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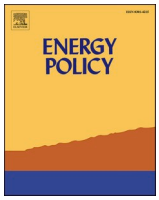

Incentivizing household action: Exploring the behavioral wedge in the 2021 Infrastructure Investment and Jobs Act and the 2022 Inflation Reduction Act

Mariah D. Caballero [a,*], Michael P. Vandenbergh [b], Jonathan M. Gilligan [c], Elodie O. Currier [d]

[a] Vanderbilt University Peabody College, Nashville, TN, United States
[b] Vanderbilt University Law School, Nashville, TN, United States
[c] Vanderbilt University College of Arts and Sciences, Nashville, TN, United States
[d] J.D., Vanderbilt Law School, 2023, Nashville, TN, United States

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ABSTRACT

In the 2021 Infrastructure Investment and Jobs Act (IIJA) and the 2022 Inflation Reduction Act (IRA), the United States (US) Congress placed a major bet on the importance of household actions, and the incentives for these actions may yield disproportionately large emissions reductions. Modeling estimates from the Rapid Energy Policy Evaluation and Analysis Toolkit (REPEAT) suggest that the IRA's $331 billion investment can reduce carbon emissions by as much as 42% below a 2005 baseline by 2030, assuming a low-friction economic environment. To evaluate the role of household actions, we use a two-part method: 1) Policy analyses of the IRA and IIJA to identify household incentives; 2) Secondary data analysis of REPEAT's policy models to identify the potential for emissions reductions associated with household action. We find that $39 billion, or 12% of climate and energy funds in the IRA and $4.3 billion or 5.7% of clean energy and power funds in the IIJA, target voluntary household actions, and that these actions contribute 40% of the cumulative emissions reductions under the IRA and IIJA, assuming a mid-range scenario for uptake. The importance of household actions to achieving IRA and IIJA's emissions reduction goals suggests that actual impacts will likely vary by behavioral plasticity, and that program design should reflect social and behavioral science insights.

1. Introduction

Scholars and advocates have long debated the importance of household behavior in climate mitigation initiatives. Household actions to increase home energy efficiency and conservation have the potential to yield substantial carbon emissions reductions. Despite this, some argue that interventions aimed at household actions will not yield substantial change (Nisa et al., 2019), or that they are an attempt by commercial interests to shift responsibility onto consumers, disincentivizing regulation and evading meaningful change (Buse et al., 2022; Chater and Loewenstein, 2022; Supran and Oreskes, 2021). Whether household initiatives can contribute prompt, large emissions reductions and complement rather than undermine corporate and government initiatives remains a central climate policy question. Still, as Sunstein has concluded, "there is no empirical support for the proposition that interventions aimed at helping individuals, which are numerous and often effective, make systemic reform less likely" (Sunstein, 2023, p. 1).

Households are integral to energy demand and carbon emissions in the United States. For example, the residential sector represented 19.1% of the United States' (US) CO_2 emissions from fossil fuel combustion) in 2021, while passenger vehicles and light-duty vehicles (of which over 90% are likely used for personal use) represented 22.2%, for a total equivalent to 41.3% of the US annual GHG emissions in 2021 (United States Department of Transportation, 2021a, United States Department of Transportation, 2021b, United States Environmental Protection Agency, 2023). Importantly, a 2009 study estimated that 7.4% of national emissions could be curbed by household actions (Dietz et al., 2009). A single initiative, the uptake of more efficient lightbulbs, may have accounted for the first reduction in per capita electricity use by U.S. households since the Second World War (Davis, 2017), reducing US GHG emissions by approximately 130 million metric tons (MMT) of carbon dioxide (CO_2) per year (Gilligan and Vandenbergh, 2020).

* Corresponding author.
E-mail address: mariah.d.caballero@vanderbilt.edu (M.D. Caballero).

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Although critiques of household behavior have focused on the political and practical barriers to regulating behavior, the subsidy approach taken in recent years by the US Congress represents a shift away from prohibiting undesired behaviors toward encouraging desired behaviors (Vandenbergh, 2022). US government laws and policies have previously achieved significant reductions in household emissions, but their adoption and implementation have been heavily contested (Gayer and Viscusi, 2013). If effective, the recent subsidy-based legislation could achieve significant emissions reductions from the household sector using a less intrusive approach that may provoke less resistance and be easier to implement from a regulatory standpoint.

Several bills and statutes, such as the Infrastructure Investment and Jobs Act (IIJA) of 2021 and the Inflation Reduction Act (IRA) of 2022, represent a choice by Congress to incentivize household actions in climate mitigation efforts. In 2021, Congress passed the IIJA, which invests significantly in transportation, climate-resilient infrastructure, and household-level actions such as weatherization (Table 1) (Infrastructure Investment and Jobs Act, 2021; White House, 2022a). Following the IIJA, in August 2022, Congress passed the IRA, boasting climate and energy provisions totaling $331 billion to support climate and energy actions through 2031 (Table 1) (Congressional Budget Office, 2022; White House, 2022b). Although media accounts frequently point to a $369 billion total (Nelson, 2023), that number is based on a previous version of Congressional Budget Office estimates. In contrast, we use the final version of the legislation adopted on August 16, 2022 and the September 7, 2022 Congressional Budget Office analysis of the final legislation. IRA provisions targeting households include tax credits for new and used personal electric vehicles, credits for door and window replacements, heat pump installation, and distributed power generation projects (Glavinskas, 2022). The incentivized actions in all three policies align with Dietz et al.'s concept of Behavioral Wedge Action Types (2009), which we define as the actions that many people or households have the agency to address, such as residential energy upgrades, travel and commute patterns, and resource consumption.

The growing role of household actions in climate legislation suggests the need to update models to fully account for the influences on individual behavior. Modeling efforts such as those from the Rapid Energy Policy Evaluation and Analysis Toolkit (REPEAT) have been used to estimate the social, environmental, and health-related impacts of the IIJA and IRA (Jenkins et al., 2022a). Notably, the models use economic forecasts to identify the least-cost scenario to determine the most plausible decarbonization pathway (Jenkins et al., 2022a). These models estimate the change in household technologies using various scenarios for implementation and programmatic uptake, noting the challenges that may be associated with creating that environment, such as rapidly expanding transmission to meet the energy demands of new technology (Jenkins et al., 2022a; Jenkins et al., 2022b).

In the same vein, we posit that the 2022 IRA and 2021 IIJA will pose significant behavioral challenges associated with uptake of efficient technologies at the household-level, such as navigating eligibility standards for tax credits, assessing cost savings, accessing new technologies locally, and contracting with qualifed local installers. These challenges can be classified using the term *behavioral plasticity*, or the proportion of individuals who could be influenced to take an action, and the concept can be used to estimate the plausible emissions reductions arising from use of state of the art interventions (Dietz et al., 2009). Behavioral plasticity has been widely used in studies of climate-relevant behaviors (Kaplowitz and Boucher, 2022; van der Linden and Goldberg, 2020).

Importantly, behavioral plasticity related to household action varies significantly by geography, demographics, and identity, which may be related to the degree of agency a household possesses. For example, research suggests an "emissions paradox" exists in the US, where white communities tend to emit more carbon than Black communities, despite living in more energy-efficient homes (Goldstein et al., 2020). Similarly, renters are more likely to be excluded from energy efficiency programs, a phenomenan called "the split incentive", where landlords are discouraged from investing in energy efficiency because the savings benefit the renter (Bird and Hernández, 2012). Further, energy efficiency programs vary significantly by state, where state-level disparities can be seen in low-income investments by utilities (Reames et al., 2019). These variations influence the efficacy of programmatic implementation and should be considered in tandem with behavioral plasticity to ensure a just energy transition. Social and behavioral science insights may enable program managers to design and implement programs that better account for human decisionmaking (Dietz et al., 2009; Kaplowitz and Boucher, 2022; van der Linden and Goldberg, 2020).

Given the ongoing scholarly debates surrounding the value of household action in reducing climate emissions, the analysis we present here demonstrates that household actions play a substantial role in the IRA and IIJA and suggests opportunities for programmatic design, given evidence-based findings based on behavioral plasticity. We followed a two-part methodological approach: 1) policy analysis of the IRA and IIJA to identify household incentives; and 2) secondary data analysis of REPEAT's policy model results to identify the potential for emissions reductions associated with household actions.

2. IRA and IIJA policy analysis

We assessed final versions of the IRA and IIJA to examine the emissions reductions associated with household actions (signed August 16, 2022, and November 14, 2021, respectively). We identified actions that many individuals or households have the agency to address, such as residential energy upgrades, travel and commute patterns, or resource consumption. For instance, replacing an aging car with an electric vehicle or replacing an old water heating system with a new heat pump water heater represent actions that many households have the agency to address.

Using this definition, we identified several provisions in the IRA and IIJA that target individual or household actions. Actions incentivized by the IRA include weatherization, distributed energy generation, personal electric vehicles, heat pumps, and others (Table 1, Fig. 1). In all, the IRA dedicated $38.8 billion to incentivizing household behaviors (11.7% of all funds aimed at energy and climate), while the IIJA dedicated $4.3 billion to household behaviors (5.7% of clean energy and power funds) (Tables 1 and 2, Fig. 1).

3. REPEAT case study

To understand the relationship between household actions incentivized by the IIJA IRA and estimated emissions, we utilized modeling results from REPEAT as a case study. REPEAT provides more technical documentation for its models than the two other leading models of IRA emissions reductions (Rhodium and Energy Innovation). REPEAT also provides summaries of its assumptions and inputs for all environmental sections of the IRA—information that was not as readily available from other groups (Jenkins et al., 2023).

REPEAT utilizes a cost-optimized modeling approach that draws on energy service demand assumptions largely based on the United States Energy Information Administration's Annual Energy Outlook 2021 and technology costs from the National Renewable Energy Laboratory Annual Technology Baseline (Jenkins et al., 2022a). Once macro-energy estimates for energy demand and technology costs are created, the model optimizes a supply-side scenario to meet demand at the lowest cost (Jenkins et al., 2022a; Larson et al., 2021).

REPEAT estimates of emissions under the Current Policies Scenario (IRA and IIJA) were made available to the public in July of 2023. The IIJA and IRA are represented using a trio of scenarios, which represent different estimates for the effectiveness of implementing the programs under 'Conservative', 'Mid-Range', and 'Optimistic' assumptions (Supplementary Table 1). In addition to historic scenarios such as Frozen Policy, which represents the policies in place when President Biden was inaugurated in January 2021, and the IIJA alone, scenarios such as the

Table 1
Household action types, section, description, and legislative funds in the 2022 IRA (Jenkins et al., 2022c; Inflation Reduction Act). Note: Tax credits do not explicitly allocate funds, and several action types are often mentioned in each section.

Action Type	IRA Section	Description	Legislative Funds
Residential HVAC/ Building Shell	60103	Creation of grants for states, municipalities, and Tribal governments to promote the penetration of clean energy technologies in communities, including distributed energy generation projects and other climate change mitigation efforts. A portion must be allocated to low income and disadvantaged communities.	$27 billion
Residential HVAC/ Building Shell	60201	Creation of grants for activities and technical assistance to promote community-engaged projects in disadvantaged communities. Projects associated with pollution monitoring and prevention, climate and health risk mitigation, low-and zero-emission technology implementation, and the reduction of indoor air pollution exposure are considered eligible.	$3 billion
Residential HVAC/ Building Shell	50121	Creation of grants for state energy offices to administer a Home Owner Managing Energy Savings (HOMES) rebate program. Additional funds available for low to moderate income individuals.	$4.3 billion
Residential HVAC/ Building Shell	50122	Creation of grants for state energy offices and Indian Tribes to administer a "high-efficiency electric home rebate program" among low and moderate income households. Weatherization upgrades include heat pumps for space heating/cooling, electric stoves/cooktops, an electric heat pump clothes dryer, breaker upgrades, insulation, air sealing, panels/wiring; not to exceed $14,000 per eligible entity.	$4.5 billion
Residential HVAC/ Building Shell	13301	Extends the credit in section 25C of the Internal Revenue Code of 1986 and replaces the 10% credit rate with 30% for eligible energy efficiency projects. Changes the lifetime credit limitation to an annual limit of $1200 for energy efficiency improvements or $600 for eligible energy property. This includes up to $600 for windows and $500 for doors. However, heat pump space heaters and biomass stoves are eligible for an increased annual credit limit of $2000 or 30% of cost.	N/A
Residential HVAC/ Building Shell	13304	Extends the credit in section 45L of the Internal Revenue Code of 1986 and increases the amount for single family and manufactured homes to $2500 that are eligible for the "Energy Star New Construction Program or the Energy Star Manufactured New Homes program".	N/A
Water Heating	50122	Creation of grants for state energy offices and Indian Tribes to administer a "high-efficiency electric home rebate program". Appliance upgrades include up to $1750 for a heat pump water heater.	Included above
Water Heating	13301	Extends the credit in section 25C of the Internal Revenue Code of 1986 and replaces the 10% credit rate with 30% for eligible energy efficiency projects. Changes the lifetime credit limitation to an annual limit of $1200 for energy efficiency improvements or $600 for eligible energy property. However, heat pump water heaters and biomass water boilers are eligible for an increased annual credit limit of $2000 or 30% of cost.	Included above
Light Duty Electric Vehicles	13401	Amends the credit in section 30D of the Internal Revenue Code of 1986 to include a $7500 credit for a "new clean vehicle", but reduces the credit if a percentage of the battery is not extracted/processed in the US or with a country with a Fair Trade Agreement or recycled in North America. Limits application of credit for individuals whose income exceeds $150,000 or $300,000 for joint filers. Limits credit for purchases less than or equal to $80,000 for vans, SUVs and pickups and $55,000 for other vehicles.	N/A
Light Duty Electric Vehicles	13402	Creates tax credit (section 25E of the Internal Revenue Code of 1986) for consumers to purchase a previously owned electric vehicle, equivalent to $4000 or 30% of the total cost and limits eligibility for individuals making more than $75,000 or $150,000 for joint filers. Limits credit's utility to previously owned vehicles which are at least 2 years older than the year of sale and does not exceed $25,000.	N/A
			Total Funds: $38.8 Billion

Net-Zero Pathway Benchmark, a yardstick assessment tool created by REPEAT to measure US progress, are estimated (Jenkins et al., 2023). We used these publicly-available model results to explore the potential contributions of household actions to calculated emission reductions.

To analyze the future impacts of energy and climate policies (e.g., Frozen Policy and the trio of scenarios associated with Current Policy), we used REPEAT's estimated emissions by fuel type and energy use for the residential and transportation sectors, except for various oil products, such as heating oil, gasoline fuel, and diesel fuel, as we explain below (REPEAT, 2023). We used the emissions intensity of coal and natural gas provided by REPEAT. Further, because the REPEAT analysis aggregates emissions from all oil products into one category, we calculated disaggregated emissions for gasoline and diesel fuel, and home heating oil, by multiplying the REPEAT estimates of energy consumption for gasoline, diesel fuel, and home heating oil by carbon emissions factors for each fuels as reported by the EPA (US Energy Information Administration, 2023). Lastly, because data on emissions from electricity generation was not available, we converted the emissions intensity associated with electricity generation from quadrillion BTU to Million Metric Tons (MMT) using the Environmental Protection Agency's (EPA) Greenhouse Gas Equivalencies Calculator (US EPA, 2015), based on the mix of fuels used for generation according to the REPEAT analysis for the different scenarios. Using these values, we summarized energy use and associated emissions for household actions for each policy scenario, using Frozen Policy as a baseline. All data analyses were conducted using R (v. 4.3.1) (R Core Team, 2023).

We concluded that actions proposed in the Mid-Range Current Policies Scenario could considerably lower total emissions, up to 1008 MMT of CO_2 could be reduced annually when compared to Frozen Policy (Fig. 2).

To assess the role of household actions in the IRA, we disaggregated the effects of those actions on household energy consumption by fuel from the impacts of actions outside the household's purview on the carbon intensity of those fuels. For instance, if utility companies shift the mix of electrical generation away from fossil fuels and toward renewable or nuclear energy sources, the emissions reduction associated with household electricity consumption would not be due to household actions. We performed this disaggregation by recalculating three baseline scenarios, each corresponding to the household energy consumption under the frozen policy scenario, but using greenhouse gas emissions coefficients for each energy source that correspond to current policies, under conservative, mid-range, and optimistic assumptions. We then calculated the emissions reduction associated with household energy consumption changing to the current-policy scenario from the corresponding baseline. By taking emissions factors from the current policy for both the baseline and current-policy scenarios, we were able to calculate the effect of changing household energy demand and fuel mix separately from changes in energy supply, infrastructure, and carbon intensity that are beyond the household's control.

When considering household actions proposed in the Current Policy Scenarios, we concluded that provisions supporting residential space and water heating in the Mid-Range Policy Scenario could result in emissions reductions of up to 261.6 MMT of CO_2 annually (199 and 62.6 MMT of CO_2, respectively), as compared to Frozen Policy. Further,

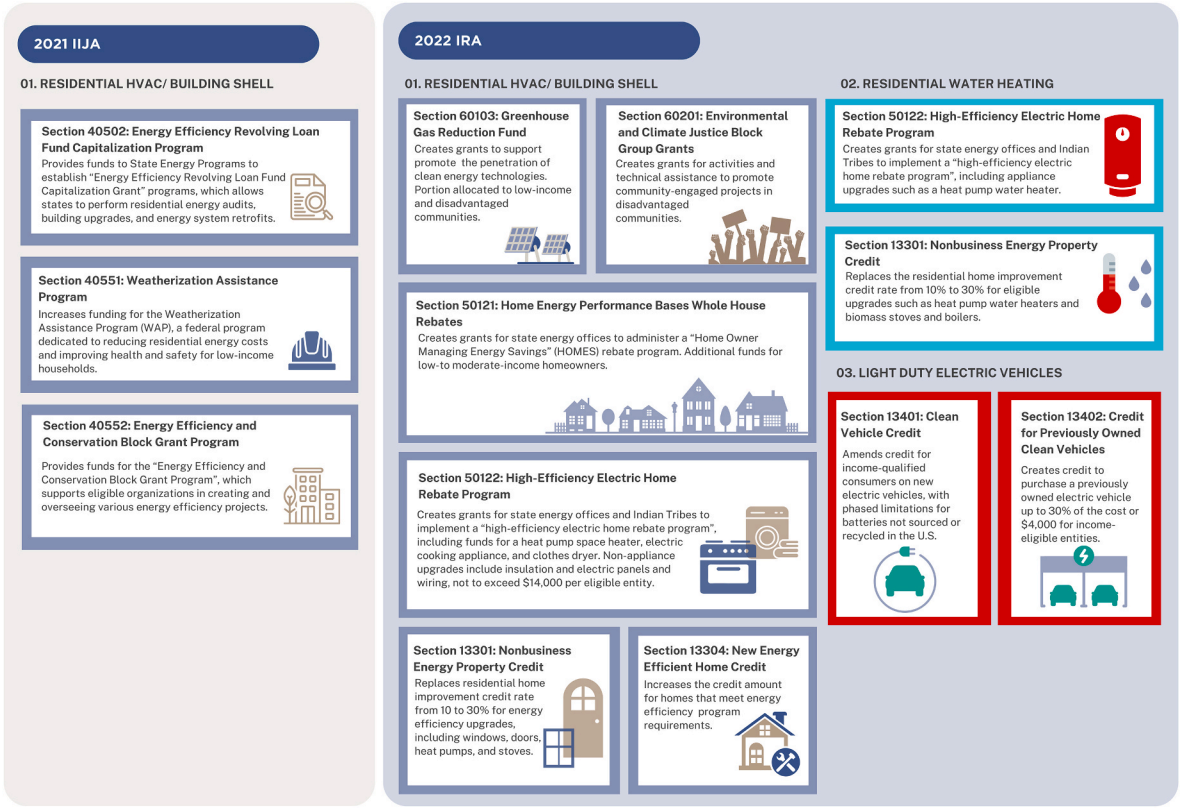

Fig. 1. Three sections in the IIJA and eight section in the IRA incentivize household actions spanning three behavioral wedge action types (Inflation Reduction Act, 2022, Infrastructure Investment and Jobs Act, 2021, and Jenkins et al., 2022c).

Table 2
Household action types, section, description, and legislative funds in the 2021 IIJA (Jenkins et al., 2022c; Infrastructure Investment and Jobs Act, 2021).

Action Type	IIJA Section	Description	Legislative Funds
Residential HVAC/ Building Shell	40502	Provides funds to State Energy programs to establish "Energy Efficiency Revolving Loan Fund Capitalization Grant" programs, which allow states to perform residential energy audits, building upgrades, and energy system retrofits.	$0.25 billion
Residential HVAC/ Building Shell	40551	Increases funding for the Weatherization Assistance Program (WAP), a federal program dedicated to reducing residential energy costs and improving health and safety for low-income households.	$3.5 billion
Residential HVAC/ Building Shell	40552	Provides funds for the "Energy Efficiency and Conservation Block Grant Program", which supports eligible organizations in creating and overseeing various energy efficiency, clean transportation, and renewable energy projects.	$0.55 million
			Total Funds: $4.3 Billion

provisions supporting changes to light-duty trucks and autos could result in emissions reductions of up to 191 MMT in the Mid-Range Current Policy Scenario as compared to Frozen Policy (Fig. 3).

Finally, we calculated the cumulative emissions reductions due to household actions from 2024 to 2050 and compared them to the total cumulative emissions reductions reported by the REPEAT project. This suggests that under the Mid-Range and Optimistic current policy scenarios, 40% of the expected cumulative emissions reductions through 2050 under IRA and IIJA will be due to household actions (Fig. 4).

4. Conclusions and policy implications

Our results suggest that household actions play a substantial role in the IRA and IIJA. The IRA and IIJA include a combined eleven sections that directly incentivize these actions, including the uptake of efficient heat pumps, water heaters, and personal electric vehicles, and these types of household actions account for roughly $38.8 billion or 11.7% of the climate and energy funds in the IRA and $4.3 billion or 5.7% of clean energy and power funds in the IIJA. Although our budgetary analysis considers appropriated funds, it is essential to note that uncapped tax credits associated with clean energy and efficiency incentives represent more than two-thirds of the climate and energy provisions in the IRA and are challenging to model (Bistline et al., 2023).

The relatively small financial subsidies in the IRA and IIJA as compared to subsidies for non-household actions could produce a disproportionately large share of the estimated emissions reductions from these laws. Based on models of the Mid-Range Current Policy Scenario, we estimated that 40% of annual estimated emissions reductions could be attributable to household actions. In short, roughly 12% of the climate and energy spending in the IRA and 5.7% of clean energy and power funds in the IIJA are focused on household actions, which may produce 40% of the total cumulative emissions reductions through 2050.

The household actions subsidized by the IRA and IIJA are only a beginning, and the recent legislative embrace of these types of actions may continue or increase. The large and growing role of household actions thus suggests the need to increase the research base and agency expertise on household policies and programs (Stern et al., 2023). An

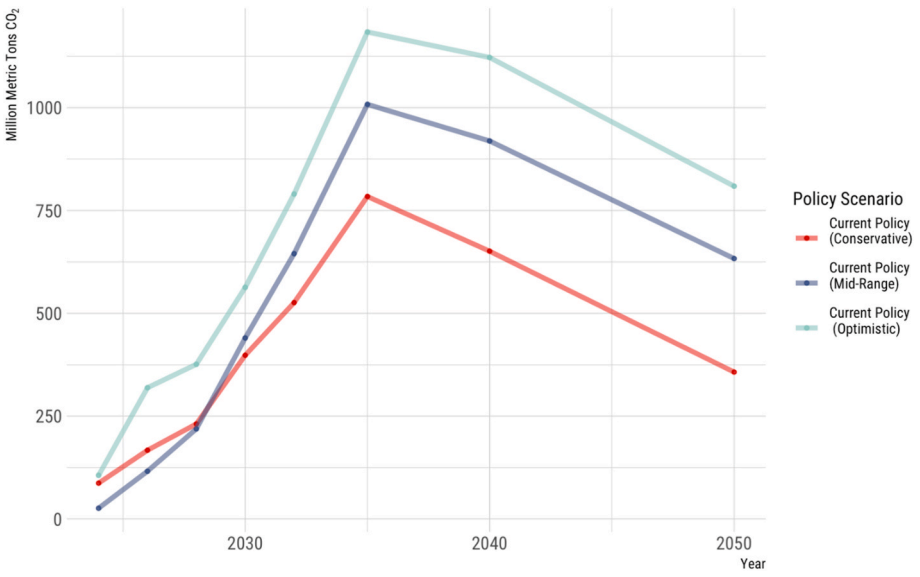

Fig. 2. Total emissions reductions estimated under the trio of Current Policy Scenarios from 2024 to 2050, using Frozen Policy as a baseline.

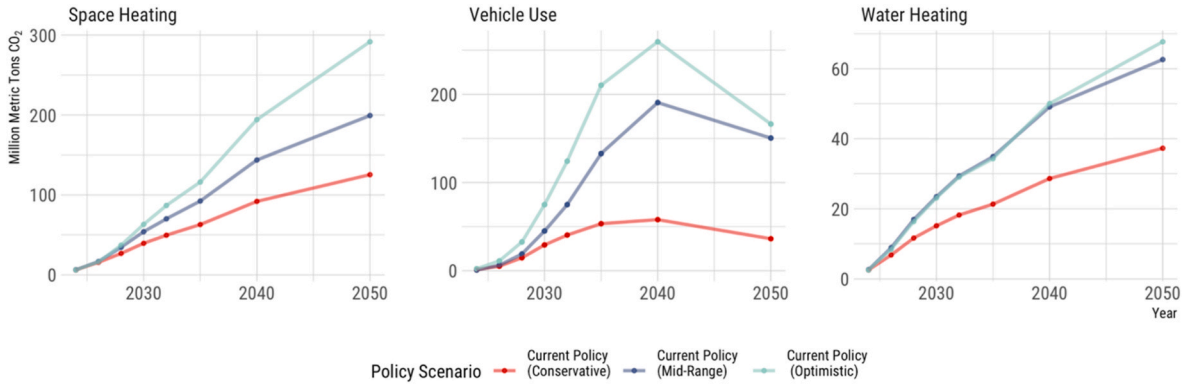

Fig. 3. Total emissions reductions estimated under the trio of current policy scenarios for household actions such as a) vehicle use, b) residential heating, and c) residential water heating as compared to Frozen Policy.

important aspect of this research and agency expertise is a better understanding of the behavioral plasticity of households, which may differ substantially from that of the traditional industrial targets of environmental laws and policies. Integrating behavioral plasticity into policy modeling estimates and program design will be critical for exploiting the opportunity to harness household actions in climate change mitigation.

To augment future policy models and programmatic interventions, we also suggest the following implementation strategies for the IIJA and IRA, aligned with the policy design principles enumerated in Stern et al. (2010) and Vandenbergh et al. (2010): 1) Ensure household programs prioritize impactful action. For example, while re-insulating one's home may effectively curb emissions (technical potential), individuals may be more likely to take advantage of smaller projects, such as replacing windows or doors (behavioral plasticity). Designing programs to balance technical potential and behavioral plasticity will help ensure rapid and widespread emissions reductions (Dietz et al., 2009). 2) Provide

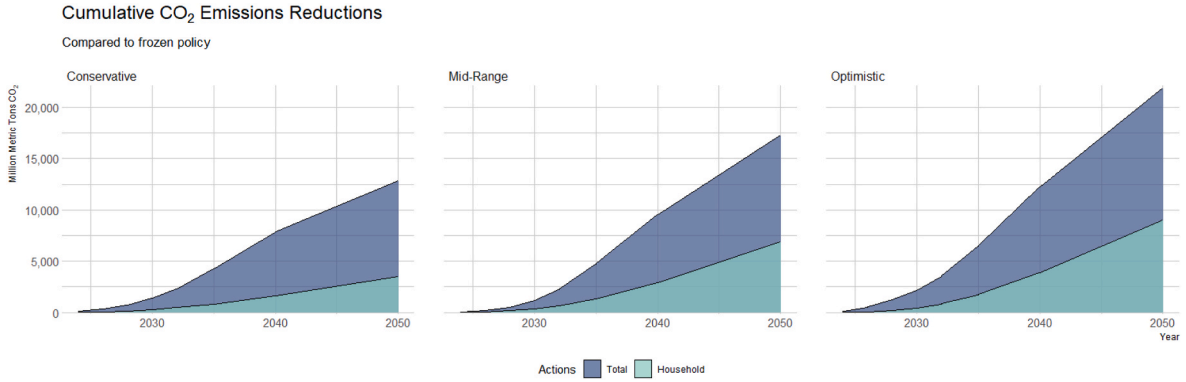

Fig. 4. Household Action and Total emissions reductions for the Trio of Current Policy Scenarios as compared to the Frozen Policy Scenario.

significant financial incentives. While the IRA offers many financial incentives in its provisions, programmatic design should focus on lowering the barriers to accessing those funds. For example, if eligibility requirements are unclear for the used clean vehicle credit program, household decision-makers may be disincentivized to take advantage of credits. 3) Strongly market the program. Although media campaigns can be effective, research suggests that local context matters in home energy efficiency programs and community-based programs can be more effective (Reames, 2016). 4) Provide valid information from credible sources at the points of decision. For example, if HVAC contractors are equipped with credit options in the IRA, they can advise their customers on savings options at the time of replacement. 5) Keep it simple. Programs are more likely to be successful if they minimize the burden on the consumer. Thus, lessening the paperwork, timelines, and organizational navigation associated with the IIJA and IRA's household provisions may significantly increase uptake. A recent example of this is the US Department of the Treasury's rule proposal, intended to provide immediate rebates for the IRA's EV tax incentives at the point of sale (US Department of the Treasury, 2023). 6) Provide quality assurance. Household decision-makers should be confident that their decision to take advantage of the IIJA and IRA's incentives will be worth the additional time spent identifying qualified car salespeople, eligible appliances, and certified contractors.

Household behavior is also significantly tied to a household's level of agency. For example, replacing an old water heating system with a new heat pump water heater in a single-family home represents an action that many households have the agency to address. In contrast, the same replacement in a multi-family dwelling is likely to be limited by external constraints or coordination requirements associated with a renter's or unit owner's agency. Behavioral wedge actions are also likely to vary by community and household-level structural inequities. For example, low-income homeowners requiring health and safety upgrades will likely be deterred from participating in low-income weatherization assistance programs until costly repairs are made (Tonn et al., 2015). At the same time, high-socioeconomic status households are responsible for far more consumption-based CO_2 emissions than their low-income counterparts, presenting a significant potential for emissions reductions (Nielsen et al., 2021). Thus, targeting higher-income households and addressing structural inequities concomitantly should be prioritized for IIJA and IRA program design.

Household action not only presents an important pathway for emissions reductions, but also provides opportunities to increase efficiency and reduce the inequitable energy burdens of low-income households. The growing focus on household action thus can promote both climate change mitigation and energy justice.

CRediT authorship contribution statement

Mariah D. Caballero: Conceptualization, Writing – original draft, Data curation, Formal analysis, Writing – review & editing. **Michael P. Vandenbergh:** Conceptualization, Funding acquisition, Supervision, Writing – review & editing. **Jonathan M. Gilligan:** Conceptualization, Data curation, Formal analysis, Supervision, Writing – original draft, Writing – review & editing. **Elodie O. Currier:** Conceptualization, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data is available publicly from REPEAT, we will provide an RMarkdown link for analysis.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.enpol.2024.113992.

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