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Freedom to Fuel: Consumer Choice in the Automotive Marketplace

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Executive Summary

As consumers become more accepting of electric vehicles (EV), taxpayer-funded incentives expand, and automobile manufacturers produce a greater variety of models, EV purchases are expected to keep growing. The public and policymakers, however, should be increasingly mindful not to put the cart before the horse when it comes to centrally planned mandates that attempt to drive consumers to purchase products they aren't ready to accept, they can't afford to purchase, and that face significant supply-chain bottlenecks that are already limiting supply and increasing costs.

Substantial infrastructure investment — in both the EV charging network and the electric generation, transmission, and distribution systems — is needed before widespread adoption can occur. Banning gasoline and diesel-powered vehicles and forcing consumers to purchase EVs before states have the requisite infrastructure needed to support this will imperil the electric grid. Such policies will also be disadvantageous for consumers and the economy in terms of electric grid reliability and cost considerations.

During the last decade, as public policy action on climate and the environment has migrated from the federal to the state level, the automotive sector has found itself the subject of new regulations that could shake up the industry, and American vehicle choice, as never before. Where once it was incremental increases in Corporate Average Fuel Economy (CAFE) standards at the federal level that had the most impact on the industry, we now have EV mandates in place in several states and under consideration in quite a few more. Many of these mandates have been handed down without adequate cost-benefit or market impact analyses.

Massachusetts and New York have both enacted legislation banning new registrations of internal combustion engine light-duty vehicles starting in 2035.[1] California has pursued an EV mandate through an Executive Order and regulatory restrictions put into effect by the California Air Resources Board (CARB) that will ban sales of internal combustion engine vehicles as soon as 2035. Other states are opting into the California ICE ban or setting informal goals and targets. New Mexico recently set a goal of having 7% of all new vehicle sales be EVs by 2025. Michigan has set a goal of 2 million EVs on the road by 2030. Another half dozen states have set more modest targets, mostly by 2030 or 2035.

Most recently, the U.S. Environmental Protection Agency (USEPA) has released two new emissions rules that require 60% of all new vehicles sold to be only electric vehicles by 2030 and 67% by 2032.[2]

While there are clearly many reasons to pursue EV as a mobility option, the push by elected officials toward mandates or target EV sales goals by a certain date, often fail to take into account many of the real-world economic, social, and practical problems created by these sorts of regulations. Too often, the consumer is completely left out of the discussion.

What is also frequently left out of the discussion are the advances in new technologies – lower carbon fuels, hybrid electric vehicles, and fuel cells – that are moving us towards a lower-emission future while also offering families and businesses multiple, and sometimes better, choices to meet their driving needs and continue our march toward meeting our environmental goals.

It is becoming increasingly clear that policymakers are not fully considering all the implications of aggressively mandating EVs. This risks near- and long-term consumer acceptance of EVs and increases the likelihood of unintended consequences causing an overall negative reaction to the increased utilization of EVs. To avoid this possible outcome, policymakers should more carefully consider several critically important issues.

In an effort to ensure consumer acceptance for EVs and reduce negative economic and societal impacts, this paper raises many important topics that should be considered and poses questions that lawmakers and regulators should address before imposing mandates which will have a significant impact on the U.S. economy—and especially those living on low and fixed incomes.

Some of these questions include:

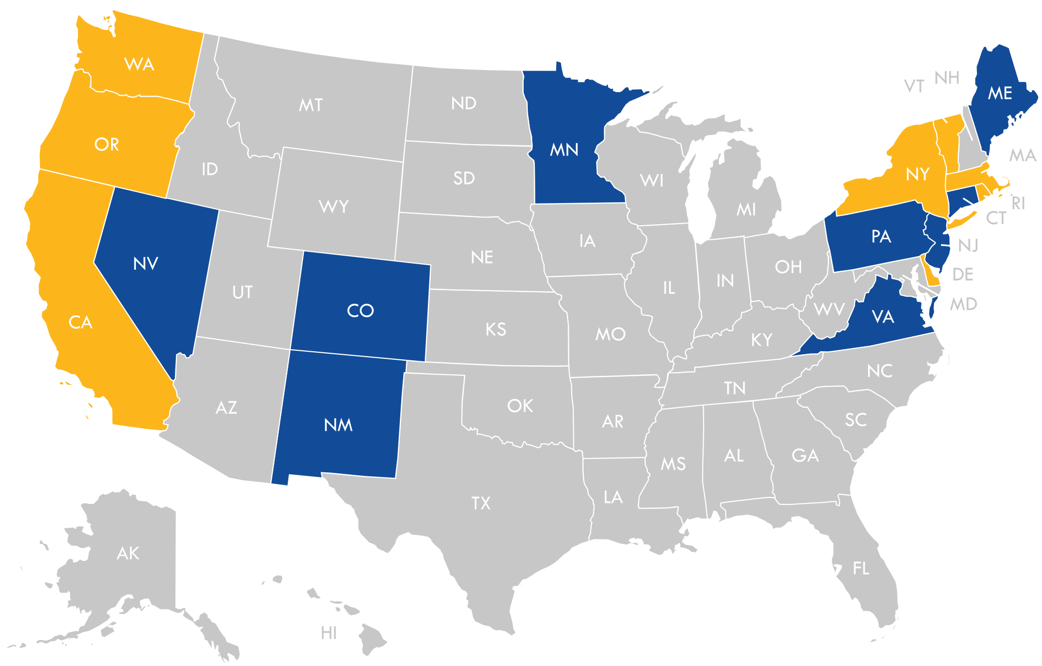
- What is a realistic timeframe for the United States to move its fleet to all-electric vehicles?
- What is the true cost to consumers of moving from internal combustion engine-powered vehicles to electric vehicles?
- What electric generation requirements are necessary to power a move to electric vehicles?
- What transmission investments are required to ensure consumers are able to conveniently charge electric vehicles?
- Is the supply chain for electric vehicles more or less advantageous to the national security prospects of the United States in comparison to ICE vehicles?
- With state transportation budgets primarily financed by gas and diesel fuel taxes, how will governments ensure our transportation infrastructure is adequately maintained?
- How does a transition and vehicle affordability affect equitable job growth in the United States?
- Is due consideration being given to EV affordability and current taxpayer-funded incentives, which at present can only be availed by higher-income earners and not the majority of Americans?

The EV Transition **by the Numbers**

Many states are considering mandates that force the transition from ICE vehicles to EVs either through executive orders or more likely, through the adoption of California's Advanced Clean Cars II regulations.[3] Unfortunately for many consumers, some states which have adopted California's regulations have triggers that automatically opt them into any future California regulatory regime for which the U.S. EPA provides a waiver. This denies residents and businesses of the affected states from having an opportunity to comment or provide meaningful input on policies that may greatly impact their everyday lives.

California's ZEV Rules Effects Beyond It's Borders

New CA rule Requires 100% zero emission vehicle sales by 2035



States that Follow CA standards and announced commitments to new rule

States that follow CA standards but not committed to new rule

Source: California Air Resources Board

Whether the result of legislation or regulation, EV mandates and ICE bans are often imposed on consumers because of statutes or executive orders laying out NetZero goals to be met by 2030, 2035, 2040 or 2050. With the transportation sector responsible for 28% of the carbon dioxide emissions in the U.S., most states currently considering a move toward NetZero are likely to consider, among other options, attempting to shift from ICE vehicles to EVs for mobility to have any hope of meeting these goals — ignoring advances in the development of lower carbon liquid fuels and other technologies.[4]

Decision-makers in those states are starting to realize that while EV adoption has been accelerating over the last few years, especially among wealthier families who can afford the higher average purchase price of an EV, the general public has been far more reluctant to adopt them. In order to stay on a path that makes NetZero commitments possible, several states are now considering or have adopted EV mandates. Typically, these mandates take the form of banning sales of new ICE vehicles after a certain date or dictating what percentage of sales on the free market should be EVs.

As is often the case, it appears many decision-makers have failed to consider the real-world implications of the mandates they are imposing. To appreciate the enormous changes these mandates will usher in, it is more helpful to look at this on a smaller scale than the national level.

Let's consider Massachusetts. The state enacted a regulatory framework at the end of 2020 which imposes a NetZero emissions limit by 2050. This includes a mandate which, "will require (zero-emission vehicle) sales to ramp up to 100% of new (light-duty vehicle) sales by 2035."[5]

In 2021, there were about 5.4 million light-duty vehicles (passenger cars, SUVs and light trucks) registered in Massachusetts.[6] Of these, 191,500 were EV, Plug-In Hybrid EV (PHEV), or Hybrid EV (HEV). There were about 275,000 new light duty vehicles sold in MA in 2022.[7] Let's assume a 1% overall growth rate, and that 20,000 EVs will be sold in the state in 2023 (vs 9,000 sold in 2021). This projects to about 7.2% of all new vehicle sales in Massachusetts in 2023 will be EVs. Further assuming about 230,000 vehicles (virtually all ICE) will be retired in Massachusetts, we will see EVs making up about 3.9% of the total registered vehicles in Massachusetts in 2023. This would put the state in the top 5 of the 50 states according to data from the U.S. Department of Energy. Certainly, this would make the state among the leaders in shifting from ICE vehicles to EVs.

If we extrapolate that new car and retirement trends continue, and EV sales in 2024 can jump to 10% of new car sales, and then increase market share of new cars by 50% for the next several years, what percentage of the registered automobiles in Massachusetts would be EVs by the start of 2028? It would be only 10.8%.

Given the current adoption of EVs in a state that is among the leaders, it seems unreasonable to think that under current market conditions this kind of pace will be achievable. Yet even under these very generous adoption rates, less than 11% of the Massachusetts fleet of light-duty vehicles would be electric by 2028.

State	Net Zero Target Date	InterimTargets
California (executive order)	2045	(Statute) 40% below 1990 levels by 2030
Hawaii (statute)	2045	26-28% below 2005 levels by 2025; 40-50% by 20302050
Louisiana (executive order)	2050	(Statute) 45% below 1990 levels by 2030; 80% by 2050
Maine (executive order)	2050	60% below 2006 levels by 2031
Maryland (statute)	2045	50% by 2030; 75% by 2040
Massachusetts (statute)	2050	26-28% below 2005 levels by 2025
Michigan (executive order)	2050	
Montana (executive order)	2050	28% below 2005 levels by 2025; 45% by 20302045
Nevada (statute)	2050	40% below 1990 levels by 2030; 85% below 1990 levels by 2050
New York (statute)	2050	50% below 2005 levels by 2030
North Carolina (executive order)	2050	10% below 1990 levels by 2020; 45%below 1990 levels by 2030; 80% below 1990 levels by 2040
Rhode Island (statute)	2050	
Virginia (statute)	2045	45% below 1990 levels by 2030; 70% by 2040; 95% by 2050
Washington (statute)	2050	

Source: Council of State Governments

Going further, if theoretically more than 50% of all new light-duty vehicles sold in Massachusetts were EVs in 2028, 80% were EVs in 2029 and 100% of all new vehicles were EVs from 2030 onward, then by 2035 less than half of all vehicles on the road in Massachusetts would actually be EVs. This is a conservative estimate, as it is highly likely that under this type of mandate ICE owners would hold onto their vehicles longer and the used ICE market would become more robust, lowering the number of vehicles retired in the later years while sustaining the number of ICE vehicle registrations overall.

Again, even with Massachusetts' robust adoption rate, it will fall short of hitting its EV target – and that assumes that the conservative assumptions here are actually met.

Massachusetts Vehicle Fleet Transition Projection

	% of New Sales as EV	Non-EV	EV	Total	New Cars	New EVs	New Non-Evs	Retired	Net	EV / Total
2022		5,200,900	191,500	5,392,400	275,000					
2023	7.2%	5,225,900	211,500	5,437,400	276,375	20,000	256,375	231,375	45,000	3.9%
2024	10.9%	5,241,186	241,664	5,482,850	277,757	30,164	247,592	232,307	45,450	4.4%
2025	16.3%	5,241,617	287,137	5,528,755	279,146	45,473	233,673	233,241	45,905	5.2%
2026	24.4%	5,219,431	355,688	5,575,118	280,541	68,550	211,991	234,178	46,364	6.4%
2027	36.7%	5,162,918	459,027	5,621,945	281,944	103,340	178,605	235,117	46,827	8.2%
2028	55.0%	5,054,429	614,811	5,669,241	283,354	155,784	127,569	236,058	47,295	10.8%
2029	82.5%	4,867,353	849,656	5,717,009	284,771	234,845	49,926	237,002	47,768	14.9%
2030	100.0%	4,629,404	1,135,851	5,765,255	286,194	286,194	-	237,948	48,246	19.7%
2031	100.0%	4,390,507	1,423,476	5,813,984	287,625	287,625	-	238,897	48,729	24.5%
2032	100.0%	4,150,660	1,712,540	5,863,200	289,064	289,064	-	239,848	49,216	29.2%
2033	100.0%	3,909,859	2,003,049	5,912,908	290,509	290,509	-	240,801	49,708	33.9%
2034	100.0%	3,668,103	2,295,010	5,963,113	291,961	291,961	-	241,756	50,205	38.5%
2035	100.0%	3,425,389	2,588,431	6,013,820	293,421	293,421	-	242,714	50,707	43.0%

Source: Calculations based on Massachusetts Vehicle Registration

This type of hyper-growth adoption is unrealistic and unlikely to occur, even if mandated, as there are many aspects of EV adoption, as outlined in this report, that are extremely difficult or impossible to overcome. Otherwise, we would be seeing EVs represent much more than their current 4% share of new vehicle sales in the state. What is clear is that officials in Massachusetts (and any other state enacting EV mandates) either have not considered what a realistic path to an all-electric transportation system looks like, or they believe that the public will give up on what is best for their livelihoods and give in on a timetable that adheres to the mandates.

Policy Consideration #1: **Cost of ICE vs EV**

One of the expected drivers of EV adoption cited by proponents is the Total Cost of Ownership (TCO), which factors in all vehicle-related costs including purchase price, fuel cost, insurance, and maintenance for the vehicle's lifespan. Numerous studies have been conducted over the last decade arguing that while the upfront cost of an EV may be substantially higher than that of an ICE vehicle, the low cost of charging versus the cost of gasoline gives EVs an advantage.

This is a very important consideration as proponents of EV mandates attempt to accelerate their mainstreaming. In order for the EV adoption math to come close to working in a state like New York for example, EVs will have to become more affordable for middle-income families. The economics matter much less for wealthy early-adopters than for those on fixed- or low-incomes. When decisions need to be made by families where discretionary spending is more limited, total cost of ownership becomes a very important issue. When states are mandating EVs, at a certain point it becomes imperative to understand how these economics impact low- and middle-income earners.

Looking at New York, it certainly appears that the total cost of ownership in reality is higher than the claims made by advocates of EV mandates.

According to the U.S. Department of Transportation Federal Highway Administration the average annual mileage for a light vehicle in New York State in 2020 was 8,404 miles.[8] Considering the average ICE vehicle achieves 25.4 MPG, this would equal 331 gallons of gasoline per year.[9] The average cost of regular unleaded gasoline in New York in 2021 was $3.028/gallon, which results in $1,002 per year in fuel costs for the average ICE vehicle.[10]

If we assume an average EV efficiency of 0.364 kWh/mile, 8,404 miles would require 3,059 kWh/yr of electricity for an EV in New York.[11] At an average residential electric rate of $0.1948/kWh[12] in 2021, we get $596 in "fuel" costs for the average EV, clearly an advantage for EVs over ICE vehicles. To the consumer, gasoline prices may appear more volatile because they move higher and lower on an almost daily basis. Electricity prices, however, are far more volatile in reality. Consumers do not see this volatility because their utility rate is regulated and subject to change only once or twice a year. From 2006 to 2021, residential electricity prices increased by over 30%, with only one year marginally lower than the prior year.[13] Over that same time period, regular gasoline prices increased 17%, with five of those years (2009, 2015, 2016, 2017, and 2020) having lower prices than 2006.[14] As will be examined, electricity generation shortfalls and electric grid reliability may also send electric rates much higher as NetZero policies and mandates to all electric transportation are imposed – making any current fuel advantage EVs possess a potential disadvantage over the long-term.

Consumers, however, must consider more than just the cost of fuel for their vehicle. They must also consider the price of the vehicle they plan to purchase or lease. The average EV cost $65,041 in 2022 while the overall average automobile (including those higher-priced EVs) cost only $48,681, according to Kelly Blue Book data.[15] This is a $16,360 upfront price difference to begin with, and assuming a five-year loan at current 6% interest rates, borrowing the price difference would add another $3,059 in interest costs over the first five years of ownership. Furthermore, according to Quadrant Information Services data as reported in Forbes, the average EV costs an additional $103 per year to insure versus a comparable ICE vehicle.[16]

The final item to consider is maintenance costs, however there is not yet any reliable data or consensus on whether ICE maintenance costs are higher than EV maintenance costs over the life of the vehicle. There are dozens of studies with conflicting conclusions as to which costs more, and many of them recognize that the long-term durability of EVs is an open question, especially regarding battery life. This is due to the fact EVs have not been mass-market vehicles for more than a decade. For consideration here, we will assume that there is no benefit for either ICE or EVs with respect to regular maintenance.

So how long would it take for a middle-income family in New York to break even on buying an EV versus a comparable ICE vehicle? With the annual benefit of $303 (the $406 annual energy benefit less the $103 disadvantage in insurance costs), it would take over 64 years to recover the $19,419 of the initial purchase price plus higher interest costs. Even considering the current $7,500 federal tax credit, there is still a 39-year payback period. This makes purchasing an EV not only unattractive economically, but it turns a mandate into a substantial economic burden on working-class families.

Even on a national level, when you consider the average price for residential electricity in 2021 was $0.1366/kWh and the cost of gasoline was $3.10/gallon, the break-even point for the average family in the United States would take almost 24 years. This level of payback is not economically viable for most families, except for those where cost considerations are secondary to other factors. State and national EV mandates ignore the financial realities for most people while imposing fewer choices, limiting transportation options, and harming working families.

Car Insurance Rates:
Electric Vehicles vs. Gas Vehicles

Model	Average annual car insurance cost (electric model)	Average annual car insurance cost (gas-powered model)
Chrysler Pacifica	$1,986	$1,891
Ford Fusion	$2,041	$1,865
Ford Escape	$1,831	$1,663
Honda Accord	$1,888	$1,988
Honda CR-V	$1,831	$1,574
Toyota Camry	$1,970	$1,899
Toyota Corolla	$1,823	$1,909
Toyota Highlander	$1,904	$1,757
Toyota RAV4	$1,776	$1,704
Subaru Crosstrek	$1,843	$1,606
Average	**$1,889**	**$1,786**

Source: Quadrant Information Services / Forbes Advisor

Total Cost of Ownership

Upfront Costs	$16,360
Interest Costs	$3,059
Annual Energy Cost	($406)
Annual Insurance Cost	$103
Annual Maintenance Cost	-
Upfront Cost Benefit to ICE	$19,419
Annual Benefit to EV	($303)
Payback Period (years)	**64.1**

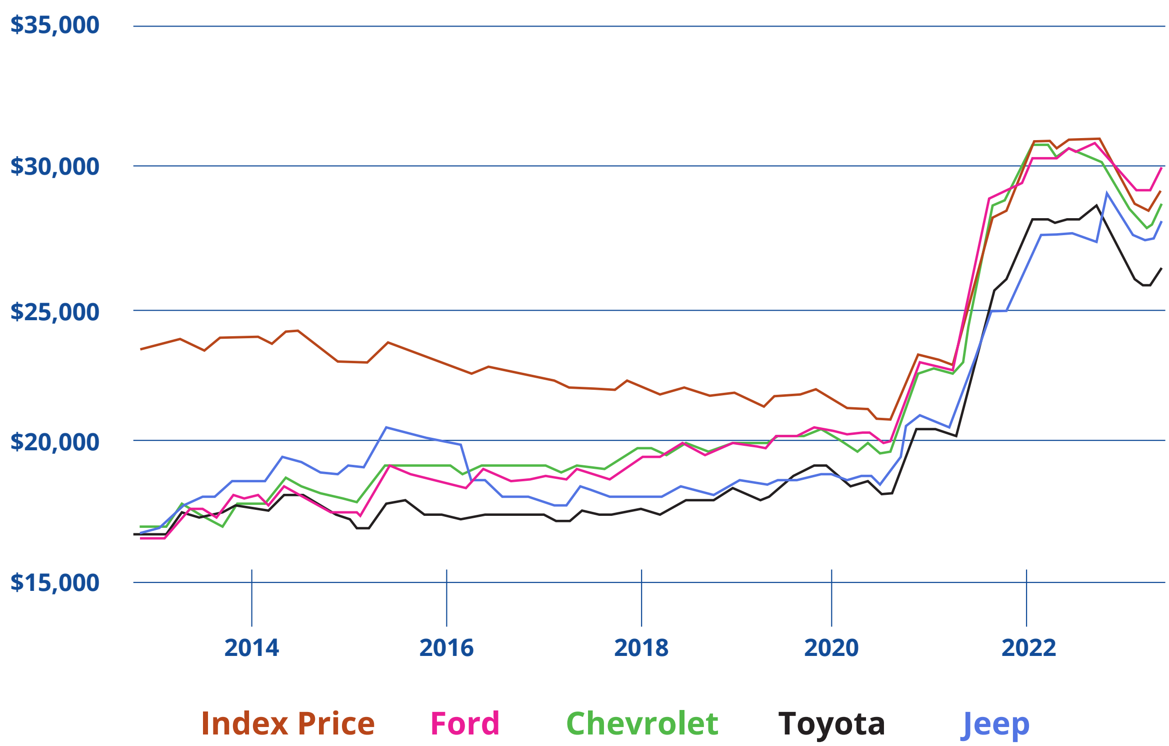
Source: Calculations based on purchase price, fuel cost, insurance, and maintenance for life of vehicle

An important factor for consideration in the TCO calculation which was not addressed here is the question of battery replacement. Typical battery replacement costs can reach $15,000 or more, in contrast to an ICE engine rebuild at $2,500-$4,000. This can dramatically affect the long-term and resale value of an EV versus an ICE vehicle. This cost differential will become better understood over time as EVs begin to mature beyond the typical 10-year/100,000-mile warranty periods. The results will not only affect the ownership cost calculations but also the used car market viability of EVs.

While the used car market may have second order impacts on new car pricing, it is far more important for low- and middle-income families who are more reliant on this market for their second vehicle or vehicles for their children. A National Automobile Dealers Association study on the cost of ownership estimated that after five years, EVs depreciate $43,515 in value, while ICE vehicles average only $27,883 in depreciation.[17] This depreciation almost eliminates any residual value advantage of the higher-priced EVs after only a short period of usage. If EVs become a non-viable option as used cars due to substantial depreciation and cost of battery replacement, used car markets operating under EV mandates will see very constrained supply despite sustained demand, eventually making even used cars too expensive for many working-class families.

Looking at the trends over the past decade, used car prices had dropped about 10% between 2014 and 2020, ensuring affordable vehicles were accessible to the middle class.[18] Since 2020 though, used car prices have risen nearly 50% in less than 3 years. With EVs priced much higher than ICE vehicles, and the potential for greater supply constraints as discussed above, used car prices could continue their recent upward trend and put used cars out of reach for millions of American families. Add to this the concerns that new cars are already out of reach for many, access to transportation could become a serious issue with additional EV mandates.[19]

Used Car Prices 2013 - 2023



Source: CarGurus

Policy Consideration #2: **Generation Requirements**

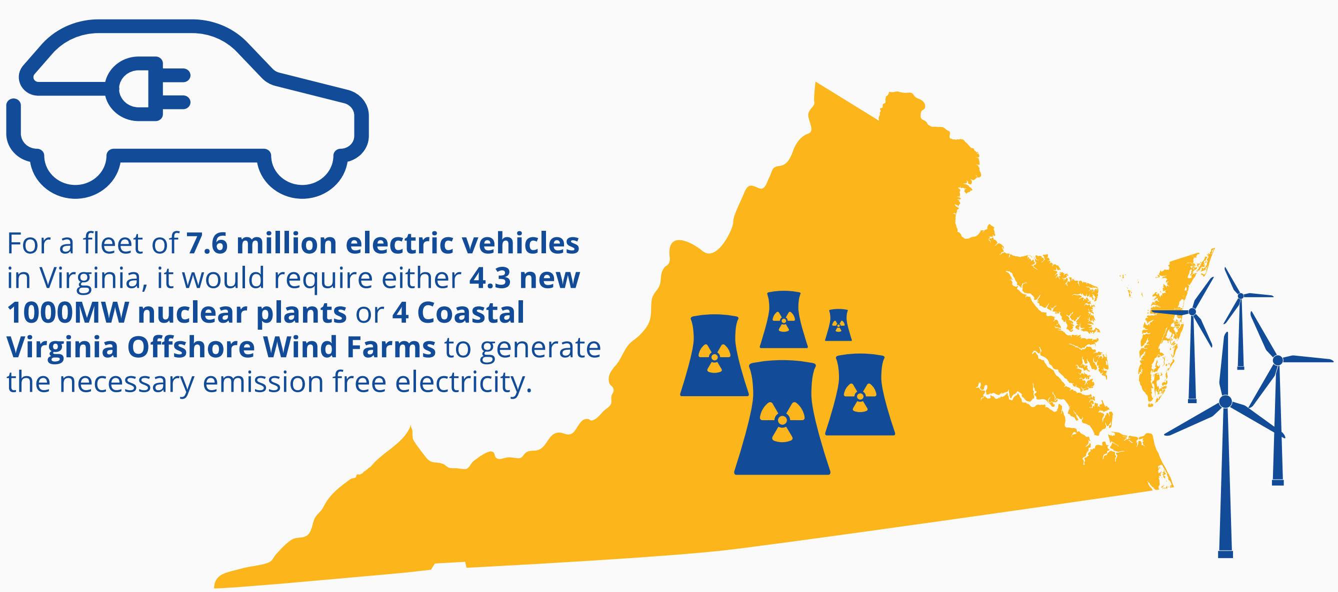
While the push to transition to EVs from ICE vehicles is an effort to shift to a low-carbon economy, the shift from a transportation system based on gasoline to one based on electricity is far more complicated and costly than most decision-makers consider. Set aside for a moment the costs of upgrading an energy distribution system that cannot currently handle the projected loads an all-EV fleet would require. The cost of supplying the necessary energy for hundreds of millions of EVs via electrical generation is vastly underappreciated.

Consider the fact that a few years ago, Virginia decided to opt into California's 100 percent EV mandate by 2035. The state currently has 7.6 million light-duty vehicles. Assume for a moment that Virginia achieves its goal and switches all its 7.6 million vehicles from using gasoline to electricity. Using the current U.S. Department of Energy standard of 0.364 kWh/mile, and the average miles travelled in Virginia of 12,879 miles per year, then the state would need 35.5 billion kWh of generation to cover the almost 100 billion miles traversed annually by its light-duty vehicle fleet.

Let us further suppose we discount transmission losses and assume a single 1,000 MW nuclear plant could be built with a 95% capacity factor, which is enough electricity to power 600,000 Virginia homes – over 16% of the households in the state.[20] For Virginia to operate an all-EV automotive fleet without just shifting emissions from tailpipe to smokestack, it would require 4.3 new nuclear generating units of that size – equivalent to the generation needed to power almost 70% of all the homes in Virginia.

Recognizing that it is rare for a new nuclear unit of that size to be built in the United States, never mind more than four within a decade. How many Coastal Virginia Offshore Wind Farms would be needed to provide the electricity demanded by an all-EV fleet? At 2,587 MW and assuming a 40% capacity factor (comparable to major offshore wind capacity factors in the United Kingdom), each wind farm would only be able to supply 25% of the needed power.[21] Thus, in order to fuel the state's fleet of light-duty vehicles under a 100% EV scenario, four offshore wind farms of comparable size to Coastal Virginia Wind – which itself will cover more than 451,200 acres or about three times the land area of Virginia Beach) – would need to be built.[22]

This is merely the incremental generation needed to power only passenger vehicles and not the entire transportation sector. For that, we would need to consider heavy-duty vehicles including semi-trucks, buses, and construction vehicles.



Source: Calculations based on U.S. Department of Energy data

Given the major hurdles in permitting just one large-scale (>500MW) generation facility either onshore or offshore in almost any jurisdiction in the United States, advocates for EV mandates need to be more forthcoming and realistic with how they believe the incremental electricity required will be sited and subsequently generated to support any substantial move to EVs. This may explain the argument being advanced in some states that wind and solar projects should be given preferential permitting treatment.

Policy Consideration #3: **Electrical Grid Infrastructure**

Elected officials and policy makers rarely consider the substantial changes that will have to be made to the existing electrical grid under an EV mandate. EVs will require major transmission and distribution system upgrades, along with upgrades to charging locations, and it is likely that these costs will be borne by consumers.

A recent study by the Brattle Group looked at the cost of "Getting to 20 million EVs by 2030" in the United States, specifically as it related to the required capital costs of upgrading the electrical grid.[23] On a national level, Brattle identified $30-$50 billion of additional costs to increase the amount of generation and storage for the incremental electricity demanded as automobiles move from ICE to EV. There was a further $15-$25 billion in required upgrades for transmission and distribution systems, and another $30-$50 billion for charging infrastructure. That's a total of $75-$125 billion in costs just to get to 20 million EVs, representing only about 7% of the US light vehicle fleet.

While there are likely some variations based on economies of scale, we can consider these costs on a more local level so that decision-makers can better understand what it may mean for a typical family that will have to pay for these additional costs added to their electric bill.

Using New Mexico as an example, there are currently 1.9 million ICE vehicles in the state. If we consider the infrastructure requirements to shift those vehicles to EVs implied by the Brattle Group model, then New Mexico would have to invest $2.8-$4.7 billion in generation, $1.4-$2.3 billion in transmission and distribution, and $2.8-$4.7 billion in charging infrastructure, for a total investment of $7.0-$11.7 billion.

As noted above, the costs for these types of expenditures have typically been passed on to consumers through their electric bill. Residential rates in New Mexico according to the EIA averaged 14.1 cents/kWh in 2022.[24] Assuming the costs for this infrastructure will be passed through to customers over the next 20 years, with the average household using 9,175 kWh/yr, and ignoring any rate of return for the utilities, the cost to upgrade the state's electrical grid could result in a 1.3 to 2.1 cent increase per kWh which equates to $117 to $195 per year.[25] Considering that nearly half of Americans don't even have $500 in savings, elected officials and other decision-makers need to consider how these policies impact average Americans living paycheck-to-paycheck.[26]

How much of this infrastructure has been rolled out to date? Per the Brattle Group study, New Mexico has provided no state funding for charging infrastructure. This is a far cry from the billions necessary as the state moves to an ICE-free future. And, almost nothing has been done for transmission and distribution system upgrades as they relate to EV adoption. With respect to generation, the state has yet to transition away from having most of its electricity generated from fossil fuels (over 63% per the EIA), with the current shift to renewable generation only focused on lowering its dependence on fossil fuels.[27] Once the low-hanging renewable generation fruit has been picked to update the current generation mix, it is likely the incremental generation needed for a shift to EVs will be even more expensive. Where will the additional funds come from and when? More importantly, will elected officials be upfront with the public and explain to them that there will be permanent 6-10% increases in their electric bills just to pay for the energy infrastructure required by EVs?

Beyond these costs that will certainly be imposed on working families, there are growing concerns about the reliability of the electric grid without even considering the challenges associated with electrifying our transportation system. Both federal agencies and Independent System Operators, which are responsible for maintaining the electric grid and ensuring just and reasonable rates for consumers, have voiced much concern and issued numerous warnings over the past several years.

Several Federal Energy Regulatory Commissioners recently testified before the U.S. Senate, stating, "We face unprecedented challenges to the reliability of our nation's electric system."[28] The Commissioners didn't even focus on the large additional demands which will be imposed under EV mandates over the next 5-10 years. The North American Electric Reliability Corporation (NERC) has also put out warnings over the past several years, including its most recent report which assessed the country's electric grid reliability for the upcoming summer season.[29] Seven of the 20 regions, "face risks of electricity supply shortfalls during periods of more extreme summer conditions" this year. These areas include New England, the Midcontinent, and every region west of the Mississippi River. Coincidentally, most of the states imposing new EV mandates, including California, New England, and New York, are the ones with the highest electricity prices in the country. And, they are in regions with growing reliability concerns. If EV mandates are continued in these states without consideration of the stresses placed on the electric grid, there could be critical problems for both the electric grid and the transportation systems.

While the experts at the Federal Energy Regulatory Commission and NERC can warn the country about these looming problems, it requires state and local officials to acknowledge them and craft sensible policy solutions to address them. It is clear that many officials seeking to impose EV mandates have not sufficiently considered the detrimental impacts on grid reliability, let alone the cost of grid modernization to families and businesses, their mandates will bring.

Policy Consideration #4: **Supply Chain of Critical Materials**

On a broader level, while many officials in the United States and globally are mandating EV usage, the question arises as to whether the world can supply the copper, lithium, cobalt and other critical materials required to build enough EVs. Consider, EVs require six times the amount of minerals than traditional cars.[30] Given the current state of the global supply chain for these raw materials and the requirements to bring additional supply to market, it is likely that the mandated goals are unachievable even over several decades.

> "Amounts vary depending on the battery type and model of vehicle, but a single car lithium-ion battery pack (of a type known as NMC532) could contain around 8 kg of lithium, 35 kg of nickel, 20 kg of manganese and 14 kg of cobalt, according to figures from Argonne National Laboratory."[31]

The U.S. Geological Survey estimates that in 2022, there was approximately 130,000 tons of lithium mined globally.[32] The quantity of lithium mined would be able to produce just under 14 million EV batteries. This doesn't account for the lithium used in other products, including laptop batteries, phones, residential power packs, and utility scale storage.

Lithium production also typically requires substantial water use, which carries the potential for large-scale and long-term environmental damage in certain regions.

Permitting also has been a hurdle to bringing any mining project online. Lithium mines coming online between 2010-2019 took an average of 16.5 years to develop into producing mines according to the IEA.[33]

Under EV mandates, the demands to eliminate ICE vehicles may rapidly run into the reality of lithium battery supply. With global annual light-duty vehicle sales of over 66 million and a global fleet of over 1.3 billion vehicles, it is going to be very difficult to practically achieve EV mandates anytime in the next several decades.

California alone would require almost 15% of current global battery supply if a theoretical 1.67 million new EVs were sold (100% of current annual light-duty vehicle sales) in the state in 2030.[34] It is highly unlikely that a material portion of the world's lithium supply will be committed in this manner, yet state elected officials and regulators are assuming that this type of allocation will take place without any deleterious economic impacts, such as higher costs, for EVs.

Unfortunately, this is not only a problem for the supply of lithium. An IEA review of critical minerals assessed global demand for copper, lithium, and cobalt. Under the current "Stated Policy Scenarios," by 2040 the world will require 12 times more lithium, six times more cobalt and nine times more copper just for EVs.[35] These forecasts would result in primary demand for these minerals outstripping supply for cobalt and lithium by 2028, and copper by 2026.[36]

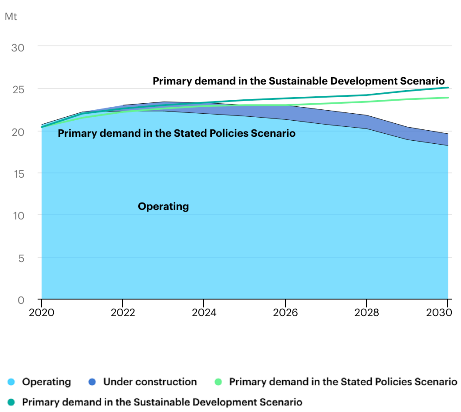
Yet, mining is only one part of the critical mineral supply chain which must be considered. After minerals are mined, they must also be processed. Of the critical minerals necessary for EV production, China controls the processing and refinement of 58% of lithium, 65% of cobalt, and 87% of rare earths.[37]

Although the United States can become less reliant on foreign supply chains for critical minerals to build a cleaner energy future, there is no strategic planning to ensure access to these resources. In January of 2022, the Biden Administration canceled leases for copper and nickel mining that had been held for more than 50 years.[38] And, in January 2023, the Administration paused mineral leasing on over 200,000 acres of land in the Superior National Forest, enacting a 20-year prohibition on mining.[39]

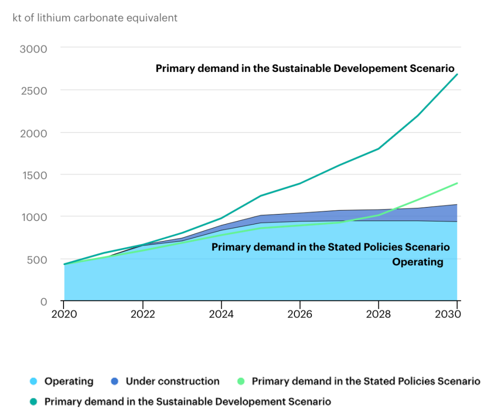
Restricting mining operations in the United States is not only counterintuitive to the promotion of electric vehicle adoption. It has additional global impacts. Gillian Caldwell, Chief Climate Officer and Deputy Assistant Administrator for the Center for Environment, Energy, and Infrastructure at the United States Agency for International Development (USAID) said USAID is seeing evidence that mining for the transition away from fossil fuels is tied to "increased corruption, human rights violations, environmental destruction and conflict."[40]

Once again, the supporters of EV mandates are not considering the real-world consequences of these policies. The projected shortfalls of lithium, copper and cobalt are very likely to dramatically raise battery costs, which would stall or reverse progress on reducing the price of this key EV component, keeping EVs much more expensive than traditional ICE vehicles.

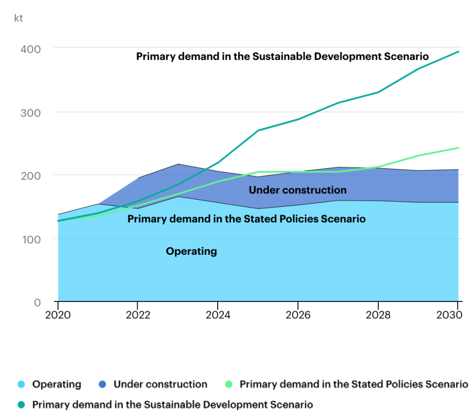
Committed mine production and primary demand for copper, 2020-2030



Committed mine production and primary demand for lithium, 2020-2030



Committed mine production and primary demand for cobalt, 2020-2040



Source: International Energy Agency

Policy Consideration #5: **Fuel Tax Revenue Impacts**

With EV adoption still accounting for single-digit percentages of any state light-duty passenger vehicle fleet, the impact of moving from ICE to EVs on state budgets has historically been a relatively minor consideration. However, if and when more states implement EV mandates, officials will be forced to evaluate how this will lower fuel tax revenues.

Historically, most fuel taxes (both gasoline taxes and diesel excise taxes) have been dedicated to spending on highways and road infrastructure. In 2020, states brought in over $52.7 billion in motor fuel tax revenue.[41] On top of those collections, the federal government collected and distributed over $43 billion in federal highway-related excise taxes, most of which is returned to the states through federal highway grants.[42]

If EV adoption increases materially, with a push from EV mandates, fuel-base tax revenue will begin to dry up at both the state and federal level. States will have to either dramatically reduce spending on maintaining highways, find new sources of revenue to maintain state and local roads, or increase taxes in other areas to replace the lost revenue.

How big an impact would that be? Let's consider Colorado as an example, which collected almost $677 million in 2019 (pre-COVID baseline) and received $589 million in 2020 Federal Highway Funding.[43] If Colorado reaches its goal of 100% EV adoption, the state will need to replace over $1.25 billion in highway and road spending that comes from taxes on gasoline and diesel, a number that will only increase with inflation over time. That amounts to over $560 per household annually.[44] Nationally, an elimination of ICE vehicles would represent a fuel tax revenue loss of $741 per household annually. Whether at the state or federal level, that is a significant amount of lost tax revenue that will need to be recouped from somewhere. EV mandate advocates have for the most part remained silent on how this tax revenue problem should be addressed.

FY 2020 FEDERAL-AID HIGHWAY PROGRAM APPORTIONMENTS UNDER FIXING AMERICA'S SURFACE TRANSPORTATION (FAST) ACT

	National Highway Performance Program	Surface Transportation Block Grant Program	Highway Safety Improvement Program[1]	Railway-Highway Crossings Program	Congestion Mitigation & Air Quality Improvement	Metropolitan Planning	National Highway Freight Program	Apportioned Total
Alabama	492,134,217	245,432,298	48,837,668	5,030,652	12,233,496	3,316,382	28,788,785	835,773,498
Alaska	311,449,135	155,857,612	32,861,826	1,225,000	29,510,597	2,445,667	19,017,598	552,367,435
Arizona	444,770,886	222,967,580	45,708,482	2,966,959	55,631,678	6,311,543	27,652,981	806,010,109
Arkansas	333,002,634	166,181,866	32,309,619	4,139,566	13,205,084	1,853,154	19,660,713	570,352,636
California	2,078,188,513	1,048,137,089	210,661,318	16,727,512	497,658,600	53,965,333	137,926,316	4,043,264,681
Colorado	321,396,882	161,270,563	31,505,959	3,666,390	45,357,082	5,704,498	20,171,449	589,072,823
Connecticut	299,029,572	150,166,240	31,340,232	1,383,449	47,442,976	4,977,836	18,959,974	553,300,279
Delaware	102,772,834	51,523,301	10,022,376	1,225,000	12,505,645	1,921,968	6,376,902	186,348,026
Dist. of Col.	97,491,778	48,852,942	9,444,590	1,225,000	10,832,815	1,914,382	6,011,421	175,772,928
Florida	1,230,552,474	613,629,270	125,049,915	9,645,070	14,581,543	22,332,190	71,396,176	2,087,186,638
Georgia	802,729,658	401,678,890	79,023,613	8,832,059	72,865,342	8,380,145	48,898,593	1,422,408,300
Hawaii	103,668,547	51,934,683	10,120,681	1,225,000	11,108,307	1,886,318	6,377,228	186,320,764
Idaho	179,413,341	89,712,341	17,695,492	1,941,086	13,741,061	1,746,334	10,835,702	315,085,357
Illinois	854,148,369	428,610,365	82,096,255	11,378,101	118,061,702	18,404,231	53,516,633	1,566,215,656
Indiana	594,777,804	297,524,632	57,135,272	7,961,587	50,525,029	5,645,449	36,104,102	1,049,673,875
Iowa	316,132,458	157,761,587	28,906,320	5,696,331	12,112,591	2,139,447	18,649,117	541,397,851
Kansas	242,235,322	120,917,351	20,004,259	6,509,648	10,204,923	2,100,918	14,323,658	416,296,079
Kentucky	428,567,666	213,825,070	42,886,877	4,022,841	14,690,724	2,732,368	25,218,395	731,943,941
Louisiana	453,696,920	226,324,212	45,222,096	4,438,479	12,274,696	4,637,158	26,576,703	773,170,264
Maine	113,877,380	57,018,934	11,152,460	1,310,716	11,042,240	1,986,927	6,962,687	203,351,344
Maryland	356,318,933	178,997,233	36,489,672	2,502,896	57,581,191	7,479,531	22,630,742	662,000,198
Massachusetts	352,553,814	177,426,422	35,923,007	2,655,165	68,009,774	9,695,577	22,796,269	669,060,028
Michigan	639,192,348	320,467,515	61,753,764	8,198,781	79,361,076	11,169,405	39,719,065	1,159,861,954
Minnesota	406,390,112	203,313,740	37,920,917	6,557,215	34,557,941	4,931,718	24,669,848	718,341,491
Mississippi	311,202,267	155,297,492	30,354,640	3,708,399	12,030,939	1,834,157	18,362,236	532,790,130
Missouri	606,806,615	302,902,609	60,376,693	6,041,419	25,277,065	5,606,369	35,870,641	1,042,881,411
Montana	260,101,310	129,949,324	26,410,791	2,057,799	15,964,596	1,939,123	15,563,794	451,986,737
Nebraska	183,111,794	91,489,420	16,141,946	3,899,958	11,032,465	1,787,676	10,949,321	318,412,580
Nevada	215,824,563	108,397,813	22,372,849	1,245,351	34,926,363	3,540,715	13,709,470	400,017,124
New Hampshire	101,199,080	50,700,532	9,850,396	1,225,000	11,098,102	1,705,104	6,234,662	182,012,876
New Jersey	581,246,558	292,446,674	59,618,357	3,985,031	111,625,812	13,427,554	37,565,516	1,099,915,502
New Mexico	234,104,595	116,909,344	23,782,027	1,841,556	12,238,985	1,736,084	13,930,085	404,542,676
New York	968,878,443	487,836,077	99,317,842	6,699,842	196,450,213	26,935,869	62,998,269	1,849,116,555
North Carolina	651,177,859	325,731,113	64,091,626	7,178,118	54,960,959	6,273,979	39,514,654	1,148,928,308
North Dakota	155,961,136	77,976,284	13,130,490	3,939,339	11,281,607	1,810,940	9,394,944	273,494,740
Ohio	813,767,125	407,992,546	79,622,819	9,435,011	102,686,164	12,494,647	50,627,736	1,476,626,048
Oklahoma	409,868,698	204,464,769	39,128,799	5,734,415	12,605,902	2,788,852	24,065,103	698,656,538
Oregon	315,048,840	157,473,486	30,670,517	3,811,656	20,804,470	3,904,366	18,905,395	550,618,730
Pennsylvania	1,005,576,239	503,765,944	102,849,149	7,202,976	112,063,118	13,990,442	62,017,204	1,807,465,072
Rhode Island	136,340,569	68,208,344	13,697,064	1,225,000	11,185,141	2,002,995	8,261,506	240,920,619
South Carolina	432,006,055	215,537,181	42,522,566	4,763,532	14,047,633	3,397,425	25,392,750	737,667,142
South Dakota	177,035,582	88,517,870	16,645,755	2,730,620	13,154,614	1,906,023	10,677,248	310,667,712
Tennessee	530,606,460	265,298,313	52,780,497	5,293,911	39,722,613	5,185,028	32,012,474	930,899,296
Texas	2,284,681,927	1,142,841,937	229,571,159	20,481,394	187,158,067	27,986,441	138,429,943	4,031,150,868
Utah	218,770,623	109,353,917	22,095,746	1,848,723	13,854,695	3,495,247	13,106,163	382,525,114
Vermont	124,798,788	62,503,850	12,433,336	1,225,000	12,703,195	2,261,098	7,652,518	223,577,785
Virginia	630,756,761	315,701,430	64,143,588	4,889,748	58,893,491	8,154,467	38,482,756	1,121,022,241
Washington	418,430,054	209,500,895	41,303,106	4,491,549	39,626,396	7,897,746	25,548,842	746,798,588
West Virginia	278,229,316	138,959,136	28,350,728	2,102,357	15,359,219	1,836,025	16,585,526	481,422,307
Wisconsin	476,081,816	237,891,534	45,855,013	6,252,793	29,380,173	4,931,298	28,493,221	828,885,848
Wyoming	161,332,135	80,645,720	16,432,799	1,225,000	11,174,403	1,705,234	9,700,318	282,215,609
Apportioned Total	**24,237,436,805**	**12,137,825,290**	**2,407,622,968**	**245,000,000**	**2,496,402,513**	**358,213,383**	**1,487,293,352**	**43,369,794,311**

[1]Amount is net of the $3,500,000 takedown for safety-related programs.

Source: Federal Highway Administration

Policy Consideration #6: **State Employment Impacts**

Industry disruptions are often accompanied by substantial shifts in employment, whether the disruption is caused by market forces or mandated government policy. This can be either movement within a particular industry or significant job losses as a particular "losing" industry is forced out of existence. Under normal market conditions, these changes would be prompted by shifting consumer preferences, leading to relatively gradual changes in capital allocation and eventually, employment patterns. With abrupt mandates from government, often there is far less time and rapid, dramatic action by companies to adhere to new realities. This can result in far more volatile employment changes and far more disruption for working-class families in particular industry segments.

Again, the consequences of these employment shifts are rarely considered when EV mandates are imposed. One of the most obvious businesses at risk under EV mandates are gas stations and their associated convenience stores. While there may be some shift to adding electric charging stations at existing fueling stations, the bulk of the funding for expanded charging is not going to installations at gas stations. Rather, it is being allocated for more public charging facilities, utility-owned locations, hotels, restaurants, shopping centers, and similar locations. Industry statistics indicate that there are over 64,000 gas stations with convenience stores in the United States, employing 890,000 individuals.[45] These jobs are typically entry level employment providing younger workers with job skills and experience that can lead to more gainful employment. Under an EV mandate and a forced transition away from ICE vehicles, these jobs will be, in effect, mandated away by the government.

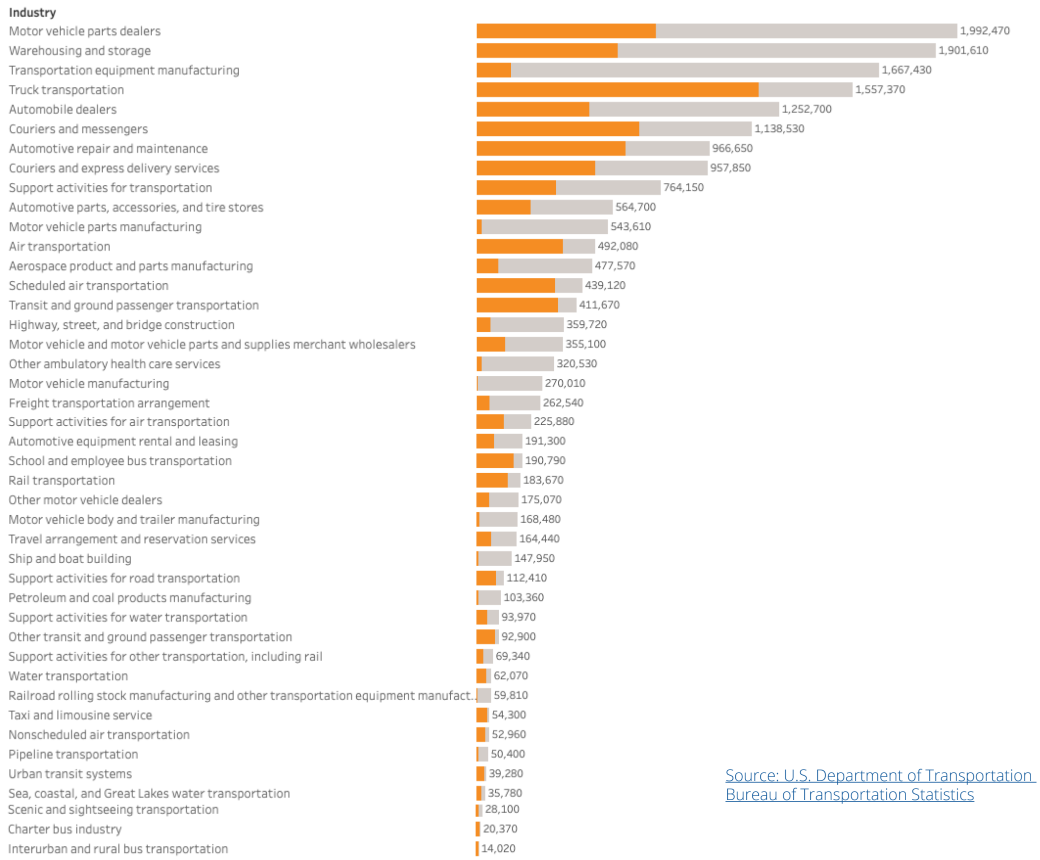
Moving further upstream, there are over 113,000 workers in the oil and gas extraction industry whose employment will be at risk as governments force the elimination of ICE vehicles from the roads.[46] The refining industry is highly dependent on road transport industry demand for liquid petroleum products to sustain its business. One recent study of refining employment in Washington State indicated that the refineries were directly responsible for 2,246 workers in the region, with average wages and benefits per worker over $200,000 per year.[47] The indirect employment effects of this industry were estimated to support an additional 22,000 to 30,000 workers.

More recently, the University of California Berkeley Labor Center examined the economic and employment effects of a refinery closure on workers in the Bay Area.[48] More than a year after the shutdown of the refinery in Contra Costa County, California, one in five workers remained unemployed. Those who were successful at finding new employment saw earnings decline sharply, with the median hourly wage decreasing from $50 to $38. Some workers reported earning as little as $14 an hour. In addition, workers reported worse working conditions at their post-layoff jobs than at the refinery.

There are currently over 1.5 million truck drivers in the United States and while segmentation data of the market is difficult to obtain, crude petroleum and petroleum product trucking activity is one of the largest and most ubiquitous segments of the markets.[49] The tank truck market as a whole represents $49 billion of economic activity. And, there are a variety of other industry segments which could also be substantially impacted, including:

- Motor Vehicle Parts Dealers – 1.926 million employees
- Automobile Dealers – 1.22 million employees
- Automotive Repair and Maintenance – 917 thousand employees
- Automotive parts and accessories retail – 542 thousand employees
- Automotive parts manufacturing – 244 thousand employees
- Motor Vehicle and Parts Wholesalers – 339 thousand employees
- Motor Vehicle Manufacturing – 244 thousand employees[50]

Employment in the Transportation and Warehousing Sector and in Transportation-related Industries by Type of Occupation - 2022



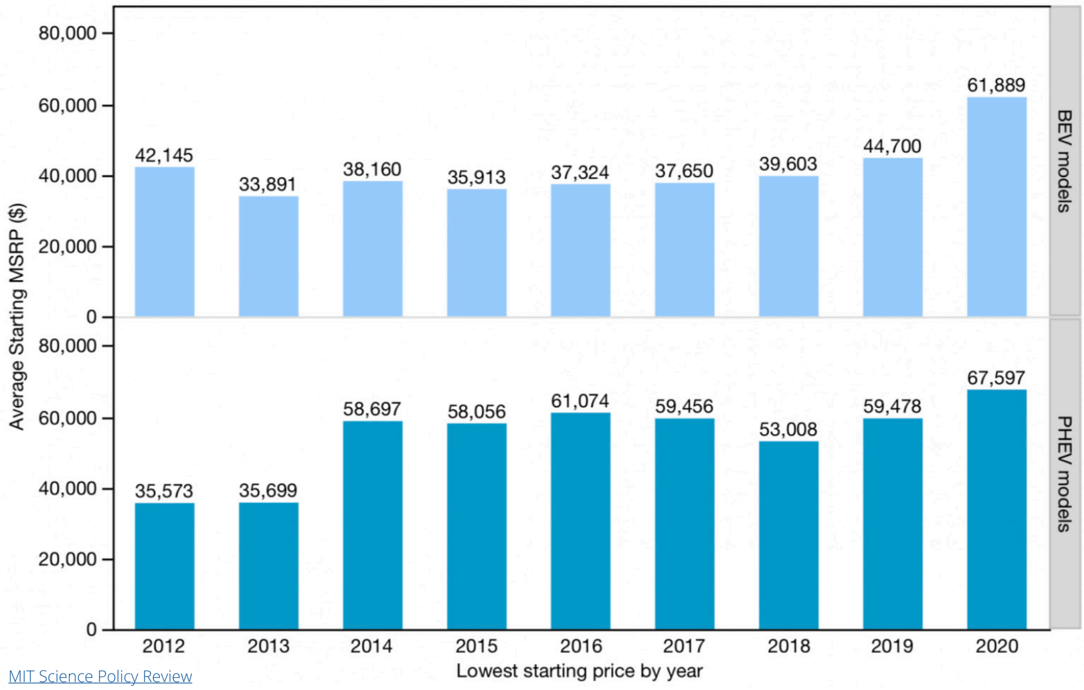
If these industry disruptions and associated employment impacts were driven by natural consumer adoption of EVs, the transition periods would likely be much more gradual and much more easily absorbed by the affected companies and their workers. Disruption imposed by mandate is likely to have much more significant, rapid, and harmful impacts on employees and their families. It is incumbent on elected officials to understand and assess the risks to their constituents as they consider these policies.

Policy Consideration #7: **Benefit Shift from Working Class to Wealthy**

There is often a component of the debate over EV mandates that declares that the benefits of shifting the public to electric vehicles is helpful to working-class and lower-income families. Typically, this is raised in the context of lowering vehicle emissions and the indirect health benefits associated with decreasing that externality. But, often ignored are the direct impacts on the practical use of EVs for a working-class family and how the benefits of an EV transition mostly flow to the wealthier segments of the population.

The initial purchase of an EV is not one that working-class families can often consider. As noted earlier, the price differential between an EV and a comparable ICE vehicle is often on the order of $15,000 or more. And contrary to popular opinion, the cost of EVs have been steadily increasing since 2015.[51] Today, the average EV costs well over $60,000, a price which can only be considered affordable by the upper quintiles of income earners. The idea that EVs can currently be an option for the average family cannot be taken seriously.

Average Starting MSRP of BEV Models and PHEV Models Available Between 2012 and 2020



MIT Science Policy Review

This then exposes the current federal and state EV tax credits as a substantial cost shift from middle-class families to the wealthy. In 2022, there were over 800,000 EVs sold in the United States.[52] Assuming the $7,500 federal tax credit was available for most of these purchases, this represents over $6 billion of tax benefits that are paid for by the average American but flow mostly to wealthier families. This does not even account for state incentives.

Looking at state-by-state EV sales for 2021 (2022 data is not available yet) in the 14 states that provide tax credits of $1,000-$4,000, we calculate an additional $600 million or more (depending on type of EV and income level) that mostly flowed to wealthier families.[53] However, some states are providing larger incentives for low-income families to purchase an EV. Yet, even with these generous federal and state incentives, the average EV purchase price of $50,000 or more is out of reach for most low-income earners.

Beyond the immediate financial benefits, the practical use of EVs benefit wealthier users as well. Charging infrastructure is a critical component for EV usage, with access to chargers (and specifically fast chargers) a major consideration in purchasing an EV. Wealthier users are far more likely to live in single family homes where installation of a fast charger costing thousands of dollars is simply a matter of fact. Lower income families who are more likely to reside in apartments or rented properties do not have the option of installing their own personal dedicated fast chargers.

Currently there are an estimated 52,510 public charging stations in the United States, with 134,697 Level 2 or better charging ports associated with them.[54] There are only 30,417 DC, Level 3, fast charger ports which allow for much more rapid charging, but at a higher cost.[55] Contrast this with the 145,000 fueling stations in the United States and while there are no reliable numbers on the amount of gasoline pumps per station, if we assume an average of 8 per location, there are likely over 1 million pumps, with refueling times on the order of five minutes to put over 350 miles of range or more in a tank.[56] Contrast that with costly DC fast chargers, which require approximately 30 minutes to obtain the same mileage, and Level 2 chargers that require hours. The time advantage of ICE fueling versus EV charging is dramatic.

Even the location of charging infrastructure tends to benefit the wealthier, whiter, male demographic that makes up 75% of the individuals who purchase EVs.[57] A recent MIT study on EVs and equity noted that:

> "According to Hsu and Fingerman [43], Black and Hispanic neighborhoods only had 0.7 times the access to public chargers as the no-majority reference group in California. They also determined that even when income, proximity to the nearest highway, and multi-family housing were controlled for, White-majority census block groups were 1.5 times more likely to have access to public charging stations compared to Black- and Latino-majority census block groups."[58]

They also noted that public charging, when available to lower income communities, typically costs more than home charging stating:

> "This higher cost would disproportionately affect low-income households who already pay a higher proportion of their income towards transportation."[59]

One additional aspect of income disparity that is often ignored when considering EV mandates is the fact that the used car market is the major resource for transportation options for low- and middle-income families. EV mandates are likely to have a substantial direct and indirect impact on the used automobile supply. As noted earlier, the life of EV batteries before replacement is an open question which the used car industry will soon be facing at a much greater scale.

With replacement costs estimated in the range of $15,000 or more, there is high likelihood that high mileage EVs will be "totaled" as battery replacement costs will be higher than the value of the car in the used car market. Under such a scenario, EV mandates will lower the number of ICE vehicles over time, winnowing the number of automobiles available in the used car market and driving up used vehicle prices and disproportionately affecting low- and middle-income families. Once again, the unintended costs and consequences of an EV mandate are likely to fall disproportionately onto the individuals and families who can least afford it.

None of these economic disparities are addressed under EV mandates, and very little of these concerns are typically raised in the debate before enacting these policies. Yet EV mandates are likely to burden working-class families with the costs of incentives while rarely enabling them to enjoy those benefits themselves. And, by creating disparities in access to the "fuel" through charging network realities and economics this further exacerbates the differences in transportation equity between rich and poor.

Conclusion

Electric vehicles will play an important role in diversifying our vehicle mix, and, if integrated correctly, can help meet our shared environmental goals. It is increasingly clear that public officials and regulators are not fully considering all the implications of aggressively mandating EVs and banning ICE vehicles. Without adequately considering the impact this will have on consumers, acceptance of EVs will suffer as overall negative impacts on low- and middle- income earners will increase.

While it is fair to say there is much to debate on how best to tackle these questions, it is incumbent on policy makers to be proactive and transparent about the implications of the policies they are advocating for, and to ensure consumers understand the costs and benefits of EV mandates and bans on ICE vehicles. The following are some questions for policy makers to consider:

- How impactful would an EV mandate be given the current fleet of passenger cars and the uptake of EVs as a percentage of new car sales? Will the presumed benefits be justified by the real and upfront costs?
- Given the economics of the Total Cost of Ownership, will EV mandates lower household discretionary income and raise the cost of transportation for working families?
- How much increased electricity generation will be required for an all-electric vehicle fleet? Where will that generation come from? At what cost?
- How much additional capital needs to be invested into the existing electrical grid to allow it to reliably provide the necessary electricity to homes and businesses with an all-electric fleet? Who will pay for this (ratepayers?) and how much will the average family pay in higher utility bills?
- Will global supply chains be able to support a rapid EV transition, and if not, will that hurt the families and businesses that are being forced to buy EVs?
- How will states compensate for the loss of billions of dollars of fuel tax revenue?
- How will an EV mandate impact the substantial number of workers whose jobs are supported by the current transportation system? What will the states do to address this potentially large economic impact?
- How do elected officials and decision makers justify the disproportionate impact an EV mandate has on low-income and working-class families, burdening them with higher costs while wealthier families can more easily benefit from the current taxpayer-funded incentives?

Sources

[1]Center for Climate and Energy Solutions "US State Clean Vehicle Policies and Incentives" https://www.c2es.org/document/us-state-clean-vehicle-policies-and-incentives/

[2]https://www.epa.gov/regulations-emissions-vehicles-and-engines/proposed-rule-multi-pollutant-emissions-standards-model

[3]https://ww2.arb.ca.gov/our-work/programs/advanced-clean-cars-program/advanced-clean-cars-ii

[4]US EPA "Sources of Greenhouse Gas Emissions" https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions

[5]MA Executive Office of Energy and Regulatory Affairs https://www.mass.gov/doc/interim-clean-energy-and-climate-plan-for-2030-december-30-2020/download

[6]US DOE Alternative Fuels Data Center "2021 Light-Duty Vehicle Registration Counts by State and Fuel Type" https://afdc.energy.gov/vehicle-registration?year=2021

[7]F&I Tools "2022 New Vehicle Sales by State" https://www.factorywarrantylist.com/car-sales-by-state.html

[8]USDOT – FHWA "Highway Statistics 2020" https://www.fhwa.dot.gov/policyinformation/statistics/2020/

[9]EPA "Automotive Trends Report" https://www.epa.gov/automotive-trends/highlights-automotive-trends-report

[10]EIA "Weekly Retail Gasoline and Diesel Prices" https://www.eia.gov/dnav/pet/pet_pri_gnd_dcus_sma_a.htm

[11]US Department of Energy www.fueleconomy.gov based on 231 electric cars, built between 2000 and 2022, and their kWh/100 miles

[12]EIA Electricity Data Browser https://www.eia.gov/electricity/data/browser

[13]Ibid

[14]EIA "Weekly Retail Gasoline and Diesel Prices" https://www.eia.gov/dnav/pet/pet_pri_gnd_dcus_sma_a.htm

[15]Kelley Blue Book https://b2b.kbb.com/news/view/new-vehicle-prices-hit-record-high-in-november-2022/

[16]Forbes (1/4/23) "Electric Car Insurance: Why It Costs More" https://www.forbes.com/advisor/car-insurance/electric-vehicle/

[17]NADA "Beyond the Sticker Price: The Cost of Ownership of EVs v. ICE Vehicles" https://www.nada.org/nada/nada-headlines/beyond-sticker-price-cost-ownership-evs-v-ice-vehicles

[18]Car Gurus "Used Car Price Trends" https://www.cargurus.com/Cars/price-trends/

[19]Washington Post "New cars, once part of the American dream, now out of reach for many" https://www.washingtonpost.com/business/2023/05/07/new-car-market-high-interest-rates/

[20]US Census Bureau https://www.census.gov/quickfacts/fact/table/VA/PST045222

[21]Energy Numbers "UK Offshore Wind Capacity Factors" https://energynumbers.info/uk-offshore-wind-capacity-factors

[22]US Dept of the Interior BOEM https://www.boem.gov/renewable-energy/state-activities/CVOW-C

[23]Brattle Group "Getting to 20 Million EVs by 2030" https://www.brattle.com/wp-content/uploads/2021/05/19421_brattle_-_opportunities_for_the_electricity_industry_in_ev_transition_-_final.pdf

[24]EIA Electricity Data Browser https://www.eia.gov/electricity/data/browser

[25]Ibid

[26]Yahoo "Nearly Half of Americans Have Less Than $500 in Savings" https://www.yahoo.com/entertainment/nearly-half-americans-less-500-120012475.html

[27]Ibid

[28]FERC testimony to US Energy and Natural Resources Committee, 05/04/23 https://www.energy.senate.gov/hearings/2023/5/full-committee-hearing-to-conduct-oversight-of-ferc

[29]NERC 2023 Summer Reliability Assessment https://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/NERC_SRA_2023.pdf

[30]https://elements.visualcapitalist.com/evs-vs-gas-vehicles-what-are-cars-made-out-of

[31]Nature 8/17/21 "Electric cars and batteries: how will the world produce enough?" https://www.nature.com/articles/d41586-021-02222-1

[32]USGS "Mineral Commodity Summaries 2022" https://pubs.usgs.gov/periodicals/mcs2022/mcs2022.pdf

[33]IEA "The Role of Critical Minerals in Clean Energy Transitions" https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions

[34]F&I Tools "2022 New Vehicle Sales by State" https://www.factorywarrantylist.com/car-sales-by-state.html

[35]IEA "Role of Critical Minerals in Clean Energy Transitions" https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions/mineral-requirements-for-clean-energy-transitions

[36]IEA "Role of Critical Minerals in Clean Energy Transitions" https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions/reliable-supply-of-minerals#abstract

[37]https://www.visualcapitalist.com/chinas-dominance-in-clean-energy-metals/

[38]https://www.doi.gov/sites/doi.gov/files/m-37072.pdf

[39]https://rollcall.com/2023/01/26/biden-administration-issues-boundary-waters-mining-moratorium/

[40]https://www.wilsoncenter.org/event/opportunity-and-risk-mining-and-green-energy-transition

[41]Tax Policy Center at Urban Institute & Brookings "Motor Fuels Tax Revenue" https://www.taxpolicycenter.org/statistics/motor-fuel-tax-revenue

[42]ENO Center for Transportation "$43.4B in FY20 Highway Funding Apportioned to States" https://www.enotrans.org/article/43-4b-in-fy20-highway-funding-apportioned-to-states/

[43]Tax Policy Center at Urban Institute & Brookings "Motor Fuels Tax Revenue" https://www.taxpolicycenter.org/statistics/motor-fuel-tax-revenue

[44]ENO Center for Transportation "$43.4B in FY20 Highway Funding Apportioned to States" https://www.enotrans.org/article/43-4b-in-fy20-highway-funding-apportioned-to-states/

https://www.census.gov/quickfacts/fact/table/CO/PST045221

[45]IBIS World Data https://www.ibisworld.com/industry-statistics/employment/gas-stations-with-convenience-stores-united-states/

[46]Statista Employment in Oil and Gas Extraction Industry https://www.statista.com/statistics/193217/employment-in-the-us-oil-and-gas-extraction-industry-since-1998/

[47]Sightline Institute "Oil Refinery Workforce 411" https://www.sightline.org/2021/10/13/oil-refinery-workforce-411/

48https://laborcenter.berkeley.edu/fossil-fuel-layoff/

[49]US DOT Bureau of Transportation Statistics "Employment in Transportation" https://data.bts.gov/stories/s/Transportation-Economic-Trends-Transportation-Empl/caxh-t8jd/

[50]Ibid

[51]MIT Science Policy Review 8/30/21 "A perspective on equity in the transition to electric vehicles" https://sciencepolicyreview.org/2021/08/equity-transition-electric-vehicles/

[52]KBB "New Car Sales Fell in 2022, But New Electric Car Sales Rose Dramatically" https://www.kbb.com/car-news/new-car-sales-fell-in-2022-but-new-electric-car-sales-rose-dramatically/

[53]US DOE Alternative Fuels Data Center "2021 Light-Duty Vehicle Registration Counts by State and Fuel Type" https://afdc.energy.gov/vehicle-registration?year=2021

KBB "Electric Vehicle Rebates by State" https://www.kbb.com/car-advice/electric-vehicle-rebates-by-state/

[54]US Dept of Energy, Alternative Fuels Data Center https://afdc.energy.gov/data_download

[55]Sona Energy Solutions "Level 2 vs DC Fast Chargers" https://sonaenergy.com/news/level-2-vs-dc-fast-chargers-determining-your-ev-charging-strategy

[56]API "Service Station FAQs" https://www.api.org/oil-and-natural-gas/consumer-information/consumer-resources/service-station-faqs

[57]Inspire "Who Owns EVs Today? EV Ownership Trends and Changes 2021 EV Consumer Behavior Report Rundown" https://inspireadvancedtransportation.com/industry/who-owns-evs-today-ev-ownership-trends-and-changes-2021-ev-consumer-behavior-report-rundown/

[58]MIT Science Policy Review 8/30/21 "A perspective on equity in the transition to electric vehicles" https://sciencepolicyreview.org/2021/08/equity-transition-electric-vehicles/

[59]Ibid

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THE VOICE OF THE ENERGY CONSUMER

About Consumer Energy Alliance

Since 2006, Consumer Energy Alliance (CEA) has been the leading voice for sensible energy and environmental policies for families, farmers, small businesses, distributors, producers and manufacturers in support of America's environmentally sustainable energy future. We are committed to leading the dialogue around energy and the environment to ensure continued access to affordable, reliable, and resilient energy for all consumers.

CEA believes it is not a question of when we evolve our energy mix, but rather how that evolution occurs to create the maximum benefit to communities across the country. Propelling our country forward are technological innovation, energy diversity, and improved efficiency to help the U.S. continue to lead the world in enhanced environmental protections with reduced emissions.

Done right, we can ensure everyone has access to affordable, reliable, and resilient energy, a cleaner environment, and a sustainable economic future.

We hope you'll join the energy conversation at **www.consumerenergyalliance.org**.