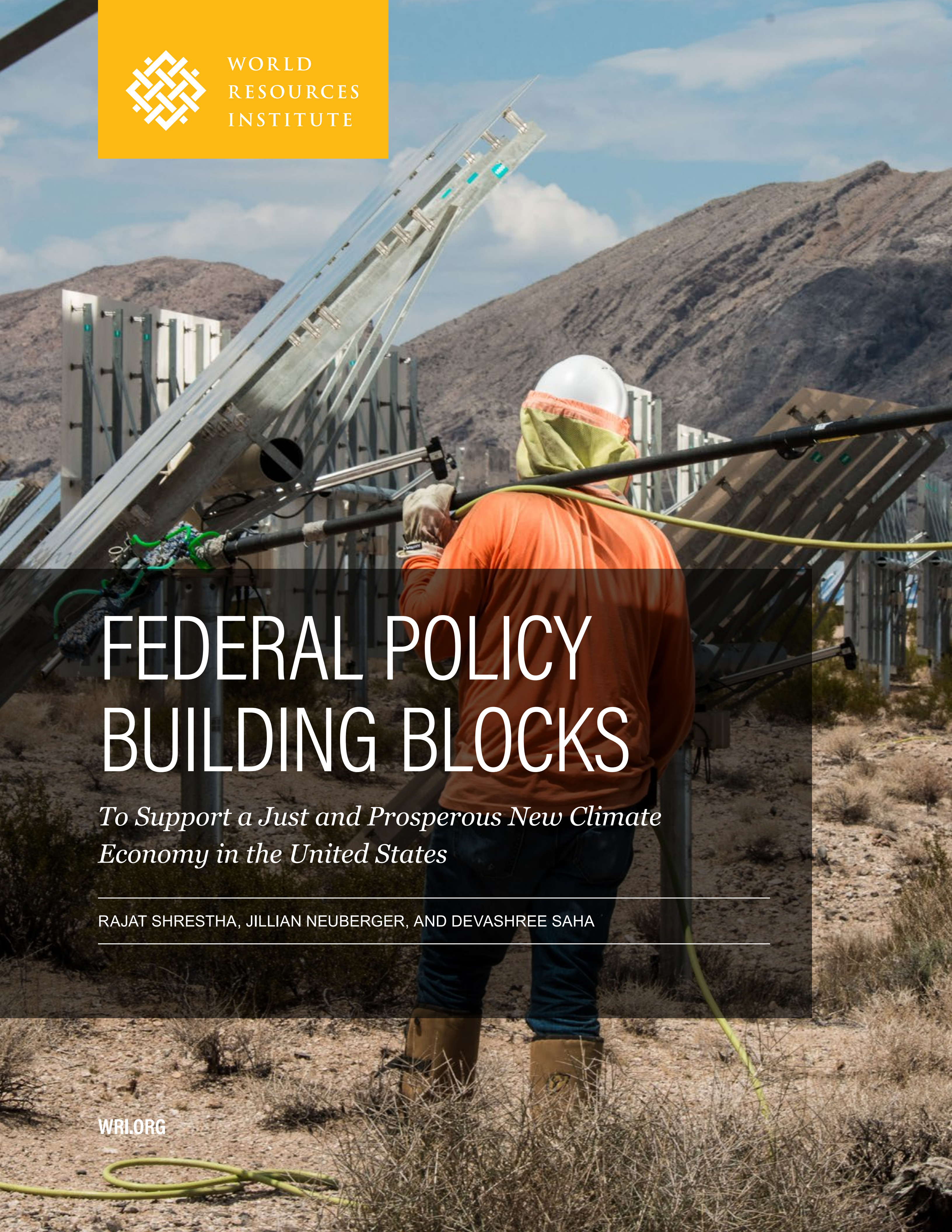


WORLD RESOURCES INSTITUTE

FEDERAL POLICY BUILDING BLOCKS

To Support a Just and Prosperous New Climate Economy in the United States

RAJAT SHRESTHA, JILLIAN NEUBERGER, AND DEVASHREE SAHA

ABOUT THE AUTHORS

Rajat Shrestha is a Research Analyst at WRI's Economics Center.

Contact: rajat.shrestha@wri.org

Jillian Neuberger is a Legislative Engagement Manager at WRI-US.

Contact: jillian.neuberger@wri.org

Devashree Saha is a Senior Associate at WRI.

Contact: devashree.saha@wri.org

Design and layout by:

Shannon Collins
shannon.collins@wri.org

Rosie Ettenheim
rosie.ettenheim@wri.org

ACKNOWLEDGMENTS

This report is premised upon modeling completed by BW Research. We wish to thank Philip Jordan, Mitchell Schirch, Julian Ugalde, and Abraham Gomez for their guidance, tireless work, thoughtful collaboration, and exceptional product.

In its early, foundational stages, this report benefited from perspectives and leadership offered by WRI colleagues who have since pursued new opportunities. We gratefully acknowledge contributions of Greg Carlock and Michelle Manion.

We would like to thank our external reviewers who have shared their expertise and insights: Kate Gordon, Trevor Higgins, Skip Laitner, Amanda Levin, Erin Mayfield, Robbie Orvis, Robert Pollin, Lindsey Walter, and Mike Williams.

Thanks also go to our WRI colleagues for providing valuable inputs and feedback: Juan-Carlos Altamirano, Lori Bird, Elizabeth Bridgwater, Christina Deconcini, John Feldmann, Sue Gander, Joel Jaeger, Kevin Kennedy, Dan Lashof, Haley Leslie-Bole, Carlos Muñoz-Piña, Sujata Rajpurohit, Carla Walker, and Debbie Weyl.

While the contributions from reviewers are greatly appreciated, the findings and recommendations presented in this report are those of the authors alone.

Finally, the authors would like to thank Laura Malaguzzi Valeri for her counsel, Renee Pineda of WRI's Research, Design, and Innovation Department for her insights, Romain Warnault for coordinating the production process, Shannon Collins and Rosie Ettenheim for design and layout, Alex Martin for copyediting, Matt Herbert for communications support and guidance, and Matthew Cronin and Ryan Whittemore for providing overall project support.

This project was made possible through the generous support of Breakthrough Energy, the Rockefeller Foundation, and the John D. and Catherine T. MacArthur Foundation.

TABLE OF CONTENTS

FOREWORD

Since the Industrial Revolution, the economic growth of the United States has primarily been built on decades of greenhouse gas emissions. These emissions are responsible for many of the climate change impacts we are seeing every day. From water insecurity and wildfires to flooding and air pollution, fossil fuel–powered growth has resulted in inequitable and deadly consequences—in the United States and around the world. All the while, American consumers and communities remain dependent on volatile, global fossil fuel markets and climate-driven global instability. Climate action is the only alternative to the fossil fuel status quo, with the clean energy transition promising more high-quality jobs, greater resilience to global shocks, and a safer future for all.

Despite significant progress in the transition toward mass adoption of renewable energy and electric vehicles (EVs) over the last decade, there is still work to be done. Reaching net-zero emissions by 2050 will require a complete transformation of the U.S. energy economy. The United States still needs to scale up the deployment of existing clean energy technologies while accelerating the adoption of emerging clean technologies.

If done right, the challenge of transforming America's energy systems can unlock tremendous economic opportunities and social benefits for the country and its citizens. The expansion of renewable energy, energy efficiency improvements in buildings, EV manufacturing and charging infrastructure deployment, and green hydrogen production can create millions of high-quality jobs. These jobs span economic sectors and industries—including construction, manufacturing, wholesale trade, and professional services.

The benefits will not materialize on their own. The clean energy transition required to reach net-zero emissions by 2050 will be disruptive for many people, particularly in certain sectors and regions of the country. Job losses would be concentrated in regions dependent on fossil fuel–based industries, exacerbating economic hardships for workers and local communities dependent on those industries. Additionally, new jobs may not be in the same region or sector facing employment dislocation. Targeted government policies will be needed in key regions and communities that will be negatively impacted by the transition or are historically disadvantaged.

Ensuring a just and equitable energy transition requires fully understanding and addressing the impacts of labor dislocation. This report assesses economic impacts from federal policies, including clean energy tax credits, low-carbon infrastructure investments, and sector-based performance standards, across three mitigation scenarios, and further explores how the economic impacts of federal climate policies can be enhanced to build a prosperous and inclusive net-zero economy. This will not only increase public acceptance of the transition but also lead to sustainable and inclusive growth, now and into the future.

The recently passed Inflation Reduction Act has made a historic investment in climate action, making clean energy more affordable, incentivizing the creation of well-paying jobs through the domestic manufacturing of clean technologies, and directing investments to disadvantaged communities. While a huge step, the fight against the climate crisis is not over. Initiatives like President Joe Biden's Justice40 are more important than ever to ensure a just and equitable transition that garners widespread participation and support.

We have a narrow window of time to cut greenhouse gas emissions in half by 2030 and lay the groundwork for net-zero emissions by 2050. Decisions made by the federal government as well as states, local governments, and the private sector can further build on the momentum seen thus far and unlock significant economic opportunities for the country. This report provides policymakers a glimpse into how the decisions they make today will determine what kind of America we will see in the next decade.

Ani Dasgupta
President & CEO,
World Resources Institute

EXECUTIVE SUMMARY

Federal policies enabling the shift to a net-zero economy present tremendous economic opportunities, with the potential to create millions of new jobs and boost economic growth. However, the energy transition will also see different groups, communities, and regions impacted in different ways. Federal policies are required to ensure that the net-zero economy is inclusive, just, and equitable.

HIGHLIGHTS

- This report uses the Economic Impact Analysis for Planning (IMPLAN), an input-output framework, to estimate the impact of proposed federal climate mitigation policies on employment. The policies include tax incentives, infrastructure investments, targeted spending, and sector-based performance standards.
- The model compares a reference scenario (RS) with an extended tax credit (ETC) scenario, an advanced tax credit (ATC) scenario, and a net-zero (NZ) scenario. These scenarios lead to a 50, 63, and 100 percent reduction in net greenhouse gas (GHG) emissions (relative to 2005 levels) by 2050, respectively.
- Assuming new investment does not displace investment elsewhere in the economy, and employment does not fall with proposed wage increases, the model finds that all decarbonization scenarios would create more jobs by 2035 than the RS.
- Compared with the RS, the ETC and ATC scenarios would add 0.4 and 0.9 million net jobs, respectively, while the net-zero scenario could add 2.3 million net jobs. New clean energy jobs would be concentrated in construction in the building and electricity sectors.
- Some subsectors and regions would lose jobs, so geographically targeted investments and policies would be needed for equitable outcomes in all communities. Domestic content regulation could avoid sectoral losses and spur manufacturing, but its unintended effects need to be carefully monitored.

Context

Effective and immediate federal policies are needed to meet U.S. climate goals. The Biden administration has committed to reducing U.S. economy-wide GHG emissions by 50–52 percent below 2005 levels by 2030 and equitably achieving economy-wide net-zero GHG emissions by 2050 (White House 2021c). Near-term policies are needed to quickly and deeply reduce emissions this decade and set up the economy to eliminate or remove remaining emissions by midcentury. This will require a combination of different policy tools, such as spending on infrastructure, tax incentives, sector-based performance standards, economy-wide carbon pricing, and policies to enhance natural and working land sinks and deploy carbon-removal technologies.

Federal policies to enable the shift to a net-zero economy also present significant economic opportunities. Scaling up demand for low-carbon products and services can create jobs, spur economic activity, and enhance U.S. competitiveness in a rapidly growing global sector, particularly when paired with domestic manufacturing incentives. However, that does not mean a net-zero transition is without its challenges. As high-emissions industries see shrinking demand, there is risk of an unmanaged transition leaving behind workers and communities dependent on those industries. Federal policies are required to ensure this climate-smart growth builds inclusive and equitable economies at the local, regional, and national scale, while redressing current economic, racial, gendered, and geographic injustices.

About This Report

This report estimates the socioeconomic impact of federal climate policies under three mitigation scenarios (Figure ES-1). We explore how different combinations of policies, which increase in ambition across mitigation scenarios, can generate economy-wide benefits. Our analysis focuses on tax incentives, infrastructure investments, targeted spending, and sector-based performance standards, which form the building blocks for a successful decarbonization strategy—and many of which have been considered by policymakers in 2021 and 2022 and some of which have been enacted in the 2021 Bipartisan Infrastructure Law and the 2022 Inflation Reduction Act.[1] We compare the three mitigation scenarios to a reference or business-as-usual scenario. This report builds on an earlier WRI working paper, "Building Blocks for a Low-Carbon Economy: Catalytic Policy and Infrastructure for Decarbonizing the United States by 2050," which estimated GHG emissions reduction across key sectors of the U.S. economy under different federal policy and spending scenarios (Saha et al. 2021b).

Figure ES-1 | Description of mitigation scenarios*

<table>
<tr><th>Scenario</th><th>Reference Scenario (RS)</th><th>Extended Tax Credits (ETC) Scenario</th><th>Advanced Tax Credits (ATC) Scenario</th><th>Net-Zero (NZ) Scenario</th></tr>
<tr><td>Goal</td><td>Reflects existing federal policies, as well as binding state-level policies, to estimate emissions reduction in a business-as-usual scenario.</td><td>Reflects extension of existing tax credits and increase in federal spending on low-carbon infrastructure, with the goal of driving early adoption required to kick-start broader sector transformation.</td><td>Reflects extension of existing tax credits and federal spending on infrastructure from ETC scenario and layers in new tax credits for technologies for which tax credits do not currently apply. Goal is to drive broader adoption of technologies.</td><td>Layers on sector-specific performance standards and economy-wide net-zero emissions cap to demonstrate policy-driven, sector-level transformation required to achieve "net zero."</td></tr>
<tr><td rowspan="4">Policy Levers</td><td rowspan="2">Existing federal policies, including tax credits for renewable power and ZEVs, CAFE standards, and NSPS methane regulations.</td><td colspan="3">Low-carbon infrastructure spending, including for building sector energy-efficiency, weatherization, and electrification programs, deployment of electric vehicle charging station infrastructure, and grid modernization and transmission.</td></tr>
<tr><td colspan="3">Extended tax credits, including extending existing incentives for LDV ZEVs and renewable power.</td></tr>
<tr><td rowspan="2">Existing state-level policies, including state-level RPS and ZEV targets.</td><td rowspan="2"></td><td colspan="2">Advanced tax credits, including new tax credits for LDV and MHDV ZEVs, electric heat pumps, renewables, and firm zero-carbon resources.</td></tr>
<tr><td></td><td>Sector-specific performance standards, including a CES, and economy-wide net-zero emissions cap.</td></tr>
</table>

Notes: CAFE = Corporate Average Fuel Economy; CES = clean electricity standard; LDV = light-duty vehicle; MHDV = medium- and heavy-duty vehicle; NSPS = New Source Performance Standards; RPS = Renewable Portfolio Standard; ZEV = zero-emissions vehicle. *Policy assumptions for the different scenarios were decided in 2021, and several climate provisions included in the 2021 Bipartisan Infrastructure Law and 2022 Inflation Reduction Act are modeled in the mitigation scenarios. Please see Table 1 and Technical Appendices B–C in Saha et al. (2021b) for more details about individual policies included under each scenario.

Source: Saha et al. 2021b.

The report also explores how the economic impacts of federal climate policies can be enhanced to build a prosperous and inclusive net-zero economy. The generation of economy-wide benefits from a net-zero transition does not automatically guarantee that the transition will be equitable and just. Discussions in Congress, the Biden administration, and the policy community are focused on advancing the country toward not just a net-zero economy but an equitable net-zero economy that creates high-quality jobs for all communities and addresses job loss and economic downturns in communities and regions at risk of being left behind. Our analysis evaluates the extent to which the addition of different policy levers, specifically domestic content (domestic manufacturing) and family-sustaining wage requirements, can further shape the initial economic outcomes.

The socioeconomic impact analysis is conducted in a two-step process (Figure ES-2).[2] First, the impacts arising from federal policies and investments across the three mitigation scenarios are estimated for key sectors of the U.S. economy (base modeling) and are compared to the reference scenario. Second, we explore how two policy levers—domestic content requirement and family-sustaining wages as a proxy for prevailing wages, which have been promoted by the Biden administration and members of the broader policy community—affect socioeconomic outcomes (policy levers modeling).

Findings and Recommendations

Several key insights emerge from the modeling analysis:

Base model insights

- **Federal climate policies and investments, like those included in the Bipartisan Infrastructure Law and the Inflation Reduction Act, deliver an energy economy with positive net job impacts across all mitigation scenarios, with policies that set the United States on track to reach net-zero GHG emissions by midcentury, maximizing economic benefits.** The net-zero (NZ) scenario results in the greatest job impacts—a net increase of 6.5 million jobs[3] from 2020 to 2035 compared to a net increase of 4.2 million jobs in the reference scenario (RS). In other words, the NZ scenario creates an additional 2.3 million jobs by 2035, relative to the RS. The extended tax credit (ETC) and advanced tax credit (ATC) scenarios lead to an additional 0.4 and 0.9 million jobs by 2035, relative to the RS (Table ES-1).[4] The ATC scenario most closely resembles both the infrastructure investments as included in the Bipartisan Infrastructure Law and tax credits for clean technologies included in the Inflation Reduction Act.

Figure ES-2 | Overview of modeling architecture estimating socioeconomic impacts

Modeling Inputs from Building Blocks Study

- Cost estimates from WRI's Building Blocks analysis that represent potential investments required to support emissions reductions, clean energy deployment, and the adoption of different clean technologies in the three mitigation scenarios are used as modeling inputs.
- These cost estimates include
  - power sector fixed costs;
  - capital costs of building sector devices and equipment;
  - capital costs of vehicles and charging infrastructure;
  - capital costs of energy-efficiency improvements in industry sector;
  - fuel costs for biofuels, hydrogen, and fossil fuels; and
  - emissions abatement costs for industrial CCS applications, waste management, and agriculture and natural and working lands.

→

IMPLAN Analysis-by-Parts

The IMPLAN Analysis-by-Parts model uses spending data and IMPLAN multipliers to evaluate changes in economic activity across various industry or supply-chain categories for different modeled sectors.

Base Modeling

- Cost inputs for different sectors are translated into spending across IMPLAN industry categories according to supply chain assumptions.
- 2020 baseline employment levels for supply chain/industry categories are derived from 2020 USEER.
- This part of the analysis uses default IMPLAN parameters that reflect existing U.S. economy trends (e.g., model multiplies spending allocated to semiconductor manufacturing and power distribution and transformer manufacturing by 0.25, assuming 25% domestic manufacturing of solar panels and inverter components).
- IMPLAN industry spending patterns and multipliers are applied to spending inputs to estimate economic impacts (employment, labor income, GDP, tax revenue) in different sectors between 2020 and 2035 in five-year intervals for the three mitigation scenarios.

Policy Lever Modeling

Domestic content analysis

- The analysis estimates employment impacts generated by changing default domestic manufacturing assumptions.
- For the three mitigation scenarios, the analysis adjusts default domestic manufacturing assumptions to reflect different domestic manufacturing requirements for solar, wind, and alternative vehicles and for the buildings sector.
- Employment impacts under adjusted domestic manufacturing assumptions are then compared with impacts under default assumptions for each sector or subsector individually.

Family-sustaining wage analysis

- Following the framework of MIT's Living Wage Calculator, the analysis assumes $22/hour or above as a national-level family-sustaining wage.
- For the NZ scenario, this analysis estimates spending required to increase wages of workers earning below $22/hour to a wage of $22/hour and assesses the induced impacts generated by higher wages.

Notes: CCS = carbon capture and storage; GDP = gross domestic product; IMPLAN = Economic Impact Analysis for Planning; MIT = Massachusetts Institute of Technology; NZ = net-zero; USEER = U.S. Energy and Employment Report. Figure ES-2 provides a high-level overview of the study framework. For more details on modeling inputs, assumptions, and methodology, see Technical Appendix A.

Source: WRI authors and BW Research.

- **The largest jobs gains are seen in the buildings and electricity sectors.** Electrification and energy-efficiency improvements in the buildings sector add more than 4.6 million jobs in the NZ scenario, driven by growth in the nonresidential efficiency subsector, while the electricity sector adds 4.0 million net jobs between 2020 and 2035.[5] The NZ scenario creates 3.0 million and 1.1 million more jobs in the electricity and buildings sectors, respectively, compared to the RS.

- **Newly created energy jobs are concentrated in construction, and the majority are well paying, though additional policies are needed to ensure high job quality. Additionally, there is no notable change in workforce diversity without interventions to influence existing trends.** Of the 13.9 million direct and indirect jobs[6] in the NZ scenario in 2035, 5.0 million will be in construction. Based on the Massachusetts Institute of Technology's Living Wage Calculator for families with two adults (one employed full time) and one child, we define a wage of $22 an hour or above as a family-

Table ES-1 | Summary of employment impacts across sectors by scenario (base model), 2020 and 2035 (in thousands of jobs)

	2020	2035	CHANGE (2020-35)	2035	CHANGE (2020-35)	2035	CHANGE (2020-35)	2035	CHANGE (2020-35)
		Reference Scenario (RS)		ETC Scenario		ATC Scenario		NZ Scenario	
Electricity	**3,679**	**4,690**	**1,011**	**5,490**	**1,810**	**6,165**	**2,486**	**7,718**	**4,038**
Distributed solar PV	395	497	101	497	102	497	102	497	101
Utility solar	101	616	516	1,002	902	1,499	1,399	2,549	2,448
Offshore wind	0	108	108	108	108	108	108	111	111
Onshore wind	188	465	277	886	698	1,057	869	1,423	1,235
Other generation	183	183	0	183	0	183	0	183	0
Natural gas	334	496	162	465	131	448	113	495	160
*Coal***	182	0	-182	0	-182	0	-182	0	-182
*Nuclear***	307	293	-15	269	-39	272	-35	272	-35
Transmission and distribution	1,877	1,909	31	1,954	77	1,975	97	2,058	180
Storage	112	124	12	126	15	126	15	131	19
Buildings	**2,511**	**6,018**	**3,507**	**6,577**	**4,067**	**6,980**	**4,470**	**7,120**	**4,609**
Residential efficiency	1,173	1,989	816	2,510	1,338	1,957	784	1,741	568
Nonresidential efficiency	886	3,389	2,503	3,396	2,510,	3,365	2,479	3,353	2,467
Residential electrification	265	401	137	417	152	919	654	1,104	839
Nonresidential electrification	188	239	51	255	67	740	552	923	735
Transportation	**5,963**	**5,819**	**-145**	**5,109**	**-854**	**4,594**	**-1,369**	**4,000**	**-1,963**
Alternative vehicles	310	1,744	1,434	2,391	2,081	2,159	1,849	3,651	3,342
AV infrastructure	17	117	100	368	351	156	139	245	228
*ICE vehicles***	5,637	3,958	-1,679	2,351	-3,286	2,279	-3,358	104	-5,533
Fuels	**4,431**	**4,280**	**-151**	**3,788**	**-643**	**3,557**	**-874**	**3,225**	**-1,206**
Hydrogen	0	6	6	6	6	8	8	369	369
Biofuels	163	159	-4	232	70	334	171	418	255
*Fossil fuels***	4,268	4,115	-153	3,549	-719	3,214	-1,053	2,437	-1,830
Industry	**0**	**0**	**0**	**125**	**125**	**170**	**170**	**765**	**765**
Waste	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Technological carbon removal	**0**	**0**	**0**	**21**	**21**	**21**	**21**	**43**	**43**
Agriculture and natural and working lands	**0**	**0**	**0**	**89**	**89**	**190**	**190**	**190**	**190**

Table ES-1 | Summary of employment impacts across sectors by scenario (base model), 2020 and 2035 (in thousands of jobs) (Cont.)

	2020	2035	CHANGE (2020-35)	2035	CHANGE (2020-35)	2035	CHANGE (2020-35)	2035	CHANGE (2020-35)
		Reference Scenario (RS)		ETC Scenario		ATC Scenario		NZ Scenario	
Total Energy Economy Employment	16,584	20,807		21,199		21,677		23,060	
Total Modeled Costs (Trillion 2020$)*	$1.65	$1.73	$0.09	$1.78	$0.13	$1.79	$0.14	$1.83	$0.18
Net Change in Employment			4,223		4,615		5,093		6,476

Notes: ATC = advanced tax credit; AV = alternative vehicle; ETC = extended tax credit; ICE = internal combustion engine; NZ = net-zero; PV = photovoltaic.

Table shows direct, indirect, and induced jobs. Direct and indirect employment numbers represent estimates of domestic jobs generated in the energy economy due to the spending modeled across these sectors, while induced jobs represent estimates of jobs supported by energy economy workers spending their income in the general U.S. economy.

For estimating potential economic impacts for the industry sector, we used cost estimates of energy savings (measured as the difference between industry energy demand in the mitigation scenarios and the reference scenario) as a proxy for spending on energy-efficiency improvements. The 2020 employment number for this sector is 0 as the estimated cost of energy improvements for 2020 is 0 (since industry energy demand in 2020 is the same in the three mitigation scenarios compared to the reference scenario as shown in Technical Appendix D, Table D1). For the agriculture, natural and working lands, and waste sectors, we used emissions abatement costs as a proxy for spending required to achieve emissions reductions (measured as the difference in emissions in the mitigation scenarios and the reference scenario). The 2020 employment number for these sectors in 2020 is 0 as estimated emissions abatement cost for 2020 is 0 (since there are no differences in emission levels in these sectors in 2020 in the three mitigation scenarios compared to the reference scenario, as shown in Technical Appendix D, Table D7). There are no changes in employment numbers for these sectors and technological carbon removal in the reference scenario as the analysis did not model any spending estimates for these sectors for the reference scenario. Additional details on each sector and our sector assumptions are included in the text of the report and appendices.

* "Total modeled costs" here refers to spending inputs used for different sectors to estimate economic impacts. This includes fixed costs of different electricity generation sources, capital costs of buildings sector devices and equipment, capital costs of vehicles and charging infrastructure, capital costs of industry energy-efficiency improvements, fuel production costs for different fuel sources, and emissions abatement costs for industrial carbon capture and storage applications, waste management, agriculture, and natural and working lands.

** Coal and nuclear generation, ICE vehicles, and fossil fuels witness decline in employment.

Source: WRI authors and BW Research.

sustaining wage. Based on this framework, results show a quarter of workers in electricity, buildings, fuels, and industry will earn below $22 an hour in 2035.[7] Based on previous trends, we estimate that the energy economy's diversity problem will persist in 2035, with no significant improvements projected in diversity of gender and ethnicity in the clean energy labor force.

- **Without policies fostering increased domestic manufacturing and supply chain growth, across all mitigation scenarios the decarbonization pathways modeled will see significant job loss associated with certain sectors.** By 2035 the NZ scenario leads to a loss of 7.6 million jobs associated with internal combustion engine (ICE) vehicle manufacturing, maintenance, and sales in the transportation sector, coal and nuclear power generation, and fossil fuel mining and extraction (Table ES-1). Most job losses (more than 70 percent) are associated with the transition from ICE vehicles to electric vehicles. Out of the 5.5 million ICE-vehicle-associated jobs lost in the NZ scenario by 2035, 1.5 million are in automobile manufacturing and 1.7 million are professional services or other supply chain jobs; these job losses in turn contribute to a decline of 2.3 million induced jobs. In terms of the fuels sector, about 50 percent (0.6 million jobs) of the 1.2 million jobs lost are induced jobs associated with the sector, while 0.4 million and 0.3 million jobs are lost in professional services and other supply chains, respectively. Within the electricity sector, coal and nuclear generation see job losses. Ideally, policy design can reverse, or at a minimum mitigate, these negative impacts.[8] In many ways this job loss reflects an underinvestment in U.S. manufacturing capacity and clean energy supply chains. As discussed in the following section, by ramping up domestic production, particularly battery manufacturing, the United States can increase its competitiveness globally and retain electric vehicle and clean energy employment opportunities domestically. This could induce job loss in the international supply chain, transferring instead of solving the just transition problems at the global level. These impacts would need to be monitored to ensure an equitable and just outcome at the global level.

Policy lever model insights

Federal policies such as domestic content and prevailing-wage requirements can manage the economic impacts of decarbonization in a way that helps address potential job loss and creates a foundation for high job quality. Modeling these policies provides the following insights:

- **Increasing the requirement for domestic manufacturing results in growing U.S. clean technology production and bolstering domestic supply chains, as well as greater employment opportunities relative to employment numbers under base modeling assumptions, across all mitigation scenarios.** The greatest employment improvement is seen in transportation, where increasing the share of domestic battery manufacturing in the model from 25 percent (base model assumption) to 50 percent and then 75 percent in the net-zero scenario leads to an additional 850,000 and 1.7 million jobs, respectively, in alternative vehicle manufacturing (Table ES-2). That represents up to 87 percent of net job losses that would otherwise occur associated with this sector. Realizing the full economic benefits of the net-zero transition depends on investing in domestic production of clean technologies and strengthening the supply chain, particularly in battery manufacturing, where investments could convert net job losses in the transportation sector to net job gains. New jobs, however, may not be located in the same geographic area where jobs are lost and may also require different skill sets, which highlights the critical role of policies to address these challenges, including investments in workforce training and place-based economic development.

Table ES-2 | Change in employment (in thousands of jobs) in NZ scenario due to increasing domestic content requirement

SECTOR AND BASE MODEL DOMESTIC CONTENT SHARE	BASE MODEL EMPLOYMENT (2035)	ADDITIONAL JOBS CREATED UNDER DIFFERENT DOMESTIC CONTENT SHARE (2035) (POLICY LEVER MODEL)				
		50%	75%	78%	90%	100%
Solar (25%)	3,046	393	786			
Storage (25%)	131	29	58			
Alternative vehicles (25%)	3,651	850	1,700			
Onshore wind (46%)	1,423		428		647	
Offshore wind (45%)	111		45		68	
Buildings (73%)	7,120			43		134

Notes: NZ = net-zero. Table shows additional jobs (direct, indirect, and induced) created under different domestic content assumptions in 2035, relative to employment in 2035 under baseline domestic content assumptions. Changes in one sector only impact that sector. This table reflects U.S. job growth and does not include any possible global job loss resulting from policies that concentrate manufacturing and clean energy supply chains domestically.

Source: WRI authors and BW Research.

- **Elevating the wages of 3.6 million underpaid workers (Table ES-3) to family-sustaining levels costs $25.0 billion annually but induces economy-wide benefits that amount to a significant share of the costs.**[9] An additional 203,400 induced jobs are created, $21.0 billion in gross domestic product (GDP) is added, and $4.7 billion in taxes are collected in 2035 in the net-zero scenario due to direct and indirect energy economy workers spending their additional income in the economy. This could be accomplished through a combination of policies, including prevailing-wage requirements discussed in this report.

There is a growing literature on the cost and deployment impacts of both domestic content and paying family-sustaining wages in the United States and globally. Research suggests that costs and deployment impacts could be minimal and possibly outpaced by efficiency and productivity gains in the United States, though concerns remain about the net global impacts of protectionist policies that could broadly drive up prices and restrict economic opportunity for the United States and its trade partners on the whole (Mayfield and Jenkins 2021; Jones 2020; Philips 2014; Manzo 2021; Clausing 2019; Platzer and Mallett 2019; Carpenter 2019). These considerations will need to be monitored from policy design through implementation.

Based on the above findings, our analysis highlights four social and economic goals that federal climate policies should be designed to achieve:

- **Strengthen the U.S. clean energy manufacturing sector and supply chains.** The net-zero transition presents opportunities to revitalize U.S. manufacturing, which can not only enhance U.S. leadership, resilience, and competitiveness in low-carbon products and services but also promote economic growth and create high-quality jobs with U.S. firms serving growing domestic and international markets. When policies supporting domestic manufacturing and a U.S. clean energy supply chain are combined with incentives or requirements that prioritize investments in clean energy industries in disadvantaged communities[10] and communities most impacted by the phaseout of fossil fuels, it helps ensure an equitable net-zero transition that benefits all communities.

Table ES-3 | Economic impacts of increasing incomes to family-sustaining wage level

	SHARE OF EMPLOYEES EARNING <$22/HR (IN 2020 NZ SCENARIO)	EMPLOYEES EARNING <$22/HR (IN 2035 NZ SCENARIO) (IN THOUSANDS)*	SHARE OF EMPLOYEES EARNING <$22/HR (IN 2035 NZ SCENARIO)	ANNUAL COST OF INCREASING WAGES TO $22/HR (IN MILLIONS)**	SECTOR SHARE OF ANNUAL COST OF INCREASING WAGES TO $22/HR	INDUCED JOBS CREATED BY EMPLOYEES SPENDING ADDITIONAL INCOME (IN THOUSANDS)***	GDP/VALUE ADDED BY EMPLOYEES SPENDING ADDITIONAL INCOME (IN MILLIONS)
Electricity	24%	1,020	22%	$7,075 (4%)	31%	58	$5,927
Fuels	23%	374	23%	$2,506 (1%)	10%	20	$2,099
Buildings	25%	1,183	25%	$7,330 (2%)	29%	60	$6,140
Transportation	40%	890	32%	$6,769 (1%)	27%	55	$5,671
Other sectors	26%	173	26%	$1,329 (2%)	6%	11	$1,113
Total		**3,640**		**$25,010 (1%)**		**203**	**$20,951**

Notes: GDP = gross domestic product; NZ = net-zero. * These are direct and indirect jobs in these sectors. ** The percentages shown in parenthesis for different sectors report the annual cost of increasing wages to $22 an hour as a share of the total modeled costs. *** These are induced jobs created by employees spending their additional income in the economy. Other sectors here include industry, waste management, agriculture and natural and working lands, and technological carbon removal. Dollar values in the table are reported in nominal 2020 dollars.

Source: WRI authors and BW Research.

- **Focus on creating inclusive and high-quality jobs**. Climate policies must create quality jobs that pay family-sustaining wages, but this is just the baseline for job quality. Additional investments in workforce training associated with available employment opportunities, policies that enforce equitable hiring and treatment of all workers in the workplace, and efforts to protect and support workers' rights to organize can further improve job quality without halting the growth of the net-zero economy.
- **Support communities and workers vulnerable to adverse economic impacts due to the energy transition.** While creating opportunities nationwide, the net-zero transition will lead to a loss of jobs and tax revenues in regions economically dependent on fossil fuels. The federal government, given the scale of its work, its role in decarbonization policy, and its engagement in a range of macroeconomic trends that impact workers, is particularly well situated to manage the uneven impacts of the transition. This can be done by adopting policies that support new employment opportunities in impacted regions, ensure new jobs are high-quality jobs, offer workforce and development assistance, provide incentives to repurpose retired fossil assets, and provide financial and other types of assistance to communities as their economies evolve. While smart policy can minimize job loss in a clean energy transition, there will be unavoidable disruption for workers, and the establishment of safety-net and workforce-development policies related to wage replacement, bridge to

retirement, and training and education funding will be essential to an equitable and prosperous net-zero transition. Investing in workforce training and development will be particularly important to ensure access to quality jobs for both new workers as well as dislocated workers impacted by the energy transition.

- **Promote equitable access to the benefits of net-zero energy systems**. Federal climate policies should aim to address current and long-standing inequities that disadvantage marginalized and low-income communities and that limit their participation in the clean energy workforce and access to clean energy broadly. Low-income; Black, Latino, and Indigenous; and other households of color are disproportionately impacted by fossil fuel dependency, in terms of pollution and public health impacts as well as the impacts of resulting climate change. Going forward, policies need to ensure that the benefits, in terms of access to new employment opportunities and beneficial clean technologies, as well as costs, are more equitably distributed among different communities. This can be connected with policies to boost domestic manufacturing and a focus on specific regions, including those transitioning away from economic dependence on fossil fuel–based industries.

INTRODUCTION

This study builds on previous WRI research published in the working paper "Building Blocks for a Low-Carbon Economy: Catalytic Policy and Infrastructure for Decarbonizing the United States by 2050," which estimated GHG emissions reductions across key sectors of the U.S. economy under different federal policy and spending scenarios. This analysis estimates socioeconomic impacts of federal climate policies under the same mitigation scenarios and identifies key considerations for policymakers to enhance the economic and equity impacts of federal policies and investment.

Global carbon dioxide emissions must reach net-zero by midcentury to limit global temperature rise to 1.5° Celsius and mitigate the worst impacts of climate change (Masson-Delmotte et al. 2021). The Biden administration has committed to reducing U.S. economy-wide greenhouse gas (GHG) emissions by 50–52 percent below 2005 levels by 2030 and achieving economy-wide net-zero GHG emissions by 2050 (White House 2021c).

Meeting the nation's climate goals will require an accelerated deployment of existing low-carbon technologies such as wind, solar, electric vehicles (EVs), and heat pumps, as well as new technologies that are not yet widely available, including clean hydrogen and carbon capture and storage (Saha et al. 2021b). Studies have found cost-effective technology pathways and policy opportunities across all sectors of the U.S. economy to achieve the country's decarbonization targets, all of which require substantial investment and economy-wide transformations (Mahajan et al. 2020; Larson et al. 2020; Williams et al. 2021; Saha et al. 2021b).

The net-zero transition presents tremendous opportunities, creating jobs across a broad range of occupational skills, industries, and regions, and spurring economic activity as new markets for low-carbon products and services emerge (Saha et al. 2021a; Saha and Jaeger 2020; Larson et al. 2020; SDSN 2020). Jobs throughout the supply chain—driven by public and private investment in renewable electricity generation, grid modernization, buildings electrification, alternative vehicles and supporting infrastructure, to name a few—can and should also provide new opportunities for households, communities, and regions that have historically been marginalized in the current fossil fuel–dominated energy economy.

Though it creates new opportunities resulting in net economic benefits, a technological and economic transition of this magnitude may not benefit all communities equally and can also impose burdens on some individuals, communities, and legacy industries facing uneven exposure. An unmanaged transition will not only impose economic costs on vulnerable workers and communities but also could create opposition to climate action that could delay the net-zero transition. How the transition is managed will be important and requires policies and accountability at every level of government, as well as actions by key stakeholders, to make the adjustments required for an equitable net-zero transition.

Delivering potential climate and economic benefits, and mitigating any challenges, from a net-zero transition, requires federal leadership. Federal climate policy designed to bolster U.S. competitiveness, retain benefits of climate action domestically, and foster family-sustaining career pathways will be critical to ensuring an inclusive and equitable net-zero transition. While federal leadership is essential, achieving our climate goals also demands a similar commitment to equity and emissions reduction from state and local governments, as well as the private sector and civil society.

In November 2021 President Joe Biden signed into law the Infrastructure Investments and Jobs Act, also known as the Bipartisan Infrastructure Law, which provides new and substantial spending on physical infrastructure, including electric vehicle charging stations, the energy grid, public transit, and environmental remediation, among other priorities. Further, the Inflation Reduction Act contains hundreds of billions of dollars in climate-smart spending and tax credits. This includes tax credits to encourage consumers to purchase clean technologies, such as rooftop solar panels and heat pumps, and incentives for companies to manufacture such technologies domestically.

Beyond opportunities for new spending through enacted legislation, the Biden administration is taking action to ensure that existing climate spending supports disadvantaged communities, including communities in transition from economic dependence on fossil industries, and to prioritize American-made products through executive orders.

This study builds on previous WRI research published in the working paper "Building Blocks for a Low-Carbon Economy: Catalytic Policy and Infrastructure for Decarbonizing the United States by 2050" (Saha et al. 2021b),[11] which estimated GHG emissions reductions across key sectors of the U.S. economy under different federal policy and spending scenarios. This analysis estimates socioeconomic impacts of federal climate policies under the same mitigation scenarios and identifies key considerations for policymakers to enhance the economic and equity impacts of federal policies and investment.

CHAPTER 1.

FEDERAL POLICIES TO BUILD AN EQUITABLE NET-ZERO ECONOMY

The federal government needs not just to invest in a net-zero transition but also to pair investment with policies that can enhance the potential economic, equity, and societal benefits of climate action. This analysis looks at two specific examples of policies related to managing and minimizing job loss and improving job quality as the energy transition progresses: first, policies boosting domestic clean energy manufacturing in the United States, and second, paying family-sustaining wages as a proxy for incorporating prevailing-wage requirements into federal spending.

The society-wide investment required for the net-zero transition could generate high-quality jobs, reduce pollution, decrease households' energy costs, and build community infrastructure and resources (Saha and Jaeger 2020; Carlock et al. 2021). In addition, such investments have the potential to significantly reduce fuel costs. However, the full realization of this investment's potential to deliver diverse benefits equitably is far from guaranteed.

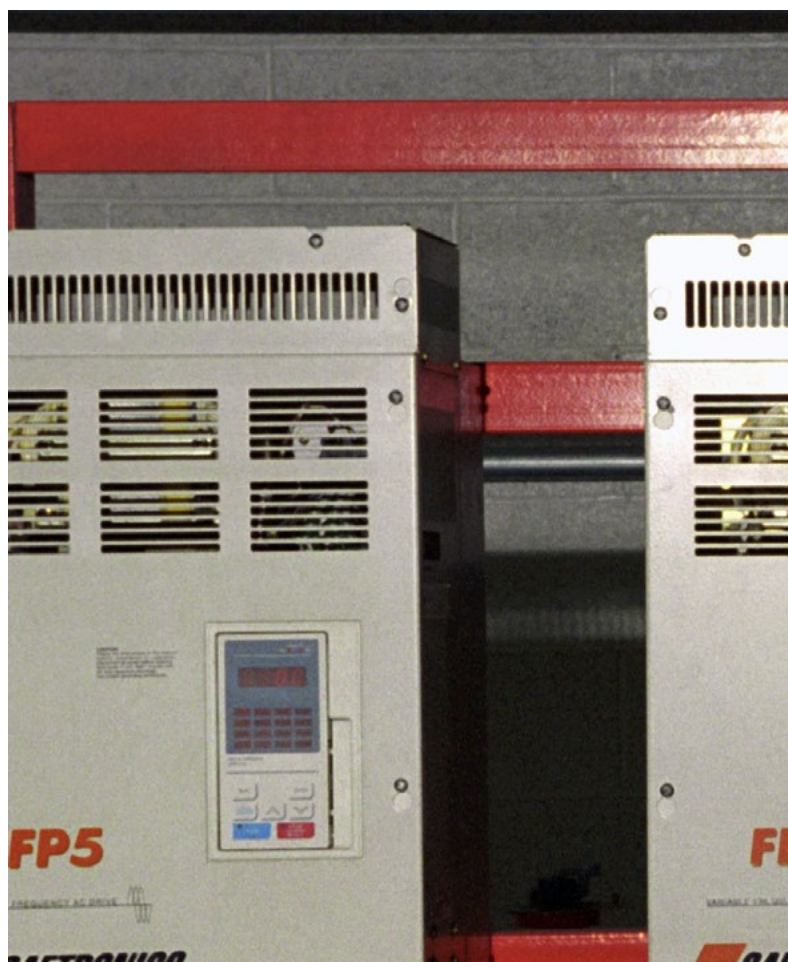
While climate action could be a net positive job creator, some sectors and communities that are closely tied to fossil fuels will see job losses in a net-zero transition, which could undermine economic and social stability in those communities. While overall this job loss may be outweighed by job creation, newly created jobs in the net-zero economy may not always provide geographically, temporally, and substantively appropriate replacements.

Further, while clean energy jobs can be, and in some cases already are, high-quality jobs—meaning they provide family-sustaining wages, offer significant health-care and retirement benefits, include opportunities for advancement, and are relatively stable forms of employment—that is not consistently the case across sectors and is not guaranteed as the clean energy economy grows.

Finally, existing and historic inequity throughout U.S. governance, financial, and social systems means that communities facing economic distress, disproportionate pollution burdens, high household energy costs, and underinvestment and underrepresentation will not benefit equitably from a clean energy transition without focused policy support. Already as result of existing historic and persistent inequities, certain households, including low-income; rural; Black, Latino, and Indigenous; and other households of color, disproportionately incur the costs of the energy system. These households also do not equitably benefit from clean energy, as access to clean energy and its benefits concentrates around wealthy households and white male workers (Saha and Jaeger 2020; Carlock et al. 2021).

The federal government needs not just to invest in an equitable net-zero transition but also to pair investment with policies that can enhance the potential economic, equity, and societal benefits of climate action. While local and state governments play an important role, the federal government works across sectors and regions, has already addressed economic dislocation issues from other macroeconomic trends like automation and globalization,[12] and either has adopted or is considering policies to facilitate the net-zero transition. This makes the federal government particularly well positioned to implement policies and programs that manage and mitigate job loss arising from the energy transition and improve the quality of jobs in the new climate economy. Further, given the breadth and scale of spending, data collection and analysis, and oversight capacity, the federal government is well positioned to drive an equitable net-zero transition that addresses existing inequities and avoids any additional harm to burdened households, including low-income; rural; Black, Latino, and Indigenous; and other households of color.

This analysis looks at two specific examples of policies related to managing and minimizing job loss and improving job quality as the energy transition progresses: first, policies boosting domestic clean energy manufacturing in the United States, and second, paying family-sustaining wages as a proxy for incorporating prevailing-wage requirements into federal spending. While these are just two policies



among many, they were selected given their direct connection to questions of domestic job growth and job quality, as well as relevance and active consideration in the current policy discourse. Forthcoming work from WRI will further evaluate policy considerations specifically related to identifying and investing in disadvantaged communities.

1.1 Domestic Content Requirements

Across supply chains, clean energy and low-carbon technologies have the potential to create jobs and drive economic growth where they are produced. Creating and supporting domestic supply chains in clean energy could substantially increase job creation within the United States, as investment in construction and inputs for clean technologies would ripple through the U.S. economy. Manufacturing is also critical for nurturing the innovation ecosystem, as the colocation of invention and manufacturing provides a continuous feedback loop to sustain innovation (Ezell 2020; Ramaswamy et al. 2017).[13] Recent supply chain disruptions[14] to clean energy technologies—like solar panels, electric vehicles, and lithium-ion batteries—have further demonstrated the vulnerability of the U.S. industry to foreign markets and global economic, geopolitical, and extreme weather shocks, as well as the potential advantages of onshoring the manufacturing supply chains of clean technologies (Williams and Sutton 2021). These considerations need to be assessed alongside analysis of how domestic content policies may directly or indirectly impact the cost and deployment of clean energy and economic opportunity for the United States and its trade partners or deliver any more growth or employment in aggregate than a free trade policy with fewer interventions (Clausing 2019; Platzer and Mallett 2019; Carpenter 2019).

However, while the United States has a history as, and the potential to again be, a global leader in manufacturing, the sector has been underperforming its potential across a number of criteria, such as employment, productivity, and manufacturing value added (Saha and Jaeger 2020; Ezell 2020). This may also be a reflection of global shifting of relative comparative advantage in the production of a product. Previous trends around technologies like semiconductors and consumer electronics suggest that domestic demand and engineering and design expertise alone may not automatically translate into onshore production and U.S. jobs (Williams and Sutton 2021).[15]

In order to create jobs and boost U.S. global competitiveness as the low-carbon economy grows, we start from the assumption that intentional policies are needed to encourage companies to invest in domestic clean energy manufacturing. This is a stated priority for the Biden administration, which has pursued a range of executive actions to support domestic clean energy manufacturing, including recently authorizing the Department of Energy to use the Defense Production Act to grow domestic manufacturing of certain clean energy technologies and using federal procurement to support domestically manufactured solar systems (White House 2022). The Biden administration has broadly focused on supporting American manufacturing through procurement (White House 2021b).[16] Several policy tools can be used to promote domestic manufacturing, including domestic content requirements ensuring that projects using federal funds source a specified share of materials from domestic suppliers. For example, the 1933 Buy American Act requires federal agencies to preference domestic materials and products for projects in the United States. It includes a requirement that federally funded public transportation projects use U.S. iron and steel and U.S.-produced and assembled goods (Platzer and Mallett 2019; Carpenter and Murrill 2021). Rule changes to the Buy American Act in 2022 require gradually raising the domestic content threshold from 55 percent to 75 percent by 2029 to be considered made in America (White House 2021b). Through the recently passed Inflation Reduction Act, Congress has enacted new policies outside of federal procurement to encourage domestic manufacturing investment, including incentives for domestic manufacturing and using domestic-content requirements to determine available tax credit value (Williams and Sutton 2021).

Beyond simply requiring clean energy manufacturing in the United States, domestic content requirements can also be paired with incentives to repurpose existing industrial facilities and polluted lands instead of pursuing greenfield development. They can also integrate equity considerations to incentivize investments in energy communities that may see comparatively high levels of job loss due to the transition and communities that are historically and currently marginalized and underserved. For instance, a tax credit that provides increased incentives to meet domestic content requirements can provide additional incentives when facilities locate their operations in certain categories of communities (Williams and Sutton 2021).[17]

Policies promoting domestic clean energy manufacturing must be intentionally equitable. A focus on growth alone will not benefit communities that have historically borne a disproportionate burden of pollution and been excluded from the local benefits of economic growth. Incentives to grow domestic manufacturing, and particularly incentives to target that growth for marginalized and underserved communities and support minority-owned and woman-owned-businesses, should be paired with policies and processes that address historic and current inequity in exposure to pollution from industry and insufficient or discriminatory development and siting procedures. To that end, new or expanded projects should collaborate and codevelop with communities and stakeholders to address their concerns, such as pollution risks and access to quality economic opportunity, and integrate their guidance on how to maximize the positive impacts of local projects.

1.2 Paying a Family-Sustaining Wage and Prevailing-Wage Requirements

Discussion of the economic benefits of decarbonization are often focused on the potential for job creation in the low-carbon economy. However, the emphasis on job creation must be paired with a focus on the quality of jobs created.

Clean energy jobs often meet some of the standards for quality employment like above-median wages, above-average unionization rates,[18] and greater availability of health and retirement benefits (E2 et al. 2020; DOE et al. 2021; Muro et al. 2019; Carlock et al. 2021). However, clean energy jobs cover a range of subsectors, including jobs in energy efficiency, renewable energy, clean vehicles, grid and storage, and fuels, and job quality and wages can vary significantly even within those subsectors (Zabin et al. 2020).

Additionally, when comparing clean energy jobs to the fossil fuel jobs they may replace, the new wages, benefits, and stability are not inherently equal to or greater than those in the fossil fuel industry (Saha and Jaeger 2020). Some new green jobs have lower wages than more established sectors where workers have a longer history of collective action and successfully setting higher base rates, like the capital-intensive fossil fuel industry, despite the declining power of trade unions (Jaeger et al. 2021).

Using policy to influence wages associated with the growing clean energy economy can help lay the foundation for job quality in the industries of the future. Prevailing-wage requirements are one policy mechanism for achieving this goal through federally supported projects. Prevailing wages are the basic hourly rate for a specific kind of job in a specific geography, and prevailing-wage requirements can set that compensation level as a wage floor (Wall et al. 2020). Already, the 1931 Davis-Bacon Act requires that government contractors pay prevailing wages for work associated with qualifying federally funded construction projects, and this requirement has been extended by Congress to other projects and funding mechanisms through related provisions (Bradley and Shimabukuro 2021). Recent congressional clean energy proposals have included prevailing-wage requirements to qualify for the full value of many proposed clean energy tax credits (Yarmuth 2022). Prevailing wages are most consistently required in government-funded construction projects currently.

There may be concerns about the trade-offs that come with increasing wages. Some argue that increasing wages will make clean energy projects more expensive and slow their development or limit engagement in federal projects by certain actors. These concerns should be seriously considered, monitored, and managed, but evidence to date suggests that higher wages and prevailing-wage requirements do not have a significant impact on project costs (Mayfield and Jenkins 2021; Jones 2020; Philips 2014; Manzo 2021). Further, higher wages can increase consumer spending and spur economic development in low-wage areas, while also helping to address historic pay inequity (Economic Policy Institute 2021; Godøy and Reich 2019).

A prevailing-wage requirement is only one among a suite of policies that can bolster job quality. Fostering and incentivizing unionization is another policy approach that can facilitate even higher compensation through a collectively bargained wage, and secure other workplace protections, as a tool of collective advocacy (U.S. Bureau of Labor Statistics 2021; White House 2021c). Additionally, state and federal minimum wage laws could broadly improve job equality across sectors. Finally, tools like community workforce agreements, negotiated between trade unions and developers, can ensure that projects deliver on job quality, local hiring, and employing disadvantaged workers (Carlock et al. 2021). While this report focuses on an approximation of prevailing-wage policies specifically, effective federal policy should embrace a range of mechanisms and incentives to maximize the compensation, benefits coverage, and safety for American workers. Some intangible components of job quality, like inclusiveness and worker voice, cannot be easily quantified in economic analysis but are essential to equitable job growth.

CHAPTER 2.

AN APPROACH TO ESTIMATING SOCIOECONOMIC IMPACTS

This section first summarizes the decarbonization mitigation scenarios included in the Building Blocks analysis and then describes the methodology for estimating the socioeconomic impacts of those scenarios.

2.1 Overview of WRI's Building Blocks Analysis

The Building Blocks analysis examines the evolution of U.S. energy demand and supply and GHG emissions trends through 2050 under different policy scenarios using the PATHWAYS and RESOLVE models developed by Energy + Environmental Economics Inc. (E3).[19] It compares the progress toward net-zero GHG emissions by 2050 under three mitigation scenarios, which represent different federal policy and spending packages that overlap and build on one another (Figure 1).

The extended tax credit scenario (ETC) extends current clean energy and zero-emission light-duty vehicle (ZEV) tax credits and increases spending for programs that target infrastructure to help drive early adoption of clean energy and energy-efficient technologies. Spending on infrastructure includes spending on priorities funded in the Bipartisan Infrastructure Law, such as EV charging, buildings efficiency, and grid transmission. The advanced tax credit scenario (ATC) layers on advanced tax credits for low-carbon technologies such as heat pumps and medium- and heavy-duty EVs to drive broader adoption of such technologies. This scenario approximates the clean energy tax credit provisions included in the Inflation Reduction Act. The net-zero scenario (NZ) builds on the ATC scenario by adding sector-specific performance standards—such as a tailpipe emissions standard for transportation—along with an economy-wide emissions cap, required to reach net-zero GHG emissions by 2050. All these scenarios also account for existing state-level actions such as CES targets and ZEV sales mandates, but these state-level actions are nonbinding or are superseded by federal actions in the mitigation scenarios.[20]

Table 1 compares changes in gross and net emissions in 2030 and 2050 relative to 2005. The combination of tax credits and federal spending on infrastructure in the ATC scenario plays an important role in helping the United States reduce its net emissions by 43 percent by 2030. While this by itself does not hit the 2030 U.S. climate target (of 50–52 percent), these policies are critical to enabling faster technology deployment and cutting more emissions than would be possible in the reference scenario (Table 1). Ultimately, stringent sector-specific performance standards, as modeled in the NZ scenario, along with enhancing natural and working land sinks and deploying technological carbon removal[21] to offset remaining emissions in harder-to-mitigate sectors, will be needed to achieve at least 50 percent emissions reduction by 2030 and a net-zero economy by 2050.

Supplementary summary tables describing key results from the Building Blocks analysis are provided in Technical Appendix D.

2.2 Design and Methodology for the Socioeconomic Impact Analysis

WRI commissioned BW Research to model the socioeconomic impacts of federal policies and investments included in the ETC, ATC, and NZ scenarios of the Building Blocks Analysis. BW Research used the Economic Impact Analysis for Planning (IMPLAN) Analysis-by-Parts model for this analysis.

IMPLAN analysis-by-parts uses spending data to evaluate changes in economic activity across different sectors. Cost data from the Building Blocks analysis serve as inputs for the IMPLAN analysis-by-parts. These include power sector fixed costs; capital costs of buildings sector devices and equipment, vehicles and charging infrastructure, and energy-efficiency improvements in industry; production costs of biofuels and hydrogen; and emissions abatement costs for industrial carbon capture and storage (CCS) applications, waste management, agriculture, and natural and working lands (Technical Appendix A).

The socioeconomic impact analysis is conducted in a two-step process. First, the impacts arising from federal policies and investments across the three mitigation scenarios are estimated for key sectors of the U.S. economy (base modeling) and are compared to the reference scenario. Second, the model introduces two policy levers—domestic content requirements and family-sustaining wages as a proxy for prevailing wages—to explore changes in socioeconomic impacts as a result of these policy interventions (policy levers modeling).[22]

Figure 1 | Description of mitigation scenarios*

Scenario	Reference Scenario (RS)	Extended Tax Credits (ETC) Scenario	Advanced Tax Credits (ATC) Scenario	Net-Zero (NZ) Scenario
Goal	Reflects existing federal policies, as well as binding state-level policies, to estimate emissions reduction in a business-as-usual scenario.	Reflects extension of existing tax credits and increase in federal spending on low-carbon infrastructure, with the goal of driving early adoption required to kick-start broader sector transformation.	Reflects extension of existing tax credits and federal spending on infrastructure from ETC scenario and layers in new tax credits for technologies for which tax credits do not currently apply. Goal is to drive broader adoption of technologies.	Layers on sector-specific performance standards and economy-wide net-zero emissions cap to demonstrate policy-driven, sector-level transformation required to achieve "net zero."
Policy Levers	Existing federal policies, including tax credits for renewable power and ZEVs, CAFE standards, and NSPS methane regulations.	Low-carbon infrastructure spending, including for building sector energy-efficiency, weatherization, and electrification programs, deployment of electric vehicle charging station infrastructure, and grid modernization and transmission.	Low-carbon infrastructure spending, including for building sector energy-efficiency, weatherization, and electrification programs, deployment of electric vehicle charging station infrastructure, and grid modernization and transmission.	Low-carbon infrastructure spending, including for building sector energy-efficiency, weatherization, and electrification programs, deployment of electric vehicle charging station infrastructure, and grid modernization and transmission.
		Extended tax credits, including extending existing incentives for LDV ZEVs and renewable power.	Extended tax credits, including extending existing incentives for LDV ZEVs and renewable power.	Extended tax credits, including extending existing incentives for LDV ZEVs and renewable power.
	Existing state-level policies, including state-level RPS and ZEV targets.		Advanced tax credits, including new tax credits for LDV and MHDV ZEVs, electric heat pumps, renewables, and firm zero-carbon resources.	Advanced tax credits, including new tax credits for LDV and MHDV ZEVs, electric heat pumps, renewables, and firm zero-carbon resources.
				Sector-specific performance standards, including a CES, and economy-wide net-zero emissions cap.

Notes: CAFE = Corporate Average Fuel Economy; CES = clean electricity standard; LDV = light-duty vehicle; MHDV = medium- and heavy-duty vehicle; NSPS = New Source Performance Standards; RPS = Renewable Portfolio Standard; ZEV = zero-emissions vehicle. *Policy assumptions for the different scenarios were decided in 2021 and several climate provisions included in the 2021 Bipartisan Infrastructure Law and 2022 Inflation Reduction Act are modeled in the mitigation scenarios. Please see Table 1 and Technical Appendices B–C in Saha et al. (2021b) for more details about individual policies included under each scenario.

Source: Saha et al. 2021b.

Table 1 | Emissions and removals across scenarios by sector for 2030 and 2050 (percent changes relative to 2005 levels)

	GHG EMISSIONS/ REMOVALS IN 2005 (MMT CO_2E)	REFERENCE SCENARIO (RS)		EXTENDED TAX CREDIT (ETC) SCENARIO		ADVANCED TAX CREDIT (ATC) SCENARIO		NET-ZERO (NZ) SCENARIO	
		2030	2050	2030	2050	2030	2050	2030	2050
Electricity generation	2,459	467 (-81%)	298 (-88%)	318 (-87%)	243 (-90%)	331 (-87%)	288 (-88%)	304 (-88%)	9 (-100%)
Transportation	2,004	1,592 (-21%)	1,381 (-31%)	1,444 (-28%)	954 (-52%)	1,392 (-31%)	769 (-62%)	1,335 (-33%)	342 (-83%)
Industrial energy	855	1,120 (31%)	1,329 (55%)	1,102 (29%)	1,255 (47%)	1,093 (28%)	1,210 (42%)	952 (11%)	426 (-50%)
Residential buildings	371	323 (-13%)	282 (-24%)	302 (-19%)	245 (-34%)	267 (-28%)	64 (-83%)	263 (-29%)	14 (-96%)
Commercial buildings	251	286 (14%)	302 (21%)	274 (9%)	273 (9%)	232 (-7%)	72 (-71%)	229 (-9%)	9 (-96%)
Agriculture	578	619 (7%)	627 (9%)	594 (3%)	527 (-9%)	519 (-10%)	427 (-26%)	519 (-10%)	427 (-26%)
Industrial process emissions	397	353 (-11%)	267 (-33%)	340 (-14%)	253 (-36%)	340 (-14%)	253 (-36%)	293 (-26%)	135 (-66%)
Oil and gas systems	241	334 (39%)	348 (44%)	298 (24%)	278 (15%)	288 (20%)	230 (-5%)	166 (-31%)	65 (-73%)
Waste management	191	175 (-8%)	212 (11%)	175 (-8%)	212 (11%)	175 (-8%)	212 (11%)	166 (-13%)	198 (4%)
Coal mining	78	52 (-33%)	43 (-45%)	49 (-37%)	18 (-77%)	49 (-37%)	18 (-77%)	9 (-88%)	2 (-97%)
Natural and working lands*	-788	-744 (-6%)	-696 (-12%)	-804 (2%)	-876 (11%)	-864 (10%)	-1,056 (34%)	-864 (10%)	-1,056 (34%)
Technological carbon removal**	0	0 (--)	0 (--)	-39 (--)	-39 (--)	-39 (--)	-39 (--)	-32 (--)	-571 (--)
Total Gross Emissions	**7,423**	**5,321 (-28%)**	**5,089 (-31%)**	**4,896 (-34%)**	**4,258 (-43%)**	**4,686 (-37%)**	**3,543 (-52%)**	**4,236 (-43%)**	**1,627 (-78%)**
Total Net Emissions	**6,635**	**4,577 (-31%)**	**4,392 (-34%)**	**4,053 (-39%)**	**3,342 (-50%)**	**3,784 (-43%)**	**2,446 (-63%)**	**3,339 (-50%)**	**0 (-100%)**

Notes: CO_2e = carbon dioxide equivalent; GHG = greenhouse gas; MMT = million metric tonnes. *Natural and working lands values are negative, therefore a positive percent change denotes an increase in carbon stored relative to 2005. **The baseline for technological carbon removal is 0 in all scenarios, thus a percentage change cannot be calculated.

Source: Saha et al. 2021b.

Base Modeling

Base modeling outputs include direct, indirect, and induced effects on jobs; economic value added; employee compensation (e.g., wages and salaries); industry composition of employment; and tax revenue generated. These outputs are generated for electricity, transportation, buildings, industry, fuels, waste management, agriculture and natural and working lands, and technological carbon removal across the three mitigation scenarios between 2020 and 2035. For the NZ scenario, we also present results for the wage distribution[23] of workers in each of these sectors along with the demographic composition of workers in sectors like electricity, buildings, transportation, and fuels. For the latter, the model assumed that subsector demographics (pulled from U.S. Energy and Employment Report [USEER] data) changed based on a three-year rolling average of change from 2018 to 2021 (see Technical Appendix A, Table A5). Demographic outputs also change based on a sector's composition of subsectors. For example, holding the rolling average mentioned above constant, if solar generation employs more women than coal generation, and solar employment grows and coal employment drops between 2020 and 2035, then the electricity sector will employ more women in 2035 than it did in 2020. The USEER data are based on survey responses and Bureau of Labor Statistics (BLS) data, where the former accounts for geographic trends through survey data quotas. They are also weighted on BLS industry demographics, which account for geography through their survey and extrapolation effort.

Our analysis also estimates the negative impact on employment in parts of the electricity, transportation, buildings, and fuels sectors as the low-carbon transition necessitates a shift away from fossil fuel–based technologies. The cost of the energy transition goes beyond jobs to include significant impacts on public finances, especially in rural fossil-producing communities (Raimi et al. 2022). Exploring the impact on local communities arising from the loss of tax revenues is, however, beyond the scope of this report.

Further details on key inputs and assumptions by sector as well as the methodology for translating these inputs and assumptions into industry spending are provided in Technical Appendix A.

Policy Levers Modeling

In the second part of our analysis, we adjust key modeling assumptions to investigate the potential impacts of enhanced U.S. domestic manufacturing and improvements in wages. Technical Appendix B provides details related to assumptions and methodology for the policy lever analysis. The report presents the impacts of these two policy levers for the NZ scenario, and results from the domestic manufacturing policy lever modeling for the ETC and ATC scenarios are included in Technical Appendix C.

The domestic content assumption regarding the solar, storage, and alternative vehicles subsectors is centered on battery manufacturing. The base model assumes that 25 percent of solar panels and battery manufacturing takes place in the country, with the rest imported, based on market share estimates reported by the U.S. International Trade Commission and the U.S.-China Economic and Security Review Commission.[24] Currently the United States imports 80 percent of solar panels from Southeast Asia; with Malaysia, Thailand, and Vietnam accounting for nearly 60 percent of total U.S. panel supply (Hopper 2021). The United States also relies heavily on importing lithium-based batteries, which are integral to electric vehicles and stationary grid storage. Estimates of the U.S. share of the global market range from 10 percent to 24 percent.[25]

For onshore and offshore wind, the base model assumes 46 percent and 45 percent domestic content, respectively, figures derived from NREL's Jobs and Economic Development Impacts (JEDI) Wind model defaults.[26] The United States has a comparative advantage in wind turbine and component manufacturing to serve its domestic market.[27] The need for domestic manufacturing is driven by the increasing size and complexity of wind turbines, which imposes significant transportation and logistical challenges.

The base domestic content for the buildings sector is derived from IMPLAN spending patterns, the average of which is about 73 percent.

We increase the threshold for domestic content in solar, wind, storage, alternative vehicles, and buildings in the policy lever modeling to explore how it impacts employment in those sectors in 2035

(Table 2). Theoretically, the domestic content share can be increased up to 100 percent in the model, but that may not be feasible given the marginal cost of increasing domestic content shares above the free-market outcome.[28] In Section 3.3, we present data assuming 50 percent and 75 percent domestic content for battery manufacturing in solar, storage, and alternative vehicles. For onshore and offshore wind, we increase the domestic content share to 75 percent and 90 percent. We also increase the share of domestically produced content in buildings from 73 percent to 78 percent to comply with the Buy American Act and further increase the share to 100 percent, where all efficiency products are domestically sourced.[29] It should be noted that these are "what if" scenarios, meaning the market-development scenarios are based on assumed domestic content share that, when changed, produces different employment outputs as well as different energy and emissions impacts.

We also evaluate the additional economic impacts of improving workers' wages. Our analysis does not model the impact of incorporating prevailing wages given the required geographic and occupational granularity. Instead, we do a family-sustaining wage analysis. The base model categorizes wages of workers across different modeled sectors into three ranges—below $22 an hour, $22–$34 an hour, and above $34 an hour—based on MIT's Living Wage Calculator.[30] Using MIT's framework, we assume that any worker earning below $22 an hour qualifies as a worker earning less than a family-sustaining wage. For the NZ scenario, we estimate

Table 2 | Overview of base and policy lever modeling domestic content assumptions

SECTOR	SUBSECTOR	DOMESTIC CONTENT ASSUMPTIONS	
		Base Modeling	Policy Lever Modeling
Electricity	Onshore and offshore wind	▪ 46% for onshore wind. ▪ 45% for offshore wind. ▪ Derived from default JEDI model parameters.	▪ Increased to 75% and 90%.
	Solar	▪ We multiply the spending allocated for semiconductor manufacturing (IMPLAN code 307) and power distribution and transformer manufacturing (IMPLAN code 329) by 0.25.	▪ Increased to 50% and 75% by multiplying the spending allocated to relevant IMPLAN codes by 0.5 and 0.75.
	Storage	▪ We multiply the spending allocated to power distribution and transformer manufacturing (IMPLAN code 329) and storage battery manufacturing (IMPLAN code 333) by 0.25.	
Transportation	Alternative vehicles	▪ For electric vehicles in the light-, medium-, and heavy-duty vehicle segments, we multiply the spending allocated to storage battery manufacturing (IMPLAN code 333) by 0.25.	▪ Increased to 50% and 75% by multiplying the spending allocated to relevant IMPLAN codes by 0.5 and 0.75.
Buildings	Energy efficiency	▪ The base domestic content assumption of 73% for the buildings sector is derived from IMPLAN spending patterns. The assumption applies to equipment and devices such as lighting fixtures, cooking appliances, refrigerators, freezers, and other electrical appliances.	▪ Referring to the Federal Acquisitions Regulation Buy American Act (S 52.225-1), we assume that at least 65% of energy-efficiency measures is sourced domestically by 2030. This benchmark increases the 73% baseline domestic content assumption to 78%.

Notes: IMPLAN = Economic Impact Analysis for Planning; JEDI = Jobs and Economic Development Impacts. The analysis adjusts default or base domestic content assumptions to reflect different domestic manufacturing requirements for solar, wind, alternative vehicles, and the buildings sector for the three mitigation scenarios. For each scenario, employment impacts under adjusted domestic content assumptions are then compared with impacts under base modeling assumptions for each sector or subsector individually (the analysis assumes that changes in one sector only impact that sector).

Source: WRI authors and BW Research.

the cost of increasing the wages of workers earning below $22 an hour to be at least $22 an hour and assess the additional economic impacts generated by increasing these workers' earnings to a family-sustaining wage level.[31]

Further details on policy levers are provided in Technical Appendix B.

Additional Modeling Details

Our estimations of economic impacts across different sectors and subsectors of the U.S. energy economy cover direct, indirect, and induced impacts. Direct and indirect employment numbers presented in the report are estimates of domestic jobs generated in the energy economy due to the spending modeled across these sectors. These direct and indirect job estimates include construction, manufacturing, professional services, and other supply chain jobs associated with different activities and technologies specific to the energy sector. In contrast, induced jobs represent estimates of domestic jobs supported by energy economy workers (employed in direct and indirect jobs) spending their income in the general U.S. economy. Induced jobs are a native output from IMPLAN that are generated using labor income (generated from sector- and subsector-specific direct and indirect outputs) and general spending patterns of individuals and households. It is important to note that these estimations do not cover potential impacts coming from savings in energy-, fuel-, or maintenance-related expenditures consumers and businesses may experience as they transition to cleaner or efficient energy sources or technologies.

IMPLAN multipliers (jobs/$ ratios) for the different modeled sectors and associated IMPLAN industries are derived from multiple data sets, but they mostly draw from 2020 U.S. Bureau of Economic Analysis and Bureau of Labor Statistics data. These data include salary and wage data, which IMPLAN uses, along with interindustry spending (i.e., intermediate goods purchases) and various other expenditure types (taxes, proprietor income, etc.) that make up the industry spending pattern as a whole. A list of IMPLAN multipliers used for this report is provided in Technical Appendix A, Table A6.

A few key factors need to be considered when interpreting estimations from this report.

Job estimates refer to the number of jobs the modeled spending supports in a specific year. Since IMPLAN is a linear input-output model, it assumes constant returns to scale based on fixed multipliers and a static time dimension. Hence, our analysis does not take into consideration potential changes in labor productivity. All dollar values presented in the report are in nominal 2020 dollars and do not account for inflation. Also, as IMPLAN is not a general equilibrium model, our analysis only captures changes pertinent to the sectors or subsectors modeled and does not capture macroeconomy-level changes. Since we rely on cost or spending inputs that cover domestic activities of the energy economy (e.g., in the transportation sector, the modeling inputs measure capital costs of different vehicle types sold in the United States under the different scenarios, while for the fuels sector, modeling inputs measure the cost of fulfilling or meeting domestic fuel demand for different fuel sources), estimating potential economic impacts coming from U.S. exports is beyond the scope of this report. Additionally, our modeling analysis does not take into account opportunity costs for investments. We do not break down the costs or spending used as modeling inputs (provided in Technical Appendix A, Table A2) into private versus public spending due to data unavailability, and we assume that the source of investment is exogenous (either the government decides to allocate or the private sector is forced to invest through regulation).

For the policy lever modeling, our analysis depends on a couple of key underlying assumptions. For the family-sustaining wage analysis, we assume that increasing wages of employees does not impact the amount of labor demanded or the final costs of products or services. For the domestic manufacturing policy lever modeling, the analysis estimates potential impacts under different domestic content assumptions for each sector studied individually and assumes that changes in one sector only impact that sector; there is no effect on the balance of trade or other macroeconomic connections.


ESC

CHAPTER 3.

THE SOCIOECONOMIC IMPACTS OF FEDERAL DECARBONIZATION POLICIES: ECONOMY-WIDE RESULTS

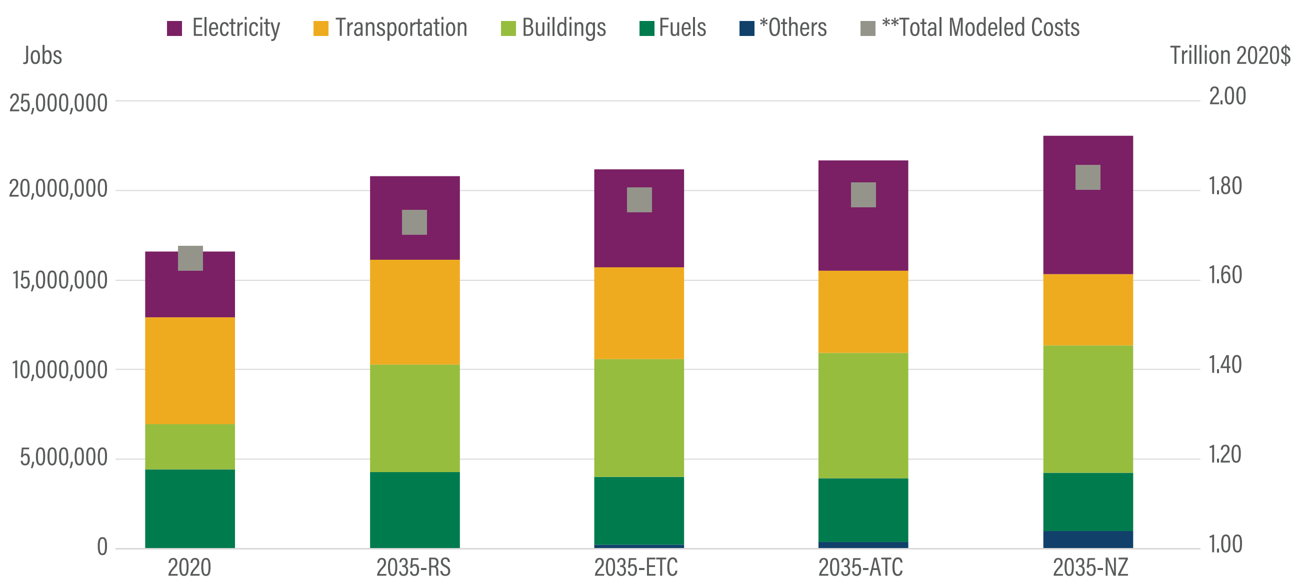
Using the aforementioned assumptions, our simulations show investments in the low-carbon economy leading to significant GHG emissions reductions and generating new economic opportunities, the benefits of which can be amplified through policies that target domestic job growth and quality.

3.1 Net Employment and Other Economic Impacts (Under Base Modeling Assumptions)

Federal climate policies and investments help deliver an energy economy with positive net job impacts across all mitigation scenarios, with policies that put the United States on track to reach net-zero emissions by midcentury, achieving the largest economic benefit. The net-zero scenario results in the greatest job gains, adding 6.5 million net jobs in the energy economy from 2020 to 2035, which is 2.3 million more than net jobs added during the same period in the RS (Figure 2). The ETC and ATC scenarios, which include a combination of tax incentives for low-carbon technologies and federal spending on climate-friendly infrastructure at different ambition levels, lead to a net increase of 4.6 million and 5.1 million jobs, respectively, from 2020 through 2035. Compared to the RS, the ETC and ATC scenarios create an additional 0.4 million and 0.9 million jobs by 2035. In 2035, the net-zero economy also generates $1.5 trillion in employee compensation and $0.7 trillion in tax revenues, adding $2.6 trillion to the national GDP (Table 3).

The largest job increases are seen in the buildings and electricity sectors. The buildings sector adds more than 4 million jobs across all mitigation scenarios, with 4.6 million jobs added in the NZ scenario between 2020 and 2035. In comparison, 3.5 million jobs are added in the RS during the same period. Measures taken to improve the energy efficiency of buildings are the most labor-intensive of all clean energy measures and generate local construction jobs in every part of the country.[32] The next biggest job-creating sector is power

Figure 2 | Net employment across different sectors by scenario, 2020 and 2035



Notes: ATC = advanced tax credit (scenario); ETC = extended tax credit (scenario); NZ = net-zero (scenario); RS = reference scenario. Figure 2 compares net employment in 2020 with net employment in 2035 across the RS and mitigation scenarios. "Net employment" here refers to the number of modeled fossil fuel–based and clean energy jobs (direct and indirect jobs as well as induced jobs arising out of spending within each sector) supported by the different sectors in 2020 and 2035.

* The "Others" category includes sectors like industry, waste, technological carbon removal, agriculture, and natural and working lands.

** "Total modeled costs" here refers to spending inputs used for different sectors to estimate economic impacts. This includes fixed costs of different electricity generation sources, capital costs of buildings sector devices and equipment, capital costs of vehicles and charging infrastructure, capital costs of industry energy-efficiency improvements, fuel production costs for different fuel sources, and emissions abatement costs for industrial carbon capture and storage applications, waste management, agriculture, and natural and working lands.

Source: WRI authors and BW Research.

Table 3 | Summary of net economic impacts by scenario, 2020 and 2035

	EMPLOYMENT (MILLION)	LABOR INCOME (TRILLION 2020$)	VALUE ADDED (TRILLION 2020$)	TAXES (TRILLION 2020$)
2020 baseline	16.6	$1.3	$2.3	$0.5
RS 2035	20.8	$1.5	$2.6	$0.6
ETC 2035	21.2	$1.5	$2.6	$0.6
ATC 2035	21.7	$1.5	$2.6	$0.6
NZ 2035	23.1	$1.5	$2.6	$0.7

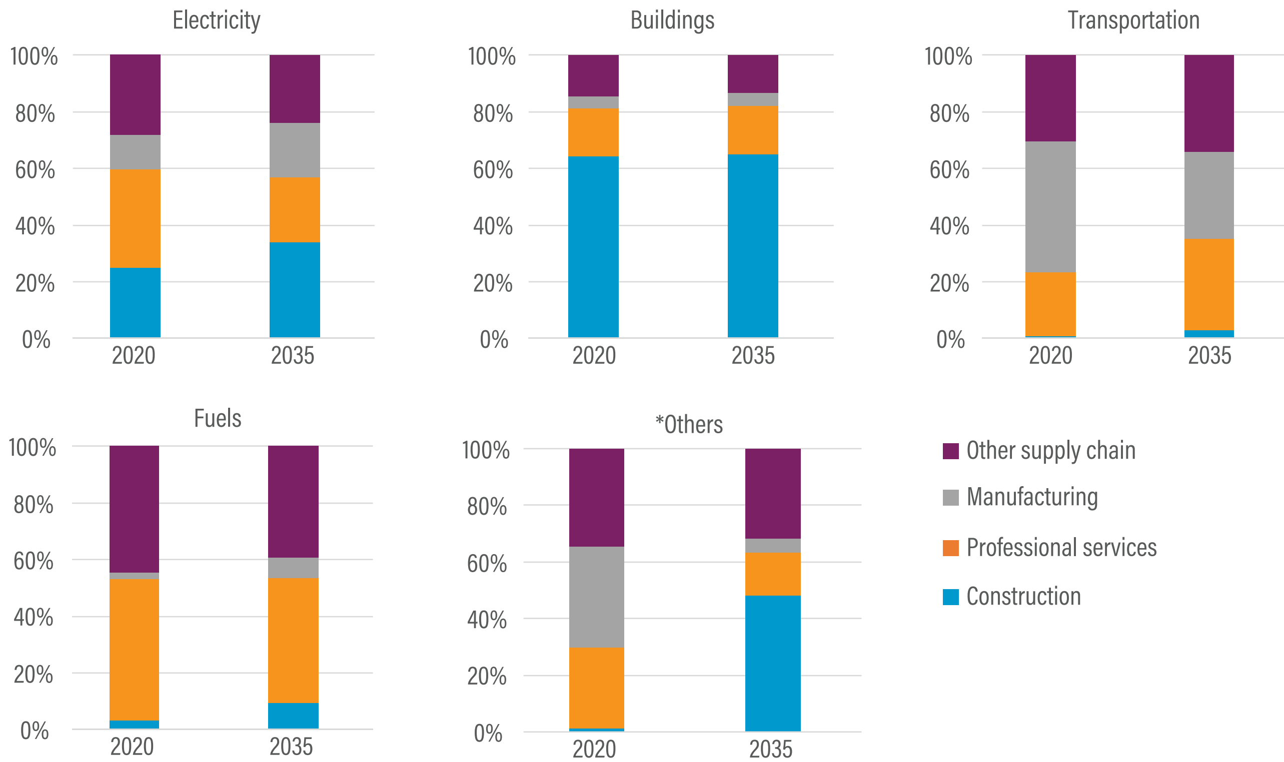
Notes: ATC = advanced tax credit (scenario); ETC = extended tax credit (scenario); NZ = net-zero (scenario); RS = reference scenario. Table shows direct, indirect, and induced impacts. This covers the electricity, transportation, buildings, fuels, industry, waste, technological carbon removal, and agriculture and natural working lands sectors. Dollar values in the table are reported in nominal 2020 dollars. Values in the table appear similar due to rounding (please see Technical Appendix C, Table C1, for actual estimated values). Details on our baseline assumptions can be found in Technical Appendix A.

Source: WRI authors and BW Research.

generation, where federal policies and investments to generate zero-carbon electricity and modernize the electric grid lead to an additional 4.0 million net jobs by 2035 in the NZ scenario, compared to 1.0 million net jobs added in the RS. The industry, waste, negative emissions technology, and agriculture sectors also see job growth by 2035 in the NZ scenario, adding more than 998,000 jobs compared to no job growth in these sectors in the RS.

Construction jobs—both in the construction industry as well as in installation and repair occupations—grow the most across all mitigation scenarios. Of the 13.9 million direct and indirect energy jobs in the net-zero scenario in 2035, 5.0 million jobs are in construction (see Technical Appendix C, Table C2).[33] Other jobs are in manufacturing, professional services, and other parts of the supply chain. Between 2020 and 2035, the industry composition of jobs across sectors changes in different ways (Figure 3). For instance, the massive deployment of utility solar and onshore and offshore wind in the NZ scenario leads to a shift away from professional services jobs and toward construction and manufacturing jobs in the power sector between 2020 and 2035. However, the EV transition leads to direct and indirect job loss associated with the transportation sector across all scenarios. The job losses are largely concentrated in manufacturing, with some losses in other parts of the supply chain. There is an increase in construction jobs associated with the installation of EV charging infrastructure and in professional services

Figure 3 | Sector composition of direct and indirect jobs for the net-zero scenario, 2020 and 2035



Notes: Figure 3 shows direct and indirect jobs associated with the modeled costs for different sectors. Cost inputs for different sectors are allocated to sector-specific supply chain activities in IMPLAN to estimate direct and indirect jobs across construction, manufacturing, professional services, and other supply chains. For the electricity sector, for example, manufacturing jobs include employment associated with power distribution and transformer manufacturing, semiconductor manufacturing for solar, wind turbine manufacturing, and so on, while for the transportation sector, manufacturing jobs include employment associated with automobile and vehicle parts manufacturing.

* The "Others" category includes sectors like industry, waste, negative emissions activities, and agriculture and natural and working lands. Details on our baseline assumptions can be found in Technical Appendix A.

Source: WRI authors and BW Research.

jobs associated with scientific research (e.g., materials scientists and chemists involved in battery research) and EV design and development (e.g., engineers and software developers). But job gains in those categories are not enough to counter the job losses in manufacturing and other supply chain categories. The fuels sector also sees an increase in the share of construction employment, due to the construction of new biofuel and hydrogen fuel facilities. Preparing the skilled workforce needed to deploy various clean technologies will require robust effort across the entire workforce-development system—labor unions, pre-apprenticeship and apprenticeship programs, community colleges, nonprofits, and others. We already have the capacity to identify, and knowledge of, communities that are seeing and will see disruption from the transition to a net-zero economy. Efforts can and should start today to mobilize that workforce development system to prepare those communities to capitalize on potential clean energy job creation.

3.2 Ensuring a Managed Transition That Protects Workers

Despite net job growth across the economy and without policies fostering increased domestic manufacturing and supply chain growth, the decarbonization pathways modeled entail significant decline in jobs in some sectors across all mitigation scenarios (in the base model), primarily in transportation due to the transition from internal combustion engine (ICE) vehicles to EVs and in the fossil fuels subsector. Job losses associated with the electricity sector result from coal phaseout and in the buildings sector from declining natural gas building connections and natural gas fuel consumption. These job losses related to the buildings sector have been captured in the fuels sector.[34] While both the ETC and ATC scenarios lead to a decline of approximately 4.2–4.6 million jobs associated with these subsectors by 2035, the NZ scenario sees the maximum decline of 7.6 million jobs. In comparison, the RS sees a decline of 2.0 million jobs by 2035 (Table 4). The RS in this analysis does not capture recent developments such as the Advanced Clean Cars II proposal, hence our RS estimates could be underestimating the changes likely to occur under a business-as-usual scenario. The move to a net-zero economy is essential. While the shift toward it will unleash new employment and economic opportunities in manufacturing and deployment of clean technologies and associated infrastructure, it also entails negative

Table 4 | Summary of employment impacts across sectors by scenario, 2020 and 2035, in thousands of jobs

	2020	2035	CHANGE (2020–35)	2035	CHANGE (2020–35)	2035	CHANGE (2020–35)	2035	CHANGE (2020–35)
		Reference Scenario (RS)		ETC Scenario		ATC Scenario		NZ Scenario	
Electricity	**3,679**	**4,690**	**1,011**	**5,490**	**1,810**	**6,165**	**2,486**	**7,718**	**4,038**
Distributed solar PV	395	497	101	497	102	497	102	497	101
Utility solar	101	616	516	1,002	902	1,499	1,399	2,549	2,448
Offshore wind	0	108	108	108	108	108	108	111	111
Onshore wind	188	465	277	886	698	1,057	869	1,423	1,235
Other generation	183	183	0	183	0	183	0	183	0
Natural gas	334	496	162	465	131	448	113	495	160
*Coal***	182	0	-182	0	-182	0	-182	0	-182
*Nuclear***	307	293	-15	269	-39	272	-35	272	-35
Transmission and distribution	1,877	1,909	31	1,954	77	1,975	97	2,058	180
Storage	112	124	12	126	15	126	15	131	19
Buildings	**2,511**	**6,018**	**3,507**	**6,577**	**4,067**	**6,980**	**4,470**	**7,120**	**4,609**
Residential efficiency	1,173	1,989	816	2,510	1,338	1,957	784	1,741	568
Nonresidential efficiency	886	3,389	2,503	3,396	2,510,	3,365	2,479	3,353	2,467
Residential electrification	265	401	137	417	152	919	654	1,104	839
Nonresidential electrification	188	239	51	255	67	740	552	923	735

Table 4 | Summary of employment impacts across sectors by scenario, 2020 and 2035, in thousands of jobs (Cont.)

	2020	2035	CHANGE (2020-35)	2035	CHANGE (2020-35)	2035	CHANGE (2020-35)	2035	CHANGE (2020-35)
		Reference Scenario (RS)		ETC Scenario		ATC Scenario		NZ Scenario	
Transportation	**5,963**	**5,819**	**-145**	**5,109**	**-854**	**4,594**	**-1,369**	**4,000**	**-1,963**
Alternative vehicles	310	1,744	1,434	2,391	2,081	2,159	1,849	3,651	3,342
AV infrastructure	17	117	100	368	351	156	139	245	228
*ICE vehicles***	5,637	3,958	-1,679	2,351	-3,286	2,279	-3,358	104	-5,533
Fuels	**4,431**	**4,280**	**-151**	**3,788**	**-643**	**3,557**	**-874**	**3,225**	**-1,206**
Hydrogen	0	6	6	6	6	8	8	369	369
Biofuels	163	159	-4	232	70	334	171	418	255
*Fossil fuels***	4,268	4,115	-153	3,549	-719	3,214	-1,053	2,437	-1,830
Industry	**0**	**0**	**0**	**125**	**125**	**170**	**170**	**765**	**765**
Waste	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Technological carbon removal	**0**	**0**	**0**	**21**	**21**	**21**	**21**	**43**	**43**
Agriculture and natural and working lands	**0**	**0**	**0**	**89**	**89**	**190**	**190**	**190**	**190**
Total Energy Economy Employment	**16,584**	**20,807**		**21,199**		**21,677**		**23,060**	
Total Modeled Costs (Trillion 2020$)*	**$1.65**	**$1.73**	**$0.09**	**$1.78**	**$0.13**	**$1.79**	**$0.14**	**$1.83**	**$0.18**
Net Change in Employment			**4,223**		**4,615**		**5,093**		**6,476**

Notes: AV = alternative vehicle; ATC = advanced tax credit; ETC = extended tax credit; ICE = internal combustion engine; NZ = net-zero; PV = photovoltaic. Table shows direct, indirect, and induced jobs. Direct and indirect employment numbers represent estimates of domestic jobs generated in the energy economy due to the spending modeled across these sectors, while induced jobs represent estimates of jobs supported by energy economy workers spending their income in the general U.S. economy.

* "Total modeled costs" here refers to spending inputs used for different sectors to estimate economic impacts. This includes fixed costs of different electricity generation sources, capital costs of buildings sector devices and equipment, capital costs of vehicles and charging infrastructure, capital costs of industry energy-efficiency improvements, fuel production costs for different fuel sources, and emissions abatement costs for industrial carbon capture and storage applications, waste management, agriculture, and natural and working lands.

** Coal and nuclear generation, ICE vehicles, and fossil fuels see declines in employment.

For estimating potential economic impacts for the industry sector, we used cost estimates of energy savings (measured as the difference between industry energy demand in the mitigation scenarios and the reference scenario) as a proxy for spending on energy-efficiency improvements. The 2020 employment number for this sector is 0 as the estimated cost of energy improvements for 2020 is 0 (since industry energy demand in 2020 is the same in the three mitigation scenarios compared to the reference scenario as shown in Technical Appendix D, Table D1). For the agriculture, natural and working lands, and waste sectors, we used emissions abatement costs as a proxy for spending required to achieve emissions reductions (measured as the difference in emissions in the mitigation scenarios and the reference scenario). The 2020 employment number for these sectors in 2020 is 0 as estimated emissions abatement cost for 2020 is 0 (since there are no differences in emission levels in these sectors in 2020 in the three mitigation scenarios compared to the reference scenario, as shown in Technical Appendix D, Table D7). There are no changes in employment numbers for these sectors and technological carbon removal in the reference scenario as the analysis did not model any spending estimates for these sectors for the reference scenario. Additional details on each sector and our sector assumptions are included in the text of the report and appendices.

Source: WRI authors and BW Research.

impacts on workers, families, and communities dependent on fossil fuels, especially on the extraction side. Policymakers will need to address this economic change no matter the pace of the energy transition unfolding in the economy.

The increasing deployment of EVs has implications for workers in auto manufacturing and related sectors, with impacts ranging from job losses to a need for retraining and transitioning to opportunities in zero-emissions mobility. Electric vehicles are expected to take less labor to manufacture, assemble, and maintain than ICE vehicles and will also require a shift in the infrastructure associated with vehicle fueling. This will mean fewer jobs across auto parts manufacturing, vehicle assembly, car dealerships, vehicle maintenance and repair shops, and gas stations.[35] Our analysis reveals that employment associated with ICE vehicles drops by 5.5 million jobs in 2035 in the NZ mitigation scenario (compared to a decline of 1.7 million jobs in the RS), while the employment increase associated with EV and charging infrastructure deployment is significantly less, at 3.6 million jobs (Table 4). Out of the 5.5 million ICE vehicle–associated jobs lost in the NZ scenario by 2035, 1.5 million are automobile manufacturing jobs and 1.7 million are professional services or other supply chain jobs; these job losses contribute to a decline of 2.3 million induced jobs. The NZ scenario shows a net loss of about 887,500 manufacturing jobs—after factoring in manufacturing job losses associated with ICE vehicles and job gains associated with EV manufacturing—by 2035 across the transportation sector (see Technical Appendix C, Table C2). According to the Building Blocks analysis, BEVs reach a 100 percent market share (share of BEVs in annual sales) in the LDV segment, 74 percent in the MDV segment, and 35 percent in the HDV segment by 2035 in this scenario, compared to 27 percent, 20 percent, and 11 percent for LDVs, MDVs, and HDVs, respectively, in the RS (see Technical Appendix D, Table D5). Some workers will experience a relatively seamless transition from assembling ICE vehicles to assembling EVs; for others the jobs may require different skills, amounts of time and engagement, or they may be in different locations.

Significant job losses are associated with the fuels sector, concentrated in petroleum, natural gas, and coal mining and extraction as well as wholesale trade, distribution, and transportation. Even though biofuel and blue and green hydrogen employment grows, it is less than the fossil fuel employment loss driven by declines in oil and natural gas consumption due to transportation and buildings electrification and efficiency improvements. Approximately 1.8 million fossil fuel jobs are lost between 2020 and 2035 in the NZ mitigation scenario, which is about 12 times higher than the 153,000 fossil fuel jobs lost in the RS. This job loss includes both induced job loss as well as direct and indirect job loss across the fuels sector supply chain, from mining and extraction to distribution to pipes and power plants. Nearly half of the job losses in the NZ scenario (0.9 million) are from induced jobs; another 0.9 million jobs are lost in professional services or other supply chain; and 0.03 million jobs are lost in manufacturing and construction (see Technical Appendix C, Table C2). While this does reflect the impacts of a clean energy transition, for some fuels like coal this is the culmination of a market-driven transition already in motion. The U.S. coal industry has been in decline for years, largely because of competition from more cost-effective energy sources, like natural gas and renewable energy (Saha 2016).

In the electricity sector, more than 180,000 jobs associated with coal power generation, which includes jobs across the supply chain and induced jobs, are lost by 2035 across all three mitigation scenarios. Job losses are also seen in the nuclear industry, as both generation from nuclear power plants (see Technical Appendix D, Table D4) and the share of nuclear energy in total electricity generation declines across all mitigation scenarios between 2020 and 2035.[36] The job losses in coal and nuclear are, however, small compared with the overall gain of 4.0 million jobs in the NZ scenario in the electricity sector. If you consider both job losses in coal and nuclear and job gains in natural gas generation, in the NZ scenario between 2020 and 2035 there is a net loss of 0.06 million jobs. Job growth is mostly positive across job categories, except for other supply chain employment, where 0.09 million jobs are lost, and induced employment, where 0.05 million jobs are lost (see Technical Appendix C, Table C2).

Federal policy can help mitigate and manage these job losses, while maximizing the replacement potential of new clean energy jobs. Federal policies can mitigate the impact of local job losses by creating accessible replacement opportunities, including through policies that promote the retention of clean energy jobs in the United States and direct investment in communities most impacted by the low-carbon transition. Such polices can include domestic content requirements, the impacts of which are discussed below, enhanced tax incentives or dedicated grants for clean energy facilities located in fossil-fuel dependent communities, and support for repurposing fossil fuel assets and rehabilitating polluted sites for clean energy projects. This spending can be made more effective by investments in technical assistance, workforce development, and training programs, directly connected to pipelines for quality employment such as apprenticeships that equip workers in fossil fuel–based, energy-intensive industries to transition to new and related clean energy–based opportunities and opportunities in other growing sectors of the U.S. economy.

While job creation in the low-carbon transition has the potential to far outpace job losses, it will be impossible to ensure a perfect geographic and skills profile match between new and phased-out jobs. A significant federal investment in place-based economic development is important to ensure an equitable net-zero transition and create alignment between phasing out industries and new opportunities when possible. Further, federal support will be essential to support workers during the transition through income replacement, bridges to retirement funding, relocation support, education assistance, community transition support, and local economic diversification investments.

3.3 Using Federal Domestic Content Requirement to Create U.S. Jobs

Our simulations show that increasing the requirement for domestic manufacturing of clean technologies results in additional employment in 2035 across all scenarios relative to employment numbers in the base model.[37] A principal goal of domestic content requirements is to ensure that climate policies produce local economic benefits, including job creation—fostering a nascent industry to grow into a globally competitive industry—and energy security. Doubling domestic content share in solar and storage to 50 percent and requiring at least 75 percent domestic content manufacturing in wind leads to an additional 895,500 jobs associated with the electricity sector by 2035 (Table 5), which is substantially more than the 217,000 lost jobs associated with coal and nuclear generation (Table 4). In fact, a domestic content share of 38 percent for solar and storage would result in job creation that outpaces job losses associated with coal and nuclear generation, while the domestic content share for wind that could result in job creation outpacing job losses is 60 percent.

The greatest employment impact arising from higher domestic content requirements is seen in alternative vehicles, where securing a high share of battery manufacturing in the United States can substantially mitigate

anticipated job losses associated with the entire ICE supply chain. Given the significant job loss due to the transition from ICE vehicles to EVs, supportive federal policies to incentivize manufacturing of lithium-ion batteries and EVs in the United States can help counter some of that job loss. The employment impacts generated from the alternative vehicle sector assuming 75 percent domestic content of batteries would lead to an additional 1.7 million jobs, potentially creating job growth equal to as much as 87 percent of net job losses associated with the transportation sector experiences in the NZ scenario (Table 5).

To conform with the 2022 rule changes to the Buy American Act, at least 65 percent of all efficiency measures must be sourced domestically. When this assumption is incorporated into the model, the average of domestically produced content in the buildings sector increases from 73 percent to 78 percent. This requirement increases buildings employment in 2035 by about 43,000 jobs, while sourcing 100 percent of efficiency products domestically adds 134,300 jobs, achieving a 1 and 3 percent increase in employment supported by energy-efficiency measures in the buildings sector in 2035, respectively (Table 5).

Pairing incentives for domestic manufacturing of clean energy technologies with targeted investment in regions and communities most impacted by the transition can help create an equitable net-zero economy. Incentivizing domestic manufacturing through domestic content requirements can increase job growth in the United States and help counter some of the job loss associated with fossil fuels subsector. Paired with additional incentives connected with subnational targeting,[38] domestic content requirements can direct that growth toward communities with the greatest need, including those that host industries experiencing significant job loss through the clean energy transition. Further, through codevelopment and with community support, they can support clean energy deployment and economic benefits in communities that have generally faced high pollution, economic distress, and limited access to federal investments.

There are concerns that regulatory policies focused on growing domestic clean energy manufacturing, beyond what the market would do, may directly or indirectly impact the cost and deployment of clean energy, while contributing to more protectionist policies that could broadly drive up prices and restrict economic opportunity for the United States and its trade partners (Clausing 2019; Platzer and Mallett 2019; Carpenter 2019). While empirical evidence is limited on the actual cost of domestic content requirements and assessing that impact in the context of other economic forces is difficult, some researchers have sought to evaluate costs and

Table 5 | Change in employment (in thousands of jobs) in NZ scenario from increasing domestic content requirement

SECTOR AND BASE MODEL DOMESTIC CONTENT SHARE	BASE MODEL EMPLOYMENT (2035)	ADDITIONAL JOBS CREATED UNDER DIFFERENT DOMESTIC CONTENT SHARE (2035) (POLICY LEVER MODEL)				
		50%	75%	78%	90%	100%
Solar (25%)	3,046	393	786			
Storage (25%)	131	29	58			
Alternative vehicles (25%)	3,651	850	1,700			
Onshore wind (46%)	1,423		428		647	
Offshore wind (45%)	111		45		68	
Buildings (73%)	7,120			43		134

Notes: NZ = net-zero. Table shows additional jobs (direct, indirect, and induced) created under different domestic content assumptions in 2035, relative to employment in 2035 under baseline domestic content assumptions. Changes in one sector only impact that sector.

Source: WRI authors and BW Research.

benefits using data from industry sources and macroeconomic modeling (Platzer and Mallett 2019). A review of how such requirements impacted transportation infrastructure and U.S. manufacturing found that the requirements have likely preserved some domestic iron and steel jobs while bolstering the U.S. production of railcars and buses. However, it may have increased the cost for some projects and has been blamed for delays in project completion (Platzer and Mallett 2019). In the context of clean energy investments, it is certainly important to monitor and integrate these concerns, including ensuring that job creation potential is accurately projected and not overestimated and that indirect effects on other sectors and countries, especially regarding job losses, are taken into account. Recent work suggests that, in the case of solar and wind, boosting domestic manufacturing only results in a small increase in total project capital costs (Mayfield and Jenkins 2021).[39] Enhanced domestic manufacturing also brings other benefits, including increasing resilience in the face of supply chain disruptions and maintaining U.S. leadership in technology and innovation.

Balancing both domestic production and rapid deployment of low-carbon technologies will be essential, with the understanding that it will take time to build domestic manufacturing capacity and require an integrated strategy of strengthening the supplier base, which typically comprises small and medium-sized enterprises (SMEs) that have trouble accessing capital directly as well as technical and financial assistance (Lin et al. 2022) and developing a high-skilled manufacturing workforce. Federal policies that help SMEs enhance their operations through financing programs, tax incentives, and business accelerators will be key (Ezell 2020; Ramaswamy et al. 2017). On the workforce front, apprenticeship programs that pay trainees while they learn on the job can be effective in preparing workers for clean energy employment (Haimson and Sattar 2021).[40] It will be important to monitor the evolving evidence and political consensus around balancing the benefits of economic openness and protecting domestic jobs and capacity as climate policy develops and new programs are implemented.

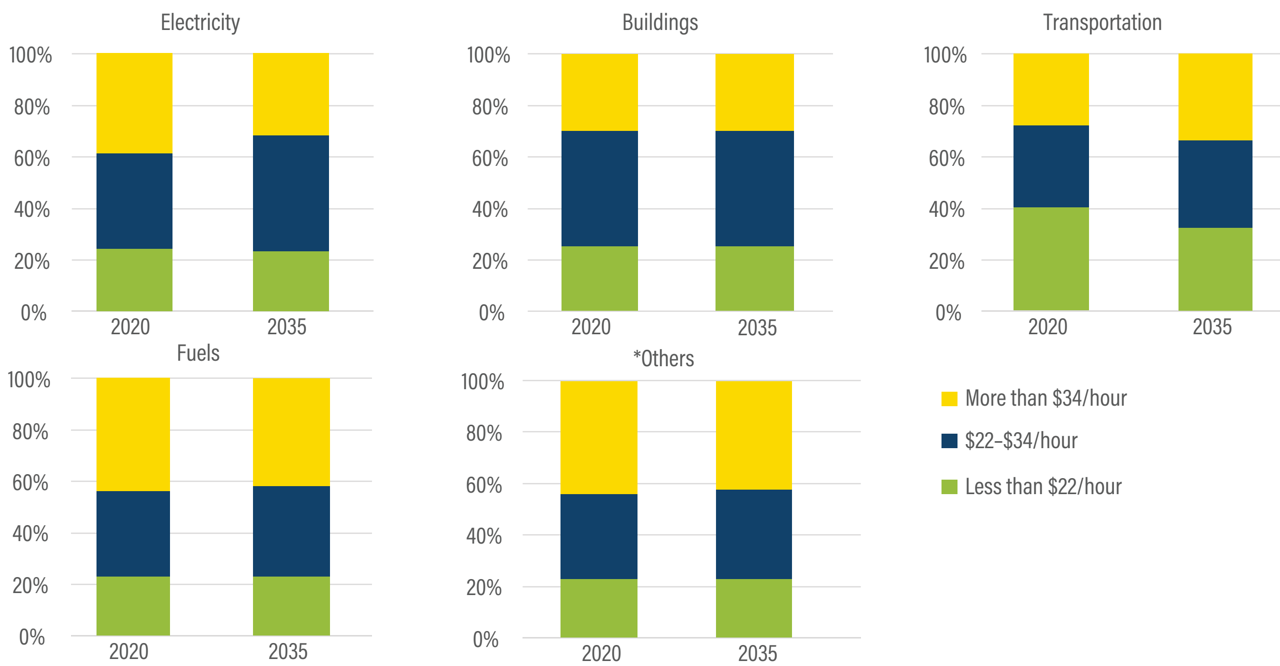
3.4 Enhancing Job Quality through Family-Sustaining Wages

Investments in the net-zero economy can create jobs with family-sustaining wages across sectors. In our analysis, a "below family-sustaining" wage is defined as less than $22 per hour, an "above family-sustaining" wage is defined as more than $34 per hour, and a family-sustaining wage is defined as $22 to $34 per hour (in nominal 2020 dollars). This family-sustaining measure is one way to assess wage quality at a national level, but it cannot account for regional differences in wages and the cost of living. Aside from the transportation, waste management, and agriculture sectors, where a third or more of workers are likely to earn below family-sustaining wages in 2035 (without policy intervention), less than a quarter of workers in other sectors fall into this category.

Simulations show no change in the wage distribution of workers in the buildings and fuels sectors between 2020 and 2035 (Figure 4). The electricity sector sees an increase in the share of workers earning a family-sustaining wage, but it does so by drawing from the share of workers earning an above family-sustaining wage, therefore reducing net gains. The transportation sector sees a significant decline in the share of workers earning below family-sustaining wages and a corresponding increase in the share of workers earning above family-sustaining wages. These changes are a reflection of shifts in industry composition of employment across sectors between 2020 and 2035. For instance, the share of workers in professional services, which tend to be better paid, increases from 23 percent in 2020 to 32 percent in 2035 in transportation.

Putting in place requirements to pay prevailing wages and stronger labor standards can help ensure that the net-zero transition generates well-paying jobs with benefits and opportunities for career advancement. Our analysis looks at the economic impacts of increasing the income of workers currently earning a below family-sustaining wage to a wage of $22 an hour.[41] In the NZ scenario, by 2035 approximately 3.6 million workers across the eight sectors earn

Figure 4 | Hourly wage distribution of direct and indirect jobs for the NZ scenario, 2020 and 2035



Notes: NZ = net-zero. The "Others" category includes sectors like industry, waste, negative emissions activities, and agriculture and natural and working lands. Dollar values in the figure are reported in nominal 2020 dollars.

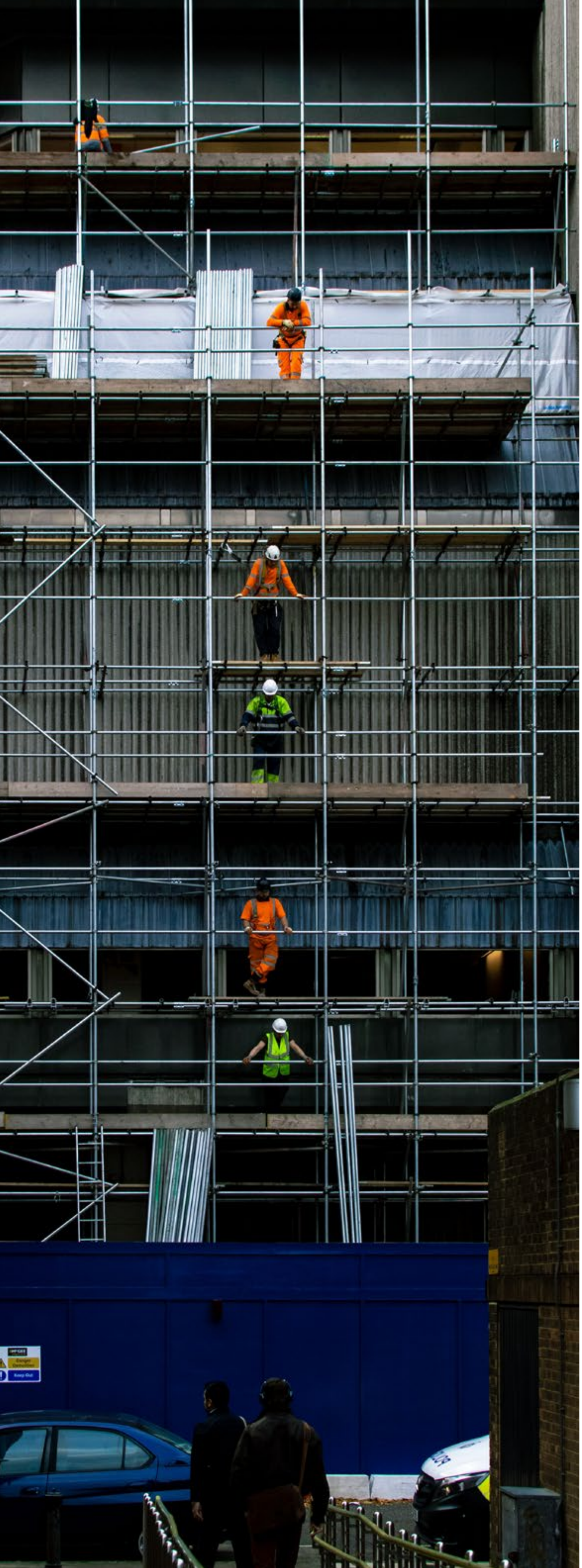
Source: WRI authors and BW Research.

Table 6 | Economic impacts of increasing incomes to family-sustaining wage level

	SHARE OF EMPLOYEES EARNING <$22/HR (IN 2020 NZ SCENARIO)	EMPLOYEES EARNING <$22/HR (IN 2035 NZ SCENARIO) (IN THOUSANDS)*	SHARE OF EMPLOYEES EARNING <$22/HR (IN 2035 NZ SCENARIO)	ANNUAL COST OF INCREASING WAGES TO $22/HR (IN MILLIONS)**	SECTOR SHARE OF ANNUAL COST OF INCREASING WAGES TO $22/HR	INDUCED JOBS CREATED BY EMPLOYEES SPENDING ADDITIONAL INCOME (IN THOUSANDS)***	GDP/VALUE ADDED BY EMPLOYEES SPENDING ADDITIONAL INCOME (IN MILLIONS)
Electricity	24%	1,020	22%	$7,075 (4%)	31%	58	$5,927
Fuels	23%	374	23%	$2,506 (1%)	10%	20	$2,099
Buildings	25%	1,183	25%	$7,330 (2%)	29%	60	$6,140
Transportation	40%	890	32%	$6,769 (1%)	27%	55	$5,671
Other sectors	26%	173	26%	$1,329 (2%)	6%	11	$1,113
Total		**3,640**		**$25,010 (1%)**		**203**	**$20,951**

Notes: GDP = gross domestic product; NZ = net-zero. * These are direct and indirect jobs in these sectors. ** The percentages shown in parentheses for different sectors report the annual cost of increasing wages to $22 an hour as a share of the total modeled costs. *** These are induced jobs created by employees spending their additional income in the economy. Other sectors here include industry, waste management, agriculture and natural and working lands, and technological carbon removal. Dollar values in the table are reported in nominal 2020 dollars.

Source: WRI authors and BW Research.



a below family-sustaining wage, with nearly 2.2 million of them in the electricity and buildings sectors (Table 6).

The total cost of increasing the wages for these workers to $22 an hour is estimated to be $25.0 billion per year, which represents a 1 percent increase in total modeled costs (see Technical Appendix B for methodology). For context, in 2015 the United States provided $649 billion in fossil fuel subsidies (Coady et al. 2019). At the same time, by increasing workers' earnings and thereby consumer spending in the economy, an additional 203,400 jobs are created and $21.0 billion in GDP is added (or 84 percent of the cost of increasing wages), along with $4.7 billion in tax revenue.

There may be concerns that increasing wages will make clean energy projects more expensive and slow their development. However, evidence to date does not show that higher wages as a result of prevailing-wage requirements will have this impact (Mayfield and Jenkins 2021; Jones 2020; Manzo 2021). Labor costs for solar projects, for instance, represent 6–11 percent of total project costs. Even a 50 percent increase in labor costs would increase project costs by only 3 to 5 percent, which could be absorbed by other cost categories without necessarily impacting overall project cost. In addition, the modest increase in cost could be offset by productivity improvements if higher wages induce more efficient work and/or project developers and contractors hire more productive workers in response to a wage increase (Mühlau and Lindenberg 2003; Philips 2014). The wage range that would produce and maximize these efficiency and productivity improvements is an area for further study.

3.5 Diversity in the Energy Workforce

Compared to 2020, the energy workforce of 2035 in the net-zero scenario is only slightly more diverse. Simulations show a slight improvement in female participation by 2035 across the electricity, buildings, transportation, and fuels sectors, but, in general, we see a continuation of the lack of meaningful diversification in the energy workforce from 2018 to 2021 (Table 7).[42] Significant gender gaps persist even in 2035, compared to the 2020 national average. Without policy intervention such as training programs tied to employment

Table 7 | Demographic composition of employment by sectors in the NZ scenario, 2020 and 2035

		ELECTRICITY		BUILDINGS		TRANSPORTATION		FUELS	
		2020	2035	2020	2035	2020	2035	2020	2035
GENDER	Male	72%	71%	75%	72%	77%	75%	74%	71%
	Female	28%	29%	25%	28%	23%	25%	26%	29%
ETHNICITY	Hispanic or Latino	17%	17%	15%	16%	17%	18%	12%	12%
	Not Hispanic or Latino	83%	83%	85%	84%	83%	82%	88%	88%
RACE	American Indian or Alaska Native	2%	1%	1%	1%	2%	1%	2%	1%
	Asian	9%	11%	6%	10%	5%	5%	5%	5%
	Black or African American	10%	9%	8%	9%	12%	11%	8%	13%
	Native Hawaiian or other Pacific Islander	1%	1%	1%	1%	1%	1%	1%	1%
	White	69%	68%	77%	73%	73%	71%	76%	73%
	Two or more races	9%	11%	7%	6%	8%	10%	9%	7%
AGE	55 and over	15%	22%	13%	12%	19%	17%	19%	16%

Notes: NZ = net-zero. For sectors shown in Table 7, the share of employment for different demographic groups is based on trends in 2018–21 USEER data. Please see Technical Appendix A, Table A5, for the data used. Trends during the 2018–21 period varied by sector, but change is generally minimal. Some notable trends (greater than 5 percent change over three years) include an increase in representation of women in fuels and energy efficiency; decreased American Indian or Alaska Native worker participation in energy efficiency, electric power generation, and fuels; an increase in Asian worker participation in energy efficiency and electric power generation but decrease in fuels; decreased Hispanic or Latino participation in the electric power generation workforce; increased Black or African American worker participation in energy efficiency, fuels, and motor vehicles; a decrease in Native Hawaiian or other Pacific Islander worker participation in electric power generation and an increase in motor vehicles; a decrease in the share of the workforce over 55 in all assessed sectors other than electric power generation; and, overall, no major change in white worker participation across sectors. Data for sectors like industry, waste management, agriculture and natural and working lands, and technological carbon removal are not included in the table due to data unavailability.

Source: WRI authors and BW Research.

opportunities (pre-apprenticeship and apprenticeship programs, etc.), mentorship and supportive networks for women, workplaces that accommodate women's caregiving obligations and needs, and gender targets, jobs in the low-carbon economy, especially those in construction and manufacturing, are more likely to be taken up by men (Jaeger et al. 2021; Carlock et al. 2021).

In terms of racial and ethnic diversity, there would be no change in the ethnic composition of the energy workforce between 2020 and 2035, which in 2020 varied across sectors but was generally—though not always—near the national average (Carlock et al. 2021).[43] Asian American workers see a small increase in employment in the electricity and buildings sectors during this period, as do African American workers in the fuels sector. On the whole, however, the clean energy economy's diversity problem would continue in 2035 as the workforce will not diversify further without intervention, making it imperative that policies to support the low-carbon transition explicitly focus on inclusion of women and underrepresented racial and ethnic groups.[44]

Beyond racial or gender breakdown within sectors, other patterns must be considered when thinking about workforce diversity. These include a lack of diversity in ownership and leadership in clean energy, as well as the gender and racial wage gap that is an issue across the economy. In the solar industry, the pay gap for women was found to be higher than the national average, while pay for Hispanic, white, and Black workers in the solar industry was found to be generally similar (Solar Foundation 2019). Pay equity is an important consideration that impacts job quality, influences the average wage, and will become increasingly relevant as efforts are made to diversify the workforce.

CHAPTER 4.

SOCIOECONOMIC IMPACTS BY SECTOR

This section explores sector results in more depth. In addition to presenting data on job impacts across scenarios, we also discuss the industry composition of employment, wage distribution, demographic composition of workers, negative employment impacts, and job gains resulting from domestic content requirements.

4.1 Electricity

Decarbonizing electricity is important both in itself and for decarbonizing other sectors of the U.S. economy. Strategies for decarbonizing the power sector include rapidly phasing out coal, accelerating deployment of renewables, building other zero-emissions generating sources, adding short- and long-term energy storage, and upgrading the electric grid, including building new transmission capacity to move clean energy between different parts of the country. In terms of the socioeconomic impacts of these strategies, our analysis yields the following key results:

- The electricity sector supports 7.7 million jobs in 2035 in the NZ scenario, compared to 4.7 million jobs in the RS. In addition, it generates $399.6 billion in labor income, $844.5 billion in value added, and $269.0 billion in tax revenues (Table 8). The electricity sector adds 4.0 million jobs between 2020 and 2035 in the NZ scenario, representing a 110 percent growth during that period. In comparison, 1.0 million jobs are added between 2020 and 2035 in the RS, representing a 27 percent increase.
- Utility-scale solar and onshore wind drive much of the job growth across all scenarios. In the NZ scenario, utility-scale solar and onshore wind add 2.4 million and 1.2 million jobs (Figure 5), respectively, by 2035, driven by significant capacity additions. The renewable electricity sector, including storage, grows from fewer than 1 million jobs in 2020 to 4.9 million jobs in the 2035 NZ scenario (compared to 2.0 million jobs in 2035 in the RS). Nuclear, however, sees an associated job loss of 35,000–38,000 between 2020 and 2035 depending on the mitigation scenario due to nuclear capacity retirements (compared to 15,000 job losses in the same time period in the RS).
- The share of manufacturing jobs doubles by 2035 in all mitigation scenarios, with wind emerging as the biggest winner. In the NZ scenario onshore and offshore wind account for 54 percent of the electricity sector's manufacturing jobs in 2035.
- In the NZ scenario, 78 percent of electricity sector workers make more than $22 an hour by 2035 (Figure 4). However, there is an increase in the share of workers earning a family-

sustaining wage of $22–$34 an hour and a corresponding decrease in the share of workers earning an above family-sustaining wage of more than $34 an hour. This is because there are more new construction and installation workers and fewer professional and managerial workers in 2035 relative to 2020.

- The electricity sector's diversity problem remains unaddressed, with 68 percent of the sector's workers white even in 2035, while the rate of female participation stands at 29 percent (Table 7). Another concerning issue is an aging workforce, with the share of workers aged 55 and older increasing to 22 percent in 2035 from 15 percent in 2020. With nearly a quarter of the workforce close to retirement in 2035, the industry will need to attract and train their replacements.
- Job losses are associated with fossil fuel–based electricity generation, with all coal generation jobs lost by 2035 across all mitigation scenarios. Loss of employment associated with fossil energy is the lowest in the NZ scenario, with 21,300 jobs displaced, compared to a high of 68,400 jobs displaced in ATC. This is because investments in gas combustion turbine capacity in the NZ scenario lead to an employment increase in gas-fired electric generation.
- Enhanced domestic manufacturing in the sector enables additional job creation that is greater than job loss associated with fossil-based generation. In the NZ scenario, the increase in jobs as a result of doubling the domestic content share in solar and storage and requiring at least 75 percent domestic manufacturing in wind is five times higher than the job losses associated with fossil-based electricity generation.

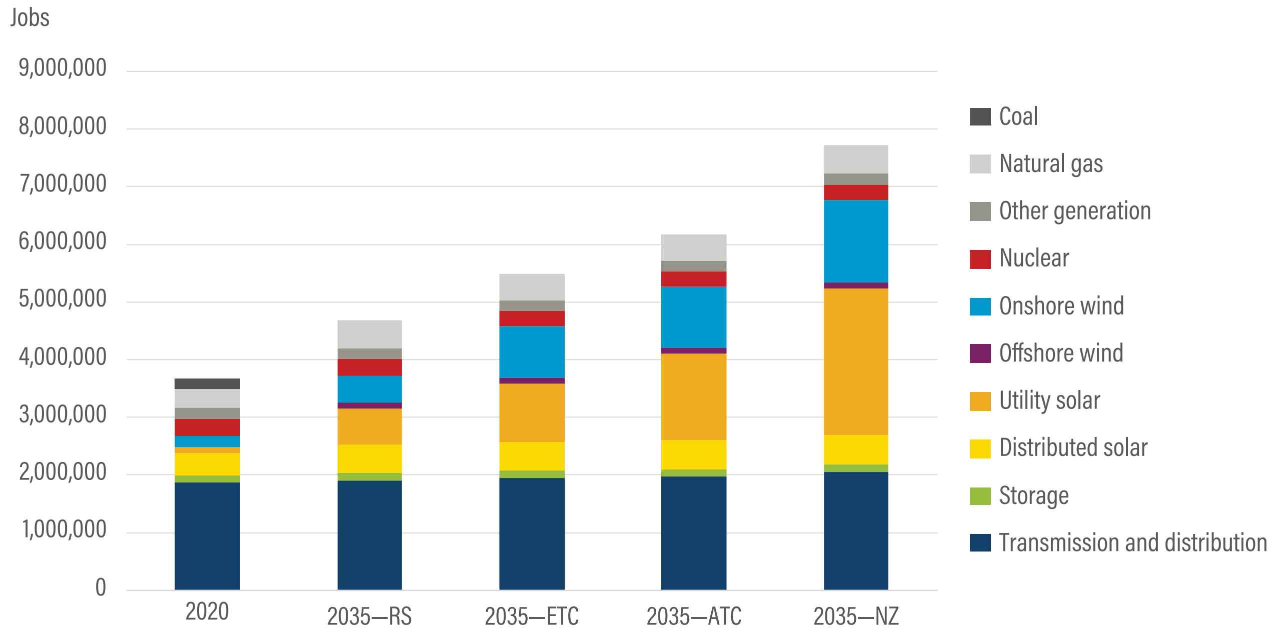
Table 8 | Electricity sector economic impacts in 2035 across mitigation scenarios

	EMPLOYMENT (MILLION)	LABOR INCOME (BILLION 2020$)	VALUE ADDED (BILLION 2020$)	TAXES (BILLION 2020$)
2020 baseline	3.7	$287.7	$547.1	$132.7
RS 2035	4.7	$294.1	$588.9	$170.8
ETC 2035	5.5	$344.2	$689.2	$199.9
ATC 2035	6.2	$359.8	$737.1	$219.4
NZ 2035	7.7	$399.6	$844.5	$269.0

Notes: ATC = advanced tax credit (scenario); ETC = extended tax credit (scenario); NZ = net-zero (scenario); RS = reference scenario. Table shows direct, indirect, and induced impacts. Electricity sector includes distributed solar, utility solar, offshore wind, onshore wind, nuclear, other generation, transmission and distribution, storage, coal, and natural gas. Dollar values are reported in nominal 2020 dollars.

Source: WRI authors and BW Research.

Figure 5 | Electricity sector jobs by subsector in 2035 across mitigation scenarios



Notes: ATC = advanced tax credit (scenario); ETC = extended tax credit (scenario); NZ = net-zero (scenario); RS = reference scenario. Figure shows direct, indirect, and induced impacts. Other generation includes sources like geothermal and bioenergy.

Source: WRI authors and BW Research.

4.2 Buildings

Major opportunities to reduce emissions from buildings come from increased electrification and greater energy efficiency, which can also save consumers money on utility bills and create hundreds of thousands of new jobs. Our analysis yields the following key results:

- The buildings sector, including both energy efficiency and buildings electrification, supports 7.1 million jobs in 2035 in the net-zero scenario. In addition, it generates $469.6 billion in labor income, $698.8 billion in value added, and $152.8 billion in tax revenues (Table 9). In comparison, the RS supports 6.0 million jobs in 2035.
- Energy efficiency shows the largest gain in the ETC scenario, growing from 2 million jobs in 2020 to 5.9 million jobs in 2035 (compared to 5.3 million jobs in 2035 in the RS), driven by tax credits and federal investments in energy-efficiency programs. While energy efficiency remains a major employer across all scenarios, it supports fewer jobs in the ATC and NZ scenarios.[45] The Building Blocks analysis includes more ambitious federal policies, including tax credits for heat pumps, to advance buildings electrification in the ATC and NZ scenarios. Compared to an addition of 188,100 buildings electrification jobs by 2035 jobs in the RS, the ATC scenario adds 1.2 million jobs in the buildings electrification subsector by 2035, while the NZ scenario adds 1.6 million jobs, driven by aggressive electrification policies and building emissions standards in the latter. Residential electrification adds 839,000 jobs over the 15-year period, while nonresidential electrification adds 735,000 jobs over the same time period (compared to an addition of 137,000 and 51,400 residential and nonresidential electrification jobs, respectively, under the RS).

- The majority of workers in energy efficiency (65 percent) and buildings electrification (51 percent) are employed in the construction sector in the NZ scenario, installing or servicing energy-efficiency equipment and heat pumps or performing energy efficiency–related services (Figure 3). The remaining direct and indirect jobs in the buildings efficiency and electrification subsectors are spread across professional services, manufacturing, and other parts of the supply chain.
- Three-quarters of workers are paid family-sustaining or above family-sustaining wages in 2035 in the net-zero scenario (Figure 4). The buildings sector experiences no change in the wage distribution of its workers between 2020 and 2035, given that there is little change in the types of workers employed in industry groups (construction vs. manufacturing, for instance) across time.
- Despite a 3 percent and 4 percent increase in female and Asian participation, respectively, in 2035 (compared to 2020) in the NZ scenario, the sector's diversity challenges persist (Table 7).

Table 9 | Buildings sector economic impacts in 2035 across mitigation scenarios

		EMPLOYMENT (MILLION)	LABOR INCOME (BILLION 2020$)	VALUE ADDED (BILLION 2020$)	TAXES (BILLION 2020$)
Buildings Total	2020 baseline	2.5	$164.7	$246.1	$53.9
	RS 2035	6.0	$395.5	$589.2	$128.9
Buildings Efficiency	2020 baseline	2.1	$134.8	$201.4	$44.2
	ETC 2035	5.9	$388.3	$578.3	$126.5
	ATC 2035	5.3	$350.5	$521.3	$113.9
	NZ 2035	5.1	$335.7	$498.9	$108.9
Buildings Electrification	2020 baseline	0.5	$29.9	$44.7	$9.8
	ETC 2035	0.7	$43.9	$65.7	$14.4
	ATC 2035	1.7	$109.5	$163.7	$35.9
	NZ 2035	2.0	$133.9	$199.9	$43.8

Notes: ATC = advanced tax credit (scenario); ETC = extended tax credit (scenario); NZ = net-zero (scenario); RS = reference scenario. Table shows direct, indirect, and induced impacts. Dollar values are reported in nominal 2020 dollars.

Source: WRI authors and BW Research.

4.3 Transportation

Fully decarbonizing transportation will require rapidly phasing out sales of ICE vehicles and aggressively adopting zero-emission vehicles, among other actions. Our analysis of the three mitigation scenarios reveals the following impacts:

- In the NZ scenario, employment generated by the alternative vehicles subsector (vehicles and infrastructure) in 2035 increases by more than 3.6 million jobs, compared to an addition of 1.4 million jobs in the RS. This results in the sector generating more than $316 billion in labor income, $543 billion in value added, and $116 billion in tax revenues by 2035 (Table 10). The adoption of alternative vehicles like battery EVs in the light-duty vehicle segment is a major driver of employment growth, with this segment supporting about 3 million jobs (83 percent of total employment) in 2035 (Figure 6).
- Phasing out ICE vehicles negatively impacts the jobs of many who earn a living by manufacturing conventional cars and trucks and their components, as well as jobs involved in ICE vehicle support such as vehicle repair, maintenance, sales, and so forth. Between 2020 and 2035, 5.5 million jobs are lost in the NZ scenario. Taxes, both direct taxes such as those imposed on fuels, the sale of vehicles, and purchase of support services and indirect taxes linked to production and employment in transportation-related industries, are also significantly affected. It is beyond the scope of this report to more fully explore how reductions in ICE-vehicle-related taxes will impact revenue available to state and local governments.
- Bolstering domestic manufacturing in the alternative vehicles sector can significantly increase the number of jobs created. The additional employment generated from the alternative vehicles sector by doubling the domestic content of batteries (compared to an assumed baseline of 25 percent) would generate job creation equal to 43 percent of the net job loss associated with the transportation sector in the NZ scenario. Increasing the domestic content share to 75 percent leads to an additional 1.7 million jobs associated with the alternative vehicles subsector, potentially equaling up to 87 percent of the transportation-related net job losses in the NZ scenario (Table 5).
- The industry composition of employment shifts away from manufacturing and toward professional services as the shift from ICE vehicles to EVs takes place. In the NZ scenario, the share of workers in manufacturing decreases from 46 percent in 2020 to 31 percent in 2035, while that in professional services goes up from 23 percent to 32 percent (Figure 3). Understanding how the transition from ICE vehicles to EVs will impact traditional auto manufacturing and job creation more broadly can help policymakers and the private sector determine where and how job losses may happen and prepare training programs in advance.
- Shifts in the industry makeup of employment also impact workers' wages. In the NZ scenario, 34 percent of workers earn more than $34 an hour in 2035 compared to 28 percent in 2020, while 32 percent of workers earn less than $22 an hour, dropping from 40 percent in 2020 (Figure 4).
- There are no significant changes in the demographic composition of the transportation workforce between 2020 and 2035 (Table 6). While women influence 80 percent of the car-buying decisions in a household, they are only 25 percent of the transportation workforce in 2035 NZ scenario. This signals a huge missed opportunity in diversifying the industry, including women's perspectives, and ensuring equitable access to the benefits of a burgeoning EV industry (Wachunas 2021).

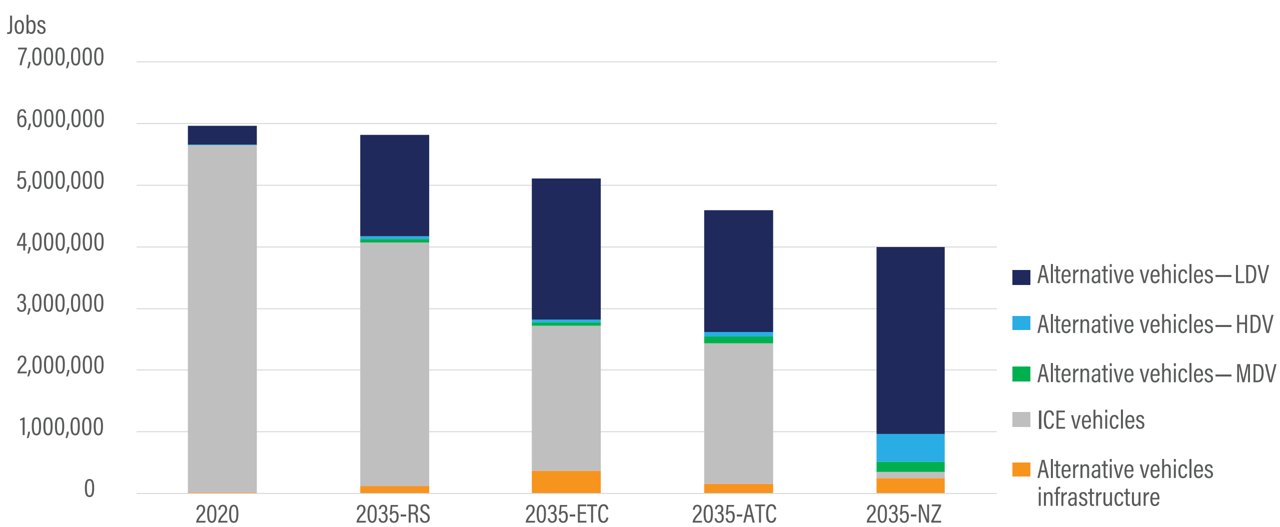
Table 10 | Transportation sector economic impacts in 2035 across mitigation scenarios

		EMPLOYMENT (MILLION JOBS)	LABOR INCOME (BILLION 2020$)	VALUE ADDED (BILLION 2020$)	TAXES (BILLION 2020$)
Transportation Total	2020 baseline	5.9	$437.1	$813.0	$160.0
	RS 2035	5.8	$422.3	$754.6	$154.6
Alternative Vehicles	2020 baseline	0.3	$22.3	$38.5	$8.2
	ETC 2035	2.4	$172.0	$296.9	$63.3
	ATC 2035	2.2	$178.3	$307.6	$65.6
	NZ 2035	3.7	$297.7	$512.1	$109.5
Alternative Vehicles Infrastructure	2020 baseline	0.0	$1.1	$1.8	$0.4
	ETC 2035	0.4	$26.3	$43.5	$9.3
	ATC 2035	0.2	$12.1	$19.9	$4.4
	NZ 2035	0.2	$19.0	$31.3	$6.9
ICE Vehicles	2020 baseline	5.6	$413.7	$772.7	$151.4
	ETC 2035	2.4	$172.5	$322.2	$63.1
	ATC 2035	2.3	$165.9	$309.9	$60.7
	NZ 2035	0.1	$7.5	$14.1	$2.8

Notes: ATC = advanced tax credit (scenario); ETC = extended tax credit (scenario); NZ = net-zero (scenario); RS = reference scenario. Table shows direct, indirect, and induced impacts. Dollar values are reported in nominal 2020 dollars. The 2020 baseline for alternative vehicles infrastructure employment appears as 0 due to rounding (this subsector supports 16,700 jobs in 2020).

Source: WRI authors and BW Research.

Figure 6 | Transportation sector jobs by subsector in 2035 across mitigation scenarios



Notes: HDV = heavy-duty vehicle; ICE = internal combustion engine; LDV = light-duty vehicle; MDV = medium-duty vehicle. Figure shows direct, indirect, and induced impacts. Alternative vehicles include electric vehicles and fuel cell vehicles, while ICE vehicles include gasoline, diesel, and natural gas vehicles.

Source: WRI authors and BW Research.

4.4 Fuels

The fuels sector sees both significant growth and some contraction, varying by fuel type. Hydrogen and biofuels demand in the three mitigation scenarios (see Technical Appendix D, Table D1) adds employment opportunities and economic benefits through fuel production and supply-related activities. Fossil fuels, in contrast, see a decrease in employment across decarbonization scenarios. Our results reveal the following key impacts:

- Compared to employment levels in 2020, by 2035 biofuels[46] employment more than doubles under both the ATC and NZ scenarios. The production of biofuels supports about 334,100 jobs in 2035 in the ATC scenario, while biofuels employment reaches 418,200 jobs in 2035 in the NZ scenario, compared to about 159,100 jobs in 2035 in the RS and 232,400 jobs in the ETC scenario (Table 11).

- Growth in hydrogen demand across sectors, such as industry and heavy-duty transport in the NZ scenario, also adds significant employment opportunities through activities associated with hydrogen production. Employment supported by hydrogen production in 2035 increases by about 369,000 jobs from 2020 levels in this scenario, compared to an addition of 5,600 jobs in the RS (Figure 7).[47]
- In 2035, activities related to the construction of new biofuel and hydrogen fuel facilities account for 9 percent of direct and indirect employment supported by the fuels sector, increasing from 3 percent in 2020 (Figure 3).
- 42 percent of workers employed in these two subsectors earn more than $34 an hour in 2035, while 35 percent earn between $22 and $34 an hour, and 23 percent earn less than $22 an hour.
- Female participation in this sector's workforce increases to 29 percent in 2035 (compared to 26 percent in 2020), while the share of African American workers reaches 13 percent in 2035, from 8 percent in 2020. The share of workers aged 55 and above in 2035 is 16 percent, declining from 19 percent in 2020.
- The economic impact of the NZ scenario for fossil fuels, by 2035, is 2.4 million jobs and 92.9 billion in tax revenue, less than in the 2020 baseline (Table 11). As discussed in our economy-wide analysis, under the decarbonization pathways there are job losses related to fossil fuels—including petroleum, natural gas, and coal. Associated losses occur in labor income and tax revenues. It is beyond the scope of this report to more fully explore how declining revenues would impact state and local budgets and services; these impacts are significant, however, and merit further consideration through existing literature on the topic and further analysis. Job losses associated with the fuels sector can be mitigated by policies that minimize lost jobs, maximize alternative job creation, and support workers through replaced wages, training, and more.

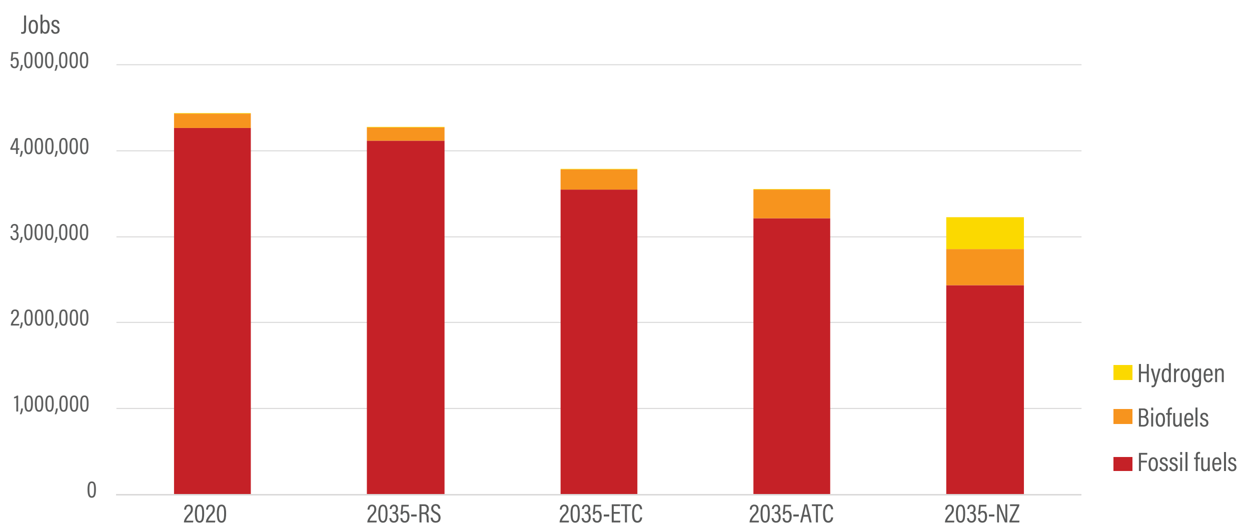
Table 11 | Fuels sector economic impacts in 2035 across mitigation scenarios

		EMPLOYMENT (JOBS)	LABOR INCOME (BILLION 2020$)	VALUE ADDED (BILLION 2020$)	TAXES (BILLION 2020$)
Fuels Total*	2020 baseline	4.4	$402.4	$673.2	$166.4
	RS 2035	4.3	$386.0	$644.7	$159.0
Hydrogen	2020 baseline	29	$0.0	$0.0	$0.0
	ETC 2035	6,018	$0.5	$0.9	$0.2
	ATC 2035	8,489	$0.7	$1.2	$0.3
	NZ 2035	369,025	$14.9	$27.0	$5.7
Biofuels	2020 baseline	162,817	$10.9	$16.4	$3.6
	ETC 2035	232,359	$15.5	$23.4	$5.1
	ATC 2035	334,139	$22.4	$33.6	$7.3
	NZ 2035	418,248	$28.0	$42.1	$9.2
Fossil Fuels*	2020 baseline	4.3	$391.5	$656.9	$162.9
	ETC 2035	3.5	$325.6	$546.3	$135.4
	ATC 2035	3.2	$294.5	$494.3	$122.5
	NZ 2035	2.4	$223.3	$374.5	$92.9

Notes: ATC = advanced tax credit (scenario); ETC = extended tax credit (scenario); NZ = net-zero (scenario); RS = reference scenario. Table shows direct, indirect, and induced impacts. Labor income ($2,006,959), value added ($2,948,172), and taxes ($659,691) for the 2020 hydrogen baseline appear as 0 due to rounding. *Jobs for Fuels Total and Fossil Fuels in the table are reported in million jobs. Dollar values are reported in nominal 2020 dollars.

Source: WRI authors and BW Research.

Figure 7 | Fuels sector jobs by subsector in 2035 across mitigation scenarios



Notes: ATC = advanced tax credit (scenario); ETC = extended tax credit (scenario); NZ = net-zero (scenario); RS = reference scenario. Figure shows direct, indirect, and induced impacts. Fossil fuels include natural gas, petroleum, and coal.

Source: WRI authors and BW Research.

4.5 Industrial Energy-Efficiency Improvements

We evaluate employment opportunities and economic benefits supported by industrial energy-efficiency improvements in the three mitigation scenarios. Our analysis reveals the following key impacts:

- Energy-efficiency improvements driven by federal actions modeled in the NZ scenario result in this scenario adding significantly more employment than the ETC and ATC scenarios. By 2035, the industry sector adds more than 764,000 jobs in the NZ scenario (Table 12) through the installation of different energy-efficient measures at manufacturing facilities, while the ETC and ATC scenarios support about 124,000 and 170,000 jobs, respectively. Employment growth under the NZ scenario produces more than $50 billion in labor income by 2035.
- The installation of energy-efficient measures at manufacturing facilities—including energy-efficient machinery and controls; efficient water-use technology; and efficient heating, ventilation, and air conditioning as well as lighting systems—is a major driver of employment creation in the NZ scenario. Construction-related activities account for the largest share (66 percent) of direct and indirect employment generated in this sector by 2035 (Figure 3).
- Of workers taking these jobs, 46 percent earn between $22 and $34 an hour (Figure 4), while 31 percent earn more than $34 an hour and 22 percent earn less than $22 an hour.

Table 12 | Economic impacts from industry energy-efficiency improvements in 2035 across mitigation scenarios

	EMPLOYMENT (MILLION JOBS)	LABOR INCOME (BILLION 2020$)	VALUE ADDED (BILLION 2020$)	TAXES (BILLION 2020$)
2020 baseline	0.0	$0.0	$0.0	$0.0
RS 2035	0.0	$0.0	$0.0	$0.0
ETC 2035	0.1	$8.3	$12.2	$2.7
ATC 2035	0.2	$11.3	$16.7	$3.6
NZ 2035	0.8	$50.9	$75.0	$16.3

Notes: ATC = advanced tax credit (scenario); ETC = extended tax credit (scenario); NZ = net-zero (scenario); RS = reference scenario. Table shows direct, indirect, and induced impacts. Economic impacts for this sector under the different mitigation scenarios were modeled using estimates of capital costs of energy-efficiency improvements—the cost per unit of energy use saved relative to the reference scenario studied by Saha et al. (2021b). The 2020 baseline for this sector is 0 as the estimated capital cost of energy improvements for 2020 is 0 since energy demand in the industry sector in 2020 is the same in the three mitigation scenarios compared to the reference scenario (see Technical Appendix D, Table D1). There are no changes in economic impacts in the RS as the analysis did not model any spending estimates for industry energy-efficiency improvements in this scenario. Dollar values are reported in nominal 2020 dollars.

Source: WRI authors and BW Research.

4.6 Other Sectors

In addition to the previously discussed core sectors, other sectors—including waste management, agriculture and natural and working lands, and technological carbon removal—see job growth through climate action (Table 13).

- The waste sector can be a significant source of greenhouse gas emissions, particularly methane (EPA 2022). Federal action that will address the waste sector is only included in the most ambitious climate policy and investment scenario modeled (NZ). This analysis finds that by 2035, waste management activities could support 862 jobs and produce $59.1 million in labor income, $100.2 million in value added, and $21.7 million in tax revenues. The vast majority of created jobs pay family-sustaining wages and are in professional services in 2035.
- Achieving near-net-negative emissions by 2050 will require reliable, focused federal investment in natural carbon sinks and agriculture practices that reduce emissions (Saha et al. 2021b). By 2035, federal investment in agriculture and natural and working lands under the ATC and NZ scenarios supports 189,600 jobs, while generating $7.8 billion in labor income, $10.8 billion in value added, and $581.9 million in tax revenues. In 2035, 63 percent of the workforce earns family-sustaining wages, and the vast majority of jobs in the NZ scenario (95 percent) are created along the supply chain.
- Technological carbon removal will be needed to meet U.S. climate goals (Saha et al. 2021b). Under the NZ scenario, federal support for the nascent technological carbon-removal industry could provide for 43,000 jobs in 2035. Economic opportunities associated with development of technological carbon removal are likely to be higher after 2035. This would also generate $3.2 billion in labor income, $6.2 billion in value added, and $1.3 billion in tax revenues. The majority of these jobs will be captured in communities as induced jobs, resulting from increased wages and spending on goods and services, and 75 percent would have hourly wages of $22 or more.

Table 13 | Economic impacts for waste management, agriculture and natural and working lands, and technological carbon removal in 2035 across mitigation scenarios

	EMPLOYMENT (JOBS)	LABOR INCOME (BILLION 2020$)	VALUE ADDED (BILLION 2020$)	TAXES (BILLION 2020$)
2020 baseline	30	$0.0	$0.0	$0.0
RS 2035	30	$0.0	$0.0	$0.0
ETC 2035	110,176	$5.3	$8.2	$0.9
ATC 2035	210,956	$9.4	$14.0	$1.2
NZ 2035	233,540	$11.1	$17.1	$1.9

Notes: ATC = advanced tax credit (scenario); ETC = extended tax credit (scenario); NZ = net-zero (scenario); RS = reference scenario. Table shows direct, indirect, and induced impacts. Labor income ($2,461,844), value added ($4,812,404), and taxes ($976,545) for the 2020 baseline and 2035 in the RS appear as 0 due to rounding. There are no changes in employment numbers for these sectors in the RS as the analysis did not model any spending estimates for these sectors in this scenario. Dollar values are reported in nominal 2020 dollars.

Source: WRI authors and BW Research.

CONCLUSIONS AND RECOMMENDATIONS

Despite the significant opportunities presented by a net-zero economy, the economic benefits from the transition should not be assumed as given. The United States needs specific policies designed to both capitalize on the economic potential of climate action and ensure an equitable and inclusive net zero transition that provides adequate support to communities and individuals adversely impacted by the transition.

Immediate action is required to seize the climate and economic benefits of the net-zero transition. A portfolio of near-term federal policies—including investments in critical infrastructure such as electric grid and EV charging, tax incentives to make low-carbon technologies more cost-competitive, various sector-based performance standards that set benchmarks for emissions reduction, carbon pricing, and spending on R&D to provide new technology options—can put the United States on the path to net-zero emissions by 2050. The Bipartisan Infrastructure Law enacted in late 2021 was an important foundational investment, and in 2022 the Inflation Reduction Act made history as the most significant U.S. climate legislation ever passed; however, more federal action is needed.

In addition to cutting emissions, the above policies can foster economic growth, job creation, global competitiveness, and community well-being. Our analysis shows that by 2035 the energy economy in the net-zero (NZ) scenario would support 23.1 million jobs, adding nearly 6.5 million jobs relative to 2020. In comparison, the reference scenario adds 4.2 million jobs during the same period. The ATC scenario, with its focus on a suite of low-carbon technology tax credits and federal spending on infrastructure, also has the potential to create high-quality jobs and build a more competitive U.S. economy, with 5.1 million jobs added between 2020 and 2035 in this scenario. This scenario mostly closely aligns with the policies considered by the current, 117th Congress, including those enacted in infrastructure bill passed in 2021 and the Inflation Reduction Act passed in 2022.

Despite the significant opportunities presented by a net-zero economy, the economic benefits from the transition should not be assumed as given. The United States needs specific policies designed to both capitalize on the economic potential of climate action and ensure an equitable and inclusive net-zero transition that provides adequate support to communities and individuals adversely impacted by the transition. Our analysis highlights four social and economic goals that federal climate policies should be designed to advance:

- **Strengthen the U.S. clean energy manufacturing sector and supply chains.** The net-zero transition presents opportunities to revitalize U.S. manufacturing, which can not only enhance U.S. leadership, resilience, and competitiveness in low-carbon products and services but also promote economic growth and create high-quality jobs with U.S. firms serving growing domestic and international markets. When policies supporting domestic manufacturing and a U.S. clean energy supply chain are combined with incentives or requirements that prioritize community-driven and supported investments in clean energy industries in disadvantaged communities and communities impacted most by the phaseout of fossil fuels, this helps ensure an equitable net-zero transition that benefits all communities.
- **Focus on creating inclusive and high-quality jobs**. Climate policies must create quality jobs that pay family-sustaining wages, but this is the just the baseline for job quality. Additional investments in workforce training associated with available employment opportunities, policies that enforce equitable hiring and treatment of all workers in the workplace, and efforts to protect and support workers' rights to organize, can further improve job quality without halting the growth of the low-carbon economy.
- **Support communities and workers vulnerable to adverse economic impacts due to the energy transition.** While creating opportunities nationwide, the net-zero transition will lead to a loss of jobs and tax revenue in regions economically dependent on fossil fuels. The federal government, given the scale of its work, its role in decarbonization policy, and its engagement on a range of macroeconomic trends that impact workers, is particularly well situated to manage the uneven impacts of the transition. This can be done by adopting policies that support new employment opportunities in impacted regions, ensure that new jobs are high-quality jobs, offer workforce and development assistance, provide incentives to repurpose retired fossil assets, and provide financial and other types of assistance to communities as their economies evolve. While smart policy can minimize job loss in a clean energy transition, disruption for workers will be unavoidable, and safety net

and workforce-development policies related to wage replacement, bridge to retirement, and training and education funding must be established to bring about an equitable and prosperous net-zero transition. Investing in broad-based workforce training and development, career services, and education programs will be particularly important to help both dislocated workers in legacy industries as well as new workers find opportunities in the net-zero economy.

- **Promote equitable access to benefits of net-zero energy systems**. Federal climate policies should aim to address current and long-standing inequities that disadvantage marginalized and low-income communities and that limit their participation in the clean energy workforce and access to clean energy broadly. Low-income; Black, Latino, and Indigenous; and other households of color are disproportionately impacted by fossil fuel dependency, in terms of pollution and public health impacts as well as the impacts of resulting climate change. Going forward, policies need to ensure that the benefits, in terms of access to new employment opportunities and beneficial clean technologies, as well as the costs, are more equitably distributed among different communities. This can be connected with policies to boost domestic manufacturing and with a focus on specific geographies, including those transitioning away from economic dependence on fossil-fuel-based industries.

A few issues, arising from the limitations of the modeling analysis, are also worth highlighting and should be monitored as decarbonization policies are adopted and implemented. First, domestic content policies in clean technologies could reduce jobs in other countries and other sectors of the U.S. economy, through direct and indirect connections. The assumption that they will not, in the short or long term, needs to be carefully monitored. Otherwise, just transition challenges will only be transferred to others.

Raising wages to a family-sustaining level based on MIT's Living Wage Calculator is assumed to have had no effect on the quantity of jobs demanded by industry. While our literature review finds some studies of places and periods where raising the minimum wage or adopting prevalent-wage requirements in public procurement did not lead to negative impact on employment, these assumed effects still need to be carefully monitored in any decarbonization policy adopted following our recommendations.

In our modeling, the effect of domestic content and wage policies on the price of goods and services is either assumed to be zero, or to have no effect on the public and private decisions to decarbonize. These assumptions are central to our scenarios, but during any implementation phase of any of the recommended policies, their real effect needs to be monitored and verified. And an adaptative strategy needs to be ready in case they become significant problems.

Additionally, our analysis does not evaluate the potential opportunity costs of clean energy and low-carbon investments modeled under the different decarbonization pathways. Different factors like inflation, interest rates, and socioeconomic shocks will ultimately determine the level of investments that different actors, including federal and state governments, firms, and consumers, can allocate toward cleaner technologies and services. Input-output frameworks such as IMPLAN also inherently assume that more investments will lead to greater economic activity and employment impacts. Further analysis on potential spillover impacts of increasing investments in the clean energy economy can strengthen these recommendations.

The findings from our analysis serve as a clear call to action to secure a prosperous, inclusive, equitable, and orderly transition to a net-zero economy. Actions taken by the federal government, in coordination with other public and private actors, can help move the U.S. economy toward these goals. In addition to emissions-reduction benefits, Congress and the Biden administration should not lose sight of the economic and social opportunities presented by the net-zero transition.

TECHNICAL APPENDICES

Technical Appendix A describes the IMPLAN analysis-by-parts framework and different inputs used in the base model. The policy lever modeling framework is described in Technical Appendix B.

Technical Appendix C provides supplementary modeling results while Technical Appendix D includes a summary of estimates from WRI's Building Blocks analysis.

TECHNICAL APPENDIX A. IMPLAN ANALYSIS-BY-PARTS BASE MODELING FRAMEWORK

BW's IMPLAN analysis-by-parts uses spending data to evaluate changes in economic activity across various industry or supply-chain categories for different sectors. Our analysis uses cost estimates that represent potential spending required to support emissions reductions, clean energy deployment, and the adoption of different clean technologies in the three mitigation scenarios as inputs for the IMPLAN analysis-by-parts. These inputs (Tables A1 and A2) include modeled power sector fixed costs, capital costs of buildings sector devices and equipment, capital costs of vehicles and charging infrastructure for the transportation sector, fuel costs for different fuel sources, capital costs of energy-efficiency improvements in industry, as well as emissions abatement costs for industrial carbon capture and storage applications, waste management, agriculture, and natural and working lands for the three mitigation scenarios.

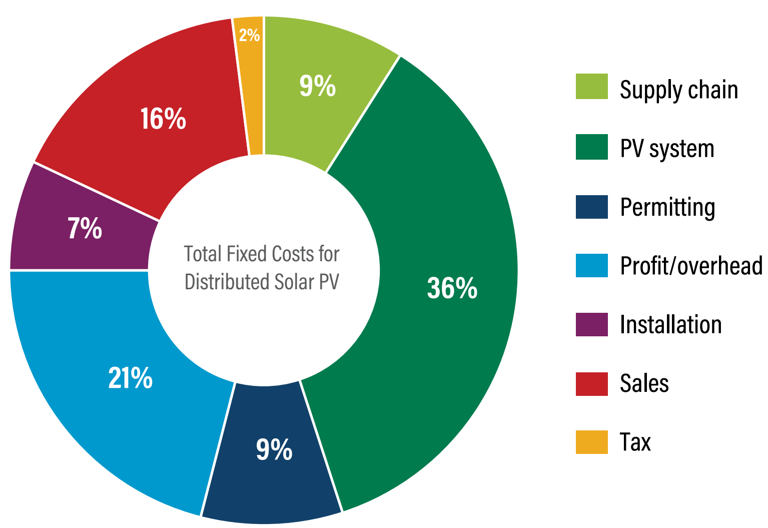
Box A1 shows the IMPLAN analysis-by-parts framework, while Table A1 describes how these inputs are translated into spending for different IMPLAN industry categories. Inputs for the sectors we model are disaggregated into spending for different IMPLAN industry categories to create spending inputs for 2020–35 for the three mitigation scenarios. Direct, indirect, and induced effects on jobs; economic value added; employee compensation (e.g., wages, salaries); and tax revenue are estimated for five-year intervals using IMPLAN industry multipliers and spending patterns.

BOX A1 | Overview of IMPLAN analysis-by-parts framework

Allocate cost inputs into different IMPLAN industry categories:

- Cost inputs for different sectors are translated into spending across IMPLAN industry categories according to supply-chain assumptions.
- For example, in the power sector, solar technical component costs based on NREL's U.S. Solar Photovoltaic System and Energy Storage Cost Benchmark: Q1 2020, are used to allocate total fixed costs of distributed solar PV in all the scenarios into different IMPLAN industry categories, which represent the solar PV supply chain.

Illustrative example (allocation of solar PV total fixed costs across different IMPLAN industry categories)



BOX A1 | Overview of IMPLAN analysis-by-parts framework (Cont.)

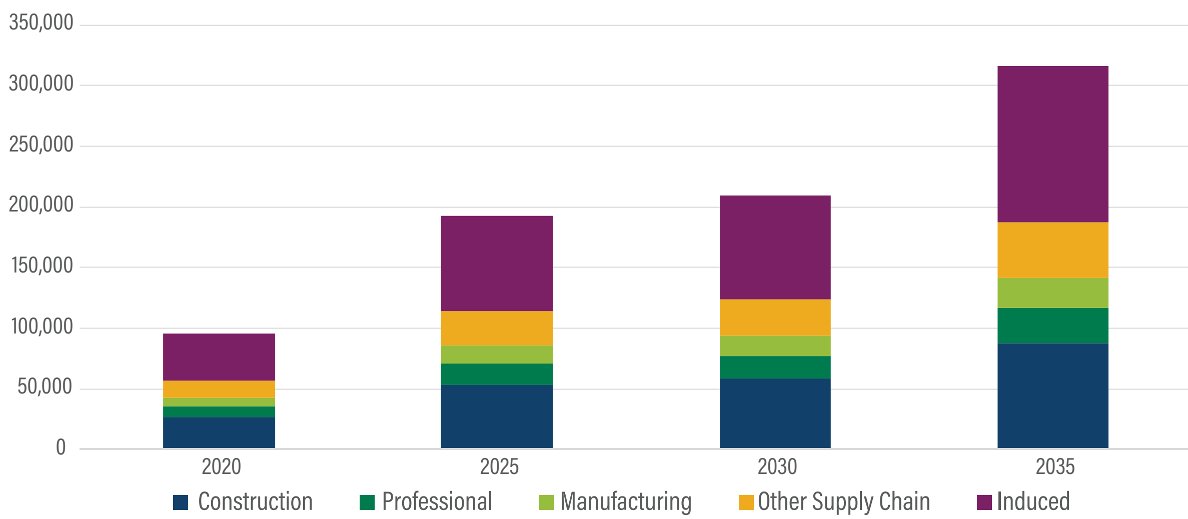
Set up baseline modeling assumptions:

- Baseline employment levels in 2020 for supply chain/industry categories are derived from 2020 USEER.
- Baseline modeling assumptions are adjusted if needed (e.g., model assumes 25 percent domestic manufacturing of solar panels and inverter components as a baseline).

Estimate outputs:

- IMPLAN industry spending patterns and multipliers are applied to spending inputs to estimate economic impacts between 2020 and 2035 in five-year intervals. The IMPLAN input-output model is a linear economic model, meaning that there are constant returns to scale based on fixed multipliers and a static time dimension. The industry multipliers are derived from multiple data sets, but they mostly draw from U.S. Bureau of Economic Analysis and Bureau of Labor Statistics data. Among these data are salary and wage data, which IMPLAN uses, along with interindustry spending (i.e., intermediate goods purchases) and various other expenditure types (taxes, proprietor income, etc.) that make up the industry spending patterns as a whole, to determine employment impacts.
- Direct, indirect, and induced effects on jobs; economic value added; employee compensation; and tax revenue are reported for 2020–35 in five-year intervals.

Illustrative example of employment outputs



Notes: PV = photovoltaic; USEER = U.S. Energy and Employment Report.

Source: WRI authors and BW Research.

Table A1 | Translation of modeling inputs to spending for different IMPLAN industry categories

Sector: Electricity

Subsector: Distributed solar photovoltaic

Input: Annual fixed costs (in 2020$) for 2020–35

Translation to Industry Spending: Data derived from NREL's U.S. Solar Photovoltaic System and Energy Storage Cost Benchmark: Q1 2020, are used to allocate distributed solar PV fixed costs across the supply chain. Assuming only 25% of solar panels are manufactured in the United States, we multiply the dollars allocated for semiconductor manufacturing and for power distribution and transformer manufacturing by 0.25.

INPUT SHARE	IMPLAN CODE	IMPLAN INDUSTRY
21%	457	Architectural and engineering services
7%	52	Construction of new power structures
9%	455	Legal services
16%	465	Advertising and public relations
9%	395	Wholesale equipment and supplies
9%	336	Other energy wire manufacturing
3%	236	Fabricated metal structure manufacturing
15%	307	Semiconductor manufacturing
9%	329	Power distribution and transformer manufacturing

Sector: Electricity

Subsector: Utility-scale solar

Input: Annual fixed costs (in 2020$) for 2020–35

Translation to industry spending: Data derived from NREL's U.S. Solar Photovoltaic System and Energy Storage Cost Benchmark: Q1 2020, are used to allocate utility-scale solar fixed costs across the supply chain. Assuming only 25% of solar panels are manufactured in United States, we multiply the dollars input for semiconductor manufacturing and for power distribution and transformer manufacturing by 0.25.

INPUT SHARE	IMPLAN CODE	IMPLAN INDUSTRY
16%	457	Architectural and engineering services
11%	52	Construction of new power structures
5%	455	Legal services
7%	336	Other energy wire manufacturing
12%	236	Fabricated metal structure manufacturing
41%	307	Semiconductor manufacturing
5%	329	Power distribution and transformer manufacturing

Sector: Electricity

Subsector: Offshore and onshore wind (modeled using NREL's JEDI models)

Inputs: Annual capacity (in MW) for 2020–35

JEDI framework: Data for offshore wind capacity used in NREL's JEDI Offshore Wind Model rel.2021-1 (using the United States as the study area, 12 MW turbine size, all other input parameters default). Data for onshore wind capacity used in JEDI Land-Based Wind Model rel. W6.28.19 (using the United States as the study area, 2,500 kW turbine size, and all other input parameters default).

Table A1 | Translation of modeling inputs to spending for different IMPLAN industry categories (Cont.)

Sector: Electricity

Subsector: Storage

Inputs: Annual fixed costs (in 2020$) for 2020–35

Translation to industry spending: Data derived from NREL's U.S. Solar Photovoltaic System and Energy Storage Cost Benchmark: Q1 2020. Assuming only 25% of batteries are manufactured in the United States, we multiply the dollars for power distribution and transformer manufacturing and for storage battery manufacturing by 0.25.

INPUT SHARE	IMPLAN CODE	IMPLAN INDUSTRY
1%	455	Legal services
4%	47	Electric power transmission and distribution
10%	457	Architectural and engineering services
8%	52	Construction of new power structures
13%	336	Other energy wire manufacturing
4%	236	Fabricated metal structure manufacturing
7%	329	Power distribution and transformer manufacturing
49%	333	Storage battery manufacturing

Sector: Electricity

Subsector: Other generation

Inputs: Annual capacity (in MW) for 2020–35

Translation to industry spending: Capacity for biomass, geothermal, and hydropower generation is used to scale current utilities employment from USEER data in biomass generation, geothermal generation, and hydropower generation. This scaled employment is then used as input into IMPLAN codes 39 (electric power generation—hydroelectric), 44 (electric power generation—geothermal), and 45 (electric power generation—biomass) to derive impacts.

Sector: Electricity

Subsector: Transmission and distribution

Inputs: Annual fixed costs (in 2020$) for 2020–35

Translation to industry spending: We apply employment-derived industry spending patterns used in WRI's Rural America modeling project. This takes national transmission and distribution employment data by industry from the 2020 USEER and translates them into the following IMPLAN codes.

INPUT SHARE	IMPLAN CODE	IMPLAN INDUSTRY
10%	47	Electric power transmission and distribution
30%	52	Construction of new power structures
5%	56	Construction of other new nonresidential structures
5%	60	Maintenance and repair construction of nonresidential structures
11%	302	Broadcast and wireless communications equipment manufacturing
2%	315	Totalizing fluid meter and counting device manufacturing
9%	316	Electricity and signal testing instruments manufacturing
7%	339	All other miscellaneous electrical equipment and component manufacturing
3%	428	Software publishers
2%	436	Data processing, hosting, and related services
7%	459	Custom computer programming services

Table A1 | Translation of modeling inputs to spending for different IMPLAN industry categories (Cont.)

INPUT SHARE	IMPLAN CODE	IMPLAN INDUSTRY
7%	460	Computer systems design services
1%	461	Other computer related services, including facilities management

Sector: Buildings

Subsector: Efficiency (residential)

Input: Annual capital costs (in 2020$) of energy-efficient devices across residential end uses for 2020–35

Translation to industry spending: We apply employment derived industry spending patterns used in WRI's Rural America modeling project to overnight capital costs. This takes national energy-efficiency employment data by industry from the 2020 USEER and translates them into IMPLAN codes.

INPUT SHARE	IMPLAN CODE	IMPLAN INDUSTRY
29%	57	Construction of new single-family residential structures
16%	58	Construction of new multifamily residential structures
16%	59	Construction of other new residential structures
30%	61	Maintenance and repair construction of residential structures
9%	457	Architectural, engineering, and related services

Sector: Buildings

Subsector: Efficiency (nonresidential)

Input: Annual capital costs (in 2020$) of energy-efficient devices across commercial end uses for 2020–35

Translation to industry spending: We apply employment-derived industry spending patterns used in WRI's Rural America modeling project to overnight capital costs. This takes national energy-efficiency employment data by industry from the 2020 USEER and translates them into IMPLAN codes.

INPUT SHARE	IMPLAN CODE	IMPLAN INDUSTRY
13%	50	Construction of new health-care structures
13%	51	Construction of new manufacturing structures
18%	52	Construction of new power and communication structures
13%	53	Construction of new educational and vocational structures
13%	55	Construction of new commercial structures, including farm structures
13%	56	Construction of other new nonresidential structures
9%	60	Maintenance and repair construction of nonresidential structures
9%	457	Architectural, engineering, and related services

Sector: Buildings

Subsector: Electrification (residential)

Input: Annual capital costs (in 2020$) of electrification devices across residential end uses for 2020–35

Translation to industry spending: We apply employment-derived industry spending patterns used in WRI's Rural America modeling project to overnight capital costs. This takes national energy-efficiency employment data by industry from the 2020 USEER and translates them into IMPLAN codes.

INPUT SHARE	IMPLAN CODE	IMPLAN INDUSTRY
29%	57	Construction of new single-family residential structures
16%	58	Construction of new multifamily residential structures
16%	59	Construction of other new residential structures

Table A1 | Translation of modeling inputs to spending for different IMPLAN industry categories (Cont.)

INPUT SHARE	IMPLAN CODE	IMPLAN INDUSTRY
30%	61	Maintenance and repair construction of residential structures
9%	457	Architectural, engineering, and related services

Sector: Buildings

Subsector: Electrification (nonresidential)

Input: Annual capital costs (in 2020$) of electrification devices across commercial end uses for 2020–35

Translation to industry spending: We apply employment-derived industry spending patterns used in WRI's Rural America modeling project to overnight capital costs. This takes national energy-efficiency employment data by industry from the 2020 USEER to allocate cost inputs into IMPLAN codes.

INPUT SHARE	IMPLAN CODE	IMPLAN INDUSTRY
13%	50	Construction of new health-care structures
13%	51	Construction of new manufacturing structures
18%	52	Construction of new power and communication structures
13%	53	Construction of new educational and vocational structures
13%	55	Construction of new commercial structures, including farm structures
13%	56	Construction of other new nonresidential structures
9%	60	Maintenance and repair construction of nonresidential structures
9%	457	Architectural, engineering, and related services

Sector: Transportation

Subsector: Alternative vehicles

Input: Annual capital costs (in 2020$) of alternative vehicles across light-, medium-, and heavy-duty vehicle segments for 2020–35

Translation to Industry Spending: Based on an Argonne National Laboratory study, 50% of total vehicle capital costs are attributed to vehicle manufacturing, 6.5% are attributed to engineering and research, 11.5% to production overhead, 7% to corporate overhead, 23.5% to distribution and selling, and 2.5% to profit. Depending on the type of vehicle (light-, medium-, or heavy-duty), costs are allocated to automobile, light truck and utility vehicle, and heavy-duty truck manufacturing, respectively. Industry allocation of total costs is detailed in the table below. The amount allocated to storage battery manufacturing is multiplied by 25% to adjust for domestic manufacturing content before input into IMPLAN.

INPUT SHARE	IMPLAN CODE	IMPLAN INDUSTRY
25.7%	402	Retail: Motor vehicle and parts dealers
43.8%	340/341/342	Automobile manufacturing / light truck and utility vehicle manufacturing / heavy-duty truck manufacturing
23.5%	333	Storage battery manufacturing
7.1%	457	Architectural, engineering, and related services

Sector: Transportation

Subsector: Alternative vehicles charging infrastructure

Input: Annual electric vehicle charger installation costs (in 2020$) for 2020–35

Translation to industry spending: We assume 0.5 L2 chargers per light-duty vehicle are installed in residential cases. Public infrastructure needs data are derived from NREL's 2017 National Plug-In Electric Vehicle Infrastructure Analysis, in which the central scenario studied calculates the need for 27,500 DCFC chargers and 601,000 public L2 chargers for 15 million electric vehicles by 2030. Cost data are derived from levelized cost of charging electric vehicles in the United States.

Table A1 | Translation of modeling inputs to spending for different IMPLAN industry categories (Cont.)

CHARGER TYPE	TOTAL COST	IMPLAN CODE AND INDUSTRY
Residential L1	$0	Charging equipment costs are input into IMPLAN code 329 (power, distribution, and specialty transformer manufacturing). Residential charging is input into IMPLAN code 61 (maintenance and repair construction of residential structures), while commercial charging is input into IMPLAN code 60 (maintenance and repair construction of nonresidential structures).
Residential L2	$1,836	
Public L2	$6,000	
Public DCFC 50 kW	$58,000	
Public DCFC 150 kW	$150,000	

Sector: Fuels

Subsector: Hydrogen—electrolysis

Input: Annual fuel costs (in 2020$) of hydrogen produced through electrolysis for 2020–35

Translation to industry spending (electrolysis): Industry spending data for different IMPLAN codes are derived from the DOE's Hydrogen and Fuel Cells Program Record 19009: Hydrogen Production Cost from PEM Electrolysis—2019.

INPUT SHARE	IMPLAN CODE	IMPLAN INDUSTRY
58%	307	Semiconductor manufacturing
15%	236	Fabricated metal structure manufacturing
17%	336	Other energy wire manufacturing
11%	52	Construction of new power structures

Sector: Fuels

Subsector: Hydrogen–steam methane reforming (SMR)

Input: Annual fuel costs (in 2020$) of hydrogen produced through SMR for 2020–35

Translation to industry spending: Industry spending data for different IMPLAN codes are derived from the DOE's Hydrogen, Fuel Cells and Infrastructure Technologies Program: 2002 Annual Progress Report.

INPUT SHARE	IMPLAN CODE	IMPLAN INDUSTRY
66.8%	160	Industrial gas manufacturing
11.0%	286	Air and gas compressor manufacturing
22.2%	242	Metal tank (heavy gauge) manufacturing

Sector: Fuels

Subsector: Hydrogen—bioenergy carbon capture and storage (BECCS)

Input: Annual fuel costs (in 2020$) of hydrogen produced through BECCS for 2020–35

Translation to industry spending: Industry spending data are derived from NREL's JEDI Fast Pyrolysis Model rel. FP12.23.16.

INPUT SHARE	IMPLAN CODE	IMPLAN INDUSTRY
7.4%	16	Commercial logging
25.1%	160	Industrial gas manufacturing
0.1%	479	Waste management and remediation services
1.4%	47	Electric power transmission and distribution
54.7%	51	Construction of new manufacturing structures
11.2%	457	Architectural, engineering, and related services

Table A1 | Translation of modeling inputs to spending for different IMPLAN industry categories (Cont.)

Sector: Fuels

Subsector: Biofuels

Input: Annual fuel costs (in 2020$) for 2020–35

Translation to industry spending: Impacts for this subsector are modeled using the JEDI model. Allocations of spending across different production and construction components derived from NREL's JEDI Biorefinery Sugars to Hydrocarbon Model rel. SH1.13.17.

Sector: Industry

Input: Annual capital costs (in 2020$) of energy-efficiency improvements for 2020–35

Translation to industry spending: We apply employment-derived industry spending patterns used in WRI's Rural America analysis to capital costs of industrial energy-efficiency improvements. This takes national energy-efficiency employment data by industry from the 2020 USEER and translates them into IMPLAN codes.

INPUT SHARE	IMPLAN CODE	IMPLAN INDUSTRY
13%	50	Construction of new health-care structures
13%	51	Construction of new manufacturing structures
18%	52	Construction of new power and communication structures
13%	53	Construction of new educational and vocational structures
13%	55	Construction of new commercial structures, including farm structures
13%	56	Construction of other new nonresidential structures
9%	60	Maintenance and repair construction of nonresidential structures
9%	457	Architectural, engineering, and related services

Sector: Technological carbon removal

Input: Annual emissions abatement costs (in 2020$) of carbon capture and storage (CCS) applications in ethanol refining, ammonia production, cement production, and iron and steel production for 2020–35

Translation to industry spending: Cost data for different components of CCS are allocated to industry codes for ethanol refining, ammonia production, cement production, and iron and steel production.

IMPLAN CODE	IMPLAN INDUSTRY
163	Other basic organic chemical manufacturing
162	Other basic inorganic chemical manufacturing
203	Cement manufacturing
215	Iron and steel mills and ferroalloy manufacturing

Sector: Waste

Input: Annual capital costs (in 2020$) of emissions abatement costs for 2020–35

Translation to industry spending: Cost data are allocated to IMPLAN code 479 (waste management and remediation services).

Sector: Agriculture and natural and working lands

Input: Annual emissions abatement costs (in 2020$)

Translation to industry spending: Multipliers derived from the WRI Rural America analysis are applied to the input costs.

Notes: DCFC = direct current fast charging; DOE = U.S. Department of Energy; IMPLAN = Economic Impact Analysis for Planning; JEDI = Jobs and Economic Development Impacts; kW = kilowatt; MW = megawatt; NREL = National Renewable Energy Laboratory; PV = photovoltaic; USEER = U.S. Energy and Employment Report.

Source: WRI authors and BW Research.

Table A2 | 2020–35 Modeling inputs for IMPLAN analysis-by-parts (2020$)

		2020	2025	2030	2035
Sector	**Subsector**	**Reference Scenario**			
Electricity	Solar PV	$431,794,203	$487,563,013	$487,654,138	$544,226,093
	Utility solar	$737,678,192	$2,610,901,215	$2,921,292,673	$4,975,220,677
	Offshore wind	$0	$4,207,872,972	$5,085,494,113	$7,156,244,636
	Onshore wind	$2,224,308,017	$16,309,353,394	$16,309,353,394	$16,309,353,394
	Nuclear	$15,726,988,122	$15,571,426,331	$15,381,472,125	$14,968,789,650
	Coal and gas	$139,554,415,825	$101,609,389,705	$74,118,707,092	$73,317,073,279
	Other generation	$21,789,699,059	$21,808,265,566	$21,808,265,566	$21,808,265,566
	Transmission and distribution	$164,126,830	$1,721,713,993	$2,230,649,231	$2,957,015,508
	Storage	$9,467,250	$952,653,135	$1,751,962,545	$2,199,215,342
Buildings	Residential efficiency	$72,437,410,631	$95,806,431,362	$105,272,096,197	$122,853,807,973
	Nonresidential efficiency	$47,684,585,311	$103,881,967,122	$144,956,671,360	$182,461,147,408
	Residential electrification	$17,390,608,035	$23,773,434,724	$25,078,799,172	$26,377,268,636
	Nonresidential electrification	$12,072,217,910	$11,511,519,124	$12,027,309,514	$15,371,552,382
Transportation	Alternative vehicles	$31,892,000,000	$39,671,000,000	$88,900,000,000	$183,837,000,000
	Alternative vehicles infrastructure	$871,374,830	$1,165,577,588	$3,156,768,131	$6,852,309,346
	Internal combustion engine vehicles	$718,411,000,000	$621,878,000,000	$557,256,000,000	$504,409,000,000
Fuels	Hydrogen	$2,156,203	$45,840,319	$259,259,217	$699,017,864
	Biofuels	$63,011,097,466	$63,321,114,692	$61,953,241,803	$61,586,013,603
	Fossil fuels	$502,510,323,908	$513,867,564,587	$508,120,664,911	$484,512,701,064
Industry		$0	$0	$0	$0
Waste		$0	$0	$0	$0
Technological carbon removal		$0	$0	$0	$0
Agriculture		$0	$0	$0	$0
Total (Trillion 2020$)		**$1.65**	**$1.64**	**$1.65**	**$1.73**

Table A2 | 2020–35 Modeling inputs for IMPLAN analysis-by-parts (2020$) (Cont.)

		2020	2025	2030	2035
Sector	**Subsector**	**ETC Scenario**			
Electricity	Solar PV	$431,794,203	$487,563,013	$487,654,138	$544,226,093
	Utility solar	$737,678,192	$1,298,908,619	$3,407,798,146	$8,089,545,334
	Offshore wind	$0	$711,007,451	$4,605,595,912	$6,217,076,079
	Onshore wind	$1,777,820,191	$2,361,965,649	$5,143,189,682	$7,201,810,733
	Nuclear	$15,726,994,332	$15,578,501,808	$15,202,039,770	$13,740,245,689
	Coal and gas	$139,554,415,825	$100,061,477,885	$69,758,122,531	$69,982,401,775
	Other generation	$21,789,699,059	$21,808,265,566	$21,808,265,566	$21,808,265,566
	Transmission and distribution	$164,126,830	$1,602,870,995	$2,905,335,773	$4,083,536,281
	Storage	$9,467,249	$1,033,620,052	$1,901,531,237	$2,601,661,384
Buildings	Residential efficiency	$77,240,000,000	$124,778,000,000	$155,033,000,000	$165,378,000,000
	Nonresidential efficiency	$58,340,000,000	$160,061,000,000	$222,972,000,000	$223,689,000,000
	Residential electrification	$17,431,000,000	$25,105,000,000	$27,659,000,000	$27,460,000,000
	Nonresidential electrification	$12,384,000,000	$12,893,000,000	$14,397,000,000	$16,771,000,000
Transportation	Alternative vehicles	$51,109,000,000	$190,379,000,000	$294,619,000,000	$394,021,000,000
	Alternative vehicles infrastructure	$1,401,839,985	$6,090,886,087	$11,132,442,170	$34,598,825,453
	Internal combustion engine vehicles	$705,451,000,000	$499,212,000,000	$354,115,000,000	$294,204,000,000
Fuels	Hydrogen	$2,000,000	$46,000,000	$259,000,000	$699,000,000
	Biofuels	$39,362,000,000	$49,445,000,000	$53,425,000,000	$56,174,000,000
	Fossil fuels	$502,679,036,186	$500,732,054,321	$466,614,585,192	$418,039,239,127
Industry		$0	$1,445,000,000	$4,408,000,000	$8,221,000,000
Waste		$0	$0	$0	$0
Technological carbon removal		$4,000,000	$1,360,000,000	$2,715,000,000	$2,725,000,000
Agriculture		$0	$723,000,000	$1,445,000,000	$2,825,000,000
Total (Trillion 2020$)		**$1.65**	**$1.72**	**$1.73**	**$1.78**

Table A2 | 2020–35 Modeling inputs for IMPLAN analysis-by-parts (2020$) (Cont.)

		2020	2025	2030	2035
Sector	**Subsector**	**ATC Scenario**			
Electricity	Solar PV	$431,794,203	$487,563,013	$487,654,138	$544,226,093
	Utility solar	$737,678,192	$1,332,279,723	$3,973,556,712	$12,094,894,611
	Offshore wind	$0	$711,007,451	$4,605,595,912	$6,217,076,079
	Onshore wind	$1,777,820,191	$2,893,695,591	$5,495,130,432	$8,711,751,464
	Nuclear	$15,727,006,113	$15,578,537,922	$15,200,652,744	$13,927,968,508
	Coal and gas	$139,554,415,825	$99,917,499,822	$71,680,691,928	$71,875,331,446
	Other generation	$21,789,699,059	$21,808,265,566	$21,808,265,566	$21,808,265,566
	Transmission and distribution	$164,126,830	$1,806,321,384	$2,837,826,838	$7,374,844,251
	Storage	$9,467,249	$966,956,041	$1,897,411,083	$2,599,169,038
Buildings	Residential efficiency	$77,260,000,000	$114,235,000,000	$130,753,000,000	$128,942,000,000
	Nonresidential efficiency	$58,340,000,000	$159,504,000,000	$221,495,000,000	$221,664,000,000
	Residential electrification	$17,610,000,000	$38,802,000,000	$54,117,000,000	$61,129,000,000
	Nonresidential electrification	$12,457,000,000	$27,310,000,000	$37,074,000,000	$49,038,000,000
Transportation	Alternative vehicles	$59,319,000,000	$234,900,000,000	$300,488,000,000	$408,233,000,000
	Alternative vehicles infrastructure	$1,629,530,492	$7,175,894,824	$11,170,319,567	$15,196,473,586
	Internal combustion engine vehicles	$699,889,000,000	$462,986,000,000	$349,263,000,000	$282,926,000,000
Fuels	Hydrogen	$2,000,000	$46,000,000	$259,000,000	$986,000,000
	Biofuels	$41,792,000,000	$61,886,000,000	$73,690,000,000	$80,780,000,000
	Fossil fuels	$501,587,713,766	$490,651,342,687	$443,561,479,770	$378,228,570,040
Industry		$0	$2,168,000,000	$6,613,000,000	$11,210,000,000
Waste		$0	$0	$0	$0
Technological carbon removal		$4,000,000	$1,360,000,000	$2,715,000,000	$2,725,000,000
Agriculture		$0	$1,570,000,000	$3,140,000,000	$6,030,000,000
Total (Trillion 2020$)		**$1.65**	**$1.75**	**$1.76**	**$1.79**

Table A2 | 2020–35 Modeling inputs for IMPLAN analysis-by-parts (2020$) (Cont.)

		2020	2025	2030	2035
Sector	**Subsector**	**NZ Scenario**			
Electricity	Solar PV	$431,794,203	$487,563,013	$487,654,138	$544,226,093
	Utility solar	$737,678,192	$1,343,156,299	$6,326,435,875	$20,772,045,466
	Offshore wind	$0	$711,007,451	$4,605,595,912	$6,340,761,207
	Onshore wind	$1,777,820,191	$2,866,299,043	$5,789,039,450	$12,153,832,859
	Nuclear	$15,726,985,378	$15,577,594,367	$15,174,522,510	$13,919,859,229
	Coal and gas	$139,554,415,825	$102,722,663,748	$76,049,007,010	$75,734,505,688
	Other generation	$21,789,699,059	$21,808,265,566	$21,808,265,566	$21,808,265,566
	Transmission and distribution	$164,126,830	$1,814,339,818	$4,478,990,189	$14,020,670,741
	Storage	$9,467,249	$1,113,163,697	$2,371,530,679	$3,373,189,793
Buildings	Residential efficiency	$77,260,000,000	$114,235,000,000	$130,753,000,000	$114,689,000,000
	Nonresidential efficiency	$58,340,000,000	$159,504,000,000	$221,495,000,000	$220,873,000,000
	Residential electrification	$17,610,000,000	$38,802,000,000	$54,117,000,000	$73,441,000,000
	Nonresidential electrification	$12,457,000,000	$27,310,000,000	$37,074,000,000	$61,147,000,000
Transportation	Alternative vehicles	$59,319,000,000	$234,900,000,000	$444,106,000,000	$679,555,000,000
	Alternative vehicles infrastructure	$1,629,530,492	$7,175,894,824	$16,763,692,050	$23,871,398,068
	Internal combustion engine vehicles	$699,889,000,000	$462,986,000,000	$206,947,000,000	$12,862,000,000
Fuels	Hydrogen	$1,000,000	$2,618,000,000	$9,445,000,000	$21,430,000,000
	Biofuels	$41,815,000,000	$66,597,000,000	$79,647,000,000	$107,415,000,000
	Fossil fuels	$501,829,100,931	$484,404,109,010	$413,828,331,714	$286,611,511,224
Industry		$0	$10,450,000,000	$27,837,000,000	$50,369,000,000
Waste		$0	$32,000,000	$66,000,000	$74,000,000
Technological carbon removal		$4,000,000	$2,477,000,000	$4,574,000,000	$5,359,000,000
Agriculture		$0	$1,570,000,000	$3,140,000,000	$6,030,000,000
Total (Trillion 2020$)		**$1.65**	**$1.76**	**$1.79**	**$1.83**

Notes: ATC = advanced tax credit; ETC = extended tax credit; MW = megawatts; NZ = net-zero; PV = photovoltaic.

Source: WRI authors and BW Research.

For offshore and onshore wind, we model economic impacts using generation capacity (in MW) for 2020–35 as inputs (Table A3) for NREL's JEDI Offshore Wind and Land-Based Wind Models. Similarly, for coal and natural gas, economic impacts are estimated using generation capacity in NREL's Coal and Natural Gas Models.

Table A3 | 2020–35 modeling inputs for JEDI (generation capacity in MW)

	2020	2025	2030	2035
Reference Scenario				
Onshore wind	111,047	285,636	285,636	285,636
Offshore wind	0	17,762	20,650	28,950
Coal	267,598	133,709	3,851	0
Natural gas	577,409	543,289	556,814	559,141
ETC Scenario				
Onshore wind	111,047	157,059	393,444	561,173
Offshore wind	0	3,006	20,650	28,950
Coal	267,598	133,709	63	0
Natural gas	577,367	536,901	537,720	540,082
ATC Scenario				
Onshore wind	111,047	213,456	419,867	668,114
Offshore wind	0	3,006	20,650	28,950
Coal	267,598	133,709	0	0
Natural gas	577,326	530,210	543,566	545,500
NZ Scenario				
Onshore wind	111,047	210,953	457,745	893,740
Offshore wind	0	3,006	20,650	29,691
Coal	267,598	133,709	0	0
Natural gas	577,363	547,458	570,660	569,173

Notes: ATC = advanced tax credit; ETC = extended tax credit; JEDI = Jobs and Economic Development Impacts; MW = megawatts; NZ = net-zero.

Source: WRI authors and BW Research.

Our analysis also estimates potential negative employment impacts in the electricity, transportation, buildings, and fuels sectors (Table A4) due to the changes in the deployment of fossil fuel technologies and fossil fuel use we see under the different mitigation scenarios between 2020 and 2035.

In the electricity sector, we use coal and natural gas generation capacity data as inputs for the JEDI Coal Model and the JEDI NGas Model to evaluate how baseline employment levels in 2020 change through 2035 according to trends in coal and natural gas capacity in the three mitigation scenarios. For the transportation sector, capital costs for traditional internal combustion engine (ICE) vehicles (e.g., diesel and gasoline cars and medium- and heavy-duty vehicles) are used as inputs for the IMPLAN analysis-by-parts to see how employment associated with automobile manufacturing changes in 2035, compared to 2020 levels. We adopt a similar approach for the fuels sector, where fuel costs for fuel sources like natural gas, gasoline, and diesel are used as spending inputs. Impacts resulting from changes in natural gas consumption and distribution capture potential negative impacts coming from buildings electrification and efficiency improvements.

Additionally, we examine the wage distribution and demographic composition of direct and indirect employment for the NZ scenario. For sectors like electricity, transportation, buildings, and fuels, we use a rolling average of USEER 2018–21 data (Table A5) to derive changes in the share of employment for different demographic groups in 2020 and 2035. Further details on the wage distribution analysis for the NZ scenario are described in Technical Appendix B.

Table A6 provides a list of IMPLAN multipliers (jobs/$ ratios) used for this report. IMPLAN multipliers for the different modeled sectors and associated IMPLAN industries are derived mostly from 2020 U.S. Bureau of Economic Analysis and Bureau of Labor Statistics data. These data include salary and wage data, along with data on interindustry spending (i.e., intermediate goods purchases) and data on various other expenditure types (taxes, proprietor income, etc.).

Table A4 | Overview of negative employment impacts analysis

SECTOR	SUBSECTOR(S)	METHODOLOGY
Electricity	Coal	Coal capacity data are used in JEDI Coal Model rel. C12.23.16 using the United States as the study area, 85% capacity factor, 9,370 Btu per kWh heat rate, and all other default input parameters.
	Natural gas	Natural gas capacity data are used in JEDI NGas Model rel. NG4.17.17, using the United States as the study area, 65% capacity factor, 7,000 Btu per kWh heat rate, and other default input parameters.
	Nuclear	Fixed costs for nuclear generation are allocated to IMPLAN industry code 41 (nuclear electric power generation).
Transportation	Internal combustion engine vehicles	Capital costs for light-, medium-, and heavy-duty ICE vehicles are allocated to IMPLAN industry codes 340/341/342 (automobile manufacturing / light truck and utility vehicle manufacturing / heavy-duty truck manufacturing).
Fuels	Natural gas, gasoline, diesel, LPG, coal petroleum coke, and still gas	Fuel costs for natural gas and petroleum are allocated to IMPLAN industry code 20 (oil and gas extraction), while fuel costs for coal are allocated to IMPLAN industry code 21 (coal mining).

Notes: Btu = British thermal units; ICE = internal combustion engine; IMPLAN = Economic Impact Analysis for Planning; JEDI = Jobs and Economic Development Impacts; kW = kilowatt; LPG = liquefied petroleum gas.

Source: WRI authors and BW Research.

Table A5 | U.S. Energy and Employment Jobs Report demographic trends

ENERGY EFFICIENCY	2018	2019	2020	2021	AVERAGE CHANGE (2018–21)	2035
Male	77%	76%	75%	75%	-2%	67%
Female	23%	24%	25%	25%	7%	33%
Hispanic or Latino	15%	16%	15%	15%	2%	17%
Not Hispanic or Latino	85%	84%	85%	85%	0%	83%
American Indian or Alaska Native	1%	1%	1%	1%	-7%	1%
Asian	5%	5%	6%	6%	27%	17%
Black or African American	8%	8%	8%	8%	5%	10%
Native Hawaiian or other Pacific Islander	1%	1%	1%	1%	-3%	1%
White	78%	78%	77%	77%	-1%	66%
Two or more races	7%	7%	7%	7%	-6%	5%
55 and over	14%	14%	13%	13%	-7%	9%
ELECTRICITY GENERATION	**2018**	**2019**	**2020**	**2021**	**AVERAGE CHANGE (2018–21)**	**2035**
Male	68%	67%	68%	68%	0%	70%
Female	32%	33%	32%	32%	-1%	30%
Hispanic or Latino	19%	19%	18%	18%	-5%	14%
Not Hispanic or Latino	81%	81%	82%	82%	1%	86%
American Indian or Alaska Native	2%	1%	1%	1%	-42%	0%

Table A5 | U.S. Energy and Employment Jobs Report demographic trends (Cont.)

ELECTRICITY GENERATION	2018	2019	2020	2021	AVERAGE CHANGE (2018–21)	2035
Asian	9%	10%	10%	10%	7%	13%
Black or African American	9%	9%	9%	9%	0%	9%
Native Hawaiian or other Pacific Islander	2%	1%	1%	1%	-44%	0%
White	70%	69%	69%	69%	-1%	65%
Two or more races	9%	10%	10%	10%	7%	13%
55 and over	11%	14%	14%	14%	25%	39%
FUELS	**2018**	**2019**	**2020**	**2021**	**AVERAGE CHANGE (2018–21)**	**2035**
Male	76%	76%	75%	74%	-2%	67%
Female	24%	24%	25%	26%	7%	33%
Hispanic or Latino	12%	12%	12%	12%	0%	12%
Not Hispanic or Latino	88%	88%	88%	88%	0%	88%
American Indian or Alaska Native	2%	2%	2%	2%	-13%	1%
Asian	5%	5%	5%	5%	-6%	3%
Black or African American	5%	5%	7%	8%	48%	37%
Native Hawaiian or other Pacific Islander	1%	1%	1%	1%	2%	1%
White	78%	78%	77%	77%	-1%	55%
Two or more races	9%	9%	8%	8%	-12%	3%
55 and over	23%	23%	21%	20%	-15%	9%
MOTOR VEHICLES	**2018**	**2019**	**2020**	**2021**	**AVERAGE CHANGE (2018–21)**	**2035**
Male	77%	77%	77%	77%	-1%	73%
Female	23%	23%	23%	23%	4%	27%
Hispanic or Latino	17%	17%	17%	17%	2%	19%
Not Hispanic or Latino	83%	83%	83%	83%	0%	81%
American Indian or Alaska Native	2%	2%	2%	2%	-2%	1%
Asian	5%	5%	5%	5%	0%	5%
Black or African American	8%	8%	8%	8%	5%	10%
Native Hawaiian or other Pacific Islander	1%	1%	1%	1%	32%	3%
White	78%	78%	77%	77%	-2%	68%
Two or more races	7%	7%	8%	8%	11%	13%
55 and over	20%	20%	19%	19%	-5%	15%

Source: WRI authors and BW Research.

Table A6 | IMPLAN industry multipliers (jobs/$million)

IMPLAN CODE	DESCRIPTION	DIRECT	INDIRECT	INDUCED	TOTAL
15	Forestry, forest products, and timber tract production	10.48	3.59	7.81	21.89
16	Commercial logging	10.63	5.19	7.58	23.40
19	Support activities for agriculture and forestry	21.79	1.15	7.83	30.77
39	Electric power generation—hydroelectric	1.02	2.04	3.29	6.35
44	Electric power generation—geothermal	1.27	2.02	3.46	6.76
45	Electric power generation—biomass	0.63	2.77	2.96	6.36
47	Electric power transmission and distribution	0.75	1.70	2.87	5.32
50	Construction of new health-care structures	8.18	2.54	6.01	16.73
51	Construction of new manufacturing structures	8.22	2.90	6.36	17.48
52	Construction of new power and communication structures	6.42	2.34	5.05	13.80
53	Construction of new educational and vocational structures	7.69	2.31	5.70	15.70
55	Construction of new commercial structures, including farm structures	8.75	2.83	6.41	17.99
56	Construction of other new nonresidential structures	6.31	3.63	5.63	15.56
57	Construction of new single-family residential structures	8.39	2.98	6.17	17.55
58	Construction of new multifamily residential structures	11.21	1.45	6.90	19.56
59	Construction of other new residential structures	4.01	3.87	4.33	12.21
60	Maintenance and repair construction of nonresidential structures	4.62	3.81	4.71	13.14
61	Maintenance and repair construction of residential structures	5.03	4.16	4.80	13.99
160	Industrial gas manufacturing	0.99	3.03	3.65	7.67
162	Other basic inorganic chemical manufacturing	1.01	3.22	3.53	7.76
163	Other basic organic chemical manufacturing	0.61	4.38	3.37	8.36
203	Cement manufacturing	1.63	3.58	3.65	8.86
215	Iron and steel mills and ferroalloy manufacturing	0.80	3.87	3.38	8.05
236	Fabricated structural metal manufacturing	2.85	4.45	4.46	11.76
242	Metal tank (heavy gauge) manufacturing	3.52	3.98	4.78	12.28
286	Air and gas compressor manufacturing	1.63	3.92	4.03	9.58
302	Broadcast and wireless communications equipment manufacturing	2.09	2.79	4.46	9.34
307	Semiconductor and related device manufacturing	1.38	3.16	4.61	9.15
315	Totalizing fluid meter and counting device manufacturing	2.16	3.12	3.91	9.18
316	Electricity and signal testing instruments manufacturing	1.73	4.54	4.93	11.20
329	Power, distribution, and specialty transformer manufacturing	2.57	3.26	4.20	10.03
333	Storage battery manufacturing	2.94	2.41	3.70	9.05
336	Other communication and energy wire manufacturing	2.04	3.28	3.60	8.92
339	All other miscellaneous electrical equipment and component manufacturing	2.95	3.60	5.13	11.68
340	Automobile manufacturing	0.74	3.93	3.23	7.90

Table A6 | IMPLAN industry multipliers (jobs/$million) (Cont.)

IMPLAN CODE	DESCRIPTION	DIRECT	INDIRECT	INDUCED	TOTAL
341	Light truck and utility vehicle manufacturing	0.47	4.41	3.29	8.17
342	Heavy-duty truck manufacturing	0.92	4.30	3.43	8.65
395	Wholesale—Machinery, equipment, and supplies	3.44	3.53	4.60	11.57
402	Retail—Motor vehicle and parts dealers	7.10	2.73	5.12	14.95
428	Software publishers	2.39	0.59	3.56	6.54
436	Data processing, hosting, and related services	1.90	5.12	4.74	11.75
455	Legal services	4.65	2.35	5.06	12.07
457	Architectural, engineering, and related services	5.83	3.51	6.45	15.79
459	Custom computer programming services	6.56	2.84	7.34	16.74
460	Computer systems design services	7.78	1.74	7.96	17.48
461	Other computer related services, including facilities management	3.57	3.51	5.18	12.26
465	Advertising, public relations, and related services	5.43	3.42	5.29	14.14
479	Waste management and remediation services	4.30	3.10	4.52	11.92

Source: WRI authors and BW Research.

TECHNICAL APPENDIX B. IMPLAN ANALYSIS-BY-PARTS POLICY LEVER MODELING FRAMEWORK

Domestic content requirements

Through this policy lever analysis, we evaluate potential economic impacts of enhanced U.S. domestic manufacturing under "what if" scenarios by changing our domestic content requirement assumptions from the base modeling analysis.

We change these assumptions for solar, wind, and storage in the electricity sector; for light-, medium-, and heavy-duty EVs in the transportation sector; and for the buildings sector. Table B1 describes our domestic content base modeling assumptions for these sectors and how we evaluate impacts of differing domestic content assumptions.

Sustainable wages

Through this policy lever analysis, we evaluate economic impacts resulting from higher earnings for workers in the NZ scenario. We assess additional induced impacts that are generated if workers earning below sustainable wages receive a higher income.

Using the framework of MIT's Living Wage Calculator, we classify workers into three groups: workers earning less than $22 an hour, between $22 and $34 an hour, and above $34 an hour (in nominal 2020 dollars). MIT's tool uses expenditure data related to a household's minimum food consumption, childcare, housing, health insurance, transportation,

Table B1 | Overview of domestic content assumptions

SECTOR	SUBSECTOR	DOMESTIC CONTENT ASSUMPTIONS	
		Base Modeling	**Policy Lever Modeling**
Electricity	Onshore and offshore wind	▪ The base modeling domestic content assumption is set at 46% for the onshore wind subsector and 45% for the offshore wind subsector. These assumptions are derived from default JEDI model parameters.	▪ For these two subsectors, we change these domestic content assumptions to 75% and 90%.
	Solar*	▪ For the solar subsector, we multiply the spending allocated for semiconductor manufacturing (IMPLAN code 307) and power distribution and transformer manufacturing (IMPLAN code 329) by 0.25.	▪ For these subsectors, we change the baseline domestic content assumption of 25% to 50% and 75%, multiplying the spending allocated to these IMPLAN codes by 0.5 and 0.75.
	Storage*	▪ In storage, we multiply the spending allocated to power distribution and transformer manufacturing (IMPLAN code 329) and storage battery manufacturing (IMPLAN code 333) by 0.25.	
Transportation	Alternative vehicles*	▪ For electric vehicles in the light-, medium-, and heavy-duty vehicle segments, we multiply the spending allocated to storage battery manufacturing (IMPLAN code 333) by 0.25.	▪ For these subsectors, we change the baseline domestic content assumption of 25% to 50% and 75%, multiplying the spending allocated to these IMPLAN codes by 0.5 and 0.75.
Buildings	Energy efficiency	▪ The base domestic content assumption of 73% for the buildings sector is derived from IMPLAN spending patterns. The assumption applies to equipment and devices such as lighting fixtures, cooking appliances, refrigerators, freezers, and other electrical appliances.	▪ Referring to the Federal Acquisitions Regulation Buy American Act (S 52.225-1), we assume that at least 65% of energy-efficiency measures is sourced domestically by 2030. This benchmark increases the 73% baseline domestic content assumption to 78%.

Notes: IMPLAN = Economic Impact Analysis for Planning; JEDI = Jobs and Economic Development Impacts. * Assumptions for domestic content in the solar, storage, and alternative vehicles subsectors focus on battery manufacturing. Based on the U.S. market share in battery manufacturing reported by the U.S. International Trade Commission and the U.S.-China Economic and Security Review Commission, we set domestic content for battery-related components at 25 percent in the base model.

Source: WRI authors and BW Research.

and other basic essential costs to determine the minimum wage necessary to meet a household's basic needs. Following this framework, we assume that workers earning below $22 an hour are earning below sustainable wages.

Results for direct and indirect jobs in 2035 are used to evaluate the distribution of employment across these three wage groups. We use data on current wages for sector-specific occupations in different IMPLAN industry groups (construction, professional, manufacturing, and other supply-chain) through JobsEQ to classify different occupations into these three wage groups and to determine the distribution of employment within each wage group (Table B2). We calculate the average difference between an occupation's current wage and a wage of $22 an hour for occupations classified in the below $22 an hour category. We then weight the difference on 2035 employment results falling in this category to estimate the spending required to increase wages to $22 an hour and use IMPLAN industry spending patterns to estimate induced impacts resulting from additional earnings. This part of our analysis assumes that increasing wages of employees does not impact labor demand or demand-side costs.

Table B2 | 2035 employment with wages below $22 an hour in the NZ scenario

SECTOR	EMPLOYEES EARNING <$22/HOUR
Electricity	1,019,757
Fuels	373,597
Buildings	1,183,287
Transportation	890,469
Industry	108,854
Waste	235
Technological carbon removal	6,269
Agriculture and natural and working lands	57,370
TOTAL	**3,639,839**

Notes: NZ = net-zero. Employment numbers presented in the table show direct and indirect jobs in 2035 for the NZ scenario.

Source: WRI authors and BW Research.

TECHNICAL APPENDIX C. SUPPLEMENTARY MODELING RESULTS

Table C1 | Summary of economic impacts by scenarios, 2020 and 2035

ELECTRICITY				
	Employment	Labor Income	Value Added	Taxes
2020 baseline	3,679,160	$287,652,839,214	$547,074,579,270	$132,747,289,695
Reference 2035	4,690,437	$294,073,860,671	$588,889,951,879	$170,824,021,298
ETC scenario 2035	5,489,568	$344,176,554,123	$689,221,795,954	$199,928,082,277
ATC scenario 2035	6,164,901	$359,782,173,772	$737,136,048,574	$219,446,266,132
NZ scenario 2035	7,717,523	$399,620,610,808	$844,537,808,799	$268,990,050,857
BUILDINGS				
	Employment	Labor Income	Value Added	Taxes
2020 baseline	2,514,825	$164,652,790,034	$246,090,772,360	$53,963,873,859
Reference 2035	6,017,948	$395,474,603,985	$589,204,306,550	$128,892,907,647
ETC scenario 2035	6,577,464	$432,243,645,704	$643,985,264,696	$140,876,657,427
ATC scenario 2035	6,994,534	$460,085,229,154	$684,912,171,554	$149,733,115,128
NZ scenario 2035	7,136,877	$469,616,150,408	$698,886,344,693	$152,750,676,474
TRANSPORTATION				
	Employment	Labor Income	Value Added	Taxes
2020 baseline	5,963,197	$437,151,135,431	$813,029,206,459	$160,032,351,318
Reference 2035	5,818,508	$422,321,719,924	$754,577,552,639	$154,608,823,571
ETC scenario 2035	5,109,468	$370,857,860,124	$662,625,205,542	$135,768,289,342
ATC scenario 2035	4,593,718	$356,362,636,952	$637,390,557,376	$130,733,342,932
NZ scenario 2035	3,999,965	$324,242,890,395	$557,529,532,609	$119,117,809,892
FUELS				
	Employment	Labor Income	Value Added	Taxes
2020 baseline	4,430,591	$402,430,152,925	$673,273,643,520	$166,437,556,687
Reference 2035	4,279,831	$386,019,666,522	$644,685,837,563	$159,006,506,546
ETC scenario 2035	3,787,530	$341,616,568,358	$570,528,868,339	$140,716,294,593
ATC scenario 2035	3,556,985	$317,578,229,693	$529,087,710,403	$130,113,487,349
NZ scenario 2035	3,224,726	$266,084,098,508	$443,585,474,955	$107,700,355,272

Table C1 | Summary of economic impacts by scenarios, 2020 and 2035 (Cont.)

OTHERS				
	Employment	**Labor Income**	**Value Added**	**Taxes**
2020 baseline	30	$2,461,844	$4,812,404	$976,545
Reference 2035	30	$2,461,844	$4,812,404	$976,545
ETC scenario 2035	234,970	$13,591,252,269	$20,474,279,001	$3,556,788,687
ATC scenario 2035	381,123	$20,774,323,930	$30,668,513,111	$4,831,091,819
NZ scenario 2035	998,141	$62,032,205,505	$92,136,334,809	$18,130,674,435
ECONOMY TOTAL				
	Employment	**Labor Income**	**Value Added**	**Taxes**
2020 baseline	16,587,803	$1,291,889,379,448	$2,279,473,014,013	$513,182,048,104
ETC scenario 2035	21,199,000	$1,502,485,880,578	$2,586,835,413,532	$620,846,112,326
ATC scenario 2035	21,691,261	$1,514,582,593,501	$2,619,195,001,018	$634,857,303,360
NZ scenario 2035	23,077,232	$1,521,595,955,624	$2,636,675,495,865	$666,689,566,930
Reference 2035	20,806,754	$1,497,892,312,945	$2,577,362,461,034	$613,333,235,608

Notes: ATC = advanced tax credit; ETC = extended tax credit; NZ = net-zero. Table shows direct, indirect, and induced impacts. The "Others" category includes sectors like industry, waste, technological carbon removal, and agriculture and natural and working lands. Dollar values are reported in nominal 2020 dollars.

Source: WRI authors and BW Research.

Table C2 | Employment across different industry categories by scenarios, 2020 and 2035

	ELECTRICITY (OVERALL)		ELECTRICITY (FOSSIL-BASED GENERATION)		BUILDINGS	
	2020	2035	2020	2035	2020	2035
ETC Scenario						
Construction	521,586	991,935	49,132	121,378	1,034,801	2,721,911
Professional services	724,252	875,406	92,774	92,991	272,075	719,829
Manufacturing	251,485	592,628	5,953	6,229	69,274	188,199
Other supply chain	583,078	742,141	263,996	170,706	231,752	573,575
Induced	1,598,759	2,287,459	411,561	342,153	902,795	2,373,950
ATC Scenario						
Construction	521,586	1,149,957	49,132	110,710	1,034,801	2,891,612
Professional services	724,252	922,387	92,774	90,406	272,075	765,855
Manufacturing	251,485	680,224	5,953	5,949	69,274	201,578
Other supply chain	583,078	850,864	263,996	174,103	231,752	599,434
Induced	1,598,759	2,561,471	411,561	338,674	902,795	2,521,755
NZ Scenario						
Construction	521,586	1,532,880	49,132	127,355	1,034,801	2,950,530
Professional services	724,252	1,043,364	92,774	96,997	272,075	781,899
Manufacturing	251,485	872,307	5,953	6,587	69,274	206,316
Other supply chain	583,078	1,082,181	263,996	178,537	231,752	607,851
Induced	1,598,759	3,186,793	411,561	357,325	902,795	2,573,059

Table C2 | Employment across different industry categories by scenarios, 2020 and 2035 (Cont.)

	TRANSPORTATION		FUELS		OTHERS		TOTAL	
	2020	2035	2020	2035	2020	2035	2020	2035
ETC Scenario								
Construction	19,721	55,650	73,617	95,409	0	52,564	1,649,725	3,917,468
Professional services	807,800	833,463	1,128,798	953,067	5	19,914	2,932,930	3,401,680
Manufacturing	1,633,401	1,192,912	54,408	49,927	6	7,896	2,008,573	2,031,562
Other supply chain	1,066,083	970,240	1,007,699	849,491	6	83,941	2,888,617	3,219,388
Induced	2,436,193	2,057,203	2,166,070	1,839,637	13	70,654	7,103,830	8,628,904
ATC Scenario								
Construction	19,722	48,481	73,617	129,967	0	71,661	1,649,725	4,291,679
Professional services	807,798	754,614	1,128,798	878,747	5	27,959	2,932,928	3,349,560
Manufacturing	1,633,402	1,061,317	54,408	50,064	6	10,242	2,008,574	2,003,425
Other supply chain	1,066,083	881,619	1,007,699	783,432	6	165,665	2,888,617	3,281,012
Induced	2,436,193	1,847,687	2,166,070	1,714,776	13	105,596	7,103,830	8,751,285
NZ Scenario								
Construction	19,722	67,304	73,617	159,676	0	321,227	1,649,725	5,031,617
Professional services	807,798	781,475	1,128,798	751,589	5	99,605	2,932,928	3,457,931
Manufacturing	1,633,402	745,943	54,408	125,010	6	34,185	2,008,574	1,983,761
Other supply chain	1,066,083	824,138	1,007,699	668,515	6	210,745	2,888,617	3,393,430
Induced	2,436,193	1,581,105	2,166,070	1,519,935	13	332,380	7,103,830	9,193,272

Notes: ATC = advanced tax credit; ETC = extended tax credit; NZ = net-zero. The “Others” category includes sectors like industry, waste, technological carbon removal, and agriculture and natural and working lands.

Source: WRI authors and BW Research.

Table C3 | Industry composition of direct and indirect employment by scenarios, 2020 and 2035

	ELECTRICITY		BUILDINGS		TRANSPORTATION		FUELS		OTHERS		TOTAL	
	2020	2035	2020	2035	2020	2035	2020	2035	2020	2035	2020	2035
ETC Scenario												
Construction	25%	31%	64%	65%	1%	2%	3%	5%	1%	32%	17%	31%
Professional services	35%	27%	17%	17%	23%	27%	50%	49%	29%	12%	31%	27%
Manufacturing	12%	19%	4%	4%	46%	39%	2%	3%	36%	5%	21%	16%
Other supply chain	28%	23%	14%	14%	30%	32%	44%	44%	34%	51%	30%	26%
ATC Scenario												
Construction	25%	32%	64%	65%	1%	2%	3%	7%	1%	26%	17%	33%
Professional services	35%	26%	17%	17%	23%	27%	50%	48%	29%	10%	31%	26%
Manufacturing	12%	19%	4%	5%	46%	39%	2%	3%	36%	4%	21%	15%
Other supply chain	28%	24%	14%	13%	30%	32%	44%	43%	34%	60%	30%	25%
NZ Scenario												
Construction	25%	34%	64%	65%	1%	3%	3%	9%	1%	48%	17%	36%
Professional services	35%	23%	17%	17%	23%	32%	50%	44%	29%	15%	31%	25%
Manufacturing	12%	19%	4%	5%	46%	31%	2%	7%	36%	5%	21%	14%
Other supply chain	28%	24%	14%	13%	30%	34%	44%	39%	34%	32%	30%	24%

Notes: ATC = advanced tax credit; ETC = extended tax credit; NZ = net-zero. The "Others" category includes sectors like industry, waste, technological carbon removal, and agriculture and natural and working lands.

Source: WRI authors and BW Research.

Table C4 | Wage distribution of direct and indirect employment in the NZ scenario, 2020 and 2035

	ELECTRICITY		BUILDINGS		TRANSPORTATION		FUELS		OTHERS	
Hourly Wages	2020	2035	2020	2035	2020	2035	2020	2035	2020	2035
Less than $22	24%	23%	25%	25%	40%	32%	23%	23%	26%	26%
$22–$34	37%	45%	45%	45%	32%	34%	33%	35%	48%	48%
More than $34	39%	32%	30%	30%	28%	34%	44%	42%	26%	26%

Notes: NZ = net-zero. The "Others" category includes sectors like industry, waste, technological carbon removal, and agriculture and natural and working lands.

Source: WRI authors and BW Research.

Table C5 | Employment impacts under different domestic content assumptions in 2020 and 2035 in the ETC scenario

SECTOR/SUBSECTOR (BASELINE DOMESTIC CONTENT)	2020	2035 (UNDER BASELINE ASSUMPTION)	2035 (UNDER DIFFERENT DOMESTIC CONTENT ASSUMPTIONS)				
			50%	75%	78%	90%	100%
ETC Scenario							
Solar (25%)	495,970	1,499,163	1,671,844	1,844,526			
			(172,682)	(345,363)			
Storage (25%)	111,780	126,376	154,556	182,735			
			(28,180)	(56,360)			
Alternative vehicles (25%)	309,912		2,950,981	3,510,810			
	2,391,152		(559,829)	(1,119,658)			
Onshore wind (46%)	187,686	885,635		1,152,114		1,288,118	
				(266,479)		(402,483)	
Offshore wind (45%)	0	108,100		152,121		174,170	
				(44,021)		(66,070)	
Buildings (73%)	2,510,696	6,577,464			6,600,966		6,696,582
					(23,502)		(119,118)

Notes: ETC = extended tax credit. Table shows direct, indirect, and induced impacts. Numbers in parentheses show changes in 2035 employment under different domestic content assumptions, relative to 2035 employment under baseline domestic content assumptions. Numbers may not add up due to rounding.

Source: WRI authors and BW Research.

Table C6 | Employment impacts under different domestic content assumptions in 2020 and 2035 in the ATC scenario

SECTOR/SUBSECTOR (BASELINE DOMESTIC CONTENT)	2020	2035 (UNDER BASELINE ASSUMPTION)	2035 (UNDER DIFFERENT DOMESTIC CONTENT ASSUMPTIONS)				
			50%	75%	78%	90%	100%
ATC Scenario							
Solar (25%)	495,970	1,996,340	2,239,857	2,483,374			
			(243,517)	(487,034)			
Storage (25%)	111,780	126,362	154,538	182,715			
			(28,177)	(56,353)			
Alternative vehicles (25%)			2,664,059	3,168,895			
	309,912	2,159,224	(504,836)	(1,009,672)			
Onshore wind (46%)	187,686	1,056,809		1,374,793		1,537,084	
				(317,984)		(480,275)	
Offshore wind (45%)	0	108,100		152,121		174,170	
				(44,021)		(66,070)	
Buildings (73%)	2,510,696	6,980,233			7,379,675		7,112,318
					(399,442)		(132,085)

Notes: ATC = advanced tax credit. Table shows direct, indirect, and induced impacts. Numbers in parentheses show changes in 2035 employment under different domestic content assumptions, relative to 2035 employment under baseline domestic content assumptions. Numbers may not add up due to rounding.

Source: WRI authors and BW Research.

Table C7 | Employment impacts under different domestic content assumptions in 2020 and 2035 in the NZ scenario

SECTOR/SUBSECTOR (BASELINE DOMESTIC CONTENT)	2020	2035 (UNDER BASELINE ASSUMPTION)	2035 (UNDER DIFFERENT DOMESTIC CONTENT ASSUMPTIONS)				
			50%	75%	78%	90%	100%
ATC Scenario							
Solar (25%)	495,970	3,045,560	3,438,596	3,831,632			
			(393,036)	(786,072)			
Storage (25%)	111,780	130,704	159,849	188,994			
			(29,145)	(58,290)			
Alternative vehicles (25%)	309,912	3,651,432	4,501,424	5,351,415			
			(849,992)	(1,699,983)			
Onshore wind (46%)	187,686	1,423,033		1,851,210		2,069,741	
				(428,177)		(646,708)	
Offshore wind (45%)	0	110,764		155,870		178,463	
				(45,106)		(67,699)	
Buildings (73%)	2,510,696	7,119,655			7,162,640		7,253,924
					(42,985)		(134,269)

Notes: NZ = net-zero. Table shows direct, indirect, and induced impacts. Numbers in parentheses show changes in 2035 employment under different domestic content assumptions, relative to 2035 employment under baseline domestic content assumptions. Numbers may not add up due to rounding.

Source: WRI authors and BW Research.

TECHNICAL APPENDIX D. MODELING RESULTS FROM WRI'S BUILDING BLOCKS ANALYSIS

Table D1 | Final energy demand (TBtu) by fuel and by sector, across mitigation scenarios

		REFERENCE SCENARIO				ETC SCENARIO				ATC SCENARIO				NZ SCENARIO			
Sector	**Fuel**	**2020**	**2025**	**2030**	**2035**	**2020**	**2025**	**2030**	**2035**	**2020**	**2025**	**2030**	**2035**	**2020**	**2025**	**2030**	**2035**
Buildings	Electricity	10,013	9,645	9,296	9,065	9,994	9,418	8,987	8,752	9,994	9,571	9,526	9,855	9,994	9,571	9,526	10,095
	Hydrogen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	49
	Biofuels/ waste	675	672	660	645	673	665	641	614	673	663	627	573	673	726	737	745
	Natural gas	9,515	9,334	9,120	8,940	9,486	9,135	8,563	8,088	9,486	8,775	7,391	5,847	9,486	8,775	7,391	5,381
	Petroleum	1,773	1,778	1,765	1,748	1,769	1,760	1,716	1,670	1,769	1,700	1,508	1,260	1,769	1,637	1,398	999
	Coal	18	18	18	18	18	18	18	18	18	18	17	16	18	18	17	15
Industry	Electricity	3,813	3,947	4,089	4,240	3,813	3,936	4,057	4,180	3,813	3,931	4,040	4,158	3,813	3,976	4,276	4,748
	Hydrogen	0	0	0	0	0	0	0	0	0	0	0	0	0	222	771	1,677
	Biofuels/ waste	2,446	2,532	2,624	2,721	2,446	2,520	2,587	2,652	2,446	2,514	2,568	2,627	2,446	2,582	2,658	2,793
	Natural gas	12,079	12,628	13,219	13,856	12,079	12,544	12,961	13,371	12,079	12,502	12,832	13,194	12,079	12,072	11,318	9,881
	Petroleum	7,410	7,865	8,366	8,913	7,410	7,851	8,321	8,830	7,410	7,843	8,298	8,800	7,410	7,575	7,638	7,517
	Coal	1,162	1,130	1,101	1,076	1,162	1,128	1,095	1,064	1,162	1,127	1,092	1,060	1,162	1,101	1,037	972
Transportation	Electricity	40	107	250	588	62	303	914	1,671	64	332	959	1,809	60	355	1,223	2,660
	Hydrogen	0	4	24	73	0	4	24	73	0	4	24	103	0	30	112	521
	Biofuels/ waste	1,277	1,307	1,170	1,034	1,197	1,491	1,553	1,595	1,274	1,839	2,151	2,382	1,275	1,801	2,011	2,643
	Natural gas	974	971	958	947	974	969	955	943	974	969	955	943	971	968	956	931
	Petroleum	20,685	22,911	21,247	19,638	20,708	22,240	19,197	16,427	20,644	21,820	18,493	15,330	20,658	21,786	17,702	12,267

Notes: ATC = advanced tax credit; ETC = extended tax credit; NZ = net-zero; TBtu = trillion British thermal units.

Source: Saha et al. 2021b.

Table D2 | Assumptions for hydrogen production by production route

	SHARE OF FINAL ENERGY DEMAND			
Production Route	**2020**	**2025**	**2030**	**2035**
Hydrogen BECCS	0%	0%	0%	4%
Hydrogen electrolysis	0%	0%	31%	96%
Hydrogen SMR	100%	100%	69%	0%

Notes: BECCS = bioenergy carbon capture and storage; SMR = steam methane reforming.

Source: Saha et al. 2021b.

Table D3 | Electricity demand (TWh) by sector, across mitigation scenarios

	REFERENCE SCENARIO				ETC SCENARIO				ATC SCENARIO				NZ SCENARIO			
Sector	**2020**	**2025**	**2030**	**2035**	**2020**	**2025**	**2030**	**2035**	**2020**	**2025**	**2030**	**2035**	**2020**	**2025**	**2030**	**2035**
Buildings	2,934	2,827	2,724	2,657	2,929	2,760	2,634	2,565	2,929	2,805	2,792	2,888	2,929	2,805	2,792	2,959
Industry	1,117	1,157	1,198	1,243	1,117	1,154	1,189	1,225	1,117	1,152	1,184	1,219	1,117	1,165	1,253	1,392
Transportation	12	31	73	172	18	89	268	490	19	97	281	530	18	104	358	780
Electrolysis	0	0	0	0	0	0	0	0	0	0	3	35	0	0	113	756
DAC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**4,064**	**4,015**	**3,996**	**4,072**	**4,065**	**4,003**	**4,091**	**4,280**	**4,065**	**4,055**	**4,260**	**4,672**	**4,064**	**4,074**	**4,517**	**5,886**

Notes: ATC = advanced tax credit; DAC = direct air capture; ETC = extended tax credit; NZ = net-zero; TWh = terawatt-hours.

Source: Saha et al. 2021b.

Table D4 | Power generation (GWh) by fuel source across mitigation scenarios

	REFERENCE SCENARIO				ETC SCENARIO			
Fuel Source	**2020**	**2025**	**2030**	**2035**	**2020**	**2025**	**2030**	**2035**
Coal	1,031,138	498,629	14,284	0	1,030,778	547,734	237	0
Natural gas	1,122,098	749,352	1,158,431	1,115,865	1,123,167	1,302,354	826,207	427,468
Natural gas w/ CCS	0	0	0	0	0	0	0	0
Nuclear	901,819	880,264	885,214	864,356	901,822	894,924	859,204	717,462
Bioenergy	181,300	180,820	180,820	180,820	181,300	180,820	180,820	180,820
Solar	130,409	252,028	291,628	417,709	130,409	183,869	346,700	635,297
Onshore wind	365,329	1,061,174	1,066,460	1,065,719	365,329	552,028	1,482,886	1,912,597
Offshore wind	0	74,631	86,143	120,380	0	12,598	86,143	119,653
Geothermal	31,918	31,918	31,918	31,918	31,918	31,918	31,918	31,918
Hydropower	312,860	312,356	313,592	315,176	312,883	311,893	312,537	313,535
Total	**4,076,871**	**4,041,170**	**4,028,491**	**4,111,944**	**4,077,607**	**4,018,138**	**4,126,652**	**4,338,749**

Table D4 | Power generation (GWh) by fuel source across mitigation scenarios (Cont.)

	ATC SCENARIO				NZ SCENARIO			
Fuel Source	**2020**	**2025**	**2030**	**2035**	**2020**	**2025**	**2030**	**2035**
Coal	1,030,771	547,326	0	0	1,030,749	543,160	0	0
Natural gas	1,123,812	1,130,094	856,743	362,338	1,122,679	1,166,040	792,477	217,532
Natural gas w/ CCS	0	0	0	0	0	0	0	0
Nuclear	901,827	894,940	858,360	733,778	901,818	894,531	847,484	713,695
Bioenergy	181,300	180,820	180,820	180,820	181,300	180,820	180,820	180,820
Solar	130,409	185,824	382,332	839,900	130,409	186,459	513,316	1,302,692
Onshore wind	365,329	774,123	1,588,487	2,135,604	365,329	762,113	1,685,691	2,352,914
Offshore wind	0	12,598	86,143	120,179	0	12,598	86,143	121,011
Geothermal	31,918	31,918	31,918	31,918	31,918	31,918	31,918	31,918
Hydropower	312,863	312,289	314,229	314,752	312,875	312,371	313,311	315,795
Total	**4,078,229**	**4,069,932**	**4,299,033**	**4,719,289**	**4,077,078**	**4,090,011**	**4,451,160**	**5,236,376**

Notes: ATC = advanced tax credit; CCS = carbon capture and storage; ETC = extended tax credit; GWh = gigawatt-hour; NZ = net-zero.

Source: Saha et al. 2021b.

Table D5 | Battery electric vehicle share of light-duty vehicle and medium- and heavy-duty vehicle sales and stock across mitigation scenarios

	REFERENCE SCENARIO				ETC SCENARIO			
	2020	**2025**	**2030**	**2035**	**2020**	**2025**	**2030**	**2035**
LDV BEV								
Sales Share	2.10%	3.80%	12.70%	27.30%	3.50%	20.60%	43.90%	58.20%
Stock Share	0.54%	1.61%	3.85%	10.90%	0.70%	4.90%	16.47%	31.23%
MHDV BEV								
Sales Share	0.21%	3.64%	12.60%	20.25%	0.21%	3.64%	12.60%	20.25%
Stock Share	0.01%	0.54%	2.73%	6.91%	0.01%	0.54%	2.73%	6.91%

Table D5 | Battery electric vehicle share of light-duty vehicle and medium- and heavy-duty vehicle sales and stock across mitigation scenarios (Cont.)

	ATC SCENARIO				NZ SCENARIO			
	2020	2025	2030	2035	2020	2025	2030	2035
LDV BEV								
Sales Share	4.10%	25.50%	43.90%	58.20%	4.10%	25.50%	66.10%	100.00%
Stock Share	0.75%	5.59%	17.25%	31.88%	0.66%	5.50%	21.54%	46.64%
MHDV BEV								
Sales Share	0.21%	3.64%	24.89%	42.54%	0.21%	3.64%	24.89%	65.59%
Stock Share	0.01%	0.54%	3.62%	12.31%	0.01%	0.54%	3.62%	16.12%

Notes: ATC = advanced tax credit; BEV = battery electric vehicle; ETC = extended tax credit; LDV = light-duty vehicle; MDHV = medium- and heavy-duty vehicle; NZ = net-zero.

Source: Saha et al. 2021b.

Table D6 | Residential space heating stocks and market share across mitigation scenarios

		REFERENCE SCENARIO				ETC SCENARIO			
		2020	2025	2030	2035	2020	2025	2030	2035
Fuel Type	**Market Share (%)**								
	Distillate	6.27%	5.86%	5.45%	5.04%	6.27%	5.86%	5.45%	5.04%
	LPG	4.95%	4.71%	4.47%	4.23%	4.95%	4.71%	4.47%	4.23%
	Natural gas	48.38%	48.68%	48.99%	49.29%	48.37%	48.64%	48.91%	49.18%
	Wood	4.37%	4.07%	3.78%	3.48%	4.37%	4.07%	3.78%	3.48%
	Electric resistance	24.95%	24.95%	24.95%	24.95%	24.95%	24.95%	24.95%	24.95%
	Heat pump	11.08%	11.72%	12.37%	13.01%	11.09%	11.76%	12.44%	13.12%
	Stock (Million Devices)								
	Distillate	8	9	9	8	8	9	9	8
	LPG	7	7	7	7	7	7	7	7
	Natural gas	64	67	69	71	64	67	69	71
	Wood	6	6	6	6	6	6	6	6
	Electric resistance	33	34	35	36	33	34	35	36
	Heat pump	15	15	16	17	15	15	16	18

Table D6 | Residential space heating stocks and market share across mitigation scenarios (Cont.)

Fuel Type	ATC SCENARIO				NZ SCENARIO			
	2020	2025	2030	2035	2020	2025	2030	2035
Market Share (%)								
Distillate	6.27%	4.17%	2.58%	2.58%	6.27%	4.17%	2.58%	0.78%
LPG	4.95%	3.21%	1.96%	1.96%	4.95%	3.21%	1.96%	0.60%
Natural gas	48.32%	39.30%	30.57%	30.57%	48.32%	39.30%	30.57%	11.63%
Wood	4.37%	4.07%	3.78%	3.78%	4.37%	4.07%	3.78%	3.48%
Electric resistance	24.55%	22.54%	20.52%	20.52%	24.55%	22.54%	20.52%	18.51%
Heat pump	11.54%	26.70%	40.59%	40.59%	11.54%	26.70%	40.59%	64.99%
Stock (Million Devices)								
Distillate	8	8	7	5	8	8	7	5
LPG	7	6	5	4	7	6	5	4
Natural gas	64	64	60	53	64	64	60	50
Wood	6	6	6	6	6	6	6	6
Electric resistance	33	34	33	32	33	34	33	32
Heat pump	15	19	31	46	15	19	31	50

Table D7 | Emissions and removals (MMT CO_2e) across scenarios by sector

	REFERENCE SCENARIO				ETC SCENARIO			
	2020	2025	2030	2035	2020	2025	2030	2035
Electricity generation	**1,595**	858	467	431	1,595	1,111	318	165
Transportation	**1,550**	1,712	1,592	1,476	1,552	1,663	1,444	1,244
Industrial energy	**1,041**	1,078	1,120	1,165	1,041	1,073	1,102	1,132
Residential	**347**	336	323	311	346	329	302	279
Commercial	**284**	285	286	288	283	281	274	269
Agriculture	**611**	615	619	621	611	603	594	584
Industrial process emissions	**377**	402	353	319	377	395	340	305
Oil and gas systems	**284**	303	334	337	284	287	298	291
Waste management	**161**	168	175	185	161	168	175	185
Coal mining	**63**	57	52	49	63	57	49	38
Natural and working lands	**-769**	-757	-744	-732	-769	-787	-804	-852
Technological carbon removal	**0**	0	0	0	0	-20	-39	-39
Total gross emissions	**6,315**	5,815	5,322	5,181	6,315	5,967	4,897	4,492
Total net emissions	**5,546**	5,058	4,577	4,449	5,546	5,160	4,053	3,600

Table D7 | Emissions and removals (MMT CO_2e) across scenarios by sector (Cont.)

	ATC SCENARIO				NZ SCENARIO			
	2020	2025	2030	2035	2020	2025	2030	2035
Electricity generation	1,596	1,044	331	140	1,595	1,054	304	84
Transportation	1,547	1,632	1,392	1,163	1,548	1,630	1,335	940
Industrial energy	1,041	1,070	1,093	1,120	1,041	1,020	952	833
Residential	346	319	267	210	346	316	263	187
Commercial	283	267	232	191	283	266	229	169
Agriculture	611	565	519	471	611	565	519	471
Industrial process emissions	377	395	340	305	377	373	293	241
Oil and gas systems	284	285	288	275	284	230	166	138
Waste management	161	168	175	185	161	164	166	174
Coal mining	63	57	49	38	44	18	9	5
Natural and working lands	-769	-817	-864	-972	-769	-817	-864	-972
Technological carbon removal	0	-20	-39	-39	0	-20	-32	-37
Total gross emissions	6,310	5,803	4,688	4,097	6,292	5,636	4,236	3,243
Total net emissions	5,541	4,967	3,784	3,085	5,523	4,799	3,339	2,234

Notes: ATC = advanced tax credit; ETC = extended tax credit; MMT CO_2e = million metric tonnes carbon dioxide equivalent; NZ = net-zero.

Source: Saha et al. 2021b.

ENDNOTES

1. While our suite of modeled policies includes some of the key policy tools that have been discussed by Congress in the past two years, this is not the definitive list of policies that can help the United States achieve its 2030 and 2050 climate goals. Other policies such as economy-wide carbon pricing, not included in this modeling work, are critical pieces of the decarbonization puzzle and should be on the table.

2. Our modeling analysis does not take into account opportunity cost for investment. The model's first underlying assumption is that additional spending or investment does not displace any spending or investment elsewhere in the economy. Second, it assumes that the source of investment is exogenous, either the government decides to allocate or the private sector is forced to invest through regulation.

3. "Jobs," here, refers to the number of jobs the modeled spending or capacity supports in a specific year. The 6.5 million figure refers to net job gain across all the modeled sectors, after taking into account modeled job losses. The employment results take into account direct, indirect, and induced jobs. Direct jobs are related to the specific industry, such as construction jobs created by retrofitting buildings to make them more energy efficient. Indirect jobs are those that support the industry, such as manufacturing jobs created in associated industries that supply components and parts for building retrofits. Induced jobs result from direct and indirect workers spending money in the community.

4. For a sense of scale, that is more than twice the number of workers in the clean energy sector as of the end of 2020 (E2 2021). While this analysis is not directly comparable to them, other studies also find significant job growth from the net-zero transition. An SDSN (2020) study finds that investments to achieve net zero by 2050 will generate more than 6.5 million direct, indirect, and induced jobs per year. Another study, by Princeton University, found that in the 2020s net-zero pathways support about 3 million energy-supply jobs on average each year (Larson et al. 2020).

5. The 4.0 million for the electricity sector is net jobs added after taking into account job losses in subsectors like coal-fired and nuclear generation. The 4.6 total for the buildings sector is total jobs added by electrification and energy-efficiency improvements. The model captured potential job losses coming from declining natural gas consumption in buildings under the fuels sector.

6. Out of a total of 23.0 million energy economy jobs in 2035. The remainder is induced jobs.

7. For additional context and comparisons, the management industry (NAICS 55) shows 8 percent earning under $22/hour, while the information industry (NAICS 51) shows 13 percent earning under $22/hour, using the same framework. The finance and insurance (NAICS 52), manufacturing (NAICS 31–33), and health-care (NAICS 62) industries show 27 percent earning under $22/hour, while education (NAICS 61) and retail (NAICS 44–45) show 33 percent and 39 percent earning under $22/hour, respectively.

8. For example, consult Barrett and Bivens (2021) on the range of policy consideration, including boosting U.S. production of vehicle powertrain components and labor standards in the vehicles sector.

9. The model assumes that labor hours (and thus full-time equivalents) needed for activities remain the same regardless of labor cost.

10. The term "disadvantaged communities" has many definitions in different contexts; here we are referring expansively to historically marginalized and overburdened communities, which is also the definition referenced in President Biden's "Tackling the Climate Crisis at Home and Abroad" executive order (White House 2021a).

11. Hereafter referred to as the Building Blocks analysis.

12. An example is the Department of Labor's Trade Adjustment Assistance program, which supports workers impacted by increased imports across industries (Employment and Training Administration n.d.). This kind of program, and its challenges and successes, can provide a model and lessons for programming to address the range of economic impacts of the clean energy transition.

13. Manufacturing has been closely linked to U.S. leadership in science and technology. Despite accounting for only 11 percent of U.S. GDP, manufacturing comprises two-thirds of total business investment in R&D, which routinely churns out new and improved products and technologies. U.S. manufacturing employs a third of the nation's scientists and engineers, with nearly 8 percent of manufacturing workers employed in science and engineering occupations (Ezell 2020).

14. For example, solar technology supply chain issues include concerns about forced labor and human rights as well as logistical challenges during and in the wake of the COVID-19 pandemic (Williams and Sutton 2021; Hackbarth 2021).

15. The trajectory of the semiconductor industry in the United States provides an informative example of a technology with high U.S. demand where the United States was initially a leader in design and manufacturing but ultimately saw an offshoring of the industry given an inability to compete with foreign competitors on cost or quality. For more, read Freeman (2021). The federal government is now looking to address this issue through the recently enacted CHIPS and Science Act of 2022, which includes about $76 billion in funding and tax incentives to drive U.S. competitiveness in semiconductor manufacturing (Ezell and Koester 2022).

16. President Biden issued Executive Order 14005, "Ensuring the Future Is Made in All of America by All of America's Workers." The administration has opened a Made in America Office, released new guidance to minimize waivers related to made-in-America laws, and proposed changes to the implementation of the Buy American Act that would raise domestic content thresholds and apply enhanced price preferences to strengthen domestic critical supply chains (White House 2021b).

17. This was also included in the Inflation Reduction Act, where certain incentives servicing low-income communities, polluted communities, or in energy communities where fossil fuels subsector job losses may be more significant receive an increased incentive (Yarmuth 2022).

18. Unionization rate data for individual technologies can be highly uncertain, complicating comparison of unionization rates from clean energy industries to the national average.

19. E3 provided modeling support for WRI's Building Blocks analysis, estimating reductions in GHG emissions over the next 10 and 30 years under different policy and federal spending scenarios with the PATHWAYS and RESOLVE models. E3's PATHWAYS and RESOLVE models utilize inputs such as fuel price projections, cost and performance-related characteristics of energy infrastructure, and equipment sales to forecast energy demand, GHG emissions, stocks and sales of energy-consuming devices, and electricity supply infrastructure under different policy scenario simulations.

20. For more details on policy assumptions included under these scenarios, please refer to Table 1 and Technical Appendices B and C in Saha et al. (2021b).

21. Technological carbon removal is the process of removing carbon dioxide from the atmosphere through technological means. An example would be direct air capture, where chemical reactions are used to pull carbon dioxide from the atmosphere, at which point it can be used or securely stored underground (Lebling et al. 2022).

22. The prevailing-wage policy lever modeling is only applied to our NZ scenario.

23. The wage analysis uses average wages by occupation weighted by employment within industry groups in each subsector (e.g., solar construction) to derive sector outputs.

24. The 25 percent domestic market share assumption for batteries is based on Coffin and Horowitz (2018) and USCC (2018).

25. The explanation and justification for our domestic content percentage assumptions can be found in Technical Appendix B.

26. JEDI Wind estimates economic impacts from wind power generation projects. The model incorporates default information for construction material and labor costs; local content and costs for turbine, tower, and blades; utility interconnection and permitting costs; annual operating and maintenance costs; and tax, lease, and financing parameters. These can be used to run a generic impact analysis assuming wind industry averages. For more details, see NREL (2020).

27. It is estimated that there are more than 500 manufacturing facilities across the country producing various wind turbine components, such as blades, towers, and generators, as well as assembling turbines. Eighty percent of nacelle assembly and tower manufacturing takes places in the United States. For more details, see DOE (n.d.).

28. For instance, the base model assumes that onshore wind has a 46 percent domestic content share. In the policy lever modeling, the model can increase the domestic content share from 47 percent to 100 percent. However, in the real world it is difficult to imagine scenarios where every part and component in a wind turbine is domestically sourced.

29. The Biden administration in July 2021 proposed changes to the implementation of the Buy American Act that aim to increase the domestic content in products procured by the federal government. The federal government spends $600 billion annually on procurement of various products. Currently products meet the requirements of the Buy American Act if 55 percent of the value of their component parts is manufactured in the United States. The Biden administration is proposing to increase that to 60 percent immediately and 75 percent in a phased manner. The increased domestic content impacts the sourcing of various components in the buildings sector. For more details, see White House (2021b).

30. This tool uses expenditure data related to a household's minimum food consumption, childcare, housing, health insurance, transportation, and other basic essential costs to determine the minimum wage necessary to meet a household's basic needs (Glasmeier 2020).

31. Wages are kept in nominal 2020 dollars for both the 2020 and 2035 outputs.

32. Building energy-efficiency measures have been found to create 2.8 times as many jobs as fossil fuels per $1 million in investment. In contrast, wind and solar energy create 1.2 and 1.5 times as many jobs, respectively, as fossil fuels for every $1 million (Jaeger et al. 2021). In addition, energy-efficiency investments can be mobilized quickly, boosting the job creation potential of this sector.

33. This excludes induced jobs, which number 9.2 million in 2035 in the NZ scenario.

34. Modeling input used for the buildings sector includes spending for electrification and efficiency measures (2020–25 capital costs of buildings electrification and energy-efficiency device sales in the three mitigation scenarios), while the fuels sector modeling input includes spending covering natural gas consumption and distribution for sectors including buildings (2020–35 natural gas fuel costs for the three mitigation scenarios).

35. A recent study by the Economic Policy Institute estimates that about 15,000–75,000 auto manufacturing–related jobs (auto assembly and auto parts jobs) may be lost by 2030, under different scenarios that assume a 25–50 percent market share for light-duty battery EVs by 2030 (Barrett and Bivens 2021).

36. Estimates of power sector trends in the scenarios studied in Saha et al. (2021b) are derived from RESOLVE, E3's power sector model. RESOLVE is a cost-optimization model and keeps sources like nuclear online until it is up for relicensing, then assumes retirement if this is more economical.

37. We applied the domestic content policy lever to all three mitigation scenarios but are showing the results only for the NZ scenario. Technical Appendix C includes the full suite of results across all mitigation scenarios.

38. One example of such a policy is providing increased tax credits for projects operating in communities most impacted by fossil fuels phasing out and low-income communities.

39. Specifically, and for example, "increasing domestic content shares by 10 percentage points (e.g., increasing the domestic content share of cells to 25%) across the PV supply chain (excluding upstream materials and products such as steel and aluminum) results in a 1% increase in average installed solar PV capital costs. Solar projects sourcing 100% domestic content from across the full polysilicon PV supply chain would have installed costs just 7% higher than current average costs" (Mayfield and Jenkins 2021, 7).

40. The Department of Labor (DOL) has provided nearly $1 billion in grants to state workforce agencies and intermediaries between 2015 and 2021. However, this comprises only a small portion of the DOL's total investment in federally funded workforce programs, which totals $10 billion to $11 billion each year (Haimson and Sattar 2021).

41. This is different from modeling a strict definition of prevailing wages, which vary by geography, sector, level of training, and cost of living. For instance, workers in urban locations command higher wages than their rural counterparts. Wages for residential electrical work have been estimated to be 36 percent lower than wages for commercial and heavy construction electrical work in Oregon (Jones 2020).

42. The share of employment for different demographic groups is based on trends in 2018–21 USEER data. Please see Technical Appendix A, Table A5, for the data used. Trends during the 2018–21 period varied by sector, but change is generally minimal. Some notable trends (greater than 5 percent change over three years) include an increase in representation of women in fuels and energy efficiency; decreased American Indian or Alaska Native worker participation in energy efficiency, electric power generation, and fuels; an increase in Asian worker participation in energy efficiency and electric power generation but decrease in fuels; decreased Hispanic or Latino participation in the electric power generation workforce; increased Black or African American worker participation in energy efficiency, fuels, and motor vehicles; a decrease in Native Hawaiian or other Pacific Islander worker participation in electric power generation and increase in motor vehicles; a decrease in the share of the workforce over 55 in all assessed sectors other than electric power generation; and, overall, no major change in white worker participation across sectors.

43. In 2020, the workforce was 52 percent male and 48 percent female; 17 percent Hispanic or Latino and 83 percent not Hispanic or Latino; and, 1 percent American Indian or Alaska Native; 7 percent Asian, 13 percent Black or African American, 0 percent Native Hawaiian or other Pacific Islander, 2 percent two or more races, and 76 percent white (DOE et al. 2021).

44. This does not account for other related challenges like inequity in leadership roles, business ownership, and pay inequity, also critical issues that require further study.

45. In the Building Blocks modeling, total investment in the energy-efficiency subsector is less in the ATC and NZ scenarios than in the ETC.

46. When we refer to biofuels we are discussing the impacts coming from processes converting biorefinery sugars to hydrocarbons; BECCS hydrogen is included under hydrogen production.

47. Given the lack of historical data for emerging technologies like hydrogen, various uncertainties are associated with these estimates.

REFERENCES

Barrett, J., and J. Bivens. 2021. "The Stakes for Workers in How Policymakers Manage the Coming Shift to All-Electric Vehicles." https://www.epi.org/publication/ev-policy-workers/.

Bradley, D.H., and J.O. Shimabukuro. 2021. "Federally Funded Construction and the Payment of Locally Prevailing Wages." Congressional Research Service. https://crsreports.congress.gov/product/pdf/IF/IF11927.

Carlock, G., J. Neuberger, L. Calle, and E. Said. 2021. "Addressing Energy Equity in the United States: Policy Considerations for Federal Investment." November. https://www.wri.org/research/energy-equity-united-states-federal-investment.

Carpenter, D.H. 2019. "President Encourages Agencies to Buy American-Produced Goods and Materials." Congressional Research Service. https://crsreports.congress.gov/product/pdf/LSB/LSB10256.

Carpenter, D.H., and B.J. Murrill. 2021. "The Buy American Act and Other Federal Procurement Domestic Content Restrictions." https://crsreports.congress.gov/product/pdf/R/R46748.

Clausing, K. 2019. "The Progressive Case against Protectionism." *Foreign Affairs*, November–December. https://www.foreignaffairs.com/articles/united-states/2019-10-15/progressive-case-against-protectionism.

Coady, D., I. Parry, N. Le, and B. Shang. 2019. "Global Fossil Fuel Subsidies Remain Large: An Update Based on Country-Level Estimates." International Monetary Fund. https://www.imf.org/en/Publications/WP/Issues/2019/05/02/Global-Fossil-Fuel-Subsidies-Remain-Large-An-Update-Based-on-Country-Level-Estimates-46509.

Coffin, D., and J. Horowitz. 2018. "The Supply Chain for Electric Vehicle Batteries." U.S. International Trade Commission. https://www.usitc.gov/publications/332/journals/the_supply_chain_for_electric_vehicle_batteries.pdf.

DOE (U.S. Department of Energy). n.d. "Wind Manufacturing and Supply Chain." *Energy.Gov*. Accessed January 25, 2022. https://www.energy.gov/eere/wind/wind-manufacturing-and-supply-chain.

DOE, National Association of State Energy Officials, Energy Futures Initiative, and BW Research Partnership Inc. 2021. *United States Energy and Employment Report 2021*. https://www.energy.gov/us-energy-employment-jobs-report-useer.

Economic Policy Institute. 2021. "Why the U.S. Needs a $15 Minimum Wage: How the Raise the Wage Act Would Benefit U.S. Workers and Their Families." Economic Policy Institute (blog), January 26. https://www.epi.org/publication/why-america-needs-a-15-minimum-wage/.

Employment and Training Administration. n.d. "Trade Adjustment Assistance for Workers Program FY 2019 Annual Report." U.S. Department of Labor. https://www.dol.gov/sites/dolgov/files/ETA/tradeact/pdfs/AnnualReport19.pdf.

EPA (U.S. Environmental Protection Agency). 2022. "Sources of Greenhouse Gas Emissions." Greenhouse Gas Emissions Program. Accessed December 15, 2021. https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions.

E2. 2021. "Clean Jobs America 2021." https://e2.org/reports/clean-jobs-america-2021/.

E2, American Council on Renewable Energy, and Clean Energy Leadership Institute. 2020. "Clean Jobs, Better Jobs: An Examination of Clean Energy Job Wages and Benefits." https://e2.org/wp-content/uploads/2020/10/Clean-Jobs-Better-Jobs.-October-2020.-E2-ACORE-CELI.pdf.

Ezell, S. 2020. "Policy Recommendations to Stimulate U.S. Manufacturing Innovation." Information Technology and Innovation Foundation. https://www2.itif.org/2020-policy-recommendations-us-manufacturing.pdf.

Ezell, S., and S. Koester. 2022. "Three Cheers for the CHIPS and Science Act of 2022! Now, Let's Get Back to Work." Information Technology and Innovation Foundation, July 29. https://itif.org/publications/2022/07/29/three-cheers-for-the-chips-and-science-act-of-2022-now-lets-get-back-to-work/.

Freeman, D. 2021. "A History and Analysis of Offshoring and Reshoring the US Semiconductor Industry." *3DInCites*, May. https://www.3dincites.com/2021/05/a-history-and-analysis-of-offshoring-and-reshoring-the-us-semiconductor-industry/.

Glasmeier, A.K. 2020. *Living Wage Calculator*. Massachusetts Institute of Technology. livingwage.mit.edu.

Godøy, A., and M. Reich. 2019. "Minimum-Wage-Effects." IRLE Working Paper no. 106-19 (July 2019). https://irle.berkeley.edu/files/2020/09/Minimum-Wage-Effects-in-Low-Wage-Areas.pdf.

Hackbarth, J. 2021. "The Impact of Covid-19 on the PV Supply Chain." *Forbes*, August 19. https://www.forbes.com/sites/forbestechcouncil/2021/08/19/the-impact-of-covid-19-on-the-pv-supply-chain/.

Haimson, J., and S. Sattar. 2021. "Workforce Policies That Support Climate Action and Reduce Disparities." *Mathematica*, November 18. https://www.mathematica.org/blogs/workforce-policies-that-support-climate-action-and-reduce-disparities.

Hopper, A.R. 2021. "SEIA's Response to Anonymous Petitioners' October 13 Submission." Solar Energy Industries Association. https://www.seia.org/sites/default/files/2021-10/SEIA%20ltr%20to%20Sec%20Raimondo%20%2810.25.2021%29%20%28002%29.pdf.

IRENA (International Renewable Energy Agency). 2019. *Renewable Energy: A Gender Perspective*. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Jan/IRENA_Gender_perspective_2019.pdf.

Jaeger, J., G. Walls, E. Clarke, J.-C. Altamirano, A. Harsono, H. Mountford, S. Burrow, et al. 2021. "The Green Jobs Advantage: How Climate-Friendly Investments Are Better Job Creators." October. https://www.wri.org/research/green-jobs-advantage-how-climate-friendly-investments-are-better-job-creators.

Jones, B. 2020. "Prevailing Wage in Solar Can Deliver Good Jobs While Keeping Growth on Track." UC Berkeley Labor Center (blog), November 12. https://laborcenter.berkeley.edu/prevailing-wage-in-solar-can-deliver-good-jobs-while-keeping-growth-on-track/.

Larson, E., C. Greig, J. Jenkins, E. Mayfield, A. Pascale, C. Zhang, J. Drossman, et al. 2020. *Net-Zero America: Potential Pathways, Infrastructure, and Impacts, Interim Report*. Princeton University. https://netzeroamerica.princeton.edu/img/Princeton_NZA_Interim_Report_15_Dec_2020_FINAL.pdf.

Lebling, K., H. Leslie-Bole, Z. Byrum, and E. Bridgwater. 2022. "6 Things to Know about Direct Air Capture." World Resources Institute, May. https://www.wri.org/insights/direct-air-capture-resource-considerations-and-costs-carbon-removal.

Lin, D.Y., S.N. Rayavarapu, K. Tadjeddine, and R. Yeoh. 2022. "Beyond Financials: Helping Small and Medium-Size Enterprises Thrive." McKinsey and Company, January. https://www.mckinsey.com/industries/public-and-social-sector/our-insights/beyond-financials-helping-small-and-medium-size-enterprises-thrive.

Mahajan, M., R. Orvis, and S. Aggarwal. 2020. "Modeling the Climate Crisis Action Plan." Energy Innovation. https://energyinnovation.org/wp-content/uploads/2020/07/Modeling-the-Climate-Crisis-Action-Plan_FOR-RELEASE.pdf.

Manzo, F.P. 2021. "The Effect of 'Federal-Aid Swap' Programs and Davis-Bacon Prevailing Wages on Highway Construction Costs and Contractor Composition: Evidence from Iowa." *Labor Studies Journal* 47 (1): 75–98. https://doi.org/10.1177/0160449x211049477.

Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, et al., eds. 2021. *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge: Cambridge University Press.

Mayfield, E., and J. Jenkins. 2021. "Influence of High Road Labor Policies and Practices on Renewable Energy Costs, Decarbonization Pathways, and Labor Outcomes." Princeton University. https://netzeroamerica.princeton.edu/img/Working_Paper-High_Road_Labor_and_Renewable_Energy-PUBLIC_RELEASE-4-13-21.pdf.

Mühlau, P., and S. Lindenberg. 2003. "Efficiency Wages: Signals or Incentives—an Empirical Study of the Relationship between Wage and Commitment." *Journal of Management and Governance* 7 (4): 385–400. doi:10.1023/A:1026261223790.

Muro, M., A. Tomer, R. Shivaram, and J. Kane. 2019. "Advancing Equity in California Climate Policy: A New Social Contract for Low-Carbon Transition." Metropolitan Policy Program at Brookings. https://www.brookings.edu/wp-content/uploads/2019/04/2019.04_metro_Clean-Energy-Jobs_Report_Muro-Tomer-Shivaran-Kane.pdf.

NREL (National Renewable Energy Laboratory). 2020. "JEDI Wind Models." JEDI: Jobs and Economic Development Impact Models. Accessed February 10, 2022. https://www.nrel.gov/analysis/jedi/wind.html.

Philips, P. 2014. "Environmental and Economic Benefits of Building Solar in California." University of California, Berkeley. https://laborcenter.berkeley.edu/pdf/2014/building-solar-ca14.pdf.

Platzer, M.D., and W.J. Mallett. 2019. "Effects of Buy America on Transportation Infrastructure and U.S. Manufacturing." Congressional Research Service. https://crsreports.congress.gov/product/pdf/R/R44266.

Raimi, D., E. Grubert, J. Higdon, G. Metcalf, S. Pesek, and D. Singh. 2022. "The Fiscal Implications of the US Transition Away from Fossil Fuels." Resources for the Future. https://media.rff.org/documents/WP_22-3_-_Fiscal_Implications.pdf.

Ramaswamy, S., J. Manyika, G. Pinkus, K. George, J. Law, T. Gambell, and A. Serafino. 2017. "Making It in America: Revitalizing US Manufacturing." McKinsey and Company. https://www.mckinsey.com/~/media/mckinsey/featured%20insights/americas/making%20it%20in%20america%20revitalizing%20us%20manufacturing/making-it-in-america-revitalizing-us-manufacturing-full-report.ashx.

Saha, D. 2016. “Five Charts That Show Why Trump Can’t Deliver on His Coal Promises.” Brookings (blog), December 6. https://www.brookings.edu/blog/the-avenue/2016/12/06/trump-cant-deliver-on-his-coal-promises/.

Saha, D., A. Rudee, H. Leslie-Bole, and T. Cyrs. 2021a. “The Economic Benefits of the New Climate Economy in Rural America.” World Resources Institute. https://www.wri.org/research/benefits-federal-investment-rural-america.

Saha, D., G. Carlock, R. Shrestha, J. Feldmann, and H. Leslie-Bole. 2021b. “Building Blocks for a Low- Carbon Economy: Catalytic Policy and Infrastructure for Decarbonizing the United States by 2050.” December. https://www.wri.org/research/building-blocks-low-carbon-economy.

Saha, D., and J. Jaeger. 2020. “America’s New Climate Economy: A Comprehensive Guide to the Economic Benefits of Climate Policy in the United States.” July. https://www.wri.org/publication/us-new-climate-economy.

SDSN (Sustainable Development Solutions Network). 2020. “Zero Carbon Action Plan.” https://www.unsdsn.org/Zero-Carbon-Action-Plan.

Solar Foundation. 2019. “U.S. Solar Industry Diversity Study 2019.” https://www.thesolarfoundation.org/diversity/.

U.S. Bureau of Labor Statistics. 2021. “Union Members Summary.” Economic News Release, January 22. https://www.bls.gov/news.release/union2.nr0.htm.

USCC (US-China Economic and Security Review Commission). 2018. *Economics and Trade Bulletin*. https://www.uscc.gov/sites/default/files/Research/December%202018%20Trade%20Bulletin_0.pdf.

Wachunas, J. 2021. “Women in EVs: Leading Women in the Industry Talk about Their Experiences.” *CleanTechnica*, February 13. https://cleantechnica.com/2021/02/13/women-in-evs-leading-women-in-the-industry-talk-about-their-experiences/.

Wall, M., D. Madl, and K. Walter. 2020. “Prevailing Wages: Frequently Asked Questions.” Center for American Progress. https://www.americanprogress.org/issues/economy/reports/2020/12/22/494144/prevailing-wages-frequently-asked-questions/.

White House. 2021a. “Executive Order on Tackling the Climate Crisis at Home and Abroad.” https://www.whitehouse.gov/briefing-room/presidential-actions/2021/01/27/executive-order-on-tackling-the-climate-crisis-at-home-and-abroad/.

White House. 2021b. “FACT SHEET: Biden-Harris Administration Issues Proposed Buy American Rule, Advancing the President’s Commitment to Ensuring the Future of America Is Made in America by All of America’s Workers.” https://www.whitehouse.gov/briefing-room/statements-releases/2021/07/28/fact-sheet-biden-harris-administration-issues-proposed-buy-american-rule-advancing-the-presidents-commitment-to-ensuring-the-future-of-america-is-made-in-america-by-all-of-americas/.

White House. 2021c. “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.” 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/.

White House. 2022. “President Biden Takes Bold Executive Action to Spur Domestic Clean Energy Manufacturing.” White House Briefing Room. https://www.whitehouse.gov/briefing-room/statements-releases/2022/06/06/fact-sheet-president-biden-takes-bold-executive-action-to-spur-domestic-clean-energy-manufacturing/.

Williams, M., and T. Sutton. 2021. “Creating a Domestic U.S. Supply Chain for Clean Energy Technology.” https://www.americanprogress.org/article/creating-domestic-u-s-supply-chain-clean-energy-technology/.

Williams, J.H., R.A. Jones, B. Haley, G. Kwok, J. Hargreaves, J. Farbes, and M.S. Torn. 2021. “Carbon-Neutral Pathways for the United States.” *AGU Advances* 2 (1): e2020AV000284.

Yarmuth, J. 2022. *H.R._To Provide for Reconciliation Pursuant to Title II of S. Con. Res. 14.* https://www.congress.gov/bill/117th-congress/house-bill/5376/text.pdf.

Zabin, C., R. Auer, J.M. Cha, R. Collier, R. France, J. MacGillvary, H. Myers, et al. 2020. “Putting California on the High Road: A Jobs and Climate Action Plan for 2030.” University of California, Berkeley Center for Labor Research and Education. https://www.documentcloud.org/documents/7197687-UC-Berkeley-report.html.

ABOUT WRI

World Resources Institute is a global research organization that turns big ideas into action at the nexus of environment, economic opportunity, and human well-being.

Our Challenge

Natural resources are at the foundation of economic opportunity and human well-being. But today, we are depleting Earth's resources at rates that are not sustainable, endangering economies and people's lives. People depend on clean water, fertile land, healthy forests, and a stable climate. Livable cities and clean energy are essential for a sustainable planet. We must address these urgent, global challenges this decade.

Our Vision

We envision an equitable and prosperous planet driven by the wise management of natural resources. We aspire to create a world where the actions of government, business, and communities combine to eliminate poverty and sustain the natural environment for all people.

Our Approach

COUNT IT

We start with data. We conduct independent research and draw on the latest technology to develop new insights and recommendations. Our rigorous analysis identifies risks, unveils opportunities, and informs smart strategies. We focus our efforts on influential and emerging economies where the future of sustainability will be determined.

CHANGE IT

We use our research to influence government policies, business strategies, and civil society action. We test projects with communities, companies, and government agencies to build a strong evidence base. Then, we work with partners to deliver change on the ground that alleviates poverty and strengthens society. We hold ourselves accountable to ensure our outcomes will be bold and enduring.

SCALE IT

We don't think small. Once tested, we work with partners to adopt and expand our efforts regionally and globally. We engage with decision-makers to carry out our ideas and elevate our impact. We measure success through government and business actions that improve people's lives and sustain a healthy environment.

PHOTO CREDITS

Cover, Dennis Schroeder / NREL; Pg. ii, Dennis Schroeder / NREL; Pg. iv, Lenny Kuhne; Pg. 2, Phyxter Home Services; Pg. 6, Dennis Schroeder / NREL; Pg. 12, Michael Fousert; Pg. 14, Alisa Reutova; Pg. 16, Marcela Gara / Resource Media; Pg. 18, Shaun Dakin; Pg. 21, Kennith Shipp; Pg. 22, Dirk Erasmus; Pg. 24, Gonz DDL; Pg. 32, Scott Blake; Pg. 35, Ascel Kadhem; Pg. 40, Ricardo Gomez Angel; Pg. 44, Chris Gray; Pg. 46, Christian Wiediger; Pg. 48, Jeremy Bezanger; Pg. 51, Justin Lim; Pg. 54, Karel Vh; Pg. 58, Ricardo Gomez Angel; Pg. 62, Silvia Brazzoduro

WORLD RESOURCES INSTITUTE

10 G STREET NE
SUITE 800
WASHINGTON, DC 20002, USA
+1 (202) 729-7600
WWW.WRI.ORG

https://doi.org/10.46830/wrirpt.21.00107