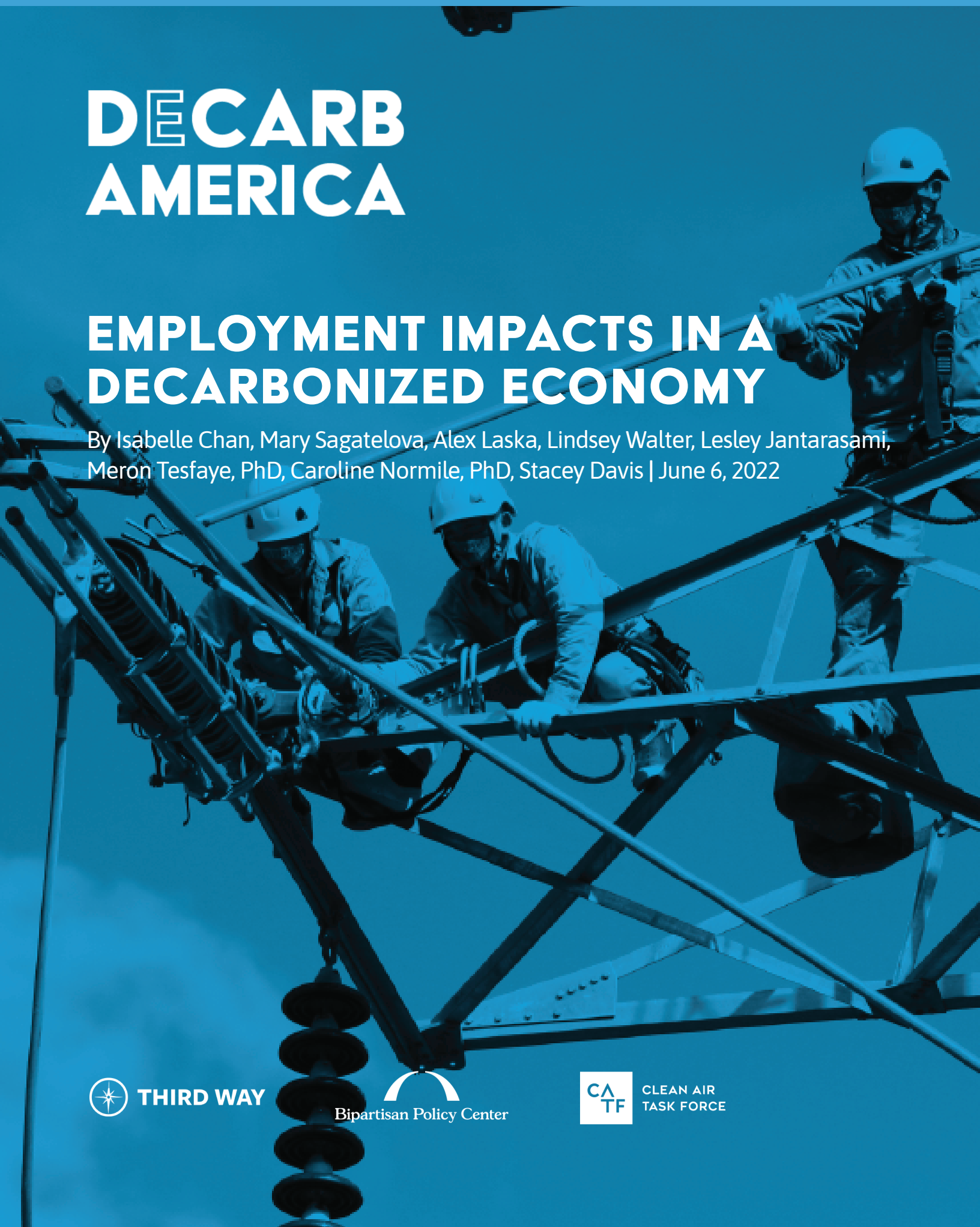
DECARB AMERICA

EMPLOYMENT IMPACTS IN A DECARBONIZED ECONOMY

By Isabelle Chan, Mary Sagatelova, Alex Laska, Lindsey Walter, Lesley Jantarasami, Meron Tesfaye, PhD, Caroline Normile, PhD, Stacey Davis | June 6, 2022



THIRD WAY

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KEY TAKEAWAYS

1. Decarbonizing the US economy will create a net increase of over 2 million jobs by mid-century.
2. The Energy Efficiency sector is a key employment driver in the first decade, but as we move toward 2050, other sectors will spur the most job growth in areas such as transmission & distribution and CO_2 pipelines, depending on various conditions like deployability, constraints, and existing technologies.
3. Electric vehicles are projected to create hundreds of thousands of jobs–with further potential if domestic supply chain management and manufacturing increases.
4. As technologies like carbon capture and storage, direct air capture, and advanced nuclear energy near commercialization, the US will build out entire industries for these technologies, creating hundreds of thousands of direct and indirect jobs.
5. Biomass-based fuels will be a major source of jobs from 2030 onward. Use of biomass feedstocks, biofuels and BECCS hydrogen to reach net-zero goals is projected to support hundreds of thousands of new jobs in 2050.

INTRODUCTION

The Decarb America Research Initiative analyzes a suite of policy and technology pathways for the United States to reach net-zero greenhouse gas emissions by 2050. Our work objectives are twofold: to improve understanding of the tradeoffs between different proposed strategies for achieving net-zero; and to identify the national, regional, and state-level economic opportunities that a new clean energy economy will generate. Our analytical results are intended to inform policymakers as they consider options for addressing climate change and modernizing America's energy systems.

To develop these results, Decarb America commissioned Evolved Energy Research and Industrial Economics, Inc. to conduct a rigorous, multi-part modeling analysis (more information is available at About the Initiative). The analysis explores five main research topics: (1) Pathways to Net-Zero Emissions, (2) Energy Infrastructure Needs for a Net-Zero Economy, (3) Power Sector Deep Dive, (4) Clean Energy Innovation Breakthroughs, and (5) Employment Impacts in a Decarbonized Economy.

This report presents key takeaways on topic (5) from the modeling analysis and responds to three critical questions that can help guide policy decisions:

1. Will economy-wide deep decarbonization lead to a net increase in employment?
2. What sectors face the greatest opportunities for job growth?
3. How will job opportunities change over the coming decades?

To answer these questions, we modeled the job impacts of two pathways to achieve net-zero emissions by 2050, a *High Electrification/High Renewables* scenario and a *Highly Constrained Renewables* scenario.

***High Electrification/High Renewables (HE/HR)* Scenario:** This pathway combines a wide variety of standards and policies to achieve net-zero greenhouse gas (GHG) emissions across the US economy by 2050. This scenario assumes high levels of electrification and renewable energy deployment and depends on carbon removal to offset residual emissions.

***Highly Constrained Renewables (HCR)* Scenario:** This scenario explores how the US can still reach net-zero if the deployment of renewables is highly constrained by siting, supply chains, social license, and other challenges. Under this pathway, deployment of renewable power is limited to historic build rates. The GHG reductions achieved reflect an increased reliance on alternative fuels, hydrogen from steam methane reformation, carbon capture and storage, direct air capture, and nuclear energy.

For each of the two scenarios described, we analyzed the direct net employment impacts and the economy-wide net employment impacts. Direct employment impacts include jobs created by the up-front investments in energy facilities and equipment to help achieve the net-zero target, as well as jobs operating and maintaining these facilities. Economy-wide employment impacts account for the ancillary effects of reaching net-zero, including effects on other sectors and a combination of both jobs gained and lost across the economy. This economy-wide assessment also reflects how consumers change spending patterns based on changing energy prices and how the transition to net-zero impacts income.

For more details on the modeled pathways, inputs, and data, read our technical report HERE.

KEY TAKEAWAY 1

Decarbonizing the US economy will create a net increase of over 2 million jobs by mid-century.

Our economy-wide and direct employment analyses find that large-scale decarbonization will create **millions of jobs in 2050** across both scenarios. The economy-wide net increase in employment encompasses spillover effects of investments and the subsequent hiring decisions influenced by the clean energy transition. Because transitioning to a net-zero economy requires more technologies, transmission lines, energy-transportation infrastructure, and a rethinking of industrial processes, both scenarios see enormous economy-wide job benefits in manufacturing and construction. As workers in clean energy industries reap cumulative economic benefits, their household spending supports other indirect jobs, thereby benefiting the entire US economy. This ripple effect is observed in the growth of jobs across “Other Services,” which include jobs in healthcare, education, childcare, entertainment, etc.. This category has the greatest job growth by 2050 in both pathways, which highlights the significant impact clean energy employment will have throughout the broader economy.

Both scenarios demonstrate the tight link between nationwide decarbonization efforts and a decline in fossil fuel sector jobs. This is largely because our model assumes a continued decline in US fossil fuel exports, an ongoing market-driven trend that is snowballing as the price of renewables drops sharply. However, it is important to note that we conducted our analysis prior to Russia's invasion of Ukraine and the subsequent upending of global energy markets. While the conflict has underscored the vulnerabilities of energy dependence and reinvigorated decarbonization efforts worldwide, it is evident that nations will have to reevaluate their fossil fuel supplies and decarbonization timelines. As such, American fossil fuel exports, like liquified natural gas, will remain integral to supporting global energy supply chains even as countries scale clean energy infrastructure. Our analyses may therefore overestimate job loss from fossil fuel sectors when accounting for this ongoing conflict. Nonetheless, our modeling affirms that investments in clean energy will, on net, increase employment and rapidly expand job opportunities over the next several decades in every region of the country—offering a direct pathway for fossil fuel workers to transfer highly-specialized skills into new, long-lasting careers.

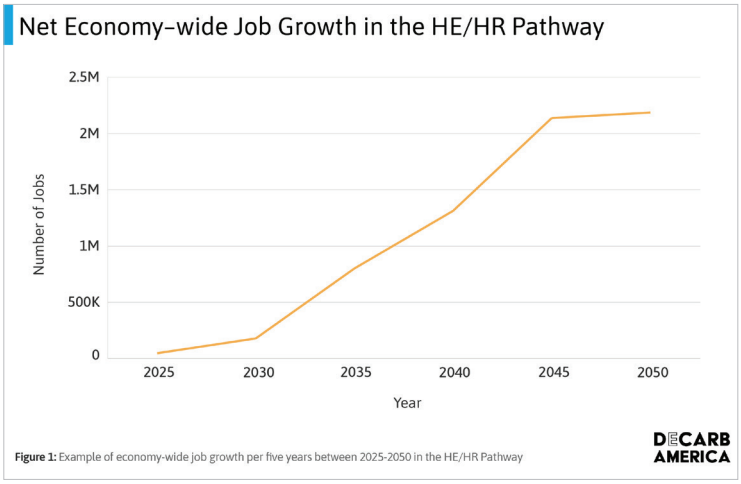

Figure 1: Example of economy-wide job growth per five years between 2025-2050 in the HE/HR Pathway

These pathways illustrate employment in a zero-emissions world. The types and distribution of jobs will depend on how we get to net-zero. This, in turn, will hinge on considerations of technology deployment, land use, cost, and resource constraints.

KEY TAKEAWAY 2

The Energy Efficiency sector is a key employment driver in the first decade, but as we move toward 2050, other sectors will spur the most job growth in areas such as transmission & distribution and CO_2 pipelines, depending on various conditions like deployability, constraints, and existing technologies.

Our direct employment analysis across both pathways finds growth in employment among all four sectors analyzed (see *Table 1* for more information on each sector). In the early years, the most significant job growth for both pathways is in the Energy Efficiency sector—accounting for over 73% of total net job growth in 2023 *(HE/HR)* and 53% of total net job growth in 2023 *(HCR)* *(Figures 2 & 3)*. These immediate economic benefits occur because the US has access to existing efficiency technologies and methods, thus demonstrating the benefits of rapidly deploying existing clean energy solutions even while simultaneously developing next-generation technologies that will expand future employment opportunities. However, in the 2030's and beyond, the key technologies driving employment growth in each pathway start to diverge.

Table 1. Description of technology or industry jobs for each of the net-zero sectors.
SMR: Steam Methane Reforming, CCS: Carbon Capture & Storage, BECCS: Bioenergy with carbon capture and storage, EV: Electric Vehicle

** Each sector includes more technologies than is practicable to present here. Please see the technical report for a full listing of these technologies. For the purposes of this analysis, electricity used for electrolysis is taken from the grid.*

SECTOR	TECHNOLOGY/INDUSTRIES
Power Infrastructure	Nuclear Energy, Coal Power Plants, Gas Power Plants, Wind, Solar, Transmission & Distribution, Battery Storage
Clean Fuels	SMR Hydrogen with CCS, SMR Hydrogen without CCS, Electrolytic Hydrogen, BECCS Hydrogen, Power-to-X, Biofuels, Ammonia, Biomass Feedstocks
Energy Efficiency	Agriculture, Commercial, Residential, Vehicles, EV Chargers, Other Manufacturing
CO_2 Removal & Transport	CO_2 Pipelines, Direct Air Capture

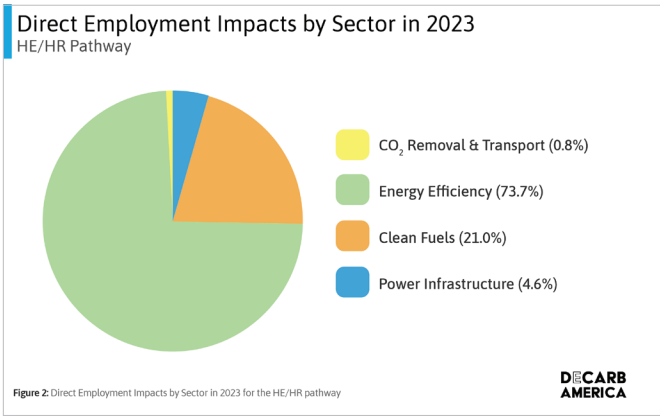

Figure 2: Direct Employment Impacts by Sector in 2023 for the HE/HR pathway

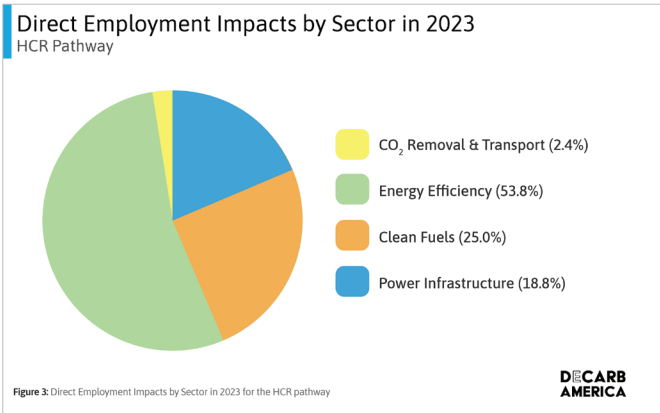

Figure 3: Direct Employment Impacts by Sector in 2023 for the HCR pathway

In the *High Electrification/High Renewables* pathway, the Power Infrastructure sector experiences the most direct job growth in 2035 and beyond *(Figure 4 & 5)*, with Transmission and Distribution (T&D) producing 18% of total direct job growth in 2035 alone. While T&D exhibits the highest job increase between 2035-2050 throughout the entire study, other technologies in the Power Infrastructure sector, such as wind, solar, nuclear, and battery storage, are also projected to have significant gains in employment. In 2050, the Power Infrastructure sector accounts for more than 1 million direct jobs, of which T&D contributes over 55%. Investment in T&D will increase due to many factors, especially the greater adoption of EVs, growing reliance on electricity for heating, and deployment of more renewable energy. In a highly electrified society, the US will need to modernize its grid and increase transmission line and distribution substation buildout to withstand intense electrification rates. To ensure reliable service of increased electricity loads, the US will also need a robust workforce to staff this ever-growing field.

While we see substantial job growth in the Energy Efficiency and Power Infrastructure sectors along different timeframes, jobs in the Clean Fuels and CO_2 Removal and Transport sectors also significantly expand in our direct jobs analysis. By 2050, the High Electrification/High Renewables pathway creates **2.4 million direct clean energy jobs**.

In contrast, with significant constraints on renewables, the *Highly Constrained Renewables* pathway sees more growth in the Clean Fuels and CO_2 Removal & Transport sectors *(Figure 6 & 7)*. By 2050, biomass and CO_2 Pipelines lead employment gains in the *Highly Constrained Renewables* scenario—accounting for 1.6 million jobs. Regardless of timeframe and pathway, a transition to a net-zero economy will yield millions of high-quality jobs.

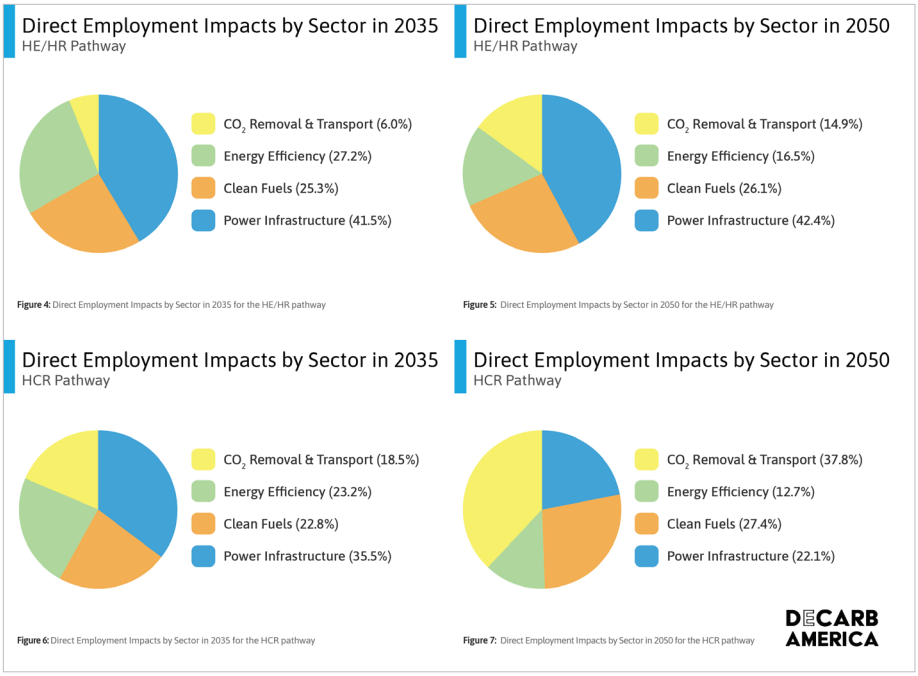

Figure 4: Direct Employment Impacts by Sector in 2035 for the HE/HR pathway

Figure 5: Direct Employment Impacts by Sector in 2050 for the HE/HR pathway

Figure 6: Direct Employment Impacts by Sector in 2035 for the HCR pathway

Figure 7: Direct Employment Impacts by Sector in 2050 for the HCR pathway

KEY TAKEAWAY 3

Electric vehicles are projected to create hundreds of thousands of jobs–with further potential if domestic supply chain management and manufacturing increases.

Decarbonizing ground transportation—including cars, all classes of trucks, and transit buses—offers an opportunity to create hundreds of thousands of jobs, but reaping the full economic benefits of our transition to zero-emission vehicles (ZEV) depends on building a domestic supply chain for these vehicles. Our analysis finds that the transition to electric vehicles (EVs) and fuel cell electric vehicles (FCEV) would add thousands of jobs over the next decade. However, because EV assembly requires less labor than internal combustion engine (ICE) vehicles, the direct employment analysis finds a net reduction of 4,800 jobs in 2050. We also expect the EV industry to achieve increased efficiency in battery manufacturing in the coming decades, a trend that will help make EVs more affordable but contribute to this net reduction in jobs.

To be clear, the transition to EVs has tremendous job potential–*if we do it right*. Our analysis shows the industry adding 180,000 jobs across the EV supply chain (direct and indirect jobs) in 2025 and nearly 1.1 million jobs in 2050. Per *Figure 3*, most of these jobs are related to light-duty vehicles, which reflects the higher spending from consumer purchases on light-duty EVs than on medium- and heavy-duty EVs. But again, this will be more than offset by the loss of jobs in ICE vehicle manufacturing as those vehicles are phased out. And while our analysis does not directly investigate the entire ZEV supply chain (we assume equipment purchased from US suppliers to be at 55% for light-duty vehicles and 81% for heavy-duty vehicles), it warrants future studies and highlights the importance of onshoring a large share of domestic supply chain for EVs–including critical mineral processing, manufacturing of cathodes, anodes, and battery cells, and battery pack assembly–to make up for these losses. Thankfully, the

market is already moving in this direction, with automakers like General Motors and Ford announcing new battery plants in the US and other companies like Intel building new semiconductor manufacturing facilities. Federal investments, including billions of dollars in the Bipartisan Infrastructure Law for domestic critical mineral processing and battery manufacturing and recycling, will help further build out the domestic EV supply chain.

Manufacturing and installation of EV charging infrastructure in the *High Electrification/High Renewables* pathway will generate 3,300 jobs in 2025 and 31,300 jobs in 2050. Our results show total net employment impacts for vehicles and chargers will exceed 9,000 jobs in 2025 and 25,000 jobs in 2050. The message is clear: to take full advantage of the global transition to EVs and ensure American workers benefit the most, we need to bolster and expand the domestic supply chain for these vehicles.

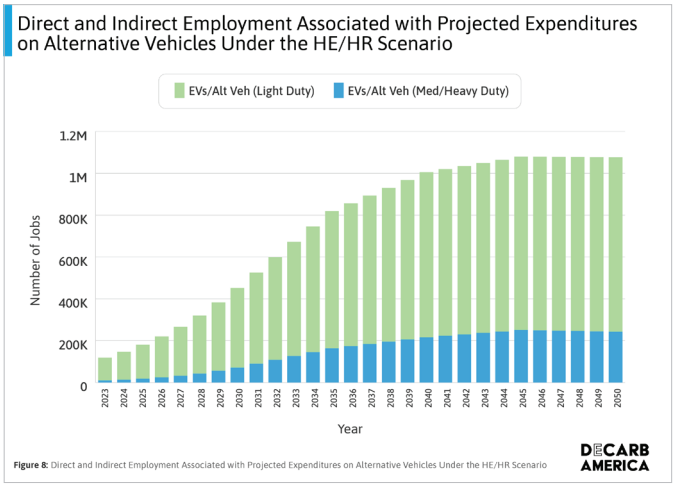

Figure 8: Direct and Indirect Employment Associated with Projected Expenditures on Alternative Vehicles Under the HE/HR Scenario

KEY TAKEAWAY 4

As technologies like carbon capture and storage, direct air capture, and advanced nuclear energy near commercialization, the US will build out entire industries for these technologies, creating hundreds of thousands direct and indirect jobs.

Reaching net-zero will require hundreds of thousands of new jobs to manufacture, construct and operate advanced clean energy and climate technology. As modeled, this includes jobs in advanced nuclear energy, zero-carbon fuels (SMR hydrogen with CCS and BECCS hydrogen), and carbon management (including direct air capture, CCS, and CO_2 pipelines). In the *High Electrification/High Renewables* pathway where renewable energy accounts for most decarbonization, advanced clean energy and climate technologies are still estimated to account for more than 500,000 direct energy sector jobs. Under the *Highly Constrained Renewables* pathway, which assumes very high barriers to renewable energy deployment, investment in advanced clean energy and climate technologies are projected to result in more than 1.6 million jobs.

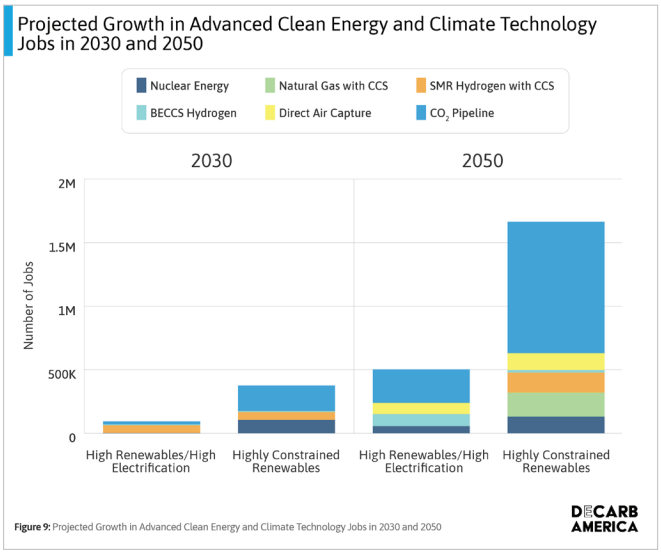

Figure 9: Projected Growth in Advanced Clean Energy and Climate Technology Jobs in 2030 and 2050

KEY TAKEAWAY 5

Biomass-based fuels will be a major source of jobs from 2030 onward. Use of biomass feedstocks, biofuels and BECCS hydrogen to reach net-zero goals is projected to support hundreds of thousands of new jobs in 2050.

Our assessment of the direct employment impacts of the *High Electrification/High Renewables* scenario projects that biomass-related jobs would increase by nearly half a million by 2050. The largest portion of projected direct jobs are in feedstock production, collection, processing, and transportation to conversion sites. In this modeling scenario, biomass feedstocks are sourced from agricultural waste, forestry residue, and energy crops grown on current corn land (thereby assuming no additional direct land-use change or conversions of land to energy crop production).

Out of all the biomass job categories, Biofuels comprise the second-largest increase in direct jobs under our *High Electrification/High Renewables* scenario. This category includes production of low-carbon liquid fuels and employs more than 175,000 personnel by 2050. The model likewise forecasts more than 95,000 jobs by 2050 coming from innovative hydrogen-producing technologies that draw energy from bioenergy sources with carbon capture and sequestration (BECCS), suggesting such technologies could be a major contributor to employment in the clean energy transition.

Our assessment of the direct employment impacts from the *Highly Constrained Renewables* scenario shows a significant increase in biomass feedstock jobs (well over 600,000) as a result of constraints imposed on intermittent renewables. This suggests the high-level direct employment findings are robust across the net-zero pathways evaluated.

Our economy-wide assessment also projects a net increase of 70,000 to 140,000 total jobs in the relevant "farms, forestry, fishing and related activities" economic sector under the two scenarios.

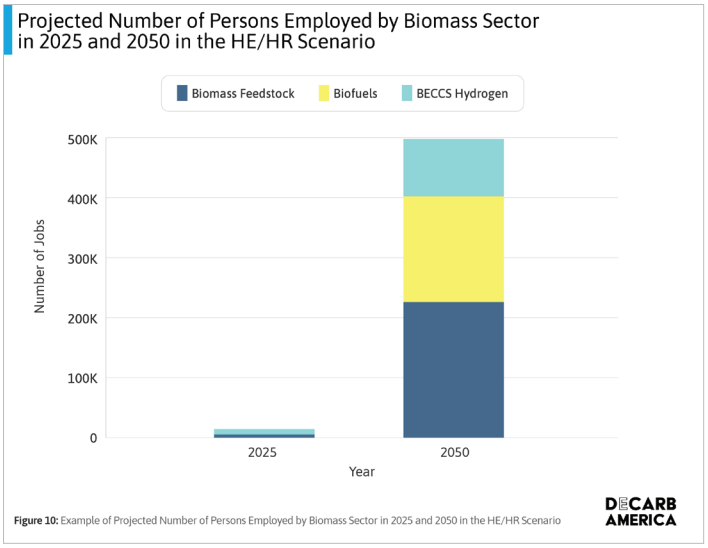

Figure 10: Example of Projected Number of Persons Employed by Biomass Sector in 2025 and 2050 in the HE/HR Scenario