REVIEWING THE IMPACT AND COST-EFFECTIVENESS FOR LOCAL CLIMATE ACTION WITHIN THE UNITED STATES: A LITERATURE REVIEW

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TABLE OF CONTENTS

Table of Contents **2**

Introduction **3**

Background and Methodology **5**

Review of Sectors **7**

Energy 7

Transportation 11

Solid Waste 16

Water and Wastewater 19

Agriculture and Conservation 21

Discussion **24**

Conclusion **26**

References **28**

Appendix A – Figure Quantifying Experimental Methodologies **43**

Appendix B – Further Reading on Impact Evaluation Methodologies **44**

Appendix C – Climate Actions **45**

Appendix D **53**

Appendix E – Sector Figures **54**

Appendix F – Geography **57**

INTRODUCTION

As climate change worsens, cities, counties, and states have emerged as central drivers of climate action in the United States. Thirty-five of the fifty largest cities in the United States have adopted local climate action plans (CAPs) laying out strategies for decarbonizing their economies and addressing climate-related impacts (Ballotpedia, 2022). While also passing CAPs of their own, counties and regions are establishing regional program portfolios like the Bay Area's Regional Energy Network or the Pacific Northwest's Northwest Energy Efficiency Alliance, which aim to foster regional collaboration and address cross-municipality climate issues, like aligning codes and standards in build permitting and establishing best practices for contractors entering the green workforce. The growing prevalence of such initiatives highlights how local jurisdictions are leading in climate action, especially with the shifting policy environment at the federal level.

The growing importance of local climate action, however, raises a key question: what does the extant experimental evidence say about the effectiveness of climate actions enumerated in CAPs or similar documents? Experimental evidence can highlight effective policy solutions–in terms of both impact and cost-effectiveness–and help policymakers avoid pitfalls identified in previously evaluated programs. Reviewing the experimental evidence also identifies evidence gaps, providing researchers foci for fertile, new areas of research, particularly in sectors vital for achieving decarbonization. For example, Princeton's Zero Lab forecasts that new policies must increase the amount of carbon sequestered by land carbon sinks by approximately 600 million metric tons of CO_2-equivalent by 2035 for the United States to maintain a net zero emissions pathway (Jenkins et al., 2024). Despite this large quantity, local policy interventions focused on expanding the capacity of land carbon sinks to sequester carbon is one of the least studied areas in local climate action within the United States.

This literature review sought to identify the extant experimental evidence by reviewing CAPs across the United States and reviewing the impact evaluation literature for climate actions listed in these documents, specifically focusing on studies utilizing credible experimental designs. This review prioritizes studies that use credible identification strategies to draw causal conclusions. A study is considered credible if it establishes a clear counterfactual—what would have happened without the intervention—through designs like randomized evaluations, regression discontinuity, natural experiments, or other quasi-experimental methods. This strict focus ensures that the findings on policy effectiveness are based on robust evidence of causal impact.

This literature review identified evidence based on five broad sectors commonly enumerated in CAPs: Energy, Transportation, Solid Waste, Water and Wastewater, and Agriculture and Conservation. This literature review found robust bases of experimental evidence for the Transportation and Energy sectors while the Solid Waste, Water and Wastewater, and Agriculture and Conservation sectors have relatively thin bases of evidence. Beyond the actual number of impact evaluations for a particular sector, this literature review identified considerable heterogeneity within sectors. Certain types of actions and target populations were studied extensively whereas others have yet to be evaluated. For example, within the Energy sector and building-facing interventions specifically, most studies have evaluated the effects of interventions on single-family homeowners, seldom evaluating the effects of similar interventions on renters. Many studies also inconsistently reported metrics for cost-effectiveness, infrequently accounted for the marginal emissions inherent to the geographic heterogeneity of power plant siting, and seldom considered the equity impacts of their studied interventions. Accordingly, this literature not only identifies major evidence bases and

gaps to inform climate action, it also identifies valuable ancillary analyses that are excluded from studies within the extant literature.

To our knowledge, this literature review is the first of its kind to review the evidence base for climate actions as they are commonly enumerated in CAPs and similar documents. Previous literature reviews have instead focused on particular sectors and types of interventions, or specific phenomena (like rebound effects) commonly observed within the impact evaluation literature on climate actions. Many of these literature reviews have naturally focused on the Transportation and Energy sectors since these sectors have the most robust bases of studies with credible experimental designs. For example, with an explicit focus on studies with credible experimental designs, Gillingham et al. (2018) conducted a literature review of energy efficiency policies and programs, also identifying the factors contributing to the energy efficiency gap and providing an aggregate measure of the cost-effectiveness of energy efficiency interventions. Similarly, Giandomenico et al. (2022) reviewed energy efficiency home retrofit evaluation studies overviewing the relative effectiveness of different retrofits while also exploring how study design impacts the magnitude of effectiveness, finding that effectiveness decreases with the rigor of the study design. Other reviews have explored the literature on particular interventions like green nudges and the activation of norms, reviewing impact evaluations across Transportation and Energy (Brandon et al., 2022; Carlsson et al., 2021; Dannenberg et al., 2024). Finally, many reviews explore the literature on particular phenomena commonly identified within climate action like the rebound effect (Gillingham et al., 2020). While previous studies have focused on a more circumscribed set of studies relevant to particular interventions (e.g., home retrofits) or particular phenomena (e.g., rebound effects), this literature review uses CAPs as the frame of reference for directing this review. By focusing on the extant evidence base for CAPs, this literature review maps the climate action space to actions directly relevant to policymakers, providing them with a comprehensive understanding of the empirical support for the strategies that they plan to implement.

Our literature review explores the extant literature for climate actions in CAPs and similar documents. The *Background and Methodology* section provides an overview on the documents used to identify common climate actions and an explanation of our methodology for conducting the review. The *Review of Sectors* section dives into the findings of the literature review summarizing the key insights and identifying evidence gaps for each sector. The *Discussion* section explores the reporting of cost-effectiveness metrics and the importance of connecting cost-effectiveness to analyses of marginal emissions and additionality while considering equity.

BACKGROUND AND METHODOLOGY

This literature review was the culmination of two projects by the SDG Policy Initiative (SDGPI) at UC San Diego and the Evidence for Climate Action Project of J-PAL North America. These projects evaluated the extant evidence for climate actions within the San Diego region's *Let's Get There Playbook*, the local regional energy network's portfolio of programs, and the County of San Diego's *Climate Action Plan* (County of San Diego, 2023a, 2023b; San Diego Community Power, n.d.). Collectively, these documents provide a broad range of interventions available to individuals and organizations throughout the region for reducing greenhouse gas emissions. There was broad overlap between the actions proposed by these three initiatives, which initially served as the basis for this literature review. In 2025, SDGPI began supporting J-PAL North America in its Climate Action Learning Lab, which is working with six state and local jurisdictions to foster evidence-based policymaking in climate action. Additional climate actions were sourced from CAPs (or similar documents) from these participating jurisdictions, expanding the literature review beyond San Diego and establishing 'universal' policy actions for applicability across a range of local contexts. A full overview of the actions can be found in Appendix C.

While the explicit focus of this literature review was on actions related to decarbonization, the scope also included actions related to sustainability and resiliency. CAPs and similar documents often include actions beyond decarbonization, such as measures for boosting waste diversion and water conservation. Although these measures often have components related to reducing GHG emissions, thereby accelerating decarbonization, such CAP actions did not necessarily correspond to decarbonization targets in all cases. Accordingly, reviewing the evidence base for climate actions as enumerated in CAPs required drawing on literature beyond decarbonization. Actions related to sustainability were most prevalent in the Solid Waste and Water and Wastewater sectors. Studies on sustainability-driven actions actually made up large portions of the evidence-base of these sectors, indicating a significant evidence gap as researchers do not conduct studies in these sectors with an explicit decarbonization focus. Boosting resiliency and adaptation was another goal present in some CAPs; however, no evidence was identified for related actions.

This literature review used the sectors, actions and measures presented in CAPs to identify relevant evidence. The five sectors forming the basis of this review are Energy, Solid Waste, Transportation, Water and Wastewater, and Agriculture and Conservation. Search terms were created based on the intervention categories and intervention types reflected in sector actions identified from the aforementioned documents. Intervention categories are defined as the subsectors of the economy in which action is taken (e.g., Renewable Energy, Public Transportation, Space Heating, etc.). Intervention types are defined as the manner in which action is taken (e.g., an incentive, regulatory change, nudge, etc.). Given that many studies implement multiple interventions simultaneously, a single article may fall under more than one intervention type. Similarly, some individual studies span multiple locations. As a result, the numeric distribution of articles by intervention type or location may exceed the actual number of distinct articles in a given sector. After devising search terms using the intervention categories and types, searches were conducted on EconLit, Nature, the National Bureau of Economic Research's Working Paper Series, the Proceedings of the National Academy of Sciences, and Google Scholar. The first 200 entries of each search were screened based on their abstracts and, if necessary, their introduction and methodological sections. This screening was guided by a set of inclusion criteria:

- The article had to be peer-reviewed.
- The article had to employ an established experimental strategy (e.g., randomized controlled trial; regression discontinuity; or natural or quasi-experiment).
- The article had to be written after the year 2000.
- The article had to evaluate a program aimed at achieving an environmental objective related to decarbonization, sustainability, or resiliency as enumerated in CAPs (e.g., the intervention had to reduce emissions, contribute to reducing emissions in some way, or facilitate sustainability or resiliency). For example, outcomes include energy consumption, waste diversion rates, uptake of solar PV, or EV adoption rates. Studies that focused exclusively on consumer savings, improved health outcomes, or consumer satisfaction were excluded.
- The article had to evaluate a program implemented in North America, Europe, Australia, and New Zealand–regions chosen for their potential generalizability to the United States.
- The article had to evaluate a clear policy intervention that attempted to change human behavior.

Backward searches were also conducted by reviewing the citations of included articles to find other relevant studies missed by the initial searches. After articles were identified, they were mapped onto the universal climate actions identified from the jurisdictions' planning documents.

REVIEW OF SECTORS

ENERGY

Overview

The Energy sector when including emissions from residential and commercial buildings emits the largest amount of GHGs out of any sector (U.S. Environmental Protection Agency, 2025). CAPs included multiple interventions in the Energy sector usually subcategorized within some version of the subsectors Buildings and Renewable Energy. This literature review identified Energy, and especially its subsector of Buildings, as the most studied sector in local climate action.

In the Buildings subsector, actions within CAPs included incentivizing purchases, mandating requirements, and providing information for boosting the adoption of energy efficiency investment and electrification. These actions focused on both residential and commercial buildings. A significant portion of CAPs also included actions directly targeting owners of multi-family buildings and commercial businesses, as well as renters. Despite their inclusion, however, the majority of studies identified in this literature review instead focused on programs targeted to single-family homeowners. Most impact evaluations in this subsector focus on evaluating the effect of such interventions on energy consumption, often measured as the reduced consumption of natural gas or electricity, measured in therms or kWh. Few studies measured actual adoption rates of energy efficient investments or building electrification despite the emphasis in CAPs. The majority of these studies were conducted in urban areas within the United States with a small number of studies conducted in the United Kingdom, Switzerland, and Australia.

Across the types of interventions within the Building subsector, studies generally found that ex-ante engineering simulations of energy savings were greater than ex-post realized savings. Studies attribute this discrepancy to behavioral factors often unaccounted in engineering simulations like the rebound effect or the lack of salience of energy prices. Studies persistently register rebounds in usage where households actually increase energy consumption in response to the cost savings from energy efficiency. This tendency is especially acute for households in lower income brackets. Salience refers to how noticeable the price of a good or service is to a consumer at the moment of a purchase. Studies show that consumers are inattentive to energy prices and the long-term operating costs of appliances, causing them to undervalue savings that accrue from increased energy efficiency or conservation. Interventions within the building sector also registered additionality effects for multiple incentive programs, especially for appliances like dishwashers, clothes washers, and refrigerators. *Additionality* describes incentives like rebates or tax credits that actually change purchasing behavior (e.g., they incentivize a purchase that would not have happened otherwise). If a household uses a rebate or tax credit for a purchase when they would have made that purchase absent the rebate or tax credit, that purchase is *non-additional*. Whether a purchase is additional or non-additional has a direct bearing on cost-effectiveness since non-additional purchases are essentially free riding where a subsidy is given to individuals who had already made a purchasing decision. Beyond additionality, there was also considerable heterogeneity between both interventions and target populations; the effectiveness of interventions varied based on the targeted appliance and on a household's socio-economic characteristics, baseline energy consumption, geographic area, and utility service area.

In the Renewable Energy subsector, actions within CAPs included measures aimed at expanding renewable (or clean) energy within the jurisdiction's energy mix. These CAP actions most commonly

focused on creating both incentive programs and, to a lesser extent, financing programs for boosting the adoption of renewable energy like rooftop solar or geothermal energy. Beyond incentives, jurisdictions included measures to streamline solar permitting processes, expand local job training programs related to renewable energy, and work with local partners to boost community renewables and storage. CAPs also commonly provided measures for expanding green tariff programs or community choice aggregation.[1] Impact evaluations identified for these actions largely focused on incentives and information programs aimed at boosting the adoption of rooftop solar. Contrary to the buildings sector, consumption was often not evaluated. Instead, most of these studies focused directly on rooftop solar adoption and increases in generation capacity. Geographically, these studies were concentrated within the United States, especially in California and Connecticut.

Impact evaluations on actions related to the Renewable Energy subsector were generally found to be effective. Subsidies and property assessed clean energy (PACE) financing for rooftop solar boosted their adoption rate. Subsidies in one case were found to be non-additional. A few studies evaluated informational programs aimed at increasing rooftop solar adoption through nudges and community ambassadors. These studies found that social learning and peer effects were important factors for increasing adoption. The types of informational interventions studied were highly heterogeneous, spanning Facebook ads for rooftop solar to large-scale municipal information campaigns to boost rooftop solar adoption. Green tariffs and community choice aggregation were not studied substantively.

Buildings

Forty-three impact evaluations were identified through the course of this literature review that used credible identification strategies in the Building subsector. The majority of these impact evaluations were quasi-experimental, usually employing a difference-in-differences strategy. Nonetheless, the Buildings subsector had the largest body of evidence with rigorous research methodologies: 10 studies used a randomized controlled trial (RCT) experimental design and 7 used regression discontinuity designs. The most commonly-studied interventions were incentive programs providing rebates or direct installations for energy efficient appliances, space cooling and space heating systems, and home weatherization (n = 26). Following incentives, building standards were also commonly studied; building standards constitute requirements or programs that contribute to greater energy efficiency, including building codes (n = 7) and building certification programs like Leadership in Energy and Environmental Design (LEED) or ENERGY STAR (n = 3).

Most CAPs contain actions related to incentivizing the adoption of energy efficient consumer durables like efficient air conditioning, space heating, or appliances. Due to the long history of energy efficient appliance rebate programs implemented by local jurisdictions and utilities, such incentives have been robustly studied. Impact evaluations of these incentive programs were usually aimed at appliances (n = 7), space cooling (n = 12), space heating (n = 10), and weatherization (n = 11). These impact evaluations usually used a treatment group of households that received an incentive for a particular energy efficient appliance and a control group of households that did not receive that incentive, comparing differences in energy consumption. Studies evaluating incentive programs for appliances like efficient clothes washers and dryers, and dish washers found such programs generally

[1] Community choice aggregation is an alternative to traditional utility-based models of electricity provision in which local governments procure electricity on behalf of their residents. In jurisdictions with community choice aggregation, local governments procure electricity from generators on behalf of their residents while the local utility remains responsible for transmission and distribution infrastructure. Consumers in communities with community choice aggregation receive a consolidated bill from the local utility with separate charges from the local government (called the community choice aggregator) and from the utility in the form of delivery and maintenance charges.

effective at increasing uptake but a few registered intertemporal substitution, the idea that households moved an already planned purchasing decision to an earlier time, a form of non-additionality (Buettner and Madzharova, 2024; Datta and Gulati, 2014; Houde and Aldy, 2017). Studies evaluating incentives for efficient air conditioning (AC) found that households who installed efficient AC reduced electricity consumption; however, price variation throughout the day affected the level of energy savings (Boomhower, 2020). One study found that this price variation actually creates an incentive to overinvest into energy efficient AC (Novan, 2018). This 'incentive to overinvest' arises due to discrepancies between the social and private benefits of investments into energy efficient AC, especially under different electricity rate structures (Liang et al., 2021). Studies of incentive programs for space heating and weatherization found these incentives generally effective at reducing energy consumption; however, many studies found ex-ante engineering predictions of energy savings were far greater than ex-post realized savings (Allcott and Greenstone, 2017; Fowlie, 2018). Recent studies of space heating and weatherization also point to the decisive impact of contractors on realized savings (n = 2); however, the impact of contractor quality remains as an understudied aspect of building decarbonization (Christansen et al., 2023; Giraudet et al., 2018).

New statutes for energy efficiency and electrification are also commonly enumerated in CAPs. These statutes include building codes that mandate particular levels of energy efficiency or electrification in a particular building, and building benchmarking and certification that signal the level of energy efficiency within a building. Impact evaluations of these different standards analyzed their impact on energy consumption. Building codes are sets of regulations that establish minimum energy requirements for new and renovated buildings. Studies evaluating building codes have found their effects to be mixed with studies registering both positive and negative effects on average energy consumption (Bruegge et al., 2018, Jacobsen and Kotchen, 2010; Novan et al., 2022; Levinson, 2016). Levinson (2016) found that the effect of building codes cannot be disentangled from the tendency for buildings to become more efficient over time, while Bruegge (2018) finds evidence that building codes do contribute to savings but at the cost of reduced housing sizes in lower income communities. Compared to building codes, building certifications like LEED and ENERGY STAR reduce energy consumption by ostensibly increasing investment into energy efficiency so buildings can meet said standards. Studies on LEED in federal buildings (Clay et al., 2021) and ENERGY STAR in commercial buildings (Brolinson et al., 2023) found building certifications ineffective on average. Clay et al. (2021) found that building owners attempting to meet LEED certification traded off energy efficiency for water efficiency. Brolinson et al. (2023) also found suggestive evidence that ENERGY STAR certification serves as an indicator of pre-existing energy efficiency rather than an incentive to invest further into energy efficiency.

Renewable Energy

Despite the importance of renewable energy for decarbonization overall, the evidence base for programs focused on decarbonizing the local energy supply is thin (n = 12). The majority of these impact evaluations were quasi-experimental employing some version of difference-in-differences. Only one study used an RCT design (Gillingham and Bollinger, 2020) and another study used a regression discontinuity design (Ameli et al., 2017). Studies in Renewable Energy focused on either state- or local-level incentives programs or municipal programs for providing information on renewable energy investments. Interventions evaluating incentives focused on measures to offset the costs of rooftop solar, either through subsidies or PACE financing (n = 5). Studies on municipal informational programs pertained to boosting adoption of rooftop solar or increasing enrollment into green tariff programs through community information campaigns or peer comparisons (n = 5).

Most CAPs included explicit actions for incentivizing the adoption of renewable energy either at the individual or community level. They also often included actions like increasing the proportion of the energy mix supplied by renewable energy, which often imply incentives or financing programs for boosting individual- or community-produced renewable energy. Despite the near ubiquitous presence of such actions within CAPs, few studies have been conducted on incentive or financing schemes for individual- and community-level renewable energy. Impact evaluations on incentive programs for rooftop solar either evaluated subsidies (n = 2) or property assessed clean energy financing (n = 3). Studies that evaluated subsidies for rooftop solar exclusively focused on installations subsidized through the California Solar Initiative, which ran between 2006 and 2016 (Bollinger and Gillingham, 2012; Hughes and Podolefsky, 2015). Bollinger and Gillingham (2012) found suggestive evidence that the installation of a rooftop solar system within a neighborhood increases the probability of additional installations within that neighborhood. Hughes and Podolefsky (2015) found that Solar Initiative incentives increased the number of installations; however, using a constructed counterfactual, they also found that many installations were non-additional. Beyond incentives, three studies also evaluated property assessed clean energy (PACE), a financing mechanism that allows property owners to finance investments into rooftop solar through a special assessment on their property tax bill. Studies on PACE have found it to be generally effective at boosting the uptake of rooftop solar (Ameli et al., 2017; Kirkpatrick and Bennear, 2014; Winecoff and Gaff, 2020). However, though PACE was generally effective at boosting uptake, Winecoff and Gaff found that PACE-funded installations did not necessarily lead to a reduction in carbon emissions, largely due to rebounds in energy usage and shortfalls between self-generation and consumption, necessitating fossil-fuel-produced energy from the electricity grid. The studies on PACE financing also only occurred in California.

CAP actions for increasing the proportion of the energy mix for a jurisdiction supplied by renewable energy also imply informational interventions aimed at boosting interest into renewable energy, and green tariff and community choice aggregation programs. However, interventions focused on information are highly heterogeneous covering multi-component programs leveraging community ambassadors, community-based recruitment, and group pricing; different message framings for encouraging rooftop solar adoption; different framings to induce pro-social behavior in peer-to-peer solar; and community-based campaigns for enrollment into green tariff schemes. In the case of multi-component programs, Gillingham and Bollinger (2021) studied the Solarize campaign in Connecticut and found that the program's use of community ambassadors had a very strong effect on installations and that group pricing led to a significant decrease in installation costs. They also underscored that social learning was the primary mechanism for the program's success. Carattini et al. (2022) studied whether rendering visible pro-social behavior in the form of providing peer-to-peer solar to neighbors increases engagement with such schemes. Peer-to-peer solar is a scheme where rooftop solar owners opt to sell their excess energy to their neighbors, an action with pro-social aspects that are usually invisible to peers (Carattini et al., 2022). Carattini et al. found that rendering the provision of peer-to-peer solar visible through the sharing of green reports on social media increased interest in prospective adopters of rooftop solar. Focusing on the adoption of rooftop solar on its own, Bollinger et al. (2020) tested whether pro-social or self-interest based messaging was the most effective for inducing rooftop solar adoption. They found that self-interest messaging was not only more effective but that households receiving self-interest messaging who chose to install rooftop solar had more productive systems (Bollinger et al., 2020). Departing from rooftop solar, Jacobsen and Kotchen (2013) studied the effects of community-based incentives on stimulating community recruitment into green tariff schemes. They found that providing municipal solar panels as a symbolic reward for particular levels of enrollment in green tariff schemes was an effective means of mobilizing community members to recruit their neighbors (Jacobsen and Kotchen, 2013).

Evidence Gaps

Of the twenty three actions identified within the energy sector, only eleven actions have at least one study. Of those 11 actions, only five had evidence bases consisting of at least four studies:

1. Require all-electric equipment and higher energy efficiency in new developments.
2. Incentivize building electrification and energy efficiency.
3. Develop a voluntary energy assessment/benchmarking program for existing development to identify opportunities for energy efficiency improvements.
4. Implement a mandatory disclosure policy for energy efficiency for existing developments entering the market.
5. Develop a program to incentivize renewable energy.

No impact evaluations were identified that studied the effects of programs for increasing municipal energy efficiency, electrification, or renewable energy. The literature review also did not identify impact evaluations that dealt explicitly with fuel-switching programs (e.g., programs aimed at phasing out propane or natural gas appliances). Renter-facing programs also lack impact evaluations, meaning the effects of incentives, information provision, and standards on renters are still poorly understood in this sub-population. No studies were identified that corresponded to training programs for homeowners or multifamily building owners. Such programs would inform such owners about energy efficiency, energy efficiency benchmarking, and available incentive programs for their buildings. Finally, impact evaluations on contractor-facing programs remain as a significant evidence gap. Given recent evidence that contractor quality can have a significant impact on realized energy savings, contractor-facing programs will likely be fruitful areas of further study (Christansen et al., 2023; Giraudet et al., 2018). Finally, impact evaluations on commercial buildings for energy efficiency and electrification programs are also few in number. The impact of incentives, information provision, and building standards on the behavior of commercial building owners also remains poorly understood.

In the renewable energy space, no impact evaluations were identified for programs related to streamlining the solar permitting process or developing a green workforce. Few studies evaluated green tariffs and community choice aggregation. Given the growth of such schemes across the country as an alternative to the provision of energy by traditional investor owned utilities, they will continue being an area of fruitful and novel study into the future. No studies have evaluated programs aimed at stimulating solar adoption at the community or commercial levels. The focus of all studies within the Renewable Energy sector was single-family homes. Moreover, as cautioned previously, the geographic specificity of studies within this sector is especially acute; nearly all studies in this sector occur in either California or Connecticut. Studying the effects of incentives and information provision in other geographic contexts with different levels of solar radiation and statutory frameworks will be important for informing where such interventions are the most effective.

TRANSPORTATION

Overview

The Transportation sector is the second largest contributor to greenhouse gas emissions in the U.S. after Energy, driven mostly by emissions from on-road sources like light-duty vehicles and medium- and heavy-duty trucks (U.S. Environmental Protection Agency, 2025, March 31; U.S. Environmental

Protection Agency, 2025, June 6). In this literature review, Transportation emerges as the second most-studied area. The interventions identified from jurisdictions' CAPs focused on accelerating electric vehicle (EV) adoption through public charging infrastructure provision, EV purchase incentive programs, school bus electrification programs, equitable adoption strategies, and information provision related to EV incentives and charging infrastructure. Interventions also focused on shifting toward alternative modes of transportation via Safe Routes to Schools programs, educational campaigns, improved infrastructure, and zero-emission landscaping ordinances. Reducing emissions from jurisdiction operations was also included. Interventions for reducing jurisdictional emissions focused on transitioning the internal fleet to EVs, adopting an anti-idling policy, establishing zero-emissions construction and landscaping mandates, providing transportation benefits to jurisdiction employees, and implementing education and incentive programs for jurisdiction staff.

Out of the 36 studies, the Fleet Transition subsector has the largest body of evidence, followed by Public Transportation, and Traffic Congestion/Transportation Demand Management. Across these three areas, the literature mainly pertained to programs and policy interventions in urban U.S. cities, with some in Europe, Canada, and Mexico. For the most part, evidence in Fleet Transition centers on programs designed to increase the adoption of electric vehicles and to expand EV charging infrastructure through demand-side subsidy programs. Fleet Transition studies also explore the interdependence of these two interventions. The findings largely indicate that these programs are effective at increasing EV adoption, both through EV purchase programs and public charging infrastructure provision. Additional analyses demonstrated that adoption increased to a greater degree for battery electric vehicles (BEVs) than plug-in hybrid vehicles (PHEVs), both in the case of incentives and charging infrastructure. The only study to carry out additionality analyses found that a means-tested EV purchase program did not increase adoption substantially above what would have likely happened absent the program. In Traffic Congestion/Transportation Demand Management, the literature spans a variety of intervention types as well as outcomes related to reducing vehicle miles travelled. Air quality alerts produced mixed results in shifting commuter behavior and encouraging transit use, while financial incentives were not effective at reducing single occupancy vehicle trips. However, less than four studies were mapped to each intervention type in this subsector so findings should be considered with caution. The literature in Public Transportation also spanned a range of interventions. Studies found substantial congestion relief benefits from public transit systems and that public transit subsidies shifted transit use in the expected direction. Real time information (RTI) led to increases in public transit use in some contexts, while it failed to increase bus ridership in one RCT.

Fleet Transition

The evidence base for Fleet Transition focuses on programs designed to increase the adoption of electric and fuel-efficient vehicles, in turn reducing on-road greenhouse gas emissions. Within this subsector, incentives are the most commonly studied interventions (n = 10), which primarily consist of programs designed to increase electric vehicle adoption. Nudges (n = 3) and public EV charging infrastructure provision (n = 7) are the second most studied behavioral interventions in the category, followed by one article on HOV lane access and one article on fuel economy standards. The majority of studies across these interventions within Fleet Transition employ quasi-experimental methods. One study (Bailey et al., 2023) uses a randomized controlled trial, which we discuss further below.

The majority of Fleet Transition studies on incentives focus on EV subsidy programs that aim to increase the adoption of electric vehicles (n = 7); some examine the impact of the U.S. fuel economy

incentive programs on the adoption of more fuel-efficient vehicles (n = 3) and one study examines the impact of financial incentives and nudges aimed at shifting at-home peak EV charger timing to off-peak hours. All literature except for Bailey et al. applies quasi-experimental methods.

Evaluations of EV subsidy programs primarily analyzed the impact of EV purchase programs on electric vehicle adoption, with some analyses of additionality and heterogeneity analyses across incentive and vehicle type. All studies found that subsidies led to a statistically significant increase in EV adoption (Clinton & Steinberg, 2019; Li et al., 2017; Muehlegger & Rapson, 2022; Narassimhan & Johnson, 2018; Springel, 2021). Springel analyzed the impact of other financial incentives on adoption in Norway including a registration fee exemption, a value-added tax exemption, and a reduced annual motor vehicle tax (2021). Muehlegger & Rapson (2022) evaluated the impact of California's means-tested Enhanced Fleet Modernization Program (EFMP) on EV adoption and the elasticity of demand in low- and middle-income households, and in a subsequent paper provided follow-up estimates of additionality and marginal pollution abatement (Muehlegger & Rapson, 2023). They found that the EFMP was largely non-additional; participants would have bought a relatively fuel-efficient vehicle of approximately 35 miles per gallon (mpg) absent the program. Using this counterfactual vehicle mpg in combination with grid electricity composition, vehicle miles travelled in low- and middle-income households, and other factors, they estimated that the program led to a relatively small marginal pollution abatement. These were the only studies to examine the impact of such programs on low- and middle-income household adoption. Heterogeneity analysis across incentive types found that direct purchase rebates led to greater adoption of battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs) than tax credits and sales tax waivers (Clinton & Steinberg, 2019; Narassimhan & Johnson, 2018). Narassimhan & Johnson found that BEV adoption was more responsive to state-level subsidy programs than PHEV adoption, and that there was no significant difference in the adoption of Tesla vehicles vs. non-Tesla vehicles.

"Cash for Clunkers" is a commonly studied program that provides subsidies to trade in older, less fuel-efficient vehicles for newer, more fuel-efficient ones. Literature analyzing the impact of the program found that it led to a statistically significant increase in fuel-efficient vehicle purchases (West et al., 2015; Hoekstra et al., 2017; Li et al., 2013). Hoekstra et al. estimated that less than half of purchases were additional while Li et al. found a higher level of additionality at 57% of purchases. Despite being a common criticism of fuel efficiency programs, two studies found that there was no evidence of a rebound effect that would offset the reduction in fuel consumption achieved through program-driven efficiency gains (Hoekstra et al., 2017; West et al., 2015).

The literature on nudges in this subsector primarily relate to fuel economy information. Allcott & Knittel (2019) found that this information failed to increase the average fuel economy of vehicles purchased, while Gillingham et al. (2021) found that U.S. consumers systematically undervalue fuel economy in vehicle purchases to a large extent. A randomized controlled trial by Bailey et al. (2023) evaluated the impact of "moral suasion" nudges on shifting at-home EV charge timing, and found that nudges do not have a statistically significant effect on behavior, while financial incentives successfully shifted at-home EV charge timing from peak hours to off-peak hours of 10 PM - 6 AM.[2] However, a second phase of the study evaluating habit formation revealed that, when payments are terminated for those who received financial incentives, their charge timing reverts back to pre-intervention behavior. As the only paper on EV charge timing that met the criteria for inclusion in

[2] Moral suasion nudges change behavior by appealing to an individual's morals or ethics. Such nudges leverage social comparison or direct appeals to morals (e.g. phrases like "Don't Litter" or "Help Your Community") to convince people to change their behavior.

this literature review, this study presents important findings related to decarbonization in the transportation sector, especially since charge timing can have a decisive impact on the electricity grid and on the amount of emissions produced.

Impact evaluations related to electric vehicle charging infrastructure analyze the impact of building public EV charging infrastructure on EV adoption. All studies found that increased EV charging infrastructure led to a statistically significant increase in EV adoption (Li et al., 2017; Narassimhan & Johnson, 2018; Schulz & Rode, 2022; Sommer & Vance, 2021; Springel, 2021; van Dijk et al., 2022). Two studies specifically quantify the impacts to both sides of the market, accounting for the interdependence between EV adoption and EV charging network expansion: Li et al. estimated that 40% of the increase in EV sales in the study period was due to this interdependence, while Springel found that EV models act as complements rather than substitutes. Evaluations also highlighted large effects associated with early infrastructure provision, including in remote and rural municipalities, where findings remained significant for at least 5 years, indicating that investment into areas without any EV charging infrastructure may lead to stronger effects (Schulz & Rode, 2022; Dijk et al., 2022). Similar to the impacts from incentive programs, the impact of charging infrastructure on adoption is substantially higher for BEVs than PHEVs (Narassimhan & Johnson, 2018; Sommer & Vance, 2021). The effect of infrastructure on EV adoption is also stronger for the provision of charging stations (new charger locations) rather than charging points (additional connectors at preexisting stations), consistent with evidence around "range anxiety" (Dijk et al., 2022).

Traffic Congestion/Transportation Demand Management

The evidence base for Traffic Congestion/Transportation Demand Management largely focuses on programs to reduce single-occupancy vehicle (SOV) driving and to shift commuters towards alternative modes of transportation. Generally, CAPs did not specify which Transportation Demand Management (TDM) interventions would be implemented to achieve emissions reductions. However, in the evaluation literature, air quality alerts are the most commonly studied interventions (n = 3), which primarily consist of public advisory programs designed to reduce single-occupancy vehicle miles travelled (VMT) during high ozone pollution days. Incentives (n = 2), nudges (n = 2), and tolls and congestion pricing (n = 2) are the second most studied behavioral interventions in the subsector, followed by vehicle use restrictions (n = 1). The majority of methodologies used in this subsector include quasi-experimental methods, though two studies (Rosenfield et al., 2020; Kristal & Whillans, 2019) employ randomized controlled trials.

The literature on air quality alerts evaluated the San Francisco Bay Area's Spare the Air (STA) alerts and Chicago's Ozone Action Day (OAD) advisories. The findings are mixed: Cutter & Neidell (2009) found that STAs did not lead to a statistically significant impact on public transit use but did significantly decrease traffic volume. Conversely, Sexton found that STAs did not shift demand for car travel or carpooling (2012). Welch et al. analyzed the effect of Chicago's OAD advisories on transit ridership in the city and found that it did not lead to a statistically detectable effect on train boardings overall (2005). However, their heterogeneity analysis revealed significant changes in hourly ridership patterns: advisories reduced ridership during the 6-7 AM and 2-3 PM commute periods and increased ridership during the 10-11 AM and 6-7 PM commute periods.

Incentives in Transportation Demand Management involve financial rewards for reducing car travel and the provision of free transit passes to increase public transit ridership. Rosenfield et al. (2020) studied such financial incentives along with informational emails that ostensibly would nudge commuter behavior. They found that there were no treatment groups with statistically detectable

effects on commuting behavior, although a group that received both informational emails and financial incentives changed their behavior the most. Survey results also highlighted discrepancies between stated and actual behavior change related to shifts in transportation choices. Kristal & Whillans (2019) found that informational emails and letters, free bus trials, and personalized travel plans all did not effectively shift travel behavior away from single-occupancy vehicles.

Public Transportation

The literature in this subsector pertains to public transit complements/substitutes, real time information, public transit subsidies and bikeshare infrastructure. Studies examining the impact of subsidies are the most common (n = 5), followed by evaluations of real-time transit information (RTI) (n = 3), bikeshare infrastructure (n = 3), public transit complements and substitutes (n = 2), and competitive public transit tendering (n = 1). Most studies use natural experiments or quasi-experimental methods; one randomized controlled trial is used by Brakewood et al. (2014) to evaluate the impacts of real-time transit information on bus ridership.

Impact evaluations on public transit subsidies estimate their impact on a range of outcomes, including transit ridership, welfare estimates, traffic congestion, and gasoline consumption. Studies estimating the effect of subsidies on ridership found that these price changes shifted transit use in the expected direction (Hahn et al., 2023; Davis, 2021). Adler and van Ommeren (2016) estimated that the congestion relief benefit of public transit in Rotterdam, Netherlands is equal to 50% of the transit subsidy level, while Anderson (2014) estimates the congestion relief benefit for the Los Angeles transit system is $1.20 to $4.10 per peak-hour transit passenger mile. Findings indicate that congestion reduction benefits are strongest during weekday rush hours and greater for inner city roads than for highways, suggesting that public transit subsidies are welfare improving, even for cities with low congestion (Adler and van Ommeren, 2016). Asensio et al. (2014) found that reduction of train fares for commuting and regional trains did not lead to a statistically significant reduction in gasoline consumption, while a speed limit reduction on highways did.

All studies on RTI examine the impact of real-time information on public transit ridership in large U.S. cities, with mixed results. Brakewood et al. (2015) and Tang and Thakuriah (2012) found that the provision of RTI led to a statistically significant increase in weekday bus ridership in New York City and in Chicago. Heterogeneity analysis by Brakewood et al. found that the increase in average weekday route-level unlinked bus trips per month primarily occurred on larger routes. In contrast, a randomized controlled trial by Brakewood et al. (2014) estimated that RTI did not lead to a significant change in bus trips in Tampa, Florida, although it did significantly decrease wait times and increase feelings of satisfaction.

Studies on public transit complements and substitutes found that Uber is a complement for the average transit agency in the U.S. and that bikesharing decreases ridership (Hall et al., 2018; Campbell & Brakewood, 2017). Two studies examine the effects of bikeshare infrastructure on frequency of use in Minneapolis-St. Paul, Minnesota (Wang & Lindsey, 2019) and on traffic congestion in Washington, D.C. (Hamilton & Wichman, 2018). Wang and Lindsey found that expanding the bikeshare network led to a statistically significant increase in the frequency of use by annual members in the bikeshare program, while Hamilton and Wichman estimated that the availability of a bikeshare station reduces traffic congestion.

Evidence Gaps

Key gaps exist in the Transportation sector of this literature review. Out of the 20 actions identified in the Transportation sector, 12 have no evidence. Zero evaluations were mapped to interventions for reducing emissions in jurisdiction operations, although some of these actions may not be as amenable to evaluation (e.g. increase the number of EVs in the jurisdiction's fleet and use zero-emission construction equipment). No evidence was identified for interventions related to landscaping and construction emission reductions. While the bulk of evidence exists for actions that focus on increasing EV adoption (e.g., installing public charging infrastructure and providing subsidies for EV purchases), only two studies examined the adoption of electric vehicles in low- and middle-income households. These two studies used evidence from the same means-tested EV purchase incentive program. Some of the evidence on incentive programs focused on older subsidy programs for more fuel-efficient vehicle adoption, indicating a need for further evaluation of more recent transportation subsidy programs for increasing EV adoption. Zero articles were identified for information provision regarding EV incentives as well as interventions improving roadway infrastructure to increase public transit use and alternative modes of transportation.

Considering the geographic scope of literature in this sector, some distinct research gaps exist. While 26 of 36 studies take place in cities and states across the U.S.–with several nationwide analyses–most local-level studies in the U.S. focus on large metropolitan areas. Decarbonization in rural areas poses distinct challenges, particularly related to electric vehicle adoption, EV charging infrastructure, and public transit. These interventions remain underrepresented in the current evidence base. Characteristics of public transit systems can vary substantially even across non-rural areas. Given the outsized contribution of the transportation sector to overall greenhouse gas emissions, there is a critical need for further research in a variety of geographical contexts to support climate action at the jurisdiction-level. Additionally, while climate actions in Transportation have explicit connections to GHG emissions reductions, only three papers provided cost-effectiveness metrics on avoided emissions resulting from the programs–all in the Fleet Transition subsector. This highlights a significant gap: absent measurement of emissions reductions achieved for a given program cost, policymakers may have to make decisions with incomplete information about program effectiveness..

SOLID WASTE

Overview

Although a lesser contributor to GHG emissions than the Energy or Transportation sectors, the Solid Waste sector contributes significant GHGs in the form of methane produced through the anaerobic decomposition of organic waste at landfills and other waste facilities. Despite having a shorter atmospheric lifespan of 12 years, methane is estimated to have a global warming potential 80 times that of carbon dioxide. Accordingly, some CAPs include actions specifically aimed at reducing the production of such emissions by increasing the diversion of organic recyclables, decreasing food waste in commercial businesses, creating local compositing programs, and investing into large-scale methane capture systems at landfills. However, despite the presence of these interventions in a few CAPS, most actions in the solid waste sections of CAPs dealt with sustainability rather than decarbonization. These sections often included policies related to reducing single-use plastic bag usage and increasing waste diversion through recycling or waste sorting. They also included actions related to hard-to-recycle sectors like clothing, wooden pallets, or construction and demolition waste. Mirroring this emphasis on sustainability in CAPs, the extant evidence base also predominantly focuses on sustainability. Impact evaluations analyze programs for residential waste diversion and policies for reducing plastic bag usage, usually measured in tons or kgs of total solid waste reduced or tons or kgs of increased conventional recycling (aluminum, paper, etc.). Few studies evaluate the

effects of interventions with decarbonization-related outcomes like mitigating methane emissions. The majority of these studies were conducted in continental Europe with a small number of studies conducted in the United States and Australia.

The effectiveness of commonly evaluated interventions related to Solid Waste CAP actions varied significantly. Unit-based pricing was found to be highly effective at reducing unsorted waste, especially in areas with high baseline unsorted waste production. However, no unit-based pricing studies related their findings to reduced emissions, instead focusing on sustainability-related outcomes like reduced total solid waste and increased recycling. The provision of organic waste bins was also found to be effective at reducing unsorted waste and increasing sorted waste with potential spillover effects that saw households increase recycling as well. However, a recent study provides suggestive evidence that the cost-effectiveness of organic waste bin provision is highly dependent on the presence of methane capture facilities at local landfills (Sommers, 2025). Informational interventions were also effective in reducing unsorted waste or increasing sorted waste but the persistence of effects was directly related to whether the nudge treatment continued over time.

This literature review identified 25 studies that evaluated programs related to solid waste programs. The majority of these papers were quasi-experimental, using difference-in-differences designs, though six studies employed RCT designs. The majority of studies within Solid Waste focused on boosting individual waste diversion through interventions like unit-based pricing, single-use plastic bans and taxes, and behavioral nudges (n = 21). More recent scholarship has begun to evaluate interventions related to decarbonization like the effects of the provision of organic waste bins on organic waste diversion or carbon footprint labels on food choices; however, these studies are few in number (n = 3).

Many CAPs contained general sustainability actions related to reducing waste and increasing waste diversion that entail a wide variety of actions. Unit-based pricing was one commonly studied intervention conducted at the county and municipal level that aimed to reduce waste and increase diversion (n = 6). In unit-based pricing schemes, households are charged based on the amount of garbage that they produce, usually through some tracking system like weight- or volume-based pricing, or a bag/tag system where households are charged by scanning a tag on each garbage bag. Unit-based pricing reduces overall waste and increases diversion by more accurately pricing waste, incentivizing large producers of waste to reduce production through higher service costs. Unit-based pricing has been generally effective at decreasing unsorted solid waste and increasing sorted solid waste (Allers and Hoben, 2010; Bueno and Valiente 2015; Bucciol et al., 2015; Carattini, 2018; Usui and Takeuchi, 2014). Studies find that the effect of unit-based pricing is consistent over time with households persistently reducing unsorted solid waste (Carattini, 2018; Usui and Takeuchi, 2014). When comparing the different unit-based pricing schemes implemented in municipalities across the Netherlands, Allers and Hoben (2010) found that weight-based pricing systems were more effective than volume-based systems for reducing waste because they disincentivize compressing garbage.

CAPs also often aim to reduce the use of single-use plastic bags through bans or taxes. These bans and taxes were also commonly studied interventions (n = 6); however, few studies directly relate these bans and taxes to reduced emissions, instead reporting their results in decreased plastic bag usage, increased paper bag usage, or increased reusable bag usage. Studies generally found that taxes were effective at reducing the usage of single-use plastic bags (Cabrera et al., 2021; Homnoff, 2018; Homnoff et al., 2022; Taylor, 2020; Taylor and Villas-Boas, 2016). Homnoff et al. (2022) find suggestive evidence that plastic bag bans create a perverse incentive to provide thicker plastic bags unregulated by the ban, showing that taxes are more effective. Contrary to Homnoff et al., Taylor

and Villas-Boas (2016) find that bans are effective at reducing single-use plastic bag consumption but also increase the use of paper bags, which can be more polluting than plastic bags from an emissions perspective. They also find that pairing a single-use plastic bag ban with a modest fee on paper bags is more effective at reducing total disposable bag usage. Taylor (2020) highlights that both bag taxes and bans have the unintended consequences of increased wait times and queueing at grocery stores. Finally, Homnoff (2018) compared a small tax on disposable bags to a small bonus for reusable bags and found that the tax reduced the likelihood of using a disposable plastic bag and increased the likelihood of using a reusable plastic bag, while the bonus had no effect on bag usage.

Given that CAPs included general actions aimed at reducing waste, behavioral nudges designed to increase waste diversion were another intervention included in this review. Nudges aimed at reducing unsorted waste and boosting waste diversion were the last commonly studied area within solid waste (n = 6). The types of nudges varied, ranging from clear trash bag policies and prompting the use of take-out bags to visual nudges in the form of human eyes posters and charitable donations for choosing to not use a plastic bag. Overall, nudges were found to be effective at reducing unsorted waste (Akbulut-Yuksel and Boulatoff, 2021; Cotterill et al., 2009; Giaccherini et al., 2021; Lotti et al., 2023; Nomura et al., 2011; Penn et al., 2021). Akbulut and Boulatoff (2021) found that, in addition to a clear trash bag policy increasing waste diversion overall, effects were stronger in areas with lower average income and educational attainment, suggesting that nudges have heterogeneous effects depending on socio-demographic characteristics. They also found that the reduction in unsorted waste was persistent over time. Cotterill et al. (2009) found that door-to-door canvassing to encourage recycling had a significant but transient effect on recycling. Comparing these disparate findings, persistent exposure to treatment may be important for persistent effects since the canvassing conducted by Cotterill et al. occurred only once whereas the clear trash bag policy evaluated by Akbulut-Yuksel and Boulatoff persisted over time. Giaccheri et al. (2021) compared the effect of activating social norms versus changing the default option for boosting the use of take-out bags by customers at restaurants, finding that using social norms had a significant impact on take-out usage while creating a default option had no effect. Similarly, Nomura et al. (2011) tested the effects of social comparison and prosocial nudges on boosting food waste recycling, finding that households receiving the same prosocial feedback consistently (e.g., a smiley face two or more times in a row or vice versa with a sad face) registered stronger increases in recycling. They also found that using social comparison was only effective on households that didn't recycle prior to the intervention, with already recycling households actually reducing their participation when exposed to descriptive norms (Nomura et al., 2011).

More recent scholarship within the Solid Waste sector has begun to evaluate solid waste programs directly related to decarbonization (n = 3). De Silva and Taylor (2024) as well as Sommers (2025) both evaluated the provision of organic waste bins on organic waste diversion, both finding that the organic waste bin provision was effective at increasing diversion. However, De Silva and Taylor (2024) note that the program that they evaluated was only effective at increasing organic garden waste rather than food waste. Moreover, despite the overall effectiveness found in the two studies on organic waste bin provision, Sommers (2025) found that organic waste bin provision for jurisdiction in Austin, Texas could be cost-ineffective when the program is implemented in localities with a methane capture system. The one other study identified within the solid waste sector related to decarbonization was Lohmann et al. (2022), which evaluated the effect of carbon footprint labels on food choices in a university cafeteria and estimated that labels decreased the likelihood of students choosing high carbon meals, but failed to increase the likelihood of choosing a low carbon meal. These studies are the only studies identified in the Solid Waste sector that evaluated an outcome directly related to decarbonization.

Evidence Gaps

Solid Waste contains significant evidence gaps, especially when compared with the interventions enumerated in CAPs and similar documents. Of the ten general actions identified in the solid waste sector, only two have significant bases of evidence:

1. Provide technical assistance and resources to support waste diversion.
2. Monitor and evaluate contamination rates in waste, recycling, organic containers, and implement programs to reduce contamination and increase the effectiveness of recycling efforts.

Actions related to municipal operations like zero wasting policies, environmentally-preferential purchasing standards, and installing landfill gas systems were not studied. Additionally, actions related to educating the public on using low-carbon materials and incentivizing the construction of composting facilities lacked evidence. Finally, no impact evaluations evaluate programs for increasing waste diversion in commercial construction and demolition or other hard-to-recycle, which is another major source of waste in jurisdictions. As in other sectors, commercial-facing interventions are not often evaluated, with the exception of the multiple studies on single-use plastic bag taxes and bans. Both demand- and supply-side interventions for boosting composting production and application also have not been evaluated substantively. On the supply side, interventions aimed at boosting compost production through the provision of composting bins or community composting sites have not been evaluated. On the demand side, no interventions focused on boosting compost application in lieu of fertilizer have been studied. Finally, only one study was found that dealt with food waste diversion; residential and commercial food waste and recovery programs remain understudied.

WATER AND WASTEWATER

Overview

Interventions in Water and Wastewaters consist of conservation measures and programs designed to decrease residential water consumption through conservation, reuse, and efficiency. Actions include financial incentive programs for water efficiency and conservation, information provision, local landscaping ordinances, and mandated water efficiency measures through building codes for existing and new development. Interventions also aim to increase water reuse and recycling through wastewater treatment efficiency programs and water-efficiency measures in jurisdiction-owned buildings and operations. While jurisdictions' climate actions may have specific greenhouse gas emission reduction targets connected to water conservation, some CAPs aim to achieve reductions in water consumption without reference to decarbonization-related outcomes. Mirroring this tendency, the literature in this section overwhelmingly does not make explicit connections to GHG emissions reductions. These studies instead focus on water savings alone while providing some cost-effectiveness metrics.

Despite having a relatively thin evidence base compared to the other CAP sectors, Water and Wastewater has the second highest number of randomized controlled trials. The literature mainly evaluates programs and policy interventions in U.S. cities, with two in Europe. All fourteen articles included in our literature review for Water and Wastewater fall under residential water conservation measures and programs, as opposed to those focused on water efficiency or reuse through building codes or wastewater treatment programs. Most studies evaluate informational nudges (n = 10),

typically using some combination of technical information, prosocial appeals and social comparisons. Findings from the literature indicate that these nudges are effective when including comparisons of household water consumption or conservation to the household's neighbor. Roughly half of these studies, however, use one randomized controlled trial that was carried out in Cobb County, Georgia in 2007. Follow-up studies found that impacts to water use were persistent, with some heterogeneity across household income and other characteristics. Studies also found evidence of spillover effects, registering reductions in electricity and gas usage as a result of the water conservation nudges. The remaining literature largely focuses on incentives (n = 4). These studies evaluate the effectiveness of rebate programs for water-conserving technologies like high-efficiency toilets,e finding that such programs successfully achieved reduction in water use.

Literature on informational nudges largely indicate that the inclusion of social comparisons are effective at reducing household water consumption (Brent et al., 2015; Brent et al., 2020; Bernedo et al., 2014; Bhanot, 2021; Bonan et al., 2024; Ferraro & Price, 2011; Jessoe et al., 2021). Ferraro and Price evaluated the impact of three nudges on residential water consumption in Cobb County, Georgia and found that pro-social nudges reduced water consumption while technical information alone did not. They also found that social comparisons of household water consumption yielded the greatest impact (2011). Studies examining the persistence and heterogeneity of these effects found that the social comparisons nudge is the only treatment to have a persistent impact on water demand, with effects remaining detectable 6 years after implementation (Ferraro et al., 2011; Bernedo et al., 2014), and that higher income, owner-occupied and high water consuming households are more responsive to the strong social norm messaging (Ferraro & Miranda, 2013). There are also consistent findings that treatment is most effective on high water consumers (Brent et al., 2015; Brent et al., 2020; Ferraro & Price, 2011, Ferraro & Miranda, 2013).

Studies providing home water reports (HWRs) also examined the impact of these nudges on preexisting utility water conservation programs, as well as potential spillovers to electricity and gas consumption. A study using three RCTs found that households receiving HWRs with social comparisons of water consumption not only reduced water use but were also more likely to participate in additional conservation programs, indicating that HWRs do not crowd out existing programs (Brent et al., 2015). Notably, Bonan (2024) found that households treated with HWRs significantly reduced electricity usage in addition to water consumption and were less likely to deactivate their gas and electricity contracts.

Evaluations on the impact of incentive programs generally found they were effective in reducing residential water consumption. Nevada's "cash-for-grass" program that pays homeowners to replace grass with water-saving landscaping led to significant reduction in water consumption for participating households, with a $1.88 cost to the water authority per thousand gallons of water conserved (Brelsford & Abbott, 2021). An evaluation of Southern California rebate programs by Pérez-Urdiales and Baerenklau found that all programs–for high-efficiency clothes washers, high-efficiency toilets, drought tolerant landscape and weather-based irrigation controllers–increased investment in the subsidized water-efficient technologies and were additional (2019). Further analysis highlighted that only rebates for outdoor technologies induced further private investment in other outdoor technologies not included in the rebate program. Last, Bennear et al. estimated that while participation in a utility's high-efficiency toilet rebate program reduced household water use, less than 40% of the reduction was additional, limiting cost-effectiveness to $11 to $15 per thousand gallons conserved (2013).

Evidence Gaps

While impact evaluations were mapped to five out of seven interventions included in this sector, key gaps remain. Interventions focused on water efficiency measures in jurisdiction-owned buildings and operations, new building standards, and outdoor landscaping ordinances have less than three articles each. Zero studies with robust methodologies were identified for interventions that aim to reduce water consumption through wastewater treatment efficiency programs or building codes for existing development projects. Additionally, many studies focused on water use without distinguishing between homeowners and renters. More research on renters and interventions focused on the commercial sector is needed to inform effective climate actions. The studies identified for this sector are also highly concentrated in Georgia and California. Further research in contexts beyond these locations can help highlight how such interventions differ in their effects on water consumption and GHG emissions as the geographic and institutional landscape varies. Finally, no studies in this sector evaluated the connection between Water and Wastewater interventions on GHG emissions. Further research is necessary to understand how interventions related to water and wastewater interact with GHG emissions.

AGRICULTURE AND CONSERVATION

Overview

CAPs with actions in Agriculture and Conservation focused on increasing carbon storage through the preservation or restoration of natural lands, community greening programs, and climate farming. CAP actions for the preservation of natural lands included incentives to landowners to preserve native prairie and wetlands and the implementation of restoration frameworks to accelerate forest, grassland, and wetland restoration. CAP actions for community greening included tree planting initiatives, educational campaigns, and programs designed to preserve native trees. Finally, CAP actions for climate farming included Purchase of Agricultural Conservation Easement (PACE) programs, carbon farming programs, community garden programs and incentives for greenhouse gas emission-reducing farm practices. While many actions included in this sector are explicitly included for carbon sequestration and sink benefits, much of the evidence on such programs does not quantify greenhouse gas emissions reductions.

The majority of evidence in this sector focuses on European "agri-environmental schemes" (AESs), which is a form of carbon farming. These programs pay farmers to adopt specific farming practices designed to achieve climate and environmental outcomes, such as area converted to organic farming, herbicide use reduction, and increased crop diversity. While evidence on these programs overwhelmingly demonstrates payments are effective in increasing intended outcomes, comparing findings across studies is challenging due to substantial variation in outcomes and measurements. Additionally, cost-effectiveness varies across program interventions, as even when subsidies have low additionality, they can still be cost-effective due to the environmental benefits obtained through the program. Studies provided heterogeneity analyses that found differing environmental outcomes according to farm type, payment type, and payment level. Larger farms benefited the most and no significant difference was found between action-based and results-based payments. Only two studies map to interventions related to agricultural land conservation, for Purchase of Development Rights Programs (PDRs) and agricultural conservation programs. The evidence highlights that U.S.-based PDRs, which are designed to avoid loss of farmland, were overwhelmingly successful. Additionally, an evaluation of informational nudges was found to increase reenrollment in the USDA's Conservation Reserve Program (CRP) but failed to increase new farm enrollment.

One study evaluates the impact of PDR programs that aim to prevent further development on farmland loss, while a second study examines the impact of nudges on farmers' participation in agricultural lands conservation programs. Using data for 269 counties in mid-Atlantic states in the U.S., Liu and Lynch found that PDR programs statistically reduced a county's rate of farmland loss (2011). Wallander et al. (2017) estimated the impact of informational nudges, in the form of reminder letters, on farmer participation in the USDA's Conservation Reserve Program (CRP). Participation was not induced in unenrolled but eligible farms across any intervention type; however, all letter types significantly increased reenrollment for those farms with expiring CRP contracts. This finding suggests that information alone may be useful in securing continued enrollment from farmers who are already familiar with the program, but may be insufficient for increasing enrollment for farms that are not already familiar with the CRP.

Eight articles in Agriculture and Conservation focused on carbon farming, all evaluating the impact of incentives. All of these studies focus on Europe's "agri-environmental schemes" (AESs), which pay farmers to adopt climate-friendly practices. Based on the targeted outcomes of the specific AES, dependent variables span a wide range, including biodiversity conservation area, cover crop area, grassland maintenance, organic farming, and herbicide, pesticide and synthetic fertilizer use. Generally, studies evaluating the impact of AESs on intended program outcomes found that they were effective, with some mixed results on cost-effectiveness (Arata & Sckokai, 2016; Bartolini et al., 2021; Bertoni et al., 2020; Kuhfuss & Subervie, 2018; Pufahl & Weiss, 2009; Wuepper & Huber, 2022). Arata and Sckokai found that if the share of the payment was larger than 5% of the farm's revenue, participation in AESs was effective in achieving intended outcomes in all countries studied except for Spain (2016). Bertoni found that while payments to farmers significantly improved farm performance across crop diversification, grassland maintenance, and organic farming, costs were large relative to benefits (2020). As we address further in the discussion, reported cost-effectiveness metrics are typically expressed in terms of their intended outcomes (e.g., per unit area converted to organic farming) rather than in terms of CO_2 emissions reductions per dollar spent.

Many studies in the Carbon Farming subsector included heterogeneity analyses. Wuepper and Huber found that both action-based payments (e.g., adopting a specific practice) and result-based payments (e.g., achieving intended outcome) significantly increased biodiversity conservation area and that there was no detectable difference between the two types of payments (2022). Pufahl and Weiss found that AESs led to heterogeneous treatment effects at the farm-level, with farms that can generate the largest benefit being the most likely to participate (2009). Bartolini et al. estimated heterogeneous treatment effects across payment levels, indicating that, when paid per farm, increasing the payment decreases the environmental benefit and that, when paid per hectare, increasing the payment increases the environmental benefit. Chabé-Ferret and Subervie analyzed additionality and windfall effects of AESs in France and found that impacts are heterogeneous across intended outcomes: subsidies to farmers had low additionality for cover crops and grass buffer strips, though payments for grass buffer strips were still cost effective due to environmental benefits (2013). By contrast, subsidies for conversion to organic farming demonstrated high additionality.

Evidence Gaps

This sector has notable gaps in the literature as only 3 out of the 17 policy interventions were mapped to impact evaluations in this literature review. Overwhelmingly, the evidence relates to the use of incentives to reduce synthetic fertilizer use and carbon farming programs to support the expansion of carbon storage and climate-smart agriculture. There are zero impact evaluations mapped to interventions designed to preserve and store natural lands, such as programs to acquire

conservation lands in perpetuity and incentives for landowners to preserve natural lands. These interventions are key for leveraging the use of carbon sinks to reach climate goals, indicating an urgent need for evaluation. Additionally, no studies were identified for actions within tree planting, voluntary manure management, community gardening, or incentives for agricultural operations to reduce emissions via cleaner fuels. Similar to other sectors, interventions related to reducing emissions in jurisdiction-owned land is largely absent. Those related to agricultural operations are also quite thin, except for the farmer subsidy programs evaluated in European agri-environmental schemes. Geographically, wide gaps exist as only two studies take place in the United States, with most taking place in Europe. Given the agricultural sector's unique contribution to climate change in the U.S.–and the varying farmer needs and agricultural practices across regions–geographic richness of evidence is especially important. These gaps highlight an urgent need for more research to inform programs leveraging natural lands, urban forests, and carbon farming to push GHG emission reductions.

DISCUSSION

The promise of evidence-based policymaking is that it helps identify policy interventions that actually deliver on desired outcomes in a *cost-effective* manner. As this literature review has established, the universe of scholarship on local climate action for decarbonizations contains strong bases of evidence in Energy and Transportation and weaker bases of evidence in Solid Waste, Water and Wastewater, and Agriculture and Conservation. However, beyond understanding the outcomes of different policy interventions, this literature review found that few studies provided consistent metrics on cost-effectiveness. Out of the 161 studies relevant to local climate action identified in this literature review, only 36 articles reported cost-effectiveness metrics. Of these 36 articles, only 14 provided their cost-effectiveness metrics in terms of cost per metric ton of CO_2 avoided, a metric that allows policymakers and researchers to easily compare interventions across sectors. Otherwise, studies provided various cost-effectiveness metrics specific to a particular sector like cost per kWh saved, cost per thousand of gallons saved, or cost per additional hectare for conservation or organic farming. The absence of reliable cost-effectiveness metrics complicates the promise of evidence-based policymaking, preventing policymakers from choosing the most cost-effective intervention among interventions that are found to actually deliver on desired outcomes. Moreover, the inconsistency of the existing cost-effectiveness metrics also makes this choice difficult given these metrics are sector specific only allowing contrasts within sectors. However, beyond reporting cost-effectiveness metrics themselves, many studies do not account for contextual factors that directly affect cost-effectiveness: varying marginal emissions across the geography of electrical systems and additionality.

Accurately accounting for marginal emissions is critical for future research as it determines the real climate benefits of programs that rely on grid electricity. Marginal emissions refers to the emissions produced by the power source that meets the next unit of demand on the electricity grid. Importantly, these marginal emissions vary geographically and temporally as the generator meeting demand in a particular location at a particular hour differs from place to place and hour to hour. In other words, the amount of emissions produced by the grid at any one time will differ based on the time of day and the location because the amount of fossil fuels in the energy mix differs temporally and geographically. Consequently, the grid's generation mix is a key determinant of the emissions reductions such programs can achieve since the amount of emissions abated will vary by the time of day and location. Marginal emissions are particularly important for evaluating interventions in Transportation and Energy. In the case of transportation, these considerations are particularly relevant for EV adoption, as greenhouse gas emissions reductions not only depend on the marginal vehicle being displaced through adoption, but also on the marginal source of electricity powering the EV. In other words, EV charging may actually produce more carbon emissions than conventional vehicle fuels in some cases if the electricity grid has high levels of coal generation in a particular area at a particular time. Only one article in Fleet Transition accounted for marginal emissions and found that the effectiveness of the program in reducing emissions is substantially smaller than was assumed (Muehlegger & Rapson, 2023). Estimates of marginal pollution abatement are therefore critical to include in future evaluations of EV programs. In the case of buildings and directly related to the concept of marginal emissions, Boomhower and Davis (2019) show that accounting for electricity price variation over time and forward capacity markets for generation significantly influences program effectiveness in their evaluation of a rebate program for efficient air conditioning. They highlight the existence of a "timing premium" for particular energy efficiency investments in which some investments lead to greater energy saving due to variation in the generation mix and energy

prices throughout the day. Boomhower and Davis advocate for researchers to account for this "timing premium" when evaluating programs directly associated with the electricity grid like energy efficiency investments. In the context of decarbonization, this concept of a "timing premium" can be extended to potential levels of carbon abatement or avoidance since the marginal emissions of the electricity grid vary along with energy prices. Notwithstanding the challenges of estimating marginal emissions or obtaining smart meter data to track daily household energy usage, including marginal emissions and temporal price variation may significantly shift the findings of studies in both outcome and cost-effectiveness.

Analyses of the additionality in demand-side programs like rebates and incentives are also critical for estimating program cost-effectiveness, but were not present in the majority of studies included in this literature review. Additionality metrics provide a measure of the outcome that has happened solely due to the policy, rather than what would have happened anyway. In other words, additionality metrics help identify individuals that actually change their behavior in response to a policy like a rebate or tax credit when compared to individuals that would've invested into a particular product regardless. When program dollars are spent on outcomes that would have already happened absent the intervention, cost-effectiveness diminishes. In the Transportation sector, a handful of papers provide additionality estimates of subsidy programs of EVs and fuel efficient vehicles, demonstrating that a substantial portion of purchases would have happened anyway absent the programs, reducing the cost-effectiveness of subsidies (Muehlegger & Rapson, 2023; Hoekstra et al., 2017; Li et al., 2013). In the Agriculture and Conservation sector, Chabé-Ferret and Subervie (2013) analyzed additionality effects of AESs for cover crops, grass buffer strips and conversion to organic farming and found that all had low additionality. In most cases, the AES subsidies that provided low additionality were not cost-effective. In the case of grass buffer strips, however, they found that the subsidy program could still be cost-effective because the high environmental benefits outweighed program costs. Further estimates of additionality for program evaluations, where feasible, are critically important for accurate estimates of cost-effectiveness as well as net environmental benefits.

Finally, while many interventions do not specify equity considerations explicitly, the evidence base for those studies that do is particularly limited. Accelerating adoption of electric vehicles at all income levels, for example, is key for decarbonization of the Transportation sector. However, only two studies examined the impact of EV subsidy programs targeted to low- and middle-income households. In the Energy sector, many studies were dedicated to evaluating weatherization assistance programs, which are explicitly aimed at providing retrofits to low-income households for home weatherization, space heating, and space cooling. Few studies, however, evaluated the equity effects of *other* energy efficiency incentive programs where the target population is not means-tested and outcomes potentially vary by income level. The few studies that do evaluate energy efficiency incentive programs across income levels find suggestive evidence that the optimal intervention may differ by income-level (Liang et al., 2018; McCoy and Kotsch, 2021; Shen et al., 2022). Important to note, one recent study by Ascensio et al. (2024) evaluated energy efficiency programs associated with federal Community Development Block Grants (CDBG) that fund low-income housing programs, finding that such programs were highly cost-effective and delivered on energy savings. This evaluation was the first to focus on energy efficiency programs instituted under housing policy departments rather than energy policy departments, indicating an untapped avenue for future research especially since their promising findings contrast strongly with the relative cost-ineffectiveness of other means-tested energy efficiency programs instituted by utilities and energy agencies. Finally, almost no studies contained equity considerations within the Solid Waste, Water and Wastewater, and Agriculture and Conservation sectors. As means-tested programs are increasingly used to achieve emission reductions in disadvantaged communities, more findings on

take-up, additionality and heterogeneous effects across demographic groups will be necessary to make informed policy decisions.

CONCLUSION

This literature review identifies evaluations of climate actions outlined in jurisdictions' CAPs, highlighting robust evidence as well as key gaps. We identify interventions that are largely unstudied across the five climate action sectors included: Energy, Solid Waste, Transportation, Water and Wastewater, and Agriculture and Conservation. Our findings indicate the urgency for continued research that employs rigorous causal inference methods across all five areas, especially as local and state policymaking play a larger role in decarbonization efforts.

This literature review identified consistent research gaps across sectors. In the Energy and Solid Waste sectors, the majority of studies focused on single-family homes. Few studies evaluated interventions aimed at commercial buildings in Energy, Solid Waste, and Water and Wastewater. Commercial buildings are a key target for decarbonization in multiple CAPs and certainly will have different responses to interventions aimed at boosting investment into energy efficiency, electrification, and waste diversion. Accordingly, implementing and researching programs aimed at commercial buildings has the potential to create important insight into this seldom studied stratum of local decarbonization. Similarly, few studies in Energy and Water and Wastewater evaluated programs aimed at multi-family homes and renters. Given that the 2023 American Community Survey estimates that 35% of US households are renters, this population will necessarily be a key target for decarbonization. Therefore, embedding research into programs aimed at multi-family homes and renters has the potential to reveal unique dynamics, especially in relation to equity as such research unveils how local policy interventions interact with the differing incentives between landlords and renters. In Transportation, only two studies evaluated EV incentive programs aimed at low- and medium-income households. Given that robust decarbonization entails the electrification of the entire US fleet of vehicles, it is imperative that policymakers and researchers begin to understand how policy interventions like EV subsidies influence purchasing behavior in low- to middle-income communities. Finally, Agriculture and Conservation as an entire sector persists as a significant evidence gap. With the growing interest in preserving natural lands, creating tree planting and community garden programs, and fostering sustainable agriculture practices, policymakers and research can likely reap dividends by embedding research into such programs. Finally, across all sectors included in this review, equity considerations remain notably understudied, even as jurisdictions frequently cite equity goals in climate planning documents and implement targeted programs. This gap is especially notable in the absence of studies aimed at low-to-middle income households, who are more likely to be renters. Addressing this research gap will be essential for linking climate policy to socioeconomic outcomes, delivering decarbonization and sustainability benefits equitably across communities.

In addition to literature gaps related to climate interventions, we highlight the need for future estimates of cost-effectiveness that will be comparable across studies. Cost-effectiveness metrics are reported infrequently, and when included, often vary substantially in their units of measurement, diminishing the ability to compare program outcomes. Additionally, while much of the literature analyzes programs and policies designed to reduce greenhouse gas emissions, relatively few studies

provide estimates of cost-effectiveness in terms of CO_2 emissions avoided. Absent these measurements, policymakers may be unable to comprehensively identify those interventions that can yield the greatest emissions reductions per program dollar spent. Researchers should also consider recent advances in cost-effectiveness metrics like marginal value of public funds (MVPF), which measures the net benefit of a program–including GHG emissions mitigation–compared to net cost (Hahn et al., 2024). MVPF is reported as a simple ratio that represents the dollar of benefit per dollar spent by a public agency and incorporates additionality effects. Accordingly, MVPF provides a potential alternative cost-effectiveness metric that would allow comparison between climate actions and between public policies *beyond* the climate space. Strengthening the evidence base vis-à-vis consistent and comparable measures of program impact is necessary to sufficiently link climate actions to GHG emission reduction goals, providing decisionmakers with accurate information for evaluating efficacy of policy interventions.

The gaps found in this literature review present opportunities for researchers to advance the evidence-base in support of high-value climate actions at the local level. Such research also presents the opportunity to calculate detailed cost-effectiveness metrics like cost per ton of CO_2 emissions avoided or MVPF, allowing policymakers to compare program effectiveness between interventions aimed at decarbonization and at life in the local jurisdiction in general. Accordingly, both jurisdictions and researchers are presented with an immense opportunity to deepen our understanding of the impact of climate action while identifying actions that are best use of jurisdictional resources. In this warming climate, capitalizing on this opportunity may be more important than ever.

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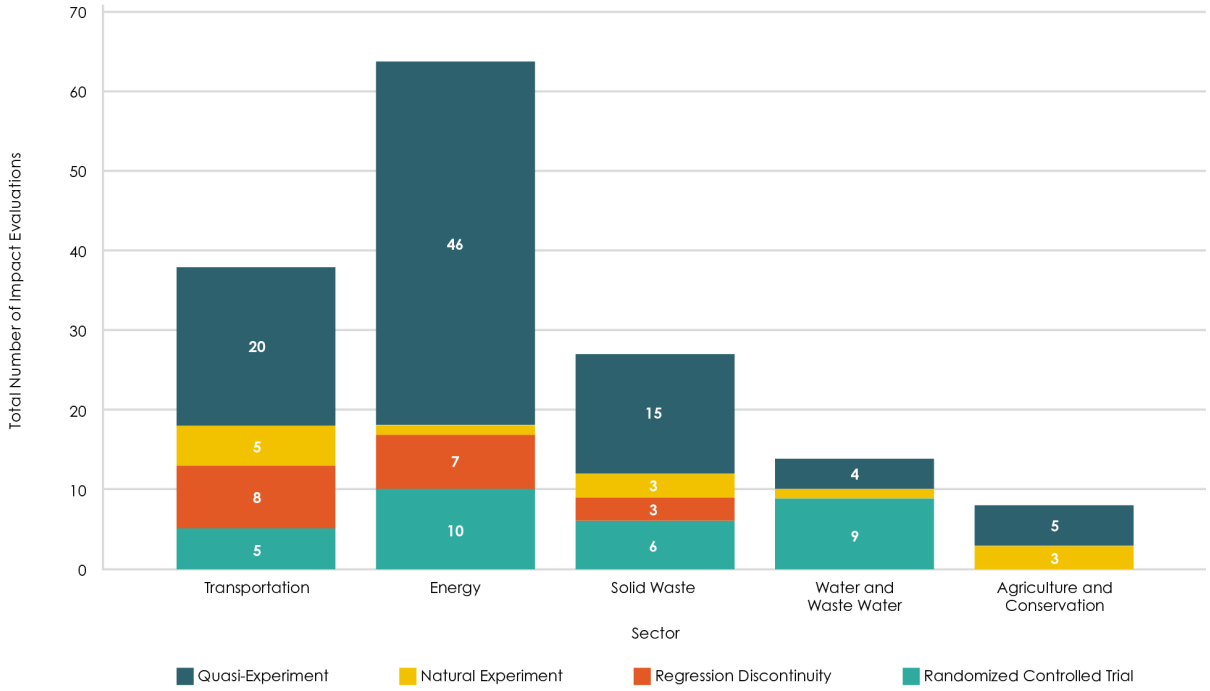
APPENDIX A – FIGURE QUANTIFYING EXPERIMENTAL METHODOLOGIES

FIGURE 1. EXPERIMENTAL METHODOLOGIES BY CLIMATE SECTOR



APPENDIX B – FURTHER READING ON IMPACT EVALUATION METHODOLOGIES

For those interested in a more detailed comparison of impact evaluation methodologies, J-PAL provides these technical overviews:

1. Introduction to randomized evaluation: This primer provides a non-technical overview to randomized evaluation and its constituent components, including examples of randomized evaluations conducted in various contexts both nationally and internationally.
2. Impact evaluation methodology chart: This chart provides an overview of the different impact evaluation methodologies. It provides an overview of the assumptions and data required for a particular evaluation to be considered causal. Importantly, it outlines and compares the relative vigor of each impact evaluation methodology.

APPENDIX C – CLIMATE ACTIONS

Transportation

T-1: Reduce fleet and small equipment emissions in jurisdiction operations	T-1.1: Increase the number of electric vehicles (EVs) in the jurisdiction's fleet and install Level II charging stations at jurisdiction-owned facilities to support the EV fleet to reduce total fleet emissions.
	T-1.2: Use alternative fuel and/or zero-emission construction equipment in jurisdiction projects to reduce emissions from medium- and heavy-duty vehicles and equipment.
	T-1.3: Adopt an anti-idling policy to reduce emissions from vehicle idling in jurisdiction operations.
	T-1.4: Require zero-emissions landscaping equipment to be used on the jurisdiction's property.
T-2: Increase the use of low-carbon and zero-emission landscaping and off-road construction equipment in the jurisdiction	T-2.1: Develop a program to provide residents and businesses incentives to purchase alternative fuel and/or zero-emission construction and landscaping equipment to reduce emissions.
	T-2.2: Develop and adopt a landscaping equipment ordinance to require the use of zero emission landscaping equipment and zero emission construction equipment.
T-3: Install electric vehicle charging stations and provide incentives for zero-emissions vehicles in the jurisdiction.	T-3.1: Increase the use of electric and fuel-efficient vehicles by: - Installing publicly available electric vehicle charging stations. - Requiring electric vehicle charging infrastructure and preferential parking for ZEVs for new multi-family residential and non-residential construction. - Developing a program to incentivize EV purchases and school bus electrification. - Employ equitable adoption strategy, prioritizing charging and incentives in frontline communities.
	T-3.2: Accelerate the transition to hydrogen fuel for medium- and heavy-duty vehicles by increasing access to hydrogen fueling infrastructure.
	T-3.3: Provide information on available incentives for EVs and charging infrastructure.

T-4: Reduce emissions from jurisdiction employee commutes	T-4.1: Provide jurisdiction employees with tax-free transportation benefits, alternative work schedules, and expand part-time or full-time teleworking options to reduce vehicle miles traveled from employee commutes.
	T-4.2: Develop a rebate program for jurisdiction employees to purchase electric vehicles, bicycles, and scooters for commute use.
	T-4.3: Provide educational programs and campaigns to encourage jurisdiction staff to walk, bike, and take transit.
T-5: Improve roadways to encourage walking, biking, rolling to/from transit and destinations and increase transportation efficiency	T-5.1: Improve sidewalk, bikeway and roadway infrastructure to encourage alternative modes of transportation.
	T-5.2: Develop a jurisdiction-wide Safe Routes to Schools program to reduce vehicle miles traveled to schools and reduce traffic fatalities.
	T-5.3: Provide educational programs and campaigns to encourage residents and businesses to use alternative modes of transportation.
T-6: Support transit and transportation demand management to reduce single occupancy vehicle trips in the jurisdiction	T-6.1: Develop a program to provide free transit passes and/or free trips in the jurisdiction to reduce vehicle miles traveled.
	T-6.2: Increase access to Transit Priority Areas and implement transit-supportive roadway treatments such as traffic signal communication and curb extensions along jurisdiction-maintained roadways to support public transit use.
	T-6.3: Increase access to first/last mile transportation services and connections (e.g., neighborhood electric vehicles, microtransit, bike/scooter-share) to reduce vehicle miles traveled.
	T-6.4: Develop a car sharing program targeted to low-income communities.
	T-6.5: Implement Transportation Demand Management strategies to reduce single occupancy vehicle trips.

Energy

E-1: Develop policies and programs to increase energy efficiency, renewable energy use, and electrification in jurisdictional operations.	E-1.1: Source renewable electricity from direct access agreements or community choice aggregators for jurisdictional operations.
	E-1.2: Replace fossil fuel burning equipment with electrical equipment in the jurisdiction's buildings.
	E-1.3: Implement energy efficiency measures in the jurisdiction's buildings
	E-1.4: Implement energy performance monitoring system
	E-1.5: Require all-electric for all new jurisdictional construction projects.
	E-1.6 Install renewable energy on jurisdictional property.
E-2: Develop policies and programs to increase energy efficiency and electrification in the jurisdiction	E-2.1: Require all-electric equipment and higher energy efficiency in new developments.
	E-2.2: Implement building performance standard requirements for all-electric equipment and higher energy efficiency in existing developments.
	E-2.3: Incentivize building electrification and energy efficiency
	E-2.4: Develop and distribute materials to assist renters with implementing energy efficiency improvements.
	E-2.5: Develop a voluntary energy assessment/benchmarking program for existing development to identify opportunities for energy efficiency improvements.
	E-2.6: Develop a program to phase out propane use for existing buildings.
	E-2.7: Develop a program to increase energy resiliency in the unincorporated area to ensure continued access to electricity and services during extreme weather events.
	E-2.8: Develop a program to train building owners, managers, and operators about energy efficiency, energy efficiency benchmarking, and available incentive programs
	E-2.9: Implement a mandatory disclosure policy for energy efficiency for existing developments entering the market

E-3: Develop policies and programs to increase renewable energy use, generation, and storage in the jurisdiction.	E-3.1: Mandate renewable energy requirements for new residential and non-residential construction to increase renewable energy generation in new developments.
	E-3.2: Streamline solar permitting process.
	E-3.3: Develop a program to incentivize renewable energy.
	E-3.4: Work with partners to promote and support on-site renewable (wind and solar) energy generation and storage (microgrids, Site-specific and/or community scale) to increase renewable energy generation and use in the jurisdiction.
	E-3.5: Support local job training program for solar installation to support green economy workforce development.
	E-3.6: Develop a program to provide 100% renewable energy to residents and businesses in the jurisdiction.
	E-3.7: Implement an information campaign to boost uptake of renewable energy
E-4: Develop market-based policies to mitigate carbon emissions	E-4.1: Establish a voluntary carbon-offset program for visitors to the jurisdiction.

Solid Waste

SW-1: Improve waste management practices and achieve zero waste in jurisdiction operations.	SW-1.1: Adopt a zero waste policy to achieve zero waste in jurisdictional operations.
	SW-1.2: Require materials to meet environmentally-preferential purchasing (EPP) standards.
	SW-1.3: Educate jurisdiction staff on zero waste practices to encourage greater participation and develop or use preexisting monitoring tools to track waste diversion (e.g. EPA Wastewise).
	SW-1.4: Install landfill gas systems at jurisdiction-owned landfills.
SW-2: Improve waste management practices to reduce emissions and achieve zero waste within the jurisdiction.	SW-2.1: Provide technical assistance and resources to support waste diversion
	SW-2.2: Monitor and evaluate contamination rates in waste, recycling, organics containers, and implement programs to reduce contamination and increase the effectiveness of recycling efforts.
	SW-2.3: Educate the public about zero waste and encourage use of low carbon materials.
	SW-2.4: Incentivize the development of new composting/anaerobic digestion facilities and on farm digesters to divert compostable waste from landfills in the jurisdiction.
	SW-2.5: Implement a landfill gas system pilot project at privately managed landfills.
	SW-2.6: Adopt strategies for circular materials management including collection, processing, and reuse options for hard-to-recycle materials such as textiles, mattresses, bulky plastic items, and e-waste.

Water and Wastewater

W-1: Increase water efficiency, retention, recycling, and reuse to reduce potable water consumption in jurisdiction operations	W-1.1: Require water-efficiency measures in all new and existing jurisdiction-owned buildings and operations, including water-efficient appliances and plumbing fixtures.
W-2: W-2: Increase indoor and outdoor water conservation in new and existing development, including water efficiency, retention, recycling, and reuse	W-2.1: Mandate indoor water efficiency measures in all new development through building codes, and outdoor water efficiency through local landscaping ordinances.
	W-2.2: Mandate indoor water efficiency requirements for existing development projects with qualifying improvements through building codes.
	W-2.3: Provide incentives for water efficiency, conservation, and reuse improvements for new and existing development.
	W-2.4: Provide incentives for water efficiency and conservation to reduce outdoor water consumption in the jurisdiction.
	W-2.5: Provide educational materials to assist renters with implementing water efficiency and conservation improvements.
W-3: Increase stormwater and wastewater treatment efficiency to reduce imported potable water use in the jurisdiction	W-3.1: Implement a program to increase wastewater treatment efficiency.

Agriculture and Conservation

A-1: Preserve and restore natural lands to maximize carbon storage potential in the jurisdiction	A-1.1: Acquire conservation lands to preserve land in perpetuity.
	A-1.2: Implement a restoration framework to accelerate forest, grassland and wetland restoration on jurisdiction-owned land and increase carbon storage.
	A-1.3: Incentivize landowners to preserve native prairie, wetland areas, and other natural resources.
	A-1.4: Partner with tribal governments to incorporate tribal ecological knowledge into land management practices.
A-2: Expand tree canopy across the jurisdiction, prioritizing undeserved communities	A-2.1: Implement a tree planting initiative on jurisdiction-owned land.
	A-2.2: Implement a tree planting initiative in the jurisdiction, prioritizing canopy in frontline communities.
	A-2.3: Implement a program to preserve native trees in the jurisdiction.
	A-2.4: Educate the public on the benefits and maintenance of native, fire-resistant, and drought-tolerant tree plantings.
	A-2.5: Implement a landscaping ordinance to require tree planting in new single family residential development.
A-3: Preserve agricultural lands to prioritize carbon storage and balance economic and development goals	A-3.1: Implement a Purchase of Agricultural Conservation Easement (PACE) Program to preserve agricultural land.
A-4: Expand carbon storage capacity on agricultural land and support climate-friendly farming practices in the jurisdiction	A-4.1: Implement a carbon farming program to increase carbon sequestration.
	A-4.2: Adopt a food sourcing policy that prioritizes contracts with local, equitable, and sustainable food suppliers in jurisdiction operations.
	A-4.3: Implement strategies to increase farmworker housing in the jurisdiction to reduce emissions from farmworker transportation.
	A-4.4: Incentivize voluntary alternative manure management and livestock feed projects to reduce manure management and enteric fermentation emissions in the jurisdiction.

	A-4.5: Incentivize the reduction of the use of synthetic fertilizers in the jurisdiction.
	A-4.6: Implement a community garden program to increase locally sourced agriculture and reduce agricultural emissions in the jurisdiction.
A-5: Reduce greenhouse gas emissions from agricultural operations	A-5.1: Incentivize energy efficiency and the transition to cleaner fuels to reduce agricultural operations emissions.

APPENDIX D

Comparing Cost-Effectiveness

ARTICLE	PROGRAM EVALUATED	COST-EFFECTIVENESS ($ PER TON OF CO2 AVOIDED)*
Li, S., Linn, J., & Spiller, E. (2013).	Incentive for Fuel Efficient Vehicles	$138
Clinton, B. C., & Steinberg, D. C. (2019).	Incentive for Battery Electric Vehicles	$99 - 106 ($608 - 651)**
Chandra, A., Gulati, S., & Kandlikar, M. (2010).	Incentive for Hybrid Electric Vehicles	$312
Alberini, A., & Towe, C. (2015).	Incentive for Energy Efficiency Audit	$97
Alberini, A., & Towe, C. (2015).	Incentive for Electric Heat Pump Space Heating	$85
Allcott, H., & Greenstone, M. (2017).	Incentive for Efficient Space Heating and Home Weatherization	$505
Fowlie, M., Greenstone, M., & Wolfram, C. (2015).	Incentive for Efficient Space Heating and Home Weatherization	$448
Gillingham, K., & Bollinger, B. (2020).	Community Information Campaign	$29
Hughes, J. E., & Podolefsky, M. (2015).	Incentive for Rooftop Solar	$182 - 275
Jacobsen, G. D., Kotchen, M. J., & Clendenning, G. (2013).	Incentive for Green Tariff Participation	$162
McCoy, D., & Kotsch, R. A. (2021).	Incentive for Cavity Wall Insulation	$80
McCoy, D., & Kotsch, R. A. (2021).	Incentive for Loft Insulation	$200
McCoy, D., & Kotsch, R. A. (2021).	Incentive for Replacement Boiler	$133
Datta, S., & Gulati, S. (2014).	Incentive for Clothes Washers	$224
Bernard, L., Hackett, A., Metcalfe, R. D., & Schein, A. (2024).	Incentive for Electric Heat Pump Space Heating	$164
Lohmann, P. M., Gsottbauer, E., Doherty, A., & Kontoleon, A. (2022).	Carbon Footprint Labels	$50
Somers, J. C. (2025).	Curbside Organics Program	$595***

* Measured in 2025 dollars.

** The cost-effectiveness in parentheses accounts for infra-marginal participation.

*** The author also calculated cost-effectiveness for curbside organics programs in municipalities with and without methane capture at their local landfill. When methane capture was present, the cost-effectiveness was $928 per metric ton of CO2e avoided. When methane capture was not present, the cost-effectiveness was $245 per metric ton of CO2e avoided.

APPENDIX E – SECTOR FIGURES

FIGURE 2. THE EVIDENCE-BASE FOR CLIMATE ACTIONS IN ENERGY: ENERGY EFFICIENCY AND RENEWABLE ENERGY

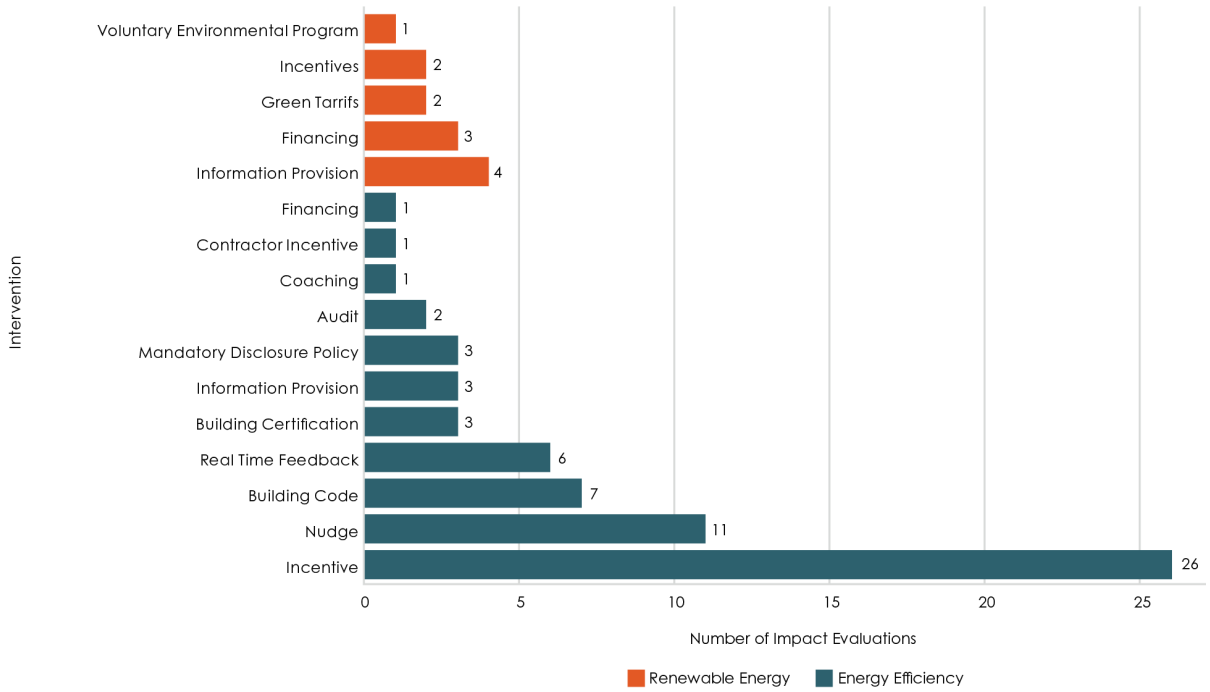


FIGURE 3. THE EVIDENCE-BASE FOR CLIMATE ACTIONS IN TRANSPORTATION: FLEET TRANSITION, PUBLIC TRANSPORTATION, AND TRAFFIC CONGESTION/ TRANSPORTATION DEMAND MANAGEMENT

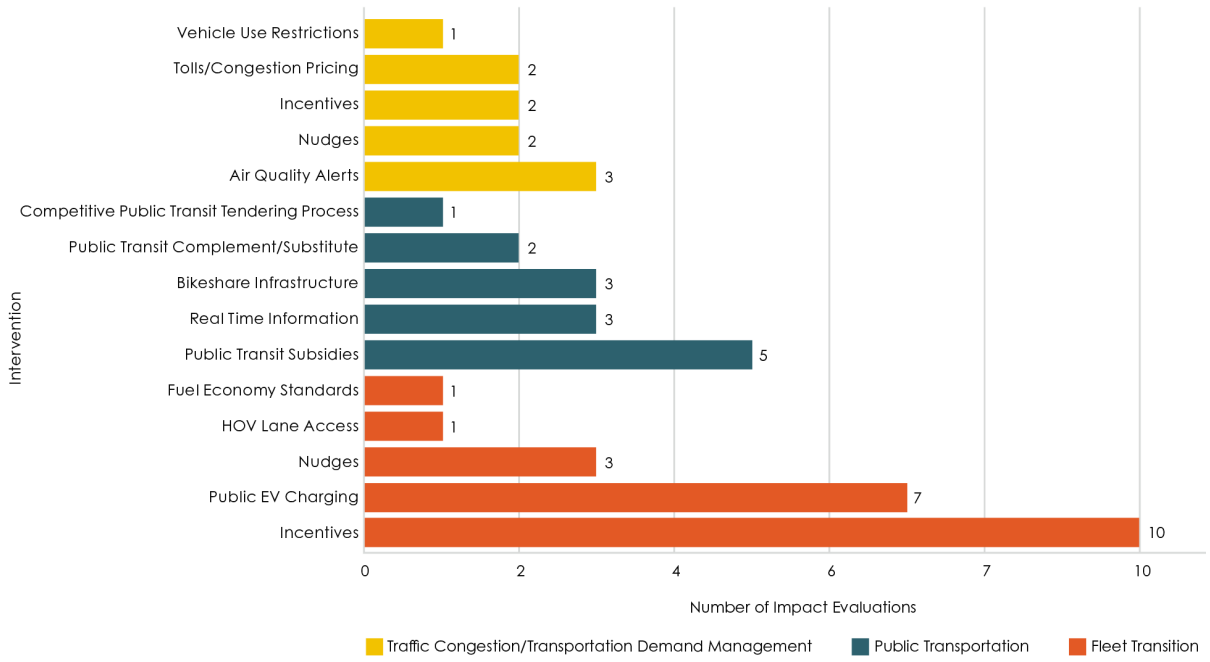


FIGURE 4. THE EVIDENCE-BASE FOR CLIMATE ACTIONS IN SOLID WASTE

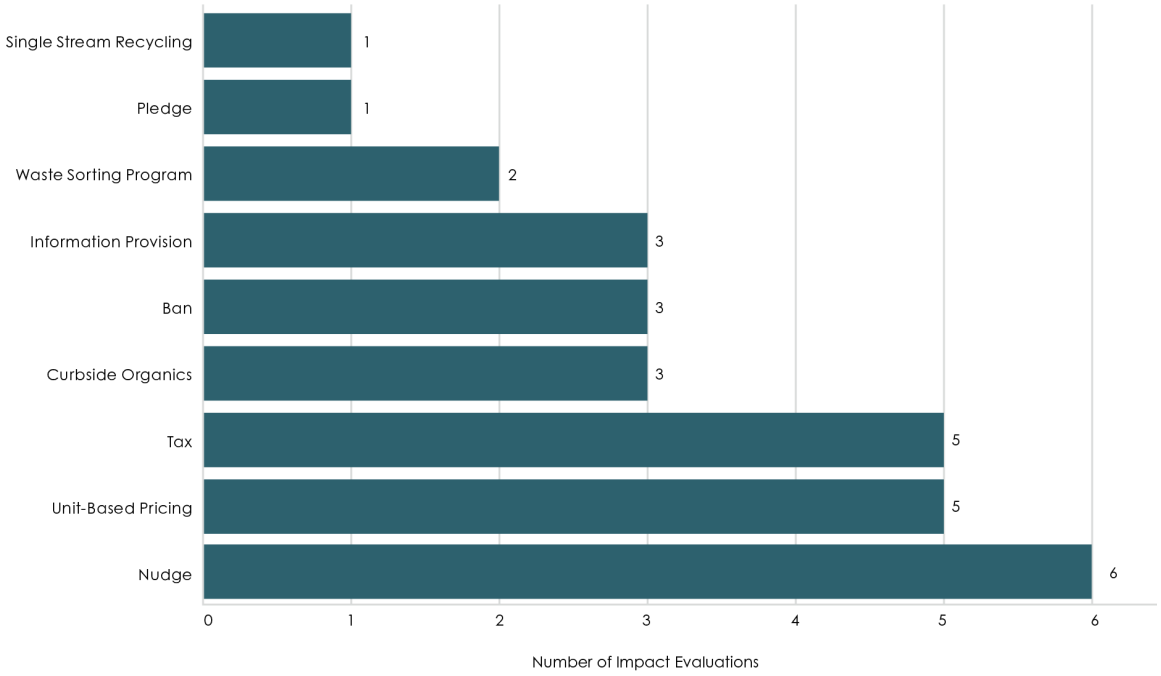


FIGURE 5. THE EVIDENCE-BASE FOR CLIMATE ACTIONS IN WATER AND WASTEWATER

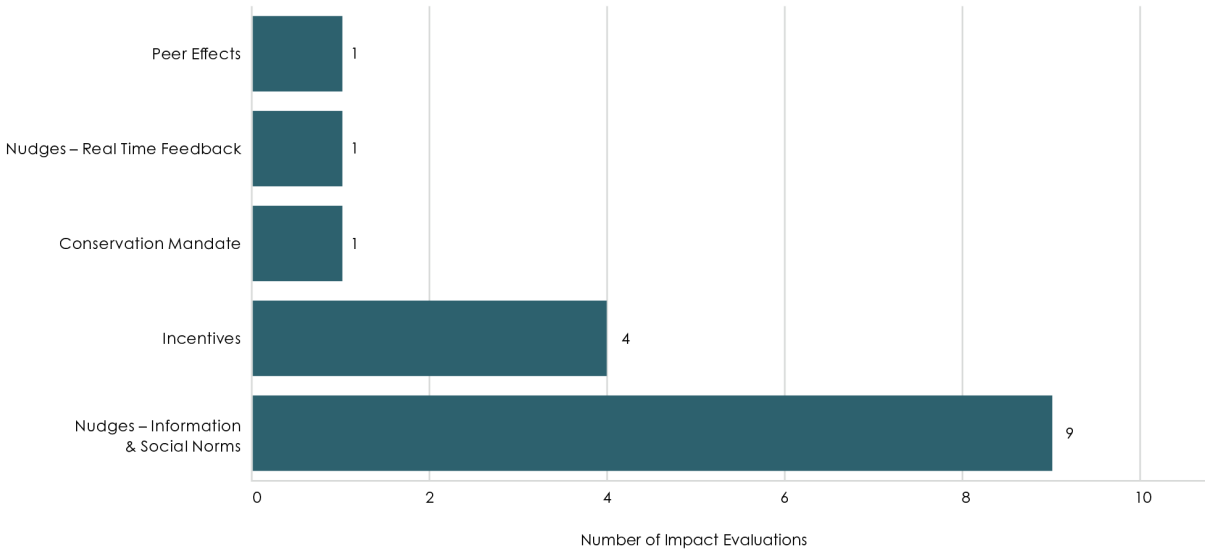
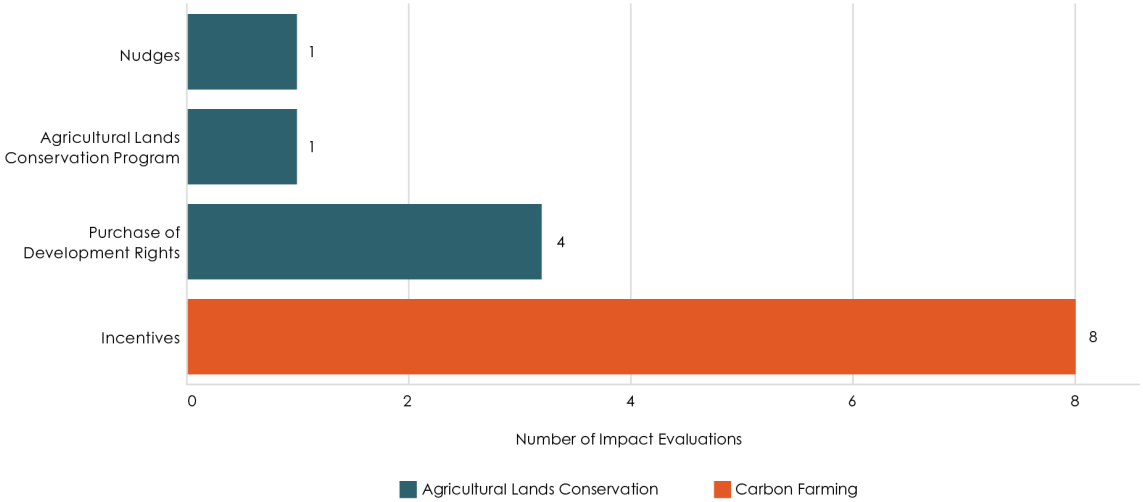


FIGURE 6. THE EVIDENCE BASE FOR CLIMATE ACTIONS IN AGRICULTURE AND CONSERVATION: AGRICULTURAL LANDS CONSERVATION AND CARBON FARMING



APPENDIX F – GEOGRAPHY

Energy

LOCATION	# OF STUDIES
United States	
Nationwide	6
Arizona	2
California	14
Connecticut	3
Florida	5
Georgia	1
Illinois	1
Maryland	1
Massachusetts	1
Michigan	1
North Carolina	1
Texas	2
Wisconsin	1
Australia	1
Austria	1
Croatia	1
Germany	3
Hungary	1
Ireland	1
Mexico	2
Netherlands	1
New Zealand	1
Sweden	1
Switzerland	1
United Kingdom	4

Transportation

LOCATION	# OF STUDIES
United States	
California	8
Nationwide	7
Illinois	2
Minnesota	2
New York	2
Texas	2
Massachusetts	1
Florida	1
Washington D.C.	1
Norway	3
Canada	2
Mexico	2
Netherlands	2
Germany	1
Spain	1
Anonymous (Europe)	1

Solid Waste

LOCATION	# OF STUDIES
United States	
California	1
Illinois	1
Kentucky	1
Maryland	1
Texas	1
Virginia	1
Washington D.C.	1
Australia	1
Italy	3
Netherlands	1
Sweden	1
Switzerland	2
United Kingdom	1

Water and Wastewater

LOCATION	# OF STUDIES
United States	
California	4
Georgia	4
Nevada	2
Arizona	1
North Carolina	1
Italy	1
Spain	1

Agriculture and Conservation

LOCATION	# OF STUDIES
United States	
Nationwide	1
Delaware	1
Maryland	1
New Jersey	1
New York	1
Pennsylvania	1
Virginia	1
France	3
Italy	3
Germany	2
Switzerland	2
Spain	1
United Kingdom	1