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To Decarbonize Households, America Needs Incentives for Electric Appliances

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Introduction and summary

Residential building electrification must be a major pillar of any federal infrastructure strategy and is an essential step on the path to limiting global warming to 1.5 degrees Celsius. For U.S. households, electrification of heat and cooking appliances is centered around the adoption of just four appliances: heat pump space heaters, heat pump water heaters, induction cooktops/ranges, and upgraded breaker boxes. Because these machines last 10 to 20 years or more before needing replacement, completing the transition by midcentury requires the mass mobilization of U.S. markets and manufacturing today. In order to fully electrify these appliances—and all 121 million American households—before 2050, the United States must replace more than 80 million of these appliances across more than 50 million households over the next decade, setting the electrified appliance replacement rate on a path to 100 percent of installations by some time in the 2030s.

In this report, the Center for American Progress and Rewiring America, a nonprofit organization dedicated to the electrification of the economy, propose new consumer rebates for the purchase and installation of the four aforementioned machines. Together, these rebates would deliver an average incentive of $4,200 to participating households and an average of $6,000 to participating low-to-moderate-income (LMI) households. These rebates are calibrated to make sure the upgrade to electric appliances is no more expensive than a fossil fuel replacement, even before counting the subsequent energy bill savings a household will realize from the transition.

The opportunity for participation in this program is substantial. According to data from the U.S. Census Bureau's American Housing Survey, there are an estimated 65 million U.S. households that could together save more than $27 billion per year on their energy bills if they were using modern electric appliances today instead of space and water heaters powered by oil, propane, and electric resistance (such as inefficient baseboard heaters). More than 35 million of these are LMI households

at or below 80 percent of annual median income that would save a combined $15 billion per year on their energy bills by choosing the electrified version of the replacement appliance when their current ones reach their end of life, with no additional cost due to the proposed credit.

Depending on uptake rates, Rewiring America and the Center for American Progress project that this new program of consumer rebates would drive an average annual federal investment of $8.8 billion to $26.5 billion over the next decade and create between 175,000 and 1.1 million jobs paying family-sustaining wages, many of which would be created in the United States.

The benefits of household electrification to energy cost savings; carbon pollution; indoor air quality; readiness for rooftop solar, home battery storage and electric vehicle deployment; affordability of the best technologies; and job creation throughout the economy are enormous, and they will be felt in every home across the country. Federal investment to accelerate this market transformation is an effective, equitable, and necessary part of the U.S. effort to build back better.

The immediate need for household electrification

Although these appliance upgrades make sense from a health perspective and will lower operating expenses for households—as discussed later in this report—the upfront capital cost of these efficient electric appliances is a deterrent for consumers at the point of purchase. This is especially true given that the time for appliance replacement often comes during an emergency—the result of a suddenly unworkable appliance. The slow payback rate of lower energy bills can make it difficult to justify a higher upfront cost for many households, especially for those without extra cash on hand. Since homeowners are not expected to be experts in or investors in what is best from a climate perspective, the choice to go all electric needs to be made the easiest and most affordable alternative for families looking to replace an old fossil fuel appliance.

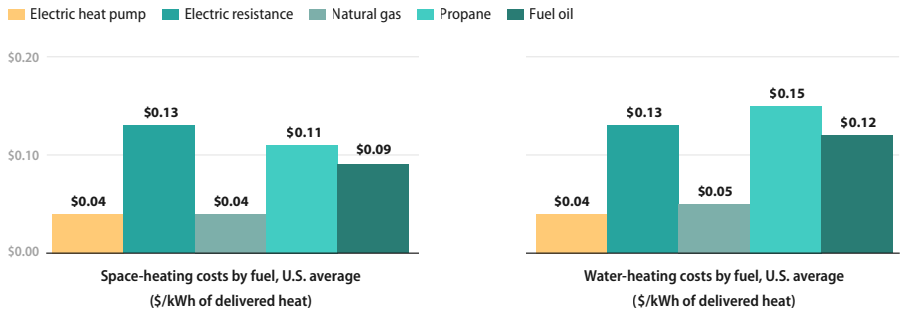
Because the life cycles of these appliances are long—often 10 to 20 years or more—spurring the high rates of adoption needed to fully electrify households must start immediately.[1] Every time a gas furnace breaks and is not replaced with an electric heat pump, that home loses the chance to be all electric for another two decades.[2] Every month the United States waits to set itself on the path to full electrification of households, the actions required to meet that end become steeper and costlier.

This demand-side view of emissions reduction leads right to the kitchen table, where household energy costs are discussed. An average U.S. household today spends 8 percent of its income on fossil fuels.[3] That number is higher still for low-income households. Of the 121 million households in the United States, there are more than 65 million—more than 50 percent—using heating oil and propane or inefficient electric resistance appliances such as baseboard heaters that could immediately lower their energy bills by upgrading to efficient, electric appliances.[4] Of these 65 million households, 36 million are LMI households. In many markets, the conversion to electricity can lower operating expenses for gas-fueled homes as well, further increasing this number. This is almost uniformly the case when electrification is coupled with rooftop solar and electric vehicles.[5]

FIGURE 1

On average, electric heat pumps are less expensive for household heating than appliances using electric resistance, propane, or fuel oil

Average price of one kilowatt-hour (kWh) of delivered heat



Source: Analysis by Rewiring America based on five-year average prices of fuel from U.S. Energy Information Administration, "Average retail price of electricity, annual," available at https://www.eia.gov/electricity/data/browser/#/topic/7?agg=1,0&geo=vvvvvvvvvvvo&endsec=8&freq=A&start=2001&end =2020&ctype=linechart&ltype=pin&rtype=s&pin=&rse=0&maptype=0 (last accessed May 2021); U.S. Energy Information Administration, "Weekly Heating Oil and Propane Prices (October - March)," available at https://www.eia.gov/dnav/pet/pet_pri_wfr_a_epd2f_prs_dpgal_w.htm (last accessed May 2021); U.S. Energy Information Administration, "Weekly Heating Oil and Propane Prices (October - March), U.S.," available at https://www.eia.gov/dnav/pet/pet_pri_wfr_dcus_nus_w.htm (last accessed May 2021); U.S. Energy Information Administration, "Natural Gas Prices," available at https://www.eia.gov/dnav/ng/ng_pri_sum_a_EPG0_PRS_DMcf_a.htm (last accessed May 2021); National Solar Radiation Database, "TMY3 hourly temperature profiles," available at https://nsrdb.nrel.gov/data-sets/download-instructions.html (last accessed May 2021); National Solar Radiation Database, "TMY3 hourly demand profiles," available at https://data.openei.org/submissions/153 (last accessed May 2021).

In addition to the benefit of lower operating costs for American households, building electrification can reduce the indoor air pollution caused by burning fossil fuels in homes. Decades of research has shown that gas stoves, in particular, release toxic pollutants indoors that can lead to serious negative health outcomes. Although the toxins released by gas stoves can contribute to levels of indoor pollution that exceed federal outdoor pollutant standards, indoor air pollution and emissions from fossil fuel-burning appliances remain unregulated.[6] Repeated, long-term exposure to indoor air pollutants can lead to the development of respiratory diseases, heart disease, and cancer.[7]

An effort to fully electrify households requires an additional consideration that may initially escape the attention of homeowners and contractors. The breaker box (also known as a fuse box, load center, electric panel, or distribution box) is the glue that pulls together these appliances, as well as other climate-forward technologies such as rooftop solar, battery storage, and electric vehicle chargers. Despite this, the breaker box is often overlooked as a primary obstacle to building electrification and as a critical enabling technology. Switching appliances to run on electricity instead of fossil fuels increases the amount of power flowing through a home's breaker box. Based on current penetration of high-power electric appliances, the authors estimate as many as 70 percent of breaker boxes in U.S. homes will need upgrading in order to handle the

increased load of electric heating and vehicle charging.[8] The breaker box, then, is often part of the upfront cost of electrification. Upgrading them at the right time makes homes electrification-ready, but doing so is an incremental expense—the authors estimate as much as $4,000 on average—that can serve as a barrier to transition.

Therefore, an attractive rebate for breaker boxes could encourage knowledgeable contractors/installers and homeowners to switch out their fossil-fueled appliances for more efficient, effective, and newly affordable electric counterparts sooner and be prepared to do so at the moment of replacement.

The household electrification incentive program

CAP and Rewiring America propose new consumer rebates for the purchase and installation of U.S. Department of Energy- and U.S. Environmental Protection Agency-certified breaker boxes, heat pump space heaters, heat pump water heaters, and induction cooktops/ranges that meet certain efficiency thresholds, including cold-climate specifications for heat pumps in certain regions of the United States. Together, these rebates would deliver an average incentive of $4,200 to participating households—and an average of $6,000 to participating LMI households. Depending on uptake rates, these rebates would result in an average annual federal investment of $8.8 billion to $26.5 billion over the next decade and create between 175,000 and 1.1 million jobs paying family-sustaining wages. As noted above, this would include an estimated 300,000 direct jobs. Of these, 200,000 would be installation jobs that could not be automated or outsourced, and 100,000 would be manufacturing jobs, most of which could be created in the United States if the U.S. government—through this program or otherwise—incentivizes domestic manufacturing of these appliances.

The next section discusses incentives for the purchase of these appliances, followed by a discussion of the incentives for installation. The authors designed both to be stacked and to encourage multiple-measure adoption, but also to be responsive to immediate household needs, such as a failed water heater. In the program design, each appliance rebate would be capped to one per household.

Incentives for the purchase of household electric appliances

For appliances that consumers purchase themselves, such as heat pump water heaters and induction cooktops, the rebate should apply at the point of sale, effectively making it a price discount. It is critical that electric appliances are consistently the least expensive option for consumers, not only in terms of the expected total lifetime cost to own—which is already true for millions of households—but

also in terms of upfront cost. Having a visible, immediate rebate is critical for influencing the often rushed, unplanned emergency purchases required when appliances unexpectedly fail. Importantly, the choice of a point-of-sale design over a nonrefundable tax credit addresses the equity concern for households with low or no tax liability. Immediate rebates are also better than refundable tax credits for households that cannot justify or afford the wait time for reimbursement. These point-of-sale rebates should also be made available through home improvement contractors at the time of installation, as discussed below, in the event that these appliances are purchased by the contractor on behalf of the consumer.

Because operating costs of these efficient electric appliances are often lower than the appliances they replace, rebates should be available to any building occupant or landlord who pays the utility bills for a property.

These new point-of-sale rebates for the purchase of residential electric appliances should approximately amount to the following:

- $1,500 for heat pump space heaters
- $750 for heat pump water heaters
- $750 for induction ranges/cooktops

The installation of any one of these rebated electric appliances may further require an upgraded breaker box. The rebate level is based on a market review of breaker box prices and contemplates the installation of a "smart" system that can support grid load management as the nation transitions to clean electricity supply. Overall, rebate support for the breaker box upgrade is a critical feature of this program, as the need for an upgraded system creates another upfront cost barrier to electrification that must be addressed. The upgraded breaker box will also support future household electrification improvements, such as rooftop solar, vehicle charging, and other appliances. In this instance, an additional rebate would cover:

- $1,000 for upgraded breaker boxes for all households
- $2,000 for upgraded breaker boxes for LMI households

These rebate sizes are based on an analysis of current, nationwide, and best-available sample data of equipment costs to estimate the retail cost differentials between common brands at comparable appliance specifications. Alongside the installation incentives described below, they are designed to make these electrification purchases competitive with their incumbent alternatives.

Alternative to consumer-facing rebates are upstream incentives to target manufacturers and/or midstream incentives to target appliance distributors. Assuming much of the value of these types of incentives is directly passed on to the consumer, they would reduce the need for a comprehensive demand-side rebate such as the one proposed in this section.

Incentives for the installation of household electric appliances

Beyond incentives that reduce the cost of purchasing electric appliances, CAP and Rewiring America also propose a set of rebates or credits for the cost of installation. To receive any rebate under this installation proposal, the contractor must provide evidence that the original fossil-fueled or electric resistance appliance was scrapped.

The appliance replacement installation rebates reimburse 50 percent of the total installation costs for an electric replacement up to the limits outlined below. For LMI households, the reimbursement levels are increased, and the 50 percent cap is removed: 100 percent of installation costs can be covered. For appliances purchased by the contractor instead of the consumer, such as in the case of heat pumps, the hardware purchase costs in excess of any rebates already received should be counted as part of the installation costs. This should also include the cost of disposing of the old appliance. The rebates are intended to be applied at the point of installation and can therefore be assigned by the consumer to the contractor, reducing market obstacles and any incremental out-of-pocket expenses a consumer would bear in a mail-in rebate model. The authors propose the following rebate amounts for installation:

- 50 percent coverage up to $2,500 for the installation of heat pump space heaters and 100 percent coverage up to $5,000 for LMI households

- 50 percent coverage up to $500 for the installation of heat pump water heaters and 100 percent coverage up to $1,000 for LMI households

- 50 percent coverage up to $500 for the installation of induction ranges/cooktops and 100 percent coverage up to $1,000 for LMI households

- 50 percent coverage up to $1,000 for the installation of breaker boxes and 100 percent coverage up to $2,000 for LMI households if the installation of any of these rebated electric appliances requires an upgraded breaker box, acknowledging the often more complicated and expensive wiring and other site-specific considerations in these homes

Additionally, this program would include the following rebates:

- $1,500 bonus for whole-home conversion

- $1,000 bonus for homes in cold climates

- $500 early adopter bonus; $1,000 for LMI households

- $1,500 rooftop solar bonus

The additional whole-home conversion rebate is made available if the electric appliance is replacing the last remaining fossil fuel appliance on the property, allowing the building or apartment unit to convert to all-electric. This $1,500 rebate will incentivize the bundling of appliance replacements and cover any costs associated with capping the natural gas line. By bundling appliance replacement in this way, total project costs can be reduced by performing electrical work at one time and reducing the total number of contractor visits.

An additional cold-climate bonus accounts for the fact that households in colder climates may need higher-capacity space-heating systems, and the price difference between the larger heat pump and the fossil fuel alternative may therefore be greater. To avoid penalizing these households, the bonus would offer a $1,000 bonus rebate, which would be added to the equipment rebate for the heat pump space heater.

An additional early adoption bonus acknowledges the U.S. electrification market is still up-and-coming and needs to be actively stimulated. For households that electrify in the first three years of this program, a $500 additional rebate would be available to all participating households with participating LMI households eligible for a $1,000 rebate.

Finally, an additional $1,500 rebate would be available to any household replacing fossil fuel appliances alongside a rooftop solar installation. This incentive is intended to support the bundling of electrical appliance upgrades during solar installation. Because most solar installations require a breaker box upgrade, this rooftop solar bonus can be combined with the breaker box rebate, creating up to $5,500 in subsidies to project costs, driving adoption synergistically. As bundling electrical appliances with locally generated solar electricity can provide the greatest reductions in emissions and utility bills, this rebate would drive adoption where impacts can be greatest and increase the pool of households that can afford to add solar.

TABLE 1

Summary of rebates proposed for year one of the rebate program

	Estimated difference in hardware cost over incumbent appliance	National average installation cost estimate	Proposed maximum rebate for low-to-moderate income (LMI) households*	Proposed maximum rebate for non-LMI households**
Heat pump space heater	$1,500	$5,000	$6,500	$4,000
Heat pump water heater	$750	$1,000	$1,750	$1,250
Induction cooktop	$750	$1,000	$1,750	$1,250
Breaker box	$2,000	$2,000	$4,000	$3,000
Bonus for whole-home conversion	--	--	$1,500	$1,500
Bonus for homes in cold climates	--	--	$1,000	$1,000
Bonus for rooftop solar	--	--	$1,500	$1,500
Bonus early adopter			$1,000	$500
Average rebate per household participating			**$6,000**	**$4,200**

* LMI rebates cover 100 percent of the difference in device cost and 100 percent of installation costs up to rebate caps.

** The maximum rebate for non-LMI households would be capped at 100 percent of the difference in device costs and 50 percent of installation costs.

Note: This table shows cost differentials for the start year of the program only because over the program's 10-year lifespan, this program will reduce the average cost differential between the efficient electric appliances and their fossil fuel or electric resistance baseline counterparts. To this end, the rebates proposed—and the overall headline cost calculated for the program—are dynamic in nature: They size down over the 10-year window in relation to cost parity projections.

Source: Analysis based on a Rewiring America model of rebate program uptake and rebate program costs, April 2021, on file with author.

Deployment levels of residential appliance electrification program

To complete the full stock turnover of these critical household appliances by midcentury, in line with a 1.5 degrees Celsius target, the authors estimate that 83 million machines must be replaced over the next 10 years, which would place the sales share of efficient electric appliances on a trajectory to reach nearly 100 percent of appliance replacements in the mid-2030s. (see Figures 2–4) At this rate of uptake, the program above would cost roughly $26.5 billion per year over the 10-year period, with an estimated 50 million households participating—more than 40 percent of U.S. homes.

TABLE 2

Summary of total program cost over a 10-year period under a high electrification uptake scenario

	Rebate value for low-to-moderate income (LMI) Households*	Estimated # of LMI households redeeming rebate	Rebate value for non-LMI Households**	Estimated # of non-LMI households redeeming rebate	Total federal cost of electrification program***
Heat pump space heater	$6,500	12 M	$4,000	15 M	$96 B
Heat pump water heater	$1,700	11 M	$1,200	13 M	$19 B
Induction cooktop	$1,700	5 M	$1,200	6 M	$11 B
Breaker box	$300	9 M	$2,500	11 M	$55 B
Bonus for whole-home conversion	$1,500	5 M	$1,500	6 M	$17 B
Bonus for LMI households	$2,000	24 M			$43 B
Bonus for homes in cold climates	$1,000	5 M	$1,000	6 M	$10 B
Bonus for rooftop solar	$1,500	4 M	$1,500	5 M	$13 B
Total					**$265 B**

* The rebate would cover 100 percent of the estimated cost differential between electric appliances and traditional alternatives.

** The rebate value is calculated to cover 50 percent of the estimated cost differential between electric appliances and traditional alternatives.

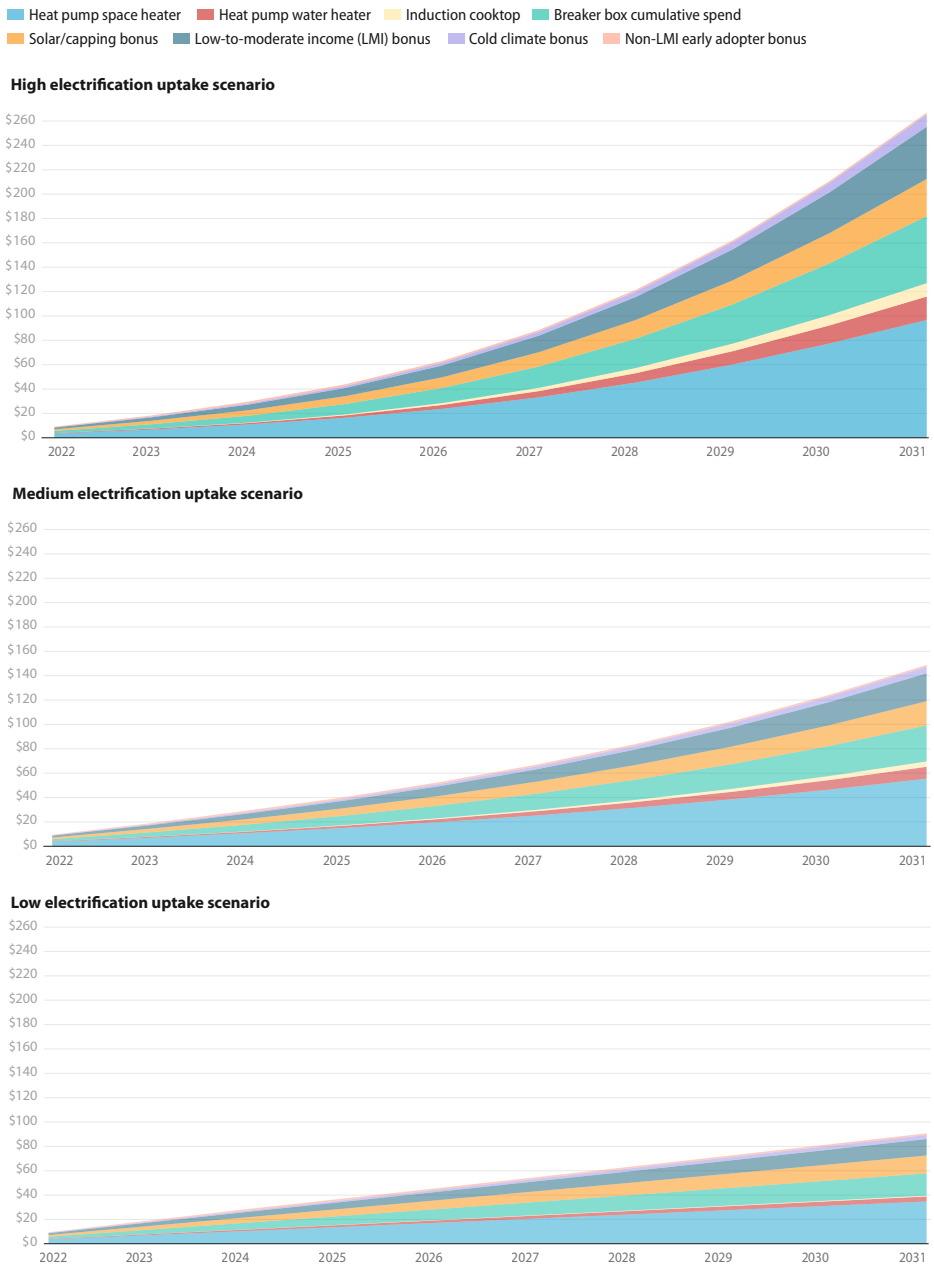
*** The federal cost is calculated after cost reductions from economies of scale.

Source: Analysis based on a Rewiring America model of rebate program uptake and rebate program costs, April 2021, on file with author.

FIGURE 2

Cumulative spending of the proposed rebate program components over a 10-year period, in billions of dollars

Viewed under low, medium, and high electrification uptake scenarios

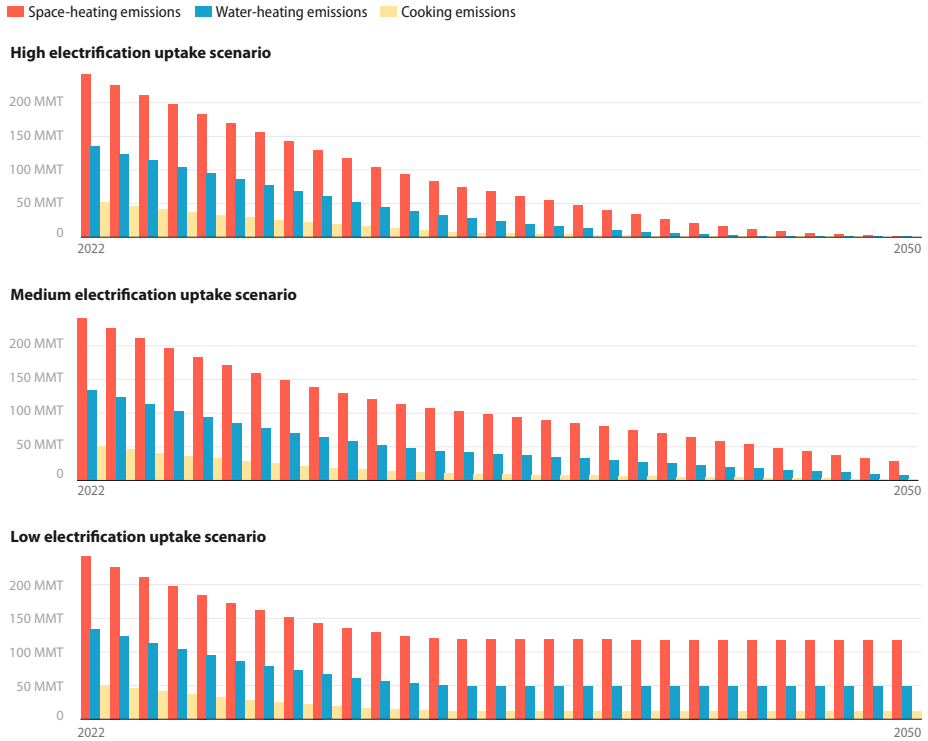


Source: Analysis based on a Rewiring America model of rebate program uptake and rebate program costs, April 2021, on file with author.

Program uptake will depend on many factors, including program awareness, availability of trained contractors, and the preparation of homes for electrification—such as upgrading the breaker box—before an emergency replacement event strikes. The 1.5 degrees Celsius uptake scenario is, therefore, not assured. Table 3 illustrates a range of uptake scenarios and associated costs and appliance penetration.

FIGURE 3

Household appliance emissions over a 30-year period under different electrification uptake scenarios, in million metric tons of carbon dioxide



Note: This scenario assumes a clean electricity grid transition commensurate with President Joe Biden's American Jobs Plan, which calls for 80 percent clean energy by 2030 and 100 percent clean energy by 2035.

Source: Analysis based on a Rewiring America model of rebate program uptake and rebate program costs, April 2021, on file with author. See The White House, "Fact Sheet: President Biden Sets 2030 Greenhouse Gas Pollution Reduction Target Aimed at Creating Good-Paying Union Jobs and Securing U.S. Leadership on Clean Energy Technologies," April 22, 2021, available at https://www.whitehouse.gov/briefing-room/statements-releases/2021/04/22/fact-sheet-president-biden-sets-2030-greenhouse-gas-pollution-reduction-target-aimed-at-creating-good-paying-union-jobs-and-securing-u-s-leadership-on-clean-energy-technologies/; U.S. Energy Information Administration, "Residential Energy Consumption Survey 2015," available at https://www.eia.gov/consumption/residential/ (last accessed May 2021); U.S. Environmental Protection Agency, "Inventory of U.S. Greenhouse Gas Emissions and Sinks, available at https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks (last accessed May 2021).

Notably, over the program's 10-year lifespan, this program will reduce the average cost differential between the efficient electric appliances and their fossil fuel or electric resistance baseline counterparts by significant margins due to industrial scale and learning rates. This program is designed to eliminate the cost difference between the average fossil fuel-burning appliance and the average electric alternative. Therefore, by 2031, the market cost difference even before rebates are applied is reduced by roughly 27 percent between heat pump space heaters and their traditional alternative, 66 percent for heat pump water heaters, and 42 percent for induction cooktops.[9]

To this end, the rebates proposed—and the overall headline cost calculated for the program—are dynamic in nature: They size down over the 10-year window in relation to the above cost parity projections. In combination with manufacturing incentives and other policies described in this report under the recommendations, there is significant potential to spur the manufacturing flywheel of these critical appliances, creating the necessary industrial scale to support ever-increasing levels of deployment.

TABLE 3

Summary of electrification uptake scenarios and associated carbon dioxide emissions reductions and program cost estimates over a 10-year period

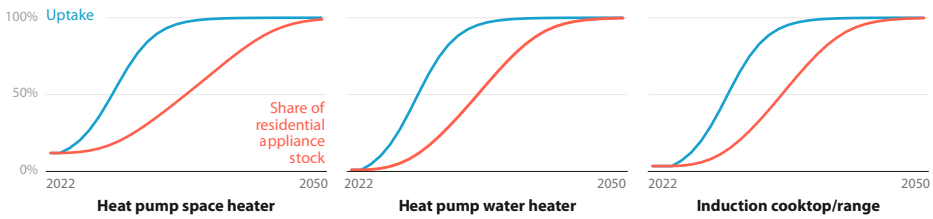
	Low-uptake scenario	Medium-uptake scenario	High-uptake scenario
Program uptake rate	5%	10%	20%
Annual emissions cut by 2050, in million metric tons (MMT)	251 MMT	388 MMT	426 MMT
Percentage of annual emissions cut by 2050	59%	90%	99%
Direct jobs created	50,000	135,000	318,000
Total jobs created	**175,000**	**471,000**	**1,110,000**
Total program cost	**$88 billion**	**$145 billion**	**$265 billion**

Note: This scenario assumes that 6 percent of households opt into the program prior to appliance end of life; 0.75 percent opt in to solar; 45 percent participation by LMI households; a 35 percent cold climate participation rate; and that 70 percent of participating households require breaker box upgrades. Uptake is modeled on an appliance-by-appliance basis, where adoption rate trajectories follow Bass diffusion curves, starting from estimated current-market adoption and penetration. Annual emissions cuts were calculated over a baseline of combined emissions from the three incented appliance sources from the 2015 U.S. Energy Information Administration's (EIA) Residential Energy Consumption Survey (RECS) and assumed a clean electricity grid commensurate with President Joe Biden's American Jobs Plan, which calls for 80 percent clean energy by 2030 and 100 percent clean energy by 2035. Total jobs include direct, indirect, and induced jobs. Direct jobs refers to construction and manufacturing jobs created through demand for electrification. Indirect jobs refers to manufacturing and service jobs created in associated industries that supply intermediate goods for electrification, such as lumber, steel, and transportation. Induced jobs refers to retail and wholesale jobs created by workers in these construction, manufacturing, and service industries when they spend the money they earn on other products in the economy.

Source: Analysis based on a Rewiring America model of rebate program uptake and rebate program costs, April 2021, on file with author.

FIGURE 4

Heat pump space heater, heat pump water heater, and induction cooktop/range share of residential appliance stock under the high electrification uptake scenario



Note: The blue curve is the percentage of households purchasing a modern electrified appliance to replace an appliance at end of life. The red curve shows the percentage of U.S. households with modern electrified appliances in use. The latter lags the former due to the 10- to 20-year lifetime of appliances, as most households will not replace appliances until they are due to be retired and it is economical to do so. In order to reach zero emissions by 2050, nearly all appliance purchases must be electric by the 2030s, an outcome possible only under the high-uptake scenario.

Source: Analysis based on a Rewiring America model of rebate program uptake and the Bass diffusion model, April 2021, on file with author.

Benefits of appliance electrification

In replacing these appliances, their modern, electrified versions become appreciating assets from an emissions reduction perspective. President Joe Biden's infrastructure plan—the American Jobs Plan—would entirely power the electricity grid with zero-carbon sources by 2035.[10] On today's grid, if all households had these appliances installed, they would save nearly 200 million metric tons of emissions per year. As the grid becomes 100 percent clean and these appliances are 100 percent adopted, those emissions savings will grow to more than 400 million metric tons per year by 2045.

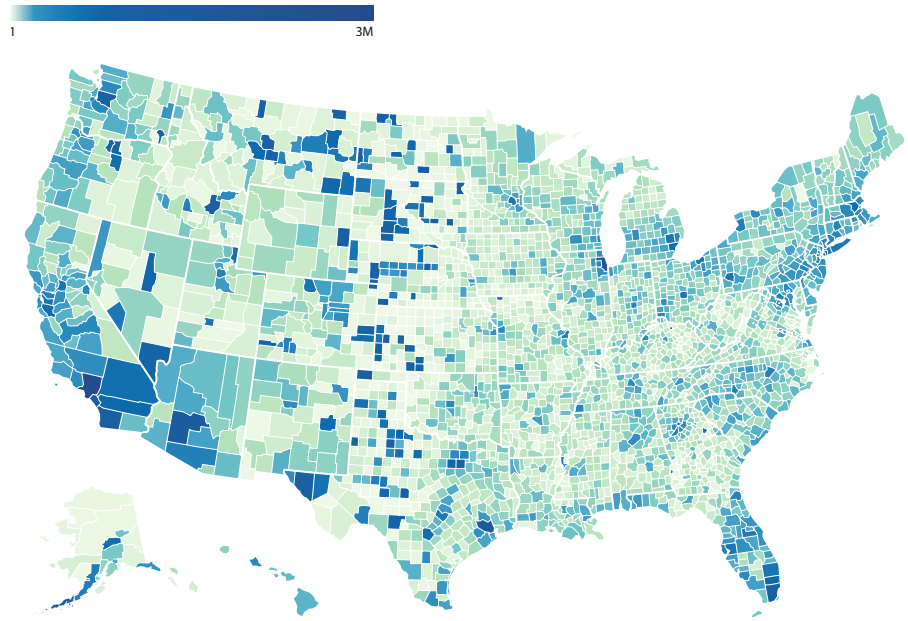
Furthermore, it is important to note that electrification is far superior from a cost-benefit standpoint to deploying Energy Star-rated fossil fuel appliances, which would prevent ever achieving zero emissions and which have a 10-times higher cost per unit of emissions reduction.[11] Finally, many existing and inefficient electric resistance devices will be replaced through this program by electric heat pump equivalents using just a fraction of the electricity. Demand for electricity is expected to rise significantly in the coming years—most notably driven by the adoption of electric vehicles. In this way, appliance replacements can play a critical role in the clean electricity transition.

Beyond the emissions benefits, these investments in appliance electrification will help accelerate industrial scaling of appliance manufacturing, dropping their prices and reducing their upfront cost—and the cost of future rebates. If domestic manufacturers do the manufacturing in the United States, there will be further economic multiplier effects.

Moreover, these investments will also disproportionately benefit LMI households. Of the 65 million homes that would immediately save on their energy bills today if they took advantage of these rebates, 36 million of those households—more than 50 percent—are LMI. Moreover, these households are distributed across the country, as seen in Figure 5 and Figure 6. Importantly, many are located in rural communities, which often face disproportionate energy burden challenges.[12]

FIGURE 5

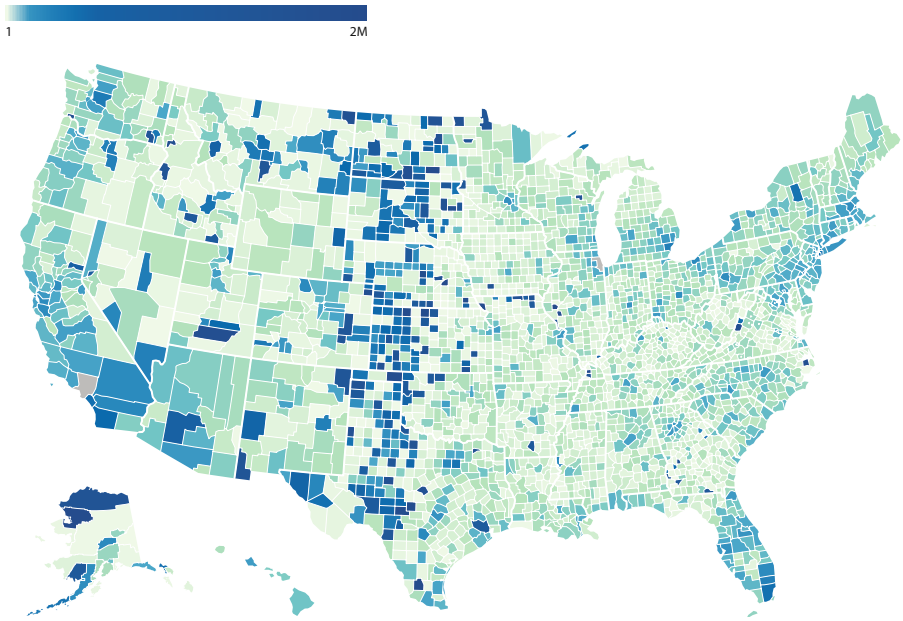
Distribution of the 65 million U.S. households using electric resistance, fuel oil, or propane as the main space-heating or water-heating fuel, by county



Source: Analysis based on a Rewiring America model of rebate program uptake and rebate program costs, April 2021, on file with author.

FIGURE 6

Distribution of the 35 million low-to-moderate income U.S. households using electric resistance, fuel oil, or propane as the main space-heating or water-heating fuel, by county



Precedent for electric appliance incentives

Consumer incentives for electric appliance replacements are a tried and tested method. Since 2018, the Sacramento Municipal Utility District (SMUD) has offered a sophisticated electric appliance mail-in rebate program, which for residential units includes heat pump space heaters, heat pump water heaters, and induction cooktops/ranges.[13] For heating, ventilation, and air conditioning replacement, SMUD offers a rebate for replacing one existing electric system with an upgraded one, and the credit quadruples for switching from a gas-powered system.[14] The program also offers rebates for commercial electric equipment.[15] Although the program is relatively new, SMUD has effectively gotten the attention of developers, builders, and homeowners in the service area and continues to push on consumer and contractor education.

Other appliance programs include the following:

- Efficiency Maine is an independent energy efficiency administrator that offers a sizable rebate for Energy Star-certified heat pump water heaters in an exceptionally cold-climate U.S. state.[16]

- NYS Clean Heat, New York state's nation-leading building electrification program, is jointly administered by the investor-owned utilities and the New York State Research and Development Authority. NYS Clean Heat is planning to invest nearly $700 million to develop the market and drive customer adoption of efficient building electrification solutions and train the workforce required for this transformation.[17]

- Massachusetts Clean Energy Center offers incentives for air-source heat pumps installed in new residential homes and existing homes served by natural gas with incentive tiers scaled by income, type of building, and appliance unit size.[18]

Many state, local, and utility appliance rebate programs were created or expanded by the $300 million State Energy-Efficient Appliance Rebate Program (SEEARP) created under the American Recovery and Reinvestment Act of 2009—the first national appliance rebate program for residential consumers.[19] The program ultimately did not last long enough or provide sufficient funds to effect broad electric appliance uptake. However, SEEARP did see varying levels of success by grantees, and it provides a good model for assessing federal incentivizing of subnational electrification programs.

Recommendations: Further action in the sector

Consumer incentives are one part of a comprehensive federal electrification strategy for buildings that will require policies for new builds; support for state and local action; utility bill affordability policies to ease the energy burden on already financially burdened households; and policies to overcome cases where the benefits of lower-cost utility bills are split between landlord and tenant. This section outlines a list of complementary policies targeting households, business owners, contractors, and appliance installers to achieve a clean, cost-effective future for America's homes designed to overcome major existing costs and consumer behavioral barriers.

Commercial, MUSH, and multifamily buildings. Policymakers should consider a parallel rebate program for serving larger buildings with centralized, higher-load appliances such as those that service commercial buildings; municipal, university, schools, and hospital (MUSH) buildings; and multifamily residential buildings with more than 20 units.[20] The rebates designed to service larger buildings can follow a similar structure to the one proposed in this report for households, but sized with different metrics such as scaling per square foot serviced.

Manufacturing incentives. Congress should consider a per-unit domestic production credit for the four aforementioned appliances—breaker boxes, heat pump space heaters, heat pump water heaters, and induction cooktops/ranges. The Natural Resources Defense Council and the American Council for an Energy-Efficient Economy recommend one such program.[21] This credit would in part pass further savings on to consumers at the point of purchase or installation and can be especially beneficial for commercial uptake.[22] It would also defray the costs of onshoring appliance manufacturing and provide industry with a reliable incentive to justify investments in new domestic manufacturing capacity. In addition, Congress should invest directly in new domestic manufacturing capacity through the successful Section 48C advanced manufacturing tax credit and the Title VII loan guarantee program at the Department of Energy.[23]

Weatherization assistance bundling. For LMI households, these new consumer rebates would be one of many programs available to improve their household energy use. Congress should provide funding to states through the Department of Energy's State Energy Program specifically to reach out to LMI households to bundle funding opportunities through the Weatherization Assistance Program (WAP); the U.S. Department of Health and Human Services Low Income Home Energy Assistance Program (LIHEAP), which funds up to 15 percent of federal funding available for weatherization; these new consumer rebates; and any other federal, state, or local programs that could benefit the household.[24] This level of education, outreach, and bundling will help households make the replacements proactively, sometimes with no upfront costs, alongside significant weatherization improvements.

Split incentive targeting program. For households who rent their homes where the landlord is responsible for decisions about appliance replacements, but the tenant is responsible for paying the energy bills, there can be obstacles to good decision-making when replacing an appliance. In this case, a landlord might forgo an appliance that costs more upfront, even though it would reduce the tenant's energy bills, or even choose an appliance that raises them. To tackle this split incentive problem, Congress should provide funding through the State Energy Program to identify the households affected and educate the landlords and tenants about available programs for purchase incentives and for ratepayer protection.

New build incentives. Congress should pass a tax credit for all-electric new builds—such as a revamped 45L credit, an energy-efficient home tax credit for developers[25]—including an additional incentive for gold-standard buildings that also have on-site solar, energy storage, a high degree of building envelope insulation, and either a level 2 electric vehicle charger or proximity to high-frequency transit. An even greater incentive should be offered for affordable housing for LMI families that meets these same additional specifications.

Funding to subnationals. In understanding that states, localities, and tribes in the United States have led the way in decarbonization policymaking and that building types and ownership structures vary greatly among states and regions in the country, the federal government should create incentives for states to continue pursuing building electrification outside of the implementation of federally designed programs and instead designed for local circumstances. This should include funding subnational efforts for planning, consumer outreach and education, contractor training, and codes/standards development.

Support for contractors and labor. Funding and programmatic support for contractor and installer training and apprenticeship will be critical for enabling the success of the program proposed in this report, both in terms of uptake and ensuring many new, quality jobs. Incentives for high labor standards and unionization tied to electrification incentive programs such as this one will also be central to this end.

Greater support for existing programs. Existing programs for household energy efficiency improvements are already available and should be given greater support. Congress should fund programs that can ensure affordability and provide customer protection, especially for lower-income and more energy-burdened households, including increasing funding to LIHEAP and raising the income eligibility cap to better serve LMI households. Funding should go to both program activities as well as increased administrative capacity to handle an increase in service. In addition, Congress should increase funding and expand eligibility for low-income families through WAP and U.S. Department of Housing and Urban Development multifamily energy efficiency programs. Both WAP and LIHEAP guidance also need to be amended to prioritize fuel switching and support systemwide solutions in addition to paying bills. Any program that promotes fossil fuel-powered appliances—even highly efficient models—should be reconsidered. Electrification is one way to improve efficiency but is not supported well enough by existing programs, which is why the new rebates proposed in this paper are needed in addition to efficiency-focused policies. Relatedly, the federal government should reinstate the Energy Efficiency and Conservation Block Grant Program with clear electrification eligibility.

Public and affordable housing electrification. Congress should pass the Green New Deal for Public Housing and also enact funding for subsidized affordable housing supported by State Housing Finance Agencies.[26] Any federal government funding going into housing or building projects should prioritize electric and efficient builds.

Financing for consumers. Even with incentives, many consumers will need better access to financing for these critical electric appliances and associated home retrofits. Congress should advance programs that create cost-effective, flexible financing, including by promoting on-bill financing through utilities and subsidizing interest rates for these kinds of loans, as well as aligning with the Clean Energy and Sustainability Accelerator, a national green bank that is under consideration by Congress.[27]

Federal procurement. The federal government, with its tremendous buying power, should directly ensure that all federal buildings are outfitted with heat pump electric space heaters and water heaters. Additionally, the federal government should promote the use of similar purchasing power at buildings that are directly or indirectly federally funded, including public housing agencies. This could aid in sending market signals for these technologies and spur the flywheel of commercial scaling.

Clean electricity. As the buildings sector increasingly electrifies, Congress must ensure the grid becomes cleaner and smarter by using, for example, a combination of tax incentives and a clean electricity standard.[28]

As household machines are installed or replaced, clean electric alternatives must become the default replacement option, and that starts with ensuring that they are the most practical and affordable in every case. The central policy idea in this report is integral to such an approach, but it will require a mix of federal policies and public education efforts that would more specifically target the broad range of different building types, building ownership structures, and resident income levels that exist across the country.

Conclusion

Building retrofits must be a major pillar of any federal infrastructure strategy. The development and redevelopment of the country's building stock has been guided by national policy directly or indirectly for more than a century, and President Biden's American Jobs Plan proposes visionary investments in affordable, accessible, energy-efficient, resilient, and increasingly electrified housing. As the country moves on from the last century's aging, centralized, emissions-intensive energy infrastructure, it is time to think about the grid-connected appliances and distributed energy resources of U.S. homes as a core part of a modern, democratized energy system.

The benefits of building electrification are numerous. Electrification will improve indoor air quality for everyone, but especially low-income communities and communities of color suffering from cumulative effects of pollutants and higher levels of pollution from older, less efficient gas appliances.[29] Electrification policy should be designed to prioritize those communities, which bear the largest burdens of energy-related pollution, by engaging environmental justice advocates and frontline and fence-line communities.

Moreover, electrification has massive potential to spur employment at a time when sustained economic recovery is crucial. The jobs associated with the installation of these appliances and breaker boxes are local, high-wage jobs that will not be automated or outsourced. It is important to note that these jobs—and the manufacturing jobs that will be created to build these machines—are not in zero-sum competition with existing jobs for natural gas distribution utilities. The residential building stock transition is inherently slow, and there are still decades of work to maintain the health and safety of the natural gas pipeline distribution system, even as additional people find work electrifying the housing stock.

As part of a strategy to reach net-zero greenhouse gas emissions economywide by 2050, CAP and Rewiring America recommend an ambitious household electrification incentive program. This is a critical component of ensuring the 100 percent uptake of efficient, electric appliances in the U.S. housing stock—a precondition to limiting warming to 1.5 degrees Celsius.

Methodology

The analysis of program costs and impacts is based on an uptake model for the proposed rebates. This model assumes the majority of uptake occurs through end-of-life replacement of the appliances covered by the rebate program—space heaters, water heaters, stoves, and breaker boxes—using average lifetimes from the National Renewable Energy Laboratory's National Residential Efficiency Measures Database.[30] Using sales data—for example, from the Air-Conditioning, Heating, and Refrigeration Institute; the Northwest Energy Efficiency Alliance; and the Residential Energy Consumption Survey (RECS)—the current rate of adoption at appliance end of life is estimated and used as the starting point for a Bass diffusion model of technology adoption. For the proposed rebates, this adoption is projected to grow in accordance with the diffusion curve, for which we choose three scenarios: low, medium, and high uptake. These three scenarios correspond respectively with 5 percent, 10 percent, and 20 percent of U.S. households taking advantage of components of the program during the 10-year window. In addition to end-of-life replacement, a small portion—approximately 5 percent—of voluntary early replacements are included, reflecting historical trends in early appliance replacement from the Cash for Clunkers program.[31] Household that meet LMI standards, according to the U.S. Department of Housing and Urban Development,[32] or living in cold climates[33] are estimated to participate in proportion to their percentage of the general population. Hardware costs for modern electrical appliances are expected to fall modestly during the program rollout, using a conservative learning rate of 15 percent. Emissions impacts are calculated assuming President Biden's clean electricity plan[34] and current consumption from RECS 2015.[35] Jobs impacts are calculated based on marginal spend introduced into the economy and converted using multipliers from IMPLAN. The co-occurrence of appliances within households is estimated by assuming uniform and independent probability distributions.

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