WORKFORCE REPORT

Electrification that works

Jobs for a clean and healthy future

AUTHORS

Alexandria Herr

Wael Kanj

Cora Wyent

EXTERNAL REVIEWERS

Alec Goodwin,
Cornell Climate Jobs Institute

Heidi Peltier, PhD

Mitchell Schirch,
BW Research Partnership

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REWIRING AMERICA

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Executive summary

Building electrification will transform our economy — from how we heat our homes, to how we drive, to what is required of our electric grid. This transformation will include an expansion of our workforce of electricians, manufacturing workers, construction workers, and more, each trained in the electrification-related skills needed to achieve a fossil fuel-free future. Electrification of the nation's building stock thus represents a once-in-a-generation opportunity: not only to curb planet-heating emissions and protect our shared climate, but for a historic jobs boom that can generate pathways to community wealth and economic development.

The Inflation Reduction Act of 2022 made unprecedented investments in the clean energy economy and stimulated growth in clean energy jobs nationally, but further investment in electrification is needed to capture the full benefits of electrification and keep pace with our climate goals.

This report aims to quantify the potential jobs growth that would arise from investing in electrifying the U.S. housing stock at the scale and pace needed to achieve net zero emissions by 2050.

EXECUTIVE SUMMARY

We begin by introducing the concept of an "electrification workforce" — the diverse set of occupations needed to convert the energy use in our buildings and transportation systems from fossil fuel to renewable electricity. Second, we model the employment effects of scaling residential electrification at the rate necessary to meet national climate goals. The findings from this report include:

1.1M

New jobs produced directly from widespread **residential** electrification

In 2035, widespread **residential** electrification would directly produce over **1.1 million new jobs** and would have an overall employment effect of **over 3 million new jobs.**[1] These employment effects are a representation of the opportunity for job creation if electrification were occuring at a pace that meets U.S. climate goals. This potential increase in jobs represents the **electrification opportunity economy.**

To realize this boom in electrified jobs, we need more federal, state, and local support in three areas:

1. Lowering the cost of electrification.
2. Increasing the supply of affordable, electrified housing.
3. Labor provisions to ensure high-road, family-sustaining job pathways.

Photo by Kamryn Harris

In this analysis, **we argue that the 'electrification workforce' is an under-explored and emerging sector of the clean energy transition that we must begin to track.** The direct job growth in the electrification workforce primarily represents an increase in jobs for plumbers, HVAC workers, home energy auditors, and electricians who install heat pump water heaters, heat pumps, weatherization, and solar and electric panels.

Defining the electrification workforce

Electrifying our economy at the rate necessary to keep pace with our climate goals and maintain a safe and habitable climate will generate millions of jobs in communities across the country. Building a well-trained, well-paid electrification workforce is critical to addressing the 42 percent of U.S. energy-related emissions that come from household energy consumption and household vehicles. These jobs — from manufacturing and distributing electric alternatives to fossil fuel appliances, to installation, to expanding our electric grid — comprise an emerging sector of the clean energy economy which has been previously under-explored: the electrification workforce. Along with supportive policies, this historic energy transition can become an engine that benefits workers and communities, while expanding affordable housing and protecting our shared climate.

Photo by Kamryn Harris

ELECTRIFICATION WORKFORCE

The Inflation Reduction Act of 2022 made historic investments in the clean energy economy, stimulating growth in clean energy and electrification jobs — in 2023 alone, 142,000 new clean energy jobs were added to the American economy, growing at a rate double that of the U.S. economy overall.[2] The IRA tax credits for residential energy spurred the installation of over a quarter of a million new heat pumps, a significant advancement of electrification goals.[3] But that was just a down payment. Further investment is needed in order to fully electrify the U.S. housing stock, creating the potential for future job growth in this sector.

Efforts to track the growing clean economy workforce have historically focused on jobs in the renewable energy or energy efficiency sectors.[4,5] While both of these sectors overlap with building electrification, we seek to define the electrification workforce as a group of workers who are pivotal to building a fossil fuel-free future for American households through weatherization and the adoption of electric technologies, including heat pumps, heat pump water heaters, EV chargers, rooftop solar, and more. While previous attention has been given to electricians in particular,[6] electricians represent but one of the many types of workers who constitute what we define as the electrification workforce. In all, the electrification workforce represents a diverse range of occupations and skill sets who fill important roles throughout the electrification process (Table 1). In this report, we focus in particular on the residential sector; however, significant numbers of electrification jobs will also be created in the commercial sector.

Photo by Adobe Stock

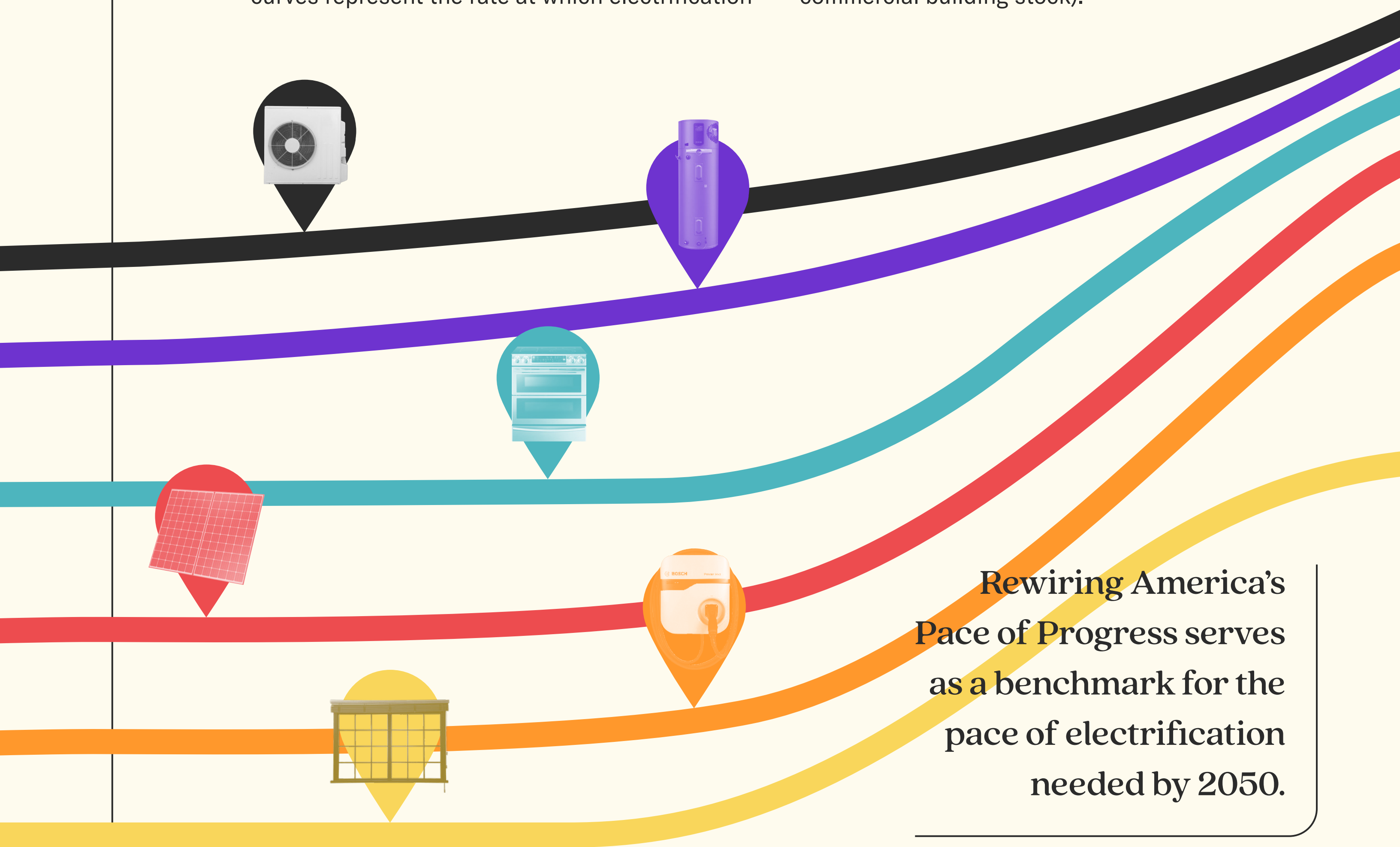
TABLE 1

Mapping the electrification workforce through the equipment supply chain

Manufacturing	Distribution	Installation	Building performance	Utility workers
Manufacturing of heat pumps, heat pump water heaters, solar panels, and electric stoves.	Supply chain sales and transportation of heat pumps, heat pump water heaters, and solar panels from manufacturer to installer.	Installation of heat pumps, heat pump water heaters, EV chargers, rooftop solar panels, panel and circuit upgrades.	Weatherization and whole-home evaluation.	Construction and maintenance of the electric grid.
				
OCCUPATIONS • Manufacturing workers (semi-conductor, HVAC manufacturing)	**OCCUPATIONS** • Retail • Warehouse • Wholesale • Trucking • Distribution workers	**OCCUPATIONS** • Electricians • Plumbers • HVAC workers	**OCCUPATIONS** • Energy auditors • Community navigators • Construction workers	**OCCUPATIONS** • Utility-scale construction • Transmission and distribution workers • Utility-scale electricians

2035 jobs analysis: The next decade of residential electrification

This analysis considers the future of the electrification workforce over the next decade, and the potential labor impacts of retrofitting the national housing stock and building zero-emission new buildings at the pace necessary to meet our national climate goal to achieve net zero emissions by 2050.[7] Here, we consider the potential labor effects of residential retrofits specifically, including both single-family and multifamily residential buildings and mobile homes, using household adoption curves for various electrification retrofits.[8] These curves represent the rate at which electrification retrofits need to occur in the residential sector in order to achieve a carbon-free housing stock by 2050,[9] assuming households upgrade their existing equipment at end of life. Rewiring America calls this scenario the Pace of Progress, which functions as a benchmark for the pace of electrification needed to achieve a net-zero economy by 2050. **This analysis evaluates the resultant labor impacts under a scenario in which electrification proceeds at a pace that is necessary to meet our climate goals in the residential sector** (and not including our commercial building stock).

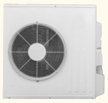


Rewiring America's Pace of Progress serves as a benchmark for the pace of electrification needed by 2050.

Methods

For the purposes of this analysis, we consider technology-specific adoption curves from the Pace of Progress scenario for a set of appliance and equipment retrofits,[10] including:

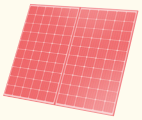
1. **Heat pumps for heating and cooling (HVAC)**



2. **Heat pump water heaters**

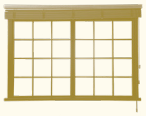
3. **Induction stoves**

4. **Rooftop solar**



5. **Electrical upgrades (including electric vehicle chargers, panel and circuit upgrades)**

6. **Weatherization**



For each of these retrofits, we consider manufacturing and installation costs. We also consider the effects of changes in electricity and gas demand associated with electrification upgrades on power generation, fuel production, transmission, and distribution.

To estimate labor impacts related to electrification retrofits, we model the annual incremental investment required for each year from 2025 to 2035 using upfront equipment and installation costs for each of six electric technologies. We calculate incremental upfront costs by taking the difference in cost between an electric upgrade and a fossil fuel like-for-like replacement to account for fossil fuel equipment installers converting to installation of electric appliances (e.g., the current HVAC workforce installing heat pumps). We then derive annual unit sales for each technology from our Pace of Progress model, a stock turnover model that assumes that households replace their current equipment at end of life. The Pace of Progress models an increasing fraction of sales shifting to electric technologies between now and 2035, which then translates into a fully electric stock by 2050. For each technology, we multiply the incremental upfront cost by the Pace of Progress annual unit sales,[11,12] to generate an incremental investment amount for each given year (for graphs of investment by year, see Appendix A). We then use IMPLAN, an Input-Output economic modeling software, to generate employment effects associated with adoption of these appliances (Appendix B).[13] This methodology is based in part on modeling conducted by Jones et. al. in their 2019 report on building decarbonization in California.[14]

In order to estimate labor impacts related to changing energy use associated with electrification retrofits, we first calculate the total change in energy consumption for both methane gas and electricity for the U.S. housing stock under a whole-home electrification scenario, based on modeled energy savings from the National Renewable Energy Laboratory (NREL)'s ResStock dataset.[15] In order to scale this change to the proportion of total homes electrified in our Pace of Progress scenario, we use the percentage of homes upgraded with a heat pump (following the Pace of Progress HVAC adoption curve)[16] as an annual scaling factor for the overall change in energy consumption, because heating and cooling comprise the majority of household energy consumption. This gives us the annual change in energy consumption for gas and electricity under a Pace of Progress scenario. We then multiply this annual change in electricity and gas usage by the county-average utility prices for households in each county to find the overall market size of the change in electricity and gas sales[17] (Appendix A).

Household energy use is largely heating and cooling.

We separate this overall incremental investment in increased electricity and decreased gas sales into generation/procurement, transmission and distribution, and public purpose charges and bond charges for each[18] (Appendix A). We further classify electric generation investment by source (solar, wind, and other) using Cambium's mid-case 95 percent decarbonization by 2050 scenario to find relative uses of energy source in a given year.[19] Finally, we input these investment values into IMPLAN to calculate the resulting jobs associated with this change in electricity and gas sales (Appendix B). Investments by sector are shown in Appendix A, Figures A1-A3.

Results

Projected direct employment in the electrification workforce and net overall employment (total net direct, indirect, and induced jobs) is shown in Table 2. **Note that these numbers are not a projection of job creation under current policy and market conditions, but rather a representation of the potential for job creation if electrification were to occur at a pace that meets our climate goals.** One important assumption to note is that since the Pace of Progress uses 2020 as a baseline, job projections for 2025-2035 assume that electrification has been occurring at the rate required by the Pace of Progress since 2020, and thus does not take into account the additional electrification needed to make up for the gap between the actual pace of electrification and the Pace of Progress scenario between 2020 and 2025.

The largest share of jobs is produced in installation of electric appliances, which accounts for over 890,000 direct jobs, or 78 percent of the overall net direct employment generated in 2035. These jobs correspond to the skilled trade workers needed to install and maintain heat pumps, heat pump water heaters, electric and solar panels, and other electric upgrades. These occupations include electricians, HVAC workers, and plumbers. A breakdown of installation jobs by technology is shown in Figure 1. Rooftop solar comprises the largest share of installation-related jobs, closely followed by heat pump installation and weatherization, in part due to the high upfront investment required for rooftop solar installation (Appendix A).

The second-largest share of jobs is in manufacturing and supply chain employment, which comprises over 275,000 direct jobs in 2035, or 24 percent of the overall net direct employment generated in 2035. These occupations include wholesale and retail jobs, semiconductor manufacturing, and heating equipment and air conditioning manufacturing, with wholesale, retail, and semiconductor manufacturing making up the majority of the jobs increase (Figure 3).

The largest share of jobs is produced in installation of electric appliances, which accounts for **over 890,000 direct jobs,** or 78 percent of the overall net direct employment generated in 2035.

890,000 + Direct jobs

TABLE 2

Employment by sector

		YEAR		
		2025	2030	2035
	Net overall employment	1,223,586	3,014,593	3,036,639
	Net direct employment	423,734	1,056,171	1,134,043
DIRECT	Installation employment	348,348	856,421	890,257
DIRECT	Manufacturing and supply chain employment	77,457	214,692	275,727
DIRECT	Methane gas employment	-2,509	-16,366	-34,631
DIRECT	Electricity employment	438	1,424	2,690

In 2035, there is a projected decrease in jobs related to methane gas due to decreased demand from residential gas use, and an increase in electricity employment due to increased residential electricity demand (Table 2). While there is some projected increase in employment related to the electric grid due to increased residential electricity use, the largest increases are in jobs generated due to installation, manufacturing, and supply chain activities. The decrease in methane gas jobs represents three percent of the overall net direct jobs produced from electrification in 2035. Building a high-road electrification transition pathway requires understanding the needs of workers who might be affected or displaced by a phase out of residential gas usage and ensuring opportunities for re-employment that do not come at the expense of job quality. In the second section of this report, to be released in 2025, we will discuss transition considerations for displaced gas workers and how to build pathways to re-employment in electrification-related sectors.

Photo by Kamryn Harris

FIGURE 1

Direct installation jobs by year and by technology resulting from electrification at the pace required to meet our climate goals.[20]

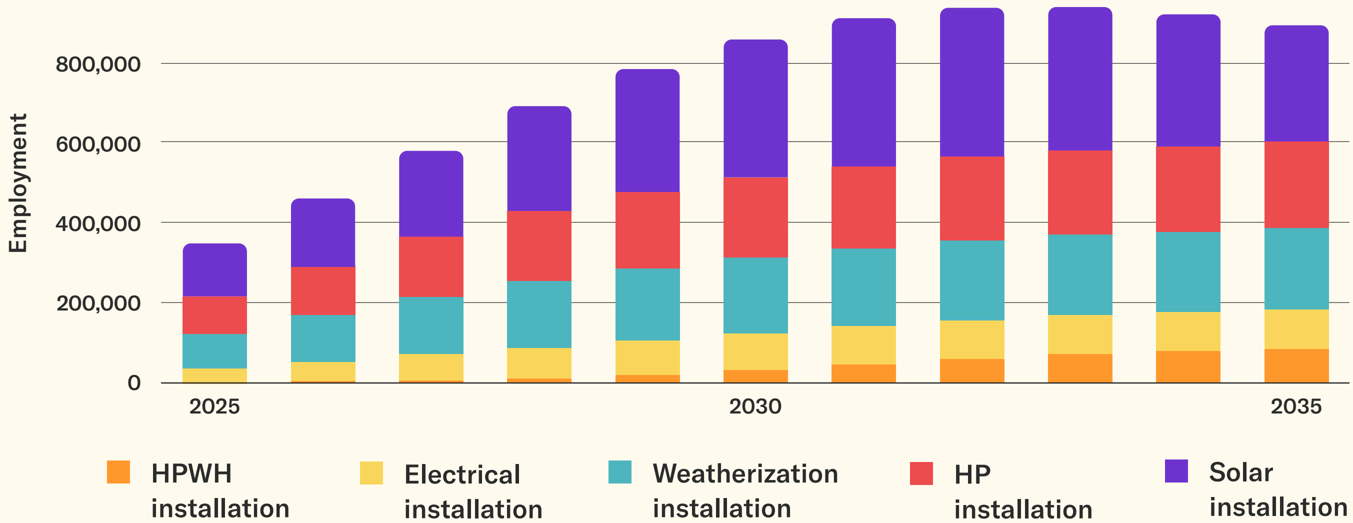


FIGURE 2

Direct manufacturing and supply chain jobs by year and by technology resulting from electrification at the pace required to meet our climate goals.

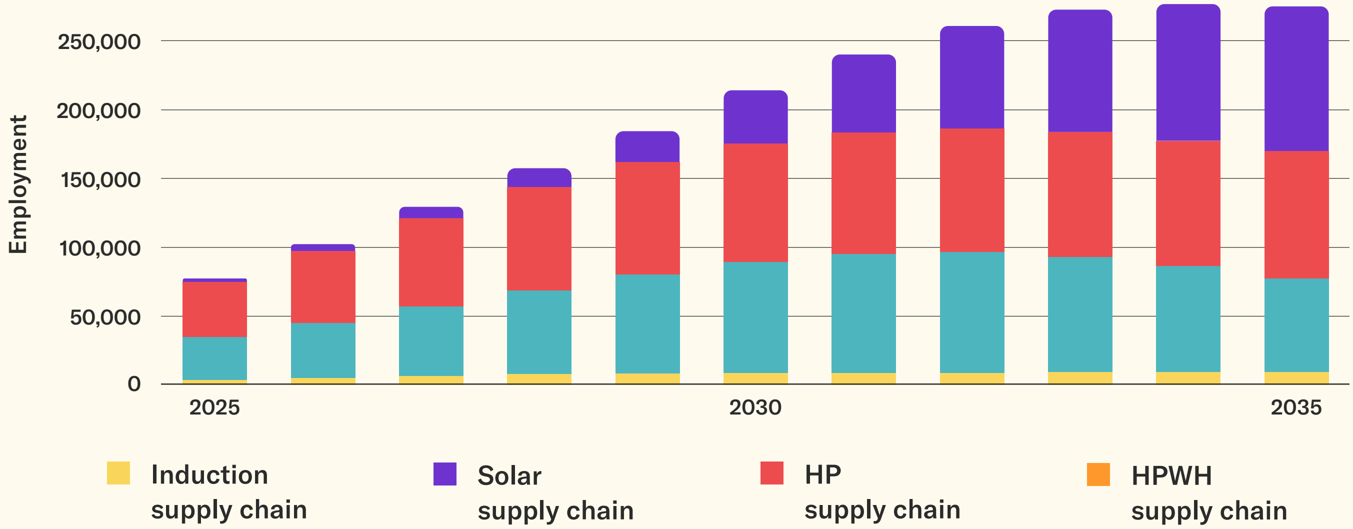
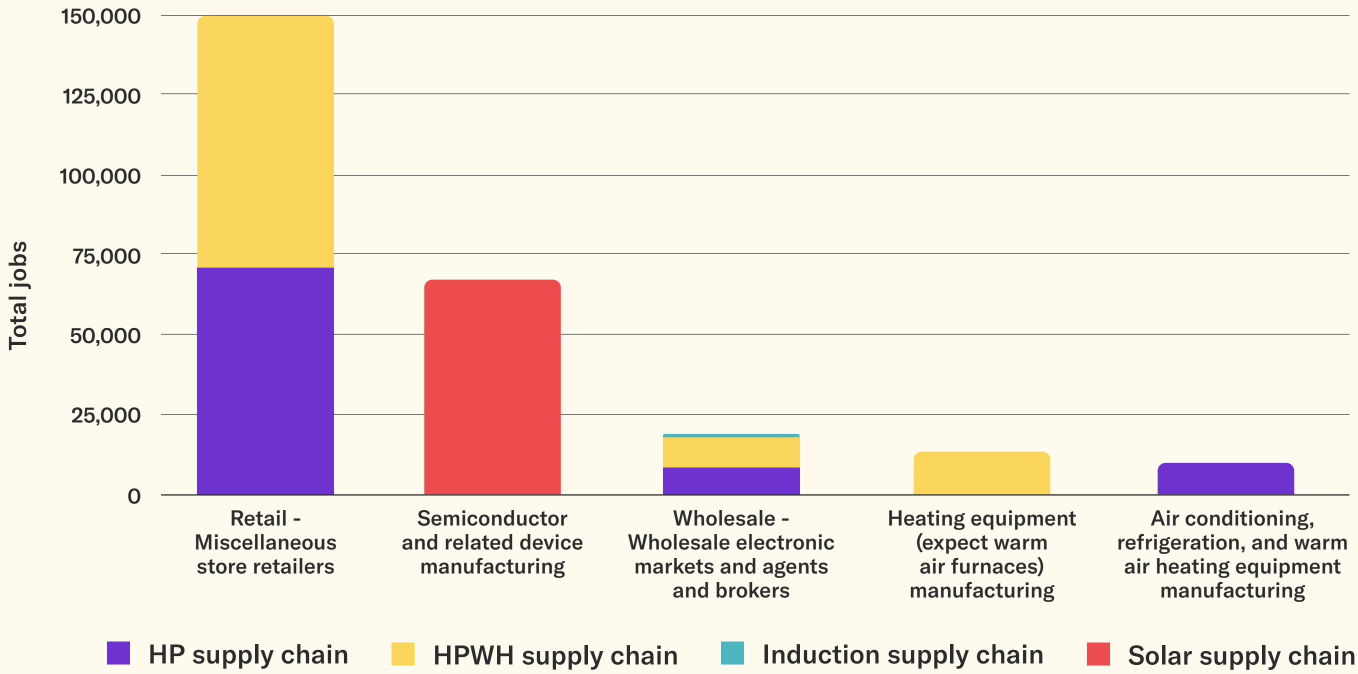


FIGURE 3

Industry breakdown of direct jobs associated with manufacturing and supply chain employment in 2035.



2035 JOBS ANALYSIS

An expansion of the electrification workforce by 1.1 million net direct jobs would represent a significant increase in the number of workers currently employed in these industries. One benchmark for the relative size of this increase in workers is the United States Energy & Employment Report (USEER) categorization of energy efficiency jobs, a category that includes the manufacturing, distribution, maintenance, and installation of non-fossil fuel energy efficiency technologies, such as HVAC and insulation, and has a significant overlap with the category of electrification workers that we define in this report.[21,22] The USEER found that there were 2.3 million energy efficiency jobs in 2023, with a growth of over 74,000 jobs from 2022 to 2023.[23] 1.1 million net direct jobs would then represent an almost fifty percent increase in today's workforce of energy efficiency workers.

For the 890,257 net direct installation jobs that would be generated in 2035 for installation of solar, heat pump water heaters, heat pumps, electric panel and circuit upgrades, and weatherization, a helpful point of comparison is to look at the current size of the occupations most commonly involved in these installations, namely electricians and HVAC workers. As of 2023, there were 441,000 HVAC workers[24] and 780,000 electricians[25] nationally. Of the increase in installation jobs, 214,000 would be heat pump installation, representing a fifty percent increase in the existing HVAC workforce, and 98,000 would be electric installation (not including solar installers), representing a twelve percent increase in the existing workforce of electricians.

50%

increase in today's workforce of **HVAC workers**

Photos by Kamryn Harris

Conclusion: Investing in our electric future

Residential building electrification presents an opportunity for a transformation of our housing stock that will help address climate change and improve public health while generating over 1.1 million direct jobs in the installation, distribution, and manufacturing of electric technologies. This includes heat pumps, heat pump water heaters, weatherization, solar panels, EV chargers, and more. We recommend three investment pathways at the federal, state, and local levels in order to realize the opportunity economy of electrification:

Investment in electrification

Further public investment is needed to make it easier and more affordable to produce, buy, install and operate electric appliances in our homes and to power them with clean electricity. At the federal level, IRA tax credits have already helped 3.4 million households pursue home energy upgrades in 2023 alone,[26] and further resources will be available to households for home electrification through the Home Energy Rebates program. But this is just a down payment on the jobs boom that will be achieved when every American household is all electric.

Tax incentives need to be refundable, transferable, and accessible to more people, including builders, rental property owners, and as part of multifamily retrofits. Federal, state, and local rebates and grant programs need to be expanded in size and technology scope.

Investment in communities

The severe shortage of affordable housing must be addressed directly with additional funding and financing dedicated to expanding our housing stock. To deliver on the promise of the electrification workforce and further improve the affordability of these homes, these future investments should support all-electric homes including rooftop- or community-solar and storage to lower the cost of heating, cooling, and cooking. To further lower costs and ensure safety, additional funding and financing should also be provided to support comprehensive home retrofits of affordable homes, including weatherization and remediation to eliminate mold and other unhealthy living conditions.

Investment in high-road jobs

The potential for job growth in the clean energy economy represents a historic opportunity for American workers, and must be bolstered by policies that ensure these jobs are well-paid, family-sustaining, and accompanied by abundant and accessible training pathways to build a diverse workforce. Building high-road labor standards in the residential electrification sector is crucial to realizing the benefits of the electrification economy, including quality installation and bill savings, economic development for communities, and avoiding labor shortages. The second half of this report, to be published in early 2025, will examine barriers to high-road electrification in the residential labor market of today and propose recommendations for strengthening job quality and investing in the training pipeline for electrification workers.

Specific recommendations to advance electrification goals and stimulate the growth of electrification jobs will be published in our federal electrification policy roadmap in late 2024.

Appendix A

Fossil fuel upfront costs

Our national fossil fuel cost estimates for heat pumps and heat pump water heaters were taken from the U.S. EIA Buildings Sector Appliance and Equipment Costs and Efficiencies Report.[27] The table of fossil fuel costs is shown in Table 1. To estimate the overall fossil fuel costs of a gas system compared to a heat pump, we added the cost of a gas-fired furnace to the cost of central AC, since heat pumps provide both heating and cooling. To find the national cost of central AC, we used an average of the cost estimates of residential central AC for North and South (Table 1). Gas stove costs were estimated using appliance prices available online.[28] We omit replacements for oil or propane heat, as we assume the costs of upgrading oil or propane heat appliances would be similar to upgrading gas appliances.

TABLE A1

Fossil fuel appliance costs

EIA fossil fuel costs	Installation	Equipment	Total
EIA gas-fired furnace, typical, 2022, (rest of country)	$2,930	$1,200	$4,130
Residential central AC, typical, 2022, (North)	$2,620	$2,700	$5,320
Residential central AC, typical, 2022, (South)	$2,540	$2,850	$5,390
Central AC, typical, 2022, (average North and South)	$2,580	$2,775	$5,355
Gas-fired furnace and AC, 2022 (aggregate)	$5,510	$3,975	$9,485
EIA residential gas fired storage water heaters, typical, 2022 (National)	$700	$900	$1,690

Electric upfront costs

Our methodology for estimating upfront costs of solar, heat pump, heat pump water heater, induction stove, insulation, and panel and wiring upgrades, are all derived from the upfront cost methodology underlying our Personal Electrification Planner.[29] For further details, please see our upfront costs report.[30] We do not include regional or geographic variation in upfront costs and do not assume any change in upfront costs because of learning related to cheaper and more efficient installation over time.

TABLE A2

Electric upfront costs

Technology	Total cost
Heat pump HVAC	$17,300
Heat pump water heater	$4,200
Solar panel installation	$24,800

TABLE A3

Insulation costs

Insulation upgrade	Cost per square foot
Attic floor insulation	$2.49
Air sealing	$.47
Duct sealing	$.87
Total insulation package	$3.44

Insulation costs

We assumed the average insulation package will include attic floor insulation, air sealing, and duct sealing. We did not include drill and fill wall insulation in the average insulation package. The cost of this package is detailed in Table 3. The average cost per square foot for each measure is derived from the LBNL report titled Cost of Decarbonization and Energy Upgrade Retrofits for U.S. Homes.[31]

We then multiplied these total costs by the percentage of households nationally that are in need of weatherization (60 percent) to derive overall costs for weatherization.[32]

Electrical work costs

We bundled circuit upgrades for stoves, water heating, and EV chargers together with panel upgrades for average total "electrical work" cost (Table 4). In order to do this, we applied the following equation:

$$C = ((WH + I + EV) \times Cc) + (P \times Cp)$$

Where C represents the average total electric work cost, WH is the fraction of homes needing a circuit upgrade for a water heater, I is the fraction of homes needing a circuit upgrade for an induction range, EV is the fraction of homes needing a circuit upgrade for an EV charger, Cc is the cost of a circuit upgrade, P is the fraction of homes needing a panel upgrade, and Cp is the cost of a panel upgrade.

We assumed that the fraction of households in need of a circuit upgrade for water heating is equivalent to the fraction of households currently using fossil fuel water heating, and that the fraction of households in need of a circuit upgrade for their stoves is equivalent to the fraction of households currently using fossil fuels for cooking.

TABLE A4

Electrical work costs

Electric upgrade	Variable	Value	Source
Panel upgrade	Cp	$2,900	Panel upgrade costs were derived from TECH Clean California data by finding the difference in project cost between projects that required a panel and those that did not[33]
Circuit upgrade	Cc	$1,300	Circuit upgrade costs were derived from TECH Clean California data by finding the difference in project cost between projects that required a circuit upgrade and those that did not[34]
Percent of homes upgrading to Level 2 EV charger	EV	60%	60 percent of Level 1 chargers say they will upgrade to a Level 2 EV charger at home[35]
Percent of homes needing induction circuit	I	38.5%	2020 EIA Residential Energy Consumption Survey[36]
Percent of homes needing water heating circuit	WH	53.7%	2020 EIA Residential Energy Consumption Survey[37]
Percent of homes needing panel upgrade	P	20%	2022 EPRI Survey[38]
Average total cost	C	$2,627.19	

Electrical upfront cost ratios

In order to separate the appliance and installation costs, we applied appliance-to-labor ratios to the overall upfront cost of the electric upgrade. These ratios and their methodology are explained more in depth in Table 5.

TABLE A5

Upfront cost ratios

Technology	Ratio (appliance:labor)	Methology
Heat pump HVAC	1:2	We looked at the appliance-only cost of heat pumps and compared it to the overall project cost of heat pump installation to find an approximate appliance to labor ratio.
Heat pump water heater	1:1	We looked at the appliance only-cost of heat pump water heaters and compared it to the overall project cost of heat pump installation to find an approximate appliance to labor ratio.
Induction stove	1:0	We assume the project costs here are all appliance-related as the labor aspect of circuit upgrades is bundled into our cost assumptions around electrical work.
Weatherization	0:1	We assume the project costs of weatherization are entirely related to labor and assume that material costs are minimal.
Electrical work (panel up-grade, circuits, EV charger)	0:1	We assume the project costs of electrical work are entirely related to labor and assume that material costs are minimal, assuming that most EV owners will use chargers that can plug into an existing 240V outlet.
Solar	1:1	We looked at the appliance/installation cost breakdown for the model market price of residential PV systems documented by NREL's 2023 Solar PV System and Energy Storage Cost Benchmark report[39]; We considered all soft costs to be labor costs, and all inverter, module, EBOS and SBOS costs to be "appliance" costs.

Incremental costs

We then subtracted fossil fuel costs from electric costs for both the installation and the appliance to determine the incremental cost. We used the incremental cost rather than the electric cost alone to reflect our assumption that fossil fuel installers will "convert" to installation of electric appliances (gas furnace and AC installers will begin installing heat pumps, etc). For weatherization, wiring, and rooftop solar, there is no fossil fuel alternative; these are simply upgrades added to a home to make it more efficient or prepare the home for other electrification measures, so we assume the fossil fuel cost to be $0.

TABLE A6

Fossil, electric, and incremental costs

Retrofit	Component	Electrical cost	Fossil fuel cost	Incremental cost
Heat pump water heater	Installation	$2,111	$700	$1,411
	Appliance	$2,111	$990	$1,121
Induction stove	Installation	$0	$0	$0
	Appliance	$1,300	$700	$600
Weatherization	Installation	$5,796	$0	$5,796
	Appliance	$0	$0	$0
Rooftop solar	Installation	$12,393	$0	$12,393
	Appliance	$12,393	$0	$12,393
Heat pump	Installation	$11,591	$5,510	$6,081
	Appliance	$5,709	$3,975	$1,734
Electrical work (panel upgrade, circuits, EV charger)	Installation	$2,627	$0	$2,627
	Appliance	$0	$0	$0

Annual unit sales

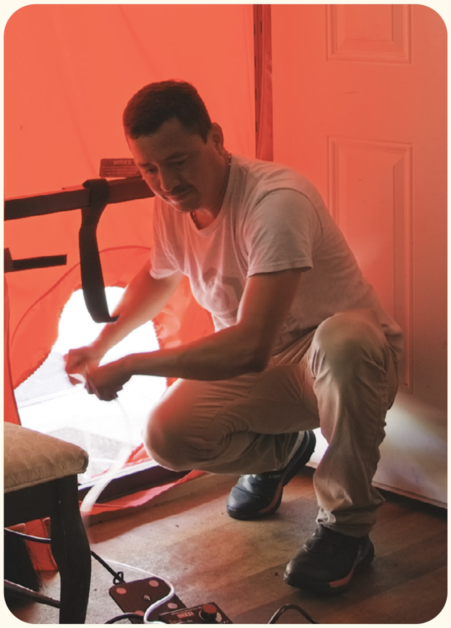
Annual unit sales by technology for solar panels, heat pump water heaters, and induction stoves, are derived from our national Pace of Progress report[40,41].

We assumed that weatherization is done at the time of heat pump installation, and therefore that weatherization upgrades track the heat pump Pace of Progress curve.

We assumed that all electrical wiring will be done at the time of EV purchase, as this is when households might consider rewiring to facilitate EV charging from a 240-volt circuit. To get the household "unit sales" for electrical upgrades, we divided the EV annual unit sales[42] by the average number of cars per household (1.7).

Electricity and gas prices

To calculate the market size of changes in electricity and gas sales, we calculated the annual changes in gas and electricity energy use under full national upgrades to heat pump water heaters and air-source heat pumps with weatherization. We then multiplied those changes in energy by the county-average utility prices, calculated using data from EIA, NREL's Utility Rate Database, and the American Gas Association, for households in each county.



Photos by Kamryn Harris

Electricity and gas component breakdown

To break down the market size of electricity and gas sales into generation, procurement, transmission, distribution, and other charges, we used the percent breakdown calculated by Jones et. al. (2019) based on revenue requirements and rate components for California Utilities[43] (Table 7). Being that these are currently derived from California utilities, in future analyses we may revise these breakdowns to reflect rates from other states.

TABLE A7

Component breakdown of electricity and gas sales[44]

Fuel	Component	Percent[45]
Gas	Procurement	26%
	Transmission, distribution, storage	67%
	Public purpose charge	7%
Electric	Generation	45%
	Distribution	36%
	Transmission	12%
	Public purpose charge	5%
	DWR and bond charges	3%

Market sizes

These market sizes for electric retrofits and gas and electric sales are the annual investment amount input into IMPLAN (Figures A1-A4).

FIGURE A1

Annual market size for installation, broken out by category.

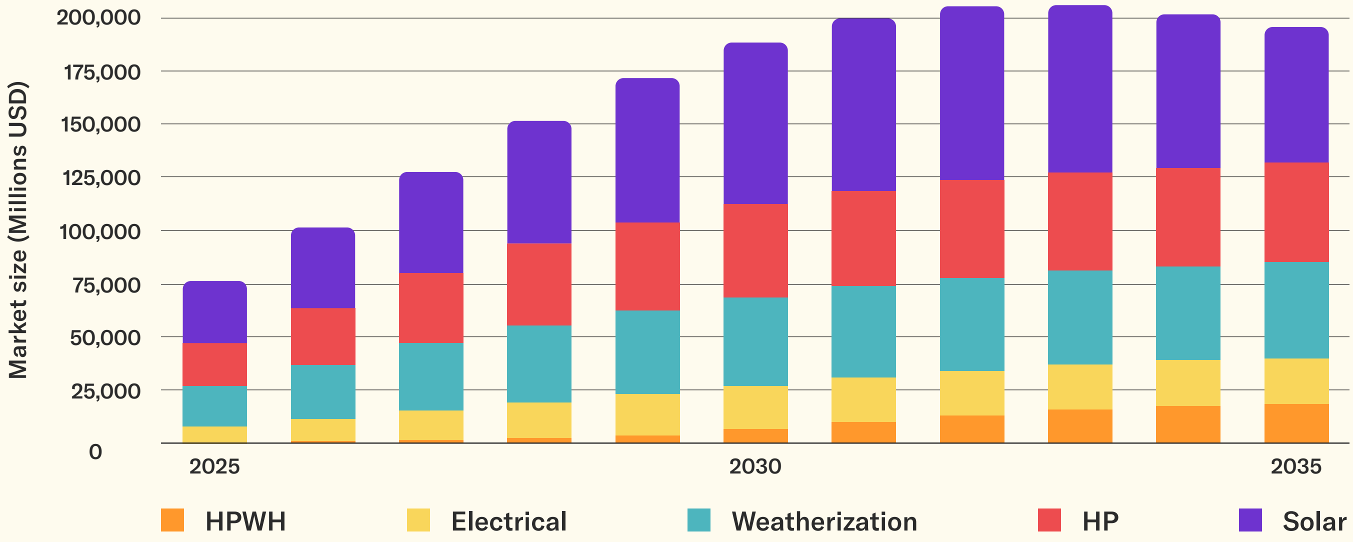
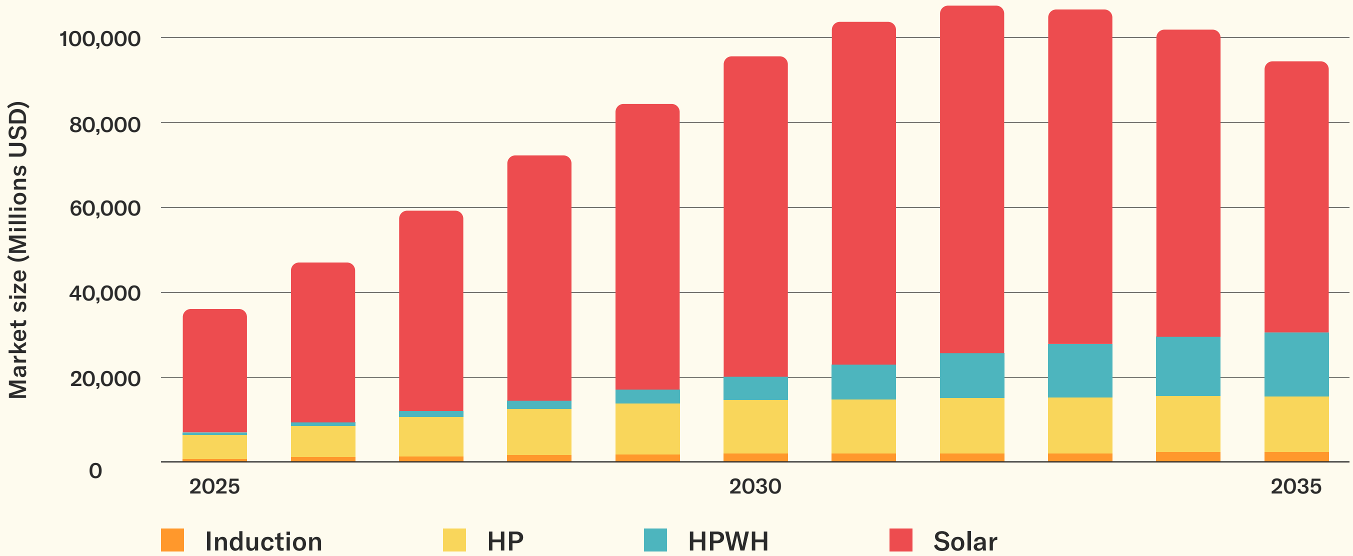


FIGURE A2

Annual market size for appliances, broken out by category.



MARKET SIZES

FIGURE A3

Annual market size for electricity, broken out by category.

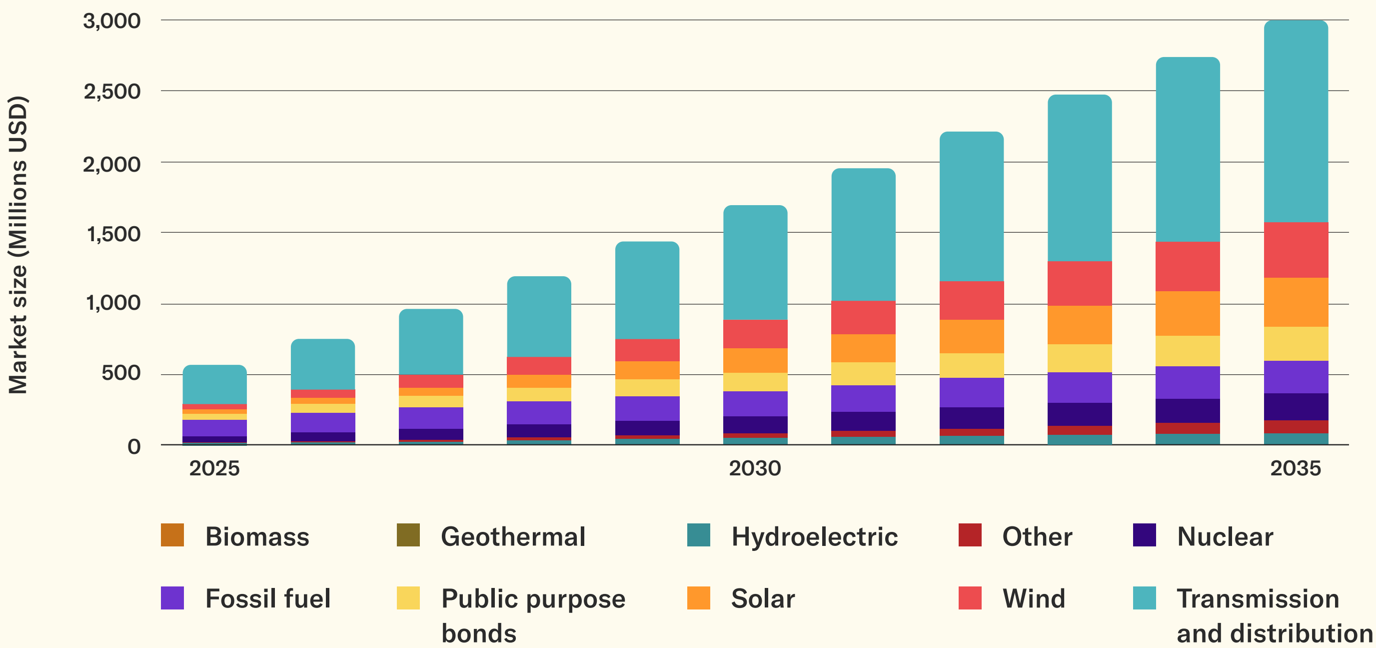
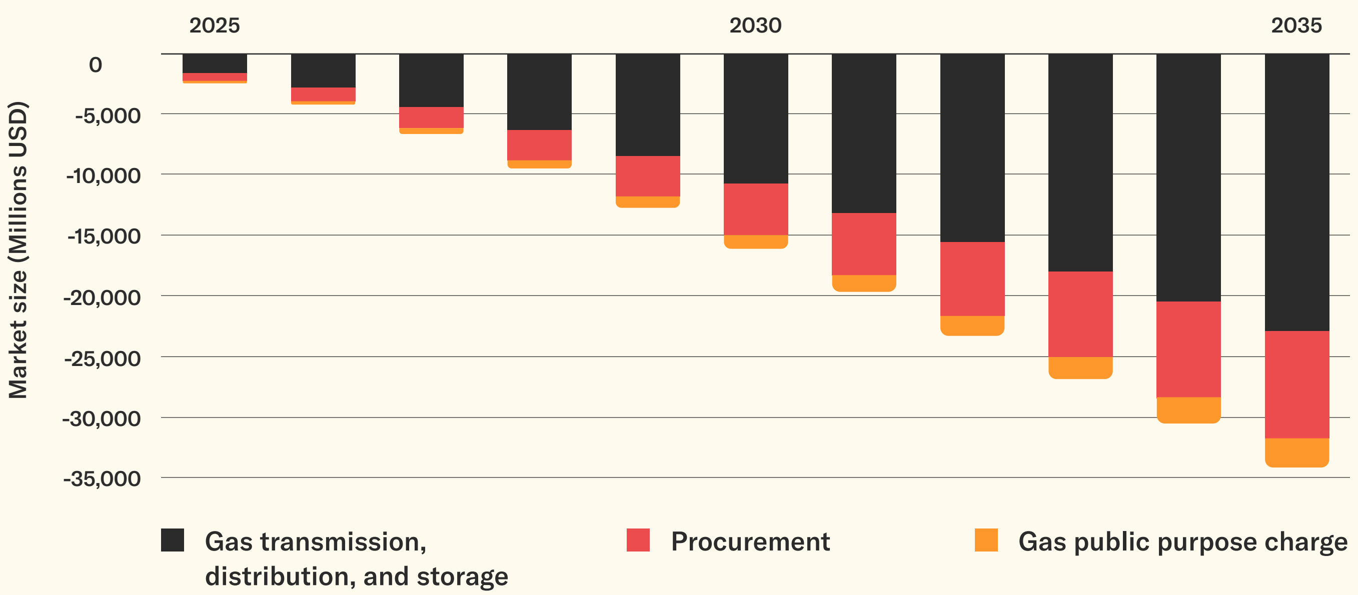


FIGURE A4

Annual market size for methane gas, broken out by category.



Appendix B

TABLE B1

IMPLAN inputs

Category	Sub category	IMPLAN industry	IMPLAN type
Electrification installation	Heat pump HVAC installation	61 – Maintenance and repair construction of residential structures	Industry output
	HPWH installation		
	Solar installation		
	Weatherization		
	Electric work		
Electric appliance manufacturing	Heat pump HVAC	3275 – Air conditioning, refrigeration, and warm air heating equipment	Commodity output[46]
	HPWH	3274 – Heating equipment (except warm air furnaces)	
	Induction stove	3325 – Household cooking appliances	
	Solar panel	3307 – Semiconductor and related devices	

TABLE B1 CONTINUED

Category	Sub category	IMPLAN industry	IMPLAN type
Electricity	Hydroelectric	39 – Electric power generation: Hydroelectric	Commodity output
	Fossil fuel	40 – Electric power generation: Fossil fuel	
	Nuclear	41 – Electric power generation: Nuclear	
	Solar	42 – Electric power generation: Solar	
	Wind	43 – Electric power generation: Wind	
	Geothermal	44 – Electric power generation: Geothermal	
	Biomass	45 – Electric power generation: Biomass	
	All other	46 – Electric power generation: All other	
	Electric power transmission and distribution	47 – Electric power transmission and distribution	
	Public purpose programs, bonds	533 – Local government electric utilities	
Natural Gas	Procurement	20 – Oil and gas extraction	
	Transmission, distribution, storage	48 – Natural gas distribution	
	Public purpose charge	534 – Other local government enterprises	

END NOTES

1 1.1 million new jobs is the net direct employment effect. Direct employment is considered employment produced directly from an investment in electrification. The overall employment effect includes direct, indirect, and induced jobs. Indirect employment is employment produced along the supply chain as a result of the initial investment, and induced employment is employment produced from household spending that occurs as a result of the initial investment.

2 U.S. Department of Energy 2024. United States Energy & Employment Report 2024. https://www.energy.gov/sites/default/files/2024-08/2024%20USEER%20FINAL.pdf

3 IRS, 2024. SOI Tax Stats – Clean Energy Tax Credit Statistics. https://www.irs.gov/statistics/soi-tax-stats-clean-energy-tax-credit-statistics

4 Muro, M., Tomer, A., Shivaram, R., and Kane, J. 2019. Advancing Inclusion Through Clean Energy Jobs. Brookings Institute. https://www.brookings.edu/research/advancing-inclusion-through-clean-energy-jobs/

5 U.S. Department of Energy 2024. United States Energy & Employment Report 2024. https://www.energy.gov/sites/default/files/2024-08/2024%20USEER%20FINAL.pdf

6 Owen, D. 2023. The Great Electrician Shortage. *The New Yorker.* https://www.newyorker.com/news/dept-of-energy/the-great-electrician-shortage

7 The White House, 2021. President Biden's Historic Climate Agenda. https://www.whitehouse.gov/climate/

8 For the purposes of this analysis, we consider "residential" to mean anything included in NREL's ResStock database. This analysis does not include commercial buildings from NREL's ComStock database. For more details, please see: National Renewable Energy Laboratory, Frequently Asked Questions about Public Datasets. https://resstock.nrel.gov/page/faq

9 Rewiring America, 2023. Pace of Progress. https://www.rewiringamerica.org/pace

10 Rewiring America, 2023. Pace of Progress Methodology. https://assets.ctfassets.net/v4qx5q5o44nj/CgpvjO5MtG3E7uBbiroIt/d153ea482b40fe3eeb2a1a47a0b94401/Pace_of_Progress_Methodology.pdf

11 We do this in order to reflect our assumption that installers of gas appliances will "convert" to electric installation. See Appendix A for further details.

END NOTES

12 For the purposes of this analysis, we assume that current import and domestic supply rates for equipment manufacturing will remain static into the future.

13 IMPLAN is an economic modeling software used to model how economic events impact different parts of the economy. For further information, see IMPLAN, 2023. For more information, see: How IMPLAN Works. https://support.implan.com/hc/en-us/articles/360038285254-How-IMPLAN-Works

14 Jones, B. Karpman, J., Chelbnikow, M., and Goggans, A. 2019. California Building Decarbonization Workforce Needs and Recommendations. https://innovation.luskin.ucla.edu/wp-content/uploads/2019/11/California_Building_Decarbonization.pdf

15 Assuming a medium-efficiency heat pump and insulation upgrade for each household. For more details on this methodology, please see Rewiring America's Personal Electrification Planner Methodology https://homes.rewiringamerica.org/data-methodology

16 For more details on our Pace of Progress adoption curves, please see: Rewiring America, 2023. Pace of Progress Methodology. https://assets.ctfassets.net/v4qx5q5o44nj/Cgpvj05MtG3E7uBbiroIt/d153ea482b40fe3eeb2a1a47a0b94401/Pace_of_Progress_Methodology.pdf

17 Using data from EIA, NREL's Utility Rate Database, and the American Gas Association for households in each county.

18 For this, we use the percentage breakdowns of utility rates described in table 35 and 37 of Jones, B. Karpman, J., Chelbnikow, M., and Goggans, A. 2019. California Building Decarbonization Workforce Needs and Recommendations. https://innovation.luskin.ucla.edu/wp-content/uploads/2019/11/California_Building_Decarbonization.pdf (see further details in Appendix A)

19 Gagnon, P., Cowiestoll, B., Schwarz, M., 2023. Cambium 2022 Scenario Descriptions and Documentation. NREL, https://www.nrel.gov/docs/fy23osti/84916.pdf

20 HPWH indicates Heat Pump Water Heater, and HP indicates Heat Pumps.

21 U.S. Department of Energy 2024. United States Energy & Employment Report 2024. https://www.energy.gov/sites/default/files/2024-08/2024%20USEER%20FINAL.pdf

22 Both the electrification jobs category defined here and the USEER energy efficiency category include the installation, distribution, and manufacturing of heat pumps, heat pump water heaters, and weatherization. The electrification jobs category additionally includes the installation, distribution, and manufacturing of solar panels and electric panel and circuit upgrades. The USEER energy efficiency category additionally includes other energy efficient upgrades that we do not include in the electrification category, including lighting and advanced building materials. Our analysis considers only residential buildings, while the USEER considers energy efficiency across all building categories.

23 Ibid.

24 Bureau of Labor Statistics, 2024. Heating, Air Conditioning, and Refrigeration Mechanics and Installers. https://www.bls.gov/ooh/installation-maintenance-and-repair/heating-air-conditioning-and-refrigeration-mechanics-and-installers.htm

25 Bureau of Labor Statistics, 2024. Electricians. https://www.bls.gov/ooh/construction-and-extraction/electricians.htm

26 U.S. Department of the Treasury, 2024. American consumer energy savings under Inflation Reduction Act, https://home.treasury.gov/news/press-releases/jy2521

27 U.S. Energy Information Administration, 2023. Updated Buildings Sector Appliance and Equipment Costs and Efficiencies. https://www.eia.gov/analysis/studies/buildings/equipcosts/pdf/full.pdf

28 Rewiring America, Personal Electrification Planner Methodology. https://homes.rewiringamerica.org/data-methodology

29 Ibid.

30 Rewiring America, Upfront cost of home electrification. https://www.rewiringamerica.org/electrification-cost-estimates

31 Walker, I., Less, B., Casquero-Modrego, N., 2021. The Cost of Decarbonization and Energy Upgrade Retrofits for US Homes. Lawrence Berkeley National Laboratory. https://escholarship.org/content/qt0818n68p/qt0818n68p.pdf

32 Webster, B., Satre-Meloy, A., Badger, L., Donovan, A., Lane, D., McGrath, K., Wilson, E., Reyna, J., Metzger, C., Pilet, T., Campbell M., Toffoli, L., 2024. Accelerating Residential Building Decarbonization: Market Guidance to Scale Zero Carbon-Aligned Buildings. Advanced Building Construction https://advancedbuildingconstruction.org/market-guidance-report/#download

END NOTES

33 Rewiring America, Personal Electrification Planner Methodology. https://homes.rewiringamerica.org/data-methodology

34 Rewiring America, Personal Electrification Planner Methodology. https://homes.rewiringamerica.org/data-methodology

35 JD Power, 2023. 2023 U.S. Electric Vehicle Experience Home Charging Study. https://www.jdpower.com/business/press-releases/2023-us-electric-vehicle-experience-evx-home-charging-study

36 U.S. Energy Information Administration, 2023. 2020 Residential Energy Consumption Survey https://www.eia.gov/consumption/residential/

37 Ibid.

38 Electric Power Research Institute, 2023. U.S. Residential Electric Panels: How Many Need to be Upgraded? https://www.epri.com/research/programs/109396/results/3002026736

39 Ramasamy, V., Zuboy, J., Woodhouse, M., O'Shaughnessey, E., Feldman, D., Desai, J., Walker, A., Margolis, R., Basore P., 2023. U.S. Solar Photovoltaic System and Energy Storage Cost Benchmarks, With Minimum Sustainable Price Analysis: Q1 2023. National Renewable Energy Laboratory. https://www.nrel.gov/docs/fy23osti/87303.pdf

40 Rewiring America, 2023. Pace of Progress. https://www.rewiringamerica.org/pace

41 Rewiring America, 2023. Pace of Progress Methodology. https://assets.ctfassets.net/v4qx5q5o44nj/Cgpvj05MtG3E7uBbiroIt/d153ea482b40fe3eeb2a1a47a0b94401/Pace_of_Progress_Methodology.pdf

42 Rewiring America, 2023. Pace of Progress. https://www.rewiringamerica.org/pace

43 See Tables 35 and 37 in Jones, B. Karpman, J., Chlebnikow, M., and Goggans, A. 2019. California Building Decarbonization Workforce Needs and Recommendations. https://innovation.luskin.ucla.edu/wp-content/uploads/2019/11/California_Building_Decarbonization.pdf

44 Ibid.

45 For more information, see Table 35 and 37 (Ibid.)

END NOTES

46 For commodity outputs, we are using the default IMPLAN assumption that the local purchaser percentage (LPP) for marginable commodities is the Regional Purchase Coefficient (RPC) which reflects the amount of the demand for a product that is met by local production. We assume that equipment is purchased locally but may not be produced locally, and IMPLAN's default assumption that RPC is equivalent to RPC for marginable commodities means we are not assuming additional on-shoring or off-shoring of any supply chain jobs. For more information, see IMPLAN 2023, Setting Local Purchase Percentage. https://support.implan.com/hc/en-us/articles/360035289433-Setting-a-Local-Purchase-Percentage-LPP and IMPLAN, 2023, Industry vs. Commodity Output. https://support.implan.com/hc/en-us/articles/360043873833-Industry-vs-Commodity-Output

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