Climate & Community Institute

Jobs for More Mobility & Less Mining

Modeling employment impacts from investment scenarios for transportation supply chain justice

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The Climate and Community Institute (CCI) is a progressive climate and economy think tank. Our growing staff and network of over 60 academic and expert fellows creates and mobilizes cutting-edge research at the nexus of inequality and the climate crisis. We fight for a transformational agenda that will rapidly and equitably decarbonize the economy by focusing on material benefits for working people.

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Executive Summary

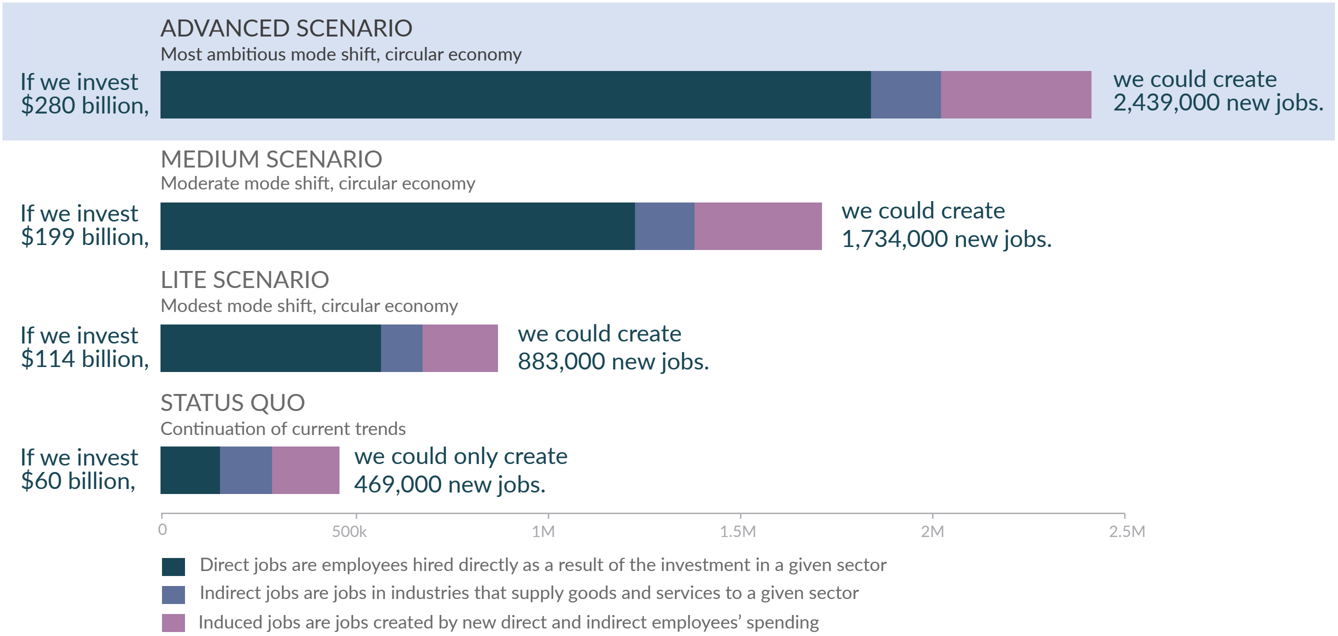
The urgency of eliminating emissions from the transportation sector—the number one source of U.S. carbon emissions—intensifies with every day of inaction. Some climate advocates believe that decarbonization hinges entirely on quickly electrifying all remaining gas-powered vehicles in a burgeoning electric vehicle market.

In contrast, this report reveals the broad benefits of a diversified, pro-worker, and pro-community transportation system. Such an approach will **not only reduce emissions faster, provide more mobility for more people, and lessen the burden of mineral extraction for batteries—but also stimulate millions of new, dignified jobs across the supply chain**. Policymakers face a unique opportunity to decarbonize the transportation system in a way that is both rapid and equitable.

We present three scenarios that assume progressively increased investment into sectors that diversify transportation options, improve working conditions, and reduce energy transition mineral demand. These scenarios build on the findings of our 2023 report, "Achieving Zero Emissions with More Mobility and Less Mining."

Each scenario that we explore—advanced, medium, lite, and status quo—corresponds to a distinct supply chain investment strategy in the year 2035, and outlines potential job impacts in four main categories: 1) vehicle manufacturing; 2) infrastructure; 3) transit operations; and 4) circular supply chains. **We find that an expansion of mobility options—including mass transit and safe streets—will produce a *net increase of 2.4 million jobs*.**

Investment in the just transportation supply chain could create up to **2.4 million** net new jobs by 2035



The investments within each scenario represent new annual investment above current levels within the United States in the single year of 2035.

- Under an “advanced” investment scenario, in which we invest $280 billion annually in diversified transportation and a circular economy, we find a **net total of more than 1.8 million new direct jobs and 2.4 million new total jobs** by 2035.
- Under the “medium” investment scenario, with an investment of $199 billion annually, we find a **net total of 1.2 million new direct jobs and 1.7 million new total jobs**.
- Under the “lite” investment scenario, with an investment of $114 billion annually, we find a **net total of 570,000 new direct jobs and 880,000 new total jobs**.
- The status quo scenario, in which we don’t shift our investment priorities, results in fewer than 150,000 new direct jobs—**less than 10 percent** of the jobs created in the advanced investment scenario. The status quo scenario would result in 469,000 new total jobs.

Shifting to a decarbonized transportation system will require building entirely new supply chains, mitigating job losses that occur in industries currently dependent on fossil fuels, and correcting practices that have discriminated against marginalized people or left them behind.

In terms of the transportation sector, this means thinking beyond simply swapping every single gas-powered vehicle for an electric one. From a climate standpoint, this the slowest pathway to reducing sectoral emissions, compared to an approach that expands transit and other mobility options. Under this status quo scenario, both workers and communities lose. Compared to the advanced scenario, there would be 90 percent fewer direct jobs, and the approximately 30 percent of people who do not drive will be left with the same inadequate options for accessing important needs in their lives. Meanwhile, rural and Indigenous communities will bear the burden of a huge increase in mineral extraction, and the consequences will affect water, air, and soil for hundreds, if not thousands, of years.

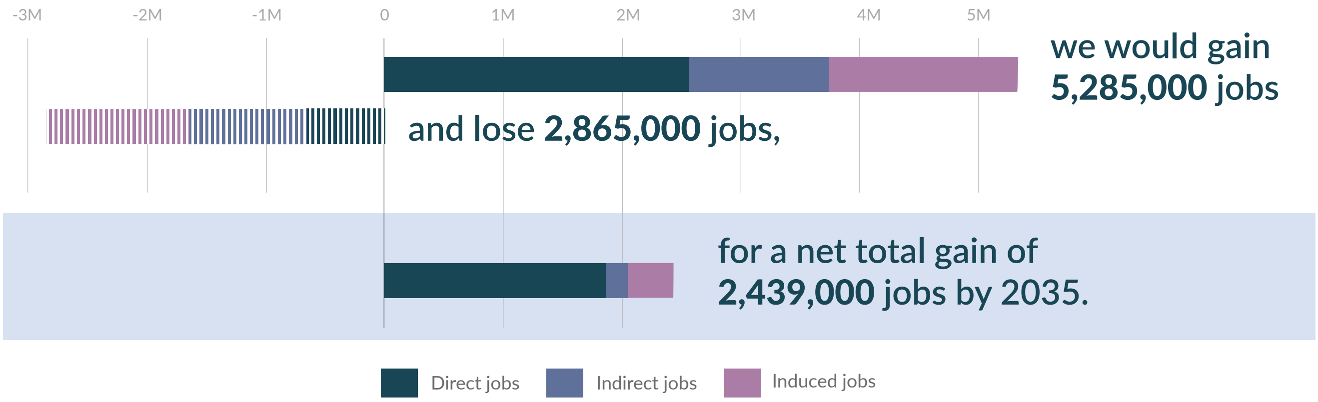
Transportation and climate planners need to diversify their strategy towards diversified transportation—including public transit, bicycling and pedestrian infrastructure, and battery recycling. This approach is not only better for the environment, it is better for workers and the green economy. By moving away from private passenger vehicles and investing in diversified transportation, the US could:

- more quickly and efficiently eliminate emissions;
- create millions of dignified jobs across the supply chain;
- reduce the demand for energy transition mineral extraction, which threatens water and biological resources and endangers frontline mining communities;
- address a host of deep structural problems within the current US transportation system: health and safety impacts from car accidents; economic losses from expensive fuel and insurance prices; and wasted space in towns and cities due to prioritization of land for parking and roads;
- account for those who either do not drive or do not own a vehicle, increasing their access to good jobs, housing, healthcare, education, recreation, and other basic needs.

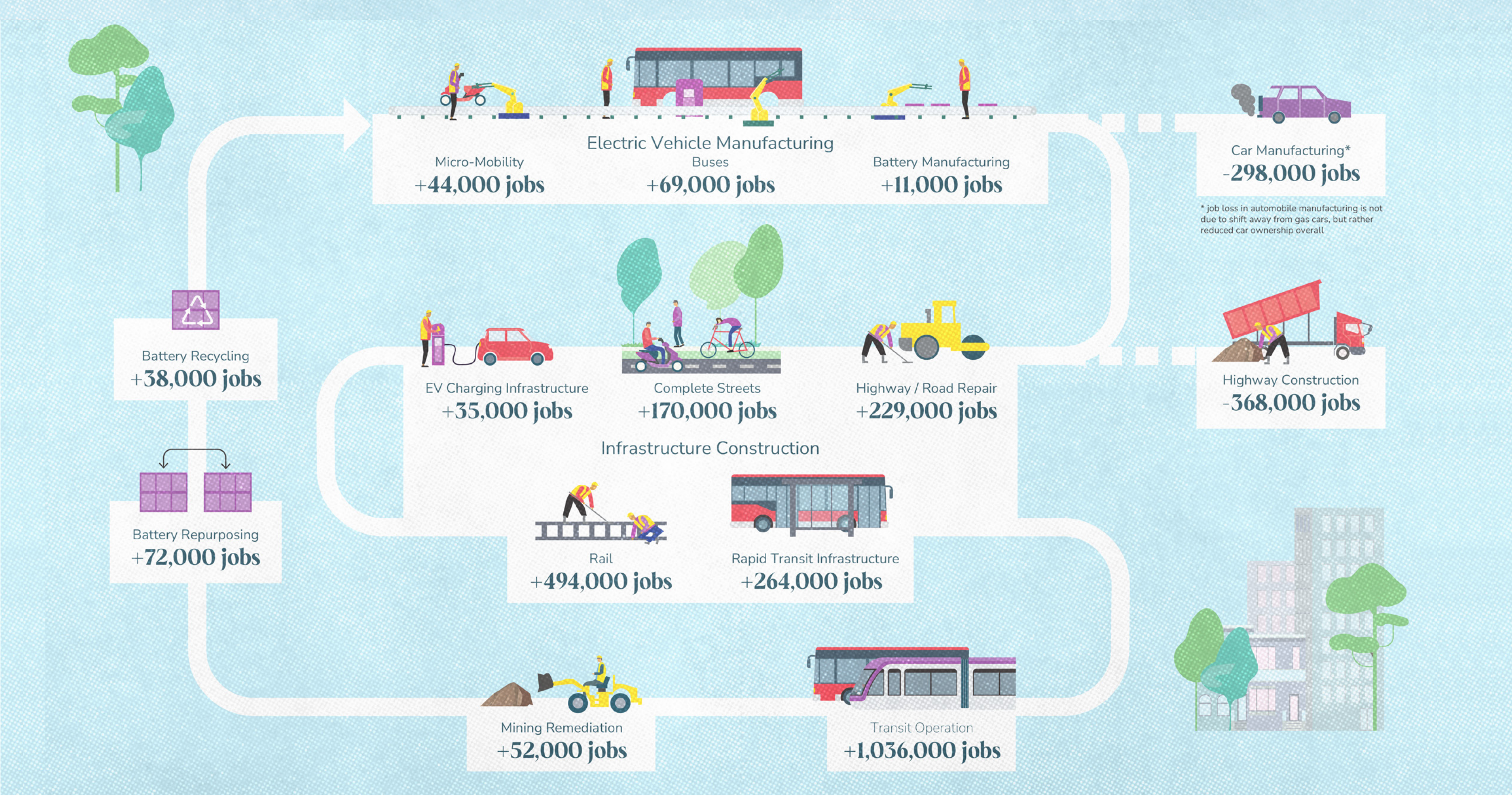
Contrary to the narrative perpetuated by car manufacturing corporations and their allies, our analysis shows that auto executives are not net “job creators.” Our findings are clear: shifting away from a transportation system anchored by private vehicles would generate more jobs overall, expand mobility options, and protect communities and ecosystems.

A whole supply chain approach that accelerates decarbonization; minimizes supply chain vulnerabilities; reduces environmental and cultural harm; upholds human, Indigenous, and labor rights; and improves mobility for millions of US residents will also generate up to 5.3 million new jobs that far outnumber job losses.

By investing $280 billion annually in diversified transportation and a circular economy,



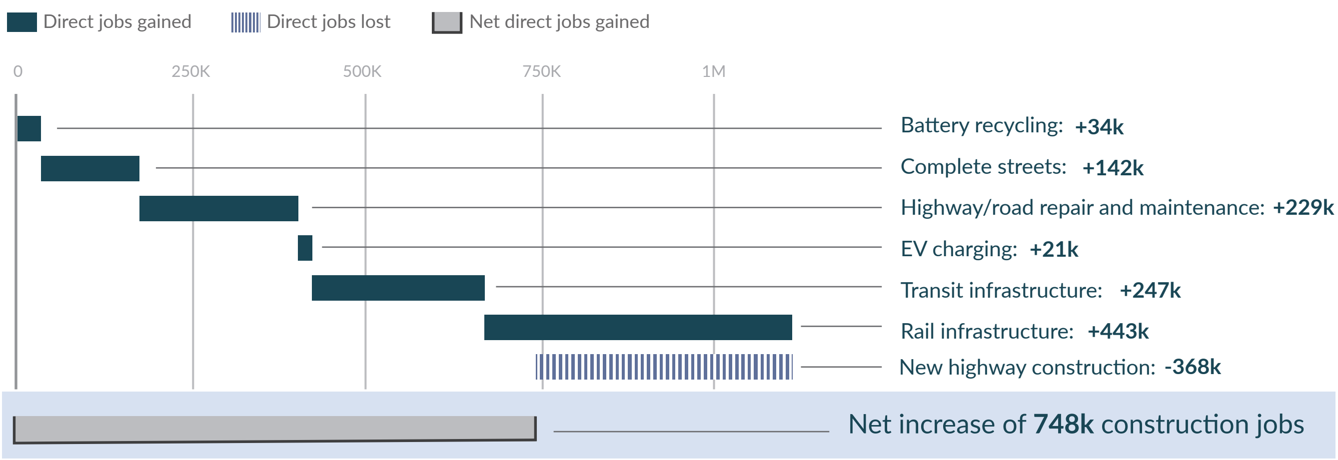
Of the net jobs gained, 1.8 million would be direct and spread across the transportation sector



Under the advanced scenario, **public transit operations employment would increase by more than 200 percent compared to current employment**. These unionized jobs would be spread across every state in the country.

Highway construction jobs would be more than replaced by construction jobs spurred by investment in transit and rail infrastructure, highway and road repair, and roads designed to provide safe access for everyone, from pedestrians to motorists.

The advanced scenario results in a net gain of more than **740,000** total construction jobs



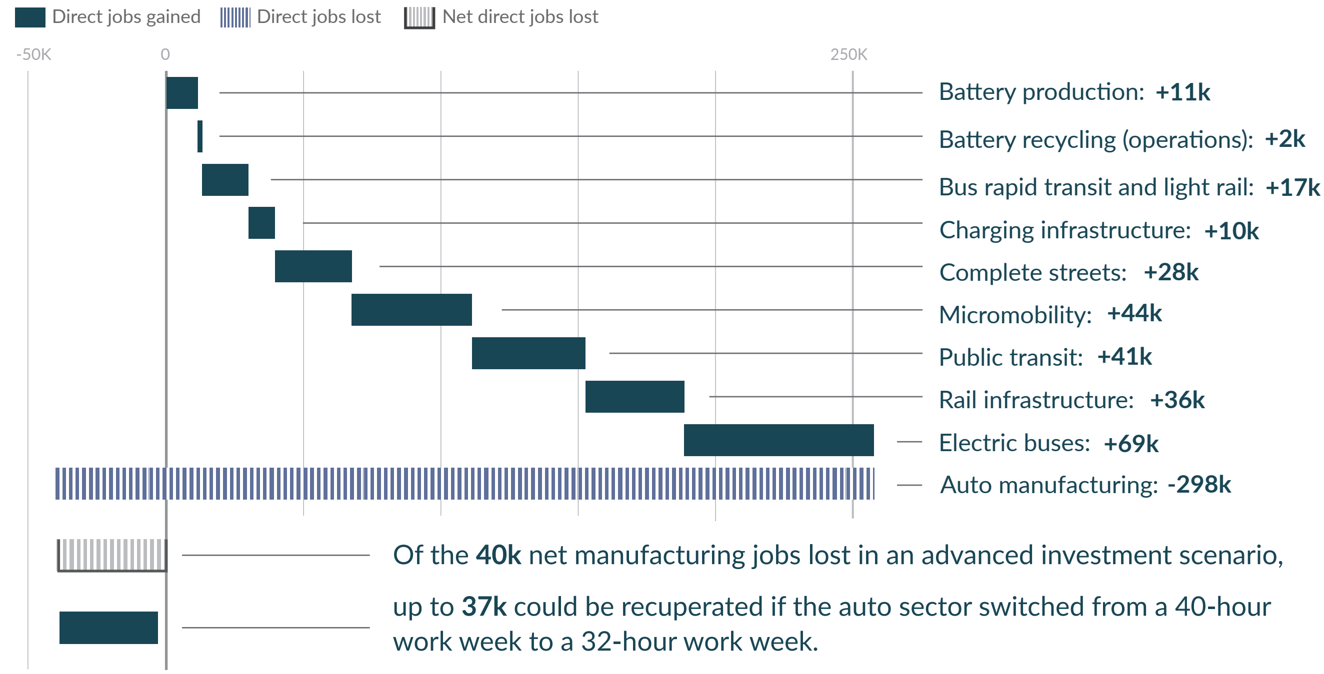
Under the advanced scenario, we can expect **over 257,000 new direct manufacturing jobs, as production of electric buses, rail, bikes, scooters, and batteries ramps up**.

In addition to the level of investment, our report shows that the business model and ownership structure are key factors in determining the number and distribution of employment.

Under the current business model and ownership structure, the auto industry is likely to see a loss of employment in the scenarios considered, where private car sales are reduced. **However, with a different business model—or even new ownership structures altogether—and greater worker control, auto companies could direct more revenue toward reducing work hours, increasing workers' pay, and retaining and hiring more workers during the transition**. For example, in the advanced scenario, the manufacturing gains from other types of vehicle manufacturing amount to 87 percent of the lost auto manufacturing jobs. A shift from a standard 40-hour work week to a 32-hour work week with no loss in pay could further mitigate job loss within the auto sector. When these additional auto jobs are combined with new manufacturing jobs in other sectors, the modeling shows an almost neutral impact on overall manufacturing jobs in the advanced scenario.

Greater worker control also represents an opportunity to operate in solidarity with people on the frontlines of the transportation supply chain, and could be one step towards facilitating a democratic planning process for the industrial transition in which workers and communities could collectively decide what these factories will produce. Such a process could even lead to a shift away from manufacturing private transportation and toward building more public transit and micromobility vehicles—a change that might give workers better job security while also improving outcomes across the supply chain.

The loss of auto manufacturing jobs in an advanced scenario could be mitigated by the auto sector switching to a 32-hour work week



Transforming our polluting and inefficient transportation sector into a diversified, pro-worker, and pro-community system would not only rapidly advance decarbonization. Crucially, it would also create massive new employment opportunities for people who may need to transition out of their jobs in auto manufacturing or highway construction while investing in infrastructure, and offer remediation for mining communities and mobility justice for people who have been left behind by the automobile era. With such an investment strategy, we can add more than 2 million net new jobs to the economy and provide off-ramps for highway construction workers and autoworkers whose jobs may be displaced during decarbonization.

The US faces a critical juncture. It can choose the status quo—a transportation network dominated by sprawling roads and large, private vehicles that perpetuate enormous mineral consumption and an underclass of people who do not drive or own a car. Or it can make intentional policy investments into a transportation system that slashes carbon, democratizes mobility, protects workers, reduces harmful extractive mining worldwide, and yields maximum economic benefits and job creation for everyone.

Taken together, these investments **represent a once-in-a-generation opportunity for a zero-emissions transportation system** which simultaneously improves the fate of the environment and communities while creating millions of good jobs to help workers transition into the green economy.

Part 1

Introduction & Discussion of Findings

Introduction

The urgency of eliminating emissions from the transportation sector, the number one source of U.S. carbon emissions, intensifies with every day of inaction. Electric vehicles (EVs) make up a small but growing share of the United States' car market — and some climate advocates believe that decarbonization hinges on quickly converting all the remaining gas-powered vehicles. We assert that only a diversified transportation system[1] — one that makes it easier to get around on transit, bike, or foot—can lead quickly to a just climate transition. **In this report, we make the case that policymakers face an opportunity to shift the trajectory of transportation-sector decarbonization in such a way that it will not only reduce emissions faster, provide more mobility for more people, and lessen the burden of mineral extraction for batteries but also stimulate millions of new jobs.**

Transportation and climate planners have ample cause to diversify their strategy beyond a simple "electrify everything on a 1:1 ratio" approach. Various societal benefits can justify investing in a range of transportation strategies, including public transit, bicycling and pedestrian infrastructure, and battery recycling.

In contrast with the current transportation system dominated by private, battery-powered vehicles, a diversified system represents a faster and more efficient way to eliminate US emissions.[2] Reduced reliance on single passenger vehicles will also reduce demand for energy transition minerals (ETMs) that threaten already stressed water and biological resources and put in peril communities —disproportionately Indigenous communities, all over the world—who reside near mineral deposits. At the same time, investing in transit and complete streets can begin to address a host of deep structural problems within the current US transportation system: health and safety impacts from fast, heavy vehicles that dominate streets; economic losses from burdensome household spending on car ownership and maintenance; and wasted space in towns and cities due to prioritization of land for parking and roads. The old status quo system assumes every American is a car owner, thus neglecting those who either do not drive or do not own a vehicle, impeding their access to good jobs, housing, healthcare, education, recreation, and other basic day-to-day needs.

A just transition for zero-emissions transportation should equitably distribute benefits and limit harm to affected communities, workers, and the environment. One aspect of this justice includes protection for communities against harmful mining for the ETMs needed to build EV batteries. To this end, modeling by Climate and Community Institute in "Achieving Zero Emissions with More Mobility and Less Mining" has demonstrated that lithium demand could be reduced by up to 92 percent by 2050 through policies that increase energy efficiency with robust recycling and reuse; reduce battery sizes; increase investment in public transit; and prioritize mixed-use, pedestrian-friendly housing and land use.[3] Such a demand reduction could spare numerous communities from the impacts of industrial extraction.

1 We define the transportation system loosely as the interconnected network of infrastructure, vehicles, and services that allow people and freight to move within communities and around the country.

2 Ignacio de Blas, Margarita Mediavilla, Iñigo Capellán-Pérez, and Carmen Duce. "The Limits of Transport Decarbonization under the Current Growth Paradigm." Energy Strategy Reviews 32, no. 100543 (2020): 100543. https://doi.org/10.1016/j.esr.2020.100543.

3 Thea Riofrancos, Alissa Kendall, Kristi K. Dayemo, Matthew Haugen, Kira McDonald, Batul Hassan, Margaret Slattery, and Xan Lillehei, "Achieving Zero Emissions with More Mobility and Less Mining," Climate and Community Project, 2023, http://www.climateandcommunity.org/more-mobility-less-mining.

Frontline mining communities represent one group with a strong stake in the evolution of the transportation system. Workers are another group that will bear the impact of these changes. One of the obstacles to shifting away from a transportation system anchored by large, private vehicles has been the assumption that such a change would hurt US workers. Corporate automakers and their allies have long perpetuated a narrative that pro-environment, pro-labor, pro-community policies are bad for the economy. In the case of the transportation transition, however, **a whole-of-supply-chain approach that accelerates the transition to zero emissions, minimizes supply chain vulnerabilities; reduces environmental and cultural harm; upholds human, Indigenous, and labor rights; and improves mobility for millions of US residents will also generate up to 5.3 million new jobs that substantially outnumber job losses.**

An equitable transition to just, decarbonized, ecologically sustainable systems can create high-quality, high-wage union jobs. It is incumbent upon government, business, and union leaders to ensure that workers in climate-harmful sectors, such as highway construction and ICE vehicle manufacturing, can maintain dignified, family-sustaining work throughout the transition away from fossil fuels.

This report follows up on "Achieving Zero Emissions with More Mobility and Less Mining" by exploring three scenarios that assume progressively increased investment into sectors that diversify transportation options and reduce energy transition mineral demand. We examine potential job impacts in the year 2035 in four main categories: 1) vehicle manufacturing; 2) infrastructure; 3) transit operations; and 4) circular supply chains. The research finds a net increase in jobs across each scenario, with variable impacts on specific job types, including an increase in construction jobs and slight decrease in manufacturing jobs.

Challenges to the Electrify-the-Status-Quo Approach to Decarbonizing Transportation

Experts have documented several major obstacles to electrifying the current car-centered transportation system on the time scale needed. First, forecasters question the ability of US utilities to supply enough renewable electricity and upgrade the nation's antiquated electric grid to meet the large demand driven by electrifying today's roughly 278 million private and commercial vehicles. Second, households in the US keep their vehicles for a decade on average, meaning that after EVs reach 100 percent of market share, it will still take many years to replace the majority of internal combustion engine (ICE) cars. Finally, the complex global supply chain that provides minerals for EV batteries—also known as energy transition minerals (ETMs)—is subject to bottlenecks and disruptions as global demand skyrockets.

OVERVIEW OF MODELING APPROACH

This report examines potential job impacts in the year 2035 in the four main categories in Table 1.

For most of these sectors, the analysis generates an estimate of direct jobs (employees hired directly as a result of the investment), indirect jobs (also known as "supplier purchase effects" or jobs in industries that supply goods and services to the direct industry), and induced jobs (also known as "employee spending effects" or jobs created by economic stimulus that happens when new direct and indirect employees spend their income on goods and services such as

Table 1: Included supply chain sectors

VEHICLE MANUFACTURING	INFRASTRUCTURE	TRANSPORTATION OPERATIONS	CIRCULAR & JUST ECONOMY
Automobile production	Highway construction	Public transit	Battery recycling
Electric bus prtoduction	Highway repair		Battery repurposing
Micro-mobility production	Complete streets		Mining remediation
Battery production	Electric charging		
	Rail		
	Transit		

groceries, healthcare, and recreation). It is important to note that this modeling is not a prognosis for how the transition to zero-carbon transportation will unfold but rather an estimate of job implications under certain scenarios; if we assume certain investment levels, we can forecast the expected employment numbers.

Using IMPLAN, an input-output model of the US economy that enables users to study the economic impacts of demand and spending changes, we examine anticipated job impacts within each sector for three scenarios. These scenarios assume progressively greater mode shift from private cars to transit and active transportation and increased circularity within the transition mineral economy supplying EV batteries. These scenarios are labeled Lite, Medium, and Advanced. We compare these scenarios against a status quo scenario that assumes a continuation of autocentric transportation with a focus on full fleet electrification. That current course assumes a change in spending in some sectors based on 1) federal and state policy goals of reaching full electrification for current fleets (requiring increased investment in areas such as electric buses and batteries for private vehicles); 2) continuation of current growth trends within an industry (such as micromobility); and 3) assumed modest investments in material circularity, including as battery repurposing and recycling.

INVESTMENT LEVELS

The investments within each scenario (Table 2) represent new investment above current levels within the United States in the single year of 2035. The extent to which investments made in the United States will create jobs for US workers depends on whether the funds are spent on goods and services produced within the country. The table below shows the assumed new investments within each sector modeled. Discussion of the rationale for each investment level can be found within the specific sector descriptions within the Breaking Down the Transportation Supply Chain section.

The advanced scenario is not simply the scenario with the most investment in each sector; rather it is intended to be an assessment of where investments are needed to achieve an outcome that integrates swift carbon reductions, improved mobility, and reduced mineral demand. With that in mind, the advanced scenario represents the highest investment in categories such as transit, complete streets, battery recycling, and repurposing. However, it represents the lowest investment in new highway construction under the assumption that a) investments in transit, micromobility, rail, and complete streets will reduce the need for new highways and b) new highway construction typically does not improve mobility in the long run and instead leads to increased greenhouse gas emissions and other negative health and economic impacts.

Similarly, the advanced scenario represents the lowest investment in battery production under the assumption that investments in transit, micromobility, and battery recycling and repurposing will reduce the need for new battery production, which will lead to less mining.

Table 2: Changes to annual investment by 2035, compared to 2024

SECTOR	ADVANCED SCENARIO	MEDIUM SCENARIO	LITE SCENARIO	STATUS QUO
Rail	$100B	$70B	$35B	$0
Public transit operations	$75B	$50B	$20B	$0
Highway and road repair	$60B	$30B	$15B	$0
Transit infrastructure (bus rapid transit and light rail)	$48B	$24B	$12B	$0
Complete streets	$35B	$20B	$5B	$0
Micromobility	$32B	$24B	$16B	$16B
Electric bus	$28.1B	$15.4B	$13.4B	$13.4B
Battery repurposing	$18.3B	$13.5B	$8.7B	$1B
Charging infrastructure	$8.7B	$6.3B	$3.9B	$6.3B
Mining remediation	$12.5B	$6.5B	$850M	$0
Battery production	$5B	$10.4B	$20B	$20B
Battery recycling (construction)	$5B	$2.9B	$730M	$2.5B
Battery recycling (operations)	$2B	$1.2B	$292M	$1B
Highway (new construction)	-$150B	-$75B	-$37B	$0
Auto manufacturing	NA	NA	NA	$0
TOTAL	**$280B**	**$199B**	**$114B**	**$60B**

Discussion of Findings

EMPLOYMENT IMPACT OF INVESTMENT IN TRANSPORTATION SUPPLY CHAIN JUSTICE

Within each scenario, there is a mix of job gains and losses across different sectors, with overall net increase of jobs. The advanced scenario—which invests the most in diversifying transportation options and increasing circularity of supply chains—yields the most overall job gains, providing the most social and economic benefit.

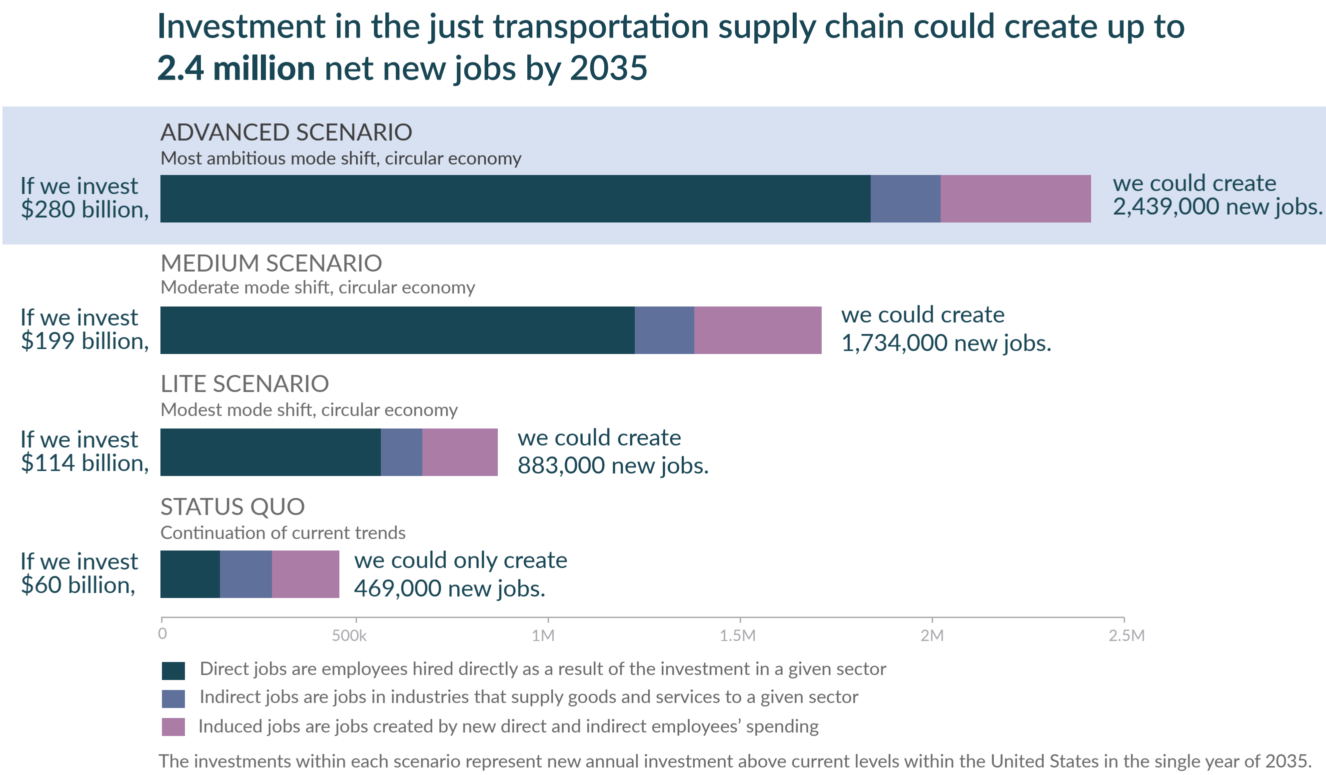


Figure 1. Projected new direct, indirect, and induced jobs in 2035 across modeled investment scenarios

- Under an "advanced" investment scenario, in which we invest $280 billion annually in diversified transportation and a circular economy, we find a **net total of more than 1.8 million new direct jobs and 2.4 million new total jobs** by 2035.
- Under the "medium" investment scenario, with an investment of $199 billion annually, we find a **net total of 1.2 million new direct jobs and 1.7 million new total jobs**.
- Under the "lite" investment scenario, with an investment of $114 billion annually, we find a **net total of 570,000 new direct jobs and 880,000 new total jobs**.
- The status quo scenario, in which we don't shift our investment priorities, results in fewer than 150,000 new direct jobs—**less than 10 percent** of the jobs created in the advanced investment scenario. The status quo scenario would result in 469,000 new total jobs.

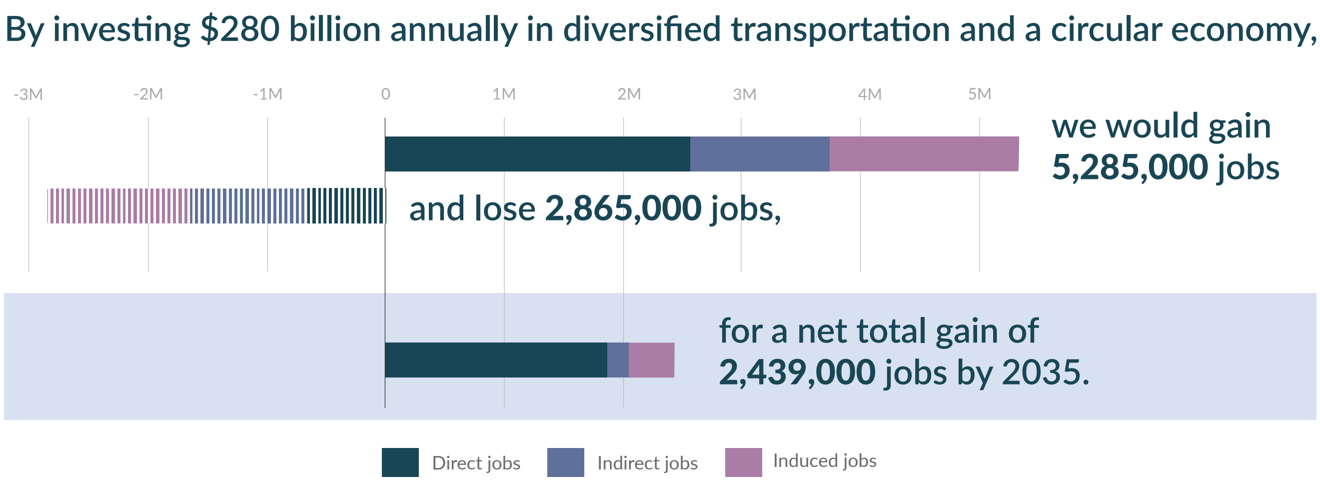


Figure 2. Projected gained, lost, and net direct, indirect, and induced jobs in 2035 in an advanced investment scenario

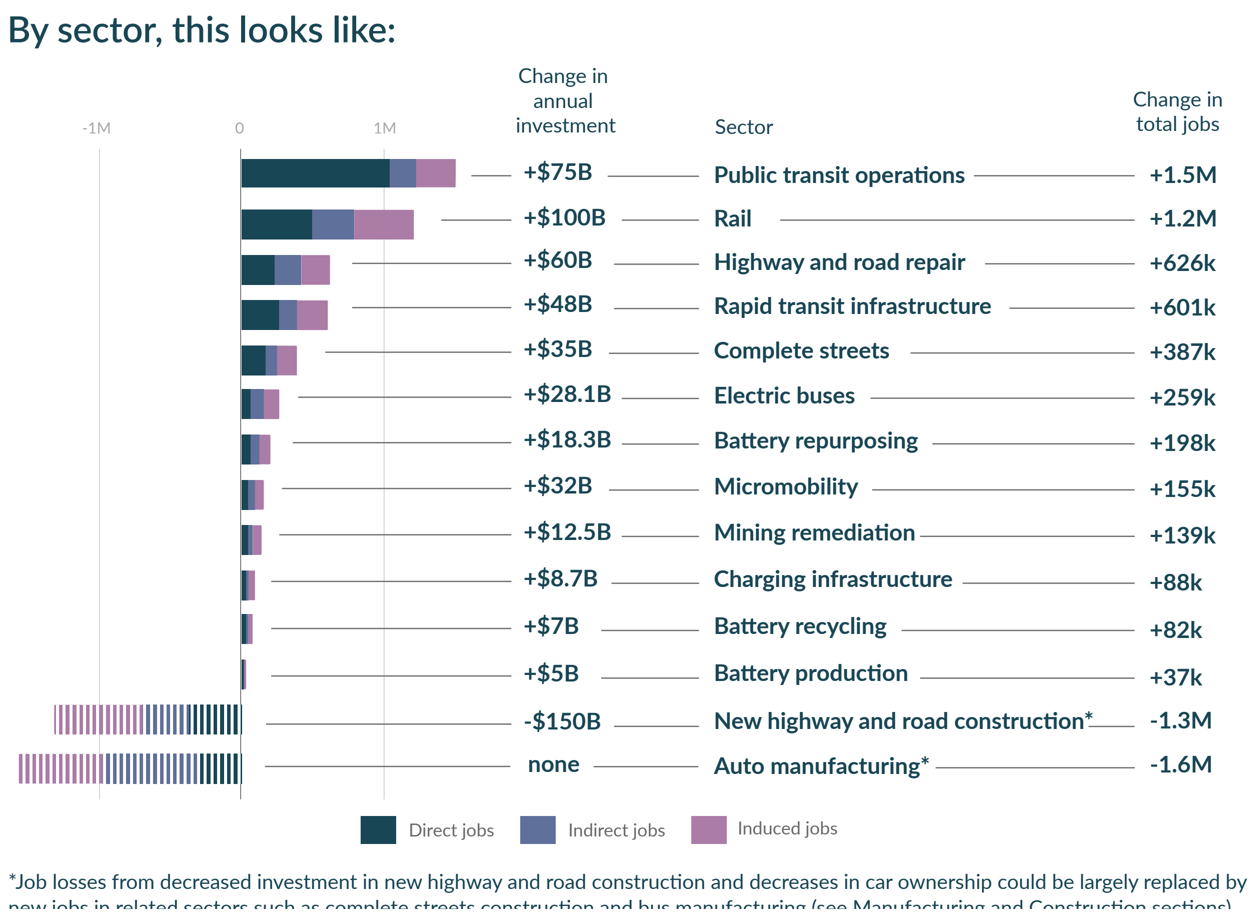


Figure 3. Projected gained and lost direct, indirect, and induced jobs in 2035 in an advanced investment scenario, per sector

Of the sectors modeled, the most job-dense sector is public transit operations, with a potential of over 1 million (1,036,000) direct jobs in the advanced investment scenario, followed by rail (494,000 direct jobs), bus rapid transit and light rail infrastructure (263,000 direct jobs), highway repair (229,000 direct jobs), and complete streets (169,000 direct jobs). Battery repurposing and recycling combine for over 100,000 projected new direct jobs.

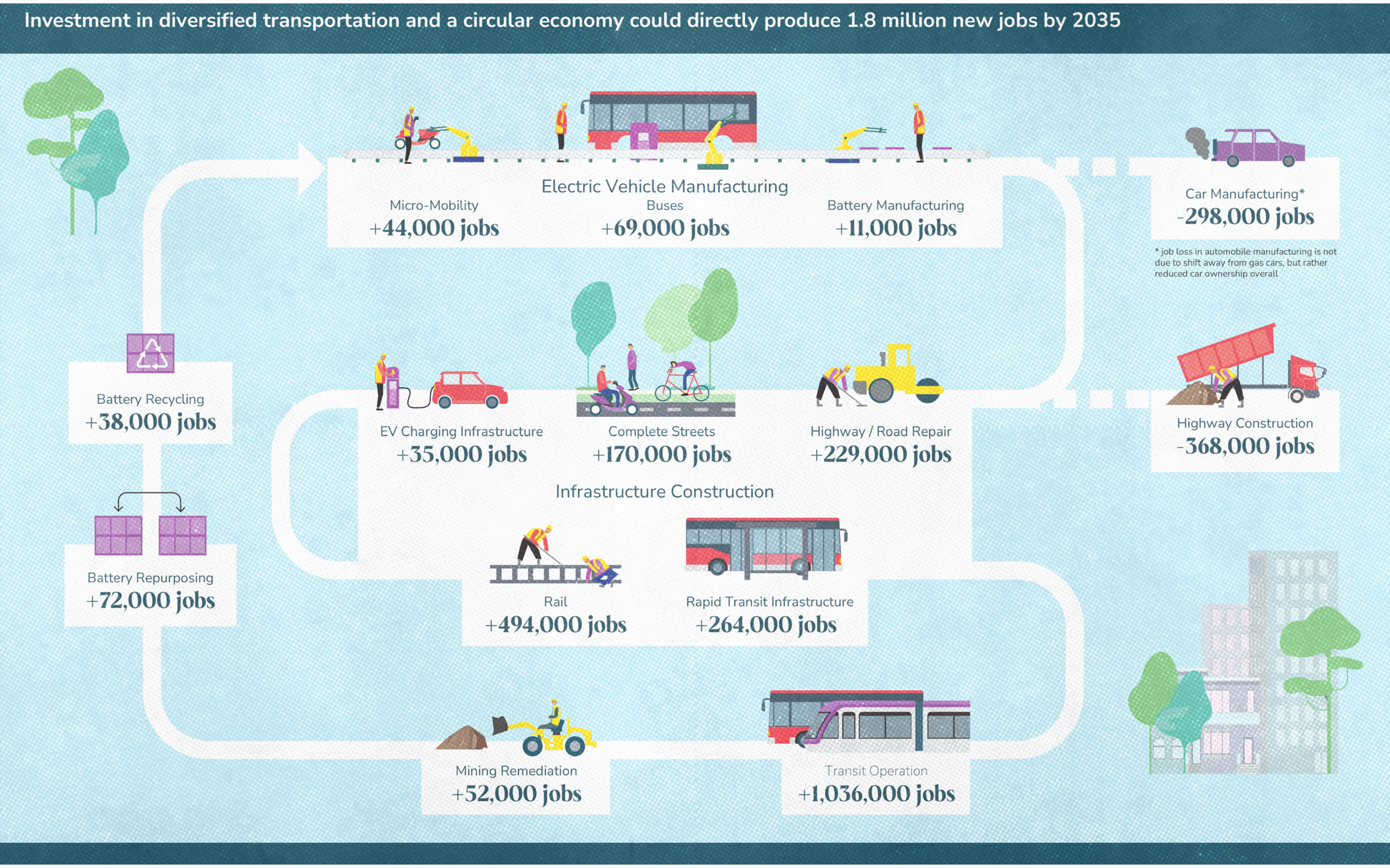


Figure 4. Net change in direct jobs across modeled sectors in an advanced scenario ($280 billion annual investment)

To benchmark projected employment numbers against current jobs, we compared them with 2024 employment in several sectors (Figure 5). To do this, we created composites of the job sectors modeled in this report that are comparable to Bureau of Labor Statistics occupation categories. For instance, we can predict the net change to current motor vehicles and parts manufacturing by combining the manufacturing job gains and losses projected by our model within auto, bus, rail, and EV battery sectors and then applying the net change to current BLS statistics for motor vehicles and parts manufacturing.

The largest increase in employment is in transit and ground transportation operations, with a net increase of 995,000 jobs and a 230 percent increase over current levels. Highway maintenance would increase by 229,000 jobs, a 152 percent increase.

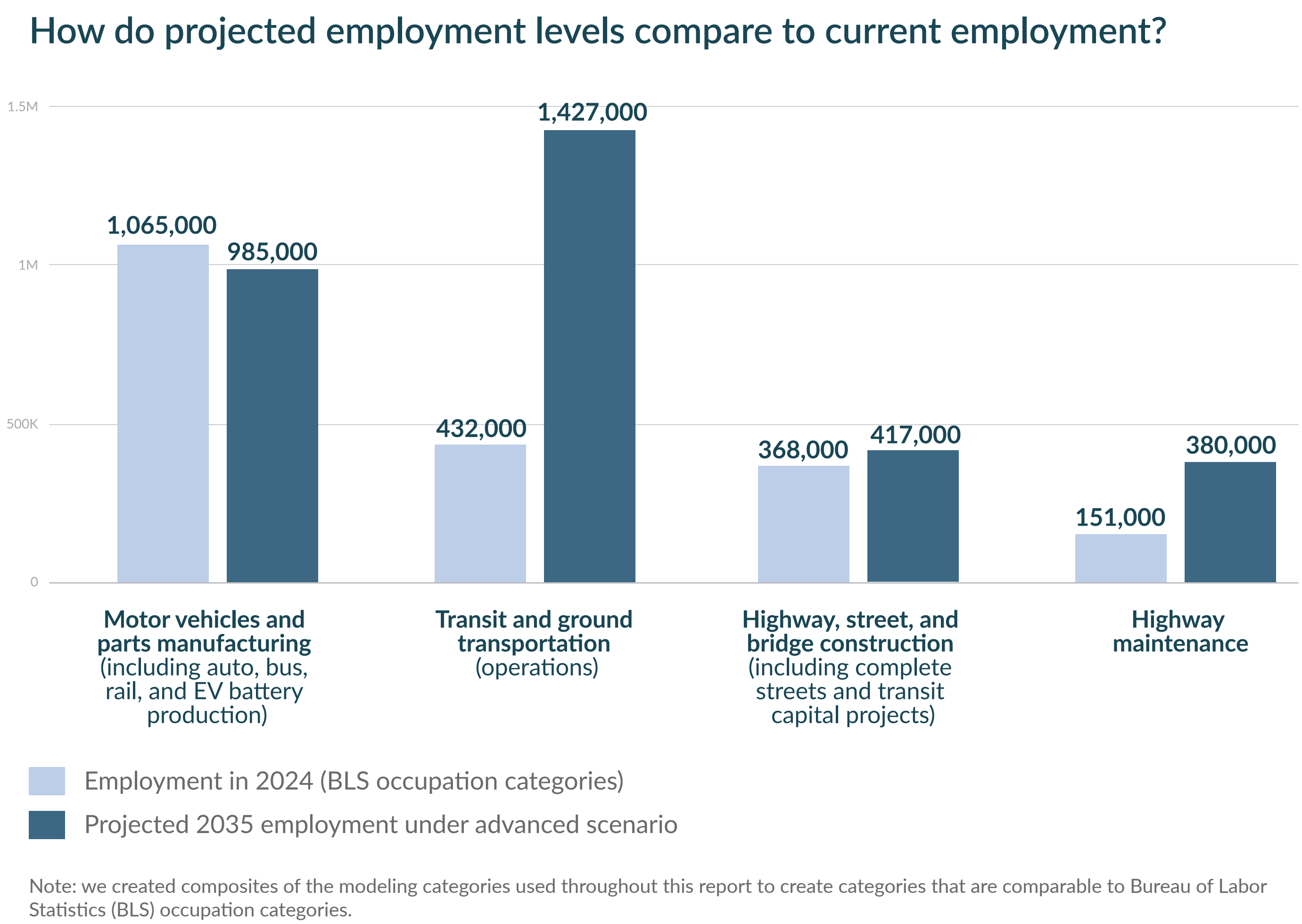


Figure 5. Current employment compared to projected 2035 employment in an advanced scenario

MANUFACTURING

Massive investments in public transit and safe streets are projected to translate into increased manufacturing of buses, e-bikes, and other types of EVs. Under the advanced scenario — which would help achieve transportation sector emissions targets — the 257,000 new direct manufacturing jobs would primarily take the form of electric bus manufacturing, other transit and rail manufacturing, production of micro-mobility vehicles such as bikes and scooters, manufacturing of complete streets materials, and battery production.

At the same time, we expect that these investments could lead to lower individual car ownership. This assumption is based on past modeling[4] that shows stronger transit and changed land use patterns reducing car

4 Riofrancos, et al. "Achieving Zero Emissions"

The advanced investment scenario would create **258,000** new manufacturing jobs in diversified transportation and the circular economy and lead to the loss of **298,000** auto manufacturing jobs, for a total net loss of **40,000** manufacturing jobs.

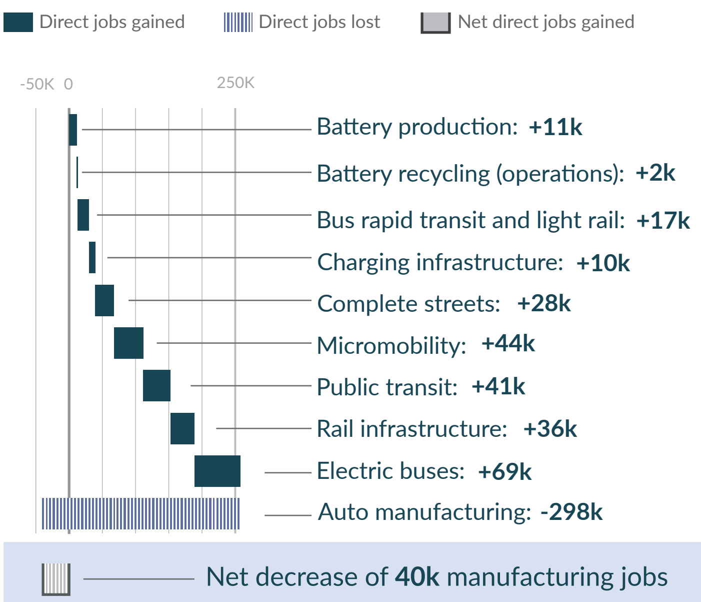


Figure 6: Impact of advanced scenario on direct manufacturing jobs

ownership by allowing people to get where they need to go more easily without a car. Reduced car sales, in turn, are projected to lead to a loss of 298,000 auto manufacturing jobs. The 257,000 new manufacturing jobs would amount to 87 percent of the lost auto sector jobs.

There is some uncertainty around auto manufacturing jobs, because the technology changes spurred by the EV transition may change auto factory productivity in ways that could either increase or decrease jobs in different manufacturing segments.[5] In fact, new research has documented that ICE auto plants converted to EV manufacturing have sustained significant job growth.[6] This factor could counteract job losses due to reduced car sales. There is also a potential alternative future in which people travel fewer miles by car but still choose to own a car at similar rates; this could result in fewer auto job losses while still achieving emissions reductions and improving transit options but would not necessarily reduce the impact of transition mineral extraction.

The auto job numbers also assume a continuation of profit maximization under corporate ownership, in which billions of dollars in annual profits go to shareholders rather than workers. Under a scenario with different ownership structures or greater worker control of the auto companies, lower car sales could continue to sustain more workers with better pay. Further research into the potential impact of management structures and ownership models on employment levels and work conditions could help clarify this potential.

5 Devashree Saha, Rajat Shrestha, Nate Hunt, and Evan Kim, "Navigating the EV Transition: 4 Emerging Impacts on Auto Manufacturing Jobs." World Resources Institute, June 13, 2024. https://www.wri.org/insights/ev-transition-auto-manufacturing-jobs.

6 Weng, A., Ahmed, O.Y., Ehrlich, G. et al. Higher labor intensity in US automotive assembly plants after transitioning to electric vehicles. Nat Commun 15, 8088 (2024). https://doi.org/10.1038/s41467-024-52435-x

32-HOUR WORK WEEK

In its historic contract campaigns with General Motors, Ford, and Stellantis, the United Auto Workers (UAW) introduced a demand to institute a 32-hour work week, while maintaining the same pay. This goal evokes Henry Ford's 1926 decision to reduce his factory from a 6-day to 5-day work week, which preceded Congress's decision to write into law the 44-hour work week (later updated to the 40-hour work week in 1940). As UAW President Shawn Fain said when testifying before a Senate committee on this topic, "eighty-four years ago, the forty-hour week was established. Since then, we've had a 400 percent increase in productivity, but nothing's changed." A 32-hour work week would spread some of this productivity benefit to workers, who could either gain more free time or earn greater overtime pay. It can also serve to minimize job loss by spreading work between workers so that workforces do not decline when work changes.

Pilot studies around the world have shown that, in many workplaces, the shift from 40 to 32 hours does not impact productivity.[7] In other words, companies have been able to continue operating with fewer worker hours without having to hire more employees. However, this increase in productivity likely has limitations in sectors such as manufacturing, construction, and transit operations because of physical constraints to productivity. A worker on an assembly line has a limit to how fast they can safely move; a bus driver cannot drive faster than speed limits and safety protocols dictate. There is not yet sufficient empirical data to determine with any certainty what the productivity gains will be in these sectors.

Another complexity of analyzing the impact of a shortened work week on jobs is the potential for workers to choose more overtime pay over more leisure time. According to the Bureau of Labor Statistics, motor vehicle parts and manufacturing workers currently work an average of 42.8 hours per week, or an average of 2.8 overtime hours. Anecdotally, however, many autoworkers put in over 60 hours per week. With the introduction of a 32-hour work week, some workers would likely work fewer hours to maintain the same pay with more free time, while other workers would likely maintain their current hours in order to raise their earnings through increased overtime pay.

For the sake of this modeling, based on review of literature and consultation with an expert involved in the pilot research programs, we assume that a reduction from 40 to 32 hours in the manufacturing and construction sectors will result in a 7.5 percent increase in employment. This is based on an assumption that, when hours decrease by 20 percent, productivity will

7 "The Impact of Work-Time Transformation," 4 Day Week Global, accessed September 7, 2024, https://www.4dayweek.com/research.

Figure 7: Impact of the auto sector shifting from a 40-hour work week to a 32-hour work week on direct manufacturing jobs

increase but by less than 20 percent. We also assume that 50 percent of workers will reduce their hours, while 50 percent will maintain hours to earn more overtime pay.

The resulting job increases show that auto manufacturing gains could partly erase job losses caused by lower car ownership and sales.

If we add the new direct manufacturing jobs in other sectors with the new auto manufacturing jobs resulting from a 32-hour work week, we end up with a net decrease of only 3,251 manufacturing jobs in the advanced scenario.

Because this change would increase the auto companies' labor costs and cut into profits, management will not make the shift without substantial pressure or regulation. The Big Three automakers each reported tens of billions of dollars in gross profits in 2023. Under a different business model, with greater worker control—or even worker or government ownership—these companies could potentially direct more of their revenues toward reducing work hours, increasing workers' pay, and retaining and hiring more workers during the transition. Further research in this area is warranted.

CONSTRUCTION

The advanced scenario results in a net gain of more than 740,000 direct construction jobs. In its 2023 modeling of emissions scenarios for Infrastructure Investment and Jobs Act (IIJA) spending in 12 states, Georgetown Climate Center found that "minimizing further highway expansion was the most important lever to avoid putting upward pressure on transportation emissions."[8] With this in mind, our advanced investment scenario assumes a complete shift of funding out of new highway construction and into a more diversified transportation portfolio.[9] Our modeling shows that highway construction jobs would be more than replaced with construction jobs spurred by investment in transit and rail infrastructure, highway and road repair, and complete streets.

8 James Bradbury, Zack Subin, Ben Holland, and Ryan Levandowski, "Issue Brief: States Are in the Driver's Seat on Transportation Carbon Pollution." Georgetown Law, Georgetown Climate Center, March 24, 2023. https://www.georgetownclimate.org/blog/states-in-the-driver-eys-seat.html.

9 For more discussion on the impacts of highway construction, see the sector-by-sector breakdown below.

The advanced investment scenario would create 1,115,000 new construction jobs in diversified transportation and the circular economy and lead to the loss of 368,000 jobs building new highways, for a total net gain of 748,000 new construction jobs.

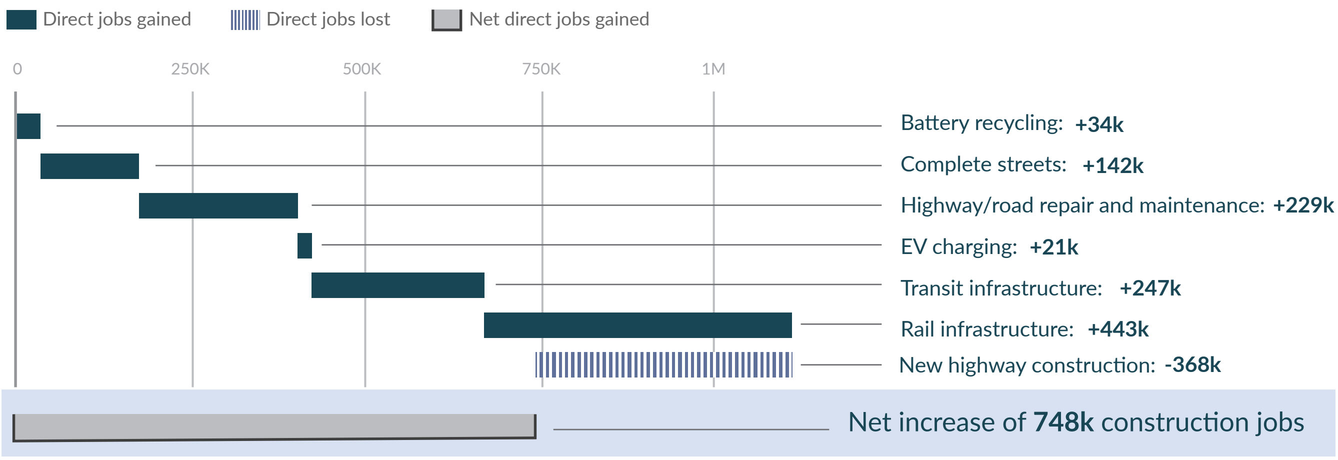


Figure 8: Impact of advanced scenario on direct construction jobs

SHIFTING HIGHWAY FUNDING TO DIVERSIFIED TRANSPORTATION

Evidence shows that new highway construction does not solve long-term traffic problems and causes numerous other harms. Advocates in communities around the country are pushing for an end to new highway construction. The Freeway Fighters Network is a nationwide coalition that brings together dozens of these local efforts to stop new projects or even remove existing highways.

From a jobs perspective, what would happen if we stopped all new highway construction today? With this question in mind, we can consider the job implications of a narrow scenario that assumes that 100 percent of funds currently spent on new highway construction will be divided up among three alternative spending categories: highway and road repair (40 percent); complete streets construction (30 percent); and public transit infrastructure (30 percent).

This scenario results in a net increase of 275,000 direct construction jobs. This suggests that construction workers would continue to find employment in a transportation future that favors transit and complete streets over new highway capacity.

Shifting all new highway construction into repair, complete streets, and transit would create a total net increase of 275,000 construction jobs.

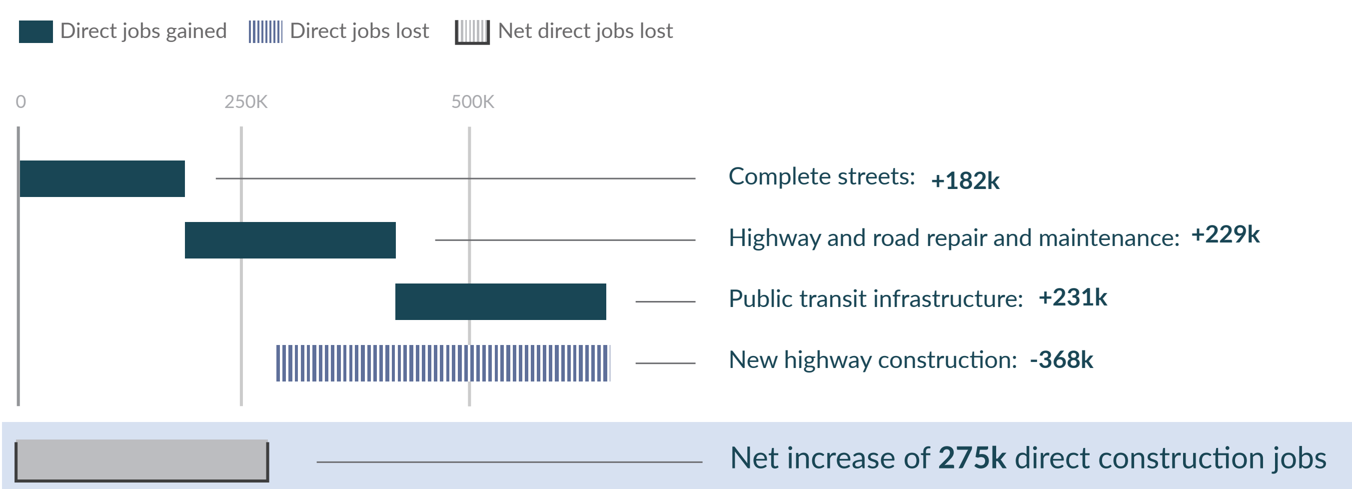


Figure 9: Impact of shifting new highway construction funding to repair, complete streets, and transit on direct construction jobs

POTENTIAL FOR WORKFORCE TRANSITION

A number of factors can influence workers' ability to transition into new jobs—and potentially new sectors. These factors include geographic distribution of available jobs, seniority, wage structure, union composition, required skill sets, and availability of training programs. Below we provide comparisons across sectors for several of these factors to give a sense for which industries might be most compatible for worker transition.

The table below compares wages across several industries modeled in this report and identifies union membership rates where data is available. Notably, rail—the second-largest job creator in the advanced scenario—offers some of the highest wages, while transit, the largest job creator, lags behind in terms of wages, indicating investments must be paired with policies that increase wages.

Comparing unionization rates can help us understand the extent to which workers can transition across sectors while still maintaining union protections, such as bargaining for fair wages and safe working conditions. Union membership has fallen substantially across industries during past decades, eroding worker power to bargain for higher wages and better working conditions.[10] Although transportation and warehousing (15.2 percent), construction (11.7 percent), and manufacturing (7.8 percent) sectors all have national union membership below 20 percent,[11] some of the more specific occupations considered in this report have

10 U.S. Department of Labor, "Union Members"; U.S Bureau of Labor Statistics, "Union membership rate 8.6 percent in manufacturing, 23.4 percent in utilities, in 2019." TED: The Economics Daily, February 3, 2020. https://www.bls.gov/opub/ted/2020/union-membership-rate-8-point-6-percent-in-manufacturing-23-point-4-percent-in-utilities-in-2019.htm.; Congressional Research Service, "A Brief Examination of Union Membership Data" (R47596). June 16, 2023. https://crsreports.congress.gov/product/pdf/R/R47596.

11 U.S. Department of Labor, Bureau of Labor Statistics, "Union Members-2023" https://www.bls.gov/news.release/pdf/union2.pdf

Table 3: May 2023 Bureau of Labor Statistics data, wages and union membership by sector

SECTOR	MEAN HOURLY WAGE	ANNUAL MEAN WAGE	UNION MEMBERSHIP RATE
Rail Transportation	$37.46	$77,920	85% (Class I workers)
Highway, Street and Bridge Construction	$34.16	$71,050	11.7%
Motor vehicle manufacturing	$31.48	$65,470	Data not available
Remediation and Other Waste Services	$29.33	$61,000	Data not available
Urban Transit Systems	$26.16	$54,410	Over 74% (public transit employees)
Highway Maintenance Workers	$23.59	$49,070	Data not available

maintained much higher union density. Rail workers are among the most likely to be union members; the American Association of Railroads estimates that 85 percent of Class I rail employees are unionized.[12]

Similarly, the American Public Transit Association estimates that 74 percent of transit workers are represented by two unions: the Amalgamated Transit Union and Transport Workers Union of America,[13] with even more represented by a collection of other unions such as Service Employees International Union, the American Federation of State, County and Municipal Employees, and Transportation Authority Engineers and Architects. By comparison, about half of Michigan's roughly 300,000[14] auto assembly workers are represented by UAW, and union rates are lower in other states' automotive sectors. Across industries nationwide, public sector employees tend to be unionized at a higher rate (32.5 percent) compared to private sector employees (6.0 percent)

12 Association of American Railroads, "Freight Rail Facts & Figures." July 2024. https://www.aar.org/wp-content/uploads/2023/04/AAR-Facts-Figures-Fact-Sheet.pdf.

13 FourSquare IT and EBP, "Transit Workforce Shortage." American Public Transportation Association, October 2022. https://www.apta.com/wp-content/uploads/APTA-Transit-Workforce-Shortage-Report.pdf

14 Mike Wilkinson, "By the numbers: How many UAW members in Michigan, how much would strike cost." Bridge Michigan, September 12, 2023 https://www.bridgemi.com/business-watch/numbers-how-many-uaw-members-michigan-how-much-would-strike-cost..

Within electric bus and micro-mobility manufacturing, there is also a push for unionization of a workforce whose required skill sets may align with those held by autoworkers.

Workers at school bus manufacturer Blue Bird in Georgia recently voted to join United Steelworkers,[15] while the UAW represents workers at a Thomas Built bus facility in North Carolina. Employees at a New Flyer electric bus plant in Alabama unionized with the Communication Workers of America[16] and BYD electric bus employees in California joined the International Association of Sheet Metal, Air, Rail and Transportation Workers.[17]

While autoworkers could potentially transition to bus, rail, and e-bike manufacturing, workers who currently build highways could transition to employment rebuilding urban areas for people-focused transportation, such as bike lanes, bus rapid transit, pedestrian streets, and light rail. Beyond the direct realm of transportation, construction trades could also build and refurbish transit-oriented development, housing, schools, recreation, and work near transit hubs.

15 Luis Feliz Leon, "In Georgia, 1,400 Bus Manufacturing Workers Have Just Won a Union." Jacobin, May 17, 2023. https://jacobin.com/2023/05/electric-bus-manufacturing-workers-united-steelworkers-union-georgia-win.

16 Chance Phillips, "Workers at an electric bus plant in Anniston unionized and won double-digit raises." Alabama Political Reporter, May 22, 2024. https://www.alreporter.com/2024/05/22/workers-at-an-electric-bus-plant-in-anniston-unionized-and-won-double-digit-raises.

17 SMART, "BYD Workers Choose SMART SM Local 105." February 9, 2017. https://www.smart-union.org/byd-workers-choose-smart.

Geographically speaking, the companies building internal combustion vehicles in the United States have concentrated their facilities in a belt spanning the Midwest and the South, from Michigan to Alabama, with smaller concentrations of industry in Texas and California. The map of auto manufacturing and planned EV battery facilities looks very similar. This suggests a potential path for workers to transition from internal combustion vehicle manufacturing to EV car, bus, and battery manufacturing without needing to completely uproot their lives. Wage and labor standards are fundamental to ensuring that the auto factories located or relocated in right-to-work states protect workers and allow for a pathway for combustion workers to work in EV industries with the same union protection, benefits, and seniority as their current job.

Figure 10: Estimated 2025 US light-duty vehicle production capacity by State[†]

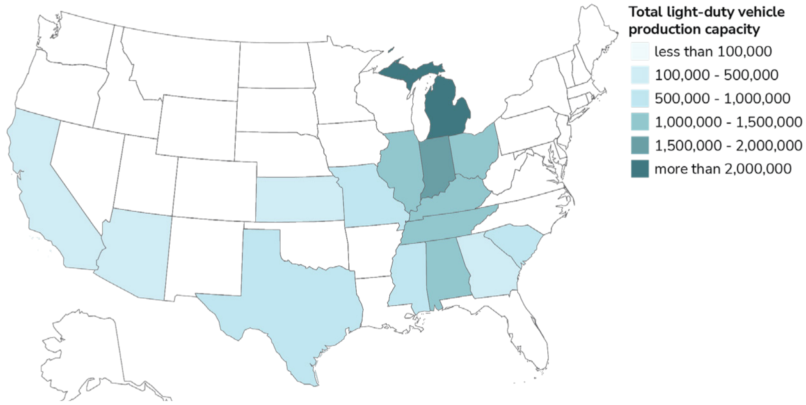
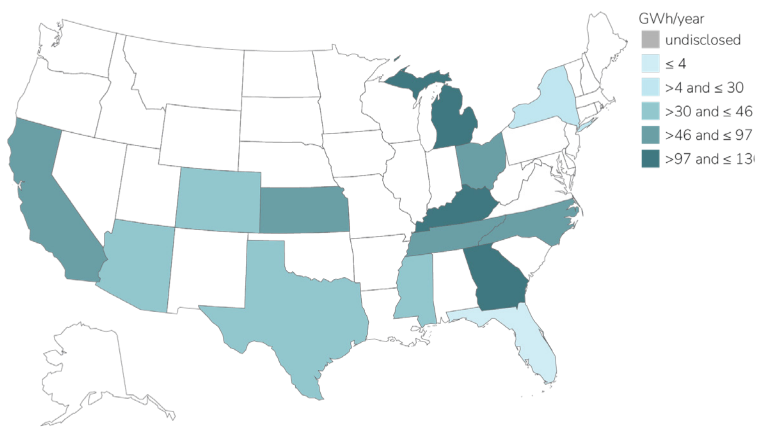


Figure 11. Planned battery plant capacity in North America by 2030[††]



[†]Anh Bui, Peter Slowik, and Nic Lutsey, "Power play: Evaluating the U.S. position in the global electric vehicle transition." The International Council on Clean Transportation, June 29, 2021. https://theicct.org/publication/power-play-evaluating-the-u-s-position-in-the-globalelectric-vehicle-transition. Used with permission as licensed under Creative Commons.

[††] David Gohlke, Yan Zhou, Xinyi Wu, and Calista Courtney, "Assessment of Light-Duty Plug-in Electric Vehicles in the United States, 2010–2021" (ANL-22/71). Argonne National Laboratory, November 2022. https://publications.anl.gov/anlpubs/2022/11/178584.pdf.

Highway maintenance workers are concentrated in the Midwest and Eastern states plus California and Texas. Demand for transit workers is most intense on the coasts, plus Michigan, Texas, Illinois, Pennsylvania, and Ohio. Meanwhile, abandoned mine reclamation work would be concentrated in Western states. High demand for transit and highway maintenance in Midwest states may present opportunities for displaced workers to shift into these fields of work while staying in the same geographic region, if they so desire.[18]

18 David Gohlke, Yan Zhou, Xinyi Wu, and Calista Courtney, "Assessment of Light-Duty Plug-in Electric Vehicles in the United States, 2010–2021" (ANL-22/71). Argonne National Laboratory, November 2022. https://publications.anl.gov/anlpubs/2022/11/178584.pdf.

Figure 12. Employment of highway maintenance workers by State, May 2023††

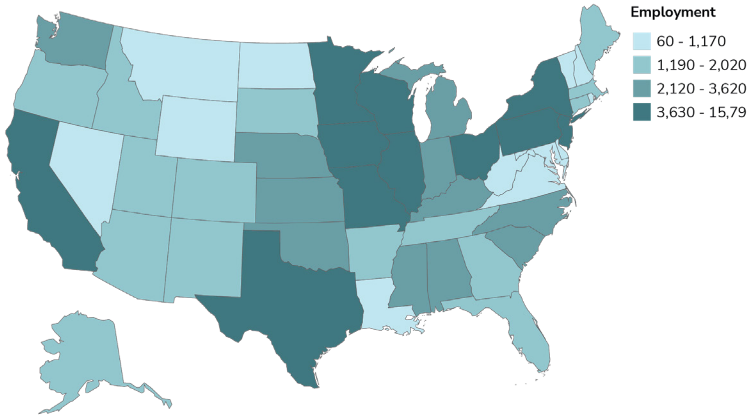


Figure 13. Employment of bus drivers (transit and intercity) by State, May 2023†††

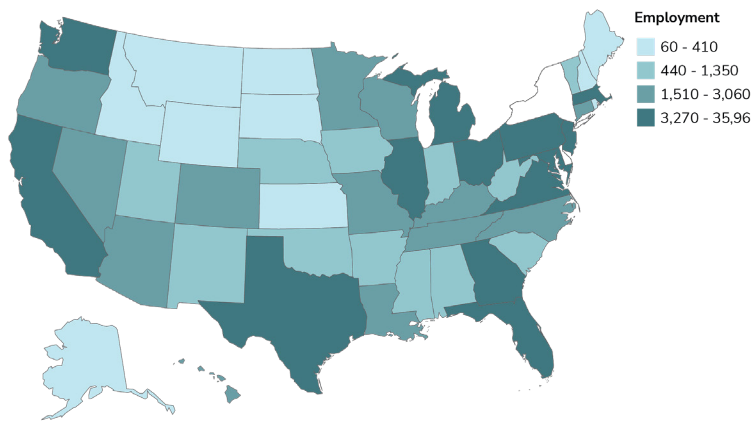
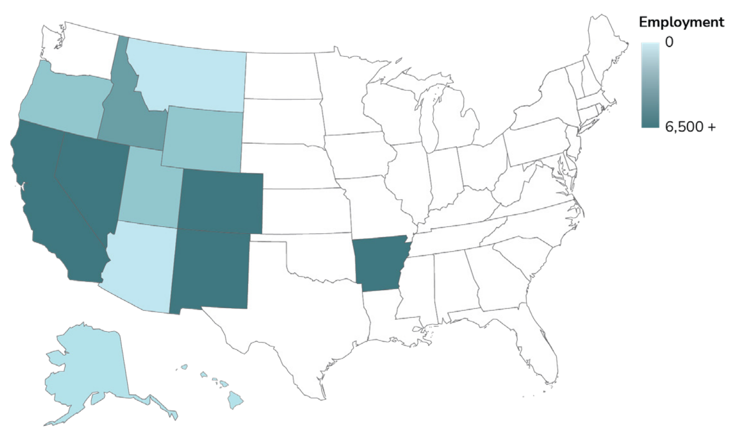


Figure 14. Concentration of abandoned mines, 2016††††



†††"Occupational Employment and Wages, May 2023, 47-4051 Highway Maintenance Workers," U.S Bureau of Labor Statistics, last modified April 3, 2024. https://www.bls.gov/oes/current/oes474051.htm.

†††† "Occupational Employment and Wages, May 2023, 53-3052 Bus Drivers, Transit and Intercity," U.S Bureau of Labor Statistics, last modified April 3, 2024. https://www.bls.gov/oes/current/oes533052.htm.

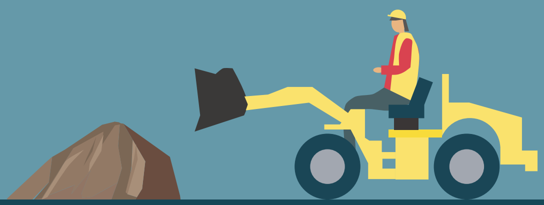
††††† Jonathan Wood, "Prospecting for Pollution: The Need for Better Incentives to Clean Up Abandoned Mines." PERC, February 11, 2020. https://www.perc.org/2020/02/11/prospecting-for-pollution-the-need-for-better-incentives-to-clean-up-abandoned-mines/#_ftn47. Used with permission.

Part 2

Breaking Down the Transportation Supply Chain

Mining Remediation

In the US specifically, mining regulation is deeply deficient and outdated, with mining on federal public lands governed by the Gold Rush-era General Mining Act of 1872, which includes neither environmental safeguards nor any provisions for Indigenous consultation or consent.



OVERVIEW OF MINING REMEDIATION

The massive global project to convert transportation systems from fossil fuel power to electricity is driving new mineral extraction to supply the lithium, copper, cobalt, nickel, and other minerals that play essential functions within batteries, wind turbines, and other renewable energy infrastructure.[19] Mining is one of the most environmentally harmful industries.[20] Globally, beyond its extensive environmental impacts, mining companies and their allies are also notorious for rights violations and targeted violence.[21]

In the United States specifically, mining regulation is deeply deficient and outdated, with mining on federal public lands governed by the Gold Rush-era General Mining Act of 1872, which includes neither environmental safeguards nor any provisions for Indigenous consultation or consent. The urgent need to transition off of fossil fuels and toward fully decarbonized transportation must not only minimize the environmental, social, and cultural impacts of mining by reducing its overall resource intensity, it must involve deep restructuring of US mining processes and practices to ensure reversal of historic precedents that prioritize rapid expansion and industry profits over rigorous environmental regulation and rights enforcement.

19 This report does not model new jobs in the mining sector; our assumption is that mining jobs will increase. One of the goals of a just transition is to minimize the growth in the mining sector through demand reduction and recycling, as reflected by strong investment seen in this model's scenarios in sectors such as public transit and battery recycling and reuse.

20 Luckeneder, Sebastian, Stefan Giljum, Anke Schaffartzik, Victor Maus, and Michael Tost. "Surge in Global Metal Mining Threatens Vulnerable Ecosystems." Global Environmental Change 69 (2021, July): 102303. https://doi.org/10.1016/j.gloenvcha.2021.102303.

21 "Transition Minerals Tracker," Business & Human Rights Resource Centre, accessed September 7, 2024.. https://www.business-humanrights.org/en/from-us/transition-minerals-tracker.; Global Witness, "Last line of defence." September 13, 2021. https://www.globalwitness.org/en/campaigns/environmental-activists/last-line-defence.

A just transition requires new mining operations to be sited and legally structured in ways that are controlled to the greatest extent possible by the public and local communities—and ensure the benefits are shared by frontline communities and the cost of any impacts are borne by the mining companies and government. In particular, any extraction projects must be required by law to seek and receive ongoing free, prior, and informed consent from any potentially affected Indigenous communities. Currently, there are over one-half million abandoned mines[22] from a legacy of poorly regulated mining, typically in the same regions where new transition mineral extraction is proposed. The federal government bears responsibility for properly cleaning and rehabilitating these lands, the largest of which are designated superfund sites. Doing so can improve ecosystem health, water quality, and health outcomes for frontline communities living near these lands.

22 United States Government Accountability Office, "Abandoned Hardrock Mines: Information on Number of Mines, Expenditures, and Factors That Limit Efforts to Address Hazards" (GAO-20-238). March 2020. https://www.gao.gov/assets/gao-20-238.pdf.

MINING REMEDIATION AND SUPPLY CHAIN JUSTICE

Over 75 percent of the lithium reserves and resources in the United States are located within 35 miles of a Native American reservation.[23] Similar percentages bear out for other minerals. As a new rush for energy transition minerals occurs, these lands already suffer a legacy of abuse and neglect by mining companies and the US government agencies responsible for regulating federal lands, namely the Bureau of Land Management and the US Forest Service. Although some mining companies and regulators point to improved regulations and benefit-sharing opportunities as different ways of business moving forward, the government needs to begin by investing in communities left behind by past mining booms. Some of the same rural communities that have borne the negative impact from decades of past mining are now facing dozens of new mine proposals–propelled by the climate transition and federally guaranteed loans from the US Department of Energy. By taking care of the land and people impacted by past mining operations, the United States can make a down payment on future justice for new transition mining communities.

23 Samuel Block, "Mining Energy-Transition Metals: National Aims, Local Conflicts." MSCI, June 3, 2021. https://www.msci.com/www/blog-posts/mining-energy-transition-metals/02531033947.

Table 4: Investment Scenario Spending and Job Estimates, Mining Remediation Sector, 2035

SCENARIO	INVESTMENT (ANNUAL)	DIRECT JOBS	INDIRECT JOBS	INDUCED JOBS	TOTAL JOBS
Advanced	$12.5 billion	51,875	35,750	51,375	139,500
Medium	$6.5 billion	26,975	18,590	26,715	72,540
Lite	$850 million	3,528	2,431	3,494	9,486

JOBS POTENTIAL OF MINING REMEDIATION

Investment in mining remediation has the potential to directly employ an additional 50,000 people in the year 2035. Remediation jobs can include treatment or removal of soil and sediments; removal of unused infrastructure; engineering and upgrading of dams and soil coverings for tailings ponds and waste piles; and designing and installing water treatment systems to keep contaminated water out of the local watersheds. Any past or present mines will need permanent observation and maintenance to ensure acid mine drainage and tailings are kept as sequestered as possible, especially in the case of natural disasters.

INVESTMENT SCENARIOS

The federal government pledged to invest $850 million[24] in mining remediation in 2022, mostly directed toward coal mines. We used this amount as our low-level Lite Scenario investment in all types of mining remediation. The US Government Accountability Office (GAO) estimates that the US government's total combined environmental liabilities—which include mine cleanup—will cost between $465 billion and $613 billion (Note: the GAO acknowledges there is still no comprehensive number for the amount of abandoned mines that need to be remediated, so this is an underestimate). Estimates by the Environmental Protection Agency, GAO, and the Mineral Policy Center[25] peg the total investment needed to clean up abandoned hard rock mining sites between $12 billion[26] and $125 billion.[27] For our advanced investment scenario, we assumed $12.5 billion per year for 10 years (for a total of $125 billion). For our medium investment scenario, we selected $6.5 billion per year, as a midpoint between the low and high estimates.

24 The Office of Surface Mining Reclamation and Enforcement made available $122.5 million in fiscal year 2022 for Abandoned Mine Land Economic Revitalization grants available to eligible states and Tribes. Additionally, the Department of the Interior announced $725 million available annually for 15 years to 22 states and the Navajo Nation, which began in FY2022 after the enactment of the Bipartisan Infrastructure Law. This is intended for reclamation of land impacted by coal mining.

25 Wood, "Prospecting for Pollution"

26 US Forest Service lands estimate only. United States Government Accountability Office, "Abandoned Hardrock Mines: Land Management Agencies Should Improve Reporting of Total Cleanup Costs"
(GAO-23-105408). January 13, 2023. https://www.gao.gov/products/gao-23-105408.

27 James S. Lyon, Thomas J. Hilliard, and Thomas N. Bethell, "Burden of Gilt." Mineral Policy Center, June 1993. https://earthworks.org/assets/uploads/archive/files/publications/REPORT-Burden-of-Gilt.pdf.

Battery Manufacturing

If car-dependent countries like the United States seek to replace every ICE vehicle with an EV, the required mining would be catastrophic for affected communities and environments.

OVERVIEW OF BATTERY MANUFACTURING

As the world turns to intermittent energy sources—like the sun and wind—to meet current and future demand, battery storage has become a critical pinch point for the energy transition. The transportation sector, in particular, presents a need for mobile energy sources that can function without connection to the power grid, whether the sun is shining or not. Needless to say, this scenario has set off a global race for countries to become dominant forces in battery production. China, South Korea, and Japan produce most of the world's EV battery components today, but recent US tax credits have led to billion-dollar investments that have spurred over 150 new factory announcements[28] that promise thousands of new jobs creating anodes, cathodes, cells, modules, and battery packs. The United States makes up about 7 percent of global battery production, but that number will likely grow in coming years.

BATTERY MANUFACTURING AND SUPPLY CHAIN JUSTICE

Battery production is not without its pitfalls. If car-dependent countries like the United States seek to replace every ICE vehicle with an EV, the required mining would be catastrophic for affected communities and environments. For this reason—along with the many benefits of multimodal transportation—we consider battery production for private automobiles to be a suboptimal strategy compared to electrification and expansion of public transit and active transportation. To achieve justice

28 "EV Jobs Hub," BlueGreen Alliance Foundation, accessed September 7, 2024. https://evjobs.bgafoundation.org.

along the supply chain, we envision new battery production and the associated jobs following a lower growth trajectory than the most dramatic peak projections.

JOBS POTENTIAL OF BATTERY MANUFACTURING

Investments in battery manufacturing have the potential to directly employ an additional 45,000 people in the year 2035. Like vehicle manufacturing plants, modern battery factories are highly mechanized and automated. Battery operations employ workers to monitor and operate equipment that assembles and tests battery components.

INVESTMENT SCENARIOS

Unlike in most sectors modeled for this report, in the case of battery production, the annual investment number for the advanced scenario ($5 billion) is lower than the investment number for the lite scenario ($20 billion). Consequently, the job creation is counterintuitively highest in the lite scenario. This is because the advanced scenario—as the scenario moving most ambitiously toward a circular mineral supply chain—represents a more ambitious investment in battery repurposing, public transit, and street designs to promote mode shift away from private car ownership. The assumption is that investments in transit, micromobility, and battery recycling and repurposing will reduce the need for new battery production. In this scenario, the demand curve for batteries will bend down (which will result in the benefit of less mineral extraction). For our medium scenario, we used RMI's projection of a cumulative $62.9 billion investment required in anode, cathode, battery cell, and battery pack production by 2030.[29] For our advanced scenario, we roughly halved this number, assuming lower battery requirements with lower car ownership and more mineral recycling. For our lite scenario, we doubled the number, assuming growth in car ownership and battery sizes.

29 Monkgogi Buzwani, "To Decarbonize Transportation, We Must Invest in the US EV Battery Supply Chain." RMI, September 26, 2023. https://rmi.org/to-decarbonize-transportation-we-must-invest-in-the-us-ev-battery-supply-chain.

Table 5: Investment Scenario Spending and Job Estimates, Battery Manufacturing Sector, 2035

SCENARIO	INVESTMENT (ANNUAL)	DIRECT JOBS	INDIRECT JOBS	INDUCED JOBS	TOTAL JOBS
Advanced	$5 billion	11,450	10,750	14,500	37,100
Medium	$10.4 billion	23,816	22,360	30,160	77,168
Lite	$20 billion	45,800	43,000	58,000	148,400

Battery Recycling & Repurposing

Battery recycling and repurposing have the potential to shrink long-term demand for new mineral extraction by recirculating transition minerals through the economy for multiple uses, thus closing the production loop.

OVERVIEW OF BATTERY RECYCLING & REPURPOSING

Battery recycling and repurposing have the potential to shrink long-term demand for new mineral extraction by recirculating transition minerals through the economy for multiple uses, thus closing the production loop. In theory, these practices embody the concept of a circular economy, where resources are reused and recycled indefinitely rather than discarded after an initial use. Typically, a recycling operation involves the messy process of shredding batteries, generating a substance known as black mass, which is essentially a mash of the various metals that make up a battery. Then the recoverable minerals are separated through either a heat-based smelting (pyrometallurgy) or liquid-based leaching (hydrometallurgy) process. Companies are experimenting with so-called “direct recycling” technologies that could increase efficiency and make the process cleaner, although today’s batteries simply are not designed to facilitate this end-of-life solution.

Because of the energy intensity and health and environmental risks of recycling, before a battery should be recycled, it should be used to its fullest potential by repurposing it from its initial use to multiple other uses. For instance, many EV batteries that would be considered end-of-life at 70 percent capacity can be dismantled and reassembled for use as energy storage in a variety of applications, including EV fast chargers, home energy storage, and stationary storage for electrical grid stabilization. [30]

30 Deborah Kapiloff, Aaron Kressig, and Sydney St. Rose-Finear, “Emerging Policies and Best Practices to Promote Lithium-Ion Battery Second-Life Applications in the United States.” Western Resource Advocates, April 2024. https://westernresourceadvocates.org/wp-content/uploads/2024/04/Emerging-Policies-and-Best-Practices-to-Promote-Lithium-Ion-Battery-Second-Life-Applications-FINAL.pdf.

BATTERY RECYCLING & REPURPOSING AND SUPPLY CHAIN JUSTICE

By reducing demand for ETMs, a strong recycling system can reduce the burden on human communities and natural ecosystems on the front lines of mining and mineral processing all over the world. It is important to note, however, that mineral recycling is not without its hazards and justice concerns. Today's battery recycling can expose workers and nearby communities to toxic substances as workers break open batteries full of minerals, salts and solvents, and chemical binders and adhesives.[31] Damaged batteries in collection and recycling facilities can also ignite and explode due to breakaway thermal reactions.[32] These hazards can be made worse because auto companies do not design their batteries for safe disassembly and, in some cases, intentionally make them difficult to take apart, as in the case of proprietary screws or integrating the battery into the chassis of the vehicle. Without oversight and regulation, recycling facilities can lead to dirty air and water and unsafe conditions for workers.

Relative to recycling, the process of repurposing keeps a higher percentage of transition minerals in circulation, produces less waste, and can be done with lower health and safety risks to workers and nearby communities. One of the key interventions to ensure safe and effective battery recycling, reuse, and refurbishment is to require batteries be designed for end-of-life reuse, remanufacture, and disassembly.

31 Ian Morse, "A Dead Battery Dilemma." Science, May 20, 2021. https://www.science.org/content/article/millions-electric-cars-are-coming-what-happens-all-dead-batteries.

32 Anuradha Varanasi, "We need safer ways to recycle electric car and cellphone batteries." Popular Science, March 1, 2022. https://www.popsci.com/energy/lithium-ion-batteries-recycling-fire.

JOBS POTENTIAL OF BATTERY RECYCLING & REPURPOSING

Investments in battery reuse and refurbishment have the potential to directly employ an additional 70,000 people in the year 2035. Battery recycling represents a relatively smaller job creator, with potential for growth as more batteries enter circulation and reach the end of their initial life cycles. Additional jobs will emerge to support a recycling system, especially in the collection and transport of batteries, part of a dense extended producer responsibility infrastructure.

INVESTMENT SCENARIOS

The jobs estimates for battery recycling used RMI's 2023 estimate of $9.47 billion cumulative capital investment required through 2035.[33] We used their 2035 spending estimate of $2.88 billion per year as our medium scenario investment. We roughly doubled this to $5 billion as the advanced scenario, and we used their average annual spending of $720 million as the lite scenario. Based on capital-to-operations spending ratios in comparable industries, we used a ratio of 2.5:1 to arrive at the respective operations spending.

To arrive at battery repurposing investment numbers, we used a second life battery supply estimate range from McKinsey & Company of 112 to 227 gigawatt-hours/year by 2030. When we plug these figures into the National Renewable Energy Laboratory (NREL) Battery Repurposing Second-Life Cost Calculator, which predicts the cost of repurposing a given quantity of batteries, this comes to a range of

33 Monkgogi Buzwani, "To Decarbonize Transportation"

Table 6: Investment Scenario Spending and Job Estimates, Battery Recycling and Repurposing Sectors, 2035

BATTERY REPURPOSING

SCENARIO	INVESTMENT (ANNUAL)	DIRECT JOBS	INDIRECT JOBS	INDUCED JOBS	TOTAL JOBS
Advanced	$18.3 billion	71,553	57,828	68,808	197,823
Medium	$13.5 billion	52,785	42,660	50,760	145,935
Lite	$8.7 billion	34,017	27,492	32,712	94,047

BATTERY RECYCLING (FACILITY CONSTRUCTION)

SCENARIO	INVESTMENT (ANNUAL)	DIRECT JOBS	INDIRECT JOBS	INDUCED JOBS	TOTAL JOBS
Advanced	$5 billion	34,000	12,000	23,300	69,700
Medium	$2.9 billion	19,584	6,912	13,421	40,147
Lite	$730 million	4,964	1,752	3,402	10,176

BATTERY RECYLING (OPERATIONS)

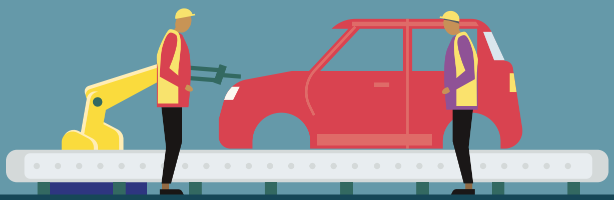
SCENARIO	INVESTMENT (ANNUAL)	DIRECT JOBS	INDIRECT JOBS	INDUCED JOBS	TOTAL JOBS
Advanced	$2 billion	3,600	4,240	5,040	13,100
Medium	$1.2 billion	2,074	2,442	2,903	7,546
Lite	$292 million	526	619	736	1,913

$4.7 billion to $9.5 billion per year for 2030. Projecting out to 2035, we arrive at $8.7 billion and $18.3 billion. We used these for the lite and advanced scenario investments, and a midpoint for the medium scenario. The NREL Calculator also produces direct employment estimates for 2030, which align with this report's modeling.[34]

34 The NREL Calculator predicts a range of approximately 30,000 to 60,000 employees for the range of 112 to 227 gigawatt-hours/year volume of batteries repurposed.

Vehicle Manufacturing

As the vehicle manufacturing landscape changes, the auto industry, unions, and government must anticipate and prepare for changes so autoworkers can continue to have access to stable jobs with good pay and benefits.



OVERVIEW OF VEHICLE MANUFACTURING

Motor vehicles have been a foundation of the transportation economy for roughly a century. Autoworkers now build about 4 million passenger cars[35] each year in the United States, in addition to about 10 million trucks, vans, and SUVs. In 2022, there were 278 million personal and commercial vehicles registered in the United States, along with over 10 million heavy trucks[36] and about 184,000 buses. Micromobility, or transportation using lightweight vehicles such as bicycles or scooters, especially electric ones, is a growing vehicle market globally and in the United States. Across many types of vehicles, internal combustion engines are being replaced by electric motors, which brings its own uncertainty into the job market for auto vehicle and parts manufacturing. The question of whether the zero-carbon future tilts more toward buses, bikes, or private cars will influence the speed, equity, and other impacts of the transition as well as the balance of vehicle manufacturing jobs. However, whatever form the decarbonized future transportation system takes, vehicle manufacturing will continue to represent a core function of the system.

35 "Alternative Fuels Data Center, Maps and Data - Light-Duty Vehicles Produced in the United States," U.S. Department of Energy, accessed September 8, 2024. https://afdc.energy.gov/data.

36 "Number of U.S. Truck Registrations by Type," U.S. Department of Transportation, Bureau of Transportation Statistics, accessed September 8, 2024. https://www.bts.gov/browse-statistical-products-and-data/national-transportation-statistics/number-us-truck.

VEHICLE MANUFACTURING AND SUPPLY CHAIN JUSTICE

More than 1 million people in the United States rely directly on auto manufacturing jobs to earn their livelihoods. As the vehicle manufacturing landscape changes, the auto industry, unions, and government must anticipate and prepare for changes so autoworkers can continue to have access to stable jobs with good pay and benefits.

Companies can invest in diversified manufacturing to capture value and shift their workforce by expanding into micromobility and other low-carbon vehicle production and ensuring that any existing union contract extends to their new ventures and joint ventures; automakers such as Ford, Stellantis, General Motors, Mercedes, and BMW have already entered the e-bike market. There may also be opportunities to retrofit factories for manufacturing transit vehicles, EV charging equipment, as well as heat pumps or other clean energy technologies. Unfortunately, the auto industry has used the transition to EVs as an opportunity to divide and undermine its workers. Companies have structured EV production as joint ventures to position them outside of union contracts; they have expanded tiered pay systems that keep wages low for EV workers.[37] The government must support unions in their effort to end this practice.[38]

Federal, state, and local governments have begun sponsoring workforce training programs to equip workers with skills for careers in battery manufacturing, EV charger installation, and renewable energy, among others, and should ensure that these training programs are tied directly to job creation opportunities.

If current events and recent history serve as our guide, we can assume that auto companies will not always independently act in their workers' best interest. To maximize their own benefits during the transition, workers will need to seek out and seize opportunities for greater control. At a minimum level, unions can support worker training programs, as well as diversify their membership bases to include growth sectors. More substantially, unions can also pursue opportunities for greater worker control of company investments and strategic priorities in order to influence how these transitions unfold. To take this thought to its full conclusion: consider a worker-owned or state-owned company that could distribute more of its revenue back to workers. In 2023, Ford, General Motors, and Stellantis reported annual gross profits of $25.64 billion, $19.13 billion, and $41.28 billion, respectively. Redistributing some of these profits under a different ownership model could translate into more jobs, shorter work weeks, and higher wages under the same level of productivity. These management and ownership models warrant further research.

Greater worker control represents a chance to capture more value and shift production toward vehicles that will more likely lead to profitability in a post-carbon world. Worker management rights also represent an opportunity to operate in solidarity with people on the frontlines of the transportation supply chain. This could be one step to help facilitate a democratic planning process for the industrial transition in which workers and communities could collectively decide what these factories will produce. Such a process could even lead to a shift away from manufacturing private transportation and toward building more public transit and micromobility vehicles—a change that might give workers better job security while also

37 Chris Viola, "In UAW's Negotiations With the Big Three Automakers, Ending Tiers Is a Central Demand." Jacobin, August 17, 2023. https://jacobin.com/2023/08/uaw-general-motors-work-tiers-electric-vehicles-green-transition.

38 Keith Brower Brown & Sara Holiday Nelson (15 Oct 2023): Working sunset to sunrise: union strategies in three California climate transitions, Environmental Politics, DOI: 10.1080/09644016.2023.2265279. https://escholarship.org/content/qt0r10d65z/qt0r10d65z_noSplash_bab0b145aa858322b9e695ed5824eb0c.pdf?t=s2s6vx

improving outcomes across the supply chain. (Note the same argument can be made for workers in various nodes of the transportation system.)

From the perspective of climate justice, all EVs are not created equal. Even within a fully decarbonized system, the environmental and health benefits from an electric bus or an e-bike outweigh those from a private electric automobile. For example, traveling by transit is 10 times safer than traveling by car, and there are further health, social, and financial benefits associated with greater availability and access to public transit, from decreased social isolation and racial segregation within cities to lowered household financial burdens.[39] Though they still require minerals, battery electric buses require fewer minerals per passenger-mile than personal vehicles. Publicly owned car-share systems offer an additional way to reduce minerals per passenger-mile while also democratizing car ownership and mobility in situations where transit is not viable. The shift from private vehicles to shared mobility and active transportation vehicles will pay dividends in terms of reduced demand for minerals (and reduced mining impacts), improved public health, reduced injuries and fatalities, and transformed public spaces.

39 American Public Transportation Association, "The Hidden Traffic Safety Solution: Public Transportation." September 2016. https://www.apta.com/wp-content/uploads/Resources/resources/reportsandpublications/Documents/APTA-Hidden-Traffic-Safety-Solution-Public-Transportation.pdf.

JOBS POTENTIAL OF VEHICLE MANUFACTURING

Investments in electric bus and micromobility manufacturing have the potential to directly employ over 110,000 people in the year 2035, while reductions in car ownership could result in 298,000 fewer direct jobs in auto manufacturing. Notably, the advanced scenario would create over 250,000 new direct manufacturing jobs. The jobs to build transit vehicles and e-bikes will have a large overlap with auto manufacturing jobs, including factory work producing and assembling vehicle bodies and parts. As automotive technology shifts from internal combustion engines to electric motors and with the growth of vehicles' software capabilities and autonomous functions, there will be an increased emphasis on software developers and electrical and electronics engineers.[40] Battery production jobs are considered separately from vehicle manufacturing jobs for the sake of this report.

40 Javier Colato and Lindsey Ice, "Charging into the future: the transition to electric vehicles." Beyond the Numbers, February 2023. https://www.bls.gov/opub/btn/volume-12/charging-into-the-future-the-transition-to-electric-vehicles.htm.

Table 7: Investment Scenario Spending and Job Estimates, Vehicle Manufacturing Sectors, 2035

AUTO MANUFACTURING

SCENARIO	REDUCTION IN CAR OWNERSHIP	DIRECT JOBS	INDIRECT JOBS	INDUCED JOBS	TOTAL JOBS
Advanced	85 million fewer cars	-298,000	-671,901	-589,648	-1,559,548
Medium	53 million fewer cars	-186,000	-19,374	-368,035	-973,409
Lite	27 million fewer cars	-94,000	-211,942	-185,996	-491,938

Table 7: Investment Scenario Spending and Job Estimates, Vehicle Manufacturing Sectors, 2035 (cont'd)

ELECTRIC BUS MANUFACTURING

SCENARIO	INVESTMENT (ANNUAL)	DIRECT JOBS	INDIRECT JOBS	INDUCED JOBS	TOTAL JOBS
Advanced	$28.1 billion	69,126	92,449	96,945	261,330
Medium	$15.4 billion	37,884	50,666	53,130	143,220
Lite	$13.4 billion	32,964	44,086	46,230	124,620

MICROMOBILITY MANUFACTURING

SCENARIO	INVESTMENT (ANNUAL)	DIRECT JOBS	INDIRECT JOBS	INDUCED JOBS	TOTAL JOBS
Advanced	$32 billion	43,840	53,120	58,240	159,680
Medium	$24 billion	32,880	39,840	43,680	119,760
Lite	$16 billion	21,920	26,560	29,120	79,840

INVESTMENT SCENARIOS

To arrive at potential job losses within the auto manufacturing sector, we build on modeling from CCI's "Achieving Zero Emissions with More Mobility and Less Mining" report, which projects car ownership in three future transportation scenarios. The most advanced transit scenario in that report projects that by 2050 the United States could return to levels of car ownership equivalent to those seen in the 1960s. From these figures, we can project car sales in 2035. Looking at past economic downturns, we generated a ratio of auto manufacturing job losses to auto sales decrease of 0.92. In other words, when auto sales decreased, auto jobs decreased by a slightly lesser amount. Combining this information with today's ratio of car sales to car jobs, we project auto job losses.

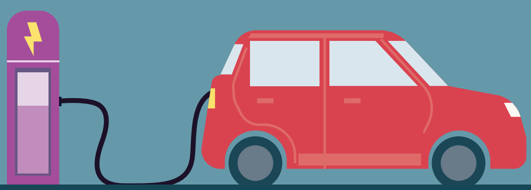
To project the cost of converting the existing bus fleet, we used projections from the Center for Transportation and the Environment[41] that peg investment at $7.4 billion per year to convert the fleet by 2035. "Achieving Zero Emissions with More Mobility and Less Mining" also projected new electric bus requirements under different transportation scenarios. We used this data, with an assumed cost of $800,000 per bus, to project the total investment needed for new buses. We assumed this cost would spread over 12 years to arrive at annual costs. Finally, the costs to convert the existing fleet and the cost to add new buses were combined for a total annual cost under three scenarios.

For projected micromobility investments, we looked at US market size projections for e-scooters and e-bikes for different years ranging from 2024 to 2035 and then averaged and extrapolated these to 2035.

41 Nathaniel Horadam and My Posner, "A Zero-Emission Transition for the U.S. Transit Fleet." Center for Transportation and the Environment, n.d. https://assets-global.website-files.com/65031a705b5de941f4c1c742/65e795a4c33026f8d520e203_ZE-Transition-for-US-Fleet-final-draft.pdfcom/65031a705b5de941f4c1c742/65e795a4c33026f8d520e203_ZE-Transition-for-US-Fleet-final-draft.pdf.

EV Charging Infrastructure

Charging infrastructure represents a key tool that can help enable a less mineral-intensive transportation future, because a comprehensive network of fast-charging stations can make smaller battery sizes possible by reducing range anxiety.



OVERVIEW OF EV CHARGING INFRASTRUCTURE

Although many early adopting EV owners rely on private charging infrastructure installed at their own homes, in order to accommodate a full range of drivers and circumstances, both rural and urban road networks will need to be dotted with public chargers. Estimates put the total number of public EV charging stations needed to support a fully electrified transportation system at anywhere from 500,000 to 1 million.

EV CHARGING INFRASTRUCTURE AND SUPPLY CHAIN JUSTICE

Charging infrastructure represents a key tool that can help enable a less mineral-intensive transportation future, because a comprehensive network of fast-charging stations can make smaller battery sizes possible by reducing range anxiety. CCI modeling found that increasing battery size from today's medium-size batteries to larger batteries could increase lithium demand by 56 percent, whereas reducing battery size from medium to small could reduce lithium demand by 29 percent. Beyond reducing battery sizes and mineral demand, an extensive fast-charging system will help democratize EV ownership. Today, many renters do not have the opportunity to be part of the EV transition because the charging infrastructure has not been built.

Table 8: Investment Scenario Spending and Job Estimates, EV Charging Infrastructure Sectors, 2035

SCENARIO	INVESTMENT (ANNUAL)	DIRECT JOBS	INDIRECT JOBS	INDUCED JOBS	TOTAL JOBS
Advanced	$8.7 billion	35,061	19,401	33,843	88,131
Medium	$6.3 billion	25,389	14,049	24,507	63,819
Lite	$3.9 billion	15,717	8,697	15,171	39,507

JOBS POTENTIAL OF EV CHARGING INFRASTRUCTURE

Investment in EV charging infrastructure production and installation has the potential to directly employ an additional 35,000 people in the year 2035. One study[42] estimates about half of EV charger jobs will go to electricians who will install and maintain the devices. The rest of the jobs will be divided among assembly, construction, software development, and planning.

INVESTMENT SCENARIOS

We based our lite scenario on an estimate for the investment needed to build out the full network of public chargers needed for full electrification by 2035. The advanced scenario used an estimate for the combined investment needed to complete the public and private charging networks. The medium scenario assumes an investment halfway between the lite and advanced scenarios.

42 Bui, et al. "Power play"

Public Transit

As of 2018, about 98 million US residents (about 30 percent) lived within the denser, urban core counties where transit could be transformed into a highly viable travel option.

OVERVIEW OF PUBLIC TRANSIT

Investment in transit is one of the most expeditious and cost-effective pathways to reducing transportation sector emissions.[43] Transit investments generally yield extensive benefits beyond climate and mobility—including public health, public safety, economic stimulus, and emissions reductions.[44] In spite of these facts, the United States has underinvested in this vital resource for decades.

The United States spends roughly $80 billion[45] on public transit each year, across 2,253 systems in 50 states.[46] (For comparison, the United States spends almost four times as much on roads and highways.) Only about one-third of these transit funds come from the federal government,[47] and urban areas with a population greater than 200,000 do not generally receive any federal

43 U.S. Department of Transportation, Federal Transit Administration, "Public Transportation's Role in Responding to Climate Change." January 2010. https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/PublicTransportationsRoleIn RespondingToClimateChange2010.pdf.

44 Christopher Ferrell, "The Benefits of Transit in the United States: A Review and Analysis of Benefit-Cost Studies." MINETA Transportation Institute, July 2015. https://transweb.sjsu.edu/research/Benefits-Transit-United-States-Review-and-Analysis-Benefit-Cost-Studies; American Public Transportation Institute, "Public Transit Is Key Strategy in Advancing Vision Zero, Eliminating Traffic Fatalities." August 2018. https://www.apta.com/wp-content/uploads/Resources/resources/hottopics/Documents/APTA%20VZN%20Transit%20Safety%20Brief%208.2018.pdf.

45 This includes capital and operating expenditures.

46 American Public Transportation Institute, "2022 Public Transportation Fact Book." January 2023. https://www.apta.com/wp-content/uploads/APTA-2022-Public-Transportation-Fact-Book.pdf

47 Nathan Musick, "Government Spending on Public Transportation and Other Infrastructure," presentation, National Tax Association's 52nd Annual Spring Symposium, Washington, D.C., May 12, 2022. https://www.cbo.gov/publication/58086.

operating support based on current formulas.[48]

Transit funding, service, and use varies widely across states and cities. New York is the only state that spends more on transit than on highways (about $1,212 per capita), while most other states spend less than 25 percent as much on transit as they do on highways. In 2021, states spent an average of only $272 per capita on transit.[49] Roughly 1 in 5 New York state residents report using transit to commute to work, but in most states, fewer than 1 in 40 commuters use transit.[50]

PUBLIC TRANSIT AND SUPPLY CHAIN JUSTICE

Effective public transit can reduce ETM demand by making it easier for people to choose not to own a car. As of 2018, about 98 million US residents (about 30 percent) lived within the denser, urban core counties[51] where transit could be transformed into a highly viable travel option. In addition to serving people who currently drive, better transit can also provide mobility and improve the quality of life for millions of people who cannot drive or do not have access to cars.

Approximately 8 percent of the population of the United States is transit dependent.[52] These 28 million people do not drive themselves anywhere but instead rely on public transit, rides from friends and family, biking, walking, or other forms of micromobility to get where they need to go. Households without access to a car are disproportionately home to people of color; about 18 percent of Black people living in the United States reside in households without a car compared with 4.6 percent of white people.[53]

Transit dollars must be spent carefully to maximize benefits. An influx in transit operations funding will be more likely to build lasting mode shift; reduce emissions; improve mobility; and create stable, family-sustaining union jobs if the funding goes to fixed-route and paratransit services—and not microtransit projects that give public dollars to corporations as part of a public-private partnership.[54]

JOBS POTENTIAL OF PUBLIC TRANSIT

Investments in public transit operations and infrastructure have the potential to directly employ an additional 1.2 million people in the year 2035. Transit operations funding creates jobs for bus drivers, vehicle mechanics, facilities custodians, accountants, secretaries, and transit planners. A substantial increase in public transit service will also require purchase

48 "Urbanized Area Formula Grants - 5307," U.S. Department of Transportation, Federal Transit Administration, accessed September 8, 2024. https://www.transit.dot.gov/funding/grants/urbanized-area-formula-grants-5307.

49 "Annual Survey of State and Local Government Finances, 2021 Tables" United States Census Bureau, accessed September 8, 2024, https://www.census.gov/programs-surveys/gov-finances.html

50 Commute Mode," U.S. Department of Transportation, Bureau of Transportation Statistics, accessed September 8, 2024, https://www.bts.gov/browse-statistical-products-and-data/state-transportation-statistics/commute-mode.

51 Kim Parker, Juliana Menasce Horowitz, Anna Brown, Richard Fry, D'Vera Cohn, and Ruth Igielnik, "What Unites and Divides Urban, Suburban and Rural Communities." Pew Research Center, May 22, 2018. https://www.pewresearch.org/social-trends/2018/05/22/demographic-and-economic-trends-in-urban-suburban-and-rural-communities.

52 Nuria Fernandez, "American Public Transportation Association (APTA) TransForm Conference 2022, Remarks of Acting Administrator Nuria Fernandez," speech, 2022 American Public Transportation Association Annual Conference, October 10, 2022. https://www.transit.dot.gov/about/speeches/2022-american-public-transportation-association-apta-annual-conference.

53 "Car Access," National Equity Atlas, accessed September 8, 2024, https://nationalequityatlas.org/indicators/Car_access.

54 Amalgamated Transit Union, "The False Promise of Microtransit." n.d. https://www.atu.org/pdfs/ATU_FalsePromiseofMicrotransit.pdf.

Table 9: Investment Scenario Spending and Job Estimates, Public Transit Sectors, 2035

PUBLIC TRANSIT (OPERATIONS)

SCENARIO	INVESTMENT (ANNUAL)	DIRECT JOBS	INDIRECT JOBS	INDUCED JOBS	TOTAL JOBS
Advanced	$75 billion	1,035,750	186,750	284,250	1,508,250
Medium	$50 billion	690,500	124,500	189,500	1,005,500
Lite	$20 billion	276,200	49,800	75,800	402,200

TRANSIT INFRASTRUCTURE (BUS RAPID TRANSIT AND LIGHT RAIL)

SCENARIO	INVESTMENT (ANNUAL)	DIRECT JOBS	INDIRECT JOBS	INDUCED JOBS	TOTAL JOBS
Advanced	$48 billion	263,520	132,480	204,960	600,960
Medium	$24 billion	131,760	66,240	102,480	300,480
Lite	$12 billion	65,880	33,120	51,240	150,240

of new vehicles and construction of new garages to store those vehicles when not in service; the siting of these new facilities will necessitate employment of local planners to ensure that agencies locate bus yards such that they do not harm low-income and Black and brown neighborhoods that, historically, have been excessively burdened with the negative community, health, and environmental impacts of urban development projects.

INVESTMENT SCENARIOS

Due to decades of underfunding, understaffing, and deferred maintenance, US public transit systems need a substantial increase in operational funding to reach an adequate baseline of service provision. In this modeling, even the lite scenario represents a significant increase from current funding levels.

For the transit operations funding lite scenario, we used $20 billion per year, which is the amount proposed in Representative Hank Johnson of Georgia's Stronger Communities Through Better Transit Act. This represents close to a 50 percent increase from current funding. Our medium scenario assumes $50 billion per year of new funding, an approximate doubling of current funding, or enough to bring every urban area with a population over 100,000 a level of service equivalent to that of New York City.[55] The advanced scenario assumes $75 billion new funds per year.

For transit Infrastructure (light rail and bus rapid transit) investments, we used the funding level proposed in the Bus Rapid Transit Act and the Light Rail Transit Act ($12 billion for each, or $24 billion total) for the medium scenario. The lite scenario assumes half that investment, and the advanced scenario assumes double that investment.

55 Yonah Freemark, "What Would Providing Every City with High-Quality, Zero-Emissions Public Transportation Look Like?" Urban Institute, November 23, 2020. https://www.urban.org/urban-wire/what-would-providing-every-city-high-quality-zero-emissions-public-transportation-look.

New Highway Construction & Highway Repair

New freeways do not save people time but do increase driving and carbon emissions.

OVERVIEW OF HIGHWAY CONSTRUCTION AND REPAIR

The National Highway System includes more than 220,000 miles of highway, which make up about 5 percent of the country's total public roads.[56] Texas (18,495) and California (14,573) have built by far the most highway miles. After the nation's early road network was built out, circa 1920, the total mileage held relatively steady until 1950, after which it then grew extensively from 1950 through 1980.[57] After that, the pace slowed, but the distance covered by highways has continued to grow steadily over the past decades.

Currently, about 367,580 people work in highway construction, and 150,860 people work in highway and road maintenance. Federal, state, and local governments collectively spend about $300 billion on highways, split roughly evenly between new construction and repair. The balance of investment between capital and maintenance proves difficult to maintain on an ever-expanding network. According to the American Society of Civil Engineers 2021 Report Card for America's Infrastructure, 43 percent of public roads are in poor or mediocre condition, and the nation has a $435 billion backlog of road maintenance.[58] Every year of delay further compounds the problem, straining local and state transportation budgets.

56 "Highway Statistics Series," U.S. Department of Transportation, Federal Highway Administration, Office of Policy & Governmental Affairs, accessed September 8, 2024, https://www.fhwa.dot.gov/policyinformation/statistics/2020/hm15.cfm

57 "Highway Statistics 2022," U.S. Department of Transportation, Office of Highway Policy Information, accessed September 8, 2024, https://www.fhwa.dot.gov/policyinformation/statistics/2022/vmt421c.cfm.

58 "2021 Report Card for America's Infrastructure, Roads," American Society of Civil Engineers, accessed September 8, 2024, https://infrastructurereportcard.org/cat-item/roads-infrastructure.

HIGHWAY CONSTRUCTION AND REPAIR AND SUPPLY CHAIN JUSTICE

Many highway expansion projects have been approved with the promise of relieving congestion to deliver shorter commute times and less wasted time in traffic, but studies consistently show that adding highway lanes does not reduce traffic or speed up travel times in the long run. Due to "induced demand," extra road capacity leads more people to drive until congestion levels return to their former intolerable levels. As such, new freeways do not save people time but do increase driving and carbon emissions. Highway expansion is also energy and resource intensive, with approximately 9 percent of global emissions coming from concrete production. Only by stopping highway expansion and providing comfortable, accessible, and expanded transit alternatives can the United States reduce its transportation emissions.

By perpetually investing in false solutions to reduce congestion, federal and state departments of transportation have been diverting resources from other viable transportation strategies that would benefit people who most need assistance, such as serious public transit, complete streets, and urban development that encourages comfortable and seamless travel without a car. The construction of freeways has also destroyed entire neighborhoods in many major cities, especially working-class neighborhoods and communities of color that have been targeted by decades of racist policies designed to drive out or segregate people of color.[59]

JOBS POTENTIAL OF HIGHWAY CONSTRUCTION AND REPAIR

Investments in road and highway maintenance have the potential to directly employ an additional 230,000 people in the year 2035, while a spending reduction in new highway construction could result in 370,000 fewer jobs. Although ending new highway construction would result in job losses, a greater number of comparable construction jobs would be created through investment in complete streets, rail, and transit infrastructure within the advanced scenario. The advanced scenario would create over 1.1 million new construction jobs.

INVESTMENT SCENARIOS

Given decades of overinvestment in highways, every scenario in this model assumes a decrease from current levels of new highway construction spending, with the exception of the status quo scenario. The advanced scenario eliminates all highway construction spending, a reduction of $150 billion. The same scenario, in turn, increases highway maintenance spending by $60 billion (40 percent of the $150 billion figure subtracted from new construction).

59 Farrell Evans, "How Interstate Highways Gutted Communities—and Reinforced Segregation." The History Channel, September 21, 2023. https://www.history.com/news/interstate-highway-system-infrastructure-construction-segregation; Noel King, "A Brief History Of How Racism Shaped Interstate Highways." NPR Morning Edition, April 7, 2021. https://www.npr.org/2021/04/07/984784455/a-brief-history-of-how-racism-shaped-interstate-highways.

Table 10: Investment Scenario Spending and Job Estimates, New Highway Construction and Highway Repair, 2035

NEW HIGHWAY CONSTRUCTION

SCENARIO	SPENDING REDUCTION	DIRECT JOBS	INDIRECT JOBS	INDUCED JOBS	TOTAL JOBS
Advanced	-$150 billion	-367,500	-318,000	-619,500	-1,305,000
Medium	-$75 billion	-183,750	-159,000	-309,750	-652,500
Lite	-$37 billion	-90,650	-78,440	-152,810	-321,900

HIGHWAY REPAIR

SCENARIO	INVESTMENT (ANNUAL)	DIRECT JOBS	INDIRECT JOBS	INDUCED JOBS	TOTAL JOBS
Advanced	$60 billion	229,200	185,400	211,800	630,000
Medium	$30 billion	114,600	92,700	105,900	315,000
Lite	$15 billion	57,300	46,350	52,950	157,500

The other scenarios reduce capital spending (new construction) by smaller amounts while keeping new operations spending (maintenance) pegged at 40 percent of the reduced capital spending. According to the Bureau of Transportation Statistics, in 2021, the federal government spent $56 billion on highways, while state and local governments spent $244 billion,[60] for a combined total of $300 billion. The balance between construction and maintenance spending has vacillated above and below 50 percent in recent years; we assumed 50 percent for this modeling to arrive at $150 billion total new highway construction spending that would be eliminated in the advanced scenario.

60 “Transportation Public Finance Statistics,” U.S. Department of Transportation, Bureau of Transportation Statistics, accesses September 8, 2024, https://data.bts.gov/stories/s/Transportation-Economic-Trends-Government-Transpor/hjpc-j5px.

Complete Streets

Along with road maintenance and repair, complete streets projects can provide an off-ramp for highway construction workers to transition to steady work in the low-carbon transportation economy.

OVERVIEW OF COMPLETE STREETS

According to Smart Growth America, complete streets represent "an approach to planning, designing, building, operating, and maintaining streets that enables safe access for all people who need to use them, including pedestrians, bicyclists, motorists and transit riders of all ages and abilities." Complete streets typically deemphasize cars by removing or narrowing lanes and often include features such as protected bike lanes, generous sidewalks, and crosswalks to make people traveling by other modes feel safe and comfortable. When paired with higher-density and mixed-use urban spaces, complete streets can make it much safer, more practical, and more enjoyable to live without a car.

COMPLETE STREETS AND SUPPLY CHAIN JUSTICE

For decades, people who are not in cars have been treated like second-class citizens by transportation planners and engineers. This problem of underinvestment in sidewalks and other pedestrian infrastructure has been even more pronounced in lower income, Black, brown and immigrant neighborhoods.[61] A slow transformation within the fields of transportation planning and engineering has assigned greater priority to the safety of pedestrians and bicyclists, but there is still a

61 Mozhgon Rajaee, Brenda Echeverri, Zachary Zuchowicz, Kristen Wiltfang, and Jennifer F. Lucarelli, "Socioeconomic and racial disparities of sidewalk quality in a traditional rust belt city." SSM Popul Health 16 (2021): 100975. doi: 10.1016/j.ssmph.2021.100975. PMID: 34917745; PMCID: PMC8666347; Emily Badger, "The inequality of sidewalks." The Washington Post, January 15, 2016. https://www.washingtonpost.com/news/wonk/wp/2016/01/15/the-inequality-of-sidewalks.

lot of work to be done. By making it easier to move around without a car, complete streets represent another example of an investment that has the potential to reduce car dependence and demand for transition minerals.

JOBS POTENTIAL OF COMPLETE STREETS

Investment in complete streets has the potential to directly employ an additional 170,000 people in the year 2035. Jobs designing and building complete streets closely resemble other road and highway construction jobs. Along with road maintenance and repair, complete streets projects can provide an off-ramp for highway construction workers to transition to steady work in the low-carbon transportation economy. Complete streets can sometimes differ from more traditional road construction projects in that they can include dynamic components that can be trialed and modified over time before permanent retrofit; this quality may spur full-time employment opportunities within a local government.

INVESTMENT SCENARIOS

The lite scenario assumes a $5 billion annual investment in complete streets, an increase from the $1 billion per year in the IIJA's "Safe Streets for All" program. The medium and advanced scenarios assume $20 billion and $35 billion annual investment, respectively. For reference, $30 billion is approximately 10 percent of US total highway and road spending.

Table 11: Investment Scenario Spending and Job Estimates, Complete Streets, 2035

SCENARIO	INVESTMENT (ANNUAL)	DIRECT JOBS	INDIRECT JOBS	INDUCED JOBS	TOTAL JOBS
Advanced	$35 billion	169,750	81,900	135,450	387,100
Medium	$20 billion	97,000	46,800	77,400	221,200
Lite	$5 billion	24,250	11,700	19,350	55,300

Rail

Given the fixed, linear layout of rail lines, the standard method for electrifying mainline rail throughout the world is catenary–or overhead wire–which avoids the need for large, mineral-intensive batteries.

OVERVIEW OF RAIL

Although trains arrived on the scene earlier than automobiles, in the evolution of dominant transportation technologies, the complex web of rail lines that used to cover much of the United States has shrunken to a faint whisper of its past self. For decades, the United States has fallen behind other high-income countries when it comes to investing in its rail infrastructure. Countries such as Australia, Austria, Germany, and Japan spend over 100 Euros per person on rail, whereas the United States spends about 25 Euros per person.[62] This ranks at the very bottom of G12 countries and is comparable to the spending level of countries like Belarus and Bulgaria.

In spite of this disparity, rail is on the rise in the United States, with ridership growing over the past decade.[63] Because of their climate benefits and resource-efficient method of transporting people and freight, trains are poised to continue their comeback. Internal combustion automobiles emit on average 0.47 pounds of carbon dioxide per passenger-mile (and much more for large trucks and SUVs) compared with 0.30 for passenger railroad and 0.17 for transit rail.[64] Modern high-speed rail moves people between 125 and 200 miles per hour, making it competitive with airplanes and cars for regional travel. Amtrak's Acela train connects Boston; New York City; Philadelphia; and Washington, D.C., at top speeds of 150 miles per hour, while Brightline's privately owned Florida train

62 "Infrastructure investment," Organisation for Economic Co-operation and Development, accessed September 8, 2024, https://www.oecd.org/en/data/indicators/infrastructure-investment.html#indicator-chart.

63 Environmental Law & Policy Center, "Passenger & Transit Rail Manufacturing in the U.S. 2024 Update" n.d. https://elpc.org/wp-content/uploads/2024/01/RailReport_ELPC_DRAFTv4.pdf.

64 "Emissions of Carbon Dioxide in the Transportation Sector," Congressional Budget Office, accessed September 8, 2024, https://www.cbo.gov/publication/58861.

reaches 125 miles per hour. New high speed rail projects are under construction in California and Nevada, although these and other planned routes still await full funding.

Looking beyond the headline-grabbing high speed rail projects, conventional intercity rail offers the more realistic option for large swaths of the country. It is quicker to introduce from an engineering perspective and is a better fit to integrate with the existing regional commuter rail and transit. Investment is needed for adding passenger service to existing tracks, adding additional trackage to facilitate more passenger or freight service, electrifying existing and future tracks, and constructing new cross-city infrastructure.

RAIL AND SUPPLY CHAIN JUSTICE

Because of the higher cost of building, operating, and maintaining rail, train tickets typically cost more than other forms of transit, making them less accessible for people with limited income. However, when integrated with bus and bike networks, trains make an essential component of low-carbon, low-mining transportation. Given the fixed, linear layout of rail lines, the standard method for electrifying mainline rail throughout the world is catenary—or overhead wire—which avoids the need for large, mineral-intensive batteries.[65]

The major Class I freight railroad companies pose a huge obstacle to justice for rail workers, passengers, and trackside communities. These companies essentially monopolize US rail freight, under a so-called "precision railroading" regime of running longer trains with fewer workers and serving only the most profitable routes. This practice degrades service, puts community and worker health at risk,[66] interferes with passenger service[67] — all while delivering the corporate shareholders maximum profits with minimal public oversight. Given this circumstance, states may benefit from purchasing rights-of-way from Class I railroad companies.[68] This would allow public funds to flow more easily toward freight rail infrastructure and remove freight railroads as obstacles to new passenger rail service. It would also help to minimize the need to establish new rail rights-of-way, which has historically been very hard on economically and politically disadvantaged communities in the U.S. A 2024 study found that a shift to public ownership of freight rail could reduce annual shipping costs by $400 billion, avert over $190 billion annually in public health, environmental, and fiscal costs, create 180 thousand new jobs in the railroad sector and avoid almost 5,000 million metric tons of greenhouse gas emissions.[69]

65 It is also possible to electrify urban bus routes without batteries, such as in the electric trolley buses operating as part of San Francisco's Muni transit system and in cities around the world; Peter Milson, "Overhead lines vs third rail: how does rail electrification work?" Railway Technology, September 13, 2023. https://www.railway-technology.com/features/overhead-lines-vs-third-rail-how-does-rail-electrification-work/?cf-view.

66 Topher Sanders, Jessica Lussenhop, Dan Schwartz, Danelle Morton and Gabriel Sandoval, "'Do Your Job.' How the Railroad Industry Intimidates Employees Into Putting Speed Before Safety." Pro Republica,
Nov. 15, 2023. https://www.propublica.org/article/railroad-safety-union-pacific-csx-bnsf-trains-freight.

67 Much of passenger rail service runs on track owned by the Class I railroads, and freight trains consistently cause passenger train delays despite federal rules that are not enforced. Stephen Coleman Kenny, "Off the rails: A call for freight railroad reform." Transportation for America, April 5, 2023. https://t4america.org/2023/04/05/off-the-rails-a-call-for-freight-railroad-reform.

68 Virginia Passenger Rail Authority, "Virginia and CSX Announce Landmark Rail Agreement." December 19, 2019. https://vapassengerrailauthority.org/virginia-and-csx-announce-landmark-rail-agreement.

69 Kira McDonald, "From Margins to Growth: The Economic Case for a Public Rail System." Rail Workers United. https://www.publicrailnow.org/research/economic-study/

Table 12: Investment Scenario Spending and Job Estimates, Rail, 2035

SCENARIO	INVESTMENT (ANNUAL)	DIRECT JOBS	INDIRECT JOBS	INDUCED JOBS	TOTAL JOBS
Advanced	$100 billion	494,000	299,000	413,000	1,211,000
Medium	$70 billion	345,800	209,300	89,100	847,700
Lite	$35 billion	172,900	104,650	144,550	423,850

JOBS POTENTIAL OF RAIL

Investment in passenger rail has the potential to directly employ an additional 490,000 people in the year 2035. Direct rail workers include those who operate and maintain the system, including train dispatchers, engineers, mechanics, inspectors, clerks and attendants, and signal people who install and maintain signal systems as well as those who build the vehicles and infrastructure that make train travel possible, like the machinists who manufacture trains and construction workers who build the tracks and bridges.

The US original equipment manufacturing supply chain currently creates a major choke point in rail expansion; the major suppliers might be able to invest in greater production with more certainty from the US government about long-term investment in rail. These supply chain workers represent the "indirect" jobs in this report's modeling. A 2013 analysis found more than 750 companies in at least 39 states manufacture the components for passenger rail and rail transit, and a 2024 follow-up reported 680,000 total employees working on the freight and passenger rail supply chain.[70]

INVESTMENT SCENARIOS

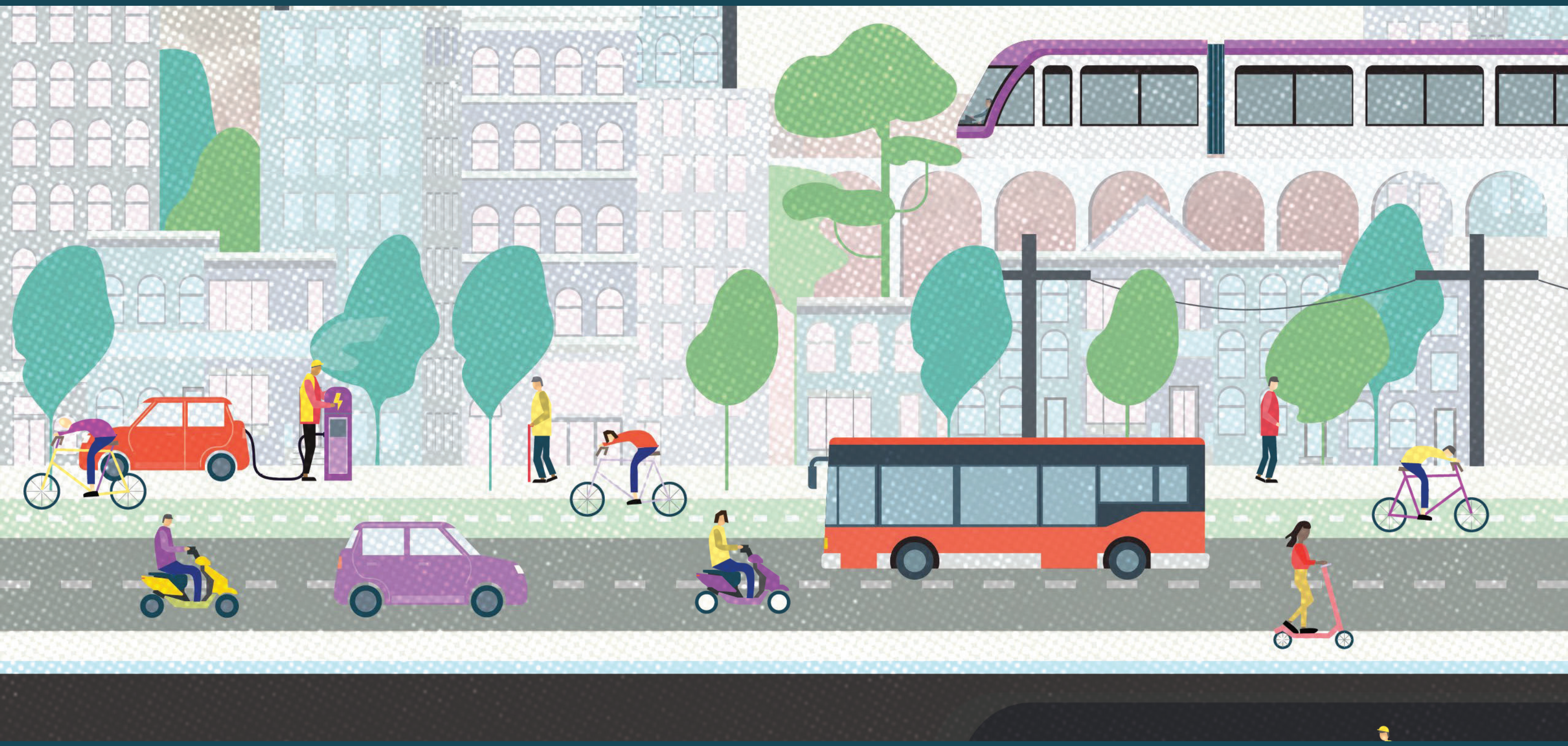
For the purpose of this study, we used a single rail investment figure, derived loosely from US high-speed rail proposals. However, as noted above, these dollars may be best spent on a combination of high-speed and conventional intercity rail and perhaps represent an undervaluing of the total funding needed to build out both types of rail network in the United States. The High Speed Rail Act, introduced in Congress in 2024, proposes investing $41 billion per year for five years, $35 billion of which would be designated for construction of rail corridors. We used this figure for our lite investment scenario. For the advanced scenario, we used $100 billion, as suggested by the US High Speed Rail Association. For the medium scenario, we used a midpoint between the high and low.

The modeling in this report focuses on direct investment in passenger rail infrastructure. However, as discussed above, improving freight rail is also a critical intervention that will allow passenger rail to succeed. The additional investment needed for freight rail—plus the ongoing funding of increased passenger rail operations—would add more jobs that are not included in these results.

70 John Paul Jewell and Zoe Lipman, "Passenger Rail & Transit Rail Manufacturing in the U.S." BlueGreen Alliance and Environmental Law & Policy Center, n.d. https://elpc.org/wp-content/uploads/2021/03/2015-ELPCPublication-PassengerRailTransitRailManufacturing_FINAL_web.pdf; Environmental Law & Policy Center, "Passenger & Transit 2024 Update"

Part 3

Conclusion



Climate Justice Alliance defines "just transition" as "a vision-led, unifying and place-based set of principles, processes, and practices that build economic and political power to shift from an extractive economy to a regenerative economy."[71] To accomplish this shift will require mitigating job losses that occur when industries currently dependent on fossil fuels become decarbonized. It will also require structuring new policies to correct and repair past or existing practices that have discriminated against or left behind people with disabilities; those who are of low income or working class; Black, Indigenous, and other people of color; and those of other marginalized groups.

The scenarios considered in this report indicate that a diversified US transportation system offers these two needed strategies: building new employment opportunities for people who may need to transition out of their jobs in auto manufacturing or highway construction while also investing in infrastructure and services to provide remediation for mining communities and mobility justice for people who have been left behind by the automobile era.

The modeling shows the potential to add more than 2 million net new jobs to the economy and provide off-ramps for highway construction workers and autoworkers whose jobs may be displaced during decarbonization. However, a just transition requires quality jobs—not just any job. For a just transition, any jobs created need to be high-pay jobs with good benefits, consistent schedules, and safe working conditions. To help ensure this future, the government can enforce and improve labor standards while also providing an essential safeguard by protecting workers' right to join or form a union. Through unions, workers can attain power to bargain for and enforce wages, working conditions, and benefits. They can also pursue opportunities for greater control of the companies' management decisions.

71 "Just Transition," Climate Justice Alliance, accessed September 9, 2024, https://climatejusticealliance.org/just-transition.

The federal government also bears responsibility to build greater support for transitioning workers, both in the form of worker training and job placement assistance programs but also as an employer of last resort. **At this time of unprecedented economic shifts, the social safety net is also more important than ever. Guaranteed housing, healthcare, basic income, employment, and childcare are all vital supports for workers in these transitioning sectors who may go through periods of intense economic uncertainty and unemployment.**

The jobs outlined in this report will only be created as a result of intentional policy decisions to direct investment in the directions and at the levels needed. The United States has two pathways ahead: It can choose the status quo—a transportation network dominated by large roads and heavy, private vehicles that perpetuate enormous mineral consumption and an underclass of people who do not drive or own a car. Or it can choose to shift investment to diversified transportation options that democratize mobility and reduce harmful extractive mining worldwide. An industrial policy that brings a greater level of government coordination and imagination to the transportation transition would include facilitating production and job creation within transit, rail, and micromobility—moving beyond the US government's current focus on incentivizing the development of a domestic EV supply chain.

Under the status quo scenario, the United States could theoretically decarbonize its transportation sector strictly through investment in battery technology and electrification of the current transportation system. This status quo strategy would create only 150,000 new jobs—less than 10 percent of the jobs forecasted in this report's advanced scenario. Under the status quo, not only will there be fewer jobs, but the approximately 30 percent of people who do not drive will be left with the same inadequate options for accessing important needs in their lives. Rural and Indigenous communities will bear the burden of a huge increase in mineral extraction, and the consequences will affect water, air, and soil for hundreds, if not thousands, of years.

The cumulative investments considered for the advanced scenario amount to a $274 billion annual investment. For comparison, President Joe Biden's 2025 budget request for the Department of Defense is $850 billion; the IIJA committed to $550 billion of new federal investments over 5 years; Congress has approved about $173 billion of aid to Ukraine over 2 years. Furthermore, the $274 billion in spending would likely yield hundreds of billions of dollars of public savings in terms of avoided healthcare costs, avoided traffic delays, and the reduction of other externalized costs currently borne by society. A recent study finds that the savings from rail reform and mode shift alone could amount to over $140 billion annually.[72] Notably, there are also foundational opportunities within these scenarios that are actually budget neutral. The model finds that simply shifting current highway construction spending to other sectors will increase transportation options and increase jobs—even construction jobs—without needing to authorize new funding.

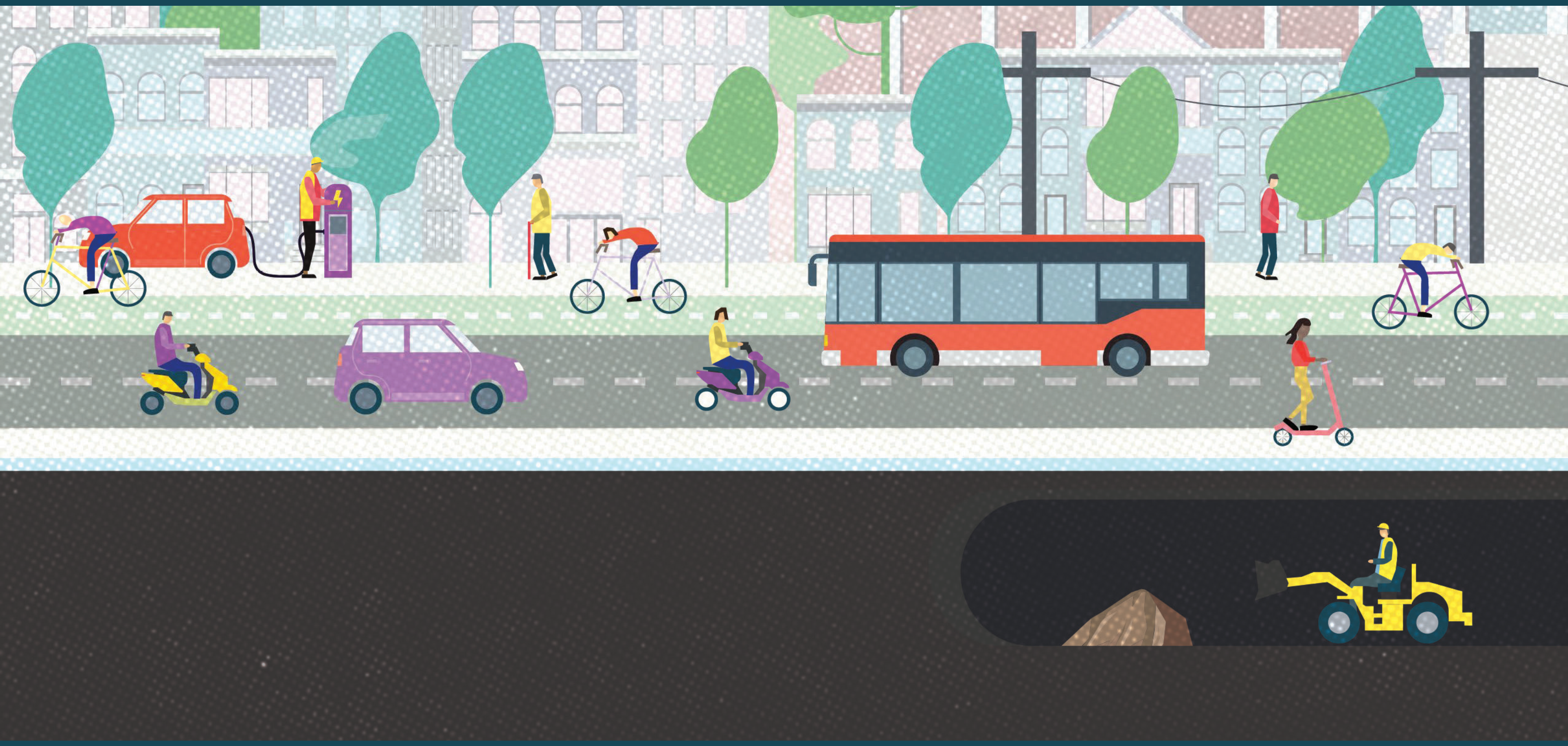
That said, there are benefits to be gained by investing in the entire package to trigger a system-wide transformation and stimulate maximum benefits—including maximum job creation. For example, the strong interconnectivity between safe streets for walking and bicycling, efficient and effective transit, and accessible micromobility vehicles means that investment in one of these areas promotes growth in the others. **If taken as a comprehensive strategy, these investments represent a once-in-a-generation opportunity for just transition within the transportation sector.** If the United States prioritizes mode shift and circular supply chains, then the decarbonization of travel can simultaneously improve the fate of rural mining communities and raise the equity of transportation, access, and opportunity for scores of people—all while creating millions of good jobs to help workers transition into the green economy.

72 Kira McDonald, "From Margins to Growth: The Economic Case for a Public Rail System." Rail Workers United. https://www.publicrailnow.org/research/economic-study/

"If taken as a comprehensive strategy, these investments represent a once-in-a-generation opportunity for just transition within the transportation sector."

Part 4

Appendix



IMPLAN Methodology

IMPLAN is an input-output model of the US economy that enables users to study the economic impacts of demand and spending changes. Input-output models capture linkages within the economy, including transactions between businesses (the purchase and sale of intermediate goods and services) and sales of final products to consumers (including households, businesses, government, and foreign purchasers).

By using an input-output model such as IMPLAN, we can evaluate the economy-wide effects of an increase in demand for an industry's output. For example, an increase in train transportation includes increased spending on railroad infrastructure construction, railroad stock manufacturing, and rail operations. This increased spending creates "direct" jobs in these three industries. Then, through the supply chain effects, indirect jobs are created in all the businesses that supply intermediate goods and services to those industries, in turn increasing spending and employment throughout the supply chain. And third, as workers in the direct and indirect industries spend their earnings, "induced" jobs are created in those industries where spending increases (including housing, education, food services, retail, and others).

Employment in most industries was estimated using the IMPLAN model with 2022 U.S. national data. Many of the sectors modeled include multiple industries within the model. For example, battery recycling (operations) is a composite of the following industries, weighted according to the percentages listed: wholesale of recyclable material and scrap material (20 percent); storage battery manufacturing (20 percent); other basic inorganic chemical manufacturing (40 percent); materials recovery facilities (10 percent); and hauling of recyclable materials and refuse (10 percent). To see the specific IMPLAN industry codes and weighted percentages used to estimate employment for each sector, see Table 5 below.

For each sector, we estimated direct, indirect, induced, and total employment per $1 million (in 2023 US dollars) and then applied these employment estimates to spending scenarios. These spending scenarios can be found in the body of the report. Discussion of the source data and rationale for each investment assumption can be found within the specific sector descriptions in the body of the report under the header "Breaking Down the Transportation Supply Chain."

After estimating direct, indirect, induced, and total jobs for each industry or set of industries, we sectorized the results in order to estimate the employment that would result in specific sectors, including "construction," "manufacturing," "services," "transportation," and "all other."

Within IMPLAN, "construction" industries are codes 50 to 62. "Manufacturing" includes codes 63 to 391. "Services" include codes 422 to 534. "Transportation" includes codes 414 to 421. "All other" includes codes 1 to 49, 392 to 413, and 535 to 546.

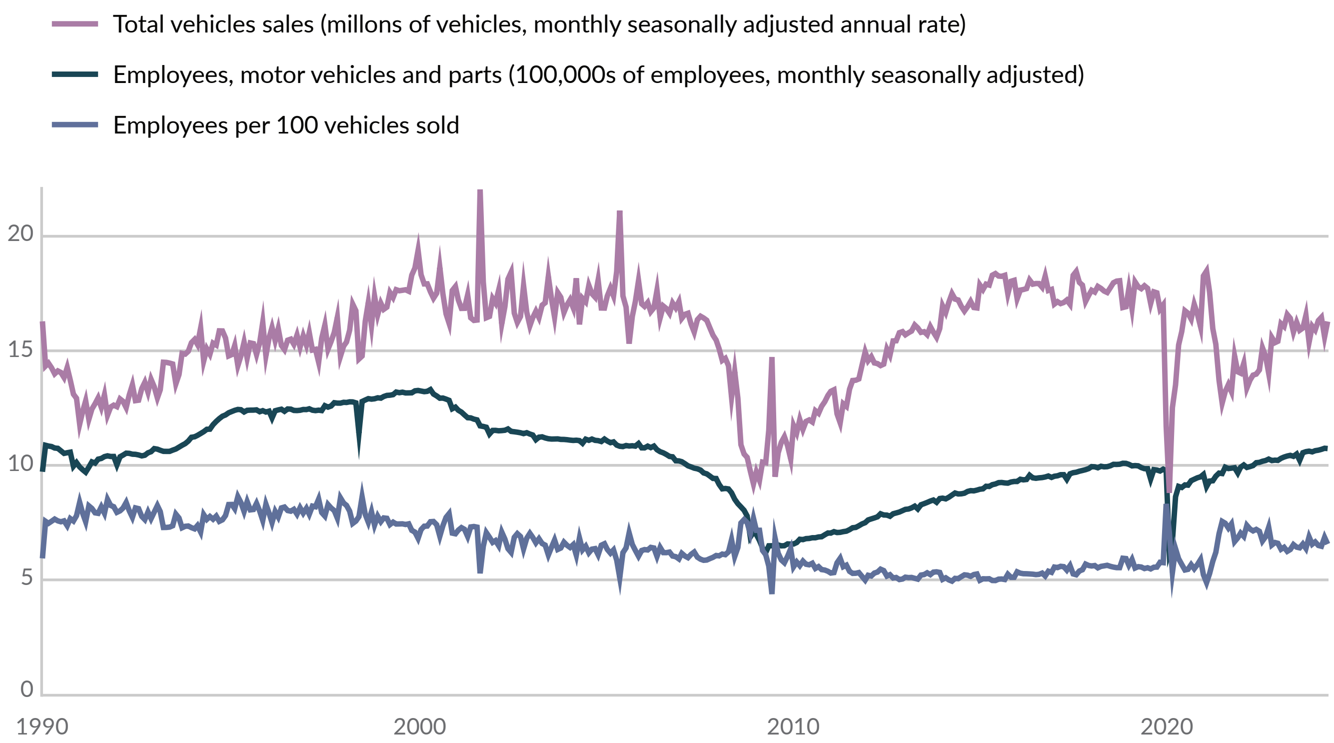
Additional Methodology Notes

AUTO MANUFACTURING

Auto manufacturing estimates were derived slightly differently than some of the other estimates in this study. To arrive at potential job losses within the auto manufacturing sector, we built on modeling from CCI's "Achieving Zero Emissions with More Mobility and Less Mining" report, which projects car ownership in three future transportation scenarios that adopt increasingly ambitious policies to support public and active transportation and reduced car dependency. From these figures, we can project car sales in 2035. Looking at data from past economic downturns, using evidence from times when auto sales declined to understand the impact on jobs, we generated a ratio of auto manufacturing job losses to an auto sales decrease of 0.92 to one. In other words, when auto sales decrease, auto jobs decrease by a slightly lesser amount. Combining this information with today's ratio of car sales to car jobs, we projected auto job losses out to 2035.

We then used a combination of IMPLAN industries to estimate indirect and induced jobs based on the level of direct jobs/$1 million.

Figure 15: Past Trends - Motor Vehicle Manufacturing Employment and Vehicles Sold, 1990 to 2024



To arrive at the indirect and induced multipliers, we calculated a weighted average based on the Bureau of Labor Statistics (BLS) 2023 employment data below:

- 336100 Motor Vehicle Manufacturing: 286,420
- 336200 Motor Vehicle Body and Trailer Manufacturing: 168,790
- 336300 Motor Vehicle Parts Manufacturing: 557,020

We applied the indirect/direct and induced/direct ratio to arrive at job losses beyond those in the direct industries for the spending scenarios.

Table 13: Auto Industry Job Multipliers

	Jobs per $1 million investment			
	Direct	Indirect	Induced	Total
Car manufacturing	0.69	3.51	2.72	6.92
Light truck and SUV manufacturing	0.63	3.86	2.77	7.26
Motor vehicle body manufacturing	2.66	3.71	3.71	10.08
Parts manufacturing	1.91	3.87	3.51	9.29
Average	1.47	3.74	3.18	8.39
Weighted average based on BLS employment in each industry	**1.68**	**3.79**	**3.33**	**8.80**

NEW HIGHWAY CONSTRUCTION

New highway construction estimates were also derived slightly differently than some of the other estimates in this study. We use current estimates of total U.S. employment in "Highway, Street, and Bridge Construction" (North American Industry Classification industry 237300) from the BLS 2023 National Industry-Specific Occupational and Wage Estimates. Employment in this industry totaled 367,580 in 2023.[1] We used spending estimates of total federal, state, and local new highway construction from a combination of sources, including the Bureau of Transportation Statistics, the Urban Institute, and the Congressional Budget Office.[2] Total spending in 2023 based on these three sources is about $150 billion. This yields a direct employment multiplier of 2.45 jobs/$1 million (367,580 jobs per $150 billion). We then use IMPLAN industry 54 (new highway construction) to estimate indirect and induced jobs based on this level of direct jobs/$1 million. We then applied these employment estimates to the spending scenarios.

1 "May 2023 National Industry-Specific Occupational Employment and Wage Estimates," U.S. Bureau of Labor Statistics, Occupational Employment and Wage Statistics, accessed September 9, 2024, https://www.bls.gov/oes/current/naics4_237300.htm.

2 "State and Local Backgrounders," Urban Institute, accessed September 9, 2024, https://www.urban.org/policy-centers/cross-center-initiatives/state-and-local-finance-initiative/state-and-local-backgrounders/highway-and-road-expenditures; Testimony on The Status of the Highway Trust Fund: 2023 Update, Before the Subcommittee on Highways and Transit Committee on Transportation and Infrastructure U.S. House of Representatives (2023) (statement of Chad Shirley, Principal Analyst, Microeconomic Studies Division). https://www.cbo.gov/publication/59667; "Transportation Public Finance Statistics (TPFS) Government Transportation Expenditures," Bureau of Transportation Statistics, Transportation Economic Trends, accessed September 9, 2024, https://data.bts.gov/stories/s/Transportation-Economic-Trends-Government-Transpor/hjpc-j5px.

Table 14: Industry Composition and IMPLAN Codes

Sector	Industry Composition	IMPLAN Industry Code	Percentage
Battery production			
	Storage battery manufacturing	333	100%
Battery recycling (operations)			
	Wholesale—other durable goods merchant wholesalers (wholesale of recyclable material and scrap material)	396	20%
	Storage battery manufacturing	333	20%
	Other basic inorganic chemical manufacturing	162	40%
	Waste management and remediation services (materials recovery facili-ties)	479	10%
	Truck transportation (hauling of recyclable materials and refuse)	417	10%
Battery recycling (construction)			
	Construction of new manufacturing structures	51	100%
Battery repurposing			
	Waste management and remediation services (materials recovery facilities)	479	60%
	Truck transportation (hauling of recyclable materials and refuse)	417	40%
Bus rapid transit and light rail			
	Construction of new highways and streets	54	40%
	Construction of other new nonresidential structures (rail infrastructure construction)	56	40%
	Heavy duty truck manufacturing (bus manufacturing)	342	10%
	Rail stock manufacturing	359	10%
Charging infrastructure			
	Architectural, engineering, and related services (electrical engineering)	457	10%
	Electric power transmission and distribution	47	10%
	Power, transmission, and specialty transformer manufacturing	329	10%
	All other miscellaneous electrical equipment and component manufacturing (battery charger manufacturing)	339	30%

Table 14: Industry Composition and IMPLAN Codes (cont'd)

Sector	Industry Composition	IMPLAN Industry Code	Percentage
	Construction of new power and communication structures	52	40%
Complete streets			
	Construction of highways and bridges	54	68%
	Cement manufacturing	203	6%
	Concrete pipe manufacturing	206	4%
	Cut stone and stone product manufacturing	211	4%
	Plastic pipe manufacturing	188	5%
	Lighting fixture manufacturing	323	5%
	Ferrous metal foundries	227	8%
Highway (new construction)			
	New construction of highways and bridges	54	100%
Highway (repair)			
	Maintenance and repair construction of highways, streets, bridges, and tunnels	62	100%
Micromobility			
	Motorcycle, bicycle, and parts manufacturing	362	100%
Mining remediation			
	Waste management and remediation services	479	70%
	Environmental and other technical consulting services	463	30%
Public transit			
	Transit and ground passenger transportation (transit operations)	418	60%
	Rail transportation (rail operations)	415	10%
	Heavy duty truck manufacturing (bus manufacturing)	342	10%
	Other motor vehicle parts manufacturing	352	10%
	Railroad rolling stock manufacturing	359	10%
Rail (emphasis on construction)			
	Construction of other new nonresidential structures	56	50%
	Maintenance and repair construction of nonresidential structures	60	25%

Table 14: Industry Composition and IMPLAN Codes (cont'd)

Sector	Industry Composition	IMPLAN Industry Code	Percentage
	Railroad rolling stock manufacturing	359	15%
	Rail transportation (rail operations)	415	10%
Electric bus			
	Motor vehicle body manufacturing	343	70%
	Motor and generator manufacturing	330	30%

Table 15: Multipliers for All Job Types, Combined

	Jobs per $1 million investment (using IMPLAN, 2022 national data)			
Sector	**Direct**	**Indirect**	**Induced**	**Total**
Battery production	2.29	2.15	2.9	7.42
Battery recycling (operations)	1.8	2.12	2.52	6.55
Battery recycling (construction)	6.8	2.4	4.66	13.94
Battery repurposing	3.91	3.16	3.76	10.81
Bus rapid transit and light rail	5.49	2.76	4.27	12.52
Charging infrastructure	4.03	2.23	3.89	10.13
Complete streets	4.85	2.34	3.87	11.06
Highway (new construction)	N/A	2.12	4.13	12.34
Highway (repair)	3.82	3.09	3.53	10.5
Micromobility	1.37	1.66	1.82	4.99
Mining remediation	4.15	2.86	4.11	11.16
Public transit	13.81	2.49	3.79	20.11
Rail	4.94	2.99	4.13	12.11
Electric bus	2.46	3.29	3.45	9.3
Auto manufacturing	N/A	3.79	3.33	8.8

Table 16: Multipliers for Construction Jobs

	Jobs per $1 million investment (using IMPLAN, 2022 national data)			
Sector	**Direct**	**Indirect**	**Induced**	**Total**
Battery production	0	0.03	0.02	0.05
Battery recycling (operations)	0	0.03	0.02	0.04
Battery recycling (construction)	6.8	0.01	0.04	6.85
Battery repurposing	0	0.02	0.02	0.04
Transit infrastructure (bus rapid transit and light rail)	5.14	0.01	0.03	5.19
Charging infrastructure	2.36	0.01	0.02	2.4
Complete streets	4.05	0.02	0.02	4.09
Highway (new construction)	N/A	0.01	0.02	6.01
Highway (repair)	3.82	0.02	0.02	3.86
Micromobility	0	0.01	0.02	0.03
Mining remediation	0	0.01	0.02	0.05
Public transit	0	0.03	0.02	0.05
Rail	4.43	0.02	0.02	4.48
Electric bus	0	0.02	0.02	0.04

Table 17: Multipliers for Manufacturing Jobs

	Jobs per $1 million investment (using IMPLAN, 2022 national data)			
Sector	**Direct**	**Indirect**	**Induced**	**Total**
Battery production	2.29	0.3	0.02	2.63
Battery recycling (operations)	0.85	0.19	0.02	1.07
Battery recycling (construction)	0	0.48	0.06	0.58
Battery repurposing	0	0.09	0.03	0.14
Transit infrastructure (bus rapid transit and light rail)	0.35	0.64	0.06	1.06
Charging infrastructure	1.1	0.33	0.05	1.49
Complete streets	0.8	0.41	0.05	1.24

Table 17: Multipliers for Manufacturing Jobs (cont'd)

Highway (new construction)	0	0.41	0.06	0.51
Highway (repair)	0	0.27	0.03	0.33
Micromobility	1.37	0.37	0.01	1.77
Mining remediation	0	0.1	0.06	0.16
Public transit	0.55	0.32	0.03	0.93
Rail	0.36	0.58	0.06	1.02
Electric bus	2.46	0.85	0.03	3.42

Table 18: Multipliers for Service Jobs

	Jobs per $1 million investment (using IMPLAN, 2022 national data)			
Sector	**Direct**	**Indirect**	**Induced**	**Total**
Battery production	0	1.06	2.22	3.32
Battery recycling (operations)	0.36	1.23	1.92	3.61
Battery recycling (construction)	0	1.28	3.56	4.85
Battery repurposing	2.14	2.19	2.87	7.18
Transit infrastructure (bus rapid transit and light rail)	0	1.29	3.22	4.5
Charging infrastructure	0.51	1.36	2.97	4.76
Complete streets	0	1.23	2.96	4.14
Highway (new construction)	0	1.09	3.15	4.27
Highway (repair)	0	1.39	2.7	4.1
Micromobility	0	0.75	1.39	2.27
Mining remediation	4.15	2.39	3.14	9.68
Public transit	0	1.63	2.9	4.52
Rail (emphasis on construction)	0	1.42	3.15	4.56
Electric bus	0	1.48	2.64	4.1

Table 19: Multipliers for Transportation Jobs

	Jobs per $1 Million Investment (using IMPLAN, 2022 national data)			
Sector	**Direct**	**Indirect**	**Induced**	**Total**
Battery production	0	0.28	0.12	0.4
Battery recycling (operations)	0.44	0.33	0.11	0.88
Battery recycling (construction)	0	0.26	0.19	0.46
Battery repurposing	1.77	0.58	0.16	2.52
Transit infrastructure (bus rapid transit and light rail)	0	0.27	0.19	0.48
Charging infrastructure	0	0.18	0.16	0.36
Complete streets	0	0.29	0.16	0.48
Highway (new construction)	0	0.25	0.18	0.43
Highway (repair)	0	0.2	0.16	0.37
Micromobility	0	0.19	0.08	0.27
Mining remediation	0	0.24	0.18	0.41
Public transit	13.26	0.22	0.16	13.65
Rail	0.15	0.31	0.18	0.66
Electric bus	0	0.32	0.15	0.47

Table 20: Multipliers for All Other Job Types

	Jobs per $1 Million Investment (using IMPLAN, 2022 national data)			
Sector	**Direct**	**Indirect**	**Induced**	**Total**
Battery production	0	0.48	0.52	1.02
Battery recycling (operations)	0.15	0.34	0.45	0.95
Battery recycling (construction)	0	0.37	0.81	1.2
Battery repurposing	0	0.28	0.68	0.93
Transit infrastructure (bus rapid transit and light rail)	0	0.55	0.77	1.29
Charging infrastructure	0.06	0.35	0.69	1.12
Complete streets	0	0.39	0.68	1.11

Table 20: Multipliers for All Other Job Types (cont'd)

Highway (new construction)	0	0.36	0.72	1.12
Highway (repair)	0	1.21	0.62	1.84
Micromobility	0	0.34	0.32	0.65
Mining remediation	0	0.12	0.71	0.86
Public transit	0	0.29	0.68	0.96
Rail	0	0.66	0.72	1.39
Electric bus	0	0.62	0.61	1.27

Table 21: Advanced Scenario Spending and Job Estimates, All Job Types, 2035

Sector	Investment (Annual)	Direct	Indirect	Induced	Total
Battery production	$5 billion	11,450	10,750	14,500	37,100
Battery recycling (operations)	$2 billion	3,600	4,240	5,040	13,100
Battery recycling (construction)	$5 billion	34,000	12,000	23,300	69,700
Battery repurposing	$18.3 billion	71,553	57,828	68,808	197,823
Transit infrastructure (bus rapid transit and light rail)	$48 billion	263,520	132,480	204,960	600,960
Charging infrastructure	$8.7 billion	35,061	19,401	33,843	88,131
Complete streets	$35 billion	169,750	81,900	135,450	387,100
Highway (new construction)	-$150 billion	-367,500	-318,000	-619,500	-1,305,000
Highway (repair)	$60 billion	229,200	185,400	211,800	630,000
Micromobility	$32 billion	43,840	53,120	58,240	159,680
Mining remediation	$12.5 billion	51,875	35,750	51,375	139,500
Public transit	$75 billion	1,035,750	186,750	284,250	1,508,250
Rail	$100 billion	494,000	299,000	413,000	1,211,000
Electric bus	$28.1 billion	69,126	92,449	96,945	261,330
Auto Manufacturing (job losses due to decreased car ownership)	NA	-298,000	-671,901	-589,648	-1,559,548
Total	**$280 billion**	**1,847,225**	**181,167**	**392,363**	**2,439,126**

Table 22: Medium Scenario Spending and Job Estimates, All Job Types, 2035

Sector	Investment (Annual)	Direct	Indirect	Induced	Total
Battery production	$10.4 billion	23,816	22,360	30,160	77,168
Battery recycling (operations)	$1.152 billion	2,074	2,442	2,903	7,546
Battery recycling (construction)	$2.88 billion	19,584	6,912	13,421	40,147
Battery repurposing	$13.5 billion	52,785	42,660	50,760	145,935
Transit infrastructure (bus rapid transit and light rail)	$24 billion	131,760	66,240	102,480	300,480
Charging infrastructure	$6.3 billion	25,389	14,049	24,507	63,819
Complete streets	$20 billion	97,000	46,800	77,400	221,200
Highway (new construction)	-$75 billion	-183,750	-159,000	-309,750	-652,500
Highway (repair)	$30 billion	114,600	92,700	105,900	315,000
Micromobility	$24 billion	32,880	39,840	43,680	119,760
Mining remediation	$6.5 billion	26,975	18,590	26,715	72,540
Public transit	$50 billion	690,500	124,500	189,500	1,005,500
Rail	$70 billion	345,800	209,300	289,100	847,700
Electric bus	$15.4 billion	37,884	50,666	53,130	143,220
Auto Manufacturing (job losses due to decreased car ownership)	NA	-186,000	-419,374	-368,035	-973,409
Total	**$199 billion**	**1,231,297**	**158,685**	**331,871**	**1,734,105**

Table 23: Lite Scenario Spending and Job Estimates, All Job Types, 2035

Sector	Investment (Annual)	Direct	Indirect	Induced	Total
Battery production	$20 billion	45,800	43,000	58,000	148,400
Battery recycling (operations)	$292 million	526	619	736	1,913
Battery recycling (construction)	$730 million	4,964	1,752	3,402	10,176
Battery repurposing	$8.7 billion	34,017	27,492	32,712	94,047
Transit infrastructure (bus rapid transit and light rail)	$12 billion	65,880	33,120	51,240	150,240
Charging infrastructure	$3.9 billion	15,717	8,697	15,171	39,507
Complete streets	$5 billion	24,250	11,700	19,350	55,300
Highway (new construction)	-$37 billion	-90,650	-78,440	-152,810	-321,900

Table 23: Lite Scenario Spending and Job Estimates, All Job Types, 2035 (cont'd)

Highway (repair)	$15 billion	57,300	46,350	52,950	157,500
Micromobility	$16 billion	21,920	26,560	29,120	79,840
Mining remediation	$850 million	3,528	2,431	3,494	9,486
Public transit	$20 billion	276,200	49,800	75,800	402,200
Rail	$35 billion	172,900	104,650	144,550	423,850
Electric bus	$13.4 billion	32,964	44,086	46,230	124,620
Auto Manufacturing (job losses due to decreased car ownership)	NA	-94,000	-211,942	-185,996	-491,938
Total	**$114 billion**	**571,315**	**109,875**	**193,948**	**883,241**

Table 24: Status Quo Scenario Spending and Job Estimates, All Job Types, 2035

Sector	Investment (Annual)	Direct	Indirect	Induced	Total
Battery production	$20 billion	45,800	43,000	58,000	148,400
Battery recycling (operations)	$1 billion	1,800	2,120	2,520	6,550
Battery recycling (construction)	$2.5 billion	17,000	6,000	11,650	34,850
Battery repurposing	$1 billion	3,910	3,160	3,760	10,810
Transit infrastructure (bus rapid transit and light rail)	0	0	0	0	0
Charging infrastructure	$6.3 billion	25,389	14,049	24,507	63,819
Complete streets	0	0	0	0	0
Highway (new construction)	0	0	0	0	0
Highway (repair)	0	0	0	0	0
Micromobility	$16 billion	21,920	26,560	29,120	79,840
Mining remediation	0	0	0	0	0
Public transit	0	0	0	0	0
Rail	0	0	0	0	0
Electric bus	$13.4 billion	32,964	44,086	46,230	124,620
Auto Manufacturing (job losses due to decreased car ownership)	NA	0	0	0	0
Total	**$60.2 billion**	**148,783**	**138,975**	**175,787**	**468,889**

Table 25: Advanced Scenario Spending and Job Estimates, Construction Jobs Only, 2035

Sector	Direct	Indirect	Induced	Total
Battery production	0	150	100	250
Battery recycling (operations)	0	60	40	80
Battery recycling (construction)	34,000	50	200	34,250
Battery repurposing	0	366	366	732
Transit infrastructure (bus rapid transit and light rail)	246,720	480	1,440	249,120
Charging infrastructure	20,532	87	174	20,880
Complete streets	141,750	700	700	143,150
Highway (new construction)	-367,500	-1,500	-3,000	-372,000
Highway (repair)	229,200	1,200	1,200	231,600
Micromobility	0	320	640	960
Mining remediation	0	125	250	625
Public transit	0	2,250	1,500	3,750
Rail	443,000	2,000	2,000	448,000
Electric bus	0	562	562	1,124
Auto Manufacturing (job losses due to decreased car ownership)	0	0	0	0
Total	**747,702**	**6,850**	**6,172**	**762,521**

Table 26: Medium Scenario Spending and Job Estimates, Construction Jobs Only, 2035

Sector	Direct	Indirect	Induced	Total
Battery production	0	312	208	520
Battery recycling (operations)	0	35	23	46
Battery recycling (construction)	19,584	29	115	19,728
Battery repurposing	0	270	270	540
Transit infrastructure (bus rapid transit and light rail)	123,360	240	720	124,560
Charging infrastructure	14,868	63	126	15,120
Complete streets	81,000	400	400	81,800
Highway (new construction)	-183,750	-750	-1,500	-186,000
Highway (repair)	114,600	600	600	115,800

Table 26: Medium Scenario Spending and Job Estimates, Construction Jobs Only, 2035 (cont'd)

Micromobility	0	240	480	720
Mining remediation	0	65	130	325
Public transit	0	1,500	1,000	2,500
Rail	310,100	1,400	1,400	313,600
Electric bus	0	308	308	616
Auto Manufacturing (job losses due to decreased car ownership)	0	0	0	0
Total	**479,762**	**4,711**	**4,280**	**489,875**

Table 27 Lite Scenario Spending and Job Estimates, Construction Jobs Only, 2035

Sector	Direct	Indirect	Induced	Total
Battery production	0	600	400	1,000
Battery recycling (operations)	0	9	6	12
Battery recycling (construction)	4,964	7	29	5,001
Battery repurposing	0	174	174	348
Transit infrastructure (bus rapid transit and light rail)	61,680	120	360	62,280
Charging infrastructure	9,204	39	78	9,360
Complete streets	20,250	100	100	20,450
Highway (new construction)	-90,650	-370	-740	-91,760
Highway (repair)	57,300	300	300	57,900
Micromobility	0	160	320	480
Mining remediation	0	9	17	43
Public transit	0	600	400	1,000
Rail	155,050	700	700	156,800
Electric bus	0	268	268	536
Auto Manufacturing (job losses due to decreased car ownership)	0	0	0	0
Total	**189,088**	**3,076**	**2,852**	**194,959**

Table 28: Advanced Scenario Spending and Job Estimates, Manufacturing Jobs Only, 2035

Sector	Direct	Indirect	Induced	Total
Battery production	11,450	1,500	100	13,150
Battery recycling (operations)	1,700	380	40	2,140
Battery recycling (construction)	0	2,400	300	2,900
Battery repurposing	0	1,647	549	2,562
Transit infrastructure (bus rapid transit and light rail)	16,800	30,720	2,880	50,880
Charging infrastructure	9,570	2,871	435	12,963
Complete streets	28,000	14,350	1,750	43,400
Highway (new construction)	0	-61,500	-9,000	-70,500
Highway (repair)	0	16,200	1,800	19,800
Micromobility	43,840	11,840	320	56,640
Mining remediation	0	1,250	750	2,000
Public transit	41,250	24,000	2,250	69,750
Rail	36,000	58,000	6,000	102,000
Electric bus	69,126	23,885	843	96,102
Auto Manufacturing (job losses due to decreased car ownership)	-298,000	-205,148	-4,803	-507,951
Total	**-40,264**	**-77,605**	**4,214**	**-104,164**

Table 29: Medium Scenario Spending and Job Estimates, Manufacturing Jobs Only, 2035

Sector	Direct	Indirect	Induced	Total
Battery production	23,816	3,120	208	27,352
Battery recycling (operations)	979	219	23	1,233
Battery recycling (construction)	0	1,382	173	1,670
Battery repurposing	0	1,215	405	1,890
Transit infrastructure (bus rapid transit and light rail)	8,400	15,360	1,440	25,440
Charging infrastructure	6,930	2,079	315	9,387
Complete streets	16,000	8,200	1,000	24,800
Highway (new construction)	0	-30,750	-4,500	-35,250
Highway (repair)	0	8,100	900	9,900

Table 29: Medium Scenario Spending and Job Estimates, Construction Jobs Only, 2035 (cont'd)

Micromobility	32,880	8,880	240	42,480
Mining remediation	0	650	390	1,040
Public transit	27,500	16,000	1,500	46,500
Rail	25,200	40,600	4,200	71,400
Electric bus	37,884	13,090	462	52,668
Auto Manufacturing (job losses due to decreased car ownership)	-186,000	-128,045	-2,998	-317,043
Total	**-6,411**	**-39,900**	**3,758**	**-36,533**

Table 30: Lite Scenario Spending and Job Estimates, Manufacturing Jobs Only, 2035

Sector	Direct	Indirect	Induced	Total
Battery production	45,800	6,000	400	52,600
Battery recycling (operations)	248	55	6	312
Battery recycling (construction)	0	350	44	423
Battery repurposing	0	783	261	1,218
Transit infrastructure (bus rapid transit and light rail)	4,200	7,680	720	12,720
Charging infrastructure	4,290	1,287	195	5,811
Complete streets	4,000	2,050	250	6,200
Highway (new construction)	0	-15,170	-2,220	-17,390
Highway (repair)	0	4,050	450	4,950
Micromobility	21,920	5,920	160	28,320
Mining remediation	0	85	51	136
Public transit	11,000	6,400	600	18,600
Rail	12,600	20,300	2,100	35,700
Electric bus	32,964	11,390	402	45,828
Auto Manufacturing (job losses due to decreased car ownership)	-94,000	-64,711	-1,515	-160,226
Total	**137,022**	**58,241**	**4,319**	**35,203**

Table 31: Advanced Scenario Spending and Job Estimates, Service Jobs Only, 2035

Sector	Direct	Indirect	Induced	Total
Battery production	0	5,300	11,100	16,600
Battery recycling (operations)	720	2,460	3,840	7,220
Battery recycling (construction)	0	6,400	17,800	24,250
Battery repurposing	39,162	40,077	52,521	131,394
Transit infrastructure (bus rapid transit and light rail)	0	61,920	154,560	216,000
Charging infrastructure	4,437	11,832	25,839	41,412
Complete streets	0	43,050	103,600	144,900
Highway (new construction)	0	-163,500	-472,500	-636,000
Highway (repair)	0	83,400	162,000	246,000
Micromobility	0	24,000	44,480	72,640
Mining remediation	51,875	29,875	39,250	121,000
Public transit	0	122,250	217,500	339,000
Rail	0	142,000	315,000	456,000
Electric bus	0	41,588	74,184	115,210
Auto Manufacturing (job losses due to decreased car ownership)	0	0	0	0
Total	**96,194**	**450,652**	**749,174**	**1,295,626**

Table 32: Medium Scenario Spending and Job Estimates, Service Jobs Only, 2035

Sector	Direct	Indirect	Induced	Total
Battery production	0	11,024	23,088	34,528
Battery recycling (operations)	415	1,417	2,212	4,159
Battery recycling (construction)	0	3,686	10,253	13,968
Battery repurposing	28,890	29,565	38,745	96,930
Transit infrastructure (bus rapid transit and light rail)	0	30,960	77,280	108,000
Charging infrastructure	3,213	8,568	18,711	29,988
Complete streets	0	24,600	59,200	82,800
Highway (new construction)	0	-81,750	-236,250	-318,000
Highway (repair)	0	41,700	81,000	123,000

Table 32: Medium Scenario Spending and Job Estimates, Service Jobs Only, 2035 (cont'd)

Micromobility	0	18,000	33,360	54,480
Mining remediation	26,975	15,535	20,410	62,920
Public transit	0	81,500	145,000	226,000
Rail	0	99,400	220,500	319,200
Electric bus	0	22,792	40,656	63,140
Auto Manufacturing (job losses due to decreased car ownership)	0	0	0	0
Total	**59,493**	**306,997**	**534,165**	**901,113**

Table 33: Lite Scenario Spending and Job Estimates, Service Jobs Only, 2035

Sector	Direct	Indirect	Induced	Total
Battery production	0	21,200	44,400	66,400
Battery recycling (operations)	105	359	561	1,054
Battery recycling (construction)	0	934	2,599	3,541
Battery repurposing	18,618	19,053	24,969	62,466
Transit infrastructure (bus rapid transit and light rail)	0	15,480	38,640	54,000
Charging infrastructure	1,989	5,304	11,583	18,564
Complete streets	0	6,150	14,800	20,700
Highway (new construction)	0	-40,330	-116,550	-156,880
Highway (repair)	0	20,850	40,500	61,500
Micromobility	0	12,000	22,240	36,320
Mining remediation	3,528	2,032	2,669	8,228
Public transit	0	32,600	58,000	90,400
Rail	0	49,700	110,250	159,600
Electric bus	0	19,832	35,376	54,940
Auto Manufacturing (job losses due to decreased car ownership)	0	0	0	0
Total	**24,240**	**193,344**	**353,036**	**571,283**

Table 34: Advanced Scenario Spending and Job Estimates, Transportation Jobs Only, 2035

Sector	Direct	Indirect	Induced	Total
Battery production	0	1,400	600	2,000
Battery recycling (operations)	880	660	220	1,760
Battery recycling (construction)	0	1,300	950	2,300
Battery repurposing	32,391	10,614	2,928	46,116
Transit infrastructure (bus rapid transit and light rail)	0	12,960	9,120	23,040
Charging infrastructure	0	1,566	1,392	3,132
Complete streets	0	10,150	5,600	16,800
Highway (new construction)	0	-37,500	-27,000	-64,500
Highway (repair)	0	12,000	9,600	22,200
Micromobility	0	6,080	2,560	8,640
Mining remediation	0	3,000	2,250	5,125
Public transit	994,500	16,500	12,000	1,023,750
Rail	15,000	31,000	18,000	66,000
Electric bus	0	8,992	4,215	13,207
Auto Manufacturing (job losses due to decreased car ownership)	0	0	0	0
Total	**1,042,771**	**78,722**	**42,435**	**1,169,570**

Table 35: Medium Scenario Spending and Job Estimates, Transportation Jobs Only, 2035

Sector	Direct	Indirect	Induced	Total
Battery production	0	2,912	1,248	4,160
Battery recycling (operations)	507	380	127	1,014
Battery recycling (construction)	0	749	547	1,325
Battery repurposing	23,895	7,830	2,160	34,020
Transit infrastructure (bus rapid transit and light rail)	0	6,480	4,560	11,520
Charging infrastructure	0	1,134	1,008	2,268
Complete streets	0	5,800	3,200	9,600
Highway (new construction)	0	-18,750	-13,500	-32,250
Highway (repair)	0	6,000	4,800	11,100

Table 35: Medium Scenario Spending and Job Estimates, Transportation Jobs Only, 2035 (cont'd)

Micromobility	0	4,560	1,920	6,480
Mining remediation	0	1,560	1,170	2,665
Public transit	663,000	11,000	8,000	682,500
Rail	10,500	21,700	12,600	46,200
Electric bus	0	4,928	2,310	7,238
Auto Manufacturing (job losses due to decreased car ownership)	0	0	0	0
Total	**697,902**	**56,283**	**30,150**	**787,840**

Table 36: Lite Scenario Spending and Job Estimates, Transportation Jobs Only, 2035

Sector	Direct	Indirect	Induced	Total
Battery production	0	5,600	2,400	8,000
Battery recycling (operations)	128	96	32	257
Battery recycling (construction)	0	190	139	336
Battery repurposing	15,399	5,046	1,392	21,924
Transit infrastructure (bus rapid transit and light rail)	0	3,240	2,280	5,760
Charging infrastructure	0	702	624	1,404
Complete streets	0	1,450	800	2,400
Highway (new construction)	0	-9,250	-6,660	-15,910
Highway (repair)	0	3,000	2,400	5,550
Micromobility	0	3,040	1,280	4,320
Mining remediation	0	204	153	349
Public transit	265,200	4,400	3,200	273,000
Rail	5,250	10,850	6,300	23,100
Electric bus	0	4,288	2,010	6,298
Auto Manufacturing (job losses due to decreased car ownership)	0	0	0	0
Total	**285,977**	**37,656**	**20,030**	**345,407**

Table 37: Advanced Scenario Spending and Job Estimates, All Other Job Types, 2035

Sector	Direct	Indirect	Induced	Total
Battery production	0	2,400	2,600	5,100
Battery recycling (operations)	300	680	900	1,900
Battery recycling (construction)	0	1,850	4,050	6,000
Battery repurposing	0	5,124	12,444	17,019
Transit infrastructure (bus rapid transit and light rail)	0	26,400	36,960	61,920
Charging infrastructure	522	3,045	6,003	9,744
Complete streets	0	13,650	23,800	38,850
Highway (new construction)	0	-54,000	-108,000	-162,000
Highway (repair)	0	72,600	37,200	110,400
Micromobility	0	10,880	10,240	20,800
Mining remediation	0	1,500	8,875	10,750
Public transit	0	21,750	51,000	72,000
Rail	0	66,000	72,000	139,000
Electric bus	0	17,422	17,141	35,687
Auto Manufacturing (job losses due to decreased car ownership)	0	0	0v	0
Total	**822**	**189,301**	**175,213**	**367,170**

Table 38: Medium Scenario Spending and Job Estimates, All Other Job Types, 2035

Sector	Direct	Indirect	Induced	Total
Battery production	0	4,992	5,408	10,608
Battery recycling (operations)	173	392	518	1,094
Battery recycling (construction)	0	1,066	2,333	3,456
Battery repurposing	0	3,780	9,180	12,555
Transit infrastructure (bus rapid transit and light rail)	0	13,200	18,480	30,960
Charging infrastructure	378	2,205	4,347	7,056
Complete streets	0	7,800	13,600	22,200
Highway (new construction)	0	-27,000	-54,000	-81,000
Highway (repair)	0	36,300	18,600	55,200

Table 38: Medium Scenario Spending and Job Estimates, All Other Job Types, 2035 (cont'd)

Micromobility	0	8,160	7,680	15,600
Mining remediation	0	780	4,615	5,590
Public transit	0	14,500	34,000	48,000
Rail	0	46,200	50,400	97,300
Electric bus	0	9,548	9,394	19,558
Auto Manufacturing (job losses due to decreased car ownership)	0	0	0	0
Total	**551**	**121,922**	**124,555**	**248,177**

Table 39: Lite Scenario Spending and Job Estimates, All Other Job Types, 2035

Sector	Direct	Indirect	Induced	Total
Battery production	0	9,600	10,400	20,400
Battery recycling (operations)	44	99	131	277
Battery recycling (construction)	0	270	591	876
Battery repurposing	0	2,436	5,916	8,091
Transit infrastructure (bus rapid transit and light rail)	0	6,600	9,240	15,480
Charging infrastructure	234	1,365	2,691	4,368
Complete streets	0	1,950	3,400	5,550
Highway (new construction)	0	-13,320	-26,640	-39,960
Highway (repair)	0	18,150	9,300	27,600
Micromobility	0	5,440	5,120	10,400
Mining remediation	0	102	604	731
Public transit	0	5,800	13,600	19,200
Rail	0	23,100	25,200	48,650
Electric bus	0	8,308	8,174	17,018
Auto Manufacturing (job losses due to decreased car ownership)	0	0	0	0
Total	**278**	**89,720**	**82,167**	**171,921**