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TRANSPORTATION

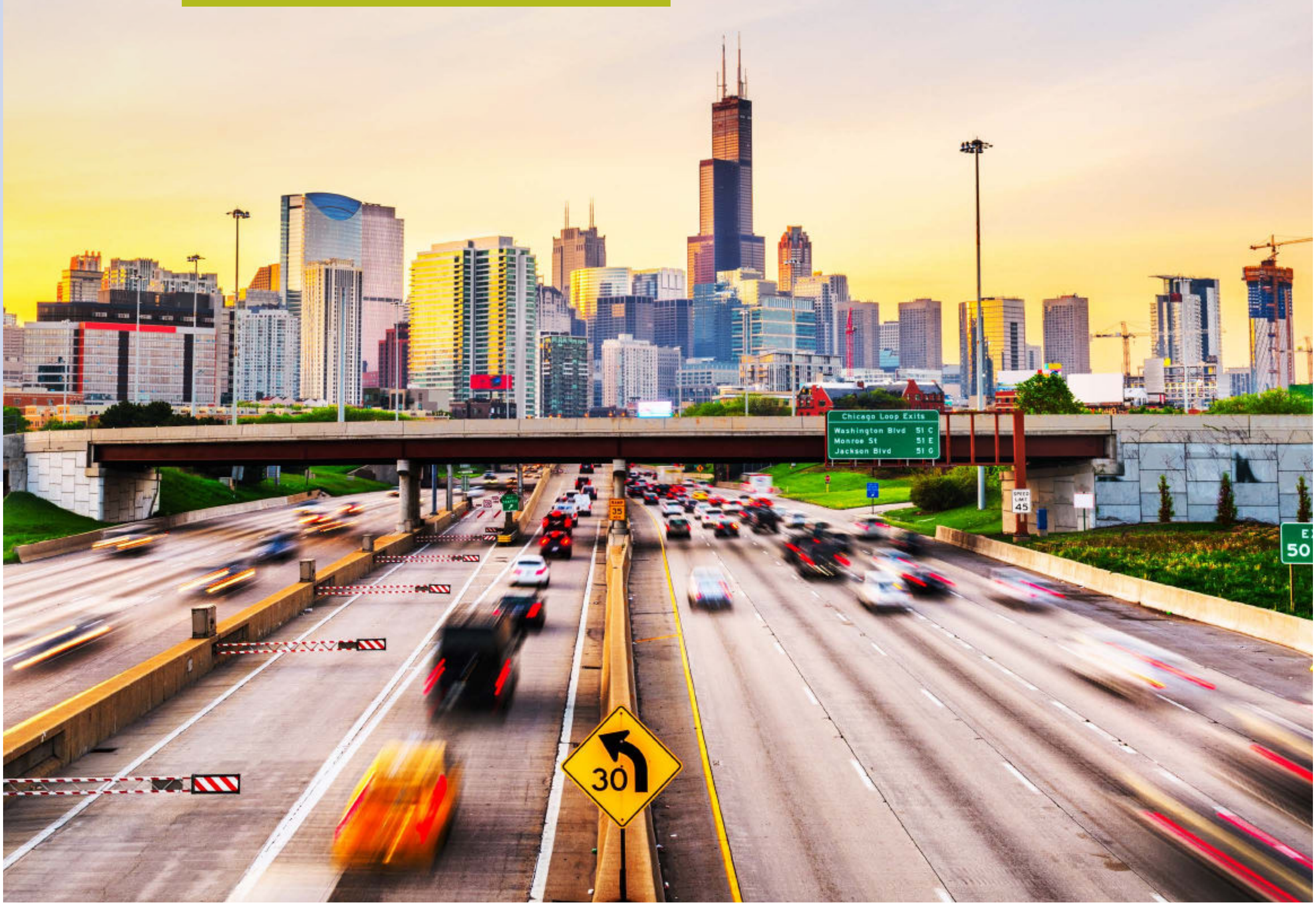
ACCELERATING CLEAN, ELECTRIFIED TRANSPORTATION BY 2035: POLICY PRIORITIES

A 2035 2.0 COMPANION REPORT

AUTHORS

Sara Baldwin, Amanda Myers, Michael O'Boyle, *Energy Innovation*

David Wooley, *Goldman School of Public Policy, University of California, Berkeley*



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EXECUTIVE SUMMARY

America is at a crossroads: we are approaching the end of fossil fuel-powered internal combustion engine vehicles (ICEVs) as the dominant mode of transport. Since the early 1900s, they have been a pillar of economic growth and improved mobility for people and goods. But, they have taken a toll on public health, consumers' wallets, and climate stability. As the largest source of greenhouse gas emissions (GHGs) in the United States, the transportation sector is key to unlocking economy-wide decarbonization by 2050 and to avoiding the worst impacts of climate change. We have the technologies to transition to a lower-cost, cleaner transportation future, but we lack a comprehensive clean transportation policy strategy to get us there.

The *2035 Report 2.0: Plummeting Costs and Dramatic Improvements in Batteries Can Accelerate our Clean Transportation Future* shows that it is technologically feasible and economically beneficial to rapidly decarbonize the transportation sector (via widespread electrification), while cleaning up the

electricity grid. **The study by University of California, Berkeley (UC Berkeley), GridLab, and Energy Innovation, finds that, compared to a business-as-usual (BAU) No New Policy Scenario, the DRIVE Clean Scenario of achieving 100 percent EV sales by 2030-2035, combined with a 90 percent clean electricity grid by 2035, could result in major benefits:**

- **$2.7 trillion in consumer cost savings through 2050;**
- **150,000 avoided premature deaths, and nearly $1.3 trillion in avoided health and environmental costs through 2050;**
- **45 percent economy-wide carbon emissions reductions by 2030 (relative to 2005 levels) when combined with additional electrification of buildings and industry; and a 93 percent reduction in ground transportation carbon emissions by 2050 (relative to 2020 levels);**
- **A dependable grid and achievable investments in renewable energy, batteries, and charging infrastructure;**
- **Over 2 million net jobs created in 2035 with opportunities to bolster job growth and global competitiveness through sound industrial policies to support manufacturing.**

Without strong policy to reach those targets, Americans will forgo these benefits and miss the chance to steer toward a better future. Policymakers and other stakeholders can take bold actions, bolstered by the widespread support among Americans for more aggressive policy action to address climate change and increasing interest in EVs. In step with this transition, America can jump-start domestic manufacturing, sustain and create millions of jobs, and reinvigorate America's economy and industries.

This report is a guide and reference for policymakers leading this transition and serves as a companion to the 2035 2.0 Report. The policy recommendations in this report are designed primarily to achieve the 100 percent EV sales by 2030/2035 targets from the 2035 2.0 Report DRIVE Clean Scenario, while also addressing social equity. We highlight the near-, mid-, and long-term actions that the federal government, states, local governments, and utilities should take to: 1) accelerate the transportation sector's transition away from fossil fuels within the decade; and, 2) overcome the most common barriers to transportation electrification.

The policy and market changes needed for such a transformation must also prioritize environmental justice, social equity, and mobility. Inclusive processes are needed to address these challenging issues meaningfully. Policies should prioritize pollution reductions, especially for those disproportionately burdened by health damaging emissions from trucks and buses. In addition, policies should support electric vehicles access for low- and moderate-income (LMI) consumers, and should proactively consider how transportation system changes will impact communities.

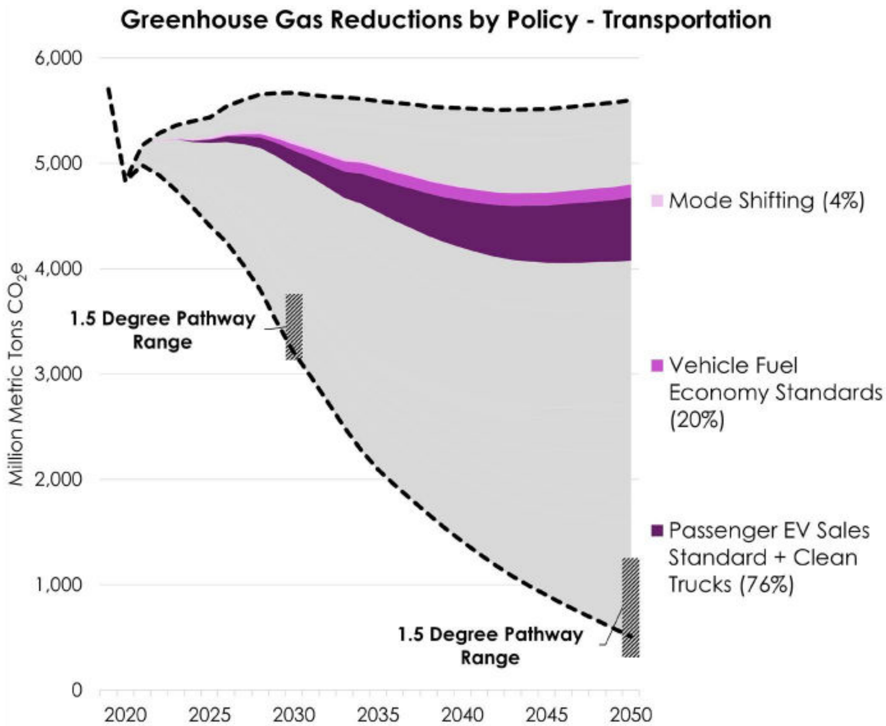

FIGURE ES-1.

Modeling from Energy Innovation's Energy Policy Simulator identifies the policies across the major sectors of the economy, including transportation, needed to align with a 1.5 degree Celsius by 2050 scenario. The transportation policies shown here reflect their contributions to overall emissions reductions in that sector, shown in percentages. Of note, this model run assumed 100% EV sales for LDVs by 2035 and HDVs by 2045, which are slower timelines than those modeled in the 2035 2.0 Report. Moving the timeline to align with the DRIVE Clean Scenario would have the effect of accelerating the overall emissions reductions, among other benefits. Source: Robbie Orvis, A 1.5° Celsius Pathway to Climate Leadership for the United States, Energy Innovation, February 2021.

The goal of achieving 100 percent EV sales by 2030/2035, supported by a 90 percent clean grid by 2035, is certainly ambitious. But so too was the notion of an automobile-dominant future at a time when horses and carriages ruled the roads. We need a fresh vision for the future to accelerate transportation electrification within this decade. Policymakers across all levels of government should focus on the policies that address near-term barriers, while also supporting the long-term transition to a zero-emission transportation system. The priority policy actions are as follows:

- **Strong national fuel economy and tailpipe emissions standards for all vehicle classes** will pave the road for market transformation, spur technology innovation, reduce local pollution, and lock in consumer savings. Combined with state leadership in ZEV standards, strong national standards will protect consumers, improve public health, and ensure U.S. manufacturers remain globally competitive. America needs strong standards to reduce greenhouse gas emissions in line with a 1.5 degree Celsius global target (see Figure ES-1). These are the highest priority policies in terms of emissions reductions.

- **Equity-focused policies and programs** designed with input from communities most adversely impacted by transportation pollution — namely communities of color in historically redlined neighborhoods, and frontline and underserved communities — will ensure all people, regardless of race or other socio-economic demographics, benefit from cleaner, more efficient transportation solutions.
- **Targeted incentives that ramp down over time as the market matures** will encourage early adoption and drive down costs to benefit all consumers. Means-based incentives will help ensure low- and moderate-income consumers and small businesses also benefit. Consumer education programs will increase awareness of expanding EV model availability and suitability. Incentive programs for EV infrastructure are also key to an all-electric future.
- **Investments in a ubiquitous charging network and a modern grid** will address range anxiety and ensure reliability as the EV market grows. Meeting the mobility needs of families and businesses will boost consumer and business confidence in EVs for urban, rural, and long-distance trips.
- **Strong "Made in America" policies to encourage domestic manufacturing** will help retool U.S. industry to manufacture batteries, EVs, energy storage, and other advanced technologies. An early focus on these policies will improve global competitiveness, sustain jobs, and support workers in the transition.
- **Smart electric utility regulations and local government leadership** will reduce permitting and other soft costs and elicit full electrification transportation value for the benefit of EV owners, utility customers, and the grid. Efforts to streamline interconnection and integration of EVs in homes, businesses, and communities will pay dividends as demand grows.

A transition away from fossil fuel-powered vehicles and toward electric vehicles powered by a clean grid is within reach, but we must enact policies that transform the transportation sector this decade. In doing so, we will secure our role as global leader in innovation and improve competitiveness. We will sustain and create jobs, while saving consumers trillions. Widespread transportation electrification will also dramatically reduce dangerous air pollution and is essential to securing a safe climate future. Now is the time to move full speed ahead.

Table ES-1 provides a summary of the policy recommendations from the full report.

TABLE ES-1.

Summary of Policy Recommendations to Achieve the DRIVE Clean Scenario from the 2035 2.0 Report. Please note that the timeline for enactment indicates when the policy action should be taken. It does not indicate the duration of the policy nor the implementation timeline.

	POLICY ACTIONS & TIMELINE FOR ENACTMENT	NEAR-TERM (2021 - 2023)	MID-TERM (2024-2026)	LONG-TERM (2027-2035)	FEDERAL ACTION	STATE ACTION	LOCAL ACTION	UTILITY ACTION
NATIONAL/STATE 100% EV SALES STANDARD	Adopt federal GHG Emissions Standards reaching 0g/mile by 2030/2035	●	●		✓			
NATIONAL/STATE 100% EV SALES STANDARD	Adopt increasingly rigorous Federal Fuel Economy (CAFE) Standards	●	●		✓			
NATIONAL/STATE 100% EV SALES STANDARD	Adopt state 100% ZEV Sales Standards	●	●			✓		
INCENTIVES AND FUNDING TO SUPPORT EV ADOPTION	Reform and expand Federal Plug-In EV Consumer Tax Credit	●			✓			
INCENTIVES AND FUNDING TO SUPPORT EV ADOPTION	Provide incentives for public and private fleet conversion	●	●		✓	✓		
INCENTIVES AND FUNDING TO SUPPORT EV ADOPTION	Provide used EV incentive	●	●		✓	✓		
INCENTIVES AND FUNDING TO SUPPORT EV ADOPTION	Offer competitive grants and funding programs for public and non-profit entities	●	●	●	✓	✓	✓	
INCENTIVES AND FUNDING TO SUPPORT EV ADOPTION	Require EV procurement for public fleets, transit, buses	●	●	●	✓	✓	✓	
INCENTIVES AND FUNDING TO SUPPORT EV ADOPTION	Offer federal/state tax exemption or reduction	●	●		✓	✓		
INCENTIVES AND FUNDING TO SUPPORT EV ADOPTION	Adopt special lane access for EVs, parking incentives, road toll fee waivers, and licensing incentives	●	●			✓	✓	
INCENTIVES AND FUNDING TO SUPPORT EV ADOPTION	Support new financing models and innovative funding programs that significantly expand consumer and business access	●	●		✓	✓	✓	✓

POLICY ACTIONS & TIMELINE FOR ENACTMENT

Priority	Policy Action	NEAR-TERM (2021 - 2023)	MID-TERM (2024-2026)	LONG-TERM (2027-2035)	FEDERAL ACTION	STATE ACTION	LOCAL ACTION	UTILITY ACTION
EXPAND EV CHARGING INFRASTRUCTURE	Expand and improve the Federal Alternative Fuel Infrastructure Tax Credit (30C)	✓			✓			
EXPAND EV CHARGING INFRASTRUCTURE	Modify and extend the Fixing America's Surface Transportation (FAST Act)	✓	✓		✓			
EXPAND EV CHARGING INFRASTRUCTURE	Make charging infrastructure an Allowable Expense in Federal Funding Programs, as applicable	✓	✓		✓			
EXPAND EV CHARGING INFRASTRUCTURE	Install charging infrastructure on federal property	✓	✓	✓	✓			
EXPAND EV CHARGING INFRASTRUCTURE	Direct electric utilities to develop plans to support and accelerate widespread transportation electrification and promptly approve the corresponding infrastructure programs	✓	✓			✓		✓
EXPAND EV CHARGING INFRASTRUCTURE	Create stackable incentives, targeted at underserved locations, to fill charging gaps	✓	✓			✓	✓	✓
EXPAND EV CHARGING INFRASTRUCTURE	Continue the Alternative Fuel Corridors and increase corridor signage	✓	✓		✓			
EXPAND EV CHARGING INFRASTRUCTURE	Update the National Highway Freight Network to align with transportation electrification goals.		✓	✓	✓			
EXPAND EV CHARGING INFRASTRUCTURE	Remove the current federal prohibition on commercial activity at rest areas to encourage EV charging (and signage) at interstate rest areas.		✓	✓	✓			
EXPAND EV CHARGING INFRASTRUCTURE	Direct funding to support "make-ready" investments		✓			✓	✓	✓
EXPAND EV CHARGING INFRASTRUCTURE	Create MUD-specific dedicated incentives	✓	✓			✓	✓	✓
EXPAND EV CHARGING INFRASTRUCTURE	Authorize utility programs targeting MUD charging infrastructure	✓	✓			✓	✓	
EXPAND EV CHARGING INFRASTRUCTURE	Expand workplace and public charging	✓	✓	✓		✓	✓	✓
INCREASE DOMESTIC MANUFACTURING	Adopt a transportation infrastructure stimulus package	✓			✓			
INCREASE DOMESTIC MANUFACTURING	Provide a 30 percent ITC for investment in domestic battery manufacturing	✓			✓			
INCREASE DOMESTIC MANUFACTURING	Create or expand EV Manufacturing Finance Programs		✓		✓			
INCREASE DOMESTIC MANUFACTURING	Create a Battery Cell Manufacturing Production Incentive	✓			✓			
INCREASE DOMESTIC MANUFACTURING	Expand R&D efforts to develop a domestic supply chain for battery raw materials (e.g., mining, processes, and battery recycling),	✓	✓	✓	✓	✓		
INCREASE DOMESTIC MANUFACTURING	Fund or support workforce training programs	✓	✓	✓	✓	✓	✓	✓
INCREASE DOMESTIC MANUFACTURING	Require procurement of EVs	✓	✓	✓	✓	✓	✓	✓

	POLICY ACTIONS & TIMELINE FOR ENACTMENT			FEDERAL ACTION	STATE ACTION	LOCAL ACTION	UTILITY ACTION
	NEAR-TERM (2021 - 2023)	MID-TERM (2024-2026)	LONG-TERM (2027-2035)				
STREAMLINE DEPLOYMENT WITH EV-FRIENDLY INTERCONNECTION, PLANNING, PERMITTING, AND CODES	Adopt interconnection best practices that proactively address EVSE				✓		✓
	Adopt and implement hosting capacity analyses (HCAs) and maps; integrate EVs and EVSE into methodologies				✓		✓
		Investigate EV and EVSE impacts on the bulk-grid and wholesale markets		✓	✓		✓
	Adopt Integrated Distribution Planning (IDP) with a framework for EVs and EVSE				✓		✓
	Direct (and fund) relevant stakeholders to convene, share relevant data and maps, and make information publicly available			✓	✓	✓	✓
		Adopt and implement streamlined EVSE permitting			✓	✓	
	Adopt EVSE, EV-ready, and EV parking provisions in building codes			Natl. Code-Setting Bodies	✓	✓	
	Allow local governments to go beyond the state code/ base code				✓	✓	
	Funding to streamline permitting processes and train building code officials			✓	✓	✓	✓
ADOPT SMART RATE DESIGN	Enable time-varying rates for LDEVs				✓		✓
	Enable Actively Managed LDEV Charging				✓		✓
		Explore V2G and Bi-Directional Charging, and Adaptive Load Management			✓		✓
	Rate reform to mitigate demand charge impacts				✓		✓
	Incentives for co-located distributed generation and/or energy storage at strategic EVSE charging locations			✓	✓	✓	✓

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ACRONYMS

ACC Program	Advanced Clean Cars Program
ACT Rule	Advanced Clean Trucks Rule
ALM	Adaptive load management
ARRA	2009 American Recovery and Reinvestment Act
ATVM	Advanced technology vehicle manufacturing
AVMTC	Advanced Vehicle Manufacturing Tax Credit
BAU	Business-as-usual
BEV	Battery electric vehicle
BNEF	Bloomberg New Energy Finance
CAA	Clean Air Act
CAFE	Corporate Average Fuel Economy Standards
CARB	California Air Resources Board
CDFI	Community developed financing institutions
CMAQ	Congestion Mitigation and Air Quality Improvement Program
DCFC	Direct current fast charger
DER	Distributed energy resource
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
EPA	U.S. Environmental Protection Agency
EV	Electric vehicle
EVSE	Electric vehicle supply equipment
FAST Act	Fixing America's Surface Transportation Act
FASTLANE	Fostering Advancements in Shipping and Transportation for the Long-Term Achievement of National Efficiencies
FERC	Federal Energy Regulatory Commission
FHWA	Federal Highway Administration
GHG	Greenhouse gas
GSA	U.S. General Services Administration
GW	Gigawatt
HCA	Hosting capacity analysis
HDT	Heavy-duty truck
HDEV	Heavy-duty electric vehicle
HDV	Heavy-duty vehicle
HFCV	Hydrogen fuel cell vehicle
HOV	High-occupancy vehicle
H.R.	U.S. House of Representatives
ICC	International Code Council
ICCT	International Council on Clean Transportation
ICEV	Internal combustion engine vehicle
IDP	Integrated Distribution Planning
ISO	Independent System Operator
ITC	Investment tax credit
kW	Kilowatt
LEV Standards	Low Emission Vehicle Standards
LDEV	Light-duty electric vehicle
LDV	Light-duty vehicle
LMI	Low- to moderate-income
MHDEV	Medium- and heavy-duty electric vehicle
MDEV	Medium-duty electric vehicle
MDV	Medium-duty vehicle
MUD	Multi-unit dwelling
NHFP	National Highway Freight Program
NHTSA	U.S. Department of Transportation's National Highway Traffic Safety Administration
NREL	National Renewable Energy Laboratory
PHEV	Plug-in hybrid electric vehicle
PEV	Plug-in electric vehicle
PUC	Public Utility Commission
R&D	Research & development
REAP	U.S. Department of Agriculture's Rural Energy for America Program
RTO	Regional Transmission Operator
SCE	Southern California Edison
TIFIA	U.S. DOT's Transportation Infrastructure Finance and Innovation Act
TVR	Time-varying rates
V1G	Unidirectional power flow from the charging source to the vehicle
V2B	Vehicle-to-building
V2G	Vehicle-to-grid
V2H	Vehicle-to-home
V2X	Bidirectional power flow from the charging source to the vehicle
VGI	Vehicle grid integration
VW	Volkswagen
ZEV	Zero-emission vehicle

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TECHNICAL REVIEW COMMITTEE MEMBERS

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Sue Gander, *Electrification Coalition*

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Nic Lutsey, *International Council on Clean Transportation*

Nick Nigro, *Atlas Public Policy*

Sky Stanfield, *Shute, Mihaly & Weinberger, LLP*

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I

TIME TO SHIFT INTO HIGH GEAR ON U.S. TRANSPORTATION POLICY

Transporting people and goods is integral to the United States economy and American way of life. Yet, the predominance of fossil fuel-powered internal combustion engine vehicles (ICEVs) as the primary mode of transport since the early 1900s has imposed an untenable cost on consumers,[i] public health,[1] and the climate. As the largest U.S. source of greenhouse gas emissions (GHGs), the transportation sector is key to unlocking economy-wide decarbonization by 2050 in order to mitigate the worst impacts of climate change.[2] The transportation sector must quickly shift gears and move away from its long-standing reliance on fossil fuels and ICEVs and toward cleaner alternatives, including electric vehicles (EVs) powered by a clean grid.

The benefits of this transition are modeled in the *2035 Report 2.0: Plummeting Costs and Dramatic Improvements in Batteries Can Accelerate our Clean Transportation Future*[3] (hereafter referred to as "2035 2.0 Report")—a technical feasibility and economic impact analysis of rapidly accelerating transportation electrification and grid decarbonization. The report compares a business-as-usual scenario (BAU) No New Policy to an alternative future scenario (the DRIVE Clean Scenario) in which the U.S. achieves 100 percent light-duty electric vehicle (LDEV) new sales by 2030 and 100 percent medium- and heavy-duty electric vehicle (MHDEV) new sales by 2035, concurrent with achieving a 90 percent clean electricity grid by 2035.[ii] The analysis found the following benefits from the DRIVE Clean Scenario as compared to the BAU scenario:

- $2.7 trillion in consumer cost savings through 2050;
- 150,000 avoided premature deaths, and nearly $1.3 trillion in avoided health and environmental costs through 2050;
- 45 percent economy-wide carbon emissions reductions by 2030, relative to 2005 levels (when combined with additional electrification of buildings and industry), and a 93 percent reduction in ground transportation GHG emissions by 2050;

i The average internal combustion engine vehicle costs nearly $10,000 to own and operate in the U.S., according to Consumer Expenditures in 2019 by the U.S. Department of Labor's Bureau of Labor Statistics, Source: https://www.investopedia.com/articles/pf/08/cost-car-ownership.asp.

ii The 2035 2.0 Report evaluates a DRIVE Clean scenario, relative to a no new policy business-as-usual (BAU) scenario. DRIVE Clean looks at achieving 100 percent EVs for new sales of LDVs by 2030 and MDHEVs by 2035 ("100 percent EV sales by 2030/2035"). The techno-economic analysis runs some sensitivity analyses to evaluate the impacts of 100 percent EVs by 2035/2035. The years 2030 and 2035 represent the bookend dates for achieving the 100 percent EV sales goals. The policy recommendations in this report are imperative whether the goal is achieved sooner or later, but the benefits of moving faster are clearly demonstrated in the 2035 2.0 technical report.

- A dependable grid and achievable investments in renewable energy, batteries, and charging infrastructure;
- Over 2 million net jobs created in 2035, with opportunities to bolster job growth and global competitiveness[iii] through sound domestic industrial policy and manufacturing support.

But new policy is required to achieve these benefits and avoid catastrophic climate change. A recent analysis by Energy Innovation shows that interim goals and targets, like 100 percent new EV sales by 2030/2035 outlined in the DRIVE Scenario, are *necessary* because they determine cumulative GHG emissions between now and 2050.[4]

iii According to BNEF's Electric Vehicle Outlook 2020 report, "[a]utomakers [will] focus their passenger EV efforts on the markets with the most stringent regulations for the next 10 years, leading to low rates of EV adoption in the Rest of the World category. Absent stronger policy, BNEF predicts the U.S. will fall further behind leading EV markets during the 2020s. Source: *BloombergNEF*, "Long-term passenger vehicle outlook," Electric Vehicle Outlook 2020, Executive Summary, 1, https://bnef.turtl.co/story/evo-2020/page/3/1?teaser=yes.

TALKING SHOP: VEHICLE AND ZEV TERMINOLOGY 101

Several terms and acronyms are used throughout this report to refer to segments of the vehicle fleet:

- **Zero-emission vehicles (ZEVs)** include both plug-in electric vehicles **(PEVs)** and hydrogen fuel cell vehicles **(HFCVs)**.
- **Internal Combustion Engine Vehicles (ICEVs)** refer to conventional vehicles that use gasoline or diesel as their fuel;
- **Plug-in Electric Vehicles (PEVs)** include both battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs);
    - **Plug-in Hybrid Electric Vehicles (PHEVs)** are vehicles that have an internal combustion engine and an electric engine that can be plugged in to recharge;
    - **Battery-Electric Vehicles (BEVs)** have no internal combustion engine and rely solely on an electric engine that can be plugged in to recharge;
- **Electric Vehicle (EV)** is often used as a shortened version of PEV and can refer to PHEVs and BEVs.

For the purposes of this report, **we use EVs throughout to refer to BEVs and not PHEVs or HFCVs**. The justification for this specific use of terminology stems from the 2035 2.0 Report analysis, in which gas vehicles are replaced entirely by BEVs and not PHEVs.

VEHICLE CLASSES

The Federal Highway Administration defines vehicle classes based on Gross Vehicle Weight Rating (GVWR), which is the maximum operating weight of the vehicle (vehicle weight plus the fuel, cargo, passengers, and the trailer tongue, etc.) measured in pounds (lb).

Based on these classifications, this report and the 2035 2.0 Report differentiate between vehicle classes as follows:

CLASS	GVWR (LB)	AGGREGATED CATEGORY	EXAMPLE VEHICLE
Class 1	0 - 6,000	Light-duty Vehicles (LDVs)	Sedan
Class 2a	6,001 - 8,500		SUV; light-duty pickup
Class 2b-3	8,501 - 14,000	Medium-duty Vehicles (MDVs)	Heavy-duty pickup
Class 4-5	14,001 - 19,500		Delivery box truck
Class 6-7	19,501 - 33,000		School bus
Class 7-8	26,001 - 33,001 +	Heavy-duty Vehicles (HDVs) or Heavy-duty Trucks (HDTs)	Tractor trailer

The acronyms for the equivalent **EV** classes are **LDEV, MDEV, and HDEV**. The acronym **MHDVs** stands for medium- and heavy-duty vehicles, which is a useful grouping for policy and technology discussions. The acronym for the equivalent EV grouping is **MHDEVs**.

The U.S. lags considerably behind other countries that are already leading in the sizable and quickly growing global EV market.[5] As of December 2020, approximately 1.78 million EVs were sold in the U.S., representing around 2 percent of the U.S. market.[6] Anemic forecasts for the future reflect the patchwork U.S. climate and energy policy landscape today—a stark contrast to the growing number of governments and automakers that have goals to phase out sales of new ICEVs or require all new sales to be electric in the coming decade.[7] Absent new policy, new LDEVS sales are projected to be somewhere between 12 to 37 percent of all new sales by 2030,[8] and new sales of MHDEVs will be a nominal percentage of total global sales by 2030.[9]

Achieving transportation electrification quickly requires policies that simultaneously address near-term challenges to widespread EV adoption, while also paving the way for long-term market growth. Fortunately, the U.S. Environmental Protection Agency (EPA) already has statutory authority to set vehicle tailpipe emissions standards such that they achieve 100 percent zero-emission vehicle (ZEV) sales by 2035 at the latest. Similarly, the U.S. Department of Transportation has statutory authority to adopt increasingly stringent fuel economy standards. Complemented by state ZEV targets and additional complementary policies, swift action on these fronts can jump-start the transition to a clean, electrified transportation future.

The U.S. must now shift into high gear and develop a comprehensive transportation policy strategy, driven by federal, state, and local decision-makers. Widespread support exists for more aggressive policy action to address climate change,[10] along with expanding interest in EVs,[11] and strong support for increased domestic manufacturing.[12,13] Policies should be targeted in their design and function: to 1) accelerate the transition away from fossil fuels within the decade; and, 2) overcome the most common barriers to transportation electrification.[iv]

POLICY PRIORITIZATION AND TIMING

Policymakers at all levels of government should remain mindful of technology adoption curves and the diffusion of innovation theory,[14] targeting actions that are both responsive to real-time market conditions and aligned with policy target timelines. ***Figure 1*** shows strong policies, particularly incentives and infrastructure investments, are needed during the early stages of market transformation (where the U.S. EV market is today) to jump-start innovation and support stronger industry ambition.

iv The barriers to EV adoption are well-documented in other reports, and not duplicated here. Though, within each section of this report, we provide a high-level summary of the barriers and offer targeted recommendations to address them. The main barriers to EV adoption include: lack of consumer and business familiarity with the technology, higher upfront vehicle costs, limited model availability, lower driving ranges, lack of sufficient public charging infrastructure, and lack of charging access for harder to reach market segments (i.e., multifamily housing and heavy-duty trucking routes). Source: "Addressing the barriers to EV Adoption," *GeoTab*, January 6. 2021, https://www.geotab.com/white-paper/barriers-to-ev-adoption/, accessed March 26, 2021, and Rob Stumpf, "Americans Cite Range Anxiety, Cost as Largest Barriers for New EV Purchases: Study," *The Drive*, February 26, 2019, https://www.thedrive.com/news/26637/americans-cite-range-anxiety-cost-as-largest-barriers-for-new-ev-purchases-study.

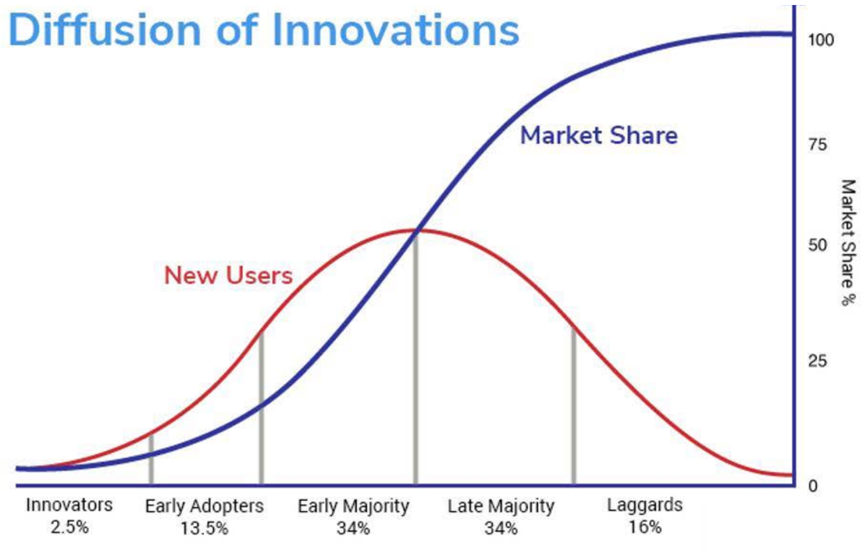


FIGURE 1.

Technology Adoption Curves, Based on the Diffusion of Innovation Theory.

The blue line represents the adoption curve, and the yellow line represents the market share of new technologies, demonstrating the need for strong policies during the early stages of market transformation. Source: Andy Swan, "How to Spot Companies Acceleration Through The Adoption Curve," Forbes, April 12, 2020.

The policy recommendations in this report are geared toward achieving targets in the 2035 2.0 DRIVE Clean Scenario (100 percent EV sales by 2030/2035) as efficiently as possible. Each section contains policy actions the federal government and states can take, as well as local governments and utilities. A summary table at the end of each section indicates when policy actions should be taken, using the following terms throughout: Near-term = 2021-2023; Mid-term = 2024-2026; and Long-term = 2027-2035. Of note, the timeline for enactment does not indicate the duration of the policy nor the implementation timeline.

We recognize that other policies not included may also be meritorious. For example, we do not address broader mobility policies, though they are an important component in a comprehensive transportation strategy aimed at reducing vehicle miles traveled (and thus harmful emissions), improving quality of life, and ensuring access to more affordable, efficient transportation options.

2020s: THE (NEXT) DECADE OF TRANSPORTATION TRANSFORMATION

Although many actions are required for EVs to reach 100 percent new sales across all vehicle classes, history offers a valuable example of rapid transformation in the transportation sector. When first introduced in 1908, automobiles were still considered a rare luxury at a time when horses, horse-drawn carriages, bicycles, and steam engines were the predominant modes of travel. In a little more than a decade, passenger cars and trucks quickly replaced horses and bicycles as the standard form of transporting people and goods, spurred by plummeting automobile prices and improved technology.[15] By the close of the 1920s, mass-produced automobiles were widely available, and nearly three vehicles were registered for every four households.[16] Today, a century later, nearly 290 million vehicles are registered in the U.S.[17]

The 2020s must be the next decade of transportation transformation. The 2035 2.0 Report demonstrates the technological feasibility and benefits of rapid vehicle electrification and grid decarbonization. This transformation also offers immense opportunities to increase U.S. global competitiveness, save money, improve public health, enhance energy security, and mitigate climate change. Smart policies and bold leadership at all levels of government will catalyze the widespread adoption of EVs, supported by extensive charging networks and a robust, clean electricity grid. The time for such bold action is now.

II

PRIORITIZE TRANSPORTATION EQUITY, ENVIRONMENTAL JUSTICE, AND MOBILITY

The policy and market changes needed for such a transformation must prioritize environmental justice and social equity. Meaningfully addressing these challenging issues begins with inclusive processes.[18] People living in underserved and frontline communities have a disproportionate lack of access to key decision-makers and are not regularly consulted with by policymakers, limiting their influence on the policies that impact their lives. Some may also lack the resources or the opportunity to take advantage of cleaner technologies,[19] even when desirable. The policymaking process should be inclusive from the outset, centering on community participation, identifying the most relevant solutions, and increasing the community's on-going influence with decisionmakers.

Policies should prioritize mitigating transportation pollution in disproportionately impacted areas,[20] with particular focus on particulate emissions from trucks and buses.[21]

Policies aimed at getting more EVs (new and used) on the road and installing charging infrastructure should be structured to ensure those unable to immediately adopt clean transportation technologies are not left behind and address concerns about changes within impacted communities. Policies and program design should target low- to moderate-income (LMI) individuals, those more vulnerable to poverty,[22] historically redlined communities,[23] and people dependent on vehicles for their income.

Charging infrastructure investments should benefit diverse housing and commercial market segments, such as multi-unit dwellings (MUDs), on-street and public parking, transportation hubs, and high-use transportation corridors. Infrastructure investments located in lower-income or frontline communities should have guardrails to avoid gentrification and dislocation of current residents. Throughout the process, policymakers, regulators, and all stakeholders engaged in transportation transformation should prioritize actions that will help rectify longstanding environmental injustices by adopting protocols, policies, and programs that target the root cause of problems.[24] While not all societal ills can be remedied with transportation policy, policies should, at a minimum, avoid exacerbating extant inequalities.

Finally, policymakers must also keep in mind that millions of U.S. residents do not have access to or choose not to own a vehicle, relying instead on other modes of transport: public transit, ride share vehicles, walking, bicycles, and scooters. Smart urban planning strategies to reduce vehicle miles traveled are proven ways to limit congestion, reduce pollution, and improve public health.[25] For more examples and suggestions on policy design for equitable transportation, we refer readers to other resources on this topic, such as The Greenlining Institute's *Mobility Equity Framework.*[26]

III

IMPLEMENT A NATIONAL STANDARD TO REACH 100 PERCENT EV SALES

The U.S. Department of Transportation's National Highway Traffic Safety Administration (NHTSA) and the EPA promulgate vehicle fuel economy standards (known as Corporate Average Fuel Economy, or CAFE standards) and emissions standards, respectively.[v,27] As shown in ***Figure 2***, these federal standards are key to achieving 100 percent EV sales by 2030/2035 and reducing GHGs in the transportation sector by 2050.[28] As both standards become more stringent, EVs become an increasingly attractive compliance option for auto manufacturers. Fuel economy and emissions standards compel automakers to make major sustained investments in mass production of EVs across all brands and vehicle classes, supporting consumer preferences, and expediting EV cost parity with ICEVs.

v NHTSA establishes fuel economy standards through authorities provided under the Energy Policy and Conservation Act of 1975, as amended by the Energy Independence and Security Act of 2007, while EPA establishes CO_2 emissions standards under the Clean Air Act, as amended.

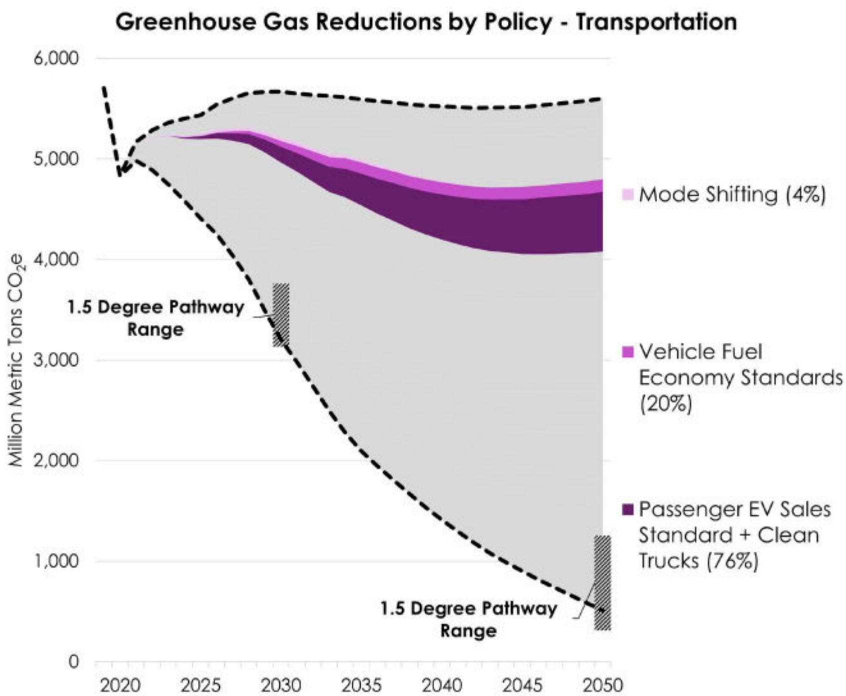


FIGURE 2.

Greenhouse Gas Reductions by Policy — Transportation.

Modeling from Energy Innovation's Energy Policy Simulator identifies the policies across the major sectors of the economy, including transportation, needed to align with a 1.5 degree Celsius by 2050 scenario. The transportation policies shown here reflect their contributions to overall emissions reductions in that sector, shown in percentages. Of note, this model run assumed 100% EV sales for LDVs by 2035 and HDVs by 2045, which are slower timelines than those modeled in the 2035 2.0 Report. Moving the timeline to align with the DRIVE Clean Scenario would have the effect of accelerating the overall emissions reductions, among other benefits. Source: Robbie Orvis, A 1.5° Celsius Pathway to Climate Leadership for the United States, Energy Innovation, February 2021.

In addition to strong federal action, states can and should continue to leverage their authority under the Clean Air Act (CAA) Section 177 to adopt more stringent tailpipe emissions standards, including adopting 100 percent ZEV requirements for all in-state vehicle sales by 2030/2035. This combination of federal and state leadership will pave the way for widespread market transformation in the coming decade.

CURRENT VEHICLE STANDARDS

The standards set by the EPA and NHTSA apply to all *new* vehicle model years under the relevant rule. The standards are harmonized such that meeting a fuel economy standard (miles per gallon or mpg) also complies with a GHG standard (gCO_2 per mile or g/mile). LDVs and MDHVs are subject to different rules. The CAA directs the EPA to set tailpipe emissions standards for GHGs reflecting "the greatest degree of emission reduction achievable through the application of technology . . . available for the model year to which such standards apply, giving appropriate consideration to cost, energy, and safety factors associated with the application of such technology."[29]

Under current EPA regulations, all fully electric and HFCVs are granted a temporary regulatory incentive to count as ZEVs (or 0 g/mile) up to a certain volume, regardless of their associated upstream emissions from the electricity grid or hydrogen production. Thus, they currently significantly reduce average fleet-wide tailpipe emissions,[30] though this accounting methodology is subject to change in future rule adjustments (see ***Addressing Upstream Emissions from EVs in a National Standard***).

ADDRESSING UPSTREAM EMISSIONS FROM EVS IN A NATIONAL STANDARD

In developing a national vehicle emissions standard, accounting for the upstream emissions (i.e., emissions from the electric grid) from EVs is a key design question. Although counting EVs as ZEVs gives them preferential treatment by failing to account for upstream grid emissions, this should be considered a near-term incentive that enables the goal of 100 percent EV sales by 2030/2035.

Analysis by the International Council on Clean Transportation (ICCT) that evaluated the impact on transportation emissions of various accounting strategies when integrating EVs into GHG standards found upstream emissions are less significant as the grid becomes cleaner.[30] Even today, 94 percent of people in the U.S. live in areas where driving an EV produces fewer emissions than that of a 50-mile-per-gallon gasoline car.[31]

If the grid fails to decarbonize by 2035, the EPA can consider reinstating upstream emissions accounting in future tailpipe emission standard compliance periods. Nonetheless, this issue highlights the need to simultaneously accelerate efforts to reduce power sector GHG emissions while electrifying the transportation sector.

Federal standards for MDHVs were most recently updated in 2016, when EPA and NHTSA jointly adopted Phase II standards that will apply to model years 2021-2027. GHG emission fuel economy standards apply to four categories of MDHVs: combination tractors, trailers pulled by combination tractors, heavy-duty pickup trucks and vans, and vocational vehicles (which include buses, refuse trucks, and concrete mixers). The rules include separate standards for the engines that power combination tractors and vocational vehicles. For each category, manufacturers can comply with an array of qualifying improvements in the engine, transmission, driveline, aerodynamic design, tire resistance, idle reduction, weight reduction, and others.[33] The Phase II standards adopted a multiplier system (i.e., an EV is counted multiple times) as an incentive to promote electrification and reduce the initial cost of GHG compliance, as follows: PHEVs (3.5x), BEVs (4.5x), and HCEVs (5.5x).[34] The rules acknowledge that such large multipliers are appropriate "at least in the short term, because they have the potential to provide very large reductions in GHG emissions and fuel consumption and advance technology developing substantially in the long term."[35]

In addition to the federal standards, California has long played a leading role in shaping U.S. transportation policy. The CAA authorizes the EPA to grant California a waiver[vi] to enact stricter vehicle emission standards than

vi In 2019, a new rule from the Trump administration attempted to revoke California's waiver to set its own vehicle emissions standards. This effort is currently in litigation. See for e.g., Emily Wimberger and Hannah Pitt, "Come and Take It: Revoking the California Waiver," Rhodium Group, October 28, 2019, https://rhg.com/research/come-and-take-it-revoking-the-california-waiver/.

those set by the federal government.[36,37] Since the adoption of the first Low Emission Vehicle standards (LEV I) in 1990, the California Air Resources Board (CARB)[38] has periodically amended its regulations California's most recent amendments, LEV III, were adopted in 2012 and include more stringent emission standards for both criteria pollutants and GHG emissions for new passenger vehicles,[vii] as well as a zero-emission vehicle (ZEV) standard as part of the Advanced Clean Cars (ACC) Program.[39,40]

California's ZEV standard for LDVs is based on a percentage of in-state sales, creating annual sales requirements for auto manufacturers for the cleanest cars available, including EVs, PHEVs, and HFCVs. Tradeable credits allow manufacturers that exceed compliance limits to sell excess credits to other manufacturers unable or unwilling to comply. California's Advanced Clean Trucks rule (ACT), instituted ZEV requirements for MDVs/HDTs starting in 2024 through 2035. The regulation also requires manufacturers to meet a specified proportion of their sales with ZEVs or purchase credits in lieu of sales.[41] In addition, California's Governor Gavin Newsom issued an executive order in September 2020 calling for 100 percent of new cars and passenger trucks sold be ZEVs by 2035, and all operations of MDV/HDT to be 100 percent ZEV by 2045 (drayage trucks by 2035). CARB is tasked with developing these regulations, which are not yet finalized.[42]

Beyond the effect of reducing harmful air pollution and GHG emissions, California's strong policies and regulations have also generated jobs and economic benefits,[43] and EVs are now one of the state's top manufacturing exports.[44] The rules will also save consumers at the pump and reduce public health costs: An Energy Innovation analysis estimates the ACT regulation will save Californians $7-$12 billion through 2040.[45] As of December 2019, California had 580,000 registered EVs (including PHEVs) — or about a third of the U.S. total.[46]

SECTION 177 STATES

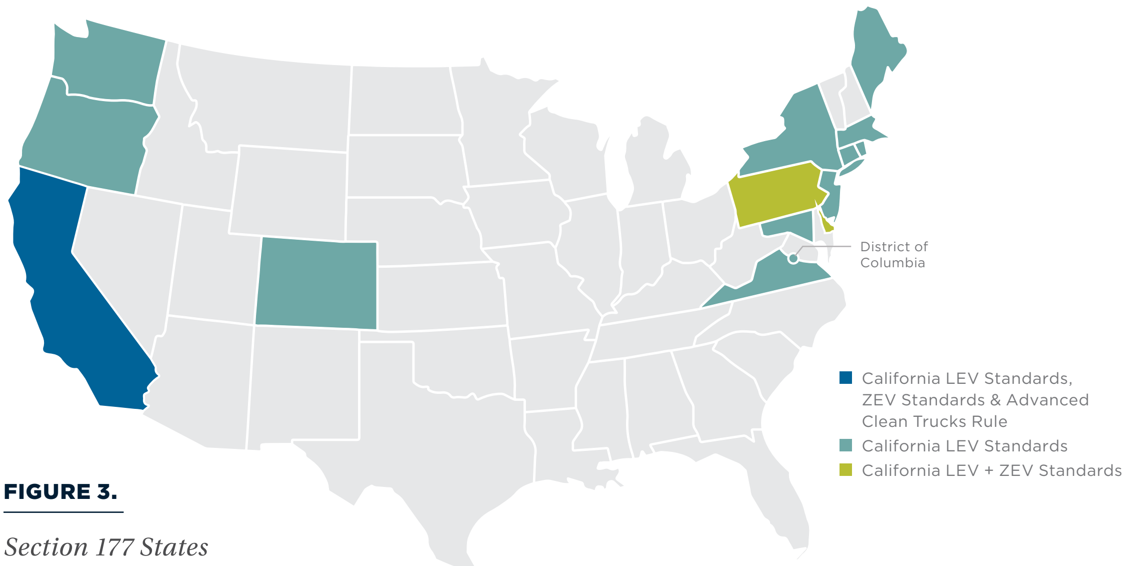


FIGURE 3.

Section 177 States by Type of Standard Adopted.

While only California can enforce its own standards, other qualifying states — specifically those classified as "nonattainment areas" based on EPA's National Ambient Air Quality Standards (NAAQS)[47] — can adopt California's vehicle emission standards through Section 177 of the CAA. As of March 2021, the following 14 states plus the District of Columbia have adopted California's emissions standards, with two adopting only the LEV standards (Delaware and Pennsylvania), and the remainder adopting the LEV standards plus a ZEV standard (Colorado, Connecticut, Maine, Maryland, Massachusetts, New Jersey, New York, Oregon, Rhode Island, Vermont, Virginia, Washington, and the District of Columbia).[viii,48] ***See Figure 3.*** California plus the other ZEV states comprise approximately 35 percent of passenger cars sales in the U.S.[49]

Ensuring EVs reach 100 percent of new vehicle sales by 2030/2035 will require a coordinated national approach, spearheaded by durable federal standards that require auto manufacturers to quickly ramp up their capabilities and transition their fleets (both LDVs and MHDVs) to ZEVs. States should continue to lead by adopting more stringent ZEV standards, along with complementary policies, that create a floor for national standard development, develop the market, and drive innovation.

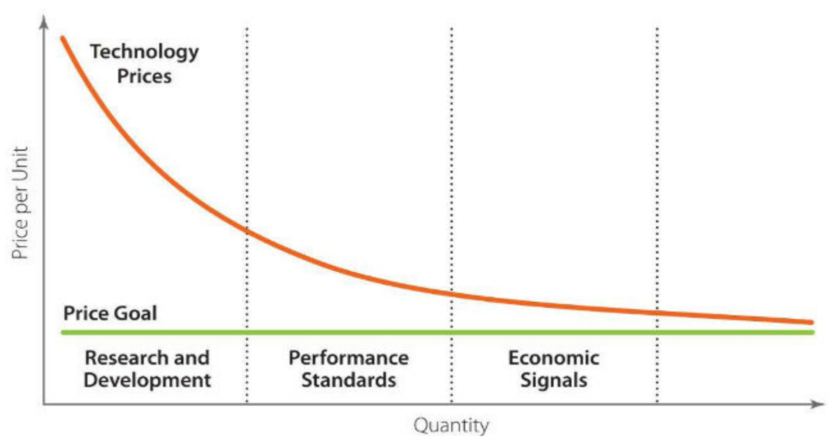
viii As of April 2021, Minnesota, New Mexico, and Nevada were considering adoption of California's standards.

FEDERAL VEHICLE EMISSION STANDARDS.

Through regulation, the EPA should establish a GHG tailpipe emissions standard for new LDVs reaching 0g/mile in 2030-35, and for new MHDVs reaching 0g/mile in 2035-40.[ix] **In addition, the NHTSA should adopt more stringent CAFE Standards for all vehicle classes.** This regulatory approach sets a uniform standard across all vehicle classes, provides "guardrails for the market, allowing competition within those guardrails, which favors least cost-solutions."[50] As illustrated in ***Figure 4***, more stringent performance-based standards reduce vehicle costs by capturing economies of scale, accelerating the pace of innovation, and getting more EVs on the road. As costs decline, the diversity of geographies, consumers, and use cases for EVs expand. Such performance standards provide auto manufacturers and their supply chains with a fair planning horizon to build in continuous improvement and a clear rationale for near-term investment.

The EPA should act quickly to set a stringent interim standard for 2030, on the path to adopting a ZEV standard by 2035 at the latest. Anything less will harm U.S. competitiveness, especially as other countries move quickly to adopt ambitious transportation electrification goals and ramp up their manufacturing capacity to meet these goals.

STATE ZEV STANDARDS



FIGURES 4.

The Policy-Technology Learning Curve (Illustrative).

Source: Hal Harvey, et al., Designing Climate Solutions: A Policy Guide for Low-Carbon Energy, 2018, 17.

ix The 2035 2.0 Report evaluates capital stock turnover within each vehicle category: light-, medium-, and heavy-duty vehicles. While this approach is illustrative from a techno-economic perspective, policymakers should consider more granular segmentation by vehicle category and class. For example, California's 100 percent ZEV sales timeline is as follows: buses by 2029, light-duty cars by 2035, drayage trucks by 2035, and the rest of MHDV by 2045. Buses and drayage trucks are parsed out from and scheduled earlier than the generalized MHDV 100 percent sales goal, in light of technology readiness and optimized ZEV use cases. Additionally, in the case of transit buses, procurement decisions are made years before the vehicles hit the road, so ZEV targets are expected to align accordingly.

States should continue to use their existing authority under Section 177 of the CAA to adopt ZEV standards and require 100 percent EV sales by 2035 at the latest. As more states pursue this approach, they will help pave the way for national efforts and help increase demand for EVs and EV charging infrastructure. State adoption of ZEV sales requirements can be a complementary and important forcing function for manufacturers and charging providers to scale their operations, and is also an important economic development strategy. Complementary state policies are also needed to quickly overcome market inertia and ensure an equitable transition for businesses and consumers.

TABLE 1.

Implement A National Standard to Reach 100 Percent EV Sales — Policy Recommendation Summary

	POLICY ACTIONS & TIMELINE FOR ENACTMENT*			FEDERAL ACTION	STATE ACTION
	NEAR-TERM (2021 - 2023)	MID-TERM (2024-2026)	LONG-TERM (2027-2035)		
NATIONAL/STATE 100% EV SALES STANDARD	Adopt federal GHG Emissions Standards reaching 0g/mile by 2030/2035			✓	
	Adopt increasingly rigorous Federal Fuel Economy (CAFE) Standards			✓	
	Adopt state 100% ZEV Standards				✓

**Please note that the timeline for enactment indicates when the policy action should be taken. It does not indicate the duration of the policy nor the implementation timeline.*

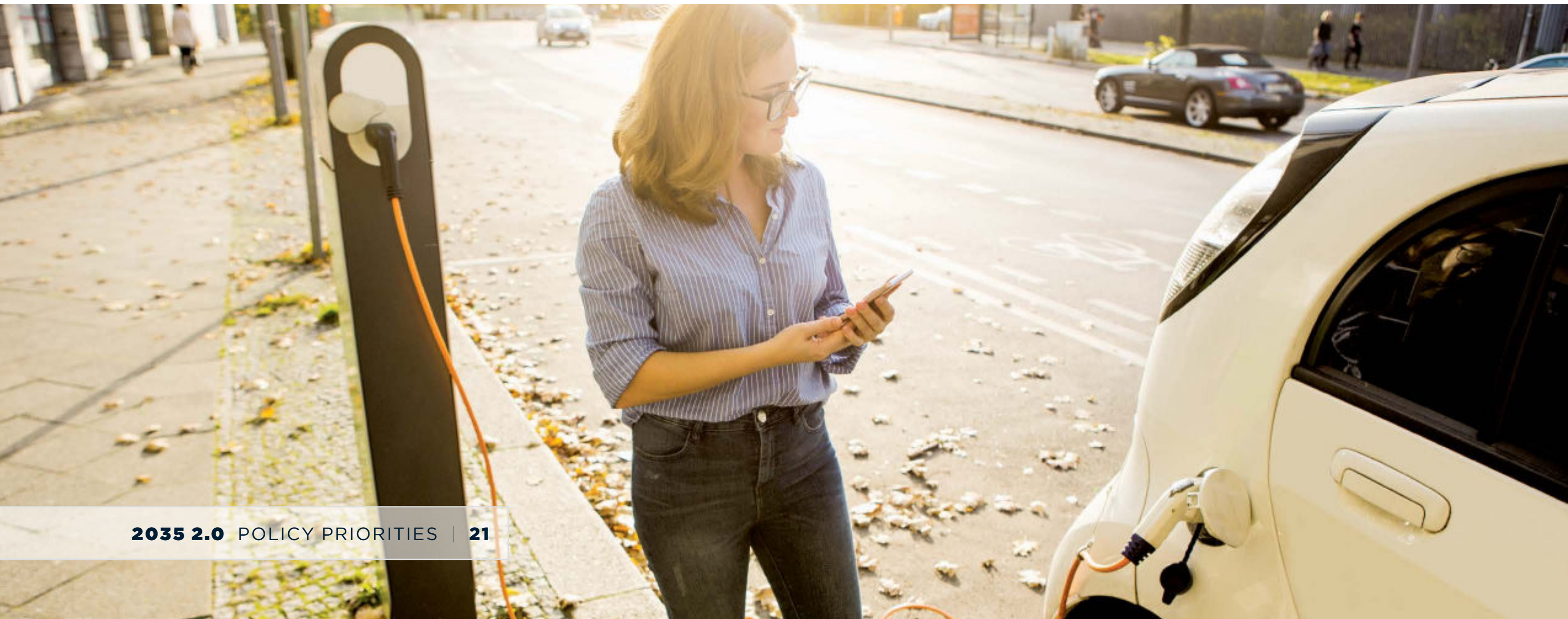
IV

ADOPT INCENTIVES AND FUNDING TO SUPPORT VEHICLE ADOPTION

Incentives will continue to play an important role in motivating consumers and businesses to purchase EVs, which still have a higher upfront cost than conventional gasoline and diesel cars and trucks.[51] Incentives should be combined with other measures that address consumer decision-making including performance, environmental impact, image, range, safety, and reliability.

Policies and programs for passenger vehicles should rectify known shortcomings of existing incentive programs, and account for limiting factors to adoption, such as socio-economic inequities, income disparities, competing financial burdens among LMI individuals and small business, and travel needs. Incentive programs targeting MDHVs should address barriers such as limited capital budgets, fleet purchasing restrictions, and limited model availability in the near term. Incentive design and structure must consider the financial and economic realities of all U.S. residents, not just affluent consumers and highly profitable businesses. Underserved markets must have equal near-term opportunity to benefit from available funds and programs.

Incentives should also be structured to phase down over time when markets have sufficiently matured to avoid overreliance or misuse. Finally, since sales of used vehicles outpace new vehicle sales by more than two to one – approximately 40.8 million used LDVs were sold in 2019, compared to just 17 million new LDVs[52] — incentive programs should support purchases of used EVs to meet the market where it is today.



INCENTIVES FOR VEHICLES AND FLEETS

The following policy recommendations can help the U.S. achieve widespread EV adoption.

Reform the Existing Federal Plug-In EV Consumer Tax Credit to align with technology trends and a 100 percent sales target. The existing federal incentive for EVs has contributed to the beginnings of a strong market for passenger EVs since its inception in 2008.[53] The tax credit is up to $7,500 for the purchase of new passenger vehicles only, and the tax credit is deducted from the amount owed on taxes to the federal government (it is neither fully nor partially refundable, which limits it to those with a tax liability).[54] The current policy should be revised and updated to support the 100 percent EV sales goals and address equity concerns. The policy should be modified as follows:

> **Expand the incentive for new MDHEV models and remove the 200,000 unit-per-manufacturer cap on LDEVs.** Creating a meaningful MDHEVs incentive will unlock this still nascent market and encourage more auto manufacturers to develop viable models. The current cap has the unintended effect of limiting market leaders and first movers, sending the wrong market signal to the auto industry.[55] Increasing the cap could also help spur innovation and expand the availability of EV models.
>
> **Align the incentive timeline with the 100 percent new sales of EVs by 2030/2035 timelines,** extending the sunset of the program to be consistent with the 2030/35 target, while phasing down the incentive level as the costs decline. This might include offering the incentive at current levels for five years, then phasing down the total incentive amount as the percentage of total sales increase over time (aligned with the technology adoption curve). For MDEVs/HDEVs, cost parity timelines will be longer and the incentive should adjust accordingly. A longer duration incentive will encourage consumer uptake and give auto manufacturers, the EV industry, and businesses greater assurance that the future is electric.
>
> **Structure the tax credit as a point-of-sale rebate to influence consumer decision-making at the time of purchase and make the incentive accessible to customers without significant tax liability.**[56] The process of receiving the rebate should be easy, understandable, and relatively seamless. States and local governments may have more flexibility to make these tax incentives more consumer-friendly. Similarly, the benefits of such an incentive should not be cancelled out by a lease with unfavorable terms.
>
> **Scale the incentive based on income levels such that moderate-, low-, or fixed-income consumers receive proportionally higher incentives.** Consider restricting incentives for higher-income individuals, such that those able to afford the vehicles without an incentive do not use up limited funds. Make the incentive applicable to both leases and purchases.

Target incentives in a manner that benefits communities most impacted by transportation pollution. In February 2021, President Biden's issued an Executive Order establishing a "goal that 40% of overall benefits flow to disadvantaged communities, from 'certain federal investments' in areas such as clean energy and energy efficiency, public transit, and affordable and sustainable housing."[57] Such a provision could be included in transportation electrification incentive programs targeting the most-polluting vehicles, to ensure such incentives are immediately beneficial to those most adversely impacted by pollution.

Offer dedicated incentives for public and private fleet conversion. In 2016, fleet sales made up five percent of new U.S. registrations, with more than 3.5 million corporate registrations for LDVs, including 1.3 million vehicles used for company and government fleets.[58,x] Trucks account for nearly two-thirds of the fleet sector.[59] Electrifying fleets will help mitigate some of the most harmful pollution from diesel vehicles, especially in frontline communities disproportionately impacted by diesel pollution and fleet traffic. A dedicated fleet incentive also sends the right market signal to businesses that their procurement decisions should trend toward electric. Beyond vehicle incentives, fleet owners and operators need confidence they will have access to sufficient charging infrastructure. As such, incentives should be paired with EV charging infrastructure policies (see Section V). Small- and medium-sized businesses that rely on driving, including independent contractors, such as delivery or ride-sharing services also deserve attention. An incentive for these businesses and contractors could be structured as a business tax exemption or a refundable tax credit.

Offer a rebate for qualifying used EVs. Even though requiring all new vehicle sales to be EVs by 2030/2035 is a climate imperative, policies can help address clean vehicle access inequities by extending incentives to qualifying used vehicles. If vehicles are sold through dealerships, rebates should be offered as a point-of-sale rebate to further influence consumer decision-making at the time of purchase. A similar incentive could be offered as a promptly-available rebate for validated private re-sales. California, through its "Clean Cars 4 All" program, offers incentives up to $9,500 toward the purchase of a new or used clean car, with the requirement that participants retire their older, higher-polluting vehicle. Incentives are based on household income level, where participants reside, and the chosen replacement vehicle. The program is implemented through designated air districts.[60] Several other states offer incentives for qualifying used EVs.[61]

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x The remaining 2.26 vehicles were rental cars. North America includes Canada and the U.S.

GRANTS, FUNDING, AND PROCUREMENT FOR PUBLIC EVS

Tax-based incentives do not apply to public or non-profit entities, such as local governments, schools, health care institutions, non-profits, public transit agencies, and state and federal government agencies. Therefore, **grants and funding programs should be incorporated into any federal or state incentive package** to ensure all entities can benefit. Although electric transit bus manufacturers have recently reached lifecycle cost parity with diesel buses in some markets, the upfront cost premium can be more than 50 percent, creating a procurement barrier.[62] School buses have an even higher premium. To help overcome this barrier, **the federal government or states could create a dedicated grant fund for school districts, public transit, mobile non-profit health care services, and other eligible state agencies to upgrade their vehicles.** For example, the Alabama Department of Economic and Community Affairs offers grants for the replacement of qualified medium- and heavy-duty diesel vehicles with new diesel or alternative fuel vehicles. Grants are available for school, shuttle, transit buses, and several other MHDV vehicles and equipment.[63] Similarly, the Michigan Department of Environment, Great Lakes, and Energy offers grants for shuttle and transit buses, and other eligible vehicles.[64] Both the Alabama and Michigan programs are funded in part by the Volkswagen Environmental Mitigation Trust.[xi]

Procurement requirements are another effective way to drive adoption of electric fleets in the public sector. For example, legislation introduced in the House of Representatives, the Green Bus Act (H.R. 2164, Brownley) would require all buses purchased or leased with Federal Transit Administration funds to be zero-emission beginning in 2029. In addition, the legislation directs the U.S. Department Of Transportation to issue an annual best practice report on zero-emission bus programs to help states and transit agencies implement zero-emission bus fleets, among other provisions.[65] States can also offer fleet

xi For more state examples, see the U.S. Department of Energy Alternative Fuels Data Center: https://afdc.energy.gov/laws/.

incentives or procurement requirements that can complement or substitute for incentives. CARB's proposed Advanced Clean Fleets rule is designed to drive demand and facilitate a faster market transition.[66]

GAS TAX, EXCISE TAX, AND TRANSPORTATION INFRASTRUCTURE FEE ALTERNATIVES

Functional, well-maintained roads are necessary for safe travel, regardless of the type of vehicles using them. State roads and federal highways are currently funded and maintained in part by gasoline taxes or excise taxes.[67] State gas tax revenue is already declining due to inflation of road construction costs and reduced fuel consumption, combined with tax rates that don't increase with inflation.[68] **Policymakers should consider funding alternatives for road infrastructure over time, as LDEVs and MDHEVs continue to gain market share. However, any measures to address future funding shortfalls should not be reactionary or preemptive, lest they prematurely curtail EV adoption.**

Many current state EV fees charge EV drivers more than they would pay if driving a comparable gas vehicle, while raising very little revenue to support highway construction and maintenance.[69] As of February 2020, 28 states had implemented an additional EV registration fee on top of standard vehicle registration fees, and 13 of those have adopted EV fees that exceed the average gasoline tax revenue for a passenger vehicle.[70] A handful of states, though, use a portion of the collected fees to support EV infrastructure investments.[71] Policy must strike a balance between the two, and successful approaches will help provide long-term market stability and avoid burdening remaining gas vehicle drivers with high gasoline taxes and road maintenance fees. In addition, any fees based on vehicle miles traveled should adjust the rate based on vehicle efficiency, technology type, and weight of the vehicle (all of which can affect the overall impact on roads and infrastructure). **Policymakers should develop solutions that sustain transportation infrastructure while encouraging EV adoption and avoiding punitive, burdensome fees.**[72]

The federal government collects an excise tax on the first retail sale of heavy-duty vehicles, as well as on long-term leases. The tax rate is 12 percent of the truck sale price, which can add $12,000–$22,000 to the price of a conventional diesel truck[73] and nearly double that for an HDEV. The tax has been criticized by the trucking industry and policymakers as "outdated and an unnecessary barrier that discourages truck buyers from upgrading to more modern, cleaner, and safer vehicles."[74] **A federal excise tax exemption or partial reduction (i.e., making the tax equivalent to that paid on a new diesel truck) would help bring down the upfront cost of HDEVs.** The tax exemption could be phased out over time as the cost of HDEVs and other zero-emission trucks decline.

States and the federal government need to consider how to best fund transportation sector construction and maintenance as electrification increases. Such an analysis should examine the primary causes of costs and develop solutions to cover those costs in a fair manner, while also promoting electrification goals.

SUPPORTING TRUCKS DRIVERS IN THE TRANSITION

Widespread electrification of the most polluting vehicles on the road, namely HDTs, will yield benefits to people living or working near freeways, rail yards, maritime ports, freight distribution centers, and oil and gas operations. Truck drivers will also experience benefits such as reduced noise, no noxious fumes, and lower vehicle maintenance costs. However, federal and state policymakers should carefully consider the overall economic impact of such a transition on truck drivers and fleet operators. In many parts of the U.S., more than half of the trucks that move freight are operated by small businesses or independent contractors with small fleets of one to five trucks.

These entities may not be able to replace a diesel truck with an electric vehicle without confidence in the ability to recharge wherever they travel. To offset the higher upfront cost of electric trucks, incentives and financial support designed to target small, owner-operator trucking companies, such as affordable leasing options, are needed. Special leasing or cooperative ownership structures could also be devised to allow multiple small companies to share electric trucks and charging equipment. In addition, programs tailored for drivers working long hours should entail convenient access to education and technical support about HDEVs. Electrification of HDTs can address a wide range of economic, health, and climate pollution problems, but it can't be done without support for small owner-operator truck companies.

OTHER SUPPORTIVE POLICIES AND FINANCING OPTIONS

Other low-cost or non-financial supportive policies, such as special lane access for EVs (e.g., HOV/carpool lanes, bus lanes), parking incentives, toll waivers, and licensing incentives, can help spur near-term EV adoption and reward early adopters.[75] Although the impact of these incentives differs between regions, existing research shows they can have a positive impact on EV adoption. Research from University of California, Davis Institute of Transportation Studies notes that, "[p]olicymakers wishing to promote the introduction of [plug-in electric vehicles] will need to consider local travel patterns, the regulatory environment, and consumer preferences to determine the most viable policy interventions for their region."[76]

For most individuals and businesses, the ability to utilize EV incentives hinges on their ability to access fair financing. Traditional financing options are not readily available to those with lower incomes, poor or no credit, and high debt-to-income ratios. In addition, communities of color, the elderly, and low-income households are often targeted by predatory lenders[77] and other financial discrimination; Black and Latinx-owned businesses similarly face disproportionate financial discrimination.[78]

The push to achieve an electrified transportation future creates a growing need for new financing models and innovative funding programs that significantly expand consumer and business access to EVs (and other clean energy and clean transportation options). These include green banks,[79] community developed financing institutions (CDFI),[80] microfinance,[81] tariffed-based financing,[82] and sustainable capital ventures.[83] Where they exist, they can and should be leveraged to maximize the impact of any incentive programs. Working alongside policymakers, the financial sector, private businesses, and utilities are key to developing and implementing workable financing options that meet the needs of more consumers and businesses.

TABLE 2.

Incentives and Funding to Support EV Adoption — Policy Recommendation Summary

	POLICY ACTIONS & TIMELINE FOR ENACTMENT*	NEAR-TERM (2021 - 2023)	MID-TERM (2024-2026)	LONG-TERM (2027-2035)	FEDERAL ACTION	STATE ACTION	LOCAL ACTION	UTILITY ACTION
INCENTIVES AND FUNDING TO SUPPORT EV ADOPTION	Reform and expand Federal Plug-In EV Consumer Tax Credit to: • Expand incentive for new MDHEV models • Remove the cap • Align with 2030/2035 timeline • Adopt point-of-sale rebates • Scale incentive based on income • Prioritize frontline communities	✓			✓			
	Provide incentives for public and private fleet conversion	✓	✓		✓	✓		
	Provide used EV incentive	✓	✓		✓	✓		
	Offer competitive grants and funding programs for public and non-profit entities	✓	✓	✓	✓	✓	✓	
	Require EV procurement for public fleets, transit, buses	✓	✓	✓	✓	✓	✓	
	Offer federal/state tax exemption or reduction	✓	✓		✓	✓		
	Adopt special lane access for EVs, parking incentives, road toll fee waivers, and licensing incentives	✓	✓			✓	✓	
	Support new financing models and innovative funding programs that significantly expand consumer and business access	✓	✓		✓	✓	✓	✓

** Please note that the timeline for enactment indicates when the policy action should be taken. It does not indicate the duration of the policy nor the implementation timeline.*

V

EXPAND EV CHARGING INFRASTRUCTURE

A 2019 National Renewable Energy Laboratory (NREL) study found that a lack of charging infrastructure in the community and at home was a primary concern among consumers; to feel comfortable driving an EV, consumers "need access to charging anywhere their travels lead them."[84] Another study found that the availability of charging infrastructure significantly influences per capita EV purchases, and that early investments in public areas and along highways are likely to increase EV adoption.[85] The NREL study found that "while most travels can be completed on a single-charge, access to an extensive and convenient network of direct current fast charging (DCFC) stations along corridors that enable reliable long-distance intercity travel is required to support long-distance travel."[86] Proactive policies are key to supporting charging infrastructure, or EV supply equipment (EVSE), expansion across the country. Every charging use case will need to increase dramatically, including residential, workplace, retail, corridor, and depot charging to ensure charging access is not a limiting factor to EV uptake. In addition, EV charger deployment must support equal access to clean mobility regardless of income and location.

The EV charging industry is relatively nascent but growing rapidly. Private investments have largely targeted areas where early EV adopters live and work, roughly proportional to the level of local EV adoption. Modeling from the 2035 2.0 Report assumes the vast majority of charging will continue to take place at home[87] because 80 percent of charging currently takes place at residences.[88] Policies and programs should continue targeting this domain, while also encouraging daytime charging locations like workplaces, that enable charging when renewable energy is abundant. Gaps in available infrastructure in low-EV density environments create a chicken-and-egg scenario that currently limits charging expansion.[89] As such, policies should address these gaps and target underserved and remote locations, such as rural areas (representing 19 percent of the U.S. population),[90] interstate highways (including rest stops and along major trucking routes), lower income and frontline communities, multi-unit dwellings, and ports and warehouses with drayage trucks.

Electric utilities have an important role to play supporting the expansion of strategically located infrastructure. Working in partnership with commercial customers with large fleets, transportation authorities, EV industry representatives, and environmental justice communities, electric utilities can help address the infrastructure needs of a highly-electrified transportation future. The issues surrounding the utility role in transportation electrification are described further below.

CHARGING UP FOR THE LONG HAUL — EV CHARGING INFRASTRUCTURE

EV supply equipment (EVSE) is the industry term used to describe EV charging infrastructure. Depending on the state, a number of stakeholders can own and operate EVSE: site hosts, utilities, or third-party providers. A variety of connector types, communications, and interoperability standards exist for each of the three main categories of EVSE:

- **Level 1 ESVE** uses a standard 110/120-volt outlet and can deliver approximately three to seven miles of range per hour of charging. Level 1 is best suited for residential applications, including multi-unit dwellings, and some workplaces. Level 1 is adequate for overnight and longer charge times, but is generally too slow for other use cases. Additionally, EVs are equipped with a portable Level 1 charger plug, enabling a driver to charge anywhere there are available outlets.
- **Level 2 EVSE** uses a 208/240-volt outlet (same as a clothes dryer outlet) and can deliver approximately 14 to 35 miles of range per hour of charging. Level 2 can be networked or non-networked. Managed charging is only possible with networked chargers. Typically, Level 2 voltage and amperage requirements require electrical work. Buildings with make-ready EV wiring can easily accommodate a Level 2 charger during new construction or retrofit.
- **Direct Current Fast Chargers (DCFCs)** use higher voltages to deliver faster charges, with the current typical voltage range between 200 and 600 volts. A DCFC supplied with 480 volts and 100 amps can fully charge a 100-mile range battery in just over 30 minutes. In other words, DCFC can deliver nearly 180 miles of range per hour of charging. DCFCs are much more expensive to build than Level 1 and Level 2 EVSE due to the increased power requirements. DCFCs are important for corridor charging, long-distance driving, and high-mileage drivers.

INCENTIVES FOR CHARGING INFRASTRUCTURE

The following policies will support equitable and widespread EVSE deployment:

Expand and improve the Federal Alternative Fuel Infrastructure Tax Credit (30C). Recently reauthorized for a year and set to expire at the end of 2021, this tax credit currently offers a 30 percent tax credit available for purchasing and installing EVSE at commercial and residential properties, with a $30,000 commercial cap and $1,000 residential cap.[91] The tax credit should be extended at least five years to provide continuity and support the infrastructure build-out necessary for widespread EV uptake. The commercial cap should be increased to support DCFC build-out, which are more expensive than Level 1 and Level 2 chargers and can support medium- and heavy-duty vehicles. Congress can improve the tax credit by converting it to a direct payment or refundable tax credit, thereby increasing customer access without tax liability.

Extend and modify the Fixing America's Surface Transportation Act (FAST Act), making EV chargers a priority investment and eligible expense. The federal FAST Act[92] is intended to fund surface transportation efforts, including freight and highway projects. Congress extended the FAST Act by one year in the 2020 House Continuing Resolution, and the Act is now set to expire September 2021. This policy should be extended another 10 years and modified to explicitly target investments in transportation electrification infrastructure in alignment with 100 percent by 2030/2035 goals. All EVSE should be made an eligible expense in various FAST Act programs to align the policy with new and near-term federal commitments.[xii]

Make charging infrastructure an allowable expense in federal funding programs, where applicable. Federal agencies should, with direction from the President, consider opportunities for where EVSE costs can be made an allowable expense in federal funding programs. For example, rural EVSE can be included in U.S. Department of Agriculture's Rural Energy for America Program (REAP).[93]

Invest in chargers on federal property. Federally owned land, facilities, and national parks offer a prime opportunity to "lead by example" and also provide charging access in strategic locations across the U.S. Such a directive is complementary to President Biden's Executive Order announced in January 2021 that the federal fleet will go all-electric.[94]

Direct electric utilities to develop plans to support and accelerate widespread transportation electrification and approve utility programs associated with those plans. Regulators and utilities must start planning now to ensure they are sufficiently prepared for EV growth. State legislators, utility regulators, municipal utility councils, and rural electric cooperative boards of directors should direct utilities to develop and file transportation electrification plans, and promptly approve the charging infrastructure (and other) programs included in those plans. For example, the Colorado Public Utilities Commission just approved Xcel Energy's $110 million transportation electrification plan, which will install up to 20,000 charging stations, provide EV rebates, and add programs and rates to help manage the new charging load. Xcel's plan also includes an emphasis on ensuring EV adoption benefits all customers, with approximately 15 percent of the program budget directed toward equity-focused programs.[95]

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xii Specific FAST Act programs that should include EVSE as an eligible expense include U.S. DOT's Transportation Infrastructure Finance and Innovation Act (TIFIA), Fostering Advancements in Shipping and Transportation for the Long-Term Achievement of National Efficiencies (FASTLANE) grants, and National Highway Freight Program (NHFP). Additionally, the Congestion Mitigation and Air Quality Improvement (CMAQ) Program can be expanded to support greater EVSE deployment.

Create stackable incentives for charging infrastructure. Federal incentives can be leveraged with additional incentives from states, utilities, or other entities, such as community choice aggregators or local governments. These incentives should be designed to be complementary and targeted at underserved locations with the aim to fill charging gaps. For example, Idaho offers funding for DCFC charger projects located along key transportation corridors, and Illinois offers grants for the installation of chargers with priority given to infrastructure that serves MHDEVs.[96]

TRANSPORTATION PLANNING AND COORDINATED INFRASTRUCTURE DEPLOYMENT

Expanding charging infrastructure along major transportation corridors, including highways, will require explicit coordination and planning. **The Federal Highway Administration (FHWA) and U.S. DOT can help states address this challenge by continuing to support Alternative Fuel Corridors,[97] enabled by the FAST Act (*see Figure 5*), and by increasing transportation awareness for EV owners with corridor signage.[98]** The federal government can also support truck electrification by updating the National Highway Freight Network to align with transportation electrification goals.[99] Notably, the current federal prohibition on commercial activity at interstate rest areas should be amended to encourage EV charging and signage.[100]

Federal, state, and regional transportation agencies should work in coordination with other stakeholders (e.g., freight companies, utilities, local governments, and land use planners) to identify optimal grid and road locations for charging. This would include an analysis to help identify available hosting capacity on the grid (see Section VII) along with a land use analysis to identify areas best suited for charging depots and other services. Existing gas

stations and service exits along the highway are the most obvious choice for EVSE, but consideration will need to be given to the distance between chargers along stretches of highway, interconnection costs, and existing capacity at these sites.

Several such efforts are underway and could be emulated throughout the country. For example, the Transportation and Climate Initiative is a collaboration by the 12 East Coast states of Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, and Virginia to reduce emissions from transportation, and includes the Northeast Electric Vehicle Network to support the development of EV fast-charging corridors. These efforts build on the region's cap-and-trade program for electric utilities, the Regional Greenhouse Gas Initiative, to help reduce carbon emissions from the transportation sector.[101] Additionally, nine electric utilities and two agencies representing more than 24 municipal utilities released a plan in 2020 to electrify I-5, a key corridor for MHDVs that runs from the U.S.-Mexico border to the U.S.-Canada border.[102] The plan has a specific focus on supporting considerable MHDEV travel compared to many existing corridor efforts (which focus primarily on supporting passenger EVs).

Such laudable efforts should continue and expand, with dedicated support from federal and state governments. Future corridor development should be complementary to, and not duplicative of, existing plans and investments.

FIGURE 5.

Alternative Fuel Corridor Map Showing EV-Corridor Ready and Pending Corridors.

Source: U.S. Department of Transportation, Federal Highway Administration

SUPPORT FOR PUBLIC AND PRIVATE CHARGING INFRASTRUCTURE TO SERVE MULTI-UNIT DWELLINGS

Access to home charging has a major influence on most EV purchase or lease decisions, but for the nearly 40 million U.S. residents who live in apartments,[103] limited or unreliable charging access represents an equity and access challenge that warrants attention from policymakers, utilities, and the private sector. A 2019 study by the International Council on Clean Transportation (ICCT) found that fewer than half of people living in apartments use home charging, due to lack of access.[104] Condominium dwellers face similar challenges to apartment dwellers but without the split incentive impediment.[xiii]

Unique barriers exist to installing charging infrastructure at multi-unit dwellings (MUDs),[xiv] including costly electrical upgrades in often older buildings, insufficient financial incentives for property owners to make investments, lack of demand from tenants, and assigned per-unit parking allocations (which makes matching EV drivers to dedicated charging spots difficult).[105]

Many actions are needed to enable widespread charging infrastructure to serve MUDs, the following policies can help overcome these barriers and increase residential charging access for more people:

Direct funding to support "make-ready" investments. Make-ready investments refer to installing electrical infrastructure in new construction in anticipation of EVSE installation or retrofits at existing buildings. These investments simplify future EV charging installations and reduce the cost of EV charging investments for utility ratepayers, EV customers, and third-party charging providers. These upfront investments can also mitigate the split incentive for building owners and renters while streamlining utility and local government permitting processes. By providing "up to the stub" infrastructure, utilities can support EV infrastructure in new MUDs along with some retrofits. As with any utility investment, regulators need to oversee the measures and test before scaling to make sure ratepayer funds are being used properly.

Create MUD-specific dedicated incentives. Providing a larger incentive amount and larger incentive pool for MUDs can overcome unique barriers to installing charging infrastructure. Educating building owners and landlords of all MUD sizes will also be necessary to effectively reach decision-makers.

Authorize utility charging programs targeting MUDs. Electric utilities seeking to expand charging investments could target their programs and resources to support underserved market segments, such as MUDs. The precise mechanism for doing so will vary from state to state, but one example is a tariffed on-

xiii The "split incentive barrier" refers to multifamily property managers or owners lack of direct financial incentive to install expensive energy-related upgrades for their tenants if they don't stand to reap the financial benefits of those investments.

xiv Multi-unit dwellings include any building with multiple housing units contained within, including apartments, condominiums, duplexes, and townhouses.

bill investment program.[106] With this model, utilities are authorized to pay for cost-effective energy improvements at a specific site and recover the costs of those improvements over time through a utility bill charge. If coupled with other energy efficiency and electrification upgrades, customers may see utility bill savings over time. Tariffed on-bill programs may help overcome the split incentive problem between tenants and property owners.

Expand workplace and public charging. More workplace and public charging is needed to sustain the electric vehicle transition, according to ICCT.[107] While expanding these market segments can provide supplementary options for some MUD residents, public and workplace charging should not be considered equal substitutes for at-home charging. Nonetheless, expanded workplace and public charging (and incentive programs to support such investments) will further fill the charging gap and support greater EV uptake over time. For example, a Duke Energy Florida pilot program will install 500 Level 2 chargers at MUDs, workplaces, and public settings.[108] Workplace charging is also an effective way for businesses to demonstrate leadership and increase the affordability of driving electric for their employees.[109] Although no longer actively funded, the U.S. DOE's Workplace Charging Challenge compiled best practices, lessons learned, tools, and templates — such federal efforts should continue and expand going forward.[110]

TABLE 3.

Expand EV Charging Infrastructure — Policy Recommendation Summary

<table>
<tr><th></th><th colspan="3">POLICY ACTIONS & TIMELINE FOR ENACTMENT*</th><th>FEDERAL ACTION</th><th>STATE ACTION</th><th>LOCAL ACTION</th><th>UTILITY ACTION</th></tr>
<tr><th></th><th>NEAR-TERM (2021 - 2023)</th><th>MID-TERM (2024-2026)</th><th>LONG-TERM (2027-2035)</th><th></th><th></th><th></th><th></th></tr>
<tr><td rowspan="13">EXPAND EV CHARGING INFRASTRUCTURE</td><td>Expand and improve the Federal Alternative Fuel Infrastructure Tax Credit (30C):
• Extend duration
• Increase commercial cap
• Convert to a direct payment or refundable tax credit</td><td></td><td></td><td>✓</td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Modify and extend the Fixing America’s Surface Transportation (FAST Act)</td><td></td><td>✓</td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Make charging infrastructure an Allowable Expense in Federal Funding Programs, as applicable</td><td></td><td>✓</td><td></td><td></td><td></td></tr>
<tr><td colspan="3">Install charging infrastructure on federal property</td><td>✓</td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Direct electric utilities to develop plans to support and accelerate widespread transportation electrification and promptly approve the corresponding infrastructure programs</td><td></td><td></td><td>✓</td><td></td><td>✓</td></tr>
<tr><td colspan="2">Create stackable incentives, targeted at underserved locations, to fill charging gaps</td><td></td><td></td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td colspan="2">Continue the Alternative Fuel Corridors and increase corridor signage</td><td></td><td>✓</td><td></td><td></td><td></td></tr>
<tr><td></td><td colspan="2">Update the National Highway Freight Network to align with transportation electrification goals.</td><td>✓</td><td></td><td></td><td></td></tr>
<tr><td></td><td colspan="2">Remove the current federal prohibition on commercial activity at rest areas to encourage EV charging (and signage) at interstate rest areas.</td><td>✓</td><td></td><td></td><td></td></tr>
<tr><td></td><td>Direct funding to support “make-ready” investments</td><td></td><td></td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td colspan="2">Create MUD-specific dedicated incentives</td><td></td><td></td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td colspan="2">Authorize utility programs targeting MUD charging infrastructure</td><td></td><td></td><td>✓</td><td>✓</td><td></td></tr>
<tr><td colspan="3">Expand workplace and public charging</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
</table>

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VI

INCREASE DOMESTIC MANUFACTURING OF EVS, EVSE, AND EV SUPPLY CHAIN

The federal government must thoughtfully structure its policies so transportation electrification and grid decarbonization maintain and expand U.S. auto industry jobs by supporting a swift manufacturing sector transition. Consumer incentives to purchase EVs will not adequately increase domestic employment by themselves. The U.S. needs policies on EV and battery manufacturing that addresses supply[111] and demand.[112]

Recent experience shows how federal policy can grow a domestic vehicle manufacturing base. The Obama Administration provided low-interest loans to support the construction of Tesla's assembly plant in California, and the renovation of Nissan's Leaf EV plant in Tennessee.[113] Battery and EV component manufacturing received some $2 billion in cost-shared grants under the 2009 American Recovery and Reinvestment Act (ARRA), which also included a 30 percent tax credit for investment in advanced energy manufacturing.[114,115] A combination of U.S. DOE funding and research programs and state funding led to the development of an advanced battery manufacturing hub in Michigan; the construction of Tesla's Gigafactory in Nevada; LG Chem Johnson Controls-Saft lithium-ion battery plants in Holland, Michigan; and other EV supply chain investments. These programs, however, were relatively small and short-lived. The U.S. needs a financial commitment on a scale similar to that made in recent years by European countries and China if its hopes to compete for domestic EV and battery manufacturing jobs.[116]

Multiple factors make the next few years a particularly good time to focus federal policy on domestic EV manufacturing. As of 2020, nearly every major vehicle manufacturer in the world is developing EVs, including heavy-duty trucks and transport vehicles. Canada, China, the European Union, India, Japan, and Korea all provide direct financial support for EV and battery manufacturing, typically in combination with other EV policies. Providing similar support is essential to maintain U.S. vehicle manufacturing competitiveness and global leadership.

Collaboration by federal agencies, motor vehicle and battery industries, national labs, research universities, public interest groups, and labor is a necessary component of a comprehensive policy for EV manufacturing. The collaborative strategy should include a combination of federal grant funding, tax credits, changes to existing procurement and Buy American policies, and trade agreement modifications. In addition, federal agencies and research labs can support ongoing R&D to support continued innovation. The following policy recommendations would help motivate the auto manufacturing industry to align with broader public health and climate goals.

FEDERAL TRANSPORTATION INFRASTRUCTURE STIMULUS PACKAGE

Congress should adopt a comprehensive transportation stimulus package modeled after the Moving Forward Act (H.R. 2) and President Biden's Build Back Better Plan,[117] to include support for domestic EV and EVSE manufacturing capacity.[118] This package should focus on a combination of grants and innovation funding to help manufacturers retool and build new factories to sustain jobs and ensure U.S. global leadership in EV manufacturing, including EV components and batteries. These programs could be structured to include a performance-based mechanism whereby manufacturers' repayment liability decreases with each vehicle produced, effectively converting the program into a conditional grant program. The Energy Independence Security Act of 2007 created a grant program to assist new EV factories and conversion of manufacturing to produce electric vehicles, among other advanced technologies.[119] These programs should be fully funded and expanded to include MDHV and EV components.[120]

Policies and programs should be designed to address the need for near-term low-cost financing to invest in new equipment, retool existing factories, and train workers. For example, Congress could establish a credit facility to supply capital for manufacturing, especially to smaller manufacturers; adopt an Advanced Vehicle Manufacturing Tax Credit (AVMTC),[121] structured as an advanceable tax credit, and a Manufacturing Communities Tax Credit; and expand the U.S. DOE's Advanced Technology Vehicles Manufacturing Loan program to include medium- and heavy-duty EVs and off-road vehicles.

DOMESTIC BATTERY SUPPLY CHAIN

The federal government should commit resources and policies to develop and grow a domestic battery supply chain, including raw materials and components, using the following policy tools:

Provide a 30 percent Investment Tax Credit (ITC) for investment in domestic battery manufacturing, modeled after the Section 48C tax incentive to strengthen an end-to-end advanced battery supply chain. Alternatively, the policy could be structured as a refundable ITC or as direct price support. Congress should also expand the 30 percent ITC to domestic manufacturers of EV charging equipment and subcomponents.

Create or expand EV Manufacturing Finance Programs. Congress could create finance programs modeled after the Small Business Administration's credit programs to help manufacturers achieve sufficient scale, effectively compete, and de-risk projects. The program could include loan guarantees, forgivable loans, and low-interest financing to transportation electrification supply-chains.[122] Title 17 of the Energy Policy Act of 2005, which provided Federal Loan Guarantees for renewable energy and energy efficiency projects, is another model to emulate. Congress could also expand and update the Advanced Technology Vehicle Manufacturing (ATVM) Loan Program to include anodes, batteries, cathodes, and upstream raw materials.

Create Battery Cell Manufacturing Production Incentives, such as a direct federal payment for battery production ($/kWh)[xv] and authorization of private activity bonds for EV and battery manufacturing.[xvi]

Expand efforts to develop a supply chain for battery raw materials (e.g., mining, processes, and battery recycling) to reduce dependence on imported materials and develop a closed loop supply chain. This could be done through increased R&D or establishing requirements for recycled material content of new battery cells manufactured in the U.S.

Fund workforce training programs to ensure the auto industry has early access to training and continuing education to keep all workers up to speed on electrification skillsets, technologies, and workforce opportunities.

xv A paper by Capricorn Investment Group proposes a $20/kWh incentive payment to subsidize production of battery cells made in the U.S. The incentive level would drop gradually to $12 as battery production costs fall. Cells produced from recycled materials would receive a larger incentive of $30/kWh to help lower dependence on raw material imports and reduce environmental impacts of battery disposal. The cost of this policy is estimated to start at $500 million rising to $5 billion by 2030. Capricorn Investment Group has proposed a $20/kWh incentive, equal to about 20 percent battery cost.

xvi An example of this kind of legislation is Section 11143 of Title XI of SAFETEA-LU which amended §142 of the Internal Revenue Code to add highway and freight transfer facilities to the types of privately developed and operated projects for which private activity bonds (PABs) may be issued by state and local government. (Source: "Private Activity Bonds," Build America Bureau, U.S. Department of Transportation, https://www.transportation.gov/buildamerica/financing/private-activity-bonds-pabs/private-activity-bonds#:~:text=Section%2011143%20of%20Title%20XI,(PABs)%20may%20be%20issued).

FEDERAL PROCUREMENT

The federal government fleet has approximately 645,000 vehicles including 200,000 passenger vehicles, 78,500 HDVs, 47,300 vans, 840 ambulances, and three limousines. Federal vehicles drive about 4.5 billion miles and consume 400 million gallons of gasoline each year.[123] Federal procurement policies can help increase demand for vehicles and expand strategic charging infrastructure through a number of ways.

Require federal ZEV procurement through the U.S. General Services Administration (GSA) to gradually increase the percent of EVs procured each year[xvii] through multi-year contracts. As a starting point, the federal government could revise GSA rules that require agencies to pay the incremental cost of an EV. Similarly, it could revive and increase U.S. domestic content requirements for government procurement (Buy American Law). President Biden's Executive Order[124] is a solid first step, however additional rulemaking and agency direction will be needed to implement the order.

Issue an executive order addressing military procurement of ZEVs and charging infrastructure to stimulate significant new domestic EV manufacturing.[125] The U.S. military has one of the world's largest fleets; enhanced EV procurement targets could complement existing military R&D efforts designed to reduce energy costs, and reduce the need for fuel convoys.

Policies that simply encourage demand for EV sales will fail to capture the full domestic economic benefits of transportation electrification. Existing and future polices to stimulate demand should be matched by policies that support domestic supply through financial support for EV and battery manufacturing.

xvii This could be modeled on California's proposed fleet rule, expected to be finalized in late 2021 or on President Obama's 2015 Executive Order (revoked by Trump in 2017) which required agencies to make EVs 20 percent of their passenger vehicle acquisitions in 2020 and 50 percent in 2025.

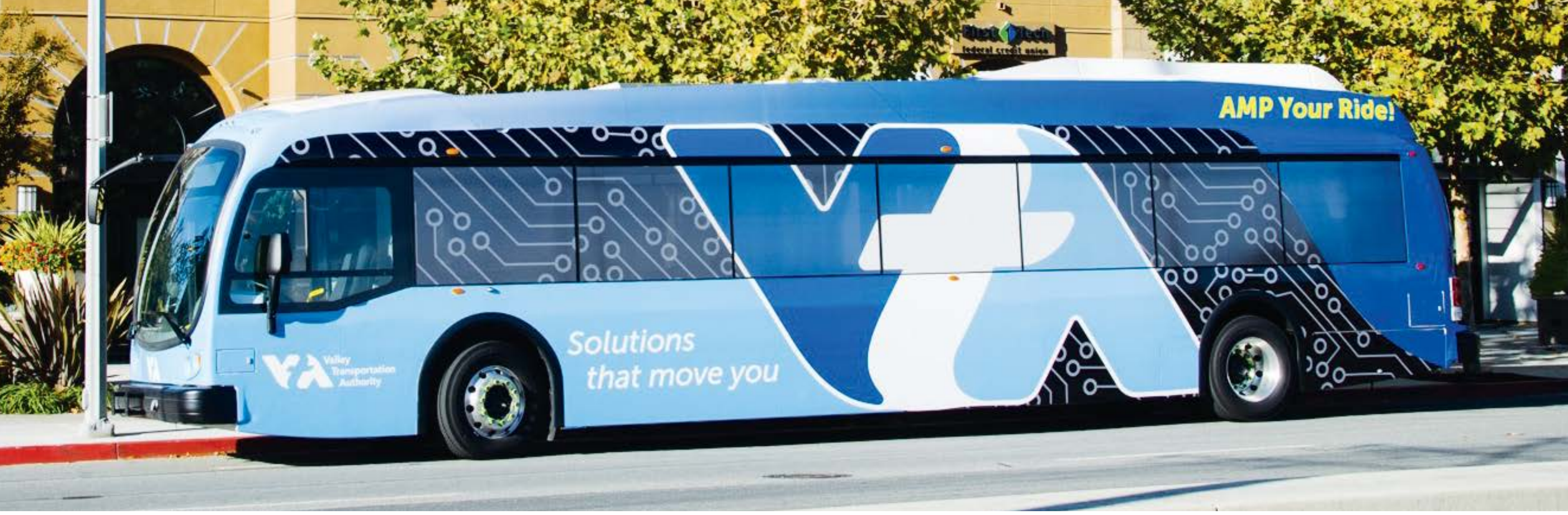

TABLE 4.

Increase Domestic Manufacturing of EVs, EVSE, and EV Supply Chain — Policy Recommendation Sum

	POLICY ACTIONS & TIMELINE FOR ENACTMENT*			FEDERAL ACTION	STATE ACTION	LOCAL ACTION	UTILITY ACTION
	NEAR-TERM (2021 - 2023)	MID-TERM (2024-2026)	LONG-TERM (2027-2035)				
INCREASE DOMESTIC MANUFACTURING	Adopt a transportation infrastructure stimulus package that includes: • Manufacturing grants and innovation funding • A credit facility to supply capital • An Advanced Vehicle Manufacturing Tax Credit • A Manufacturing Communities Tax Credit Provide a 30 percent ITC for investment in domestic battery manufacturing			✓			
	Provide a 30 percent ITC for investment in domestic battery manufacturing			✓			
		Create or expand EV Manufacturing Finance Programs		✓			
	Create a Battery Cell Manufacturing Production Incentive			✓			
	Expand R&D efforts to develop domestic battery raw, recycled and alterative materials, component capacity, and battery recycling			✓	✓		
	Fund or support workforce training programs			✓	✓	✓	✓
	Require procurement of EVs			✓	✓	✓	✓

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VII

STREAMLINE DEPLOYMENT WITH EV-FRIENDLY INTERCONNECTION, PLANNING, PERMITTING, AND CODES

Most charging infrastructure (and the EVs using them to charge) are, and will continue to be, located on the distribution grid. They are therefore subject to an array of state, local, and utility procedures: interconnection, grid planning, permitting, and building codes.

As of 2020, the total number of U.S. public chargepoints was approximately 100,000; as of 2019, there were approximately 1.5 million at-home chargepoints.[126] According to the 2035 2.0 Report, to achieve the DRIVE Clean Scenario this number must grow to 8.1 million public chargepoints over the next 30 years, including 860,000 50-kW DCFC chargepoints, 330,000 100-kW DCFC chargepoints, and 6.9 million L2 chargepoints — a combined average of about 270,000 public chargepoints for LDVs and 35,000 chargepoints for MDV/HDTs installed annually. Between 2020 and 2050, approximately 3.5 million at-home chargepoints must be built each year. In other words, achieving 100 percent EV sales by 2030/2035 will require approximately 350,000 public Level 2 chargers and 60,000 Public DCFC annually — which would increase grid load by approximately 2.2 percent each year.[127] Comparatively, the latter half of the 20th century included periods of annual energy generation growth equivalent to the electrical consumption of as many as 25 million new light-duty EVs (the equivalent of roughly 150 percent of all new LDV sales in the U.S. at the end of 2019).[128]

EV customer charging patterns and the overall impact of EVs on the grid pose new challenges and provide new opportunities for more efficient grid operations and planning. Beyond the distribution system, EVs and EVSE growth may eventually have an impact on the transmission system, or bulk grid, and this impact will need to be factored into bulk grid planning and operations to avoid unintended consequences.[xviii] In addition, aggregated EVs will increasingly participate in wholesale market tariffs as they become a more substantial part of the grid. The processes and protocols underpinning the electric grid must be considered as part of the broader goal of electrification.

Lastly, improvements in local permitting processes and building codes can streamline EVSE deployment in new construction and major retrofits. Efforts

xviii For example: "Transmission constraints must be assessed. It is acknowledged that transmission expansions must be deliberate as these investments in the U.S. power system are expensive and time consuming; Ramping capabilities of the generating fleet and spinning reserve requirements of the bulk power system should be considered for EVs at Scale; Medium- and heavy-duty vehicles account for 29% of U.S. on-road transportation fuel use. Analysis of medium- and heavy- duty EV market growth scenarios are needed to assess the impact on energy generation and generation capacity." (Source: US Drive *Summary Report on EVs at Scale and the U.S. Electric Power System*, v).

to improve efficiencies and prioritize EV-ready investments will help mitigate consumer costs over the long-run, and ensure a more electrified future.

STREAMLINED INTERCONNECTION PROCESSES TO SUPPORT RAPID TRANSPORTATION ELECTRIFICATION

All states and utilities have some formal process for connecting new load to the grid, yet very few states and utilities have a dedicated or clearly defined process for EVSE interconnections.[129] Although they are considered new load (versus new generation), most Level 2 and DCFCs are required to go through a permission process to connect their equipment to the grid. The interconnection process helps maintain grid safety and reliability while allowing new load, new generation, and new energy storage projects to connect to the grid. Proactive regulatory action is needed to ensure a transparent and publicly available set of rules clearly identify the procedural steps, timelines, fees and costs, and other requirements for EV industry and customers to connect EVSE to the grid. The vast majority of EVSE interconnections will occur on the distribution system, and these processes are governed by distribution utility tariffs and approved by state utility regulators (for investor-owned utilities and many rural electric cooperatives) or applicable governing body (for municipal utilities and some rural cooperatives).

The impacts of interconnecting larger EVSE loads associated with DCFC are a growing concern. Most DCFC on the market requires upwards of 480+ volts and 100+ amps, or 50-60 kilowatts (kW) of capacity.[xix] However, new generations of DCFC are in the range of 150-350 kW per charger.[130] At the high end, for comparison, that is equivalent to the annual power requirements of approximately 280 average U.S. homes.[xx]

Delays and backlogs for interconnections are already proving to be a challenge in states with high distributed energy resource (DER) growth plus EV growth and ambitious charging deployment targets, such as California. According to one EVSE provider, "'bottlenecks in interconnection have delayed projects anywhere from six months to 'well over a year.'"[131] The California Energy Commission acknowledged this lag in its recent report, stating "[EV] infrastructure investments are growing at a slower pace compared to trajectories of [EV] adoption."[132] The experience from utility-to-utility varies. For example, Southern California Edison has been able to accommodate approximately one charging station per week, thanks to their efforts to streamline the process. However, developers note this is not a common experience with other utilities.[133]

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xix A kilowatt is 1,000 watts, which is a measure of power. A kilowatt-hour is a measure of the amount of energy a certain appliance or device needs to run for one hour.

xx There are 1,000 kilowatts in a Megawatt (MW), and one 1 MW would power 813 average U.S. homes. 350 kW is 35 percent of 1 MW, and 35 percent of 813 homes is 284 homes.

Cost allocation for any necessary grid upgrades for new charging infrastructure is a concept that warrants further exploration to determine whether there should be a policy shift on how the upgrades are funded, particularly given the variation in potential upgrades typically needed for Level 1, 2, and DCFC. For example, Level 1 may only require modest electrical upgrades, whereas Level 2 and DCFC may trigger the need for distribution system related upgrades and service drop upgrades. The rules on who covers those costs vary across states and utilities.

In response to these existing challenges, we recommend the following policy and regulatory actions:

Adopt statewide interconnection best practices applicable to all utilities that proactively address EVSE. To get ahead of the curve, utility regulators and utilities can address EVSE interconnections proactively by either integrating them into existing procedures for load or by initiating a new proceeding. By setting a clear, standardized process, applicable to all utilities within their jurisdiction, PUCs can avoid a patchwork of procedures across utility service territories and help ensure greater market uptake. For utilities, creating a dedicated EV team within existing interconnection and distribution planning teams can enhance communications, improve relationships with market players, and address questions and challenges regarding EVSE interconnections as penetrations grow.

Adopt and implement hosting capacity analyses (HCAs) and distribution system maps that integrate EVs and EVSE into their methodologies. Hosting capacity refers to the amount of DER, including EVs and EVSE, "that can be accommodated on the distribution system under existing grid conditions and operations, without adversely impacting safety, power quality, reliability, or other operational criteria, and without requiring significant infrastructure upgrades."[134] These analyses are used to help states and utilities identify more optimal locations for DERs and can be expanded to respond to the need to quickly interconnect new EVSE. For example, the California PUC recently directed utilities to identify changes to enable the hosting capacity analysis tool to aid customers seeking to add EV charging stations.[135] States and utilities should continue to adopt and refine these tools to improve the collective understanding about the current limits of the grid and to streamline interconnections.

Investigate operational impacts and planning issues relating to the bulk grid.[xxi] The uptick in EVSE and EVs on the distribution system will eventually have an impact on bulk-grid operations and planning. FERC and the RTOs/ISOs should proactively address this issue to determine what adjustments to planning, forecasting, and operations may be warranted as transportation becomes increasingly electrified. Similar investigations into how EVs will interact with wholesale markets are timely.

xxi Note that FERC did schedule a roundtable discussion on EVs in October 2020, but it was cancelled. See: https://www.ferc.gov/news-events/news/roundtable-discussion-regarding-impact-electric-vehicles-transmission-system-and.

COORDINATION OF GRID PLANNING WITH TRANSPORTATION PLANNING

Grid planning can help identify which investments are needed as the distribution grid changes in response to consumer adoption of EVs and other DERs, such as rooftop solar and energy storage. A more proactive planning approach known as Integrated Distribution Planning (IDP)[136] or "distributed resource planning" uses sophisticated analytical tools, such as HCA[137] and DER forecasting,[138] to identify the most cost-effective grid investments to facilitate long-term growth of all DERs, while minimizing costs to ratepayers and maintaining service quality.[xxii] Several states and utilities have adopted IDP but not all have developed or refined methodologies for EVs and EVSE. As such, state policymakers and regulators should direct utilities to adopt IDP and develop a framework that explicitly incorporates the growing impact of EVs and EVSE on the grid.

Beyond grid planning, transportation planning is a multi-jurisdictional effort that involves federal, state, and local decision-makers. In urban areas, efforts are typically led by a metropolitan planning organization, in cooperation with the state transportation agency and transit providers. In rural areas, transportation planning processes are carried out by the state, in cooperation with local officials and transit providers.[139] As more vehicles become electricity grid-reliant, the need to enhance coordination and establish processes for information sharing among the various involved entities increases. Combining grid planning efforts with extant transportation planning is a nascent concept that could help bridge critical information gaps for utilities, regulators, transportation entities, and EVSE providers.

As a starting point, states could direct transportation planners, state agencies, regulators, utilities, environmental justice stakeholders, and EV industry representatives to convene, share relevant data and maps, and make information publicly available. Forecasts for EV and EVSE growth should align across multiple planning agencies. Stakeholders should agree on projected EV and EVSE growth over time, projected charging corridors, and methodologies for identifying investment priorities, including measures to address equity and mitigate pollution in frontline communities.[xxiii] In addition, local transportation planning and infrastructure maps can be overlaid with the distribution grid to identify where priority charging infrastructure might be located and targeted to fill EVSE gaps and needs and inform utility investment plans, while avoiding permitting and interconnection bottlenecks.[xxiv]

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xxii "IDP consists of four principal components: mapping a circuit's hosting capacity, forecasting the expected growth of DERs on that circuit, prioritizing grid upgrades to integrate DERs, and proactively pursuing grid upgrades (including traditional capital upgrades as well as DERs themselves) to meet anticipated grid needs." (Source, Stanfield and Safdi, *Optimizing the Grid*, 13.)

xxiii See for e.g., Greenlining's Mobility Equity Framework.

xxiv See for e.g., California Transportation Electrification Assessment, Phase 2: Grid impacts, Energy and Environmental Economics. October 2014, http://www.caletc.com/wp-content/uploads/2016/08/CalETC_TEA_ Phase_2_Final_10-23-14.pdf.

STREAMLINED LOCAL PERMITTING PROCESSES FOR EVSE

Inconsistent permitting processes and the lack of clearly defined permitting and land use best practices can impose costly delays on EVSE deployment. The rooftop solar and energy storage industries' experience with permitting hassles can help inform EVSE permitting.[140] For example, the U.S. DOE's SolSmart program is successfully streamlining solar permitting in over 300 cities and recognizing national leaders.[141] **The federal government and states should fund similar programs to identify ways to streamline permitting for EVSE and familiarize permitting officials on the technology. In addition, efforts to align local processes with utility interconnection processes can also save considerable time and energy for all involved parties**.

EV-READY BUILDING CODES

To ensure all buildings with on-site, off-street parking are able to provide cost-effective charging and can handle increased electric load from EVSE, building codes need to be amended to explicitly include charging infrastructure.[142] Most state and local jurisdictions in the U.S. currently adopt base code originally written by the International Code Council (ICC).[143] While no uniform approach to building code adoption exists in the U.S., states typically adopt (by default or through legislation) the latest available version of the ICC base code applicable to all new construction and major retrofits. In some states, local governments have the ability to adopt stretch codes that go beyond the base code. However, many jurisdictions are behind in updating and enforcing their codes.

EV-ready code requirements address the electric panel capacity, as well as the wiring and conduit terminating with an outlet that delivers electricity to EVSE. This relatively simple addition to a new building ensures it is ready to deliver sufficient power to future installed EVSE at parking spots, thus avoiding the need for costly retrofits. Because it is nearly four times more expensive to install the electrical equipment during retrofit versus new construction,[144] EV-ready code requirements will save consumers and businesses in the long run. In 2020, the ICC members voted to update its standards, including a voluntary measure that new homes be wired to support EV chargers and commercial construction projects be built with capacity for vehicle charging, among other changes. However, these decisions were challenged by a subset of the members and the ICC subsequently dropped the new EV-ready and other electrification-related language.[145] Despite this setback, states and local jurisdictions can still adopt EV-ready updates in their codes. For example, Massachusetts' code requires an EV-ready parking space for every 15 parking spaces in commercial buildings, and local governments in Atlanta, Denver, Honolulu, and Tucson have adopted EV-capable codes for single-family buildings.[146]

The following actions would make more buildings EV-ready and streamline the process to install EVSE in homes and buildings across the country:

- Incorporate EV-ready measures into base code covering all new construction and major retrofits;
- Allow local governments to go beyond the state code;
- Increase the required number of EV-ready spaces at new buildings, with particular focus on multi-unit dwellings and supporting MHDEVs at commercial buildings;
- Incentivize EV-ready upgrades to existing buildings during major retrofits;
- Provide funding to train building code officials;
- Explicitly allow or encourage the integration of adaptive load management (ALM)[xxv] to spread available electrical capacity over more charging ports and optimize EVSE usage for emissions benefits.

xxv Adaptive load management is a software or hardware solution that allows an EVSE site host to automatically and dynamically distribute load amongst several EV charging ports. This technology reduces the need for greater on-site power and can be used to reduce emissions associated with on-site charging. NREL found that adaptive technology could cut electrical service needed to power stations by 50 percent. (Source: Ethan Howland, "NREL tests adaptive EV chargers," American Public Power Association, August 24, 2018, https://www.publicpower.org/periodical/article/nrel-tests-adaptive-ev-chargers.)

TABLE 5.

Streamline Deployment with EV-Friendly Interconnection, Planning, Permitting, and Codes — Policy Recommendation Summary

<table>
<tr><th></th><th colspan="3">POLICY ACTIONS & TIMELINE FOR ENACTMENT*</th><th>FEDERAL ACTION</th><th>STATE ACTION</th><th>LOCAL ACTION</th><th>UTILITY ACTION</th></tr>
<tr><th></th><th>NEAR-TERM (2021 - 2023)</th><th>MID-TERM (2024-2026)</th><th>LONG-TERM (2027-2035)</th><th></th><th></th><th></th><th></th></tr>
<tr><td rowspan="9">STREAMLINE DEPLOYMENT WITH EV-FRIENDLY INTERCONNECTION, PLANNING, PERMITTING, AND CODES</td><td colspan="2">Adopt interconnection best practices that proactively address EVSE</td><td></td><td></td><td>✓</td><td></td><td>✓</td></tr>
<tr><td colspan="2">Adopt and implement hosting capacity analyses (HCAs) and maps; integrate EVs and EVSE into methodologies</td><td></td><td></td><td>✓</td><td></td><td>✓</td></tr>
<tr><td></td><td colspan="2">Investigate EV and EVSE impacts on the bulk-grid and wholesale markets</td><td>✓</td><td>✓</td><td></td><td>✓</td></tr>
<tr><td colspan="2">Adopt Integrated Distribution Planning (IDP) with a framework for EVs and EVSE</td><td></td><td></td><td>✓</td><td></td><td>✓</td></tr>
<tr><td colspan="2">Direct (and fund) relevant stakeholders to convene, share relevant data and maps, and make information publicly available</td><td></td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td></td><td colspan="2">Adopt and implement streamlined EVSE permitting</td><td></td><td>✓</td><td>✓</td><td></td></tr>
<tr><td>Adopt EVSE, EV-ready, and EV parking provisions in building codes</td><td></td><td></td><td>Natl. Code-Setting Bodies</td><td>✓</td><td>✓</td><td></td></tr>
<tr><td>Allow local governments to go beyond the state code/ base code</td><td></td><td></td><td></td><td>✓</td><td></td><td></td></tr>
<tr><td colspan="3">Funding to streamline permitting processes and train building code officials</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
</table>

* *Please note that the timeline for enactment indicates when the policy action should be taken. It does not indicate the duration of the policy nor the implementation timeline.*

VIII

ADOPT SMART RATE DESIGN FOR ELECTRIFIED TRANSPORTATION

The 2035 2.0 Report findings that rapid electrification could save customers trillions of dollars depends heavily on affordable electricity rates. State utility regulators, along with utilities and other stakeholders, set electricity rates administratively through regulatory proceedings, typically in response to utility rate case filings. Every state and utility approaches this differently, but typically electricity rates are designed to recover utilities' reasonable costs of serving customers — investor-owned utilities are allowed to earn an authorized rate of return on investments made that are deemed necessary and prudent. Regulators tasked with approving utility investments and setting customer rates must endeavor to balance an array of factors, including customer affordability, the cost of serving each customer, utility cost recovery, and public policy goals. Utilities and regulators are beginning to better understand the overall impacts of EVs and EVSE on rates and rate design, but more research is needed to balance goals for EV growth, while also minimizing rate impacts to all electric ratepayers, particularly the most vulnerable to increasing energy burdens.

RATE DESIGN FOR LDEVS

EVs are typically the largest electricity-consuming device in a home, but have the benefit of flexible charging times. Electricity rate design is impacted by a number of factors, including frequency and duration of EV charging across different customers, type of charger (i.e., slow or fast chargers), and their impact on the grid, along with who controls the charging, and whether or not those controls are enabled and utilized. The following preliminary recommendations address ways to increase the volume of LDEVs on the grid, while balancing their overall impact on ratepayers.

Enable time-varying rates for LDEVs. The ideal utility rate to leverage EV charging flexibility and reward customers for deferring charging during times of grid strain is a time-varying rate (TVR).[147] In contrast with typical flat volumetric rates that charge the same amount for each unit of energy consumed, TVRs charge a different rate depending on the time of day. To retain the principle of cost causation and cost recovery,[148] TVRs typically increase when the grid is stressed — for example peak demand hours (e.g., hot summer evenings when the sun is setting but air conditioning load remains high). Rates typically decline during non-peak hours, such as when the grid has excess generation or capacity (e.g., at night). Every state and region experiences different system peaks — some are winter peaking, while others are summer peaking.[149] Utility regulators should aim to give LDEV customers access to TVRs with substantial price differentials between peak and off-peak while optimizing for high penetration renewable hours. Educating EV individual and fleet customers about the ways they can save the most money as they consider buying or leasing vehicles is also essential to ensuring uptake and maintaining affordable vehicle charging rates further enhancing the economics of switching from gasoline to electricity. Several utilities across the country have implemented TVR for EV drivers, as documented by the Smart Electric Power Alliance in its 2019 report *Residential Electric Vehicle Time-Varying Rates That Work: Attributes That Increase Enrollment*.[150]

Ensure TVRs don't burden late EV adopters. Electric rates cannot go so far in the direction of supporting vehicle electrification that non-EV adopters, especially lower- or fixed-income households, see higher electricity rates as a result of increased EV adoption or EVSE deployment. Rate design must ensure a gradual transition, and the overall impact of EVs can be mitigated by encouraging charging during off-peak hours.[151] Other dedicated approaches will likely be necessary to fully address equity concerns. For example, dedicated rates for multi-unit dwelling occupants may be necessary to alleviate the split incentive between landlords and tenants, while also increasing access to EVSE.

Enable Actively Optimized LDEV Charging. In contrast to relying on consumers responding to TVRs and other price signals, LDEV charging can be managed actively, by either the consumer or utility. One NREL study determined the average LDEV could delay charging five hours and still meet the user's charging needs.[152] Actively managed charging has successfully been demonstrated through utility pilots in California, Hawaii, and Massachusetts.[153] However, success is contingent upon customer participation, education, and communication regarding expectations.

Explore Vehicle-to-Grid, Bi-Directional Charging, and Adaptive Load Management. All new EVs and many EVSE options have the capability of being programmed to automatically charge when most affordable for the user — though these features are not yet widely activated. In aggregate, controlled EV charging can theoretically shift demand to minimize grid stress, optimize EV use or renewables on the grid, and potentially delay grid infrastructure updates.[154] With adaptive load management, EV fleets have the potential to be managed as virtual power plants, throttling charging to balance supply and demand in real time. Utilizing vehicle-to-grid technologies (V2G) can provide responsive services to the grid like real-time energy, capacity, and ancillary services. However, these capabilities represent the next frontier of EVs, and more investigation of the pros and cons is needed to instill confidence in consumers, utilities, and regulators. Pilots and research can aid in expanding the technology functionality, while also providing valuable case studies to emulate.

THE NEXT FRONTIERS: VEHICLE-GRID INTEGRATION AND BATTERY-BACKED EVSE

EV supply equipment (EVSE) is the industry term used to describe EV charging infrastructure. Widespread transportation electrification presents new opportunities to utilize advanced technologies to help proactively address grid integration issues, effectively manage economic impacts on EV drivers and all ratepayers, and optimize the storage capabilities of EVs and EVSE as volumes grow. Realizing the benefits of these cutting-edge technologies will require more attention by regulators and policymakers over time to streamline adoption.

Vehicle-grid integration (VGI) refers to the ability of an EV to provide energy back to the electric grid. This is accomplished through two modes: V1G and V2X:

- **V1G** refers to the unidirectional power flow from the charging source to the vehicle that is optimized to some degree to yield grid benefits, commonly referred to as managed charging. Managed charging helps utilities manage the demand of EV charging during peak periods. Many viable V1G use cases already exist, with more feasible within the next decade.
- **V2X** refers to bidirectional power flow, absorption, and discharge, which is classified either as V2G (vehicle-to-grid), V2H (vehicle-to-home), or V2B (vehicle-to-building). V2X use cases are not widely available today, although V2H is gaining interest as a potential resiliency measure and V2B/V2G has potential with school buses.

This report primarily focuses on current and near-term V1G opportunities, but policymakers should consider developing comprehensive VGI strategies as the technologies become more widely available and as the EV market grows over time.

Battery-backed EVSE refers to pairing distributed energy resources, such as battery storage, with charging infrastructure to offer fast and reliable EV charging and predictable demand for power from the grid. Battery-backed EVSE can help mitigate grid impacts, avoid the need for costly grid upgrades, and provide a buffer against peak demand spikes thus reducing energy costs. As technology advances, the integration of bidirectional battery storage offers further opportunities for peak shaving, load shifting, islanding, and optimizing energy management at the grid edge. In the context of a rapidly evolving electric grid, next-generation battery-backed charging infrastructure can present value for grid operators through demand response, capacity, and ancillary service programs. Regulators and policymakers may want to address this in relevant proceedings to provide a smooth glidepath these systems going forward.

MITIGATE DEMAND CHARGE IMPACTS FOR FAST CHARGING

Electric trucks require higher voltage charging infrastructure, typically DCFC, which, if not managed well, could have a larger impact on the grid and other ratepayers. In aggregate and in high volume, electric truck charging poses a unique rate design challenge. Given that most MHDEVs will be owned by businesses or public entities, MHDEV charging will typically be charged a commercial or industrial customer rate — commercial rate design typically entails a demand charge and a per kilowatt-hour energy charge.[155] When high-powered stations have relatively low usage, a low number of charging sessions can incur a high monthly utility cost. This challenge is not unique to MHDEVs, LDEVs can also utilize DCFC. An RMI study found that demand charges have been responsible for more than 90 percent of electricity costs at some EVSE charging locations during summer months.[156]

DCFC-specific rate design reform is highly recommended to overcome the difficult economics of fast charging in the early years of relatively low station utilization at many sites. For example, Southern California Edison (SCE) reformed its commercial rate to remove all demand charges for all DCFC for a five-year period, followed by a transitory glide path beginning in year six to be an "optimal" blend of energy and demand cost pricing by year ten.[xxvi] SCE expects use will be higher for most DCFC locations by the end of this 10-year reform rate process, so the rate will not be punitive toward EV adoption and it will more accurately portray grid costs and shape more beneficial charging behavior. SCE's rate aligns well with cost-causation and beneficial electrification principles and offers a model for other utilities and regulators to consider. New York State offers rebates specifically for DCFC to overcome some of the demand charge operational costs.[157] Minnesota is also tackling this challenge through its utilities. Xcel Energy has a history of limiting demand charges on sporadic loads, including DCFC. Minnesota Power and Otter Tail Power are piloting new rates to prohibit demand charges from going above 30 percent of a utility bill and promoting third-party ownership of DCFC, respectively.[158]

DCFC locations may serve an important function such as rural electrification, evacuation routes, or sparsely used roads connecting critical corridors. To help mitigate grid impacts and demand charge impacts, states, utilities, and local governments may consider incentives for co-located distributed generation or battery-backed EVSE at strategic charging locations.

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xxvi At this point in time, SCE has not determined or proposed to the California PUC what the breakdown of energy and demand cost components of the rate will be at the end of the 10-year rate reform process as many factors are still evolving.

TABLE 6.

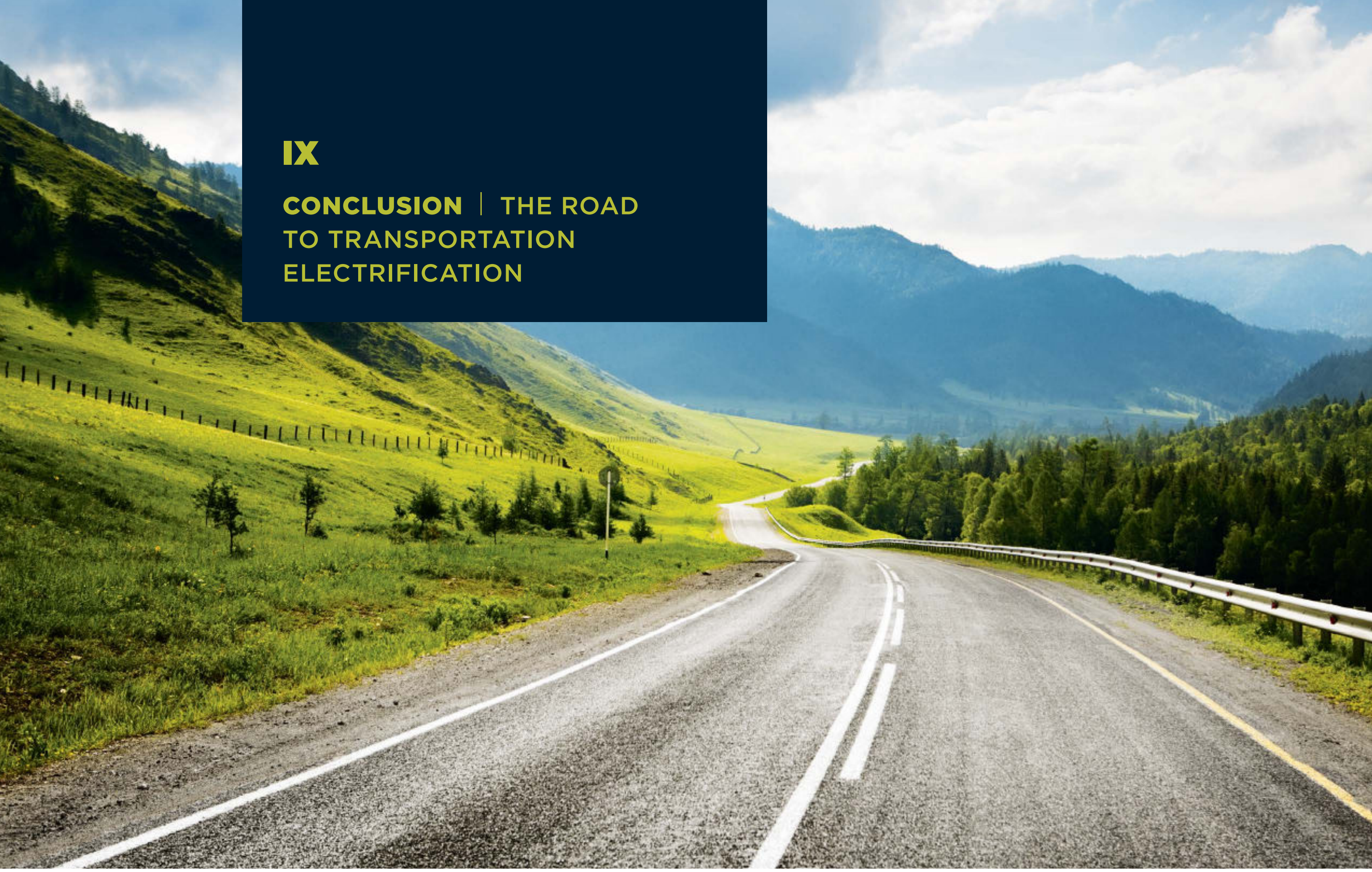
Adopt Smart Rate Design for Electrified Transportation — Policy Recommendation Summary

	POLICY ACTIONS & TIMELINE FOR ENACTMENT*			FEDERAL ACTION	STATE ACTION	LOCAL ACTION	UTILITY ACTION
	NEAR-TERM (2021 - 2023)	MID-TERM (2024-2026)	LONG-TERM (2027-2035)				
ADOPT SMART RATE DESIGN	Enable time-varying rates for LDEVs				✓		✓
ADOPT SMART RATE DESIGN	Enable Actively Managed LDEV Charging	Enable Actively Managed LDEV Charging			✓		✓
ADOPT SMART RATE DESIGN		Explore V2G and Bi-Directional Charging, and Adaptive Load Management	Explore V2G and Bi-Directional Charging, and Adaptive Load Management		✓		✓
ADOPT SMART RATE DESIGN	Rate reform to mitigate demand charge impacts	Rate reform to mitigate demand charge impacts			✓		✓
ADOPT SMART RATE DESIGN	Incentives for co-located distributed generation and/or energy storage at strategic EVSE charging locations	Incentives for co-located distributed generation and/or energy storage at strategic EVSE charging locations		✓	✓	✓	✓

** Please note that the timeline for enactment indicates when the policy action should be taken. It does not indicate the duration of the policy nor the implementation timeline.*

IX

CONCLUSION | THE ROAD TO TRANSPORTATION ELECTRIFICATION



The goal of achieving 100 percent EV sales by 2030/2035, supported by a 90 percent clean grid by 2035, is ambitious but technologically feasible and economically beneficial. It is also critical to get the U.S. on a pathway to achieve a 1.5 degree Celsius scenario for climate stability. Policymakers at all levels of government should focus on the policies that address near-term barriers, while also building long-term markets:

- **Strong national fuel economy and tailpipe emissions standards for all vehicle classes** will pave the road for market transformation, spur technology innovation, reduce local pollution, and lock in consumer savings. Combined with state leadership in ZEV standards, strong national standards will protect consumers, improve public health, and ensure U.S. manufacturers remain globally competitive. These policies are the highest priority policies in terms of emissions reductions.

- **Equity-focused policies and programs** designed with input from communities most adversely impacted by transportation pollution — namely communities of color in historically redlined neighborhoods, and frontline and underserved communities — will ensure all people benefit from cleaner, more efficient transportation solutions.

- **Targeted incentives that ramp down over time as the market matures** will further encourage early adoption and drive down costs to benefit all consumers. Means-based incentives will help ensure low- and moderate-income consumers and small businesses also benefit. Consumer education programs will increase awareness of expanding EV model availability and suitability. Incentive programs for EV infrastructure are also key to an all-electric future.

- **Investments in a ubiquitous charging network and a modern grid** will address range anxiety and ensure reliability as the EV market grows. Meeting the mobility needs of families and businesses will boost consumer and business confidence in EVs for urban, rural, and long-distance trips.

- **Strong "Made in America" policies to encourage domestic manufacturing** will help retool U.S. industries to manufacture batteries, EVs, energy storage, and other advanced technologies. An early focus on these policies will improve global competitiveness, sustain jobs, and support workers in the transition.

- **Smart electric utility regulations and local government leadership** will reduce soft costs and optimize transportation electrification for the benefit of EV owners, utility customers, and the grid. Efforts to streamline interconnection and integration of EVs in homes, businesses, and communities will pay dividends as demand grows.

A transition away from fossil fuel-powered vehicles and toward electric vehicles powered by a clean grid is within reach, but we must enact policies that transform the transportation sector this decade. In doing so, we will secure our role as global leader in innovation and improve competitiveness. We will sustain and create jobs, while saving consumers trillions. Widespread transportation electrification will also dramatically reduce dangerous air pollution and is essential to securing a safe climate future. Now is the time to move full speed ahead.

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