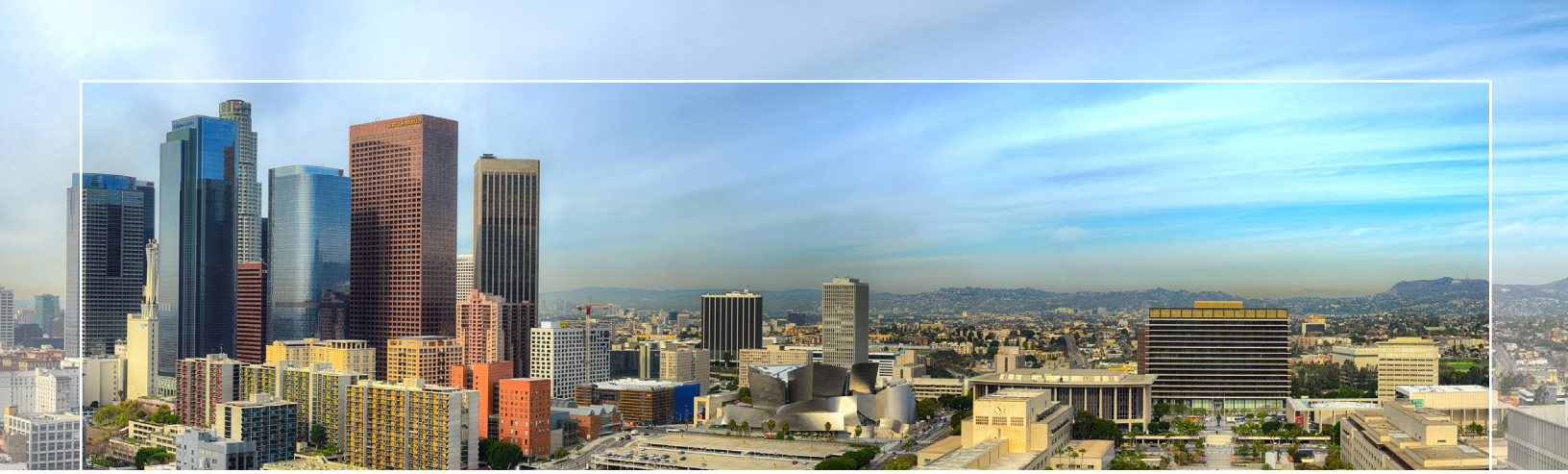


A ROADMAP TO DECARBONIZE CALIFORNIA BUILDINGS

BUILDING DECARBONIZATION COALITION

This Roadmap was made possible through the generous support of the Heising-Simons Foundation, the Energy Foundation, and the gracious input and support of the members of the Building Decarbonization Coalition. Any errors are the responsibility of the author.

The Building Decarbonization Coalition is a 501(c)(3) nonprofit organization whose mission is to convene the stakeholders necessary to drive the conversation around building decarbonization at the state level. The Coalition brings together industry, advocacy, government experts, and the private sector to develop integrated and effective approaches to make decarbonization a reality. A list of members can be found here: www.buildingdecarb.org/members.

Recognizing this Roadmap serves as a starting point, it provides a collective expression of the Building Decarbonization Coalition rather than an account of every party's position on every issue. Some parties disagree with some parts of the Roadmap, but agree the Roadmap provides a reasonable foundation for the State's transition.

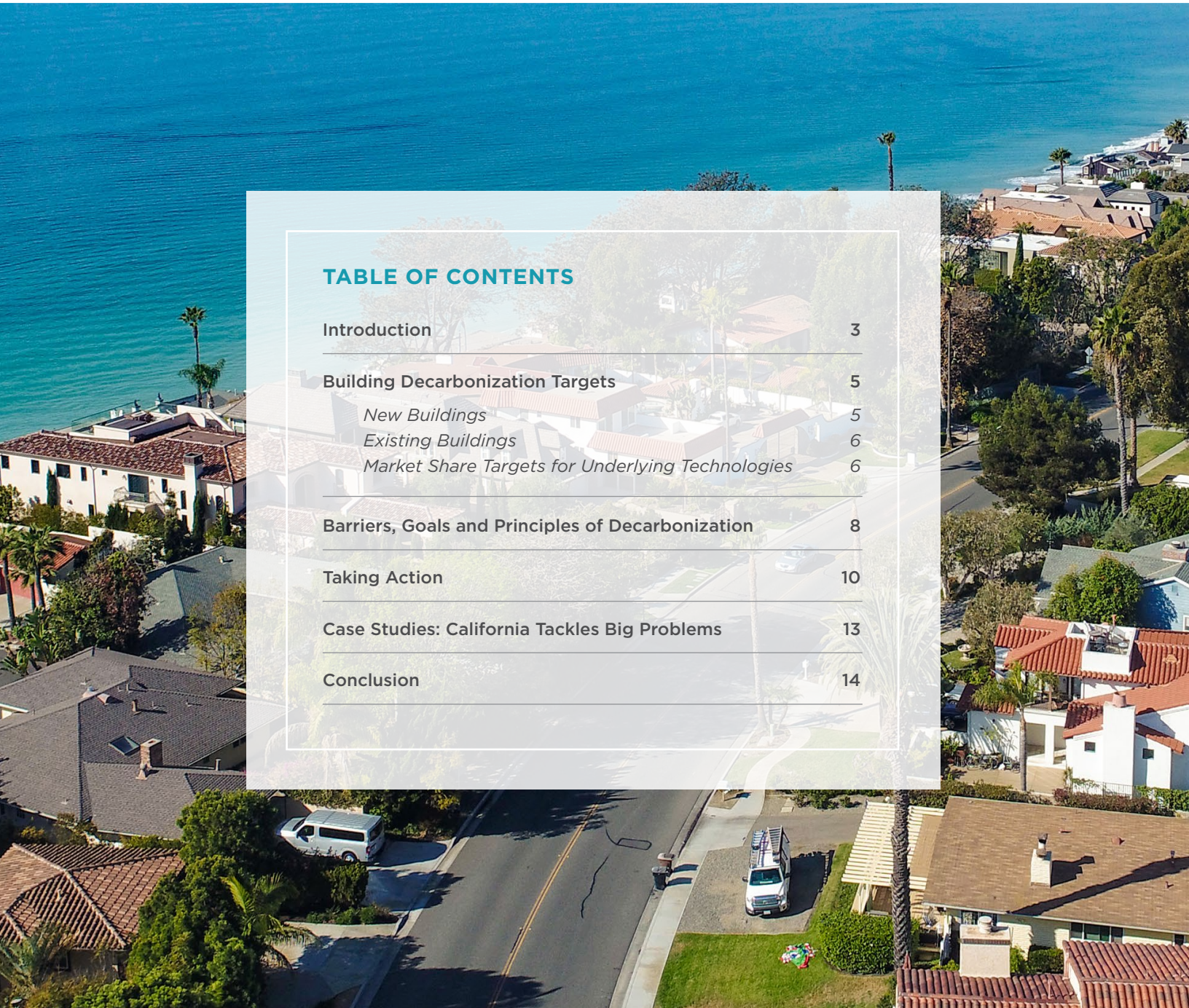


TABLE OF CONTENTS

Introduction 3

Building Decarbonization Targets 5

New Buildings 5
Existing Buildings 6
Market Share Targets for Underlying Technologies 6

Barriers, Goals and Principles of Decarbonization 8

Taking Action 10

Case Studies: California Tackles Big Problems 13

Conclusion 14

INTRODUCTION

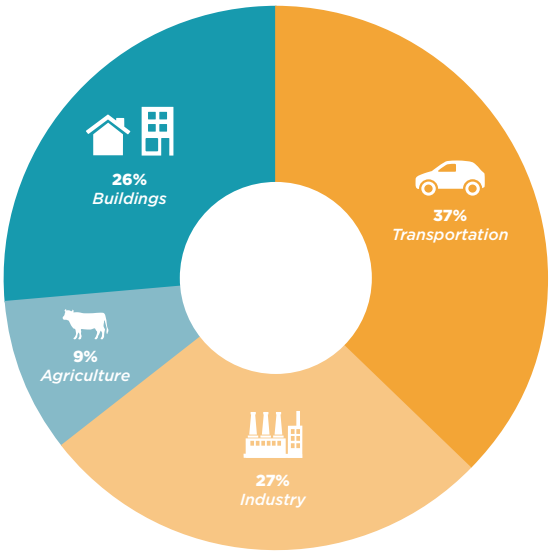
For California to meet its climate goals, homes and buildings must be decarbonized. This will require clear, ambitious targets, coordinated actions directed at key barriers, alignment of all stakeholder value propositions and clear leadership from the Governor and his administration. This Roadmap outlines an approach to fulfilling these objectives.

Motivated to lead a global effort to mitigate the deepening climate crisis, California has adopted aggressive greenhouse gas emission reduction targets, including returning to 1990 levels by 2020, 40% below 1990 by 2030, and carbon neutrality by 2045.

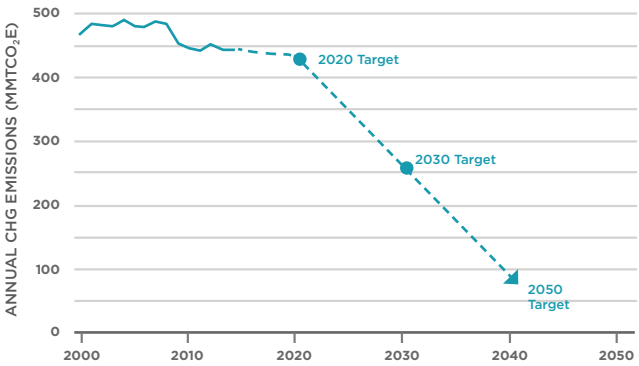
The achievement of these targets will require emissions reductions across all sectors of the economy.

Although California met its 2020 target early, the road ahead will be more challenging. A key part of that challenge will be decarbonizing buildings. In 2016, California building energy use was responsible for more than 26% of statewide greenhouse gas emissions.

CALIFORNIA END USE GREENHOUSE GAS EMISSIONS[1]



PLOTTING CALIFORNIA'S PATH FORWARD



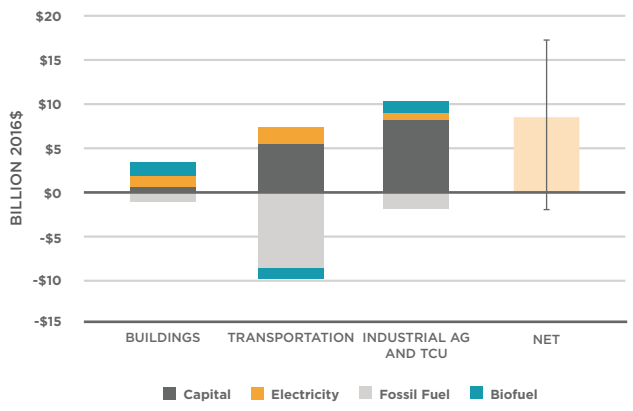
To decarbonize a building is to remove greenhouse gas emissions from the building's energy use, achieved through making the building more efficient and integrating appliances powered by clean energy sources. Thanks to California's proactive transition to carbon-free renewable electricity this can be achieved by converting appliances that are currently powered by fossil fuels to already available technologies powered by electricity. For example, high efficiency electric heat pumps can provide clean space and water heating, induction ranges can provide a superior and safe alternative to gas-powered appliances in the kitchen, and efficient electric clothes dryers can be used in place of gas-powered dryers.

1 Emission from buildings includes methane, electricity generation, fuel combustion and refrigerants.

In addition, each of these solutions has the potential to improve living and working conditions and save the building owners and occupants money. A recent analysis conducted by E3 for the California Energy Commission concludes the net cost of decarbonizing buildings, exclusive of any electric system investments required by higher electric growth or transition costs associated with declining gas throughput, is relatively small, even before accounting for the financial impact of health and environmental benefits.[2]

TOTAL 2030 NET COST OF THE HIGH ELECTRICIFICATION SCENARIO RELATIVE TO REFERENCE SCENARIO

Excluding climate benefits (2016$, billions)



In E3's High Electrification Scenario, which meets California's climate goals in 2030 using a reasonably likely, and relatively low-cost combination of strategies, the estimates range from savings of $2 billion per year to net costs of $17 billion per year in 2030, depending on the fuel price and financing assumptions. Building Decarbonization has the lowest potential net cost of the contributing sectors.

While the technologies are poised to support building decarbonization and the benefits clear, the policy and market conditions are anything but. A range of barriers, detailed herein, are preventing California from reaching its potential. This Roadmap advances a theory of change to overcome these barriers, including three phases: Market Readiness, Market Deployment and Scaling the Market.

- **PHASE 1**
  Market Readiness: Today demand for and supply of building decarbonization measures is minimal. To ready the market, reverse these conditions through ambitious targets, policy alignment, coordinated marketing, retail price reductions, clear signals to suppliers and coalition building.

- **PHASE 2**
  Market Deployment: Once readied, deployment of building decarbonization measures can be accelerated through support of the full-supply chain via mid- and upstream incentives to manufacturers and builders and financing solutions ready to reach all customers, including underserved communities.

- **PHASE 3**
  Scaling the Market: Leverage the success of Phases 1 and 2 to reach scale through downstream incentives, grid integration, and targeted solutions for hard to reach customers.

Pursued with intention and urgency, California can realize Phase 1 of this change in the near-term, while planting the necessary seeds for Phases 2 and 3. Achieving the ambitious schedule will require leadership, clear goals reflected in policy, and cross-sector strategic investments and coordination. The State will only be able to achieve its goals when each stakeholder's incentives to decarbonize buildings are aligned.

The Building Decarbonization Coalition was formed in 2018 to urge this action and support state and market leadership to decarbonize buildings. The Coalition consists of a diverse assembly of energy providers, public interest advocates, manufacturers, contractors, workers, builders, local governments, real estate interests and investors spanning California's building community. Together this Coalition has the strength and diversity to create momentum, but reaching California's goals will require leaders in state government, industry, and the public to adopt a shared path forward.

This Roadmap shows a path forward, giving the great State of California a plan to assertively, efficiently, and equitably decarbonize California's buildings. To propel California toward that goal, **we call on the Governor to establish and lead a Building Decarbonization Interagency Task Force and direct the Task Force to:**

- Reaffirm the targets and goals of this roadmap,
- Coordinate the actions identified here,
- Provide the essential leadership needed to decarbonize California's building sector.

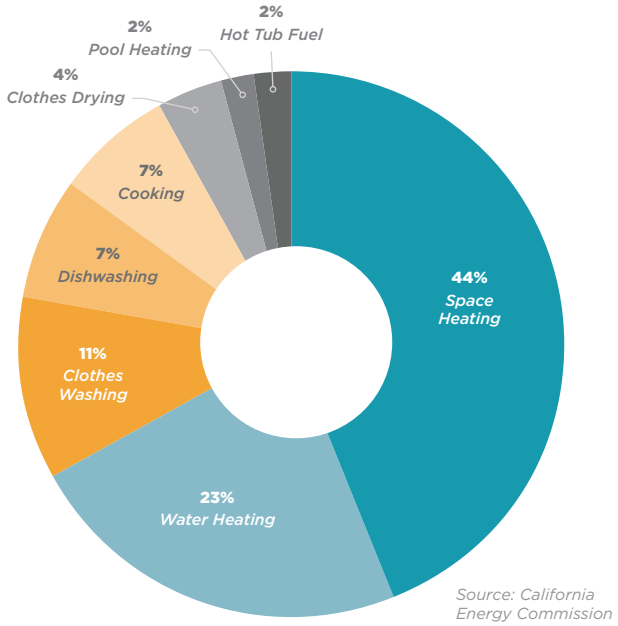
2 Energy and Environmental Economics (E3), June 2018, Deep Decarbonization in a High Renewables Future, Prepared for the California Energy Commission, Available at: https://www.ethree.com/wp-content/uploads/2018/06/Deep_Decarbonization_in_a_High_Renewables_Future_CEC-500-2018-012-1.pdf.

BUILDING DECARBONIZATION TARGETS

In order to reduce carbon emissions from the building sector to support California's overall emission reduction goals, California must enable the:

Building sector to be decarbonized no later than 2045

SHARES OF RESIDENTIAL GAS USE BY END USE



What does this target entail? In 2016, California's buildings were responsible for directly emitting 37 MMt of greenhouse gases.[3] The residential sector contributed 24 MMt, the commercial sector 13 MMt.[4] Over 65% of building emissions result primarily from space and water heating in existing buildings. Any new building construction between 2019 and 2045 that relies on fossil fuels for space and water heating represents incremental emissions, deepening the challenge of decarbonizing the sector.

Setting individual decarbonization targets for new buildings and existing residential and commercial buildings, will allow for more strategic targeting of actions, policy and investment.

NEW BUILDINGS

California can begin harvesting its relatively low-hanging fruit through the adoption of Zero Emissions Building Codes at both the state and local level. A Zero Emissions Building Code requires buildings do not emit greenhouse gases from on-site sources. Through these requirements, as grid energy increasingly gets cleaner and local renewable energy sources are developed, new buildings will begin to rely exclusively on clean energy. The following target should be adopted:

Zero Emission Building Codes will be adopted for the residential and commercial sectors by 2025 and 2028, respectively.

This target aims to accomplish three important threshold steps.

- Stop digging the hole: a third of California's 2045 building stock will be built between now and then. New buildings which rely principally on fossil fuels for heat, hot water, cooking or drying clothes undermine carbon emissions goals.
- Save money: New, decarbonized, all-electric buildings cost less to build to code than those requiring additional gas infrastructure.[5]
- Seed the market for retrofitting existing buildings: Zero Emissions Building Standards send a clear signal to critical industry stakeholders, including manufacturers, architects, real estate agents, builders and contractors: zero emissions buildings are worthy of your valuable time, attention and capital — begin investing in building decarbonization now.

This target recognizes adoption and implementation of Zero Emission Building Codes in the commercial sector will be a greater challenge than the residential sector due to size and technological complexity. By sequencing them with adoption of residential codes in 2025 followed by commercial codes in 2028, insights and momentum can be carried forward, easing the challenge of the commercial sector.

3 California Air Resources Board, 2018, Greenhouse Gas Emission Inventory - Query Tool for years 2000 to 2016 (11th Edition), Available at: https://www.arb.ca.gov/app/ghg/2000_2016/ghg_sector.php. Includes distillates, kerosene, liquified petroleum gas, natural gas, and wood.

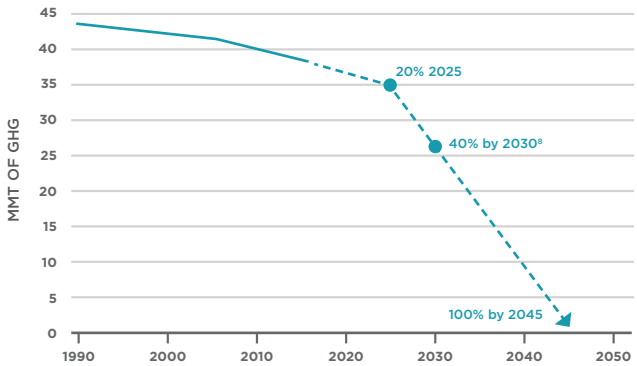
4 *ibid*

5 Rocky Mountain Institute. (2018). The Economics of Electrifying Buildings

EXISTING BUILDINGS

The largest sources of emissions within existing buildings are space and water heaters. These are appliances that are typically powered by fossil fuels and last between 8 and 20 years, providing scarce opportunities to impact whether a customer chooses a like-for-like fossil fuel replacement or an electric alternative. A progressive approach to replacing these appliances with zero-emission alternatives over time will balance the need for progress and affordability with the languid speed of appliance turnover. The following building decarbonization targets should be the starting points to determine how to strike this balance while achieving California's goals:[6]

DECARBONIZATION OF THE BUILDING SECTOR[7]



Equally important to reducing emissions from the building sector is ensuring that the buildings are efficient at retaining conditioned air and preventing air infiltration. These challenges are addressed by existing California energy efficiency targets. This Roadmap underscores those targets, but does not repeat them.

MARKET SHARE TARGETS FOR UNDERLYING TECHNOLOGIES

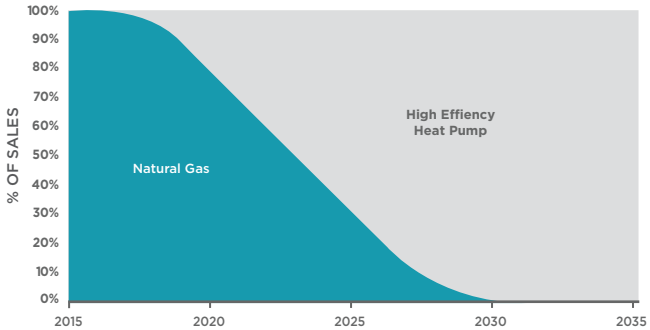
Reaching the recommended targets in new and existing buildings implies the underlying technologies achieve progressively greater market share over time and that there is a rising consumer demand based on innovative business models and technologies that deliver both customer and carbon value over time. In its 2018 analysis, the California Energy Commission found that "to decarbonize heating demands in buildings through a transition to electric heat pumps, without requiring early retirements of functional equipment, this transition must start by 2020 and achieve significant market share by 2030... new heat pump sales must represent no less than approximately 50% of new sales of HVAC and water heating equipment by 2030."[8]

Informed by this analysis, California should strive to move faster with the following target market shares of sales for underlying technologies:

PERCENT OF NEW SALES BY TECHNOLOGY TYPE FOR RESIDENTIAL SPACE HEATING AND WATER HEATING IN THE HIGH ELECTRIFICATION CASE (2015-2050)

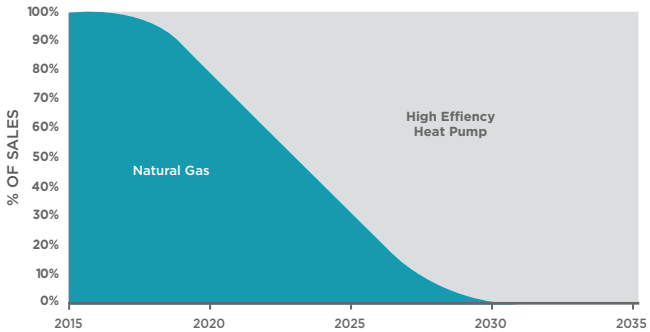
Space Heating

Increase the share of high efficiency heat pumps for space heating from 5% of sales in 2018, to 50% in 2025 and 100 % in 2030.



Water Heating

Increase the share of high efficiency heat pumps for water heating from 1% of sales in 2018, to 50% in 2025 and 100 % in 2030.



These targets are grounded in E3's analysis and recommendations, but accelerated by 5 years to reflect the imperative of decarbonization by 2045.

6 Data sourced from California Air Resources Board's "California 1990 Greenhouse Gas Emissions Level and 2020 Emissions Limit" (2007); and Greenhouse Gas Emission Inventory.

7 Assembly Bill 3232 (Friedman, 2018) requires the California Energy Commission by January 1, 2021, to assess the potential for the state to reduce the emissions of greenhouse gases from the state's residential and commercial building stock by at least 40% below 1990 levels by January 1, 2030.

8 Energy and Environmental Economics (E3), June 2018, Deep Decarbonization in a High RenewablesFuture, Prepared for the California Energy Commission.

Unless the sales numbers above are reached GHG-emitting appliances will likely still be used past 2045.

In addition, the economics of decarbonizing California's buildings depend heavily on one key factor: avoiding the cost of serving buildings with fossil fuels, especially natural gas in new construction. While cooking, clothes drying, and fireplaces may make marginal contributions to overall emissions, electrification of these measures must be accomplished to achieve desired cost savings.

Overall, these targets reflect dramatic, urgent increases in building decarbonization needed to support California's emission reduction targets.

In the following section, the Roadmap identifies some of the primary barriers to achieving progress toward and ultimately reaching these targets, followed by associated goals and principles to address those barriers.

BARRIERS, GOALS AND PRINCIPLES OF DECARBONIZATION

Between California's business as usual and its goals lie key barriers which must be overcome. These barriers include: low awareness and interest in building decarbonization measures, low perceived customer value, low perceived contractor and builder value, low availability, and misaligned policy.

LOW AWARENESS AND INTEREST	Currently there is a critical lack of awareness of and interest in decarbonized technology for residential and commercial buildings. Contributing factors include: • Lack of mainstream customer education on the health benefits and economic benefits of electrification of equipment and appliances • Lack of coordination among supportive organizations (e.g., policymakers, local governments, research institutions) • Lack of coordination with similarly focused initiatives, like the California Solar Initiative or promotion of electric vehicle adoption
LOW PERCEIVED CUSTOMER VALUE	Customers do not see a clear value proposition. Contributing factors include: • Lack of incentives encouraging customer adoption • Lack of financing solutions to help customers manage up-front costs • Lack of coordination with existing building weatherization support programs • Lack of paths to market for electric load shift enabled by heat pumps • Lack of customer bill savings in some utility service territories at current electric and gas rates • Lack of markets to monetize grid and climate values
LOW PERCEIVED CONTRACTOR AND BUILDER VALUE	Like customers, contractors and builders do not see a clear value proposition. Contributing factors include: • Lack of incentives encouraging builders to construct carbon-free structures • Lack of training for builders and contractors • Lack of recognition for builders and contractors promoting building decarbonization • Lack of coordination and support for local government permitting offices • Lack of adequate measurement and valuation of GHG emissions • Lack of consumer demand
LOW AVAILABILITY	Building decarbonization solutions are not readily available. Contributing factors include: • Lack of adequate electrical paneling at many homes and businesses • Lack of relevant, supportive appliance standards • Lack of coordination at a national-level necessary to induce increased manufacturing
MISALIGNED POLICY	Existing policy and codes support an outdated view of the energy landscape in California that does not reflect existing GHG priorities. Contributing factors include: • Lack of alignment between the state's goals, utility incentives, policies, programs and metrics • Lack of a plan for transitioning away from California's legacy infrastructure in a responsible and cost-effective manner • Lack of support for local governments who would adopt reach codes

To reach California's emission reduction targets, these barriers must be overcome. This Roadmap matches each of these barriers with a goal, thereby inverting a negative to a positive.

GOAL 1
Customers, builders, contractors and policy-makers are **aware of and demand** building decarbonization measures.

GOAL 2
Customers receive a good value from adopting building decarbonization measures.

GOAL 3
Building decarbonization provides a **better value to builders and contractors** than fossil-fuel heating.

GOAL 4
Supply-chains and delivery agents are **able to meet rising demand** for carbon-free building technologies with a quality product.

GOAL 5
Policies are aligned to maximize customer awareness of and interest in building decarbonization, the customer, builder and contractor value proposition, and the industry's ability to meet rising demand.

This Roadmap recognizes success requires more than just achieving the goal — it matters very much how California achieves the goals. The following principles will guide how California's goals are pursued.

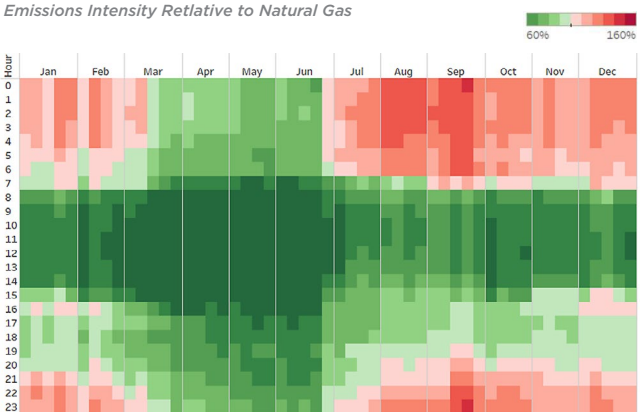
EQUITABLE AND AFFORDABLE: Deliver building decarbonization **equitably and affordably to all communities** to prevent disproportionately burdening customers least likely to be able to overcome the awareness and capital costs barriers.

ALIGNED: All stakeholder (customer, contractor, utility, agency, manufacturer) value propositions for building decarbonization must be r**ecognized and aligned** to achieve the speed and scale of transition California needs.

GRID FRIENDLY: Ensure building decarbonization solutions serve **as a benefit to the grid**, especially the need to reliably integrate renewable energy into California's power supply at least cost.

BUILDING PERSPECTIVE: 2030

Emissions Intensity Retlative to Natural Gas



Source: California Energy Commission

The emissions intensity of electricity varies by season and time of day. This figure shows the relative emissions intensity of electricity consumption compared to natural gas use. For Building Decarbonization to fully realize its potential as a reducer of emissions, measures need to use electricity when the emission intensity of the energy is low (green) instead of when it is high (red).

FORWARD THINKING: Transform the building heating market through **forward-thinking, long-term commitments** and investments, avoiding the uncertainty and churn of start-stop programmatic cycles, and working in concert with decarbonization of other sectors of the economy.

DATA-DRIVEN: Measure marginal carbon values correctly and send a price signal to ensure the actions taken to decarbonize buildings are **data-driven** and produce the results they are intended to.

INNOVATIVE: Let California's **innovators design the business models** to meet the need. Keep it simple and do not micromanage.

These principles — equitable, affordable, aligned, grid friendly, forward-thinking, data-driven, and innovative — will serve to ensure pursuit of building decarbonization avoids unnecessary pitfalls and is done with integrity.

TAKING ACTION

California can begin pursuing the targets and goals identified here immediately. In this section we identify specific actions to overcome each of the main barriers to building decarbonization and achieve the goals of this Roadmap.

GOAL 1

*Customers, builders, contractors and policy-makers are **aware of and demand** building decarbonization measures.*

A. Launch a marketing campaign to raise awareness and increase interest in building decarbonization.

B. Create a network of local governments, professional and community-based organizations to promote decarbonization, ensuring diversity in messaging and language.

C. Build partnerships between solar, storage, and electric vehicle vendors and associations to promote co-benefits and form national partnerships where necessary.

GOAL 2

***Customers receive a good value** from adopting building decarbonization measures.*

A. Create a strategic long-term (≥ 10 years) incentive program resulting in market transformation with sensitivity to customer bill impacts. Program design modeled after similar successful programs, especially the California Solar Initiative and Prop 39.

B. Develop and launch low-cost, easily accessible financing options for building owners to access and contractors to sell. Where financing programs initially rely on public or ratepayer funds, a transition schedule toward private capital should be identified to allow for scale.

C. Adopt policies that ensure attractive, stable, and affordable electricity rates, as well as all-electric rates with appropriate baselines and other designs to ensure adoption and effective use of building decarbonization measures.

D. Re-align low-income weatherization and efficiency programs to focus on GHG emissions, utility bill reduction, health, comfort and rapid deployment of measures through a comprehensive program of outreach, technical assistance, bulk purchasing, and subsidized

installation based on performance and contractor training.

E. Monetize building decarbonization measures as grid integrated solutions to address and support grid needs through participation in demand management programs, such as the California Public Utilities Commission's Load Shift Initiative.[9]

GOAL 3

*Building decarbonization provides a **better value to builders and contractors** than fossil-fuel heating.*

A. Produce midstream incentive programs for commercial and residential builders offering decarbonized new buildings and installers offering electric retrofits. Begin with expedited implementation of SB 1477.

B. Support builders' move to decarbonization through policies, programs, permitting and other solutions.

C. Support contractors' move to decarbonization through policies, programs, permitting and other solutions. Create and maintain a centralized resource for contractors to access information on best practices, technology, and programs. Deploy a building electrification professional designation.

D. Create a statewide program to voluntarily certify buildings and developments to recognize and promote builders and contractors supporting decarbonization.

E. Launch a statewide campaign with local governments to offer supportive policies for building decarbonization measures.

GOAL 4

*Supply-chains and delivery agents are **able to meet rising demand** for carbon-free building technologies with a quality product.*

A. Offer a statewide electric panel upgrade program, developed in cooperation with efforts to promote electric vehicle adoption and strategically focused to provide greatest grid and ratepayer benefit.

B. Develop an aggressive, national level campaign among policy makers to emphasize the need for massive increases in sales volumes for heat pump technology.

C. Produce industry-leading voluntary appliance standards for technologies to ensure quality,

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9 Load Shift Working Group Initiative, https://gridworks.org/initiatives/load-shift-working-group/

co-benefit achievement, durability and other desired factors. Reward products and manufacturers that meet the standards through bulk purchasing contracts through State procurement, incentives, recognition and other measurers.

GOAL 5
Align Policy

A. Align program and agency metrics focused exclusively on reducing electricity consumption with metrics focused on reducing emissions, saving energy, promoting equity and benefiting the grid in state legislation and regulation, utility and community choice aggregator programs and local government activities.

B. Support the opening of necessary CPUC proceedings to evaluate, design and implement measures to provide a just and safe transition away from the natural gas system.

C. Support local governments adopting building decarbonization policies.

These actions constitute a comprehensive approach to pursuing the targets and goals of this Roadmap. However, in many cases these actions are interdependent, demanding close coordination across a wide range of stakeholders. The following figure identifies stakeholders critical to the most urgent nine actions of the Roadmap.

It is the diversity of interests identified in this figure which underscores a key recommendation of this Roadmap: **we call on the Governor to establish and lead a Building Decarbonization Interagency Task Force and direct the Task Force to:**

- Reinforce the Targets and Goals of the Roadmap,
- Coordinate the Actions identified here,
- Provide the essential leadership needed to decarbonize California's building sector.

NEAR-TERM PRIORITY ACTIONS AND STAKEHOLDERS CRITICAL TO THEIR SUCCESS

KEY INITIATIVES	*Building Decarb Coalition*	*Utilities*	*CCAs*	*Manufacturers*	*CEC*	*CPUC*	*Local Governments*	*Workforce Associations*	*Environmental NGOs*
1 GENERAL MARKETING CAMPAIGN	●	●	●	●			●		
2 STRATEGIC LONG TERM CUSTOMER INCENTIVES		●	●			●			●
3 BUILDING ELECTRIFICATION FINANCE	●	●	●						
4 MIDSTREAM INCENTIVE PROGRAMS FOR BUILDERS		●	●			●	●		●
5 BUILDER SUPPORT THROUGH INQUIRY, ASSISTANCE, AND POLICY	●	●	●		●		●	●	●
6 VOLUNTARY CONTRACTOR SUPPORT AND ACCREDITATION PROGRAM	●	●	●	●	●			●	
7 ELECTRICAL PANEL UPGRADE AND SERVICE INNOVATION PROGRAMS	●	●	●				●	●	
8 LEGACY SYSTEM EVALUATION	●	●				●			
9 REACH CODE SUPPORT	●	●	●		●	●	●		●

CASE STUDIES: CALIFORNIA TACKLES BIG PROBLEMS

This Roadmap has identified targets, barriers, goals and actions to decarbonize California buildings by 2045. These are unabashedly ambitious targets and substantial challenges. But none of that is new to California, a state which has shown itself willing to tackle big problems over and over again. The following case studies show examples of California overcoming these same barriers, demonstrate that progress toward these targets and goals has already begun, and resinspire the leadership needed to implement this roadmap.

CALIFORNIA DECARBONIZATION CASE STUDIES

The below are three cases of policy intervention that helped to address a significant barrier to enable decarbonization. These examples demonstrate that effective public policy can come in many shapes and sizes, and that a variety of stakeholders will need to coordinate in different ways in order to overcome often complex, inter-connected barriers to growth.

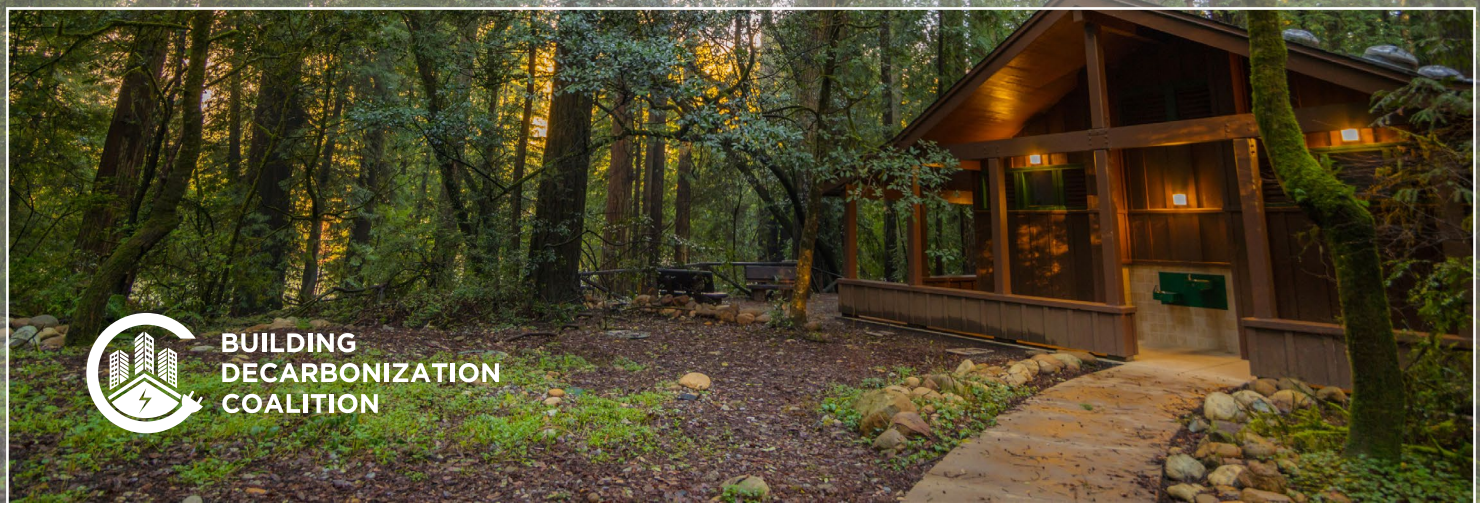
BARRIER	Low Customer Value Proposition	Low Builder Value Proposition	Low Availability
CASE STUDY	**California Solar Initiative** 10-year, $2 billion state program that offered incentives for solar installations on a per kW basis	**City Ventures** Home builder focused on low emissions housing development including townhomes, live/work lofts, condominiums, and detached single-family homes.	**Electric Panel Upgrades and Infrastructure for Electric Vehicles** IOUs are offering rebates for electric vehicle charging infrastructure, including electrical panel upgrades
ACTION	Customers offered incentives to adopt solar PV based on the size of the installation or the performance of the system. Incentives were incrementally stepped-down as total MW of solar were installed in the state. This led to innovative product offerings based on performance of installations that drove quality and production. Net metering allowed customers to reduce their electric bills in line with the production of their system. While not without controversy, the policy was central to California's observed transformation of the rooftop solar industry.	Three types of green home packages are available: all-inclusive green, solar all-electric, and solar + gas. All options are 15% more efficient than Title 24 requirements and feature products from partner vendors such as SunPower (solar PV), Nest (smart thermostats and home security), EnergyStar (appliances), Milgard (windows), and Kohler (faucets and showerheads)	SCE residential customers are reimbursed up to $1,500 for electrical panel upgrades, provided the work is performed by a certified electrician and the customer enrolls in a time of use rate. For commercial customers, IOUs offer reimbursements for customer-owned infrastructure (similar to SCE's residential program) and/or the IOU may pay for, install, own, and operate charging infrastructure.
OUTCOME	At the end of 2017, over 6,000 MW were installed at over 725,000 sites throughout California. The CSI program jump-started a successful transition to market. Solar PV scaled based on private investment in cash flows based on the alignment of performance risk through innovative product offerings and access to low-cost capital markets through project finance.	City Ventures has built over 2,700 homes throughout California and more than 2,000 of them are all-electric.	About 370 projects are underway for over 4,600 charging ports across IOU territories. 35% of projects are in disadvantaged communities, 32% are multi-family dwellings and 60% are workplaces.

CONCLUSION

For California to meet its climate goals, homes and buildings must be decarbonized. This Roadmap provides two of the three key ingredients to a dedicated pursuit of that goal: a path forward and a coalition of the willing. The path forward calls for clear, ambitious targets and coordinated actions directed at key barriers to progress.

The Building Decarbonization Coalition, consisting of energy providers, public interest advocates, manufacturers, contractors, unions, builders, local governments, real estate interests and investors spanning California's building community, stands ready to support the effort.

Together this Roadmap and Coalition has the strength and diversity to create momentum, but reaching California's goals will require leaders in state government, industry, and the public to join together to chart the course and take action. To gain that engagement California needs a critical third ingredient: visionary leadership from Governor Newsom. Governor Newsom can help California and the world unlock a better way of life, and buildings hold a critical key.



BUILDING
DECARBONIZATION
COALITION