Appendix D

LIDAC Benefits Analysis Documentation

The following summary was developed by Cascadia Consulting Group for the Air District to inform the LIDAC/Frontline Communities benefits analysis discussion in the PCAP.

Frontline Communities' Benefits Analysis for Priority Climate Action Plan Greenhouse Gas Reduction Measures

Bay Area Air Quality Management District | Bay Area Regional Climate Action Planning Initiative

Prepared by Cascadia Consulting Group, Inc.

CASCADIA CONSULTING GROUP

Table of Contents

1 Overview

1.1 Project Overview

The Bay Area Air District Management District (BAAQMD or the Air District) is leading a regional climate action planning process, funded by the U.S. Environmental Protection Agency's **Climate Pollution Reduction Grant (CPRG) program**. The regional climate planning initiative will identify implementation-ready climate measures that reduce the Bay Area's greenhouse gas (GHG) emissions and provide benefits for frontline communities. The planning process will culminate in a Priority Climate Action Plan (PCAP) and Comprehensive Climate Action Plan (CCAP), which will include the identified climate measures, a GHG inventory, and supporting analyses, including this frontline communities' benefits analysis.

1.2 Purpose of Analysis

As part of this process, the Air District conducted an analysis of the potential benefits and disbenefits on frontline communities from implementation of PCAP measures. The objective of this analysis is to identify how PCAP measures can support frontline communities while also identifying how potential disbenefits and unintended consequences of these measures can be mitigated.

2 Approach

The approach used for this analysis was adapted from the U.S. Environmental Protection Agency's (EPA) guidance document, *Benefits Analyses: Low-Income and Disadvantaged Communities* (U.S. EPA), which was developed to support regional and local government agencies to assess equity benefits and disbenefits under EPA's CPRG program.

This analysis assessed benefits and disbenefits for seven primary categories: housing quality and security; public and community health; jobs and workforce development; community engagement, awareness, and capacity; transportation access and costs; climate resilience co-benefits; and energy costs and burden (Table 1). These categories aligned with:

- Priorities identified through a review of recently completed community engagement.

- Priorities voiced by a Roundtable of community-serving organizations with deep familiarity with frontline communities in the eight counties.
- EPA's guidance document.

For each category in this assessment, we provide:

- A general summary of benefits and disbenefits.[1]
- A more detailed assessment of potential benefits and disbenefits to support overarching conclusions using peer-reviewed research, public data sources, and public reports and documents. As part of this process, we also note areas where research is still emerging and where there is a lack of consensus on directional impacts.
- Equitable implementation considerations to mitigate disbenefits. Some of these considerations are already explicitly called out in the Air District's PCAP measures and are noted as such.

Table 1. Benefit and disbenefit categories and details used in the analysis.

Benefit / Disbenefit Category	Definition and Details
Housing Quality and Security	• Housing burden and costs, particularly for renters • Housing security and public safety • Gentrification and/or displacement impacts
Public and Community Health	• Exposure to environmental hazards and/or pollution • Physical and mental health impacts from amenity access (e.g., transit hubs, green spaces) • Public safety considerations • Quality of life and comfort • Access to care and public services
Jobs and Workforce Development	• Educational and training opportunities • Employment opportunities and access to jobs • High-road jobs, with fair pay and benefits • Job security • Post training employment • Potential unemployment impacts

[1] When a measure does not directly affect a category, we noted that the benefits/disbenefits did not apply.

Benefit / Disbenefit Category	Definition and Details
Community Engagement, Awareness, and Capacity	• Community awareness of solutions and projects • Community capacity building • Trust between communities and the government
Transportation Access and Costs	• Transportation access, including access to non-vehicular mobility alternatives • Transportation costs and burden • Reliability and access of transit options • Safe transit options
Climate Resilience Co-benefits	• Ability to adapt or cope with climate-related impacts and hazards
Energy Cost Burden and Security	• Increased or decreased energy cost burden • Increased or decreased energy security

3 Results of Benefits and Disbenefits Analysis

This section describes benefits and disbenefits for the two PCAP measures, which are:

- Safe, accessible, clean, and equitable multi-modal transportation
- Holistic building decarbonization for clean, healthy, and secure housing

3.1 Safe, Accessible, Clean, and Equitable Multi-modal Transportation

Public and Community Health

SUMMARY

The connectivity of mobility hubs is anticipated to bring various benefits, such as reduced traffic congestion, improved air quality, enhanced accessibility, and increased sustainable and active commuting habits. Additionally, safety improvements in the measure can help prevent fatalities and severe injuries, particularly in high-fatality and

high-injury sections of bicycle and pedestrian infrastructure as use of this infrastructure increases. Additionally, there is potential for physical health benefits for communities surrounding mobility hubs that prioritize active transportation alternatives. However, there may be short-term increases in air pollution burden for mobility hub-adjacent communities until public fleets transition away from gas and diesel-powered vehicles. Additionally, there is potential for physical health benefits for surrounding communities of mobility hubs that prioritize active transportation alternatives.

SUPPORTING RATIONALE

- **Investments in active transportation infrastructure improve safety and access for walking, biking, and rolling activities, while facilitating better connectivity to public transportation.** These initiatives reduce air pollution that typically pose a higher risk for vulnerable groups like children, pregnant women, seniors, and those with pre-existing health considerations, particularly in frontline communities (Bay Area Air Quality Management District, 2018).
- **Investing in active transportation infrastructure mitigates obesity**, lowering the risk of expensive chronic conditions like diabetes and cardiovascular disease (Wolch et al., 2014;Department of Transportation, 2015).
- **Investing in active transportation infrastructure reduces the space needed for transportation, freeing up land and decreasing noise and pollution**. This active approach ultimately improves the quality of life, particularly in disadvantaged communities (U.S. Department of Energy, 2023).
- **Despite potential benefits, low-income communities of color, who already engage in higher rates of active transport, may face health issues if strategies promoting active travel are poorly executed** (Wolch et al., 2014). For example, introducing bike lanes with inadequate safety measures for pedestrians and cyclists could heighten the risks of accidents and injuries. This disproportionately impacts low-income individuals who may depend heavily on active transportation (Wolch et al., 2014).
- **The California Air Resources Board has established a statewide objective to transition to an all-electric public bus fleet by the year 2040.** This initiative seeks to mitigate tailpipe pollution, particularly in low-income communities, contributing to cleaner air. The shift to a zero-emissions public fleet will bring multiple advantages for transit-dependent riders. In areas where the public fleet has not fully transitioned to zero emissions, transit hubs, especially in disadvantaged communities, may experience short-term increases in air pollution burden despite the long-term benefits of improvements in public health, energy consumption, and cost savings (Alameda Contra Costa Transit District, 2022;California Air Resources Board, 2018).

EQUITY CONSIDERATIONS

To mitigate potential barriers or challenges, implementation of the measure should consider the following:

- **Conduct spatial planning and design analysis to assess environmental justice impacts**, including air quality, noise, place, landscape, and flood/wildfire risks (OCTA, 2022).
- **When identifying potential locations for mobility hubs, evaluate proximity to essential services** (healthcare facilities, greenspace, recreational areas, grocery stores, affordable housing) (OCTA, 2022).

Transportation Access and Costs

SUMMARY

There is a risk that some costs associated with transit infrastructure and operational improvements may be passed onto users. However, if investments in transit access are coupled with discounted fare integration programs and other multi-modal incentive programs, there is strong potential for short- and long-term transit cost savings, particularly for low-income residents. Enhancing access to a variety of mobility options can also play a crucial role in lowering barriers to reaching employment, educational opportunities, health care, and other essential services (Stacy et al., 2022).

SUPPORTING RATIONALE

- **Increased access to diverse mobility options can help reduce barriers to accessing employment, educational opportunities, health care, and other key services and amenities** (Stacy et al., 2022)
- **The Sacramento Metropolitan Air Quality Management District initiated a project offering subsidized transportation to participating residents, which yielded benefits such as enhanced clean mobility access and improved air quality through reductions in greenhouse gas and toxic emissions**. The program incorporated clean technology car sharing, electric bike sharing, and pre-paid vouchers for ride-hailing services and public transportation. The project has yielded benefits such as enhanced clean mobility access and improved air quality through reductions in greenhouse gas and toxic emissions. Through these alternatives, residents can transition from traditional, more energy-intensive modes of transportation to cleaner options, contributing to overall energy savings and aligning with regional and statewide goals for transportation electrification (Sacramento Metropolitan Air Quality Management District., 2017).
- **Multiple studies in California highlight the potential risks of increased cost burden for communities surrounding transit hubs** (Zhou & Zolnik, 2013;Rodier et al., 2015). **However, the same studies also highlight that**

transit hubs can lead to reductions in transportation and housing expenditures, primarily because relying on public transportation is often more cost effective than owning and maintaining a personal vehicle (Zhou & Zolnik, 2013;Rodier et al., 2015).

- Placing mobility hubs exclusively in areas with high population or employment density is likely more cost effective because it maximizes utilization of services (e.g., leads to increased ridership). This, in turn, could generate more revenue (Hachette & L'Hostis, 2024).
- **Integrating a solution offering enhanced first/last mile connectivity and off-peak trip options is crucial for individuals who commute during off-peak hours or engage in trip chaining throughout the day**. Providing options that alleviate transportation cost burdens has the potential to significantly enhance the overall quality of life for this group (OCTA, 2022). For instance, numerous property owners serving as major employers in Orange County could achieve financial savings by consolidating current private transit services and managing commute reduction programs. This consolidation effort has the potential to significantly reduce the need for expensive employee parking spaces (OCTA, 2022).
- **Adapting to new services or route changes may prompt transit agencies to make operational adjustments, often necessitating periodic small fare increases** (San Francisco Bay Area Rapid Transit District, 2024).

EQUITY CONSIDERATIONS

To mitigate barriers and challenges, the measure includes an incentive element to:

- Integrate discounted fare programs and discounted bike share passes for low-income and underserved populations and offer e-bike incentives.

In addition, mobility hubs should be subjected to a comprehensive performance and cost audit to ensure that transit costs remain affordable, cost effective, and equitable to low-income communities (Frost, 2022).

Jobs and Workforce Development

SUMMARY

Mobility hubs have the potential to reduce vehicle miles traveled (VMT), produce and sustain high-road jobs, and increase use of alternative modes of transport to improve access to employment opportunities.

SUPPORTING RATIONALE

- **Communities of color often experience lower vehicle ownership rates**, **resulting in negative impacts on their corresponding employment rates**

(Ong, 2002). Mobility hubs have the potential to reduce VMT and present a more accessible and cost-effective option than vehicle ownership for low-income households to rely on for employment, community, and traveling.

- **Construction of mobility hubs can generate critical, living-wage jobs for local communities.** While not synonymous, synergy between mobility hubs and Transit-Oriented Development (TOD) is an important aspect to consider, as it is essential for creating sustainable, accessible, and thriving urban environments that can result in more efficient transportation, greater employment opportunities, and improved quality of life for residents. For example, BART's TOD program at existing levels could generate 85,000 direct and indirect jobs in California between 2020-2030. 62% of these jobs are "middle-skill" jobs - requiring on-the-job training rather than a college degree while still offering a living wage (San Francisco Bay Area Rapid Transit District, 2023).
- **Areas adjacent to transit stops can experience enhanced commercial activity and job opportunities**, with the introduction of shops, restaurants, and other businesses that attract commuters and non-commuters alike (Cash et al., 2020).

EQUITY CONSIDERATIONS

To maximize equitable distribution of benefits, the measure should consider:

- Preference to hire local contractors and residents for capital projects.

Climate Resilience Co-benefits

SUMMARY

Mobility hubs can lead to some climate resilience co-benefits, primarily air quality benefits. Additionally, urban greening along pedestrian, bicycle, and transit infrastructure can help shade surfaces, reduce travelers' discomfort and risk of heat illness during periods of extreme heat, and reduce the risk to infrastructure from flooding during heavy rains (National Association of City Transportation Officials, 2017).

SUPPORTING RATIONALE

- **Efficient street shading and reduction of distances to transit stations, like walking and cycling infrastructure in proximity to mobility hubs, can promote use of sustainable transportation modes** (Elmarakby & Elkadi, 2024).
- **Transit infrastructure related to traditional roads and car-based infrastructure has been correlated with the urban heat island (UHI) effect**, influenced by factors such as population density, land use, and building characteristics. Measures such as urban greening can mitigate UHI impacts (Elmarakby & Elkadi, 2024).

- **Enhancing clean and efficient transportation options and optimizing vehicle efficiency can effectively mitigate the adverse impacts of climate change and air pollution**. This approach promotes a more equitable, accessible, and affordable transportation system, thereby improving all users' overall quality of life. Additionally, it helps diminish reliance on fossil fuels and enhances energy security (U.S. Department of Energy, 2023).

EQUITY CONSIDERATIONS

To maximize the equitable distribution of benefits, the measure includes connectivity and green infrastructure elements that can also improve resilience outcomes, such as:

- Urban greening along pedestrian, bicycle, and transit infrastructure.
- Bicycle and pedestrian facility improvements, incorporating complete streets and vision zero[2] in design (Vision Zero Network, 2024).
- Micro-mobility, bikeshare/e-bike share.
- Electric vehicle (EV) carshare/EV charging (on-site and in adjacent ½ mile area).

In addition, reducing heat emissions from building systems (e.g., HVAC systems) within commercial and entertainment activities can reduce the UHI effect (Elmarakby & Elkadi, 2024).

Community Engagement, Awareness, and Capacity

SUMMARY

Utilizing community-centered engagement strategies, focusing on youth and community-based organizations (CBOs), is anticipated to increase community buy-in, awareness, and capacity for utilizing individual mobility options like bicycles, electric scooters, and walking.

SUPPORTING RATIONALE

- **To prevent displacement and champion community interests, it is crucial to involve residents in the design process**, consider affordability implications, and advocate for the needs of long-time, lower-income residents to developers and stakeholders (Holland, 2022).
- **Social capital is associated with livable, walkable neighborhoods, suggesting that areas with greater walkability may have higher social**

[2] *Vision Zero is a multidisciplinary approach to road safety with the belief that every traffic-related death or serious injury is preventable, and the ultimate goal is to achieve zero fatalities or severe injuries on roadways. This approach emphasizes a holistic perspective, focusing on safe system design, technological innovations, public awareness, and the adoption of policies that prioritize human life over mobility convenience. Vision Zero has gained international recognition and has been adopted by numerous cities and countries worldwide as a guiding principle to reshape transportation systems and enhance overall road safety.*

capital and cohesion. In such communities, residents are more likely to know their neighbors and engage with other community members (Ribeiro et al., 2015).

EQUITY CONSIDERATIONS

To maximize equitable distribution of benefits, the measure includes a community engagement element that will:

- Prioritize community outreach and education, specifically targeting youth, and actively involve Community-Based Organizations (CBOs) to promote the increased utilization of single-occupancy mobility options.
- Actively engage CBOs and employ a participatory community process to identify various components addressing the community's needs.

In addition, mobility hub governance that is inclusive of stakeholder groups such as landowners, public transit operators, regional policy and funding agencies, major utility providers, and local community-based organizations, can foster greater buy-in and help mitigate potential disbenefits (OCTA, 2022).

Housing Quality and Security

SUMMARY

Generally, mobility hubs can benefit low-income communities by increasing access to job opportunities, which can benefit housing security. However, there is not a clear consensus about whether mobility hubs lead to increased housing costs or contribute to subsequent displacement. Some studies show an association between mobility hubs and gentrification, which can lead to displacement of low-income residents, especially residents who are most likely to benefit economically from transit access. Disbenefits can be mitigated with a strong affordable housing policy, which can maintain and increase housing security in light of new transportation amenities.

SUPPORTING RATIONALE

- **Mobility hubs have the potential to maintain and increase housing security if they are integrated near affordable housing**. These mobility hubs can create opportunities for residents to live near various transit options, thus reducing commuting costs and promoting housing affordability (Patel et al., 2022). Constructing and maintaining affordable housing near mobility hubs promotes economic accessibility and reduces disparities in housing security (OCTA, 2022).
- **Transit infrastructure and its attendant development have the potential to spur gentrification in racially diverse and/or low-income areas**. Transit development can be one driving factor in increasing housing costs, resulting in low-and moderate-income residents – particularly renters – being displaced. However, when executed with an intentional focus on enhancing regional equity,

transit-oriented development has enormous potential as an overall benefit for low- and moderate-income (LMI) communities (Carlisle, 2020). This inclusivity promotes economic accessibility and reduces disparities in housing security (OCTA, 2022).

- **Proximity to active transportation infrastructure, such as bike lanes, is sometimes associated with positive or neutral benefits to LMI communities but is sometimes associated with increased property values and gentrification.** Discrepancies in investment patterns have transformed bike infrastructure into a contentious topic within gentrification debates. While numerous studies demonstrate positive or neutral impacts, it is important to acknowledge the existence of studies that indicate negative associations with property values. Notably, there is a notable disagreement in the directional change, with some studies suggesting a positive shift, for instance, asserting that the presence of bike lanes correlates with higher property values (Cash et al., 2020).
- **Urban greening strategies - like parks, greenspace, urban forests, and community agriculture - all tend to increase surrounding property values** and may contribute to gentrification and displacement; therefore, ensuring equitable implementation necessitates designing accessible and inclusive green spaces, engaging the community in decision-making, mitigating gentrification risks through measures like affordable housing and job creation, and preserving cultural identity to foster fair and inclusive distribution of benefits among diverse populations (Wolch et al., 2014;Cash et al., 2020).

EQUITY CONSIDERATIONS

To mitigate potential barriers or challenges, the measure includes a housing security element that will:

- Produce, preserve, and protect affordable housing and stabilize businesses to prevent displacement, similar to the goals outlined in the MTC-Transit Oriented Community (TOC) Policy.

In addition, using anti-displacement policy tools through CASA Compact and anti-displacement strategies such as the All-In Cities Policy Toolkit developed by Policy Link (2022) can identify policy levers that can mitigate disbenefits. Some strategies these tools include are:

- Zoning near transit
- Inclusionary zoning
- Unlock public land at hubs for affordable housing
- Just cause eviction ordinances

Energy Cost Burden and Security

SUMMARY

Incorporating on-site electric vehicle (EV) car sharing and charging, coupled with suitable discount fare programs, is expected to alleviate energy cost burdens among those who use EVs. This integrated approach ensures affordability for low-income residents, particularly in frontline communities.

SUPPORTING RATIONALE

- **Beyond the cost barrier associated with acquiring electric vehicles, accessibility of charging stations is recognized as a challenge for EV adoption and usage**. Ensuring a fair deployment of charging infrastructure requires deliberate measures to prioritize underserved communities and align with the expanded provision of EV incentives to various population segments (Jackson, 2021).This shift can reduce the overall energy burden associated with EV usage in these communities.

EQUITY CONSIDERATIONS

Additional considerations include prioritizing frontline communities for installing charging stations and aligning with the expanded provision of EV incentives to various population segments, as outlined in the framework by U.S Department of Transportation (2022).

3.2 Holistic Building Decarbonization for Clean, Healthy, and Secure Housing

Public and Community Health

SUMMARY

Building electrification and energy efficiency measures are expected to produce regional and local indoor and outdoor air quality benefits. The measure can also improve residential health and safety concerns by addressing exposure to hazards such as lead, mold, and asbestos. Possible disbenefits of building electrification and energy efficiency measures include: increased PM2.5 from fossil fuel electric generating units (electricity-producing power plants) to meet increased electricity demand; increased indoor air pollution if efficiency measures are implemented without effective ventilation or electrification; and health hardships during power outages (see the *Energy Cost Burden and Security* category).

SUPPORTING RATIONALE

- **Building electrification has the potential to achieve equitable health outcomes such as reducing exposure to indoor and outdoor air pollutants** (Kime et al., 2023; Zhu et al., 2020;Holstius & Martien, 2022; Tanrikulu et al., 2022). Communities of color in the U.S. are exposed to disproportionately high levels of ambient fine particulate air pollution (PM2.5); residential gas combustion and commercial cooking are among the largest sources of relative disparities for Black, Hispanic, and Asian groups (Tessum et al., 2021). A recent analysis by the Air District found that nitrous oxides (NOx) and PM2.5 emissions from home and water heating disproportionately impact communities of color (Tanrikulu et al., 2022).
- **Public health benefits from electrification and envelope improvements accrue from reductions in exposures to natural gas combustion co-products, such as PM2.5**, due to a shift toward electric appliances and away from natural gas appliances (Moe & Gibbs, 2023;Fournier et al., 2022).
- **Electrification can improve overall regional air quality.** The Bay Area Air Quality Management District found that installing zero NOX-emitting appliances could prevent up to 85 premature deaths per year, lowering PM2.5 exposure, and avoiding up to $890 million per year in health impacts due to air pollution exposure (Tanrikulu et al., 2022). These appliances reduce pollutants that are vented outdoors, including those from natural gas appliances.
- **Additional studies have estimated decreases in illness and death (and associated economic benefits) resulting from building electrification**:
    - A Bay Area study found the following:
        - Reductions in secondary PM2.5 from BAAQMD's Rules 9-4 and 9-6 would reduce premature mortality within the Air District's jurisdiction by 23 to 52 cases per year. Reductions in total PM2.5 concentrations would reduce premature mortality by 37 to 85 cases per year. The valuations assigned to premature death cases range from 230 to 530 million U.S. dollars for secondary PM2.5 and from 380 to 870 million U.S. dollars for total PM2.5 (Tanrikulu et al., 2022).
        - For a 2020 population, 2.6 to 24 non-fatal heart attacks would be prevented with the modeled reductions in secondary PM2.5 and 4.2 to 39 non-fatal heart attacks would be prevented with the modeled reductions in total PM2.5. The associated valuations are estimated to be 0.23 to 2.1 million U.S. dollars and 0.38 to 3.5 million U.S. dollars, respectively (Tanrikulu et al., 2022).
    - A CA statewide study found the following:
        - Under a 2018 scenario where all residential gas appliances in CA were transitioned to electric, the reduction of secondary nitrate PM2.5 (from NO_X) and primary PM2.5 would result in 354 fewer

deaths, and 596 and 304 fewer cases of acute and chronic bronchitis, respectively. The reduction in associated negative health effects is equivalent to approximately $3.5 billion in monetized health benefits for just one year (Zhu et al., 2020).
    - A study estimated that building electrification in the Bay Area can lead to regional economic benefits that exceed $1.2 billion annually due to decreased mortality associated with PM2.5 and fewer pre-mature deaths associated with chronic and acute bronchitis (Zhu et al., 2020).
- **Concentrations of CO and NO_2 while cooking with natural gas can exceed national and California-based ambient air quality standards**, especially in smaller residences/apartments, which can result in greater impacts on renters and low-income residents (Zhu et al., 2020).
- **Tighter building envelope measures can result in health benefits due to better protection from outdoor air pollution** (PM2.5 exposure) (Zuraimi & Tan, 2015). See the *Climate Resilience Co-benefits* category for some additional notes on the benefit of improved air quality.
- **Addressing deferred maintenance and health and safety concerns can also result in public health benefits**, as lead, asbestos, and mold have negative health impacts (U.S. EPA, 2023).
- **Poorly or incompletely installed envelope measures could result in increased indoor pollutants**, especially if natural gas appliances are still present in the home (Moe & Gibbs, 2023). The health effects of indoor air pollution on building occupants pose additional risks to groups that have previously received poorer healthcare services and have lived in historically redlined neighborhoods (Chu, 2023).
- **Net increases in electricity demand associated with electrification can result in increased PM2.5 in areas near electric generating units (EGUs) that use fossil fuels**. When modeling electrification measures in Los Angeles County, significant health impacts from increased emissions of PM-2.5 by fossil EGUs are likely to be experienced in other areas across the state, up to and including those within the Bay Area (Fournier et al., 2022).

EQUITY CONSIDERATIONS

The measure will implement electrification of gas appliances in addition to efficiency measures for building envelopes and heating distribution systems, thus mitigating the potential disbenefits of increased indoor air pollution due to envelope measures without proper HVAC or electrification.

This is supported by studies in CA that suggest that weatherization and building efficiency measures should be coupled with residential and other building electrification measures to support multiple health, air quality, and climate co-benefits by mitigating

hazardous air pollutants and methane emissions while appliances are both off and on (Lebel et al., 2022).

The measure also includes health and safety upgrades to address health issues from lead, asbestos, and mold.

Though the Bay Area already has generally clean electricity, potential disbenefits of increased emissions by electric generating units (power plants) can be mitigated by further investing in and lobbying for clean energy sources from electric utilities.

Housing Quality and Security

SUMMARY

The risk of displacement of current residents due to residential building electrification is complex, with competing increased and decreased costs. For example, there is a risk that some landlords may pass on costs to tenants or displace tenants during housing construction and retrofit phases. However, electrification can ease housing and energy burden in the long-term, which reduces the risk of utility shut-offs and evictions.

SUPPORTING RATIONALE

- **The impact of electrification and energy efficiency projects on displacement is complex**. For example, property values generally increase with energy efficiency measures, and these increased housing values can lead to the displacement of low-income residents. Additionally, while improved energy efficiency can make housing more expensive and less affordable, it also serves to lower utility bills and burdens for renters and homeowners, thereby reducing the risk of utility shut-offs and evictions (Cash et al., 2020).
- **Studies have found correlations between energy improvements and increased cost burdens** (Kime et al., 2023). Some examples include:
    - Decarbonization could cost up to $20,000 per rental unit, and if landlords pass this cost on to tenants, this will erode affordability, resulting in larger rent burdens for low-income renters, or worse, the inability to pay rent (Kirk, 2023).
    - Landlords may use construction projects (noise, dust, and hazards that make tenants feel pressured to leave voluntarily) to displace tenants to see a quicker return on investment or capitalize on the value-add to their properties (Kirk, 2023).
    - Some statewide policy interventions, such as AB 1482, include an exception that allows landlords to evict tenants if they plan to remodel the unit for more than 30 days and it is unsafe for the tenant to stay. Building decarbonization retrofits, which may take months to complete, could lead to evictions under this loophole (Kirk, 2023).

EQUITY CONSIDERATIONS

Studies have shown that designing electrification measures with equity and justice in mind can reduce the consequences and disbenefits for low-income households and other frontline community groups (Nadel, 2019; Barker, 2021). To mitigate potential barriers or challenges and to strengthen the program, the measure includes a housing security element that will:

- Identify and implement housing security and anti-displacement best practices for retrofits and health and safety upgrades, with policy support from regional agencies, and best practices to engage and encourage rental property owners' participation in retrofits.
- Provide policy support to local governments and CBOs to address implementation barriers as they emerge.

These implementation considerations are supported by Hens & Lamon (2021), who assert that programs should provide protection against rent increases, similar to LIWP, to protect against potential displacement impacts.

As mentioned above in the *Public and Community Health* category, the measure also includes health and safety upgrades to address health issues from lead, asbestos, and mold, which will improve housing quality.

Energy Cost Burden and Security

SUMMARY

Electrification upgrades can result in both benefits and disbenefits related to energy costs and burdens. Upgrades can be expensive, though they can result in reduced utility bill costs. Natural gas prices may increase for remaining gas customers as more utility customers shift to electricity. An increased reliance on electricity may result in greater energy insecurity and associated disbenefits; however, reduced demand can improve energy reliability and security.

SUPPORTING RATIONALE

- **There are immediate up-front costs for electrification upgrades, however, these upfront costs will result in long-term savings and return-on-investment.** Programs that support electrification upgrades for low-income households can reduce the upfront cost barriers to retrofit. In a study in Richmond, CA, building envelope and electrification upgrades resulted in reduced annual utility bill costs for modeled buildings that resulted in a 100%+ return on investment for upfront costs (Moe & Gibbs, 2023).
- **It's important to note that the high upfront cost of envelope and electrification measures may be a barrier to low and moderate-income**

owner households and small-scale landlords. Even when items are cost-effective over the lifetime of the measures, a 15–30-year payback may not be feasible for many households—especially low-income households and communities of color—who are more likely to be living paycheck to paycheck and with limited savings (Moe & Gibbs, 2023).

- **The upfront costs depend on the existing infrastructure in the home**. For retrofits of existing homes, heat pumps can be lower cost than replacing furnaces and air conditioners separately. For homes currently using natural gas heating and only needing to replace a gas furnace, it is usually more expensive to electrify than to stick with gas (Billimoria et al., 2018).
- **The energy transition has the potential to increase energy burden for low-income communities, if it is not done with strategic planning and financial investment for frontline communities** (Fenton, 2022). For example, a decline in gas sales (due to more electrification of buildings) could raise gas prices further for remaining customers; as more households in the region transition to electricity, fewer customers remain to cover the fixed costs of the natural gas system. This could also accelerate further shifts away from gas for consumers able to invest in alternatives (Jones et al., 2019).
- **Rebates and other cost-saving measures are available**:
    - BayREN rebates and other community choice aggregator, utility, state, and federal programs and rebates can help lower financial cost barriers to retrofit.
    - PG&E offers an Electric Home Rate Plan for homes with EVs, electric heat pumps, or battery storage; the plan can save customers money if they are large electricity users who can shift usage to lower-priced times of day (PG&E, 2024).
- **One study found that lower-income households, renters, and households living in multifamily buildings may likely see less savings as a result of envelope and electrification upgrades** (absolute dollars and percent savings) compared to higher-income households, owners, and those living in single-family buildings. This study modeled impacts from residential upgrades in Richmond, CA. This difference stems largely from higher-income households in Richmond being more likely to live in single-family homes, which tend to be older buildings and consume more energy overall compared to lower-income households. As a result, single-family homes also see a higher decrease in overall utility payments, and a higher decrease in terms of percent change. (These trends are the same for owners versus renters, since almost all owners in Richmond live in single-family homes.) The study found that in Richmond, renters were more likely to pay for electricity while rental property owners paid for natural gas. (Moe & Gibbs, 2023).
- **Energy security and reliability may be reduced due to electrification**. **However, when electrification is coupled with energy efficiency measures, the risk of energy disruptions is reduced.**

- An increased reliance on electricity may result in greater energy insecurity and associated disbenefits. Power outages strain chronic health conditions and can result in increased rates of hospitalization. The hardship of energy insecurity intersects with other hardships, such that each compounds the severity of the others and contributes to detrimental health consequences (Jessel et al., 2019).
- The potential for critical infrastructure failures during extreme weather events is rising. Major electrical grid failure or "blackout" events in the United States increased by more than 60% over the most recent 5-year reporting period. Study results find simulated compound heat wave and grid failure events of recent intensity and duration to expose between 68 and 100% of the urban population to an elevated risk of heat exhaustion and/or heat stroke (study modeled heat waves/blackout conditions for Atlanta, Georgia; Detroit, Michigan; and Phoenix, Arizona) (Stone et al., 2021).
- PG&E sometimes conducts power shut-offs (Public Safety Power Shutoff) to minimize risk of wildfires in certain conditions (PG&E, 2024b).
- Energy efficiency measures can reduce demand and strain on the energy system, improving energy reliability and security (Ribeiro et al., 2015).

EQUITY CONSIDERATIONS

The measure includes subcomponents to increase energy resilience, such as distributed solar and storage, where strategic and feasible; this can support energy security and reliability and reduce potential disbenefits.

Additional equitable implementation considerations include:

- **Industry destabilization (from increased gas prices) can, and should, be avoided with sound planning and the right set of policy tools** (Jones et al., 2019). The focus of this measure on helping frontline communities transition to electricity can help insulate these communities from anticipated gas price increases as more households in the region transition to electricity, leaving fewer customers to cover the fixed costs of the natural gas system.
- **Programs should reduce out-of-pocket costs for residents as much as possible to improve cost-effectiveness and avoid potential disbenefits. The** measure includes incentives, direct installations, financing, and rebates, which should reduce the upfront and out-of-pocket costs for residents in frontline communities.

Jobs and Workforce Development

SUMMARY

Building energy efficiency and electrification can sustain and produce high-road jobs, especially if done with intentional workforce development, training, and support.

SUPPORTING RATIONALE

- **Models suggest that all low-carbon energy technologies create more jobs per unit of energy than their coal and natural gas counterparts** (Kime et al., 2023).
    - A study modeled that pursuing residential envelope and higher-efficiency electrification upgrades in Richmond could support up to 7,500 direct and indirect jobs, with two-thirds of those more likely to be local jobs, and half of them likely to be new jobs. This would include occupations such as HVAC technicians, plumbers, electricians, and general residential construction and remodeling. The occupations more likely to be new/net jobs are the insulators and electricians, while HVAC technician and plumbing jobs are more likely to be existing jobs installing new technologies, rather than jobs that would not otherwise exist for Contra Costa County (Moe & Gibbs, 2023).
    - An analysis of potential employment impacts of California building electrification (assuming the state electrified all buildings by 2045) projected the following (Jones et al., 2019):
        - 59k-100k jobs from construction, supported annually over 2020-2045.
        - 3k-5k from manufacturing, supported annually over 2020-2045.
        - 10k-12k new jobs from electricity generation and distribution by 2045.
        - 7k-14k fewer jobs from gas distribution by 2045.
    - Three out of five jobs required to meet CA's building electrification goals would be in "high-road" sectors. The right set of policy interventions can reform the competitive dynamics in traditionally "low-road" industries like residential and small commercial construction to improve the quality of jobs and engage more highly skilled workers (Jones et al., 2019).
- **There is the potential for new jobs to be well-paid and benefitted, allowing for improved quality of life for some frontline communities; this requires intentional workforce standards.**
    - Regarding employment indicators, the 2023 Equitable Electrification Analysis for Existing Buildings in Richmond, CA showed that 75% of private industry construction workers nation-wide had access to employer-sponsored health care benefits, 81% had access to paid vacation benefits,

69% had access to paid sick leave, and 63% had access to retirement benefits plans (Moe & Gibbs, 2023).
    - Agencies can, with deliberate effort, support high-road workforce development in the building electrification field. By establishing (or failing to establish) workforce standards, agencies set the bar for the level of skill and training of workers in the labor market, particularly in emerging industries (Jones et al., 2019).

EQUITY CONSIDERATIONS

To mitigate potential barriers or challenges and to strengthen the program, the measure includes a workforce development and contractor support element that will:

- Partner with and augment local workforce training programs for electricians, plumbers, and other decarbonization-related roles, particularly those that target workers from frontline communities, formerly incarcerated people, and people with other barriers to employment.
- Seek to develop and implement regionally consistent workforce standards for retrofit projects to increase the number of family-supporting/high-road jobs.
- Provide streamlined contractor support (e.g., increase awareness of and access to incentives, improve communication tools with customers).

This aligns with Jones et al.'s recommendations to create conditions that attract skilled workers, pre-qualify contractors, support the up-skilling of workers through stackable credentials, and structure the work to create opportunities for disadvantaged workers (Jones et al., 2019).

Additionally, a Greenlining Institute report recommends including labor and workforce development agencies in program design, building workforce transition into program budgets, and ensuring that current low-income fossil fuel workers have access to and training for electrification job opportunities (Miller et al., 2019).

Climate Resilience Co-benefits

SUMMARY

Building electrification and efficiency retrofits can protect residents and workers from wildfire smoke, extreme heat, power outages from extreme events, and outdoor air pollution.

SUPPORTING RATIONALE

- **Energy efficiency retrofits can protect against outdoor wildfire smoke; electric heat pump installation can increase comfort and safety of homes during heat events** (Fenton, 2022). See the *Public and Community Health* category for additional discussion about protection from outdoor air pollution.

- **Improving building envelopes through better insulation and air sealing can maintain more livable conditions for occupants when electricity from the grid is unavailable or unreliable**. Buildings that allow residents to stay in their homes during power outages are of particular importance for housing-vulnerable populations that are more sensitive to temperature changes, including people with health conditions and the elderly (Ribeiro et al., 2015). See the *Energy Costs and Burden* category for additional discussion about energy security and reliability.

EQUITY CONSIDERATIONS

As discussed in the *Public and Community Health* category, the measure will implement electrification of gas appliances in addition to efficiency measures for building envelopes and heating distribution systems, thus mitigating the potential disbenefits of increased indoor air pollution due to envelope measures without proper HVAC or electrification.

As discussed in the *Energy Costs and Burden* category, the measure includes subcomponents to increase energy resilience, such as distributed solar and storage, where strategic and feasible; this can support energy security and reliability, reduce potential disbenefits, and provide climate resilience benefits.

Community Engagement, Awareness, and Capacity

SUMMARY

Equitable and inclusive governance and decision-making is critical for successful and equitable programs; the measure's Community Work Group will aim to support community engagement, awareness, and capacity.

SUPPORTING RATIONALE

- **Equitable participation in decision-making processes for all communities is crucial as society undergoes significant changes through energy transition planning** (Kime et al., 2023).
- **One energy equity indicator for access is decision representation**, or control and governance over energy systems and decision-making processes (Kime et al., 2023).
- **Pursuing inclusive and equitable climate governance can be a way to combat historic underinvestment and limited access to efficient, healthy, and affordable services and infrastructure in cities**. The emergence of local and community-led approaches—coupled with increasing collaboration among city, Tribal, state, and federal governments—indicates a movement toward more inclusive planning and implementation of climate actions (Chu et al., 2023).

EQUITY CONSIDERATIONS

To mitigate potential barriers or challenges and to strengthen the program, the measure will:

- Establish a Community Work Group that includes community-based organizations (CBOs), community members, and other partners to advise on and participate in implementation so that frontline community members' needs are prioritized.

Additionally, the measure's housing security and policy support element will:

- Provide policy support to local governments and CBOs to address implementation barriers as they emerge.

This is supported by SAJE's Decarbonizing CA Equitably report (Kirk, 2023), which recommends that policy makers:

- Seek out perspectives from tenant advocates, legal service providers, and low-income tenants.
- Solicit insights into the specific hardships encountered by tenants, particularly those involving landlord harassment, displacement due to construction, rent burden, and eviction.
- Prioritize active listening to hear how tenants are currently affected by the affordable housing crisis, and whether and how they believe decarbonization efforts will compound those effects.
- Acknowledge their contributions by providing appropriate compensation for their valuable time and input.
- Develop relationships with CBOs to leverage existing relationships and connect with community members.

Transportation Access and Costs

N/A

4 References

Alameda Contra Costa Transit District. (2022). *Zero Emission Bus Transition Plan*. https://www.actransit.org/sites/default/files/2022-06/0162-22%20ZEB%20Transition%20Plan_052022_FNL.pdf

Barker, E. (2021). *Building a Just Transition: Creating a Community Engagement Building a Just Transition: Creating a Community Engagement Strategy for Building Electrification Policy in the City of Riverside Strategy for Building*

Electrification Policy in the City of Riverside [Pitzer Senior Theses.]. https://scholarship.claremont.edu/cgi/viewcontent.cgi?article=1125&context=pitzer_theses

Bay Area Air Quality Management District. (2018, October 4). *Air Pollution and Community Health*. Bay Area Air Quality Management District . https://www.baaqmd.gov/community-health/air-pollution-and-community-health

California Air Resources Board. (2018). *California transitioning to all-electric public bus fleet by 2040*. California Air Resources Board. https://ww2.arb.ca.gov/news/california-transitioning-all-electric-public-bus-fleet-2040

Equitable TOD: A Sound Transit Case Study, (2020). https://www.academia.edu/43796093/Equitable_TOD_A_Sound_Transit_Case_Study

Cash, A., Chapple, K., Depsky, N., Elias, R. R., Krnjaic, M., Manji, S., & Montano, H. (2020). *Climate Change and Displacement in the U.S. – A Review of the Literature*.

Chu, E. K. , M. M. F. J. C. S.-M. C. C. C. M. C. D. M. H. D. H. V. L. J. J. M. K. A. K. T. A. M.-E. and N. T. O. J. (2023). *Chapter 12 : Built Environment, Urban Systems, and Cities. Fifth National Climate Assessment*. https://doi.org/10.7930/NCA5.2023.CH12

Elmarakby, E., & Elkadi, H. (2024). Impact of urban morphology on Urban Heat Island in Manchester's transit-oriented development. *Journal of Cleaner Production*, *434*, 140009. https://doi.org/10.1016/j.jclepro.2023.140009

Fenton, L. (2022). *Examining Equity in Building Decarbonization: Critical Issues and Opportunities*. University of California San Diego.

Fournier, E. D., Federico, F., Cudd, R., Pincetl, S., Ricklefs, A., Costa, M., Jerrett, M., & Garcia-Gonzales, D. (2022). Net GHG emissions and air quality outcomes from different residential building electrification pathways within a California disadvantaged community. *Sustainable Cities and Society*, *86*, 104128. https://doi.org/10.1016/j.scs.2022.104128

Frost, M. (2022, May 22). *In five years, Sound Transit has racked up an additional $50 billion for rail plan*. Washington Policy Center. https://www.washingtonpolicy.org/publications/detail/in-five-years-sound-transit-has-racked-up-an-additional-50-billion-for-rail-plan

Hachette, M., & L'Hostis, A. (2024). *Mobility Hubs, an Innovative Concept for Sustainable Urban Mobility?* (pp. 245–278). https://doi.org/10.1007/978-3-031-35664-3_14

Hens, I., & Lamon, E. (2021). *A Methodology for Geographically-Targeted Building Electrification for Environmental and Social Justice Communities in California*. University of California, Berkeley.

Holland, N. (2022, August 2). *How Transit-Oriented Housing Can Advance Access to Opportunity While Curbing Climate Change*. Urban Institute.

Holstius, D., & Martien, P. (2022). *Exposure and Equity Assessment of Natural Gas Appliances in the San Francisco Bay Area*. https://www.baaqmd.gov/~/media/dotgov/files/rules/reg-9-rule-6-nitrogen-oxides-emissions-from-natural-gasfired-water-heaters/2021-amendment/documents/20221220_sr_appf_rg09040906-pdf.pdf?rev=c7a8dc1225b243298e7bd9395a292844

Jackson, C. T. (2021). Expanding access to electric vehicles in California's low-income communities. *Journal of Science Policy & Governance*, *18*(01). https://doi.org/10.38126/JSPG180107

Jessel, S., Sawyer, S., & Hernández, D. (2019). Energy, Poverty, and Health in Climate Change: A Comprehensive Review of an Emerging Literature. *Frontiers in Public Health*, *7*. https://doi.org/10.3389/fpubh.2019.00357

Jones, B., Karpman, J., Chiebnikow, M., & Goggans, A. (2019). *California Building Decarbonization Workforce Needs and Recommendations*. https://innovation.luskin.ucla.edu/california-building-decarbonization/

Kime, S., Jacome, V., Pellow, D., & Deshmukh, R. (2023). Evaluating equity and justice in low-carbon energy transitions. *Environmental Research Letters*, *18*(12), 123003. https://doi.org/10.1088/1748-9326/ad08f8

Kirk, C. (2023). *Decarbonizing California Equitably: A Guide to Tenant Protections in Building Upgrades/Retrofits Throughout the State*. https://www.saje.net/wp-content/uploads/2023/09/Decarbonizing-California-Equitably-Report-1.pdf

Lebel, E. D., Michanowicz, D. R., Bilsback, K. R., Hill, L. A. L., Goldman, J. S. W., Domen, J. K., Jaeger, J. M., Ruiz, A., & Shonkoff, S. B. C. (2022). Composition, Emissions, and Air Quality Impacts of Hazardous Air Pollutants in Unburned Natural Gas from Residential Stoves in California. *Environmental Science & Technology*, *56*(22), 15828–15838. https://doi.org/10.1021/acs.est.2c02581

Miller, C., Chen, S., Hu, L., & Sevier, I. (2019). *Equitable Building Electrification A Framework for Powering Resilient Communities*. https://ecology.iww.org/PDF/misc/Greenlining_EquitableElectrification_Report_2019_WEB.pdf

Moe, A., & Gibbs, P. (2023). *Equitable Electrification Analysis for Existing Buildings in Richmond, CA*. https://doi.org/10.2172/1998661

Nadel, S. (2019). Electrification in the Transportation, Buildings, and Industrial Sectors: a Review of Opportunities, Barriers, and Policies. *Current Sustainable/Renewable Energy Reports*, *6*(4), 158–168. https://doi.org/10.1007/s40518-019-00138-z

National Association of City Transportation Officials. (2017). *Urban Street Stormwater Guide*. National Association of City Transportation Officials. https://nacto.org/publication/urban-street-stormwater-guide/streets-are-ecosystems/complete-streets-green-streets/

Ong, P. M. (2002). Car ownership and welfare-to-work. *Journal of Policy Analysis and Management*, *21*(2), 239–252. https://doi.org/10.1002/pam.10025

Orange County Transportation Authority. (2022). *Orange County Mobility Hubs Strategy*. https://octa.net/pdf/MobilityHubsStudyFinalReport.pdf

Pacific Gas & Electric (PG&E). (2024a). *Electric Home Rate Plan (E-ELEC)*. Pacific Gas & Electric (PG&E). https://www.pge.com/en/account/rate-plans/find-your-best-rate-plan/electric-home.html

Pacific Gas & Electric (PG&E). (2024b). *Public Safety Power Shutoffs*. Pacific Gas & Electric (PG&E). https://www.pge.com/en/outages-and-safety/safety/community-wildfire-safety-program/public-safety-power-shutoffs.html

Patel, R. K., Etminani-Ghasrodashti, R., Kermanshachi, S., Rosenberger, J. M., & Foss, A. (2022). Mobility-on-demand (MOD) Projects: A study of the best practices adopted in United States. *Transportation Research Interdisciplinary Perspectives*, *14*, 100601. https://doi.org/10.1016/j.trip.2022.100601

PolicyLink. (2022). *All-In Cities Policy Toolkit*. PolicyLink. https://allincities.org/toolkit

Ribeiro, D., Mackres, E., Baatz, B., Cluett, R., Jarrett, M., Kelly, M., & Vaidyanathanmm Shruti. (2015). *Enhancing Community Resilience through Energy Efficiency* .

Rodier, C., Farzad, A., & Robert A, J. (2015). Exploring Unintended Environmental and Social-Equity Consequences of Transit Oriented Development. *UC Davis: National Center for Sustainable Transportation*. https://escholarship.org/uc/item/88d8236t#author

Sacramento Metropolitan Air Quality Management District. (2017). *Our Community CarShareSacramento Pilot Project ourcarshare.org* . https://ww2.arb.ca.gov/sites/default/files/movingca/pdfs/ourcommunity.pdf

San Francisco Bay Area Rapid Transit District. (2023). *BART's Transit-Oriented Development Program Work Plan*.

https://www.bart.gov/sites/default/files/docs/BART%20TOD_Workplan_FINAL_Spreads_200814%20Reduced.pdf

San Francisco Bay Area Rapid Transit District. (2024, January 1). On Jan. 1, BART fares to increase 5.5%, low-income fare discount to increase to 50%. *San Francisco Bay Area Rapid Transit District* . https://www.bart.gov/news/articles/2023/news20231211-0

Stacy, C., Blagg, K., Su, Y., Rainier, M., Noble, E., & Ezike, R. (2022). *Access to Opportunity through Equitable Transportation*. https://www.urban.org/sites/default/files/publication/102992/access-to-opportunity-through-equitable-transportation_0.pdf

Stone, B., Mallen, E., Rajput, M., Gronlund, C. J., Broadbent, A. M., Krayenhoff, E. S., Augenbroe, G., O'Neill, M. S., & Georgescu, M. (2021). Compound Climate and Infrastructure Events: How Electrical Grid Failure Alters Heat Wave Risk. *Environmental Science & Technology*, *55*(10), 6957–6964. https://doi.org/10.1021/acs.est.1c00024

Tanrikulu, S., Reid, S., Koo, B., Fang, Y., Baird, A., Jia, Y., Cordova, J., & Matsuoka, J. (2022). *Assessing Ambient Air Quality and Health Impacts from Natural Gas Building Appliances in the Bay Area: Supplmental Information for Proposed Amendments to Regulation 9, Rule 4 and Rule 6*. https://www.baaqmd.gov/~/media/dotgov/files/rules/reg-9-rule-6-nitrogen-oxides-emissions-from-natural-gasfired-water-heaters/2021-amendment/documents/20221220_sr_appe_rg09040906-pdf.pdf?rev=f05e1e6f12874600a0382b178b04ab0d

Tessum, C. W., Paolella, D. A., Chambliss, S. E., Apte, J. S., Hill, J. D., & Marshall, J. D. (2021). PM 2.5 polluters disproportionately and systemically affect people of color in the United States. *Science Advances*, *7*(18). https://doi.org/10.1126/sciadv.abf4491

United States Environmental Protection Agency Office of Air and Radiation. (2023). *Benefits Analyses: Low-Income and Disadvantaged Communities* . https://www.epa.gov/system/files/documents/2023-05/LIDAC%20Technical%20Guidance%20-%20Final_2.pdf

U.S. Department of Energy. (2023). *The U.S. National Blueprint for Transportation Decarbonization*. https://www.energy.gov/sites/default/files/2023-01/the-us-national-blueprint-for-transportation-decarbonization.pdf

U.S. Department of Transportation. (2015, August 24). *Active Transportation*. U.S. Department of Transportation. https://www.transportation.gov/mission/health/active-transportation

U.S. Department of Transportation. (2022). *A Toolkit For Planning and Funding Rural Electric Mobility Structure* .

U.S. Environmental Protection Agency. (2023, November). *Protecting Your Health*. U.S. Environmental Protection Agency . https://www.epa.gov/flooded-homes/protecting-your-health

Vision Zero Network. (2024). *What is Vision Zero?* Vision Zero Network . https://visionzeronetwork.org/about/what-is-vision-zero/

Wolch, J. R., Byrne, J., & Newell, J. P. (2014). Urban green space, public health, and environmental justice: The challenge of making cities 'just green enough.' *Landscape and Urban Planning*, *125*, 234–244. https://doi.org/10.1016/j.landurbplan.2014.01.017

Zhou, X., & Zolnik, E. J. (2013). Transit-Oriented Development and Household Transportation Costs. *Transportation Research Record: Journal of the Transportation Research Board*, *2357*(1), 86–94. https://doi.org/10.3141/2357-10

Zhu, Dr. Y., Connolly, R., Lin, Dr. Y., Mathews, T., & Wang, Z. (2020). *Effects of Residential Gas Appliances on Indoor and Outdoor Air Quality and Public Health in California*.

Zuraimi, M. S., & Tan, Z. (2015). Impact of residential building regulations on reducing indoor exposures to outdoor PM 2.5 in Toronto. *Building and Environment*, *89*, 336–344. https://doi.org/10.1016/j.buildenv.2015.03.010