up in 2021. From January - June 2021, there were 25,400 multifamily housing starts, 5,300 more than the same period in 2020, an increase of 26%.[28]

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.

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

Orange line = single family permits; Blue line = multifamily permits issued



Source: 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."[29]

As detailed in the California Energy Commission's 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 have a higher per square foot utility cost, approximately 25% higher than non-low-income homes, and a higher likelihood of utility disconnection.[30]

The 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, which allocate approximately $1 billion in funding, 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 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 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.

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: Evergreen Economics, 2013b, Table 10

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.

Drought

California is currently in one the worst droughts in over 100 years.[31] 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,[32] 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 of the State's existing property will be underwater by 2050, with up to $10 billion of existing property jeopardized during high tide.[33] Many of the most vulnerable areas are in disadvantaged communities.

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 that lack trees and green space can be seven degrees hotter than greener outlying areas close by.[34] The Urban Heat Island impacts are particularly difficult for low-income communities 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.

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.

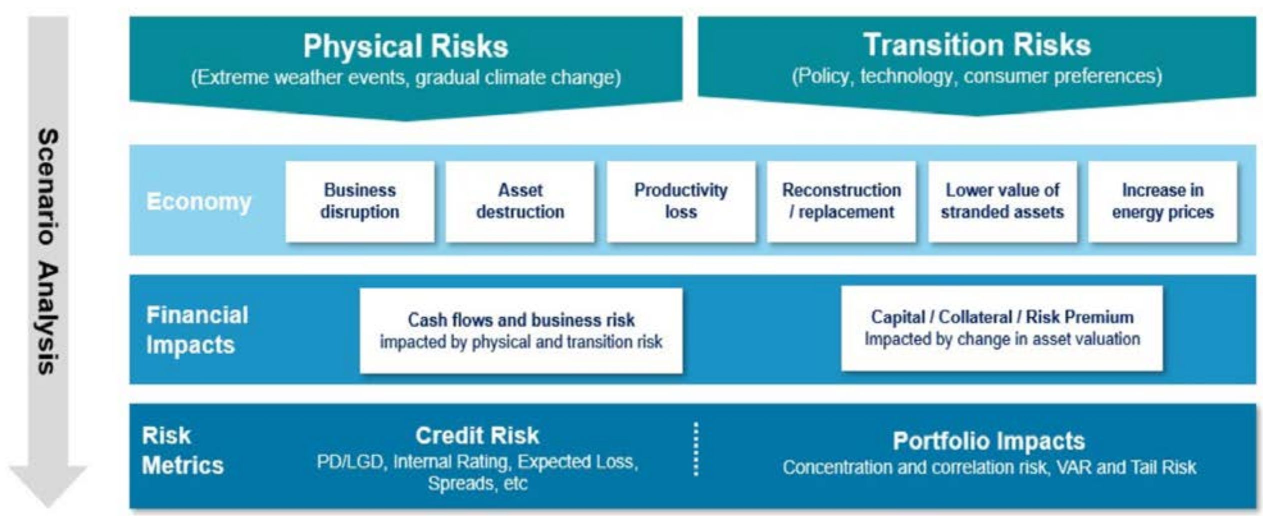
In response to increased wildfires, utilities have had to institute Public Safety Power Shutoffs (PSPS) to mitigate fire risk from live transmission lines running through forested areas. In PSPS events, large portions of the energy grid are shut off at once, causing significant disruptions to daily life 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.

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."[35]

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[36]. Likewise, in

Figure 8: Moody's Analytics Climate-Adjusted Financial and Credit Impact Analysis Steps



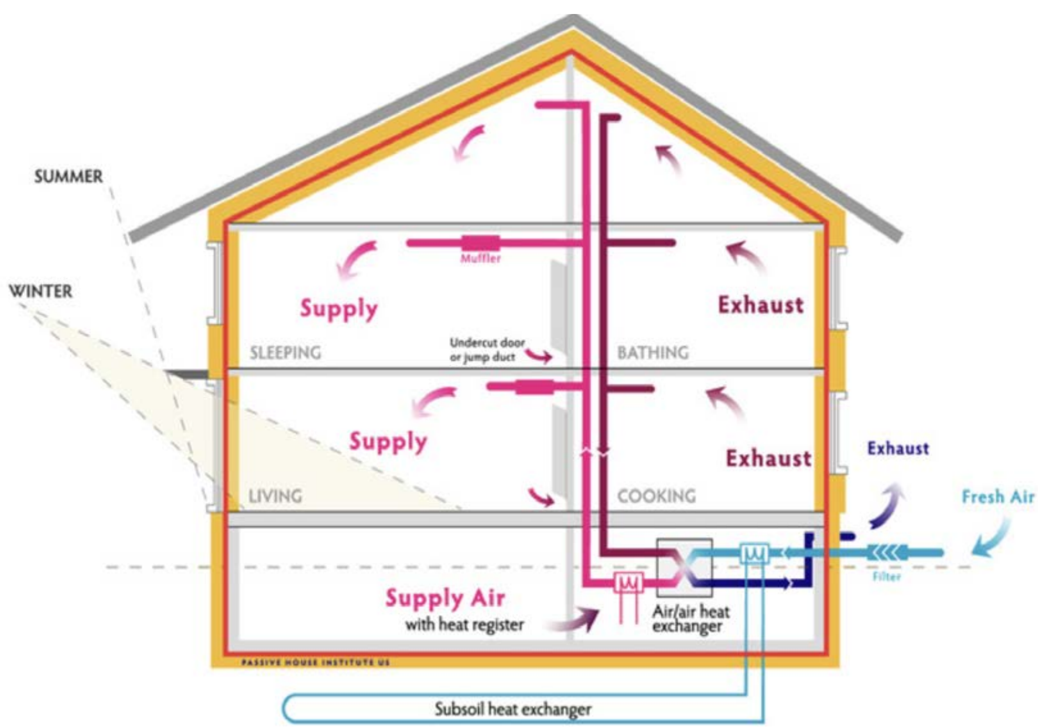
Source: Edwards, J., Cui, R, and Mukherjee, A. Assessing the Credit Impact of Climate Risk for Corporates, Moody's Analytics. (2021).

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.

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.

Figure 9: Basic Elements of Passive House Design



Source: Passive House Institute United States

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).

Thermal bridging refers to the transfer of heat between conductive building materials and can account for 30% of a building's energy loss.[37] 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 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.

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 microwaves, dishwashers, clothes washers, and refrigerators should be utilized.

Figure 10: Multifamily Energy Use Intensity Targets by Climate Zone

Climate Zone	Multifamily Site EUI (kBtu/ft²·yr)	Multifamily Source EUI (kBtu/ft²·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

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.

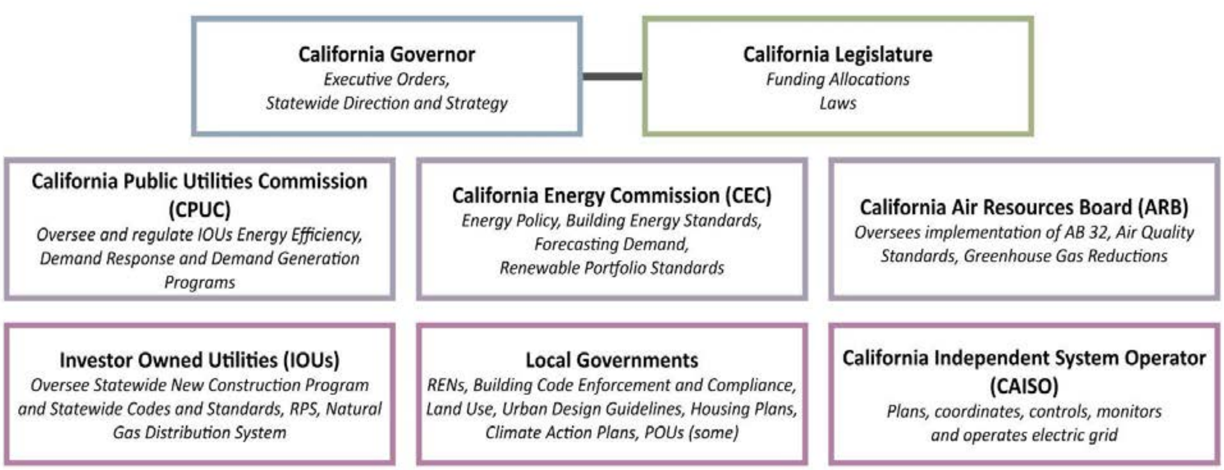
There are further opportunities for multifamily buildings and complexes to reduce energy use by installing waste heat recovery systems. These systems transfer heat energy from wastewater to water or space heating in the building, instead of creating new heat. This can greatly reduce energy use, particularly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

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,

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



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.

- **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.
- **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.

Regional Energy Networks

Two relatively new local government organization structures, the Regional Energy Network (REN) and the Community Choice Aggregator (CCA), both enabled by the CPUC, are California's newest 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.

There are four approved RENs – one covering Los Angeles County and surrounding areas (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 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.

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.

Energy Efficiency Portfolios

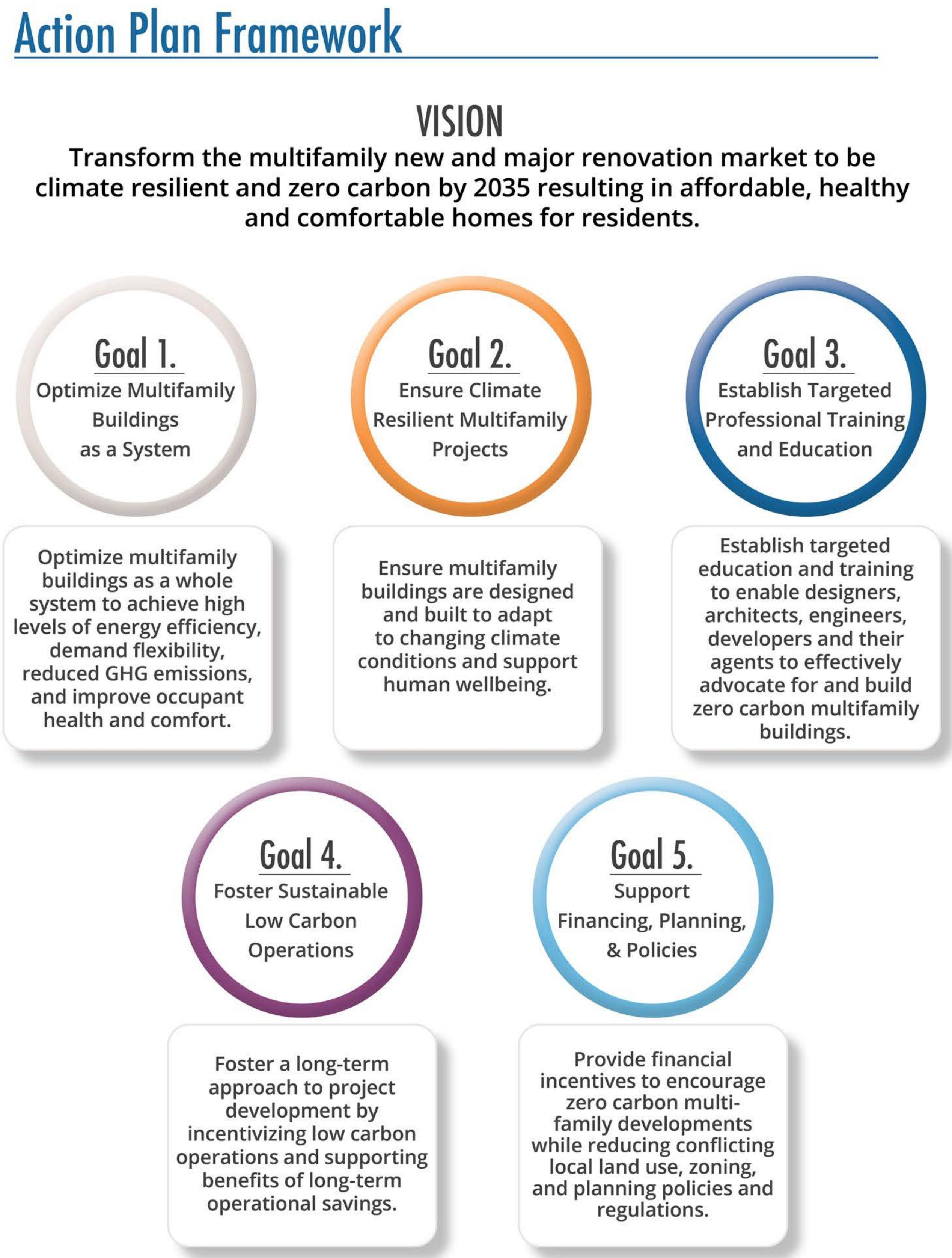
In 2022, the IOUs, RENs, and CCAs interested in EE programs will file updated 8-year business plans as dictated by the CPUC's Energy Efficiency Rolling Portfolio proceeding (R13-11-005) for 2024-2031. These plans will provide an overview of all planned priorities and spending for the coming years, including establishing a large number of decarbonization programs.

3. Strategic Framework

The market for zero or low emissions buildings has changed significantly in the past few years. Local governments, states, and recently, the nation, have adopted goals of 100% renewable energy and are moving rapidly 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 we see advances in heat pump and electrification technologies, an increase in the renewable portfolio standard (RPS), and the reduction in costs for energy storage. It is essential to design and build housing that not only works towards the State's 2045 carbon neutrality goal but is resilient to climate change effects and promotes the health and wellbeing of its occupants.

The strategies 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 aligning State and local policies to enable the construction of zero carbon multifamily buildings.

Figure 12. Multifamily Zero Carbon Action Plan Framework



Goal 1.

Goal 1. Optimize Multifamily Buildings as a System

Optimize multifamily buildings as a whole system to achieve high levels of energy efficiency and demand flexibility, reduce greenhouse gas emissions, and improve occupant health and comfort.

Objective

Utilize the New Construction Program to demonstrate and incentivize an integrated design and build approach that can move the market and ultimately codes and standards for high-performing multifamily buildings.

This goal covers the overall design and construction of the project with a focus on the following strategies:

- **1.1 Integrate Passive House approaches into the 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 multifamily 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.[38]"

The development of new and renovated multifamily 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.[39] The inclusion of natural gas appliances and heating and cooling has also contributed to health concerns, safety issues, and increased building emissions.

The shift to all-electric housing in California is underway, a key phenomenon 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.[40] 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.

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 and emissions.

Goal 1. Strategies

1.1 Integrate Passive House approaches into the Multifamily New Construction Program

The IOU New Construction program has a history in helping the marketplace test, learn, and adopt new practices that reduce risk for forward-looking developers. The program has also set the foundation for mainstream production builders to advance the energy efficiency practice, and, ultimately, codes and standards as demonstrated by the success of the ZNE programs. Refocusing the statewide Multifamily New Construction Program (Program) by 2025 to assist developers and builders in achieving aggressive zero carbon multifamily buildings is a critical step to decarbonization for new buildings in the sector by 2035.

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

A performance-based approach for zero carbon all-electric buildings requires the design team to identify and achieve energy efficiency in the following areas.

Passive House Approaches

Passive House buildings are designed to achieve high energy efficiency standards and to require little energy use 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 and windows to minimize the energy required to keep the building at a comfortable temperature. These buildings also use ventilation systems that intentionally transfer heat and moisture 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. Passive Houses require, by nature, an Integrated Design Process (IDP) in which developers,

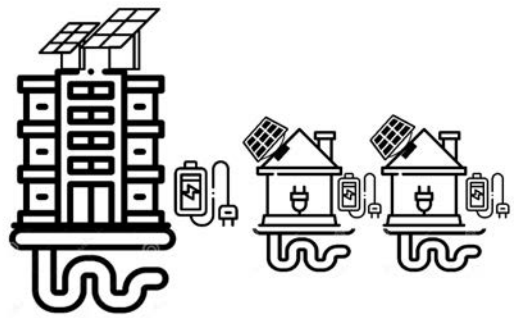
Figure 13: Zero Carbon Building Construction Process Overview

1 Design an energy efficient building incorporating Passive House techniques

Tight building envelope
Minimal thermal bridging
Passive lighting, heating, cooling, ventilation
Efficient, all-electric appliances

2 Address remaining energy needs with on-site renewables and storage

Solar panels
Battery storage systems
Geothermal heating and cooling



architects, energy consultants, contractors, and other members of the project team must communicate to ensure the building meets Passive House 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 are roughly 80% more efficient than their standard counterparts.

The following is a list of Passive House design standards from the International Passive House Association that should be considered for the New Multifamily Construction Program:

- 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 Demand: not to exceed 120kWh annually for all domestic applications (heating, cooling, hot water, and domestic electricity) per square meter of usable living space
- Airtightness: maximum of 0.6 air changes per hour at 50 Pascals pressure (as verified with an onsite 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

Building Envelope and Thermal Bridging

A well-insulated building envelope 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.

Thermal bridging refers to the transfer of heat between conductive building materials and can account for 30% of a building's energy loss.[41] As heat travels through the path of least resistance, it often enters or exits the building through wall studs or beams. Buildings should be properly insulated and designed to create breaks in thermal bridging between external walls and studs, and to stop the transfer of heat between studs and beams inside the house.

Heating and Cooling

Heating and cooling systems should be all-electric. Electric heat pumps use about 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 cooktops are more efficient than traditional electric stoves, operating at 90% efficiency compared to 70% efficiency for electric stoves and 40% for gas stoves,[42] and should be installed in new multifamily buildings. 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.[43] This percentage will only increase, as improvements to the building envelope that lower heating and cooling energy use mean that plug loads comprise a larger portion of energy use. In addition, many plug loads are not part of the building system and are from residents' plug-in equipment such as computers, TVs, gaming systems, etc., that have ongoing energy demands when not being used – also known as a vampire load. Utilizing smart outlets and tools that will automatically stop charging or lessen these loads is important.

Demand Response

The Program should ensure that new buildings are grid-responsive with effective advanced building controls. As discussed earlier in the Plan, demand response is critical to grid management and load balancing, reducing the likelihood of power outages, preventing natural gas peaker plants from coming on to the grid during peak hours, resulting in lower energy bills from Time of Use (TOU) rates.

Renewable and Battery Storage

Buildings should be designed to be solar and battery ready as well as provide electric vehicle charging that can operate as back up battery systems. Program design should enable connections to other incentive programs and financing to cover these elements.

Design and Technical Assistance

The New Construction Multifamily program should provide comprehensive design and technical assistance to designers and architects who are constructing high-performing buildings to holistically consider building energy use in the planning process and to help with project management. Designing high-performing buildings, particularly ones that utilize Passive House techniques, requires coordination between designers or architects and the construction team.

Figure 14: 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

Energy Modeling

The Program should support the use and development of robust design modeling and technical tools to ensure the optimization of multifamily building systems and controls to be grid responsive and low to zero carbon, reducing or eliminating value engineering later in the process.

It is important to support new technologies and approaches that will align modeled energy use and emissions with real, demonstrated emissions from a building. Modeling and technical tools should support multiple pathways to achieve zero carbon goals, including by adopting Passive House standards.

The enhanced Multifamily Program 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.
- Establish a way to compare results between different software (PH to CEC CEBEC model).

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

Like standard air conditioning, electric heat pump space and water heating technology relies on chemical refrigerants to circulate heat. These refrigerants have a high global warming potential (GWP) – typically 1400-2000 times that of CO2 – and can leak 10-40% of their content annually, a problem that is worsening as California gets hotter and more homes require cooling systems.[44] 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.[45] Furthermore, there has been little enforcement of the disposal of refrigerants, as refrigerants are often released into the atmosphere at the product's end of life.

CARB, CPUC, and CEC 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 has adopted regulations requiring reduced-GWP refrigerants 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 below. As the market for low-GWP refrigerants grows in the coming years, the Multifamily Program should consider requiring all heat pump technology to have low-GWP refrigerants.

1.3 Drive down embodied carbon in the construction process

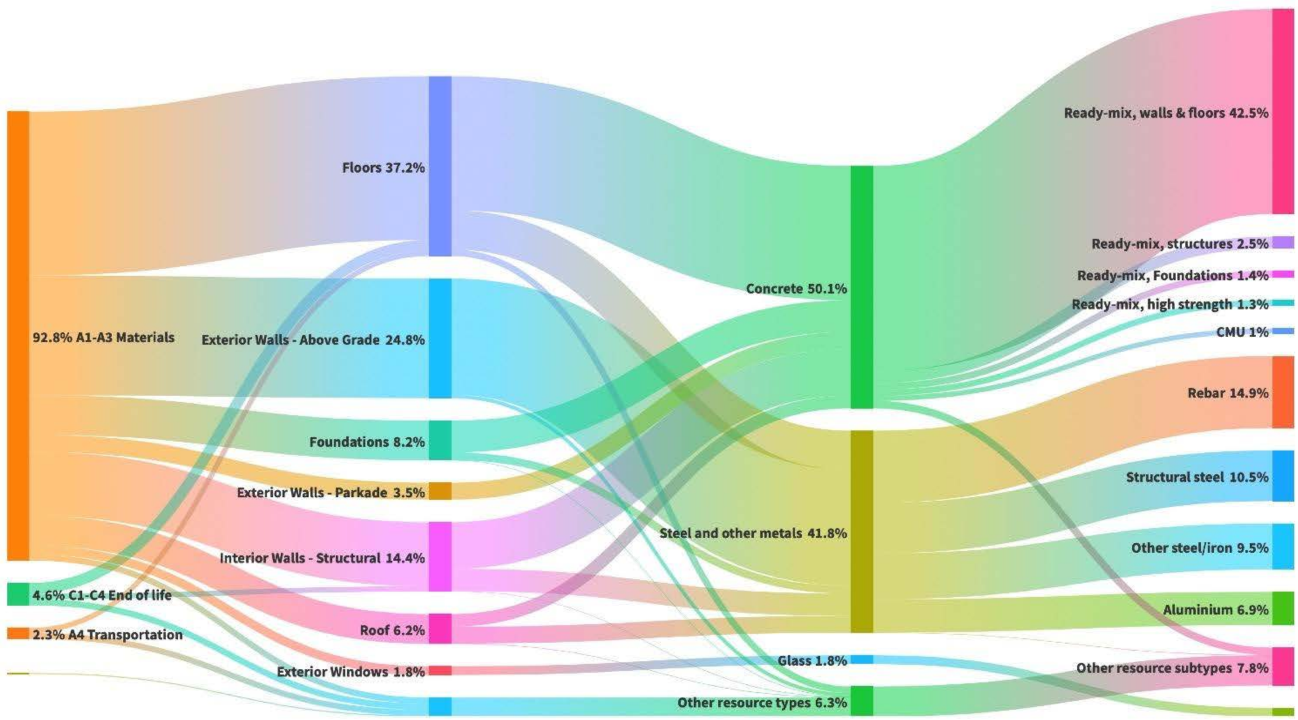
The new Multifamily Program should also require the use of low embodied carbon building materials to the greatest extent possible. The use of timber framing has potential to drastically reduce embodied carbon and is already popular in many Nordic countries and continuing to gain traction. As mentioned previously, changing a multi-story building's structure from concrete to wood could cut total embodied carbon emissions in half.[46] Timber framing is particularly beneficial when forests are responsibly managed, as wood can act as a renewable, carbon-sequestering building material. It is important to note, however, that the majority of emissions associated with timber stem from the disposal process (the most common of which are putting timber in a landfill or burning it to recover energy).[47] Some LCA models count timber as a carbon neutral building element, while others count it as carbon negative during construction (when carbon is stored in timber), and carbon positive when building materials are replaced. This creates inconsistent embodied carbon calculations and should be considered when procuring timber.

In total, the most carbon intensive building elements for which alternatives should be considered are concrete, which is used for walls and floors; steel, which is used in rebar and for structural framing; and aluminum, which is used in interior walls and roofing.

There are many ways that architects can reduce embodied carbon in buildings. The American Institute of Architects (AIA) includes the following as key methods to reduce embodied carbon:

- **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

Figure 15: 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

concrete is required for the project, using a lower cement content concrete can reduce embodied carbon emissions from concrete by 35-43%.[48]

- **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 also 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.
- **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.

1.4 Establish uniform metrics to track and monitor project performance

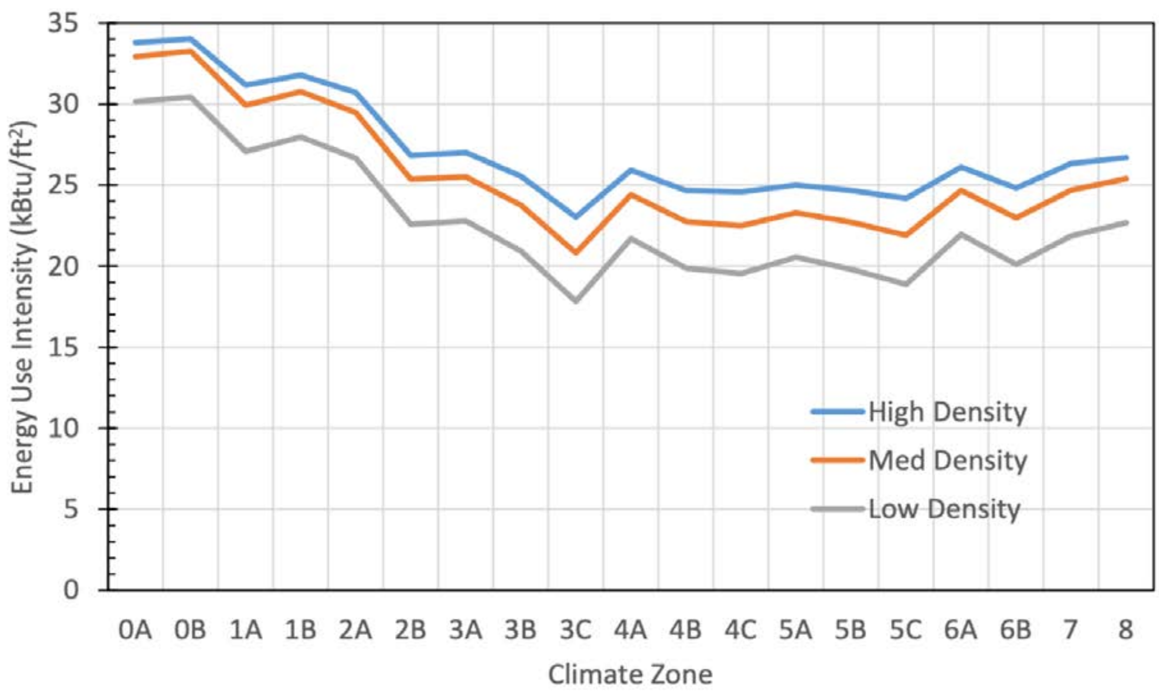
Building on existing rating and metrics systems, adopt a consistent, equitable, and aligned performance metric system for California's Multifamily New Construction Program.

The Statewide program team should work with stakeholders (potentially 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 (kWh/ m2/ 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 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. Below are EUI targets for high, medium, and low-density housing for a variety of Climate Zones, originally developed for ZNE multifamily housing. Please note that this should be used as a starting point for developing more detailed EUI targets.

Many other measures of energy efficiency, such the Energy Design Rating (EDR), can be challenging to use. An EDR rating is calculated using modeling software, can be difficult for designers to utilize, and do not always reflect actual emissions. EUI is calculated post-construction from a building's actual emissions. Setting an EUI or absolute target based on performance, rather than a target for modeling software, is an important step to creating a

Figure 16: EUI Targets for High, Medium, and Low-Density Buildings Based on Global Climate Zones



A chart of EUI targets for high, medium, and low-density buildings in global climate zones 0-8. Here, high density buildings modelled include 20 studio units and one bedroom apartments per floor; medium density buildings have a mix of 15 units including studios and one-, two-, and three- bedroom units per floor; and low-density buildings have a mix of 9 two- and three-bedroom units per floor.

Source: National Resource Energy Laboratory successful zero carbon multifamily building program.

1.5 Develop incentives to accelerate 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. As mentioned earlier, the issue of a split incentive means that many property owners have little reason to update or renovate their buildings if they cannot recoup their investment. Other barriers based on the building condition, location, and owner absence, among others, decrease the likelihood of updating the existing stock. A recent report from RMI details the reimagined concept of beneficial electrification, for which "The targeted benefits of electrification can include GHG emissions, lower costs to utility customers, and better management of the electric grid.[49]" The opportunities to reap the benefits of beneficial electrification in California with multifamily buildings could be transformational if we could make these gains in both new buildings and in existing buildings.

Statewide Working Group and Research

The Statewide Program team, working with CAEECC, RENs, and other stakeholders, including policy makers, should evaluate the opportunity to incentivize otherwise uninterested property owners to conduct a major renovation.[50] The process could open a pathway to electrifying more multifamily buildings and supporting a large portion of low-income tenants by enabling the least efficient housing stock to benefit from the most efficient and carbon reducing technologies available today, as well as be positioned to achieve further benefits from electrification later, such as EV charging, bill reductions through variable rates, and energy storage. These outcomes would directly serve the low-income housing occupants with lower bills, increased reliability, more comfort, better safety, positive health impacts, and pathways to benefit from future electrification and the use of renewable energy.

Launch Pilot Program

A pilot program that provides a bundled incentive/financing/technical assistance package should be advanced by the New Construction Program or a Regional Energy Network. The pilot 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 and extensive technologies, but also utilize a new delivery method that connects building performance with ongoing incentives to link tenant and property owner benefits.

The pilot 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.

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. This 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 Black, Indigenous, and People of Color (BIPOC) communities.

Multifamily buildings with central air conditioning (CAC) and fossil fuel heating can be great candidates for heat pumps when either of the incumbent systems requires replacement. Expanding a CAC system to a heat pump can be a relatively inexpensive switch in existing buildings. In existing buildings, some efficiency elements have already been established and are 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.

The program is presented as a pilot because of the innovation required to move the industry. A central entity would define key 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.

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 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.

Goal 1. Recommended Roles and Responsibilities

Strategy	Leads	Partners
1.1 Integrate Passive House approaches into the Multifamily New Construction Program	PG&E - Statewide implementer	CEC, CPUC
1.2 Incentivize low-GWP refrigerants and the responsible maintenance and disposal of refrigerants	PG&E - Statewide implementer	CEC, Industry market actors
1.3 Improve modeling tools to achieve zero carbon goals	CEC	PG&E - Statewide implementer, Stakeholders
1.4 Drive down embodied carbon in the construction process	PG&E - Statewide implementer	CalGREEN, CEC, Builders
1.5 Establish uniform metrics to track and monitor project performance	PG&E - Statewide implementer	CAEECC
1.6 Develop incentives to accelerate the rate of major renovations for existing multifamily buildings	RENs	PG&E, CAEECC

Success Indicators

- Multifamily buildings constructed through the Program are all-electric and have significantly lower energy use and carbon emissions than their traditional counterparts.
- Percentage of buildings built to be zero carbon increase annually.
- Buildings constructed through the Program will be built based on EUI or absolute target energy efficiency metrics.
- Incentives for Passive House approaches will be integrated as a central part of the program.
- New modeling tools are available that are consistent and support zero carbon targets.
- A pilot program is launched to encourage major renovations for existing buildings.

Goal 1.

Goal 2: Ensure Climate Resilient Multifamily Projects

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

Objective

Incorporate resilience measures including and beyond energy resilience to reduce carbon emissions and increase the ability of a multifamily building to operate, function, and withstand a range of climate hazards and support human health.

This goal extends the application of zero carbon resilient consideration beyond the building envelop 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 alternative energy sources in multiple buildings 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, extreme heat, sea level rise, wildfires, and smoke. 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. The vast majority of current buildings have not been designed to withstand more frequent extreme weather events like heat waves, wildfire smoke, and related PSPS events. It is critical to ensure that new buildings are designed to function as a

Durable Sanctuary

A "durable sanctuary" refers to a home or building that ensures a safe and healthy living space for its occupants during extreme weather events or power outages for multiple days. A durable sanctuary should ensure safe living temperatures, good air quality, and can provide electricity for key uses, such as refrigeration and health needs.

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 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 2023 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 high 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. Cool roofs can also reduce a building's indoor temperature. Green infrastructure can reduce flooding risk by allowing rainwater to infiltrate the ground.

Green Infrastructure and Stormwater Management

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.[51]" 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

Most designers are designing buildings for today's climate, not for the rapidly changing climate expected in 20, 50, or 100 years in the future. As extreme climate events become more frequent, it is important for designers – who are making structures to last well over 50 years – to actively integrate climate resilience measures in their projects.

An important component of this is to require developers to integrate resilience measures 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.[52] Similarly, the Ice Box Challenge showcased how PH homes can maintain comfortable temperatures in extreme heat.

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 checklists for new construction and extensive building renovations that are accepting incentives. Beyond that, local government building departments could employ the same checklist, with modifications for their community, to support their goals.

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. They are required 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 as a way to address specific issues identified by community members in those plans[53].

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 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.

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 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.

Figure 17: Sample from Boston Resilience Checklist

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:

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

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[54].

Microgrids

If multifamily zero carbon projects are designed as microgrids, 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.

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.[55] 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 its energy all onsite.

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

California codes are continuing to push for greater integration and application of solar plus storage systems with the advent of the new 2022 codes 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 – 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.

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.

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 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

Net Zero Water Strategies

Greywater Recycling

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

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.

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 Parking

Many green infrastructure elements can be seamlessly integrated into parking lot designs. 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.

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.[56] 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 alternative energy sources in multiple buildings projects

Incentivize projects that renovate and/or enhance the energy infrastructure outside of the building including, but not limited to, undergrounding electrical infrastructure; removing (or repurposing[57]) existing natural gas infrastructure; and connecting to other energy sources such as waste to energy and district heating and cooling systems.

Waste Heat Recovery

Waste heat recovery systems 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 take building sewage waste, run through it through a filter to separate solids, which are sent to the sewer system, and then recovered heat from the process with a heat exchanger. These systems can be connected with heat pump water heaters to heat water. In a 60-unit apartment building in Vancouver, 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.

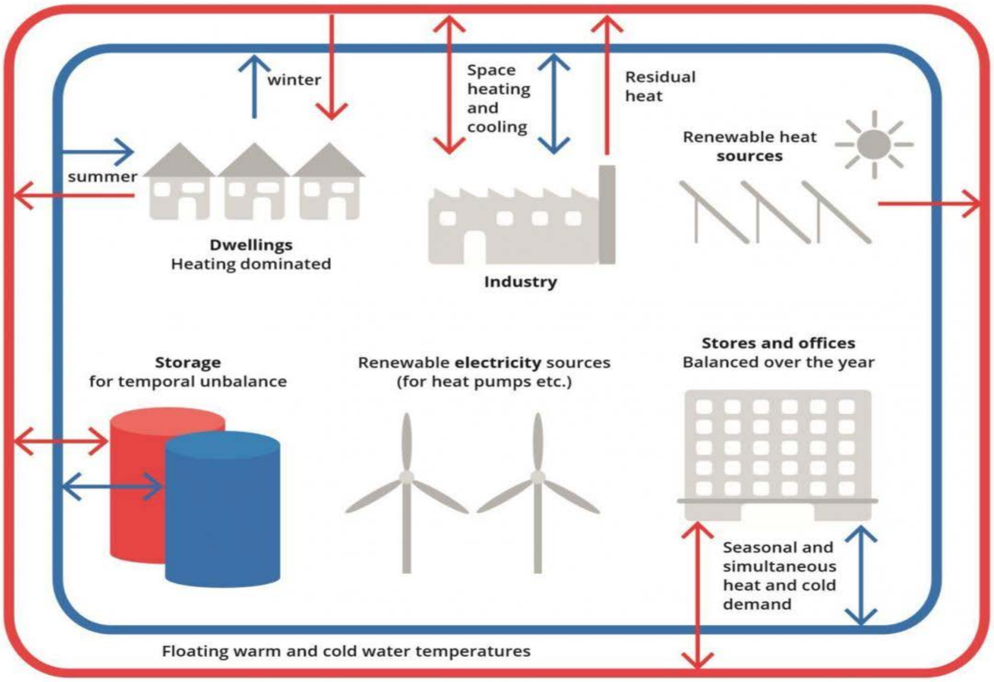
Geothermal energy is a consistent renewable energy source that can reduce energy demand for space and water heating and cooling by 50%, while also reducing emissions. Geothermal systems could be considered as a potential heating and cooling source for multi-building projects, which would be complemented by solar panels and battery storage to fully power plug loads and lighting (see additional information below).

5th Generation District Energy Systems

5th Generation District Energy Systems (DES) 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. This way, all energy exchange related to heating and cooling occurs within a closed loop system, and no energy is wasted.

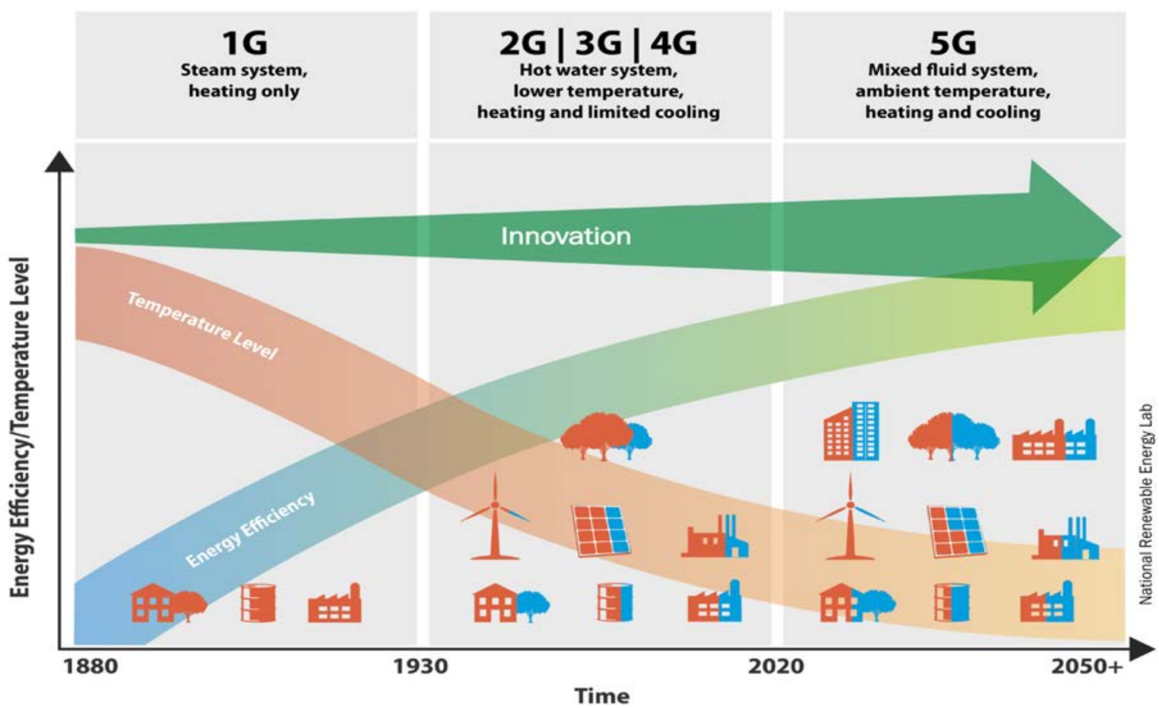
These systems are also efficient and can contribute to a more stable energy grid, as more consistent operating temperatures of water means less spiked energy demand, especially during extreme cold or heat. This provides room for use of 100% renewable energy to meet electricity demand.

Figure 18: 5th Generation DES Heat Flow Diagram



Source: 5th generation district heating and cooling systems as a solution for renewable urban thermal energy supply, Advances in Geoscience, 2019.

Figure 19: Temperature of Heating Systems vs Energy Efficiency Over Time



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

Furthermore, the cost of installing these energy systems and distribution piping falls on the district energy provider, reducing costs to developers 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 multifamily projects. Adding climate resilient design to a project adds another layer of complexity, and projects must 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, opening 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 alternative energy sources in multiple buildings 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

- Development of a Multifamily Climate Resilience Checklist that is used by local government building departments.
- An increasing number of new multifamily projects take advantage of existing solar and battery storage funding programs.
- An increasing number of new multifamily projects incorporate green infrastructure in the site plans.
- An increase in the adoption of district energy systems supporting standard DERs.

Goal 3.

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 Develop high-performing buildings Energy Modeling Certificate Program

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

Overview

The technical capability to achieve zero carbon buildings exists. 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 underperforms 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: 1. integrated design and build process; 2. effective advocacy and client engagement; and 3. policy. This Goal focuses on the first two and policy is covered in Goal 5.

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. The result is typically that high-performing building goals are not achieved or must be revisited at substantial costs later in the process.

Zero Carbon Building Advocacy

A separate but equally, if not 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 buildings 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.

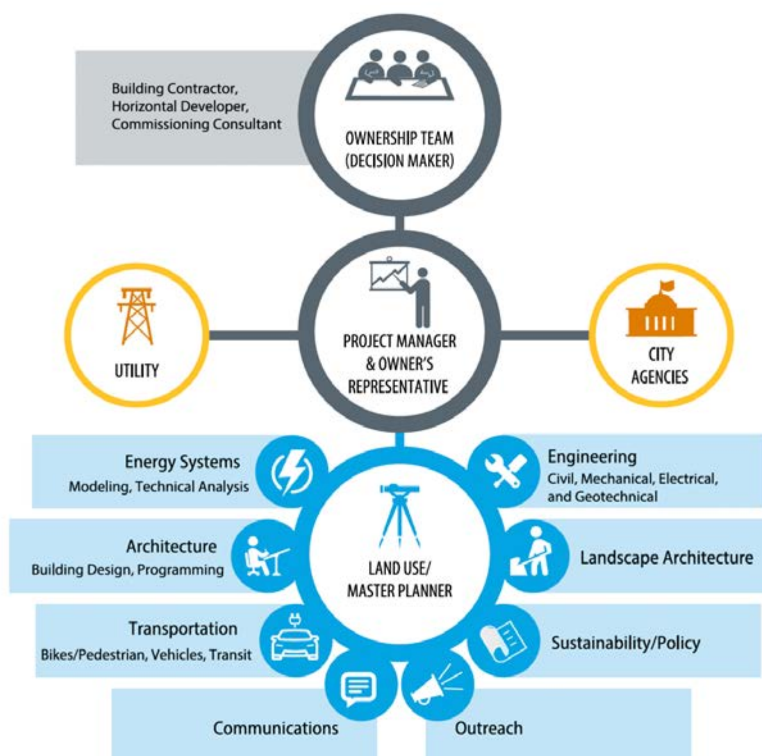
Therefore, this goal and its strategies are focused on the early phases of a project and the practitioners responsible for developing multifamily buildings rather than the construction and the trades. Without addressing these early phase concerns, scaling high-performing zero carbon multifamily buildings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

Goal 3. Strategies

3.1 Establish high-performing Integrated Design and Development Training

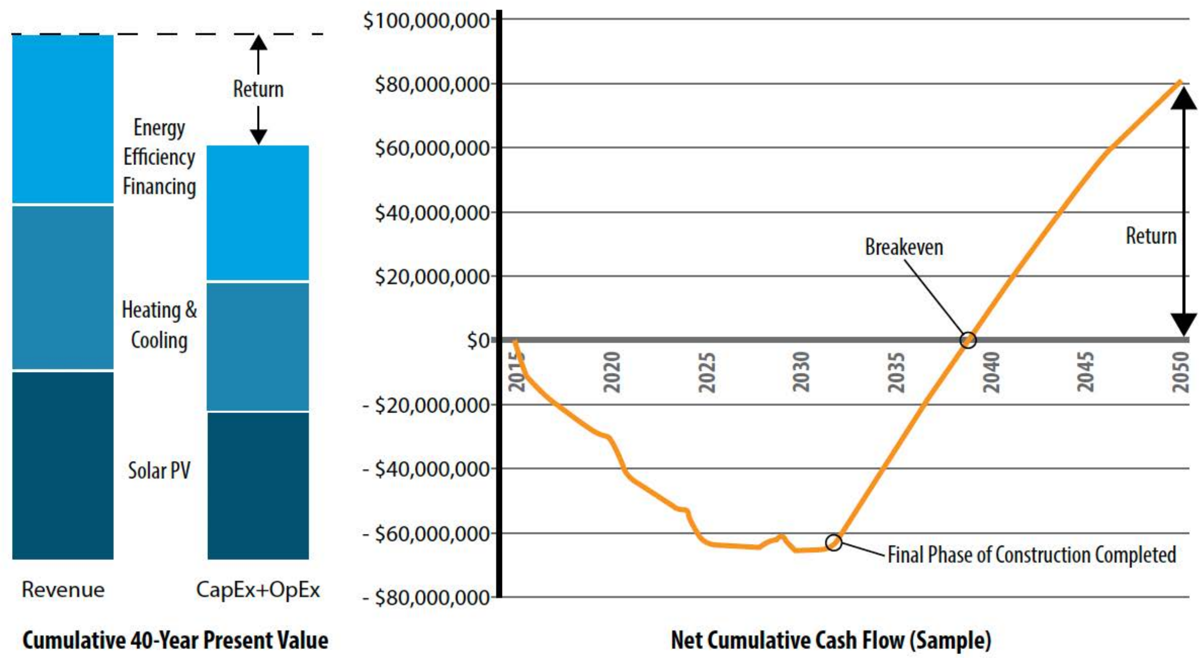
Development practices must change to create an integrated and holistic approach to building design and development that includes both technical and architectural considerations. It is necessary to help drive forward projects with an Integrated Design Process (IDP) by targeting training towards designers, architects, and to a lesser extent energy consultant, who are the professionals driving the projects. Establishing the

Figure 20: 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.

Figure 21: 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.

right project team (see Figure 20 for components of a project team) at inception and ensuring all the players are actively involved will 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 develop and 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, and how to ensure high-performing goals are met at each stage of project development from concept to construction.

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. [58] 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

The training program should also provide 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.[59] 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 should utilize a similar concept to encourage designers and architects to learn about the integrated design process and zero carbon buildings.

3.2 Develop a high-performing buildings Energy Modeling Certificate Program

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.[60] 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 recent Zero Code modeling tool from Architecture 2030 and the soon to be released PH Ribbon tool which helps to calculate embodied carbon in the design.

The WE&T program and/or program training should develop and offer on a regular basis energy modeling training using the latest technologies and tools. This should include much more than code compliance tools and should offer deep dives into products such as UrbanOp 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.

3.3 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 should include information on, but not limited to, the following:

- 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
- 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.

Case Study

Massachusetts' Passive House Incentive

Massachusetts offers a variety of incentives for PH projects. The State offers a 50% PH training reimbursement for builders, consultants, designers, raters, tradespeople, and verifiers. It also offers a variety of incentives for multifamily buildings with five or more units that are designed to achieve PH standards, and further incentives once a building is certified and saves energy. California should consider providing a similar set of incentives. The incentives are listed below.

Passive House Incentive Structure for Multi-Family (5 units or more)			
Incentive Timing	**Activity**	**Incentive Amount**	**Max. Incentive**
Pre-Construction	Feasibility Study	100% Feasibility costs	$5,000
	Energy Modeling	75% of Energy Modeling costs	$500/Unit, max. $20,000
	Pre-Certification	$500/unit	N/A
Post-Construction	Certification	$2,500/unit	
	Net Performance Bonus	$0.75/kWh	
		$7.50/therm	

Source: Passive House Incentives, MassSave, 2021

Goal 3. Recommended Roles and Responsibilities

Strategy		Leads	Partners
3.1	**Establish High-Performing Integrated Design and Development Training**	WE&T	PHIUS, NAPH, AIA, USDN, et.al.
3.2	**Develop High-performing Buildings Energy Modeling Certificate Program**	WE&T	PHIUS, CEC
3.3	**Provide training and resources to advocate and encourage development of zero carbon buildings**	CPUC, CEC	PHIUS, NAPH, AIA, USDN, et.al.

Success Indicators

- An increasing number of designers and architects complete zero carbon multifamily training.
- An increasing number of energy consultants received a high-performing buildings certification.
- Availability and distribution of tools and resources for architects, engineers, planners, and other energy consultants.
- Range of partners offering complementary and supportive training.

Goal 4.

Goal 4. Foster Low Carbon Operations

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

Objectives

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 two 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 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.

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

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.[61] 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.

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

4.2 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 retrocommissioning 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.

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.

** Haasl, T., and K. Heinemeier. 2006. "California Commissioning Guide: New Buildings" and "California Commissioning Guide: Existing Buildings". California Commissioning Collaborative.*

Goal 4. Recommendation for Roles and Responsibilities

Strategy	Leads	Partners
4.1 Employ total cost of ownership budgeting		
4.2 Ensure long-term building energy optimization through building commissioning from design through operation		

Success Indicators

- All projects utilize LEED Enhanced Commissioning or an equivalent commissioning process.
- TCO is common practice and part of the New Construction Program's technical assistance

Goal 5.

Goal 5: Support Financing, Planning, and Policies

Support enhanced financing and enabling local and state planning and policies that provide a feasible path forward to zero carbon multifamily buildings.

Objectives

Provide financial incentives to encourage zero carbon multifamily developments while reducing conflicting local land use, zoning, and planning policies and regulations.

As mentioned in Goal 3, policy is an area that can be a barrier to the implementation of high-performing buildings, particularly for complex affordable housing and multifamily projects. This Goal includes the following three strategies to address the most critical policy areas.

5.1 Leverage statewide financing tools to support zero carbon buildings

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 are second to owner demands in driving green building and zero carbon development and as such is an essential player in reaching the MZCAP goals. In addition, local governments oversee land use planning through the development of land use policies in General Plans and Specific Plans. These policies in turn set the stage for how new buildings and district or community projects can be developed. The following are some of the primary ways local governments will impact and direct the market.

There is an essential 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 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.

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.

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.

Split Incentive

Financing mechanisms and rent regulations will need to consider the split incentive issue and provide the appropriate motivation to investors to invest in high-performing appliances and appropriate upgrades.

Goal 5. Strategies

5.1 Leverage statewide financing tools to support zero carbon buildings

It is important to collaborate with State agencies to leverage funding opportunities that support zero carbon multifamily construction. This includes ongoing collaboration and streamlining efforts with the CEC, IOUs, and TCAC. As part of this collaboration, PAs should work to ensure that utility programs and incentives complement all-electric building incentives from the BUILD and TECH programs to reduce the cost of all-electric construction.

Lenders, appraisers, and financiers of affordable and market rate housing will 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 onsite 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.

BUILD and TECH Programs

BUILD and TECH are two new programs 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, energy storage, and demand response. The TECH program provides upstream incentives to manufacturers, distributors, and vendors of heat pumps and heat pump water heaters.

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 TCAC 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.

Solar Incentives

The New Solar Homes Partnership (NSHP) is a part of the State's California Solar Initiative (CSI) Program and has a separate goal and allocation for new affordable housing. NSHP provides incentives for both residential units and common areas, the latter receiving a base incentive. The 2014 incentives vary from $1 per kW for units meeting 2013 Title 24 standards up to $1.75/watt for units meeting and exceeding 2013 Title 24 energy standards by 30%. Since 2007, the program has reserved over 5 MW of solar in new affordable housing.[62]

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.

Case Study

Passive House in Pennsylvania

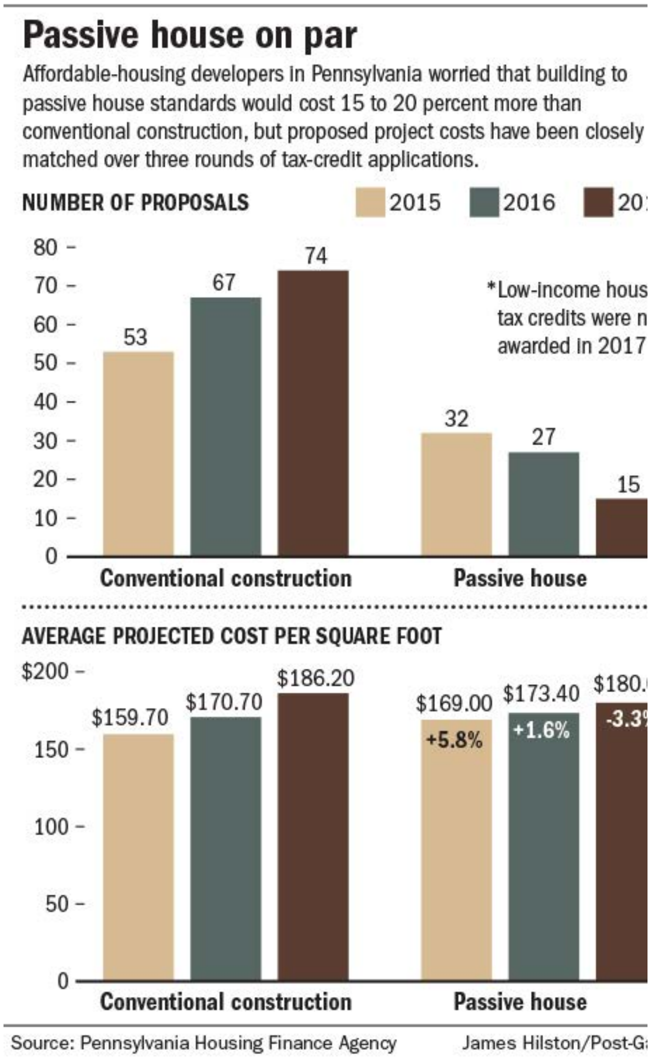
Some states have incentivized Passive House design through their affordable housing financing process. Pennsylvania has the most Passive House buildings out of any state in the country because the State has included PH design as a building characteristic that garners points in the bids for affordable 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 54.63

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.

Figure 22: Passive House Affordable Housing Proposals and Costs



Source: Post-Gazette, 2018

5.2 Establish a path to zero carbon codes for multifamily buildings

The California Energy Commission, through Title 24, part 6, has consistently increased the energy efficiency requirements of multifamily buildings, with a major update coming in 2022.

To support energy codes that enable zero carbon buildings, the codes and standards processes must consider and address issues related to Passive House integrated building processes, project scale-renewables, changing technologies, and maintenance, and behavior impacts for all of the different multifamily building types.

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 get out of the way of 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.

Ultimately, building standards and code will provide a baseline for what buildings should achieve, not necessarily the ideal goal of a zero carbon building. Therefore, while establishing zero carbon-level standards and code is important, it should not be a replacement for pushing for higher levels of efficiency and innovations, which may not be possible within the realm of the building code.

Through incentives and local reach codes, the CPUC should create a path and bridge to potential zero carbon multifamily with Passive House approaches code integration in 2025 and a performance approach to zero carbon multifamily buildings. The updated standards 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 streamline process.

This could include creating a step code similar to British Columbia's, detailed on the next page, with increasing levels of energy requirements and decreased energy use. Cities could adopt the appropriate level of the code for their jurisdiction, working towards an eventual statewide mandatory zero carbon multifamily building code. A step 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.

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 BC Building Code and allows communities in the province to tailor more stringent energy efficiency measures to their communities' needs within the 2032 timeline.

Code Requirements:

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.

Figure 23: BC Energy Code Levels for Building Type

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

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

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 need to provide sufficient signals to the market at the state level including appropriate fees and tariffs, including updating the net energy metering rules to support a robust market that can be self-sustaining and reduce impacts to nonparticipants.

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 (smaller area than the city) and by setting zoning rules, developing urban design guidelines and transportation networks, and dictating the mix and location of building types and uses. Planners 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 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.

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.

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.

The Program should also enable local government PAs, including staff from RENs and CCAs, to develop a policy template that acts as a "best practices guide" for zoning, codes and standards, and more. 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.

Goal 5. Roles and Responsibilities

Strategy	Leads	Partners
5.1 Leverage statewide financing tools to support zero carbon buildings	Local government, State	IOUs, RENs
5.2 Establish a path to zero carbon codes for multifamily buildings	RENs, Statewide C&S	Local Government
5.3 Support local government planning and building departments to implement zero carbon buildings	RENs, CCAs	Air Quality Districts, LGC

Success Indicators

1. An increasing number of local governments adopt energy codes that require increasingly stringent levels of energy efficiency requirements.
2. Guidance documents are created for local governments.
3. Cities have adopted best practices guidelines for zoning and codes and standards.

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.

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.

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

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