SAFE

The Commanding Heights of Global Transportation

Quantifying the Employment Effects

March 2021

Executive Summary

The COVID-19 pandemic has caused a deep global economic recession and highlighted a major vulnerability in the U.S. economy: an overreliance on China for critical goods. As the world undergoes one of the most important shifts in people and goods since the invention of the automobile, China is harnessing technologies and supply chains to make itself the global leader of the automotive and transportation industries of the future. The result is an historic challenge but also an opportunity for the U.S. economy and American business.

The auto industry has a long history of supporting economic stability and innovation in the United States, so China's recent dominance in this industry threatens U.S. economic and national security interests. The United States needs a long-term, comprehensive strategy to ensure that it maintains the vibrancy and efficacy of its essential manufacturing sector. The United States should not swap dependence on unstable oil markets today for a similarly tenuous reliance on China for its transportation needs tomorrow.

647,000

total jobs created and sustained over the next 1 to 5 years

3.1 million

total job-years created

SAFE's Commanding Heights of Global Transportation plan proposes to **invest in the technologies of the future – transportation, energy, and communications – to combat Chinese ambitions, ensure supply chain resilience**, **and protect and expand the U.S. manufacturing sector**. This report is intended to complement the Commanding Heights strategic report with an economic assessment focused on the job impacts of various proposals.

The nine policy proposals modeled – ranging from regulatory reform to tax incentives to new government investment in vehicles – would create or support more than **3.1 million additional job-years**, or **647,000 jobs** sustained over the next 1-5 years (depending on the model), including 198,000 direct jobs and 382,000 supported (indirect and induced) jobs.*

Investment in ***transportation manufacturing grants and tax incentives*** leads to more than **270,000 jobs** sustained over the next 1-5 years, or 1.3 million job-years. These incentives would lead to the construction or retooling of 13 facilities in areas hit hard by the pandemic-induced recession. The refitted factories would provide thousands of permanent manufacturing jobs in technologies like electric vehicle production.

154,000

jobs created through electric truck and bus incentives and sustained over 1-5 years

270,000

jobs created through EV manufacturing incentives and sustained over 1-5 years

Incentives that make it cheaper to buy ***medium- and heavy-duty electric vehicles***, like trucks and buses, would create nearly **154,000 jobs** sustained over the next 1-5 years, or 752,000 job-years. These incentives would make it easier for companies to invest in electric delivery trucks, help cities and towns pay for electric buses, and replace aging fleets of postal service vehicles and school buses with newer, electric alternatives that save money on fuel over time. Throughout this report, net jobs effects are reported, accounting for jobs lost in industries like internal combustion engine manufacturing.

** Total jobs and cost figures exclude Light-Duty EV Incentives; see Proposal 1 (page 6) for an explanation about double-counting. Additionally, numbers may not add up due to rounding.*

Executive Summary

In total, the nine proposals modeled would cost **$77.4 billion in federal funding** for grants, tax incentives, and research and development.*

The proposals with the largest employment impacts tend to involve the most federal funding. Medium- and heavy-duty EV incentives rely on almost $30 billion in federally funded grants and incentives, while the incentives for transportation manufacturing would cost about $20 billion. The proposal to replace Chinese telecommunications equipment with secure alternatives and invest in U.S.-based semiconductor fabrication plants would involve about $11 billion in federal funding. All other proposals were priced at about $6 billion or less.

Direct employment gains in key industries:

- ***EV and battery manufacturing***
- ***Critical mineral recycling and mining***
- ***Next-generation technologies (e.g., AVs)***

While the *Commanding Heights* proposals are not explicitly designed to create jobs, several proposals are quite efficient in terms of federal funding per job created. Some regulatory changes require no explicit federal cost but unlock billions in private sector spending. Revising outdated ***regulations on autonomous vehicles***, for example, could lead to **$2.5 billion in private sector investment** and the construction or retooling of 10 autonomous vehicle manufacturing facilities. The proposal focused on ***transportation manufacturing incentives*** is also efficient, at a federal cost of about **$15,000 per job per year**, due in part to the inclusion of a production phase for some of its programs beyond the partially government-funded construction phase.

Other programs may come at a relatively higher federal cost per job created. However, most of these programs are specifically intended to jumpstart relatively nascent industries or to secure U.S. dominance in sectors of strategic importance. For example, establishing a grant program to support the construction of ***urban charging depots*** would cost nearly $67,000 per job per year. However, the **rapid deployment of EV charging infrastructure is critical for EV adoption to continue to grow at scale**, so some efficiency is traded for capitalizing on a key goal.

Methodology

This research uses an economic model to estimate the employment impacts of nine *Commanding Heights* proposals. Keybridge received policy proposals from SAFE, developed a set of appropriate modeling assumptions for each proposal, and estimated employment effects. All proposals were modeled using the IMPLAN economic model, which estimates macroeconomic shocks using U.S. Bureau of Economic Analysis (BEA) data. Proposals vary in duration, with some lasting one year and others lasting five years. Each proposal and recommendation was modeled individually and does not account for interactions between proposals or recommendations.

Employment effects are expressed both as job-years and jobs sustained for the length of the model. For example, *five job-years* are equivalent to *one job sustained for five years.* Throughout, jobs gained are classified as direct or supported. For example, jobs gained at an electric vehicle factory due to a tax credit are direct. Supported jobs include both indirect or induced jobs. In this example, indirect jobs are created when the factory purchases components to produce electric vehicles (like tires or glass) or services to support its workers (like healthcare). Induced jobs are created because workers employed at the electric vehicle plant (or its suppliers) use their additional income to support other businesses – for instance, they might buy meals at restaurants near the factory.

** Total jobs and cost figures exclude Light-Duty EV Incentives; see Proposal 1 (page 6) for an explanation about double-counting. Additionally, numbers may not add up due to rounding.*

Table of Contents

Issue #1: Support the Advanced Fuel Vehicle Market and Domestic Manufacturing

Issue #2: Develop a Critical Minerals Supply Chain That is Not Controlled by China

Issue #3: Advance Next-Generation Transportation Technologies

Issue #1:

Support the Advanced Fuel Market and Domestic Manufacturing

513,000
jobs created and sustained for the next 1-5 years

2,526,000
total job-years

Proposal 1: Light-Duty EV Incentives and Regulations

Proposal Overview

Expand current federal incentives for advanced technology vehicles, and update fuel economy and emission regulations to stimulate adoption.

Light-Duty EV Tax Credit

Reform the light-duty EV tax credit (30D) to make it refundable so that it is more accessible to consumers. Encourage the expedited manufacturing and adoption of EVs in the passenger vehicle market, providing the option of an alternative $7,000 rebate instead of the $7,500 tax credit.

Eliminate the volume limitation of 200,000 vehicles per manufacturer; initiate a gradual phase-down beginning on a date to be determined.

47,714 jobs
created by reformed light-duty EV tax credit and sustained over 3 years

Update Fuel Economy Standards

Update fuel economy standards using a range of tools including zero-emission vehicle requirements or vehicle multipliers.

These tools could be used to shift the focus from obtaining decreasing marginal benefits of ever-tightening standards for internal combustion engines to accelerating the inevitable transition to EVs.

60,378 jobs
created by updated fuel economy standards and sustained over 5 years

$6.0 billion
total federal spending

Industries with Largest Direct Employment Gains

- Motor Vehicle Retail Sector
- Battery Manufacturing
- Wholesale Electronic Markets
- Automobile Manufacturing

Employment Results

Both recommendations in this proposal would increase electric vehicle production to help bolster the U.S. position as a global industry leader, though they would work in different ways.

The fuel economy standards are regulatory changes intended to ensure the U.S. keeps pace with global EV industry trends, while the EV tax credits are consumer incentives intended to accelerate the transition to these vehicles as battery costs decline. The fuel economy standards would increase EV sales to 9% of total vehicle sales by 2025, while the tax incentive would raise EV market share to 6.2% by 2025 compared to baseline estimates of 4.3% market share.[1]

While these two recommendations could be implemented simultaneously, they are modeled separately. The employment impacts of these two recommendations cannot be added together for a total jobs figure because they are both modeled as an increase in electric vehicle sales. If both programs were implemented, they would not necessarily lead to the creation of the combined number of jobs that they each support separately.

Total employment results include both direct and supported (indirect and induced) jobs. In total, the ***light-duty EV tax credit*** is estimated to create nearly **48,000 jobs** sustained over three years, consisting of 14,916 direct jobs and 32,798 supported jobs. The industries that would see the largest direct job gains include the motor vehicle retail sector and battery manufacturing. It is assumed that 40% of EVs bought through the light-duty EV tax credit recommendation would not have been purchased if the program did not exist.[2]

The recommended changes to ***fuel economy standards*** would create more than **60,000 jobs** sustained over five years, consisting of 20,858 direct jobs and 39,520 supported jobs. The automobile and battery manufacturing industries, alongside motor vehicle retail and wholesale electronics markets, are among the industries with the largest direct employment impacts. The ***light-duty EV tax credit*** is estimated to cost about **$42,000 in federal spending per job per year.** Because the recommendation around fuel economy standards is a regulatory change, it has no direct federal cost.

Recommendation	Federal Cost ($ Billions)	Length of Program	Jobs Created and Sustained Over Length of Program			Total Job-Years
			Direct	Supported	Total	
Light-Duty EV Tax Credit	6.00	3 Years	14,916	32,798	**47,714**	**143,142**
Fuel Economy Standards	0.00	5 Years	20,858	39,520	**60,378**	**301,890**

Modeling Assumptions

The average cost of an EV is assumed to be $43,411, with 1/3 of the cost going toward battery production.[3] EVs include both fully electric vehicles and plug-in hybrids but exclude conventional hybrid vehicles. Internal combustion engine vehicles are estimated to cost $32,000 each.[4] Vehicle prices are assumed to stay constant over the entire recommendation period.

This model does not consider interactions between the light-duty tax credit and the updated fuel economy standards. Finally, it is assumed that 85% of the total amount spent on EVs through these two recommendations flows to U.S.-based businesses.

Light-Duty EV Tax Credit

Because consumers tend to prefer rebates over tax credits, it is assumed that all consumers will choose the $7,000 rebate over the $7,500 tax credit.

Based on a study of California's EV rebate program, it is assumed that 40% of EVs purchased with a rebate would not have been purchased without the program.[5] Scenarios were also run using estimates of 30% and 50%. It is assumed that 10% of EVs purchased directly replace gasoline-powered vehicles that would have been purchased in the same year.[6]

Modeling Assumptions (Cont.)

Thus, it is estimated that the recommendation will spur the purchase of about 285,000 EVs per year (replacing approximately 11,500 internal combustion engine vehicles annually).[7] This would lead to an additional $4.6 billion per year in sales ($3.4 billion and $5.8 billion for the 30% and 50% estimates, respectively).

Fuel Economy Standards

Fuel economy standard changes could include such tools as vehicle multipliers, zero-emission vehicle requirements, and attribution of emissions to power plants. Rather than modeling these policies individually, it is assumed that the selected regulations would together cause EVs to reach 9% of total U.S. automobile sales by 2025, gradually ramping up from 3% in 2020.[8]

To reach 9% of sales by 2025, EV sales are assumed to increase by approximately 25% per year over the next five years. Currently, they are on track to increase by an average of 8.2% per year over the next five years.[9] The new fuel standards are assumed to push that growth factor up by 16.8 percentage points per year. For comparison, EVs are forecast to reach 20% market share in China and 25% in the E.U. by 2025.[10]

The standards are expected to lead to the sale of about 13,000 additional EVs in Year 1, ramping up to 715,000 by Year 5, for a total of nearly 1.7 million additional EVs over five years. 100% of the EV purchases are assumed to directly replace the purchase of internal combustion engine vehicles.

Appendix: Citations and Footnotes

[1] Energy Information Administration (2020), Annual Energy Outlook. See Table 38.

[2] Other scenarios assuming 30% and 50% rates resulted in job gains of 35,785 and 59,642, respectively.

[3] Based on Keybridge calculations of Department of Energy (2019) data on electric vehicle sales by make and model. The $43,411 value used in the model is a weighted average cost by vehicles sold for models with greater than 1,000 sales.

[4] Griffith, Saul, Sam Calisch, and Alex Laskey (2020), "Mobilizing for a zero carbon America," *Rewiring America*. See Table 7. The authors estimate the average cost of non-electric light-duty vehicles at $32,000.

[5] Hardman, Scott, Amrit Chandan, Gil Tal, and Tom Turrentine (2017). The Effectiveness of Financial Purchase Incentives for Battery Electric Vehicles – A Review of the Evidence. *Renewable and Sustainable Energy Reviews 80* (see Figure 5). A 2016 survey found that among recent purchasers of a new electric vehicle, without the $7,500 U.S. Federal Tax Credit, 71.5% would have still bought an electric vehicle, and around 20% would not have bought a new car.

[6] Hardman et al (2017). The same 2016 survey found that about 10% of those who purchased an electric vehicle would have purchased an internal combustion engine vehicle instead if not for the $7,500 tax credit.

[7] Note that while the rebate program would incentivize the purchase of 285,000 EVs annually, per Hardman (2017), 40% of those purchases would be directly attributable to the program of which 10% (11,500) would be purchased by consumers that otherwise would have bought ICEs in the absence of such a rebate.

[8] Energy Information Administration (2020).

[9] Energy Information Administration (2020).

[10] China forecast per Chinese State Council via Reuters (November 2020). E.U. forecast per Chemnitz Automotive Institute report via Electrek (September 2020).

Proposal 2: Medium- and Heavy-Duty EV Incentives

Proposal Overview

Expand incentives for medium- and heavy-duty EVs. Expand oversubscribed Low- or Zero-Emission Vehicle Grant Program for American manufactured vehicles, and transition other fleets and critical infrastructure.

Medium/Heavy Duty AFV Tax Credit

Establish a tax credit that covers up to 30 percent of the total cost, or a larger share of the incremental cost, of new domestically manufactured medium- and heavy-duty alternative fuel vehicles.

Low or No Emissions Grants

Provide $1 billion annually for five years for the Low- or No- Emissions Grant Program to purchase transit buses and infrastructure to support them. Additionally, establish a waiver so that agencies replacing federally funded diesel buses do not need to repay federal interest if the buses have reached six years of operation or the asset has been depreciated.

Diesel Emissions Reduction Act (DERA) School Bus Rebate Program

Appropriate $12.5 billion over five years for a rebate program to replace diesel school buses with electric, hybrid electric, or other alternative fuels buses.

Voluntary Airport Low Emissions (VALE) and Airport Zero Emissions Vehicle (ZEV) Programs

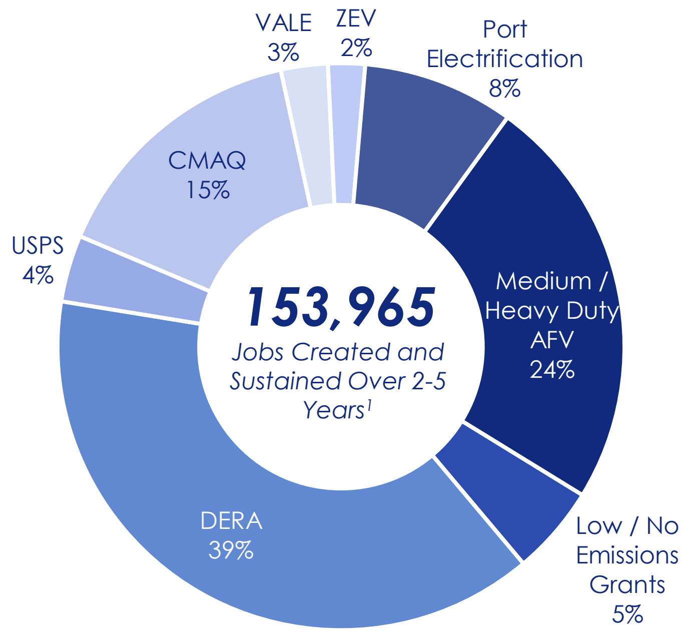
Support ground-side and air-side adoption of zero- and low-emissions vehicles at airports by providing $500 million per year for five years for the VALE program and the Airport ZEV and Infrastructure Pilot Program.

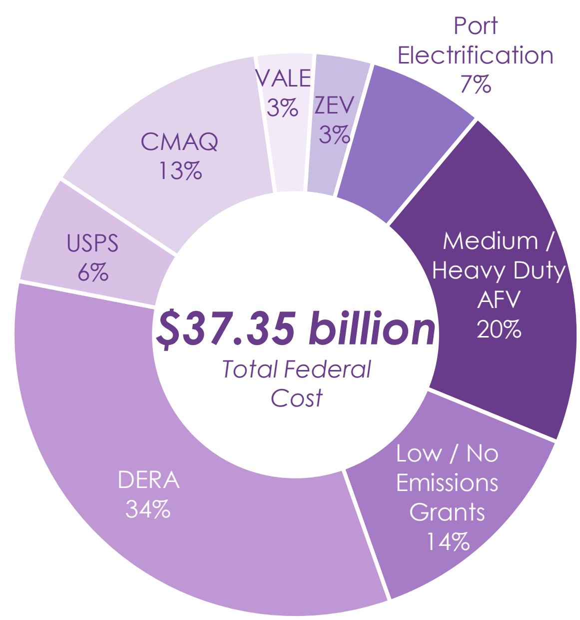
Port Electrification

Support the electrification of the nation's freight and logistics sector through a 5-year $500 million, annual competitive grant program that supports the integration of EVs and AFVs at ports and intermodal facilities.

USPS Fleet Electrification

Enable electrification of up to one-half of USPS delivery fleet with a direct appropriation of $2.35 billion for vehicle and charging infrastructure.





Congestion Mitigation & Air Quality (CMAQ)

Expand funding for the CMAQ program by $1 billion per year for five years so state and local fleet managers can replace existing vehicles with EVs or AFVs. Waive requirements that eligible projects come from a transportation plan and TIP and for non-federal matching dollars.

The following recommendation was not modeled:

Electricity Tax Credit

Create a tax credit for the sale of electricity used to power vehicles, to align electricity's tax treatment with other alternative fuels.

Employment Results

The EV grants and incentives outlined in this proposal are estimated to create almost 154,000 jobs sustained over the next 2-5 years, with about 148,000 jobs sustained over five years and 5,800 jobs over one year. in total. The ***DERA school bus rebate*** program, which costs $2.5 billion per year, has the highest impact at nearly **60,000 jobs**. Total employment results include both direct and supported (indirect and induced) jobs.

The ***medium/heavy duty AFV tax credit*** would add nearly **37,000 jobs** (primarily concentrated in truck and battery manufacturing and motor vehicle retail) over five years. An alternative scenario was also run for the medium/heavy duty AFV tax credit, splitting the funding evenly between Class 2-3 and Class 4-8 trucks. A program with this funding structure would create 37,403 jobs.

The ***Low or No Emissions Grant*** program adds **7,850 jobs** over five years, with its direct employment gains concentrated in heavy duty truck manufacturing.

DERA would cost the federal government $12.5 billion in the five-year time period modeled, unlocking over $32 billon in private sector spending. Much of the nearly 15,000 direct job gains would occur in the motor vehicle retail sector, heavy duty truck manufacturing, and storage battery manufacturing sectors.

The ***USPS*** program adds or saves nearly **6,000** jobs over two years, with the highest direct job gains included in the light duty truck and battery manufacturing industries and the motor vehicle retail sector.

The ***CMAQ*** program involves projects related to congestion reduction, the Surface Transportation Program, bicycle and pedestrian programs, and transit improvements. It creates or saves nearly **23,500 jobs** over five years.

Of those jobs, 9,707 are from congestion reduction, 7,338 are from the Surface Transportation Program (STP), 4,307 are from bicycle and pedestrian programs, and 2,072 are from transit improvement. Most job gains come from hiring to construct new highways and streets, and the maintenance of highways, streets, bridges, and tunnels.

The ***VALE*** program, which supplies charging stations, pre-conditioned air units (PCAs), and ground power units (GPUs), adds or saves over **4,000 jobs** over five years. 2,876 jobs are from purchasing and constructing charging stations, 834 jobs are from PCAs, and 417 are from GPUs. Direct jobs gains are centered in the retail electronics and construction sectors.

Recommendation	Federal Cost ($ Billions)	Length of Program	Jobs Created and Sustained Over Length of Program			Total Job-Years
			Direct	*Supported*	*Total*	
Medium/Heavy Duty AFV Tax Credit	7.50	5 Years	9,143	27,456	**36,599**	**182,995**
Low or No Emissions Grants	5.00	5 Years	1,388	6,462	**7,850**	**39,250**
DERA School Bus Rebate	12.50	5 Years	14,882	44,692	**59,574**	**297,870**
USPS Fleet Electrification	2.35	2 Years	1,515	4,351	**5,865**	**11,730**
CMAQ	5.00	5 Years	9,637	13,787	**23,424**	**117,120**
VALE	1.25	5 Years	1,907	2,221	**4,128**	**20,640**
ZEV	1.25	5 Years	930	2,310	**3,240**	**16,200**
Port Electrification	2.50	5 Years	4,124	9,160	**13,285**	**66,425**
Proposal 2 Total	37.35		43,526	110,439	**153,965**	**752,230**

Employment Results (Cont.)

Nearly **3,250 jobs** sustained over 5 years are created through the ***ZEV*** program, which consists of charging station and EV purchases at airports. This includes 620 jobs from the purchase and installation of charging stations and 2,620 from EVs. Many of the direct job gains are in truck and battery manufacturing as well as the motor vehicle retail sector.

The ***port electrification*** program, which supplies charging stations and EVs, adds or saves over **13,000 jobs**, with 4,135 of those from the purchase and installation of charging stations and 9,150 from EV purchases and production. Direct job gains are highest in the motor vehicle and electronics retail sectors as well as heavy duty truck manufacturing and construction.

The recommended policies included in this proposal would cost about **$53,000 in federal funding per job per year.** For the medium/heavy duty AFV tax credit, $40,985 is spent per job per year. Approximately $127,389 would be spent per job per year on the Low or No Emissions Grant program. The DERA program would cost about $41,965 per job per year, while the USPS fleet electrification is estimated to cost $200,341 per job per year.[2]

The CMAQ program would cost about $42,691 per job per year. About $60,562 would be spent per job per year for the VALE program, and $77,161 would be spent for the ZEV program. Finally, the Port Electrification program would cost about $37,636 per job per year.

Modeling Assumptions

Most recommendations were modeled as a demand shock for the additional spending that would occur if the recommendation were implemented. For example, the Low or No Emissions Grant Program is estimated to trigger about $920 million annually in electric bus purchases. The CMAQ program, by contrast, was modeled as an injection of cash into specific industries, including construction and repair of highways and streets.

These scenarios do not consider interactions between recommendations and they assume vehicle prices stay constant over the entire recommendation period. For each recommendation, it is assumed that one-third of the cost of an electric vehicle is for battery production.

Medium/Heavy Duty AFV Tax Credit

The average price of Class 4-8 trucks is estimated at $150,000 for EVs and $100,000 for diesel trucks.[3] It is assumed that 85% of vehicles are purchased solely because of the program and that 10% of the EVs purchased directly replace diesel vehicles. 90% of electric trucks are estimated to be produced domestically. This program is assumed to lead to $4 billion per year in additional spending on Class 4-8 EVs.

An alternative scenario allocated half the funds to Class 2-3 EV trucks instead of Class 4-8 trucks. Class 2-3 EV trucks are assumed to cost $54,167, and Class 2-3 gasoline- or diesel-fueled trucks are assumed to cost $47,500.[4] In this case, the program would spur $1.9 billion each in additional yearly spending on Class 4-8 and Class 2-3 electric trucks.

Low or No Emissions Grants

It is assumed that 70% of grants are used for compressed natural gas (CNG) buses, and 30% are used for electric buses.[5] 85% of the cost of projects are estimated to be covered by the grant program, and 85% of buses are assumed to have been purchased solely because of the program.[6]

It is assumed that 10% of electric buses directly replace new diesel buses that would have been purchased during the same year. Diesel buses are estimated to cost $342,910, while CNG and electric buses are priced at $374,600 and $604,550, respectively.[7] It is assumed that the lifetime total cost of ownership for electric buses (i.e., savings on maintenance and fuel) is sufficiently lower than that of diesel buses, which incentivizes their purchase despite the higher upfront cost. Finally, it is assumed that 90% of the amount spent on these buses is for U.S.-based production.

Modeling Assumptions (Cont.)

DERA School Bus Rebate Program

The DERA program allocates $65,000 per electric school bus purchased, at an average cost of $295,000 each. As a result, the grant program is assumed to fund the purchase of nearly 38,500 alternative fuel buses per year (roughly 192,500 total).[8] The average cost of a diesel bus is estimated at $130,000. 75% of the electric buses purchased are assumed to directly replace diesel buses that would otherwise have been purchased.[9] 90% of the cost of electric school buses is assumed to be for U.S.-based production.

USPS Fleet Electrification

The federal government is assumed to cover 100% of the costs to electrify USPS vehicles. It is assumed that all USPS vehicles are Class 2-3 trucks. The average cost of an electric USPS truck is estimated at $54,167, while the cost of non-electric trucks is estimated at $30,000.[10]

It is estimated that no electric USPS trucks would be purchased without this program, and that 90% of the electric trucks would directly replace ICE trucks that would have been purchased otherwise. As with the other bus purchase programs, 90% of the spending on USPS trucks is estimated to be for U.S. production.

CMAQ

The CMAQ grant funding distribution is based on 2018 projects and narrowed down to project types that received at least 10% of total CMAQ funding: Bicycle and Pedestrian Facilities and Programs (14.6% of total funding), Transit Improvements (10.5%), the Surface Transportation Program (15.7%), and Congestion Reduction and Traffic Flow Improvements (59.2%).

Each project is assumed to cover a different share of total costs. Bicycle and Pedestrian grants cover 39.1%, Transit Improvements cover 65.2%, the Surface Transportation Program covers 43.4%, and Congestion Reduction covers 70.4%.[11] The grants are measured as an increase in spending in each of these industries (primarily construction and maintenance of roads and structures).

VALE

Funding from VALE programs is split between charging stations (74%), PCAs (15%), and GPUs (12%). Charging stations are priced at $65,000 ($50,000 for materials and $15,000 for installation), PCAs are priced at $90,000, and GPUs are estimated at $200,000. It is assumed that 75% of the cost of the components are covered by VALE grants.[12]

The program is modeled as an increase in demand for each component. The proportion of spending met by domestic production is 32% for charging station materials, 100% for charging station installation, 74% for PCAs, and 45% for GPUs, based on IMPLAN defaults.

ZEV

Funding from the ZEV program is split between charging stations (15%) and electric buses (85%). 60% of the cost of buses and chargers is covered by the grant. As in the VALE program, the cost of a charging station is estimated at $65,000.[13]

10% of electric buses are assumed to directly replace diesel buses that would have been purchased otherwise. The cost of an electric bus is estimated at $604,550, and the cost of a diesel bus is estimated at $342,910.[14] 85% of electric buses are assumed to have been purchased solely because of the ZEV program.

The recommendation is modeled as an increase in demand for each component. Domestic spending from each of the recommendations is 32% for charging station materials, 100% for charging station installation, and 90% for electric bus production, based on IMPLAN model default assumptions.

Port Electrification

Funding is split between charging stations (25%) and Class 4-8 electric trucks (75%). It is assumed that these grants cover 30% of all costs and that 85% of trucks and chargers are purchased due to the program.

The average cost of a charging station is estimated at $65,000, and the average cost of an electric truck is 150,000. 10% of electric trucks are assumed to directly replace diesel trucks, which are priced at $100,000.[15] Finally, the program is modeled as a direct increase in demand for chargers and trucks. 32% of spending on charging station materials, 100% of spending on charging station installation, and 90% of spending on electric bus production is estimated to remain in the United States, based on IMPLAN model default assumptions.

Appendix: Citations and Footnotes

[1] 148,100 jobs are created and sustained over five years in models with five-year lengths (medium/heavy duty AFV tax credits, Low or No Emissions Grants, DERA, CMAQ, VALE, ZEV, Port Electrification), while 5,865 jobs are created and sustained over 1 year in the model with one-year length (USPS fleet electrification).

[2] While this cost per job saved in the short run is relatively high, this analysis does not take the lifetime benefits of these vehicles into account. EVs are expected to have a much lower operating cost than traditional ICE USPS vehicles. These economic benefits will accrue over the coming years.

[3] Electric Class 4-8 truck prices are estimated based on the price of a Tesla Semi. The price of diesel- or gasoline-fueled Class 4-8 trucks comes from the State of California Air Resources Board Staff Report (2019) (see Table IX-6) and the National Automobile Dealers Association (2019).

[4] Electric Class 2-3 truck prices are estimated based on the costs of Tesla, Rivian, and Lordstown electric trucks. Diesel Class 2-3 truck prices come from the State of California Air Resources Board Staff Report (2019) (see Table IX-6).

[5] Estimated based on buses built in 2019, from the American Public Transportation Association (APTA). CNG buses accounted for 35% of buses produced while electric buses accounted for 4.5%; however,electric buses have been increasing in popularity over the last several years.

[6] Per the Federal Transit Administration, up to 85% of a project can be funded by a Low or No Emissions Grant.

[7] Holland, Stephen P., Erin T. Mansur, Nicholas Z. Muller, and Andrew J. Yates (2020), "The Environmental Benefits from Transportation Electrification: Urban Buses," *NBER* Working Paper No. 27285. See Table 6.

[8] EPA, 2020 Diesel Emissions Reduction Act (DERA) School Bus Rebates Program Guide. See Table 2 for rebate amounts. For further context, according to *School Bus Fleet*, an industry publication, 40,000 school buses are purchased each year in the U.S., and there are about 480,000 school buses in total.

[9] The cost of an electric school bus is based on Keybridge calculations of the average cost estimates from Austin, Wes, Garth Heutel, and Daniel Kreisman (2020), "School bus emissions, student health and academic performance," *Economics of Education Review*, Vol. 70, p. 109-126; and Miller, Alana, Hye-Jin Kim, Jeffrey Robinson, and Matthew Casale,(2018) "Electric Buses: Clean Transportation for Healthier Neighborhoods and Cleaner Air," *U.S. PIRG Education Fund.* The cost of a diesel school bus is based on Austin et al (2020).

[10] Electric Class 2-3 truck prices are estimated based on the costs of Tesla, Rivian, and Lordstown electric trucks. Average ICE USPS truck prices are based on Zwahlen, Cyndia, "U.S. Postal Service Delays New Mail Truck Choice to 2020," *Trucks.com*, September 3, 2019.

[11] CMAQ Project data is from the U.S. Department of Transportation's Federal Highway Administration (2018).

[12] VALE project data, including funding distributions, percent of cost covered by grants, and price estimates for PCAs and GPUs, comes from Keybridge calculations of Federal Aviation Administration (2019) data. Cost estimates for charging station materials and installation are based on the cost of Proterra chargers.

[13] ZEV project data comes from Keybridge calculations of Federal Aviation Administration (2019) data.

[14] See footnote 6.

[15] Electric Class 4-8 truck prices are estimated based on the price of a Tesla Semi. The price of diesel- or gasoline-fueled Class 4-8 trucks comes from the State of California Air Resources Board Staff Report (2019) (see Table IX-6) and the National Automobile Dealers Association (2019).

Proposal 3: Transportation Manufacturing Grants & Tax Incentives

Proposal Overview

Support strategic investment in next-generation vehicle manufacturing and their supply chains.

Advanced Technology Vehicle Manufacturing (ATVM) Grant Program

Establish and fund the competitive ATVM grant program already authorized by the Energy Independence and Security Act of 2007 to provide expeditious financial support to companies in building or retooling domestic manufacturing facilities during the economic recovery.

48C Advanced Manufacturing Tax Credit

Revive the 48C advanced manufacturing tax credit to make available a 30% investment tax credit to provide $2.5 billion annually for three years to re-equip, expand, or establish domestic manufacturing facilities in the clean energy and transportation technology sectors.

Battery Research & Development

Fund R&D to improve the energy density of batteries, new battery chemistries such as improved cathodes, and charging technology. Research is chronically underfunded and better or alternative chemistries can lower costs and reduce charging times.

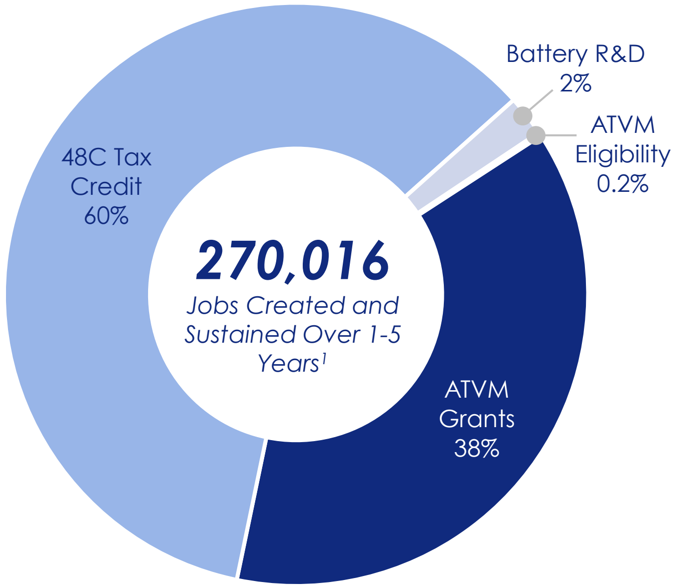
Advanced Technology Vehicles Manufacturing (ATVM) Program Eligibility

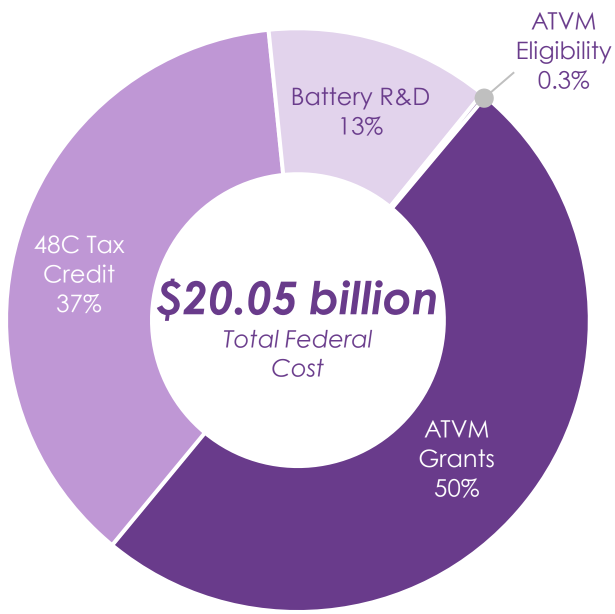
Appropriate $50 million to reduce application costs, including the cost of independent financial advisors, and to accelerate the loan review process. Expand eligibility to include manufacturing facilities for medium- and heavy-duty alternative-fuel vehicles (AFVs), autonomous vehicles (AVs), micromobility devices, and their associated components.

The following recommendations were not modeled:

OMB Oversight

Direct the Office of Management & Budget (OMB) to review new significant regulations to determine if they reduce anticompetitive features.





White House Coordination

Designate an official at the White House to coordinate federal policies affecting the vehicle manufacturing industry and national security.

Job Training & Assistance

Take into account the extent to which the companies commit to retrain workers and offer displaced workers the first opportunity for newly created jobs in selecting grant recipients and fund robust job training and assistance as workers across the supply chain transition to new jobs.

Employment Results

The grants and tax incentives outlined in this proposal are estimated to create 270,016 jobs sustained over the next 1-5 years, including 558 jobs over one year from the ATVM eligibility change and about 269,000 jobs over five years from the ATVM grants, 48C tax credit, and battery R&D. Reviving the ***48C advanced manufacturing tax credit*** would have the biggest impact, creating or saving over **160,000 jobs**. Total employment results include both direct and supported (indirect and induced) jobs.

The ***ATVM grant program*** would provide $10 billion in funding to the private sector to retool manufacturing facilities, resulting in over **101,000 jobs** over five years. Direct employment gains are concentrated in the motor vehicle retail sector and EV battery manufacturing.[2] The construction phase would create 60,310 jobs over the first two years, while the production phase would yield 128,210 jobs over the final three.[3] Roughly 667,000 additional EVs are sold each year over the three-year production phase.[4]

Reviving 48C would cost $7.5 billion in federal dollars. It is assumed to stimulate $25 billion in private-sector investment and create 162,336 jobs over five years, with the largest direct employment effects impacting the motor vehicle retail sector and the battery manufacturing industry.

The construction phase for vehicles would create 85,942 jobs over the first two years, while the production phase would yield 182,699 jobs over the final three years. For renewable energy facilities, the construction phase would yield 79,390 jobs in the first year while the operations phase would produce 3,076 jobs over the final four years.

Funding further ***battery R&D*** would add about **1,600 direct jobs** in the scientific research sector and support over **4,400 indirect and induced jobs**. Changes to ATVM eligibility would cost $50 million over one year and create 558 government jobs.

The recommendations laid out in this proposal would cost about **$15,000 per job per year**. The ATVM grant program would cost $19,792 per job per year, 48C would cost $9,240 per job per year, battery R&D would cost $82,345 per job per year, and changes to ATVM eligibility would cost $89,670 per job per year.[5]

Recommendation	Federal Cost ($ Billions)	Length of Program	Jobs Created and Sustained Over Length of Program			Total Job-Years
			Direct	*Supported*	*Total*	
ATVM Grants	10.0	5 Years	37,722	63,328	**101,050**	**505,250**
48C Tax Credit	7.50	5 Years	60,174	102,161	**162,336**	**811,680**
Battery R&D	2.50	5 Years	1,630	4,442	**6,072**	**30,360**
ATVM Eligibility	0.05	1 Year	255	303	**558**	**558**
Proposal 3 Total	20.05		99,781	170,234	**270,016**	**1,327,848**

Modeling Assumptions

The scenarios modeled here do not consider interactions between recommendations, and vehicle prices are assumed to stay constant throughout the modeling period. The average price of an EV is assumed to be $43,411, while the price of an internal combustion engine (ICE) vehicle is assumed to be $32,000.[6] For each recommendation, it is assumed that one-third of the cost of an electric vehicle is for battery production. Where new EV purchases are estimated to take place, it is assumed that there is a 95% offset in ICE vehicles purchased.

Modeling Assumptions (Cont.)

All vehicle manufacturing facilities are assumed to be retooled factories for EV production rather than new facilities. Factory retooling is modeled as a demand shock for the construction of motor vehicle manufacturing structures and the capital equipment purchased to outfit the factory. EVs produced at these facilities are assumed to be 100% American made.

ATVM Grants

It is assumed that all $10 billion in program funding is disbursed in the first year and that 13 recipients receive an average grant of $750 million.[7] It is assumed that each grant covers the full investment cost of upgrading the facility (i.e., no additional private sector investment is modeled). It is assumed to take two years to re-fit facilities, so the construction spending is modeled as $5 billion in Year 1 and $5 billion in Year 2. While electric auto, truck, and bus manufacturers would be eligible to receive the grants, this model focuses on light-duty auto manufacturers.[8]

The two years of construction is assumed to be followed by three years of production, and the average grant recipient is assumed to produce 50,000 vehicles per year.[9] The model includes EV production in order to capture the longer-term employment gains incentivized by ATVM grants, not just the temporary construction jobs.

Given the assumptions on production, ICE cost, and EV cost, each year in the production phase leads to $28.9 billion in EV purchases that is offset by a $20.2 billion reduction in ICE purchases for a net total of $8.7 billion in additional consumer spending per year.

48C Tax Credit

It is assumed that program demand is sufficient to stimulate $25 billion in private investment (exhausting the $7.5 billion in funding allotted for the 30% tax credit). Program-induced investment is assumed to be concentrated in three industries with 57% of tax credits allocated to facilities that produce EVs, 29% allocated to wind power facilities, and 14% allocated to solar power facilities.[10] Credits allocated to EVs are modeled the same way as the ATVM grant program. $14.3 billion in spending is assumed to be spread out over 19 facilities for an average investment of $750 million per facility. Each year of the production phase leads to $41.2 billion in EV purchases that is offset by a $28.8 billion reduction in ICE purchases for a net total of $12.4 billion in additional consumer spending per year. The program would result in the production of 950,000 EVs per year beginning in Year 3.

Remaining credits are allocated to develop solar and wind energy facilities.[11] The construction phase of the renewable energy projects are assumed to last one year. Wind projects receive $7.3 billion in funding, impacting 29 facilities with an average facility investment of $227 million. Solar projects receive $3.5 billion in funding, impacting 13 facilities with an average facility investment of $243 million.[12] Construction phase capital costs are broken down into construction of structures, mechanical equipment, and electrical equipment.[13]

Longer-term employment gains for the renewable energy projects are modeled as the costs of operating and maintaining the energy facilities. Operating costs – relatively cheap compared to capital costs – are modeled as a demand shock for industrial equipment repair with costs totaling $151 million per year at the wind plants and $62 million per year at solar facilities.

Battery Research & Development

Funding for research into improving the energy density of batteries is modeled as a $500 million per year injection into the scientific research and development services sector. Based on IMPLAN's default for this sector, 98.52% of this spending is assumed to occur within the United States.

ATVM Eligibility

This recommendation involves $50 million in federal funding to reduce ATVM application costs and accelerate the loan review process. It is assumed all funding is spent on hiring government employees to expand DOE administrative capabilities.

Appendix: Citations and Footnotes

[1] 269,458 jobs are created and sustained over five years in models with five-year lengths (AVTM grants, 48C tax credit, battery R&D), while 558 jobs are created and sustained over 1 year in the model with one-year length (AVTM eligibility).

[2] Auto manufacturing is notably absent from the list of industries with the highest direct employment gains. Because this model is focused on net impact, the majority of jobs created in EV manufacturing are offset by jobs lost in ICE vehicle manufacturing.

[3] For both the ATVM Grant program and the 48C Tax Credit, the modeled scenarios involve two separate phases: a construction phase followed by a production phase (or, in the case of the renewable energy projects in 48C, an operations phase). Headline employment numbers reported are per-year averages rather than the sum of the two phases. This accounts for the loss of construction jobs once production/operations begins.

[4] The initial ATVM loan program committed $8 billion in funding leading to the production of roughly 572,000 vehicles per year (Department of Energy, 2016; from 2009 to 2016 funding supported production of 4 million cars).

[5] This proposal's relatively low cost per job per year is due to the inclusion of a production/operations phase post-construction for the ATVM grant program and 48C. Including production/operations rightly accounts for the longer-term employment impacts that construction alone would not capture; however, it also lowers the overall cost per job as jobs are created in the production phase without any additional federal spending.

[6] The $43,411 value is a weighted average based on Keybridge calculations of Department of Energy (2019) data of electric vehicle sales by make and model for vehicles with greater than 1,000 sales. The $32,000 value is from Griffith, Saul, Sam Calisch, and Alex Laskey (2020), "Mobilizing for a zero carbon America", Table 7, *Rewiring America*.

[7] Average grant amount is based off Keybridge calculations of recent EV factory retooling efforts (See VW, Ford, and Rivian) and facility investments from the original ATVM loan program (Department of Energy, 2016; CRS, 2015).

[8] While the ATVM grant program and the 48C tax credit would apply to electric bus and truck manufacturing in addition to light-duty vehicle manufacturing, this model focuses on light-duty EVs given the relative nascency, scale, and size of the electric bus and truck markets compared to the market for light-duty EVs.

[9] Assumption based off recent EV factory retooling efforts (See Rivian and GM).

[10] Keybridge calculations based off initial round of 48C tax credits (data from Obama White House, 2010). Scenario modeled only includes industries receiving greater than 10% of credits and provides greater support to EV production and less to solar energy than the previous round of 48C. Note however, that funding from this program could be used to support a much wider array of clean energy and advanced manufacturing facilities.

[11] See Table 20-1 and 25-1,"Capital Cost and Performance Characteristic Estimates for Utility Scale Electric Power Generating Technologies", *EIA* (2020). The average wind facility is assumed to be a large onshore plant with a total capacity of 200 MW and an operating cost of $26.34/kW. The average solar facility is assumed to be a 150 MW photovoltaic plant with 200 MWh of batter storage and an operating cost of $31.27/kW.

[12] EIA (2020), Table 20-1 and Table 25-1 with Keybridge calculations removing unproductive transfer payments (EPC fee and contingency fee).

[13] EIA (2020), Table 20-1 and Table 25-1 with Keybridge calculations. Capital costs for solar facilities are modeled as 12% construction of structures, 15% mechanical, and 73% electrical (including purchases of solar panels and batteries). Capital costs for wind facilities are modeled as 20% construction of structures, 72% mechanical (including purchases of wind turbines), and 8% electrical.

Proposal 4: Electric Charging & Storage Infrastructure

Proposal Overview

Invest in nationwide electric charging and refueling infrastructure, and develop an additional utility energy storage capacity system to support a reliable, resilient electric grid.

Clean Corridors Act (CCA)

Establish a grant program, such as the CCA, to fund the development of a nationwide network of electric vehicle charging infrastructure corridors throughout the United States. The CCA is assumed to have an annual appropriation of $750 million over five years.

AFV Refueling Property Tax Credit (30C)

Update the alternative fuel vehicle (AFV) refueling property tax credit (30C) by converting it to a refundable tax credit, eliminating the $30,000 limit per refueling property, increasing the size of the credit for bidirectional charging infrastructure, and extending the credit through December 31, 2025.

Urban Charging Depots

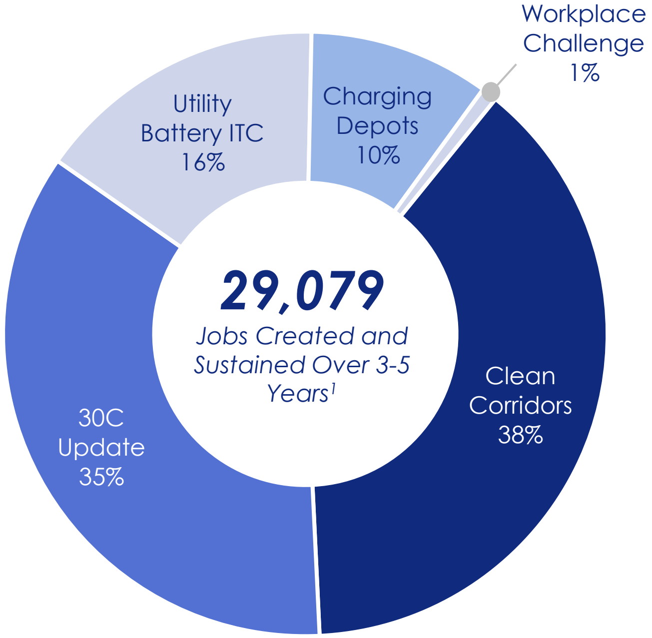
Create a competitive grant program of $200 million annually to support the construction of charging depots equipped with DC Fast Chargers in urban areas.

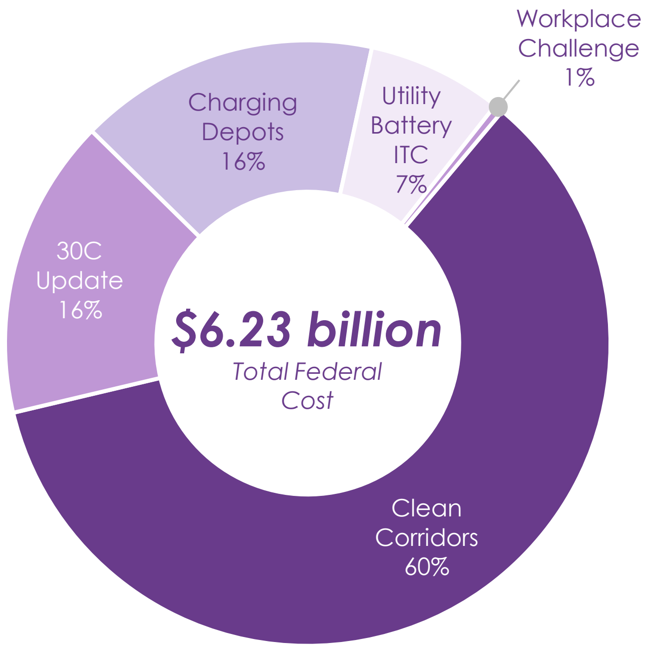
Workplace Charging Challenge

Revitalize the Workplace Charging Challenge through a new cooperative agreement to provide $10 million in annual support over the next three years. Funding would provide support for stakeholder engagement, in-depth technical assistance to employers, and a matching grant program for private-sector investment to help defray costs of infrastructure installations.

Utility-Scale Battery Storage Investment Tax Credit

To support utility-scale energy storage capacity, Congress should enact an energy storage investment tax credit (ITC) as laid out in bipartisan bills S. 1142 and H.R. 2096. While the tax credit would apply to several forms of energy storage, this modeling focuses on battery storage only.





Employment Results

The recommendations outlined in this proposal are primarily focused on closing the charging infrastructure gap – an essential prerequisite for widescale EV adoption; the scenarios modeled are estimated to create **almost 30,000 jobs** sustained over the next 3-5 years, including 211 jobs lasting three years and 29,000 jobs from the proposals modeled over five years. Passage of the ***Clean Corridors Act*** would have the largest impact, creating over **11,500 jobs** over five years.[2]

The Clean Corridors Act would induce $3.75 billion in federal spending over five years. Direct job gains would primarily impact industries involved in the manufacturing of electric vehicle (EV) charging hardware and the construction and installation of charging stations.

Updating the ***AFV refueling property tax credit (30C)*** would lead to $1.0 billion in federal spending over five years. It would stimulate $3.33 billion in private-sector investment and create nearly **10,400 jobs** over five years, with direct employment gains concentrated in EV charger manufacturing and installation.

The ***urban charging depots grant program*** would also spend $1.0 billion over five years, leading to about **3,000 jobs** sustained over five years. Direct job gains are similarly concentrated in charger manufacturing and installation. The ***Workplace Charging Challenge*** would cost $30 million over three years and create just over **200 jobs**. The combined impact of these recommendations would encourage the installation of over **1.1 million electric chargers by 2024** – over half of the 2.1 public charging ports that the Edison Electric Institute forecasts will be needed by 2030.[3] For comparison, the Biden presidential campaign included a policy goal of 500,000 charging stations.[4]

The ***utility battery storage tax credit*** would incentivize the installation of additional energy storage capacity to, in part, help power the increase in electric charging infrastructure. The program would create about **4,000 jobs** sustained over five years with direct job gains in retail and wholesale electrical equipment markets as well as in the construction and installation of battery storage systems.

These recommendations would use about **$43,000 in annual federal funding per job.** The Clean Corridors Act would cost $65,178 per job per year, the Charging Depots program would cost $66,711, and the Workplace Charging Challenge would cost $47,369. By incentivizing substantial private-sector investment, updating 30C is estimated to cost the government $19,246 per job per year, while the Battery Storage ITC is estimated at $22,664 per job per year.

Recommendation	Federal Cost ($ Billions)	Length of Program	Jobs Created and Sustained Over Length of Program			Total Job-Years
			Direct	*Supported*	*Total*	
Clean Corridors Act	3.75	5 Years	4,722	6,785	**11,507**	**57,535**
30C Expansion	1.00	5 Years	4,260	6,131	**10,392**	**51,960**
Charging Depots	1.00	5 Years	1,230	1,768	**2,998**	**14,490**
Workplace Charging Challenge	0.03	3 Years	98	113	**211**	**633**
Utility-Scale Battery Storage Tax Credit	0.45	5 Years	1,710	2,261	**3,971**	**19,855**
Proposal 4 Total	6.23		12,020	17,058	**29,079**	**144,473**

Modeling Assumptions

The model does not consider interactions between recommendations. For all recommendations that model the construction of new EV charging stations, 100% of components of the charging hardware are assumed to be sourced domestically. For each charging port, total capital costs are broken down into hardware costs and installation costs.[5] Capital costs for public Level 2 (PL 2) chargers are assumed to be 40% hardware & 60% installation, workplace chargers are assumed to be 43% hardware and 57% installation, while direct current fast chargers (DCFCs) are assumed to be 68% hardware and 32% installation costs.[6] Hardware costs are modeled as a demand shock for manufactured electrical components, while installation costs are modeled as a direct funding increase for the construction/installation industry.

For PL 2 chargers, workplace chargers, and DCFCs, labor costs account for 55%, 55%, and 42% of total installation costs, respectively.[7] The model accounts for the discrepancy in labor costs between PL 2 and workplace chargers and the relatively more capital-intensive DCFCs. For each applicable recommendation, the labor share is used to specify the total level of employee compensation associated with the installation of a given type of charger. Unless otherwise noted, all recommendations assume that federal funding will cover 100% of costs (i.e., no corresponding private-sector investment is modeled).

Clean Corridors Act

It is assumed that all spending on this program would go toward EV charging stations.[8] Specifically, one-third of funding would support the deployment of PL 2 chargers, while two-thirds would support new DCFCs. Based on the capital-cost assumptions stated above, 13% of funding would go toward PL 2 charging hardware, while 20% would go toward installation costs (including $82.5 million in annual employee compensation). Meanwhile, 45% of funding would go toward DCFC hardware and 21% would go toward installation costs (including $67.2 million in annual employee compensation).

Assuming an average total cost of $5,440 per PL 2 charger and $81,818 per DCFC charger, this program is assumed to incentivize the installation of 689,338 PL 2 chargers and 30,556 new DCFCs.[9]

AFV Refueling Property Tax Credit (30C)

It is assumed that program demand would be sufficient to stimulate $3.33 billion in private investment (exhausting the $1 billion in funding allotted for the 30% tax credit). As in the Clean Corridors Act, all modeled spending is allocated to the development of EV charging stations.[10] 40% of spending is apportioned to DCFCs, 35% to workplace chargers, and 25% to PL 2 chargers.[11]

Using the stated cost assumptions for DCFCs and PL 2 chargers and an average cost of $3,880 per workplace charger, this program would lead to the installation of 16,296 new DCFCs, 153,186 PL 2 chargers, and 300,687 workplace chargers.

Urban Charging Depots

The urban charging depots grant program is assumed to fully fund the construction of new DCFCs. Capital costs are 68% hardware and 32% installation (including $26.9 million in annual employee compensation).

With an average cost of $81,818 per charger, this program would lead to the installation of 12,222 new DCFCs.

An alternative scenario modified the grant program to cover 50% of capital costs rather than 100%. In this scenario, it is assumed that program demand would be sufficient to stimulate an additional $1 billion in private sector investment. This scenario would double the total employment impact (4,921 jobs vs. 2,458 jobs) and the numbers of chargers deployed (24,444).

Workplace Charging Challenge

Half of program funding ($15 million) is assumed to be spent on hiring people to provide technical assistance to employers and support stakeholder engagement. The other $15 million is assumed to create a matching grant program to help defray the costs of infrastructure installation. It is assumed that this grant program would lead to an additional $15 million in matching private-sector investment. The combined $30 million in government and private spending from the grant program would help fund the installation of charging infrastructure.

Modeling Assumptions (Cont.)

Utility-Scale Battery Storage Tax Credit

This scenario assumes that all newly created energy storage is lithium-ion battery storage.[12] The average battery system is assumed to be 60 MW and 240 MWh (four-hour duration). Over the period modeled, average storage costs are assumed to decline from a 2019 baseline of $380/kWh to $281/kWh by 2024.[13] Thus, the cost of the average battery system would decline from $85.7 million in Year 1 to $67.5 million by Year 5. Finally, it is assumed that a standalone energy storage tax incentive would follow the same schedule as the current solar tax credit (26% until 2022, 22% in 2023, and 10% in 2024).[14]

In a baseline scenario without a tax incentive, battery storage projects would add 9.27 GW to the energy grid from 2020 to 2024.[15] The 9.27 GW increase is equivalent to 154 new battery systems or $14.0 billion in investment.

The utility battery storage tax incentive is expected to increase battery storage projects by 16 percent.[16] With the tax incentive, battery storage projects would add 10.75 GW from 2020 to 2024, which is equivalent to 179 new battery systems or $16.3 billion in investment. Thus, the standalone battery storage tax credit would directly incentivize the construction of 25 new battery systems or $2.275 billion in investment.

It is assumed that all 154 new systems in the baseline scenario would have been paired with solar in order to receive the solar investment tax credit and that none of the battery systems incentivized by the standalone battery storage tax credit would be paired with solar.[17]

Because of this, the federal government cost includes only the cost of the 25 battery systems directly incentivized by the battery storage tax credit. The total federal cost would be about $500 million over five years, resulting in an additional $2.275 billion in investment.

Appendix: Citations and Footnotes

[1] 28,868 jobs are created and sustained over five years in models with five-year lengths (Clean Corridors Act, 30C, charging depots, utility-scale battery storage), while 211 jobs are created and sustained over three years in models with three-year lengths (Workplace Charging Challenge).

[2] Total employment results include both direct and supported (indirect and induced) jobs.

[3] By charger type, the Clean Corridors Act, 30C Expansion, and Charging Depots programs would encourage the installation of 59,074 DCFCs, 300,687 workplace chargers, and 842,525 PL 2 chargers. Based on Edison Electric Institute forecasts on charging infrastructure needs by 2030 (see footnote 7), the programs modeled in this proposal would cover 59% of estimated DCFC charging infrastructure needs, 105% of PL 2 charging infrastructure needs, and 25% of workplace charging infrastructure needs by 2025.

[4] Biden For President (2020), "The Biden plan to build a modern, sustainable infrastructure and an equitable clean energy future." Note that these may not be directly comparable as the Biden plan references charging stations, while the modeling in this report is calculated based on the number of charging ports.

[5] In IMPLAN, electric charging ports are classified under miscellaneous electrical equipment – a commodity for which IMPLAN classifies as 31.6% domestic. However, given a heightened focus on "Buy American" incentives by the Biden administration and in the incoming Congress, it is assumed that 100% of EV charger equipment is sourced domestically.

[6] Nicholas, Michael (2019). Estimating Electric Vehicle Charging Infrastructure Costs Across Major U.S. Metropolitan Areas. *International Council on Clean Transportation.* See Figure 3. Hardware costs as share of total capital costs listed in the text. Table 3 and Table 4 indicate installation costs are the sum of labor, materials, permits, and taxes.

Appendix: Citations and Footnotes

[7] Nicholas (2019). Keybridge calculations based off Table 3 and Table 4. Labor as a share of total installation costs across varying levels of chargers per site is roughly 55% for workplace chargers, 55% for PL 2 chargers, and 42% for DCFCs.

[8] While the Clean Corridors Act would support the deployment of other forms of AFV refueling / recharging stations (such as hydrogen or natural gas refueling stations), they are not modeled in this program. The electric vehicle market is much more developed than the relatively nascent hydrogen- and natural gas-fueled vehicle market. Per the Department of Energy, there are currently 26,591 EV charging stations (and 85,572 charging outlets) compared to 44 retail hydrogen refueling stations and 936 compressed natural gas and liquified natural gas refueling stations.

[9] Nicholas (2019), Table 7. Note that the cost per charger does not affect employment impacts in any of the IMPLAN models. Rather, it's provided to estimate the program's impact in closing the charging infrastructure gap as outlined in Cooper, Schefter (2018). Electric Vehicle Sales Forecast and the Charging Infrastructure Required Through 2030. *Edison Electric Institute*.

[10] See footnote 6. 30C similarly would support the construction of non-EV refueling / recharging stations but is not modeled in this analysis.

[11] Specifically, based off the stated capital cost assumptions, PL 2 charging hardware would receive 10% of total program funding, while PL 2 installations would receive 15% of funding (including $55 million in annual employee compensation). Workplace charging hardware would receive 15% of total program funding with 20% going towards charger installation (including $73.2 million in annual employee compensation). DCFC hardware costs would receive 27% of program funds, while DCFC installation would receive 13% (including $35.8 in annual employee compensation).

[12] The EIA makes a similar assumption in its 2020 Annual Energy Outlook. See p. 30.

[13] 2019 battery system baseline cost are from the 2018 National Renewable Energy Laboratory benchmark of U.S. utility-scale energy storage. Energy costs are assumed to decline at the mid-point rate per the National Renewable Energy Laboratory's Cost Projections for Utility-Scale Battery Storage: 2020 Update (see Appendix, Table 2, "Normalized Cost Reduction").

[14] See Title 26-Internal Revenue Code §48(a) Energy Credit for details.

[15] Baseline scenario is based on the October 2020 EIA 860M Generator Report and an assumption that storage capacity brought online in 2023-2034 will mirror 2022-2023 levels.

[16] A 2019 Wood Mackenzie analysis found a standalone battery storage tax credit had the potential to increase investment by 16%.

[17] According to a December 2020 Wood Mackenzie report, "Solar-paired storage will account for a large majority of these installations [from 2020 to 2025], and potentially the vast majority, as developers aim to capture value from the Investment Tax Credit." Further, a July 2020 EIA report stated, "Of all operating battery storage capacity in the United States as of 2019, 25% was installed in paired systems…By December 2023 47% of operating battery storage is planned to be paired onsite with renewable generation."

Issue #2:

Develop a Critical Minerals Supply Chain That Is Not Controlled By China

24,000

jobs created and sustained for the next 2-5 years

74,000

total job-years

Proposal 5: Domestic Rare Earth Processing

Proposal Overview

Support a domestic supply chain for critical minerals.

Federal Charter for Rare Earth Processing Co-Op & Antitrust Safe Harbor

Grant interested companies from the United States — and our economic and security partners — a federal charter for a cooperative to refine and process rare earth elements in the United States. Contribute $500 million to the co-op and provide it an antitrust safe harbor so that the companies may work together to form the cooperative.[1]

Fund Research of Thorium Applications

Fund research to develop industrial, defense, and energy applications for thorium.

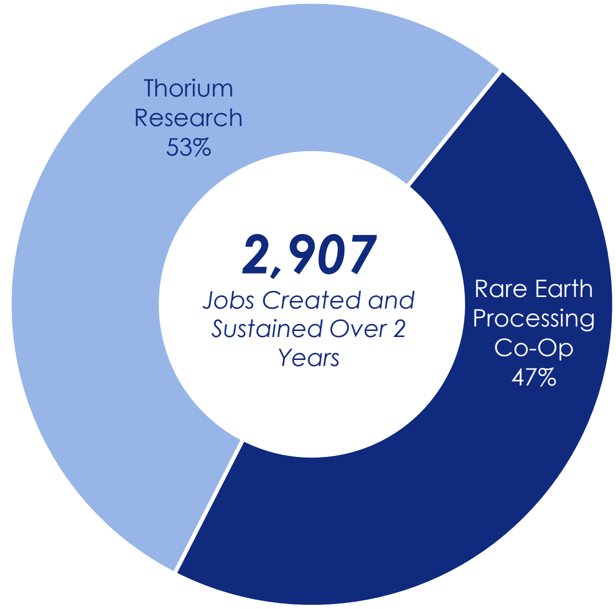
The following recommendations were not modeled:

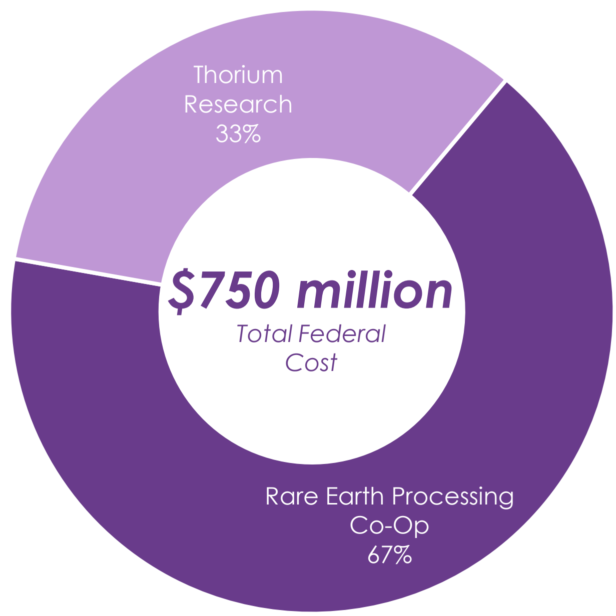
Thorium Bank

Develop a thorium bank to manage the byproduct of the refining process.

Federal Charter for Thorium

Grant a federal charter to an entity to take ownership of, and accept liability for, the mildly radioactive element, thorium, produced as a byproduct of rare earth refining, store it consistent with all regulatory requirements, and expand the market for thorium.





Industries with Largest Direct Employment Gains

Rare Earth Metal Processing

199 direct jobs

Scientific Research & Development

416 direct jobs

Employment Results

The rare earth processing co-op and thorium applications research are estimated to create **2,900 jobs** sustained over two years, including direct and supported (indirect and induced) jobs.

The federal government spending required to establish the ***rare earth processing co-op*** is expected to create nearly **1,400 jobs** over two years. All the direct jobs created by this recommendation are in rare earth metal processing. ***Research into thorium applications*** would create **1,550 jobs** over two years, with all direct jobs added in scientific research and development services.

The federal government would spend about **$130,000 per job** created each year on the recommendations in this proposal. The rare earth processing co-op recommendation would cost $184,180 per job per year, while the thorium research program would cost $80,630 per job per year.

Recommendation	Federal Cost ($ Billions)	Length of Program	Jobs Created and Sustained Over Length of Program			Total Job-Years
			Direct	*Supported*	*Total*	
Rare Earth Processing Co-Op	0.50	2 Years	199	1,159	**1,357**	**2,714**
Fund Research of Thorium Applications	0.25	2 Years	416	1,134	**1,550**	**3,100**
Proposal 5 Total	0.75		615	2,293	**2,907**	**5,814**

Modeling Assumptions

Each recommendation was modeled as a direct injection of funding to an industry. For example, funding for the thorium research program was modeled as an $125 million increase in annual federal funding for scientific research and development.

This modeling work does not consider interactions between recommendations. The recommendations to create an antitrust safe harbor and federal charter for rare earth refining and thorium programs are not explicitly modeled. While these measures would likely unlock some private industry spending, it is unclear how much net private investment might be stimulated. Only direct federal spending toward establishing a rare earth processing co-op and researching thorium applications are modeled.

Help Fund Rare Earth Processing Co-Op

Federal funding for a rare earth processing co-op is modeled as a direct injection of $500 million into the rare earth processing sector. It is assumed that the federal funding is spent on rare earth processing, modeled in IMPLAN as nonferrous metal smelting and refining. The funding is assumed to be spread over two years, with $250 million spent each year and 100% of the funding being spent domestically.

Funding could support the construction of a processing plant, processing of the metals themselves, or both. Cost estimates of building a rare earth processing plant vary by plant size but are likely to be at least $100 million.[2]

Fund Research of Thorium Applications

Thorium, a byproduct of rare earth element processing, shows potential as a lower-waste alternative to uranium in nuclear power generation. More R&D work could help to establish a better understanding of potential uses.[3]

Thorium research is modeled as an injection of federal dollars into scientific research and development services at a rate of $125 million per year for two years. Based on IMPLAN's default for this sector, 98.52% of this spending is assumed to stay in the United States.

Appendix: Citations and Footnotes

[1] Downstream supply chain uses include electric vehicles, consumer electronics, and military equipment such as unmanned aerial vehicles and high-tech manned aircraft. See "Critical Materials Rare Earths Supply Chain: A Situational White Paper," Office of Energy Efficiency & Renewable Energy, U.S. Department of Energy, April 2020.

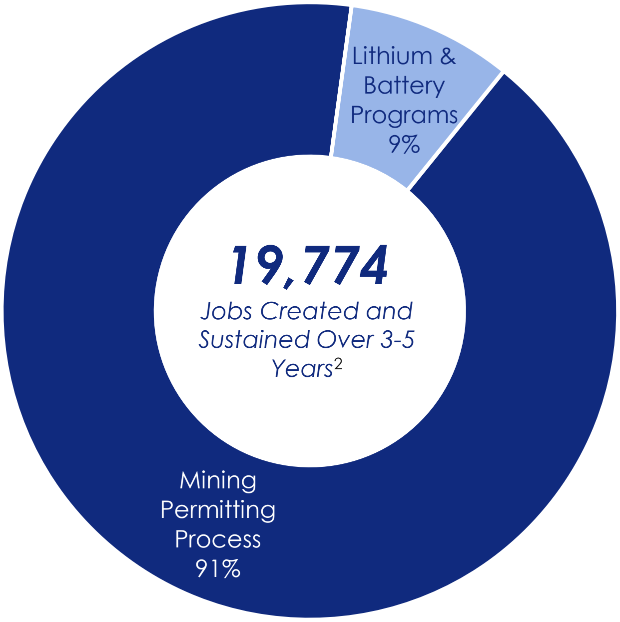
[2] In December 2019, industry executives estimated the cost of building a processing plant at $100 million. USA Rare Earth, a rare earths company, is opening a processing plant at an estimated cost of $290 million for its upcoming Round Top Mountain Project as of June 2020. See Scheyder, Ernest, "Exclusive: U.S. Army will fund rare earths plant for weapons development," *Reuters,* December 11, 2019; and Guthrie, Craig, "USA Rare Earth to open processing plant," *Mining Magazine*, June 11, 2020.

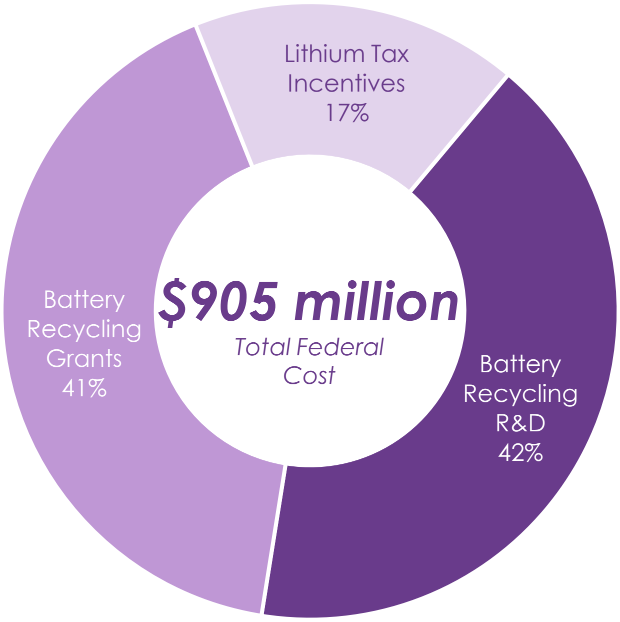
[3] See World Nuclear Association (2017), Information Library, Current and Future Generation: Thorium; Arnold, John, Thomas L. Gianetti, and Yannai Kashtan (2014), "Thorium lends a fiery hand," *Nature Chemistry* 6, p. 554.

Proposal 6: Domestic Critical Mineral Supply Chain

Proposal Overview

Support a domestic supply chain for critical minerals.





Battery Recycling R&D, Battery Recycling Grants, and Recycled Lithium Tax Incentives [1]

Support R&D, grants, and tax incentives to support recycling and development of new materials, including a tax credit to offset the incremental cost of recycled lithium above the cost of virgin lithium.

Updated Approach to Mining

Convene an advisory group representing all relevant governments and stakeholders to shape an updated approach to mining consistent with the following principles:

- Accelerate the permitting process while ensuring that all mines meet strict environmental standards;

The following recommendations were not modeled:

- Modernize our nation's mineral permitting system by implementing best practices that reduce duplication and unnecessary delays, like requiring coordination among agencies;
- Fund R&D regarding the efficient production, use, and recycling of critical minerals throughout the supply chain and support mineral recycling though grants or tax incentives; and
- Explore tax incentives such as higher depletion allowance or limits on use of depletion allowances for production of critical minerals.

Federal Permitting Improvement Steering Council

Permanently authorize the Federal Permitting Improvement Steering Council, which provides transparency on the process of permitting large infrastructure projects. Prior to the end of 2022, the government should examine whether the mining sector's participation in the Council has improved mine permitting.

Battery Recycling Code

Require that battery manufacturers place a code on batteries that can be used to identify the mineral components of the battery to facilitate recycling.

Mining Industry Metrics

Collect data and publish regular reporting of key quantitative metrics in the mining industry, similar to what the U.S. Department of Energy does with its Energy Information Administration.

Employment Results

The battery recycling, lithium recycling, and mining permitting recommendations are estimated to create almost **20,000 jobs** sustained over the next 3-5 years, including 1,400 jobs over five years from battery recycling R&D and grants and 18,400 jobs over three years from lithium recycling and mine permitting. Most of the job creation comes from accelerating the ***mining permitting process,*** which would create more than **18,000 jobs** over 3 years**.**

Federal funding to support ***battery recycling R&D*** is expected to create **911 jobs** over five years. All the direct jobs created by this program are in scientific research and development services. ***Grants to the battery recycling industry*** are expected to create **480 jobs** over five years, with all direct jobs being added to lithium recycling processing facilities.

Meanwhile, the ***lithium recycling tax incentives*** are expected to create **322 jobs** over three years, with all direct job gains similarly occurring at recycling processing facilities.

The battery recycling, lithium recycling, and mine permitting recommendations are estimated to cost the federal government about **$9,200 per job** per year. Excluding the mining permitting change, the recommendations would cost about $106,000 per job per year.

Accelerating the mining permitting process is a regulatory change that does not require any explicit federal funding. It is assumed to unlock $8.4 billion in private sector spending through the development of 12 new mines.[3]

The mining permitting process is assumed to take two years and lead to no new jobs, while the construction of mines would take two years and lead to about 18,000 jobs, with direct jobs concentrated in construction and mining machinery manufacturing.

Finally, mine production (modeled over one year) would lead to 18,125 jobs, including 5,431 direct jobs at all 12 new mines, or roughly 450 direct jobs per mine.[4] The direct job additions would account for a 3% rise in total mining employment in the United States.[5]

Recommendation	Federal Cost ($ Billions)	Length of Program	Jobs Created and Sustained Over Length of Program			Total Job-Years
			Direct	*Supported*	*Total*	
Battery Recycling R&D	0.375	5 Years	245	666	**911**	**4,555**
Battery Recycling Grants	0.375	5 Years	53	427	**480**	**2,400**
Lithium Recycling Tax Incentives	0.16	3 Years	36	286	**322**	**966**
Mining Permitting Process	0.00	3 Years *(Excludes Permitting Phase)*	5,431	12,630	**18,061**	**54,183**
Proposal 6 Total	0.91		5,765	14,009	**19,774**	**62,104**

Modeling Assumptions

The model does not consider interactions between recommendations. Each recommendation was modeled as a direct injection of funding to an industry. For example, R&D funding for battery recycling was modeled as an additional $75 million in annual federal funding for scientific research and development.

Battery Recycling R&D

Federal funding for research and development into lithium-ion battery recycling is modeled as a direct injection of $375 million into scientific research and development services over five years ($75 million per year).

Modeling Assumptions (Cont.)

Government spending in this area is intended to help fund scientists and researchers to help develop novel techniques that allow for more technologically- and cost-efficient battery recycling.

Battery Recycling Grants

Grant money for battery recycling facilities is assumed to total $375 million over five years ($75 million per year). Grant funding is modeled as a direct boost to the lithium-ion battery recycling industry, modeled in IMPLAN as secondary processing of nonferrous metals.

As the lithium-ion battery recycling industry comes online over the next decade, federal funding for this recommendation (alongside R&D) is intended as seed funding to jump-start facilities and help them achieve economies of scale so that costs decline over time.

Lithium Recycling Tax Incentives

The lithium recycling tax incentives recommendation is intended to reduce the cost of recycled lithium to the point of cost parity with that of virgin lithium.[6] Virgin lithium is assumed to cost $10/kg, while recycled lithium is assumed to cost $20/kg.[7] The tax incentive is modeled to begin in Year 3 – giving an additional two years for the nascent industry to bring recycling capacity online. The tax incentive is $10/kg in Year 3, $8/kg in Year 4, and $6/kg in Year 5. It is assumed that the cost of recycled lithium correspondingly drops by $2/kg each year as the industry's supply capacity increases, thus bringing costs down.

It is assumed that, beginning in Year 3, lithium recycling facilities will process and recycle 98% of spent electric vehicle (EV) lithium-ion batteries in the U.S.[8] It is assumed that EV batteries reach their end-of-life after eight years, with estimates of EOL EV batteries determined from the Department of Energy's Alternative Fuels Data Center EV sales data.[9]

It is assumed that the average EV battery pack is 300 kg and that 1 kg of battery-grade lithium can be recovered from 28 kg of recycled battery waste at a 98% rate of lithium recovery.[10] Further, it is assumed that EV batteries account for 50% of the lithium-ion batteries recycled annually.[11] Thus, the amount of recycled lithium recovered from EOL EV batteries is doubled to estimate the amount of annual recycled lithium and therefore the federal cost to subsidize its purchase.[12]

Mining Permitting Process

It is assumed that changes to the mining permitting process would effectively reduce the permitting approval timeline to two years. No new jobs are added during the permitting stage.

The expedited permitting process is assumed to lead to the development of two mines each of lithium, cobalt, graphite, manganese, nickel, and rare earth elements. Each of these minerals plays a role in EV battery production. As the U.S. produces more EVs, it will be critical to have a steady supply chain of these minerals available. It is assumed that there are enough economically viable reserves in the United States to support the development of these mines.

The mine permitting phase is followed by two years of construction and one year of mine production. The initial capital expenditure is assumed to be $500 million per mine.[13] For the distribution of capital expenditures, IMPLAN's default inputs for mining projects were used.

Mine production is modeled using operating expenditures for each mine, which are estimated at $200 million per mine annually.[14] The production phase of each mine is modeled based on the expenditure categories suggested in IMPLAN. The IMPLAN model is well-suited to model mine development, as it includes 12 distinct mining categories.

Appendix: Citations and Footnotes

[1] Note that while this is technically listed as only one recommendation per the *Commanding Heights of Global Transportation* report, given multiple components to the recommendation, a more detailed breakdown is provided here. For the remainder of this proposal, the various components – Lithium R&D, Grants, and Tax Incentives – are referred to and treated as distinct recommendations.

Appendix: Citations and Footnotes (Cont.)

[2] 1,391 jobs are created and sustained over five years in models with five-year lengths (battery recycling R&D and grants), while 18,383 jobs are created and sustained over three years in models with three-year lengths (lithium recycling and mine permitting).

[3] Currently, the permitting process can take seven to 10 years, according to SAFE conversations with industry experts and SNL Metals & Mining (2015), "Permitting, Economic Value, and Mining in the United States."

[4] As of December 2020, about 180,000 workers were employed in the mining (except oil and gas) subsector (Bureau of Labor Statistics).

[5] The mining scenarios model two separate phases: a construction phase followed by a production phase. Headline employment numbers reported are per-year averages rather than the sum of the two phases to account for the loss of construction jobs once production begins. For comparison, the recently proposed Thacker Pass lithium mine project in Nevada is projected to create 800 direct jobs in construction, while the operating mine is projected to employ 292 workers. It has an estimated initial capex of $581 million and operating expense of $234 million per year, according to its preliminary feasibility study.

[6] Note that the lithium recycling recommendation is primarily focused on recycling lithium-ion batteries.

[7] Cost of virgin lithium rounded up per London Metal Exchange. Cost of recycled lithium per SAFE conversations with industry leading lithium-ion battery recycler.

[8] It is assumed that non-recycled U.S. lithium consumption is 100% imported, while recycled U.S. lithium consumption is 100% domestic.

[9] EV batteries typically must be replaced every seven to 10 years. The Afterlife of Electric Vehicles: Battery Recycling and Repurposing. *Institute for Energy Research*. EV sales data sourced from Alternative Fuel Data Center: U.S. Plug-in Electric Vehicle Sales by Model. *Department of Energy*. End-of-life batteries available for recycling in 2022 are assumed to be total EV sales from 2014, available batteries for recycling in 2023 are assumed to be EV sales from 2015, etc.

[10] Berjoza (2017), Figure 1. Influence of Batteries Weight on Electric Automobile Performance. 300 kg battery pack based on popular EV models from the early 2010s (Nissan Leaf battery pack 218-270 kg, Ford Focus Electric 300 kg). Used Lithium-ion battery to recycled lithium conversion factor per Department of Energy (2019). Research Plan to Reduce, Reuse, Recycle, and Recover Critical Materials in Lithium-Ion Batteries.

[11] Per SAFE conversations with industry leading lithium-ion battery recycler.

[12] As a result, in 2022, 36,000 metric tons of used batteries is estimated to come from 120,000 EVs, resulting in the recovery of 1,250 tons of lithium. In 2023, 34,000 tons of used batteries is estimated to come from 114,000 EVs resulting in the recovery 1,200 tons of lithium; while in 2024, 59,000 tons of used batteries is estimated to come from 195,000 EVs, resulting in the recovery of 2,000 tons of lithium. Per the United States Geological Survey, U.S. lithium consumption since 2016 has been 2,000 – 3,000 tons, which is expected to increase significantly as EV adoption rises.

[13] A sample of 14 recent mine projects (Giga Metals in Canada, Arguaia Brazil, FPX Nickel in Canada, Talon Metal in the British Virgin Islands, Ivanhoe in South Africa, E3 Metals in Canada, Thacker Pass in Nevada, Mina de Barroso in Portugal, Jervois Mining in Idaho, Capstone in Chile, Formation in Idaho, Texas Mineral Resource Corp, Graphite One, and Alabama Graphite) had an average capital expenditure of $483 million.

[14] A sample of 13 recent mine projects (same as above, without Formation in Idaho) had an average operating expenditure of $176 million.

Proposal 7: Diversified Mineral Imports

Proposal Overview

Diversify mineral supplies for which there are not reserves in the United States.

Substitute Material Research

Commit to long-term R&D funding for the purpose of developing substitute materials for any critical minerals that are expected to face supply shortages.

The following recommendations were not modeled:

Limit Chinese Investments

Work with allied nations to encourage them to limit Chinese investment in critical resource reserves.

Deepsea Mining

Ratify the United Nations Convention for the Law of the Sea and join the International Seabed Authority so that American companies can explore and eventually access valuable mineral resources on the seabed.

1,214 jobs
created and sustained over five years by funding for scientific R&D

$500 million
total federal spending

Employment Results

R&D funding to ***research substitute materials for critical minerals*** is estimated to create over **1,200 jobs** over five years, including direct and supported (indirect and induced) jobs. All 326 of the direct jobs created by this program are expected to benefit scientific research and development services. With a cost of $100 million per year, the R&D funding would cost the federal government about **$82,000 per job per year**.

Recommendation	Federal Cost ($ Billions)	Length of Program	Jobs Created and Sustained Over Length of Program			Total Job-Years
			Direct	*Supported*	*Total*	
Substitute Material Research	0.50	5 Years	326	888	**1,214**	**6,070**

Modeling Assumptions

This recommendation is intended to support research into substitute materials for critical minerals that are expected to face supply shortages. It would also support research into new battery chemistries that could eliminate the need for critical minerals (e.g., batteries that don't require minerals like cobalt, which has a high supply chain risk). Funding is modeled as a direct injection of federal dollars into scientific research and development services at a rate of $100 million per year for five years.

Issue #3:

Advance Next-Generation Transportation and Semiconductor Technology

108,000

jobs created and sustained over the next 2-5 years

512,000

total job-years

Proposal 8: Promote Autonomous Vehicles

Proposal Overview

Modernize motor vehicle regulations in order to preserve and strengthen American leadership in autonomous vehicle (AV) technology.[1]

Increase Exemption Cap

Enable the domestic, at-scale manufacturing of AVs by providing the National Highway Traffic Safety Administration (NHTSA) with the authority to grant Federal Motor Vehicle Safety Standards (FMVSS) exemptions for up to 100,000 vehicles per manufacturer — if the manufacturer demonstrates to NHTSA that the vehicle is as safe as, or safer than, FMVSS-compliant vehicles.

The following recommendation was not modeled:

Regulatory Efficiency

Federal regulation of automotive safety should evolve to a more flexible and collaborative model predicated on performance-based standards, by adopting industry consensus standards within 18 months of their completion.

40,647 jobs created and sustained over five years by revising outdated regulations

$0 in federal spending required due to rule change

$2.5 billion in private sector investment unlocked

Employment Results

The recommendation to ***increase the exemption cap*** is estimated to create or **40,000 jobs** over five years.[2] The exemption cap increase is a regulatory change that does not require any explicit federal funding, and it is expected to unlock $2.5 billion in private sector spending.

The first two years of the recommendation consist of the construction or re-fitting of **10 factories** to produce AVs, which is expected to involve annual spending of **$1.25 billion in private investment** for two years.[3] The two years of construction are expected to create about 15,000 jobs.

Autonomous vehicle production is modeled over the following three years and is expected to lead to an **additional $5.85 billion in spending on autonomous vehicles**. AV production is expected to create 57,963 jobs over three years.

Recommendation	Federal Cost ($ Billions)	Length of Program	Jobs Created and Sustained Over Length of Program			Total Job-Years
			Direct	*Supported*	*Total*	
Increase Exemption Cap	0.00	5 Years	14,682	25,965	**40,647**	**203,235**

Modeling Assumptions

The exemption cap was modeled in part as an increase in demand for materials necessary to construct AV factories and in part as a demand shock for the approximate additional spending that would occur if the cap were lifted. Lifting the cap is estimated to trigger $1.95 billion annually in AV purchases.

The recommendation to increase the FMVSS exemptions cap from 5,000 to 100,000 vehicles is a regulatory change that would unlock private spending. It is assumed that, currently, AV companies are refraining from building factories and producing AVs because regulations are so uncertain.

It is assumed that the regulatory change would incentivize the construction or re-fit of 10 factories that could each produce 30,000 AVs per year.[4] It is estimated that the construction or refit of one production facility would cost an average of $250 million over two years, for an increase of $2.5 billion in total private investment.

Construction is modeled over the first two years following the regulation change, while production is modeled over Years 3 through 5. Construction is modeled as an increase in demand for construction materials and services using the IMPLAN model.

Most of the annual $1.25 billion in private industry spending on construction is modeled as demand for newly constructed manufacturing structures, machine tools, special tools and fixtures, and custom computer programming services.

All AVs are assumed to be electric vehicles and one-third of the cost of an electric AV is assumed to go toward battery production.[5] AVs are estimated to cost an average of $43,411 per vehicle.[6] It is assumed that demand will be high enough that all vehicles produced will be purchased. Demand in Years 3 through 5 could come from individuals, rideshare companies, or delivery services. It also is assumed that AV and non-AV prices stay constant over the 5-year period modeled.

It is assumed that 95% of AVs purchased directly replace a non-AV vehicle that would have been purchased during the same year, and it is assumed that the average cost of a non-AV vehicle is $32,000.[7]

Spending that occurs because of construction of facilities flows partly inside the U.S. and partly internationally, depending on the spending category.[8] AV production is modeled as 100% domestic, because all the newly-constructed facilities would be located within the United States.

Appendix: Citations and Footnotes

[1] For further information on the economic impacts of AVs, see SAFE (2018), "America's Workforce and the Self-Driving Future: Realizing Productivity Gains and Spurring Economic Growth."

[2] The scenario modeled involves two separate phases: a construction phase followed by a production phase Headline employment numbers reported are per-year averages rather than the sum of the two phases. This accounts for the loss of construction jobs once production begins.

[3] While the manufacturing of autonomous delivery vans and trucks would also be incentivized by this recommendation, this model focuses on light-duty AV manufacturing.

Appendix: Citations and Footnotes (Cont.)

[4] There are at least 10 U.S.-based AV companies with over $2 billion in estimated market valuation each, including Argo ($7.25 billion); Aptiv ($4 billion); Aurora ($2 billion); Cruise ($19 billion); Nuro (valued at $2.7 billion); Pony.ai ($3 billion); Tesla; Uber (AVs valued at $7.25 billion); Waymo ($30 billion); and Zoox (purchased by Amazon for $1.2 billion). It is not assumed that these particular companies would build or re-fit an AV factory if the exemption cap were raised; rather, this list is representative of the financial strength of the industry.

[5] Most AVs, though not all, are expected to be electric. Marshall, Aarian, "The Intersection Between Self-Driving Cars and Electric Cars," *Wired*, July 13, 2020.

[6] Based on Keybridge calculations of Department of Energy (2019) data on electric vehicle sales by make and model. The $43,411 value used in the model is a weighted average cost by vehicles sold for models with greater than 1,000 sales. Though it is unclear exactly how much they will cost, experts suggest that AVs will be priced similarly to EVs already on the road. See Ritchie, Earl, "Self-Driving Automobiles: How Soon And How Much?", *Forbes*, May 21, 2019.

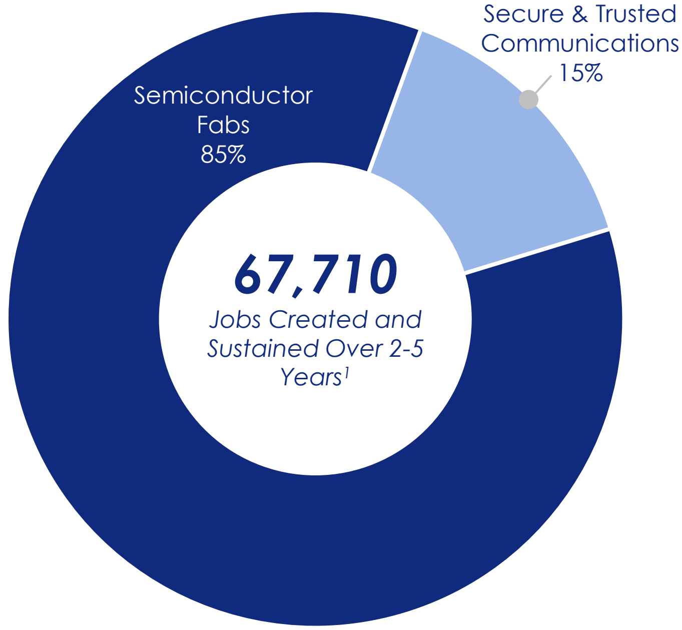
[7] Griffith, Saul, Sam Calisch, and Alex Laskey (2020), "Mobilizing for a zero carbon America," *Rewiring America*. See Table 7. The authors estimate the average cost of non-electric light-duty vehicles at $32,000.

[8] For example, it is estimated that 51.6% of spending on machine tools and 98.6% of spending on custom computer programming services stay within the U.S., based on IMPLAN model's default regional purchase coefficients for these categories. Each of the construction spending components is modeled based on the IMPLAN defaults, which are derived from BEA demand and supply data from 2018.

Proposal 9: Telecommunications Security & Semiconductor Fabrication

Proposal Overview

Establish strict oversight of the operation of Chinese-owned telecommunications networks in the United States, implement strict limits on the use of Chinese equipment in U.S. telecommunications networks, and incentivize high-tech manufacturers to establish manufacturing facilities in the United States.

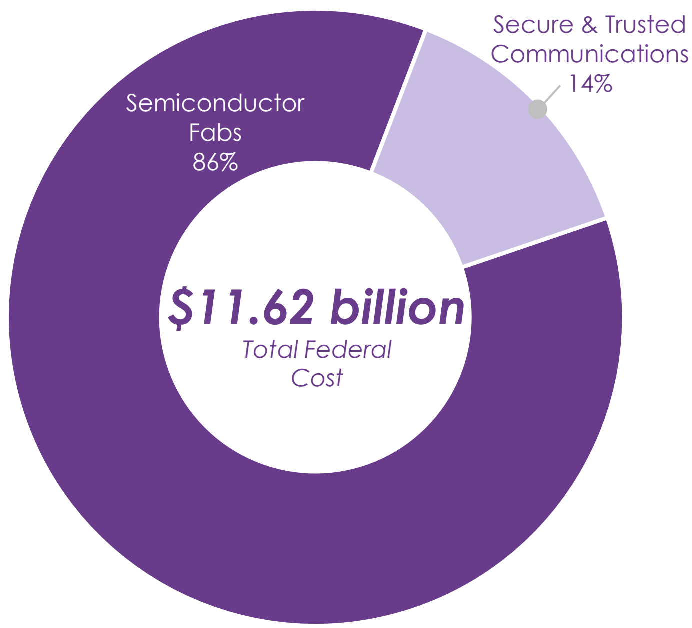


Secure and Trusted Communications Network Reimbursement Program

Congress should monitor the Secure and Trusted Communications Networks Reimbursement Program and appropriate additional funding if needed to complete the replacement of suspect 5G equipment.

Semiconductor Fabrication Plant Grants

Establish a $10 billion grant program over the next five years for the purpose of supporting construction of semiconductor fabrication plants ("fabs") in the United States.



The following recommendations were not modeled:

Screen Telecommunications Equipment

The Federal Communications Commission (FCC) must rigorously screen all mobile telecommunications equipment to ensure networks are secure. It must limit use of components from companies or nations that pose a risk to the security of U.S. 5G networks.

Authorize and Fund FCC Committees

Congress should authorize the advisory role of appropriate departments to the FCC regarding the operation of foreign telecommunications companies in the United States and ensure that the function is appropriately staffed and funded.

Standard for Revoking Operating Authorization

The FCC should establish a clear standard for revoking operating authorization for foreign telecommunications firms, and then carefully review all Chinese operators.

Committee on Foreign Investment in the United States (CFIUS) Coordination

Future foreign investments in the U.S. telecommunications networks should be coordinated with CFIUS.

Employment Results

The ***Secure and Trusted Communications Network Reimbursement Program*** is modeled over 18 months and is expected to cost about $1.08 billion in Year 1 and $539 million in Year 2. Because the recommendation is modeled over 18 months, it would support 13,325 jobs over an 18-month period, which is equivalent to an average of nearly **10,000 jobs** over two years.

The recommendation would add 4,604 direct jobs, primarily in the electronics and appliance retail sector, followed by the electronic equipment repair sector. It would also add 5,365 supported jobs.

The ***semiconductor grant program*** would incentivize the construction of three additional fabrication plants, creating over **57,000 jobs** sustained over five years. The construction phase would lead to over 72,000 jobs, while the production phase would lead to about 36,000.[2] Each of the three incentivized semiconductor fabrication plants would directly employ over 1,700 workers, for a total of 5,150.[3]

The two recommendations modeled here would cost about $41,500 per job per year in federal spending. The program to "rip and replace" insecure communications equipment is estimated to cost about **$81,000** in federal dollars per job per year, while the semiconductor grant program would cost about **$35,000** per job per year.

The semiconductor program appears to be highly efficient in part because two years of semiconductor production are modeled in addition to three years of partially government-funded construction, and the production phase does not rely on any federal funding.

Recommendation	Federal Cost ($ Billions)	Length of Program	Jobs Created and Sustained Over Length of Program			Total Job-Years
			Direct	*Supported*	*Total*	
Secure & Trusted Communications Network Reimbursement	1.62	2 Years	4,604	5,365	**9,969**	**19,938**
Semiconductor Fabrication Plant Grants	10.00	5 Years	18,413	39,328	**57,741**	**288,705**
Proposal 9 Total	11.62		23,017	44,693	**67,710**	**308,643**

Modeling Assumptions

Secure & Trusted Communications Network Reimbursement Program

The recommendation is modeled as an increase in demand for the labor and materials necessary to remove unsecure telecommunications equipment and replace it with similar equipment from trusted sources.

The Secure and Trusted Communications Network Reimbursement Program is estimated to cost $1.618 billion, based on estimates from the FCC.[4] This funding has not yet been appropriated.[5] The recommendation is modeled over an 18-month period, with two-thirds of the funding spent in Year 1.

While the Secure and Trusted Communications Network Act specified that the program should be completed within one year, the FCC can grant extensions for up to six months following the deadline.[6]

It is assumed that 70% of the program's funding would be used for equipment purchases, while 30% would be used for installing the equipment.[7] The equipment purchases are modeled as an increase in demand for broadcast and wireless equipment, with 8.1% of the funding staying within the United States (based on IMPLAN's default domestic purchase share for that commodity).

Modeling Assumptions

By contrast, the installation costs are modeled as an injection of money into the electronic and precision equipment repair and maintenance sector, with 100% of spending staying domestic.

Semiconductor Fabrication Plant Grants

This scenario assumes that seven new fabrication plants will be constructed over the next five years, with three of those plants being built specifically because of the $10 billion grant program. [8] This scenario is intended to model the employment impacts of the three incentivized fabs, though all seven plants would receive federal grant money.

The grant program is assumed to disburse funds equally to the seven newly built fabs, and each fab is assumed to cost $10 billion to build.[9] Thus, the grant program covers 15% of capex costs for each new fab.

Construction is assumed to take place evenly over three years, leading to $10 billion in additional private sector investment each year. Construction is modeled as a demand shock for the construction of semiconductor manufacturing facilities and the capital equipment purchased to outfit the plant. The distribution of capital expenditures is based off IMPLAN recommendations, with almost half (45%) going towards the purchase of semiconductor manufacturing equipment.

Following the construction phase, semiconductor production is modeled over two years. Production is modeled as operating expenditure for each semiconductor fab. Operating expenses are assumed to be $1.3 billion per plant per year,[10] for a total of $3.9 billion in additional spending each year.

Appendix: Citations and Footnotes

[1] 57,741 jobs are created and sustained over five years in models with five-year lengths (semiconductor grants), while 9,969 jobs are created and sustained over two years in models with two-year lengths (Secure and Trusted Communications).

[2] As modeled, this recommendation contains two separate phases: a construction phase followed by a production phase. Headline employment numbers reported are per-year averages rather than the sum of the two phases. This accounts for the loss of construction jobs once production/operations begins.

[3] For comparison, recent fabrication plants from TSMC, Global Foundries, and Intel are expected to directly employ 1,600 - 1,900 workers, 1,400 workers, and 3,000 workers, respectively.

[4] Federal Communications Commission (2020), Public Notice DA 20-1037: Wireline Competition Bureau and Office of Economics and Analytics Release Results from Supply Chain Security Information Collection.

[5] Johnston, Jeff (2020), "Funding Uncertainties Wreak Havoc for Rural Communications at the Worst Time Possible." CoBank.

[6] H.R. 4998: Secure and Trusted Communications Networks Act of 2019.

[7] The 30% installation cost is based on two sources: a Strand Consult report that estimated installation costs at 40% of total costs and a set of comment letters to the FCC from small telecommunications firms who estimated installation costs at 17% to 64% of total costs. See Strand Consult (2019), "The real cost to rip and replace of Chinese equipment in telecom networks," and Federal Communications Commission (2019), FC 19-121, Page 45.

Appendix: Citations and Footnotes

[8] These assumptions are based on a September 2020 report from Boston Consulting Group (BCG) and the Semiconductor Industry Association (SIA), which found that nine fabs would be built in the U.S. from 2020-2030 without any new incentives and that five additional fabs would be built with $20 billion in government incentives. This report covers a five-year timeframe, so the BCG/SIA numbers are halved and rounded up. It is assumed that four fabs would be build from 2020-2025 without incentives, and that three additional fabs would be built with $10 billion in government incentives.

[9] The $10 billion capex figure is based on recent fabrication plants including the Intel Fab 42 ($7 billion) and TSMC ($12 billion), as well as the *New York Times* (June 2020), "Lawmakers Push to Invest Billions in Semiconductor Industry to Counter China," ($10 billion) and the 2020 BCG report ($5 - $20 billion).

[10] Operating expenses are based on the midpoint of a $0.6 to $2 billion range from the BCG report (2020).

Appendix I : Employment Totals

Proposal	Federal Cost ($ Billions)	Total Spending ($ Billions)	*Jobs Created and Sustained Over 1-5 Years*			Total Job-Years
			Direct	*Supported*	*Total***	
Issue #1: Support the Advanced Fuel Vehicle Market and Domestic Manufacturing						
Proposal 1: *Light-Duty EV Incentives & Regulations*	$6.00 (EV Incentives) - (Regulatory Reform)	$13.80 (EV Incentives) $19.20 (Regulatory Reform)	14,916 (EV Incentives) 20,848 (Regulatory Reform)	32,798 (EV Incentives) 39,520 (Regulatory Reform)	**47,714** (EV Incentives) **60,378** (Regulatory Reform)	**143,142** (EV Incentives) **301,890** (EV Incentives)
Proposal 2: *Medium- and Heavy-Duty EV Incentives*	$37.35	$76.70	43,526	110,439	**153,965**	**752,230**
Proposal 3: *Transportation Manufacturing Grants & Tax Incentives*	$20.05	$101.45	99,781	170,234	**270,016**	**1,327,848**
Proposal 4: *Electric Charging & Storage Infrastructure*	$6.23	$10.03	12,020	17,058	**29,079**	**144,473**
Issue #2: Develop a Critical Minerals Supply Chain That is Not Controlled by China						
Proposal 5: *Domestic Rare Earth Processing*	$0.75	$0.75	615	2,293	**2,907**	**5,814**
Proposal 6: *Domestic Critical Mineral Supply Chain*	$0.91	$9.30	5,765	14,009	**19,774**	**62,104**
Proposal 7: *Diversified Mineral Imports*	$0.50	$0.50	326	888	**1,214**	**6,070**
Issue #3: Advance Next-Generation Transportation and Semiconductor Technology						
Proposal 8: *Promote Autonomous Vehicles*	-	$14.20	14,682	25,965	**40,647**	**203,235**
Proposal 9: *Telecommunications Security & Semiconductor Fabrication*	$11.62	$39.40	23,017	44,693	**67,710**	**308,643**
Commanding Heights Total	**$77.41***	**$271.53***	**220,590***	**425,099***	**645,690***	**3,112,307***

**Excludes Light-Duty EV Incentives. See Proposal 1 (page 6) for an explanation about double-counting.*
***607,797 jobs are created and sustained over five years in models with five-year lengths; 18,594 jobs are created and sustained over three years in models with three-year lengths; 18,741 jobs are created and sustained over two years in models with two-year lengths; 558 jobs are created and sustained over one year in models with one-year lengths.*
Note: numbers may not add up due to rounding. Total proposal employment impacts were calculated by summing total impacts of each recommendation within a proposal rather than summing the full proposal's direct and supported employment impacts.

Appendix II : Technical Note & About Keybridge

Technical Note

Keybridge quantified the impact of the Commanding Heights proposals on main components of aggregate demand in U.S. GDP (e.g., investment spending on structures, investment spending for transportation equipment, state and local government infrastructure spending, investment spending on research and development, etc.) and then used the IMPLAN Model of the U.S. Economy to calculate employment effects from these revised demand components. IMPLAN estimates employment effects of economic shocks using Bureau of Economic Analysis (BEA) data. All employment results reflect both part-time and full-time jobs as defined by the BEA (not full-time-equivalent jobs).

In normal "full employment" economic conditions, increased spending on one component of GDP might be expected to crowd out spending in other areas. For example, a new job created in one area, like advanced auto, truck, and bus manufacturing, might offset a job that might be lost in another sector. However, given a national unemployment rate in late 2020 of about seven percent, Keybridge believes that this constraint can be relaxed at this time, and that most of the jobs that might be created by the Commanding Heights policies would be filled by workers who otherwise would be unemployed.

Over the course of years, moderately higher budget deficits due to the higher levels of government spending envisioned by the Commanding Heights proposals would be expected to lead to modestly higher interest rates, and this could have a mild dampening effect on other private investment spending in the future. For this reason, ultimate employment effects estimated in this report might be somewhat lower over the long term.

Appendix II : Technical Note & About Keybridge

About Keybridge

Keybridge is a boutique economic and public policy consulting firm. Founded in 2001, Keybridge's mission is to be a highly trusted source of analysis and advice on issues at the forefront of public policy economics. Keybridge staff serve as economists, policy experts, and strategic advisers to a diverse clientele that includes Fortune 500 companies, global financial firms, leading trade associations, non-profit organizations, federal government agencies, and other institutions that operate at the intersection of economics and public policy.

Keybridge is dedicated to delivering analysis and advice that shapes business decisions and drives policy debates. For this project, Keybridge received policy proposals from SAFE and worked with SAFE to develop a set of reasonable modeling assumptions for each proposal. Keybridge did not create the proposals, nor does Keybridge advocate for the recommendations laid out in this document. Rather, Keybridge's role was to provide sound economic analysis and employment modeling.

Keybridge specializes in developing creative analytical approaches to complex problems, often using a mix of methods and data sources to triangulate on results and stress test key conclusions. The firm's services range from economic modeling and investment analysis to policy design.

Keybridge's senior staff includes individuals with distinguished academic credentials, exceptional analytical skills, and practical experience within institutions at the highest levels of policymaking, including the Council of Economic Advisers, the National Economic Council, the Government Accountability Office, the International Monetary Fund, the Board of Governors of the Federal Reserve, and the World Bank.

Keybridge's work is guided by a set of core values. We believe that public policy economics makes a difference, and we have a duty to conduct analysis in a thoughtful and responsible manner. We believe that solving problems at the forefront of public policy economics requires creative thinking and a willingness to question conventional wisdom. We believe that sound decisions demand impartial analysis and that clients are always best served by objective advice.

For more information, please visit our website at www.keybridgedc.com.