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NRDC, Earthjustice, EDF Joint Comments on AB 3232 Assessment Scope

Additional submitted attachment is included below.

Comments of the Natural Resources Defense Council (NRDC), Earthjustice, and the Environmental Defense Fund (EDF) on the Building Decarbonization Assessment Scope

Docket Number 19-DECARB-01

January 10, 2020

Submitted by:

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The Natural Resources Defense Council (NRDC), Earthjustice, and Environmental Defense Fund (EDF) appreciate the opportunity to comment on the Building Decarbonization Assessment Project Scope. NRDC is a non-profit membership organization with more than 95,000 California members who have an interest in receiving affordable energy services while reducing the environmental impact of California's energy consumption to avoid the worst impacts of the climate crisis. Earthjustice is the nation's largest nonprofit public interest environmental law organization with approximately 250,000 supporters in California dedicated to creating a sustainable, clean energy future. EDF is a non-profit membership organization with over 400,000 active members in California in every major electric and gas utility service territory.

I. Introduction

California has set ambitious goals to reduce greenhouse gas emissions across all economic sectors and achieve carbon neutrality by 2045. Addressing the greenhouse gas impact of residential and commercial buildings is critical to achieve long-term climate goals; residential and commercial buildings account for approximately 25 percent of the state's climate footprint.[1] To advance statewide efforts to address building carbon emissions, the California Assembly passed Assembly Bill 3232 (AB 3232).

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[1] AB-3232 Zero-emissions buildings and sources of heat energy, https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180AB3232

AB 3232 requires the California Energy Commission (the Commission) to assess the potential to reduce greenhouse gas (GHG) emissions from residential and commercial buildings by at least 40 percent below 1990 levels by January 1, 2030. The Commission will produce a report, "The Building Decarbonization Assessment" ("the Assessment"), to evaluate the cost effectiveness of strategies to decarbonize buildings. This planning effort is critical to enable the transition to a zero-emission building sector in a manner that is the most economically beneficial, equitable, and fair for workers. While numerous policy efforts address the greenhouse gas impact of electricity generation and transportation energy use, the Assessment will serve as the first comprehensive policy analysis of the GHG reduction potential from energy use in buildings, and will guide the transition of California's building sector to clean energy and the necessary grid infrastructure planning to support this transition.

A. NRDC, Earthjustice, and EDF generally support the Commission's proposed baseline greenhouse gas emissions for the Assessment, with the exception that upstream methane emissions should be included.

NRDC, Earthjustice, and EDF support the Commission's proposal to include in the Assessment "core" GHG emissions in buildings (emissions from fuel combustion and high global warming potential gases), incremental electricity emissions from fuel substitution, and behind-the-meter methane leaks. The Commission proposes to exclude electricity emissions already included in the 1990 baseline, and upstream methane emissions (production, transmission, distribution and meter).

Core building emissions are one of the biggest gaps in the state's climate policies: current policies such as appliance and building energy efficiency standards and programs provide incremental energy savings but fall far short of the scale and pace necessary to achieve a carbon-neutral building sector by 2045, or even reduce emissions by 80 percent by 2050. The former is necessary to keep global temperature rise below 1.5 degrees C by 2050 and prevent the worst outcomes of the climate crisis. California needs a clear blueprint for how it can reduce core building emissions in line with its climate and clean energy goals.

NRDC, Earthjustice, and EDF also support the Commission's approach of including increased electricity emissions from fuel substitution activities. This will accurately reflect the emissions impact of fuel switching on electricity emissions and account for any growth in

emissions. Including electricity emissions from fuel substitution (i.e. increased electricity use from heat pumps replacing gas systems), but not those that were already included in the 1990 emissions baseline (i.e. air conditioning, lighting, and plug load energy use) is the correct approach because AB 3232 aims to reduce net emissions from buildings.

B. The Assessment should evaluate the potential to achieve carbon-neutrality in buildings by 2045, in addition to the AB 3232 target of 40 percent by 2030

AB 3232 says the Assessment should evaluate the ability to reduce emissions "at least 40 percent below 1990 levels by January 1, 2030."[2] The law does not limit the Commission's assessment to 2030 and allows the Commission to assess a target higher than 40 percent. Given Executive Order B-55-18, which requires carbon-neutrality by 2045, AB 3232 should extend the assessment to quantify how 2045 carbon-neutrality goal can be achieved in the building sector. Limiting the assessment to 2030 reduction goals could lead to pathways that are not scalable or cost-effective for meeting the 2045 goals. For example, allocating scarce and expensive biogas supplies to buildings, combined with limited electrification may achieve 2030 goals, but would not provide a scalable path to longer-term goals. Strategies and actions put in place before 2030 are vital to enable achievement of long-term climate goals. Assessing the impact of strategies to achieve the 2045 target of carbon neutrality will ensure current action aligns with longer-term goals.

C. The Assessment should evaluate the pace and scale of transformation required in the heating and hot water market to achieve the AB 3232 goal, set out a framework to achieve such market transformation, and evaluate policies—including investment level and timing—necessary to transform the market from gas-fired to efficient electric-powered equipment.

Achieving 40 percent emissions reductions across the entire building sector by 2030 is a necessary but ambitious goal that requires retrofitting many existing buildings to high efficiency electric heating, ventilation, and cooling (HVAC) and water heating equipment. Such equipment has a lifecycle of 10 to 20 years, sometimes longer, which means that most natural equipment

[2] https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180AB3232

replacements during that period will need to be efficient electric models. It is important to understand how quickly the market share of the electric alternatives to the main gas equipment types needs to increase to achieve the AB 3232 goal. NRDC, Earthjustice, and EDF recommend that the Assessment explicitly evaluate the pace and scale of market transformation needed in space and water heating equipment needed to achieve AB 3232's 2030 goal.

The Assessment should set out a framework to achieve market transformation. Ultimately, achieving market transformation at the pace and scale needed will require performance standards, i.e. policies that set minimum requirements for energy, greenhouse gas emissions, criteria pollutants, or other performance metrics for buildings and appliances. Examples of such policies include building codes for new buildings, performance standards for existing buildings, federal and state appliance efficiency standards, or air district nitrogen oxides (NOx) standards for combustion appliances, etc. Such policies are the most cost-effective and equitable, and the most scalable. However, they can only be implemented for a particular equipment type and market when they are cost effective and there is sufficient market capacity to support performance standards. Therefore, the role of the market development phase is to prepare the market for performance standards. This is typically accomplished through financial incentive programs paired with workforce and vendor development, which accelerates market deployment of key technologies.

The Assessment should then evaluate policies—including investment level and timing—necessary to achieve these market development milestones. We provide further information on the major equipment types and conversion pathways that require focused market transformation efforts in response to question #7.

D. Evaluate equity and workforce impacts and benefits of all strategies and actions.

NRDC, Earthjustice, and EDF strongly support the Commission's plan to identify the challenges to reducing emissions in low-income housing and further suggests the Assessment consider the equity implications of proposed strategies and actions. There are equity implications of most, if not all, strategies that reduce building emissions. Key issues include the equitable distribution of public money, protecting low-income renters from displacement following building upgrades, and protecting low-income customers from being stranded on an increasingly unaffordable gas system. NRDC, Earthjustice, and EDF recommend, in addition to assessing the

impacts of strategies on gas customers, construction costs, and grid reliability, that the Commission explicitly assess these potential impacts and benefits on low-income customers.

NRDC, Earthjustice, and EDF recommend the Commission also consider the labor implications of different building emissions reduction strategies. Building decarbonization will increase demand for high-skilled, well-paid workforce in some sectors, while the gas system transition could reduce the existing gas workforce in the long-run.[3] In the Assessment, the Commission should consider how to advance and encourage high quality jobs while reducing GHG emissions.

Responses to Questions

1. **The legislation calls for a building decarbonization assessment for 2030. Should CEC staff also include a review of feasibility for California's 2045 zero-carbon goals?**

NRDC, Earthjustice, and EDF recommend the Assessment review how strategies and actions track towards meeting both AB 3232's 2030 goal and the feasibility of fully decarbonizing the building sector by 2045, in line with Governor Brown's Executive Order B-55-18 of economy-wide carbon neutrality by 2045. AB 3232 requires the Commission to assess the potential to reduce emissions by "at least" 40 percent below 1990 baseline levels by 2030. The Commission can, and should, also evaluate how policies needed for AB 3232 align with California's 2045 goal of carbon neutrality (EO B-55-18).

AB 3232 policies and targets should put California on a trajectory that is the most likely and most affordable way to achieve 2045 climate goals. If we ignore the long-term trajectory, we risk pursuing strategies that are not scalable economically. For example, bio- and synthetic gas can provide some GHG reductions, but current evidence suggests they cannot achieve full decarbonization of buildings in an affordable manner. Another reason for aligning the 2030 target with California's 2045 carbon-neutrality goal is that climate impacts are driven by cumulative emissions, not just the emissions achieved in 2045 or even 2030. It is critical to

[3] Jones, Betony, et al. "California Building Decarbonization Workforce Needs and Recommendations." *UCLA Luskin Center*. November 2019.

achieve emissions reductions as soon as possible, and at a minimum on a linear trajectory to carbon-neutrality by 2045, if not earlier.

2. **Is the proposed baseline recommendation the best approach for the Assessment? Why or why not?**

The Assessment will be the most actionable, strategic, and impactful if it focuses on core emissions. Electricity emissions included in the 1990 baseline are already being addressed through a variety of other policies and programs, particularly clean electricity requirements mandated by SB 100, and doubling energy efficiency savings required through SB 350. Combining these emissions with core building emissions would dilute the AB 3232 goal and distract from the biggest gap that needs to be addressed. For example, including electricity emissions in the AB 3232 baseline would count the major renewable energy advances in the electricity sector toward AB 3232's 40 percent target, making it achievable with only minor reductions in core emissions by relying on existing policy while actually failing to reduce direct emissions from buildings.

Reducing emissions from a baseline that includes both direct building emissions and electricity emissions is insufficient to meet 2045 goals, as shown in Figure 2 below. To be on track to meet carbon neutrality targets by 2045, California needs to reduce building emissions 62 percent below 1990 by 2030. Setting a target of 40 percent emission reductions by 2030 would be weaker than the business-as-usual existing policy scenario and falls short of 2045 targets.

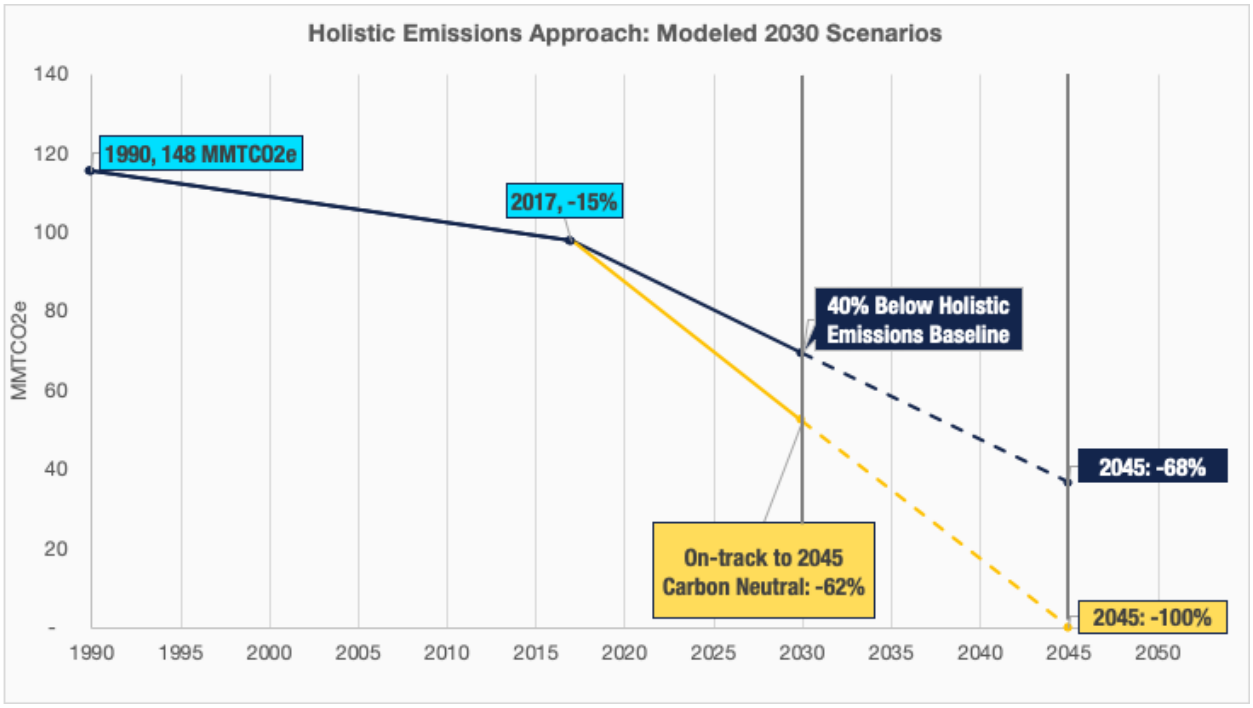

Figure 2. Holistic Emission Analysis: Modeled 2030 Scenarios

Setting the baseline and 40-percent target to include direct and incremental emissions from electrification would put California on track to achieve carbon-neutrality in buildings by 2045, as shown in Figure 3 below.

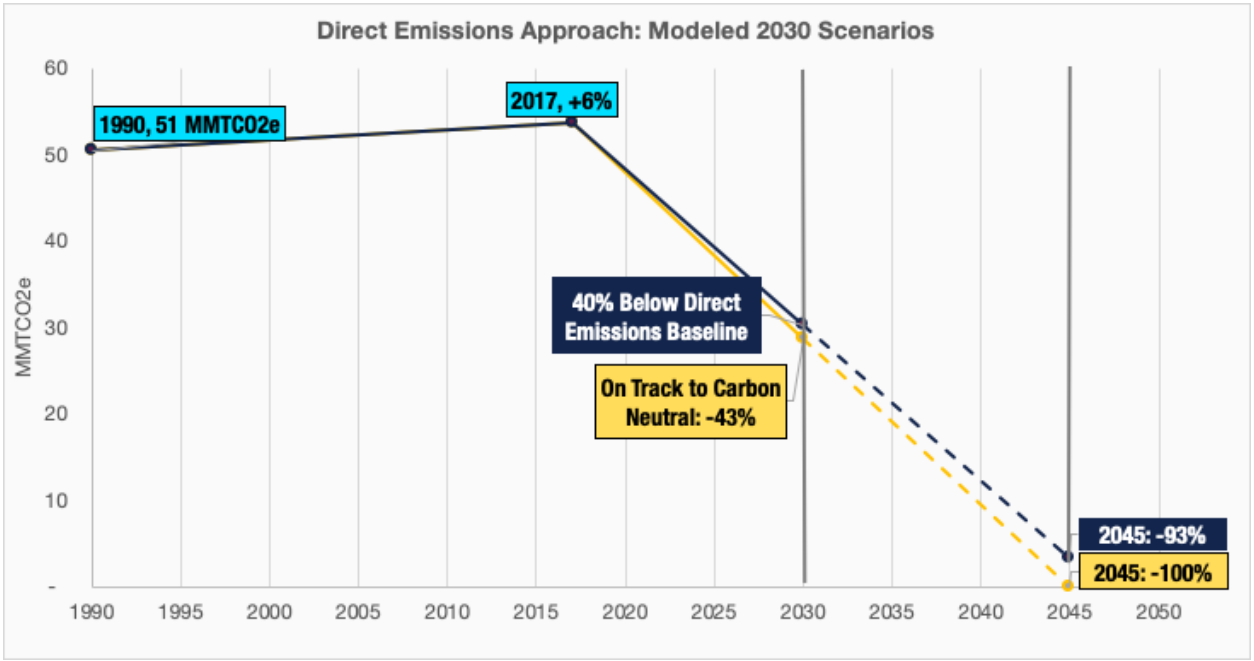

Figure 3. Direct Emissions Approach: Modeled 2030 Scenarios

Upstream methane emissions should either be included in the baseline in the initial assessment with a reasonable estimate of their impact, or the Assessment should create a working group to develop a methodology that will enable their inclusion.

Upstream emissions include fugitive methane emissions all the way along the gas supply chain, from wellhead to processing, compressor stations, transmission, distribution, and meter. This must include out-of-state emissions since California imports 90 percent of the gas it uses, and the majority of fugitive emissions for gas used in California occurs at production and processing, therefore mostly out-of-state. Out-of-state emissions from power generation for electricity used in California are included in CARB's emissions inventory. Out-of-state emissions from gas use should also be included for an accurate assessment of emissions impacts of each energy source. The California legislature passed AB 2195 (Chau, 2018) requiring that out-of-state emissions from gas use be quantified and published annually. The primary purpose of such a requirement is to enable such emissions to be considered in California's energy policies, such as in this Assessment.

Upstream methane emissions are a significant contributor to the climate impacts of gas use in buildings. NRDC's analysis indicates that accounting for out-of-state fugitive methane emissions increases the greenhouse gas impacts of building energy use from 97 million metric tons CO2-equivalent up to 148 million metric tons CO2-equivalent (a 53 percent increase), when using a 20-year global warming potential (GWP), which NRDC believes is a key timeframe over which to evaluate the impacts of fugitive methane, given the short time the world has to stave off the worst impacts of climate change.[4,5]

The uncertainty in how much methane reduction to attribute to gas use reduction should not prevent the inclusion of upstream methane leakage. Attribution is a valid question when including upstream emissions in demand-side policies: electrifying one home will not necessarily reduce upstream methane emissions by a share equivalent to the home's share of gas use: the same amount of gas leakage may still occur at the wellhead and along compressor stations and pipelines. However, electrifying at scale, i.e. millions of homes and buildings, will significantly reduce the number of new wells drilled, pipelines built or maintained in production,

[4] https://www.nrdc.org/experts/joe-vukovich/real-climate-impact-californias-buildings

[5] "Global Warming of 1.5°C, an IPCC special report on the impacts of global warming of 1.5°C", Oct. 2018

and therefore upstream leakage. Accounting for the impact of large-scale demand-side policy requires considering the impacts on the supply infrastructure, in the same way as long-run marginal (or "build" marginal) accounting does for emissions from electricity generation. Given that AB 3232 aims to make large reductions in building sector gas use, it is reasonable to assume these reductions will have a significant impact on the gas supply infrastructure, and to account for associated fugitive emissions. In the absence of a study that estimates gas supply infrastructure reductions associated with demand reduction scenarios, CEC could use a rough estimate as a starting point, such as a 50 percent attribution factor for upstream emissions. This is probably too low in the long-run as climate mitigation will likely require winding down much of the gas supply infrastructure, but it would be a more accurate approach than ignoring upstream emissions entirely. Alternatively, the agencies could set up a working group to develop a methodology to estimate upstream methane reductions in various gas demand reduction scenarios, building off the assessment required by AB 2195.

Even if other policies to mitigate upstream emissions at production, transmission and distribution level will also help, California has little to no direct influence on out-of-state emissions other than through demand reduction. Even within the state, while California's methane leakage policies are critical, they're realistically not 100-percent effective, leaving an important role for demand-side policies. Including upstream emissions in the baseline may affect the stringency of the goal, but it is nevertheless important because at 50 million metric tons CO2e in additional annual emissions (using 20-year GWP values), this pollution is a major part of the climate impact of gas use in California buildings, and cannot be ignored.

NRDC, Earthjustice, and EDF support the Commission's approach of including increased electricity emissions from fuel substitution activities. This will accurately reflect the emissions impact of fuel switching on electricity emissions and account for any growth in emissions.

NRDC, Earthjustice, and EDF recommend excluding emissions from refrigeration because they are not related to fuel substitution and are already addressed through refrigerant GWP policies. Staff proposes to not include residential use of nitrogen fertilizer on turf since they are outside of the scope of fuel substitution. NRDC, Earthjustice, and EDF agree and note that the same rationale applies to sources of refrigerant emissions related to refrigeration. As such we recommend the baseline does not include those emissions.

We support including refrigerant emissions from air conditioning because they are related to fuel substitution emissions, even though those emissions will occur regardless of fuel substitution for heating since most air conditioning is already electric-powered. It makes sense to include them in the Assessment because electrification of heating presents opportunities to reduce refrigerant emissions from air conditioning through the use of lower-GWP and lower-emissions technologies.

NRDC, Earthjustice, and EDF support including refrigerant emission associated with fuel substitution. As fuel substitution drives heat pump adoption, it will be essential to quantify and manage the impact of refrigerants. In particular, there is a risk of refrigerant leakage during installation, operation, and end-of-life disposal.[6] Climate benefits of heat pumps and fuel switching can be maximized by reducing refrigerant leakage. Refrigerant leakage can be managed with appropriate end-of-life disposal, installation standards, and regulations requiring the use of low-GWP refrigerants in appliances. Appropriate refrigerant management is driven by existing policies targeting short-lived climate pollutants such as SB 1383.

Additional emissions of high-global warming potential refrigerants should be evaluated as part of the assessment of electrification, but in most cases, we expect heat pumps to remain very advantageous.

HPWH have a relatively small amount of refrigerant, roughly equivalent to that of two refrigerators, and they are factory-charged and hermetically sealed, which makes the risk of operational leakage relatively low. Even in the worst-case scenario where HPWH refrigerant gets entirely released at end-of-life, GHG benefits from avoided methane combustion and leakage far outweigh the GHG emissions from HPWH refrigerant and result in significant net lifecycle climate benefits. However, given the large-scale market adoption of HPWH in California expected over the next decade, the high GWP of the most commonly used HPWH refrigerant, R134a, the availability of a low-GWP alternative (R1234yf, GWP 4), and the lack of policy on this issue, NRDC, Earthjustice, and EDF recommend California implements policies that will transition the HPWH market to low-GWP refrigerants in a timely manner.

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[6] Hopkins, Asa S., et al. "Decarbonization of Heating Energy Use in California Buildings." *Synapse.* October 2018. https://www.synapse-energy.com/sites/default/files/Decarbonization-Heating-CA-Buildings-17-092-1.pdf

Regarding space heating heat pumps, many California homes already have air conditioning or would adopt it anyway over the next two decades given the increase in frequency and severity of heat waves due to the climate crisis. In buildings that already have AC, the delta in refrigerant requirements for electrifying heating with heat pumps is **the additional amount of refrigerant** needed to meet the increment between the heating and the cooling load in a given unit (i.e. refrigerant charge scales with conditioning load, and whichever requires a higher capacity carries the day), including the consideration of how heating loads will decline as the climate warms over the coming decades in California. The assessment must be careful in attributing only this additional amount of refrigerant to electrification, not that which would have happened anyway.

NRDC, Earthjustice, and EDF's biggest refrigerant emissions concern comes from the replacement of gas rooftop units with **variable refrigerant flow (VRF) technology**, which is already seeing robust market adoption in commercial and large multifamily buildings due to its moderate cost and high efficiency. This technology presents a higher risk of leakage than sealed units because the refrigerant is piped throughout the building, with a large number of fittings between pipe segments, each of which can potentially leak. While installation quality standards can mitigate leakage risk, there is a lack of evidence that VRF installations leakage is minimal building stock-wide. There is also no technology pathway towards VRFs with very low-GWP alternatives that are needed for deep building decarbonization, and no regulatory pathway to VRFs with sub-750 GWP refrigerant in the short-term. There is a critical need for innovation and policy action to move the industry toward low-GWP VRF technology over the mid- to long-term.

3. **Staff has identified sectors and topics that will be assessed for impacts, challenges, and opportunities. Do you think this list is appropriate? What additional sectors or topics should be added to the scope of the Assessment?**

The proposed Assessment scope includes discussion of the opportunities, benefits and challenges of reducing emissions in low-income, multifamily, and high-rise housing, as well as in disadvantaged communities. NRDC, Earthjustice, and EDF recommend the Assessment also includes a discussion of ownership type such as owners vs. renters, because there are differences between ownership types that will limit or dictate what technologies and policies will apply.

4. **Building costs from substituting end-use appliances include direct and indirect costs. One example of indirect costs are fuel infrastructure costs, such as gas piping to and within buildings, and electric distribution systems. Which indirect costs should be included in this Assessment and what are sources for this information?**

Indirect costs associated with building electrification will vary depending on how the transition is managed: with appropriate load management and infrastructure planning, building electrification costs could be lower than in the current policy scenario. But without adequate planning and policy, gas infrastructure assets could be stranded, with low or no value while not fully depreciated. Electric distribution upgrade costs could also be higher than needed. Infrastructure planning and load management standards are critical to ensure building electrification delivers on its promise to transition California's buildings to clean energy at significantly lower costs than a current policy scenario.

The Assessment should draw on findings from both the 2019 Gridworks' study, "California's Gas System in Transition," and E3's 2019 draft report for the CEC "Natural Gas Distribution in California's Low Carbon Future," which demonstrate the risk of high costs associated with an unmanaged gas transition. The assessment should also consider EDF's report on stranded gas assets, which provides a foundation for how these costs can be contained but require active leadership from the Commission and other state agencies. These studies provide an estimate of baseline costs associated with the continued reliance on the gas system and costs of an unmanaged, voluntary transition to electrification. Costs and savings associated with the gas system include the potential to avoid stranded assets and new investments in gas infrastructure. Unmitigated transitions from gas to electricity could increase societal costs and lead to stranded infrastructure with an insufficient revenue to recover costs.

The Assessment should include, to the extent possible, the lifecycle costs and savings associated with electrification. NRDC, Earthjustice, and EDF recommend using estimates from E3's report, "Residential Building Electrification in California," to estimate lifecycle costs of residential electrification. E3's report includes estimated energy consumption data, energy costs, and capital and operating costs associated with installation. The Assessment could employ a similar methodology to estimate lifecycle costs of commercial building electrification.

The Assessment should estimate any incremental grid costs attributable to electrification, beyond investments necessary to enable electric vehicle adoption, wildfire risk mitigation, and AC loads. The electric system also has highly variable costs associated with fuel switching. There will need to be both customer-side building infrastructure investments—like panel upgrades, service upgrades, wiring upgrades, and load management technologies—as well as grid-wide investments to increase distribution capacity. However, there are multiple demands driving the need for increased grid investments. Growing AC loads due to climate change, wildfire-related grid shoring, and electric vehicle adoption will necessitate distribution upgrades. If fuel switching were the only driver of grid capacity needs, load increases would not likely require substantial new investment. The Assessment should attempt to include grid costs associated with electrification that exceed investments driven by EVs, wildfire upgrades, and growing AC demand.

Sources that include estimates of marginal grid costs due to electrification include studies by E3 and Synapse. In California's cooling-dominated climate zones, the electric grid is sized for peak summer air conditioning loads. E3's 2019 study, "Residential Building Electrification in California," finds an increase in winter electricity demand due to heat pump adoption remains lower than typical, summer peaks.[7] In addition, the 2018 Synapse study, "Decarbonization of Heating Energy Use in California Buildings," finds that grid costs vary based on the coincidence of new heating electricity loads with daily, peak demand. If new heating loads add flexibility and can absorb excess electricity generation during peak supply, electrification could increase grid efficiency and reduce costs system-wide.[8]

5. **The total costs to reduce or eliminate emissions from energy usage are uncertain. However, reducing or eliminating emissions will have cost impacts, at the individual and social level. Which cost-effectiveness tests should be included in this Assessment?**

The National Standard Practice Manual (NSPM) provides an unbiased and accurate framework for structuring cost-effectiveness tests to reflect policy requirements. NRDC,

[7] https://www.ethree.com/wp-content/uploads/2019/04/E3_Residential_Building_Electrification_in_California_April_2019.pdf

[8] https://www.synapse-energy.com/sites/default/files/Decarbonization-Heating-CA-Buildings-17-092-1.pdf

Earthjustice, and EDF recommend that the CEC follow the NSPM to develop a cost-effectiveness test for AB 3232. Specifically, NRDC, Earthjustice, and EDF recommend that any cost-effectiveness test applied in this assessment should adhere to the following principles to properly account for impacts of policies to reduce emissions on customers and society at large:

(1) **The test should account for costs and benefits incurred by the customer through the equipment lifecycle**: Customer lifecycle cost-effectiveness is necessary to identify the least-cost measures for customers on average over the lifecycle of measures under consideration. This should include gas bills as the cost of gas increases as projected in CEC's soon-to-be-published Future of Gas study.

(2) **The test should symmetrically account for the costs and benefits of decarbonization measures**. This means that if the program only accounts for GHG-related benefits of the program then it should also only account for the program cost of acquiring those GHG savings - which are the total costs of running the program (sum of administration and incentives costs). Conversely, if the test accounts for customer contribution to measure adoption, then it should also account for all the benefits a customer accrues from that spending including non-energy benefits like health, safety, and comfort.

(3) **The test should account for all environmental benefits incurred by society through the life of the measure**. These benefits should at a minimum include the benefits of reduced carbon and methane emissions, and the health benefits of reduced particulate matter emanating from gas combustion.

(4) **Long-term societal cost-effectiveness needs to enable the CEC to assess the cost and benefits of policies to achieve long-term goals such as carbon-neutrality by 2045, to determine how these goals can be attained at the lowest possible abatement cost**. The chosen cost-effectiveness test needs to thus compare the costs of a well-managed electrification strategy with the costs of alternatives to reducing emissions from the gas sector. These alternatives should at a minimum account for stranded gas infrastructure costs as estimated in the Future of Gas study, and cost savings from increased utilization of the electric system due to heating and hot water electrification loads.

(5) **The costs and benefits included in the test should be adjusted to account for technology and market learning curves**. Most cost-effectiveness studies are based on current equipment and technology costs, with some conservative rate projections, but

without market learning. AB 3232 costs needs to include realistic learning curves for equipment and installation (soft costs). Future rates need to reflect Future of Gas findings on gas rates. While both learning curves and rates are uncertain and difficult to project, we encourage CEC to avoid making overly conservative projections as those are more likely to be wrong and not lead to the best policy outcomes than best estimates from experts.

6. **What additional data, analyses, or studies should be reviewed as part of the Assessment? Please specify sources, and include links or electronic copies, if possible. Also, include a brief rationale on the relevance to the Building Decarbonization Assessment.**
    a. "California's Gas System in Transition." Gridworks. 2019. *https://gridworks.org/wp-content/uploads/2019/09/CA_Gas_System_in_Transition.pdf*
    This study analyzes cost, equity, workforce, and economic risks of declining gas demand in California and managing the gas transition can reduce negative impacts.
    b. Hopkins, Asa S., et al. "Decarbonization of Heating Energy Use in California Buildings." *Synapse*. October 2018. https://www.synapse-energy.com/sites/default/files/Decarbonization-Heating-CA-Buildings-17-092-1.pdf
    This study finds looks at the grid impacts and costs of electrification and finds costs vary significantly based on the coincidence of new heating electricity loads with daily, peak demand, energy efficiency measures, and load shifting.
    c. Jones, Betony, et al. "California Building Decarbonization Workforce Needs and Recommendations." *UCLA Luskin Center*. November 2019. https://innovation.luskin.ucla.edu/wp-content/uploads/2019/11/California_Building_Decarbonization.pdf
    This study estimates the employment impacts of building decarbonization to inform workforce planning and industry engagement.
    d. Aas, Dan, et al. "Draft - Natural Gas Distribution in California's Low-Carbon Future." *California Energy Commission.* October 2019. https://ww2.energy.ca.gov/2019publications/CEC-500-2019-055/CEC-500-2019-055-D.pdf

This study assesses the role of the natural gas distribution system as California works towards achieving its climate goals.

e. Mahone, Amber, et al. "Residential Building Electrification in California." E3. April 2019. https://www.ethree.com/wp-content/uploads/2019/04/E3_Residential_Building_Electrification_in_California_April_2019.pdf
This study analyzes the costs and benefits, environmental footprint, and grid impacts of electrifying existing, residential buildings in California.

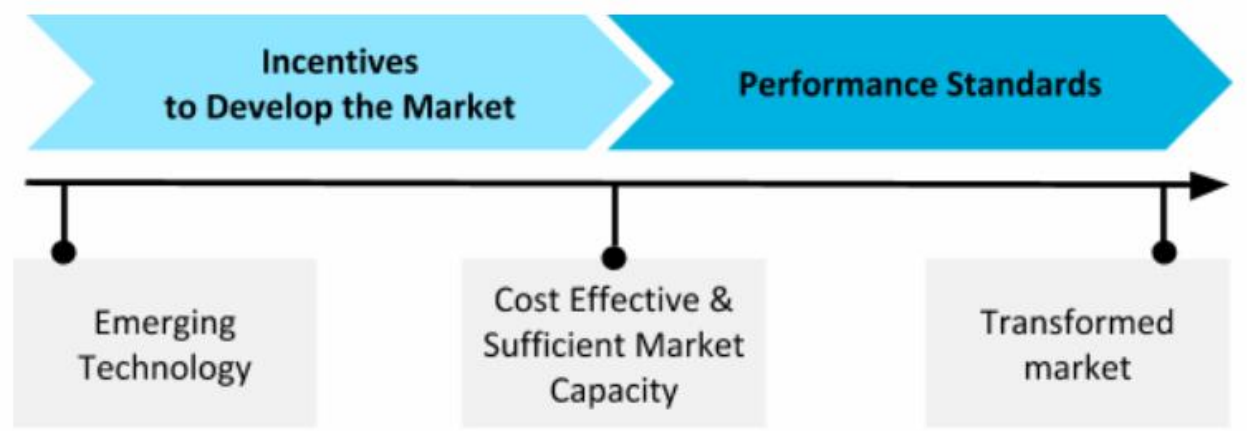
7. What strategies or actions should be analyzed as options for reducing GHG emissions in the building sector?

The Assessment should evaluate the pace and scale of transformation required in the heating and hot water market to achieve the AB 3232 goal, set out a framework to achieve such market transformation, and evaluate policies—including investment and timing—necessary to transform the market from gas-fired to electric-powered equipment.

Achieving 40 percent emissions reductions across the entire building sector by 2030 is a necessary but ambitious goal that requires retrofitting many existing buildings to high efficiency electric heating, ventilation, and cooling (HVAC) and water heating equipment. Such equipment has a lifecycle of 10 to 20 years, sometimes longer, which means that most natural equipment replacements during that period will need to be efficient electric models. It is important to understand how quickly the market share of the main gas equipment types needs to increase to achieve the AB 3232 goal. NRDC, Earthjustice, and EDF recommend that the Assessment explicitly evaluate the pace and scale of market transformation needed in space and water heating equipment needed to achieve AB 3232's 2030 goal.

A simplified market transformation framework typically comprises two main phases: market development and performance standards as illustrated below:

Market Transformation Framework



Ultimately, achieving market transformation at the pace and scale needed will require performance standards, i.e. policies that set minimum requirements for energy, greenhouse gas emissions, criteria pollutants, or other performance metrics for buildings and appliances. Examples of such policies include building codes for new buildings, performance standards for existing buildings, federal and state appliance efficiency standards, or air district nitrogen oxides (NOx) standards for combustion appliances, etc. Such policies are the most cost-effective and equitable, and the most scalable. However, they can only be implemented for a particular equipment type and market when they are cost effective and there is sufficient market capacity to support performance standards. Therefore, the role of the market development phase is to prepare the market for performance standards. This is typically accomplished through financial incentive programs paired with workforce and vendor development, which accelerates market deployment of key technologies.

For example, the **California Solar Initiative** provided generous financial incentives for early adopters when solar photovoltaic was an emerging technology and few could afford it. The incentives stepped down as prices declined and market share increased, to the point where the market no longer needs incentives and the 2019 California Building Energy Standards now require a modest amount of solar on all new low-rise residential buildings.

The Assessment should focus on the top gas end uses in buildings and the market transformation policies needed to transform them. The table below provides a preliminary analysis of the main gas-fired heating and water heating end uses in California's existing building stock, and the primary efficient electric replacement solutions. This table highlights the

main system types and conversion pathways that policies will need to focus on to transform the market for heating and hot water electrification technologies. It is meant to be illustrative, not exhaustive.

Gas system	Sector	Prevalence (CA)	Most obvious retrofit replacement
Central furnace	Residential	High	• Central HP • Mini-split
Wall furnace	Residential	Medium	• Mini-split • PTHP
Individual gas water heater	Residential	High	• HPWH
Central gas boiler for domestic hot water	Residential MF, Commercial	High	• Central HPWH
Central gas boiler for VAV or four-pipe fan coil systems	Residential MF, Commercial	VAV: High FPFC: Low	• Central HPWH • VAV + electric reheat + PV • VRF
Individual water-source HPs w/ central gas-fed water loop	Residential MF, Commercial	Low	• Replace boiler with HPWH • VRF
RTU/Packaged unit	Commercial	High	• Packaged HP • VRF

The Assessment should evaluate the policies—including investment level and timing—necessary to develop the market for each of these technologies and conversion pathways.

8. **The Commission is planning to hold workshops on the Building Decarbonization Assessment in early 2020. Are there specific topics that you would like to have discussed at a workshop?**

   We suggest the following topics:

   a. Evaluate successful clean energy technology market transformations and how they can be leveraged for building electrification. For example, rooftop solar photovoltaic and LED light bulbs.

   b. Refine the list of the major space and water heating technologies and conversion pathways that need to be transformed to achieve the AB 3232 goal.

   c. Assess performance standard policies that are applicable to each technology, including appliance energy efficiency standards, building energy efficiency

standards, emissions standards (e.g. low NOx standards), and technology standards (e.g. requiring that every air conditioner installed be a heat pump where applicable).

NRDC, Earthjustice, and EDF appreciate the opportunity to provide comments on the baseline emissions approach and project scope.

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