



Clean and Just: Electric Vehicle Innovation to Accelerate More Equitable Early Adoption

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Rapid adoption of electric vehicles by low-income and disadvantaged populations is necessary for decarbonization. Innovative products and business models are emerging that accelerate such adoption. Supportive policies should extend these innovations and amplify their benefits.

KEY TAKEAWAYS

- Three central barriers to EV adoption—range, price, and charge time—are more pronounced for individuals in low-income and disadvantaged communities. Policies and business models that aim to accelerate adoption must account for these barriers.
- EV innovations target these barriers to make adoption easier while also reducing other disparities. Businesses, non-profits, and government programs are advancing innovation in technology, workforce training, and community engagement.
- Strategies that integrate innovation and equity include prioritizing communication and marketing, revisiting assumptions and biases about early adopters, and designing government programs to increase demand and maximize universal benefits.
- The federal government can help extend benefits by revising the federal tax credit for EV purchases to make it refundable and eligible for carry-forward, expanding access to charging infrastructure, and helping with upgrades in older homes.

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INTRODUCTION

Electric vehicles (EVs) are at the core of U.S. and global strategies to address climate change. Transportation is a major source of carbon emissions, accounting for approximately 29 percent of U.S. greenhouse gas (GHG) emissions and 26 percent of global emissions in 2019.^{1,2} A mass conversion from vehicles with internal combustion engines to EVs, including both battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs), has the potential to significantly reduce GHG emissions.³

The decarbonization potential of EVs has led to a flurry of policy activity and business investment worldwide. Several countries have announced bans on gasoline-powered internal combustion engines. 11 U.S. states have committed to zero-emission vehicle mandates in addition to incentives and programs to encourage EV adoption, and major automakers, such as GM and Volvo, are committing to an electric future as a cornerstone of their long-term strategies.⁴ Nearly every major automaker now offers at least one EV model, with many more on the way—a significant change from just a decade ago.⁵

Despite these developments, EVs are still an early stage technology, with less than 1 percent penetration globally.⁶ The majority of innovations take a long time to reach mass adoption, and the early stages of the adoption process are crucial for the technology's development. Early adopters actively engage, assess compatibility, provide feedback, and help to refine the technology and encourage adoption in their communities. Technologies such as EVs that require substantial behavioral adjustments or compromises may experience particularly slow diffusion trajectories, or even stall out entirely.⁷

The need for EVs to be a market success is immense given the lack of low-carbon alternatives to the internal combustion engine and the urgency of emissions reduction requirements. The technology maturity pathway for EVs therefore needs to move faster than is typical for an emerging technology. This young technology needs to reach near-complete adoption quickly if local and global policy goals are to be met. This implies a broader range of consumers must purchase EVs earlier in the adoption process than in similar technologies.

Many studies of technology adoption have noted that individuals belonging to different socioeconomic groups frequently adopt at different stages of development. For example, early adopters are often typified as “advantaged” (i.e., wealthy, educated) while those who purchase later tend to be relatively “disadvantaged” (i.e., low income, less educated). In the scholarly literature, this trend is referred to as the “Innovativeness-Needs Paradox,” which posits that those who are most poised to benefit from a technology are often the last to adopt it.⁸

Studies have identified that early EV sales follow this pattern, as do other low- to no-carbon energy technologies such as solar power, battery storage, and LED lightbulbs, among others.⁹ Such disparities in adoption often reflect an asymmetry in access to resources and information needed to adopt the new technology, as well as the biases and strategies used to market it. For EVs to be successful as a way to mitigate climate change, the technology must defy such trends and achieve mass adoption, inclusive of all socioeconomic and demographic groups. If only an advantaged minority in the richest countries purchase EVs in the next 10 years, the impact on emissions will be minimal.

In this report, we examine the connection between equity and innovation in the context of EVs. We note that conventional approaches to encourage the purchase of EVs may fail to reach low-income and disadvantaged communities because these groups face distinct challenges in adopting the technology. We argue that innovation is a key strategy to both addressing disparities in EV adoption and aiding the broader goal of mass adoption. By intentionally including a diverse range of users early in the adoption process, technology providers can more effectively identify issues and modify the technology to successfully appeal to a mass market. We identify a set of unique organizations that have put this theory into practice and developed unconventional approaches to meet the needs of low-income and disadvantaged communities with respect to EVs. Finally, we provide a set of proposals to accelerate this work, including a roadmap for both other organizations that seek to incorporate equity into their EV programs and businesses and the government as it tailors and expands its EV and charging policies.

Key recommendations at the federal level include:

- revising the federal tax credit for EV purchase so that it is refundable or eligible for carry-forward, and expand eligibility to pre-owned EVs;
- expanding access to charging infrastructure in underserved communities; and
- establishing programs to offset the cost of home-panel upgrades needed for older homes to install charging equipment.

We present these arguments with support from semi-structured interviews we conducted with thought leaders and program managers in the EV industry, as well as with support from the peer-reviewed literature. We interviewed a dozen practitioners representing a broad range of industry roles and geographies over the course of 2021. Details on the research design and survey sample are included in Appendix A. Through this analysis, we aim to provide insights into the benefits of equity within EV programs that reflect the perspectives of those on the cutting edge of the field.

The technology maturity pathway for EVs needs to move faster than is typical for an emerging technology.

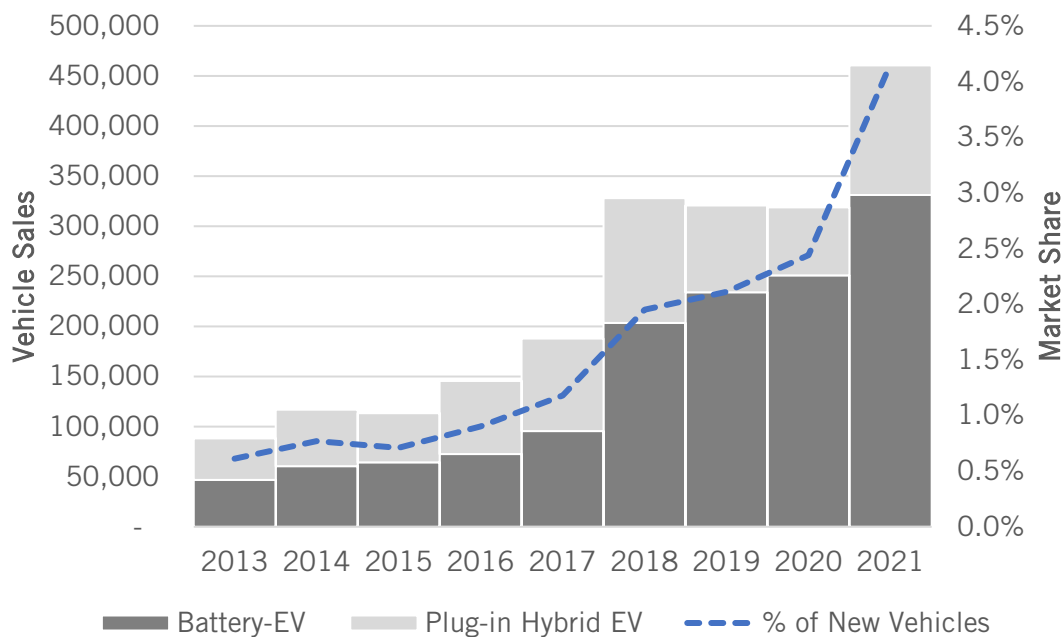
While this report focuses specifically on the role of innovation and equity in the case of EVs, similar arguments can extend to other low-carbon and efficient energy technologies. A key finding of our research into the unconventional approaches taken by equity-focused EV organizations is that their approaches ultimately benefit a broad base of users, even though the technology and business innovations created by these groups have been motivated by equity considerations.

The remainder of the report proceeds as follows: Section 1 reviews the evidence on the demographics of EV adoption in the United States. Section 2 presents evidence for why innovation is a critical solution to address disparities in EV purchases. Section 3 describes the unique barriers to EV adoption in low-income and disadvantaged communities. Section 4 highlights organizations that are tackling this problem in creative ways. And section 5 provides recommendations for how other organizations can address equity in their own work and how to leverage public policy accordingly.

THE DEMOGRAPHICS OF U.S. EV ADOPTION

Sales of EVs in the United States have grown significantly in the last decade, claiming a 4.2 percent market share of new passenger vehicles in 2021, up from 0.6 percent in 2013 (see Figure 1). New product choices from automakers, incentives provided by federal and state governments, and investment in charging stations nationally have all played a role in spurring the product's growth. The rate of increase is roughly on track with levels required to meet decarbonization goals, though the curve, in aggregate, remains steep. For example, Bloomberg New Energy Finance estimates that nearly 60 percent of new car sales globally must be EVs by 2030—up from 4 percent globally in 2020—in order to reach net zero carbon emissions by 2050.¹⁰ In the United States, this target demands an annual average growth rate of about 35 percent—an increase of roughly 10 percent over the 23 percent average from 2013 to 2021.

Figure 1: Annual sales and market share of electric vehicles in the United States, 2013–2021¹¹



If 60 percent of new car sales are to come from EVs by the end of the decade, the technology must reach a broader range of shoppers and consumer preferences.

Research shows that early adopters of EVs tend to be higher income, well educated, and predisposed to environmentally friendly technologies. For example, consumers with the highest intent to purchase an EV were more likely to be highly educated, environmentally conscious, and already own a hybrid.¹² In addition, most federal tax credits for clean energy technology—inclusive of, but not limited to, EVs—have been claimed by individuals with annual adjusted gross incomes of \$75,000 or above.¹³ A similar pattern appears in an evaluation of California's Clean Vehicle Rebate Program, even after the state imposed income restrictions.¹⁴

These findings suggest that conventional approaches that encourage adoption of this early stage technology are primarily reaching a distinct group of higher-income individuals. This selectivity can pose a problem for decarbonization goals. If 60 percent of new car sales are to come from

EVs by the end of the decade, the technology must reach a broader range of shoppers and consumer preferences.¹⁵

BARRIERS TO EV ADOPTION IN LOW-INCOME AND DISADVANTAGED COMMUNITIES

Members of low-income and disadvantaged communities face distinct challenges to purchasing EVs, which contribute greatly to the limited reach of federal tax incentives and similar policies. Research into why consumers choose not to purchase them highlights three central barriers:¹⁶

1. The price of an EV, which is typically thousands of dollars more than the internal combustion engine alternative
2. The limited availability of charging stations for EVs, which generates fear of being stranded while out on the road
3. The perceived range of EVs, which many assume to be less than is needed for daily commutes or personal transport

In this section, we review the specific ways these three barriers can be more pronounced for individuals in low-income or disadvantaged communities. The findings here rely heavily on the work of nonprofits such as the Greenlining Institute, as well as original interviews conducted as part of this report. (See Appendix A.)

Ability to Purchase

Although federal and state incentives exist to lower the prices of EVs, the design of these programs can create barriers to their utilization by low-income and disadvantaged consumers. For example, a federal program provides a tax credit of up to \$7,500 for the purchase of a new EV; however, the tax liability for many low-income consumers falls below \$7,500. Because the credit is not refundable and does not carry forward, the effective value of the federal EV tax incentive decreases significantly for individuals at lower income brackets.

In addition, because the incentive is administered through tax returns, there is a gap in time between the purchase of the vehicle and when the benefit is received, which requires individuals to have enough cash on hand to purchase the vehicle up front, even if they are eligible for the tax credit. Moreover, the tax credit does not reduce the financed amount of the vehicle. Low-income individuals may have additional difficulty being approved for financing or be offered high interest rates, based on their credit history. The qualification, liquidity, and credit constraints limit the use of the federal tax credit by low-income and disadvantaged communities. Similar problems are often present within state incentive programs.

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Many low-income consumers also struggle to afford a new car altogether, even at a reduced price with incentives. The purchase of a used EV is an alternative, but their overall availability remains low, reflecting the low penetration of the technology in past years. In addition, many dealerships do not stock new EVs, and sales teams often are either misinformed themselves or intentionally

misinform customers, perhaps out of concern that service revenues will decline because EVs typically require less maintenance.¹⁷ Prior academic research has also uncovered racial bias in car sales pitches, which suggests that salespeople may be less likely to introduce individuals from outside the common “early-adopter” categories to EVs, either used or new.¹⁸

Accessible and Affordable Charging

Low-income individuals are more likely to live in rental units and pay a large share of their income in rent than own their own homes.¹⁹ This pattern presents a challenge to accessing affordable and convenient charging. Owners of single-family residences can take advantage of dealer and state programs to install fast-charging units at a low-cost so they can recharge their EVs overnight and pay the retail rate for electricity. In contrast, renters must rely on their landlords to install such units—and have little incentive to do so. This challenge is pronounced for large, urban apartment buildings and multifamily units. In order to recharge, EV owners living in such dwellings must rely on public charging stations, which typically charge rates above retail and may be inconveniently located. Public officials have also been less likely to install charging stations in low-income communities and communities of color.²⁰ Many in these communities who do own their homes live in older buildings that would require an electrical upgrade to support the power draw of a fast charger. This barrier adds significant expense and is often not covered by charging incentives.

Suitability of an EVs’ Range to Users’ Transportation Needs

Drivers from low-income and disadvantaged communities often rely on their vehicles to travel long distances. Those who live in rural areas, for example, tend to rely on their vehicles as their sole means of transportation, and the annual miles driven by such vehicles typically exceed those in more densely populated areas.²¹ At the same time, people living in urban areas tend to be located relatively far from city centers and other locations of employment, reflecting historical patterns of discrimination as well as lower rents and living costs.²² In either instance, reliance on an EV as the primary vehicle in a low-income household is likely to be more challenging than reliance on a conventional auto compared with more affluent drivers.

INNOVATION: A KEY WAY TO ADDRESS DISPARITIES IN EV ADOPTION

Innovation is a critical solution to address disparities in EV adoption. Meeting the needs of low-income and disadvantaged consumers through technological innovation brings two advantages. First, by expanding the pool of early adopters to more diverse communities, EV manufacturers can better identify issues and develop a product with mass-market appeal later in the adoption process. Second, by prioritizing these communities, innovators can maximize the total social benefit of their technology by reducing air pollution and transportation costs where these reductions are most needed.

Innovation is a critical solution to address disparities in EV adoption.

The following sections support these claims with evidence from the academic literature and practitioner interviews. Although we’ve tailored our evidence here to the EV industry, the logic for the benefits of linking equity to innovation may apply to other early stage technologies, particularly adjacent solutions in the cleantech space.

Early Adoption to Drive Innovation

To reach mass adoption, EVs need to appeal to a diverse range of customers, including those from low-income and disadvantaged communities. As we have seen, numerous barriers inhibit early adoption of EVs by these groups. Yet, early adopters often strongly influence the design and functionality of an evolving technology, which, in turn, influences its potential to become a successful mass-market product. If historically marginalized communities are engaged early in the EV adoption process, EV makers will be more likely to develop innovations that overcome the challenges owners and drivers in these communities face. Such innovations may ultimately result in broader appeal of the product across a wide range of consumers.

The connection between innovation, equity, and mass adoption finds support in a few streams of academic research. In an international context, Prahalad and Hart proposed that many opportunities exist for companies to serve consumers at the “bottom” of the economic pyramid, and that, in meeting the distinct needs of these consumers, these firms should leverage innovations that would benefit wealthier consumers as well.²³ A central tenet of this “bottom of the pyramid” strategy is that the business goal of profit and the social goal of poverty alleviation are aligned. Prahalad and Hart’s ideas have been tested by a number of large corporations, with varying results, and adapted by social enterprises and nonprofits.²⁴

Second, there is evidence that designing solutions for the most vulnerable users can bring positive, unexpected benefits for a much broader set of users. For example, “curb cuts” required by the Americans with Disabilities Act created sloped entries to sidewalks, removing a barrier for those in wheelchairs. Angela Blackwell, writing in the *Stanford Social Innovation Review*, showed that this innovation has benefited many individuals who are not disabled, such as those pushing strollers or wheeling carts. She coined the term “curb-cut effect” to describe this phenomenon.²⁵

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Finally, scholarship on diffusion suggests that engaging users who might otherwise reject a new technology can trigger innovations that improve it.²⁶ Broad acceptance is not inevitable, because innovations must compete with both existing products and “non-use” as they are rolled out. Several factors, such as complexity, the difficulty of learning, high switching costs, and strong social norms supporting the status quo, increase the likelihood that an innovation will fail to replace its predecessor. Innovators that seek out potential nonadopters as part of their product development cycle are more likely to avoid rejection and speed diffusion.²⁷

Our research finds that practitioners in the EV industry see a direct benefit between the goal of equity and the goal of mass adoption, echoing ideas in the academic literature. Specifically, leaders we interviewed argue that including a diverse group of early-adopting customers will help EVs appeal broadly and reach mass adoption successfully. Findings from our interviews with participants are highlighted in the following box.

Perspectives From Practitioners on Equity, Innovation, and EV Mass Adoption

Practitioners noted that early adoption of EVs within low-income and disadvantaged communities can help them reach mass adoption by increasing demand. Government action is central in this framing and is seen to complement business strategies. While EV manufacturers may have initially planned to target higher-income groups, government policies and incentives may induce adoption by those who would otherwise have been overlooked.

For example, one interviewee framed this idea as allowing the private sector to work “top-down” based on ability to pay, while the public sector works “bottom-up” based on need, so that the two “meet in the middle”:

You have a new technology. You start at the top of the pyramid with the wealthiest people who can. The price is no object. Then you work your way down with innovation, but it's all based on ability to pay. And so where the government ... comes in is, “Well, while you do that, you should have some other go-to-market strategies that start from the bottom-up based on need,” right? And then instead of having to wait forever for the market to go all the way to the bottom ... you get there a lot faster because you meet in the middle (R9).

In addition, a number of interviewees noted that attention to equity can aid mass adoption through an expanded user base and the potential for resulting improvements in the technology. For example, one noted that manufacturers typically design products for the average consumer, or those who reside metaphorically in “the middle of the bell curve.” However, in their view: “I think that designing towards the use case of people, of residents, of users who might have different or higher needs ... if you can figure out how to serve that community first, it'll benefit everyone” (R11).

A second echoed this thought and explained that, when a product is designed for the most disadvantaged and hard to reach, “If it works for [these communities], then it is probably going to work for everybody” (R10). Similarly, a third practitioner suggested that the needs of historically disenfranchised groups—such as affordability or usability—may be more indicative of the broader populations’ preferences than the needs of better-off demographics:

[I]f you're thinking with [historically disenfranchised] folks in mind, you're going to have a product that is going to be able to appeal to more people and therefore be more successful instead of ... doing this flashy new technology and then ... thinking, “Okay, so it doesn't work for a lot of people. Now we kind of have to pivot a little bit.” You can still make something flashy at the end, and it still can appeal to early adopters while also appealing to more people that may actually find it useful in their day-to-day lives from ... a needs standpoint (R5).

Two interviewees also argued that technology design has path dependencies. As one practitioner put it, if you do not design with the broader market in mind initially, “it's harder to go back ... It's just like construction. It's like build it in first, or else you're going to mess things up, and it's going to be costly and clunky later if you try to go in and renovate and add it in after the fact” (R11). Another offered a similar idea: “[I]f we're not considering all communities which include frontline and low-income communities into products or planning or anything related to electric transportation, then ... as the market develops, it's going to miss them because they weren't involved up front” (R2).

Co-benefits of Early Adoption and Associated Innovations

Low-income communities and communities of color bear a disproportionate share of the negative environmental externalities of the current transportation system. The racial and socioeconomic disparities of air pollution, broadly, are well documented.²⁸ For instance, recent work shows that emissions from light-duty gasoline and heavy-duty diesel vehicles are among the sources of fine-particulate PM2.5 air pollution that has the most disparate impact by race.²⁹ Low-income and racial-minority households are more likely to live close to major roadways, raising their exposure to pollutants such as PM2.5 and nitrogen dioxide (NO₂).³⁰ These pollutants have been linked to adverse health impacts such as low birth weight, childhood asthma, and cardiovascular disease.³¹ Such disparities persist over time, even after overall emission levels have fallen.³² The disproportionate health burdens placed by the transportation system on these communities is an element of a broader pattern of environmental injustice.³³

Reliance on private vehicle ownership in the United States creates additional challenges for low-income communities in meeting their basic transportation needs. Public transit is constrained in part because cars are so prevalent, and research finds that low-income individuals frequently value and still rely on the flexibility of automobiles.³⁴ Yet, 28 percent of households in the lowest U.S. income quintile did not own a vehicle in 2020, compared with 3 percent in the highest.³⁵ Low-income households tend to spend less on transportation as a share of monthly income than wealthier counterparts do, but this difference reflects both the disparity in car ownership and a host of coping strategies they undertake to limit transportation costs.³⁶ These households report taking fewer trips, purchasing used vehicles rather than new ones, and driving older cars until they break down. Moreover, studies have identified a trade-off between transportation and housing costs—the choice between living closer to employment and paying less for transportation but more for housing, or vice versa—and note that the combined housing and transportation burden of low-income households remains higher than in higher-income brackets.³⁷

Low-income and disadvantaged communities stand to benefit significantly from both the environmental and technological advantages of EVs. The use of EVs results in less local tailpipe emissions, thereby decreasing the harmful air pollution to which these communities are exposed. In addition, while EVs currently have a higher average sticker price than comparable internal combustion cars, their operating costs are expected to be lower. The miles-per-gallon equivalent cost of fueling at average retail electricity rates is typically lower than refilling with gasoline, and electric motors require less ongoing maintenance and repairs than do gasoline engines.³⁸ These savings can make a significant difference to cash-constrained drivers who make heavy use of their vehicles.

Low-income and disadvantaged communities stand to benefit significantly from both the environmental and technological advantages of EVs.

Half the practitioners we interviewed argued that the potential health and cost benefits of EVs were the primary reasons to prioritize equity in EV development. Most interviewees used the language of “environmental justice” to explain why equity was essential for the EV industry. One participant noted that electrification of the transportation sector is justified, broadly, by three public goals: decreasing GHG emissions, decreasing the cost of transportation, and improving air

quality. Because communities of color are disproportionately burdened on all three dimensions, their interests should be prioritized in the technology’s development and implementation (R3).

UNCONVENTIONAL APPROACHES TO ENCOURAGE EV INNOVATION

A barrier reframed is a business opportunity waiting to be claimed. Our research identifies several organizations and initiatives using new approaches to address the needs of low-income and disadvantaged communities that may seek to acquire or use EVs. We summarized the most promising of these in table 1. (Appendix B provides a summary of the most common approaches used by states and utilities to address equity in EV adoption.) Importantly, while the technological and business innovations presented in this summary table are motivated by equity considerations, they all ultimately serve to benefit a broad base of users.

Table 1: Organizations or initiatives addressing equity and electric vehicles

Organization or Initiative	Description	Innovations
SparkCharge <i>(For-profit)</i>	Offers a subscription for a mobile charging service, allowing those without access to charging infrastructure to “re-fuel” consistently.	<ul style="list-style-type: none"> In-house mobile charging technology Subscription-based business model
Recurrent Energy <i>(For-profit)</i>	Uses data monitoring of existing EVs to create used-EV purchase reports, which can decrease purchase barriers for affordable, used vehicles.	<ul style="list-style-type: none"> Data science technology
Sway Mobility <i>(For-profit)</i>	Develops “micro” car-sharing programs (as small as one vehicle) for partner organizations working in marginalized communities.	<ul style="list-style-type: none"> Business model decreases the cost of creating a car-sharing program, increasing access to new communities
Charger Help <i>(For-profit)</i>	Employs a diverse workforce to maintain and fix charging stations.	<ul style="list-style-type: none"> In-house technology to manage repair dispatch Unique process to attract, hire, train, and retain diverse workers
Grid Alternatives and EVGo <i>(Nonprofit and for-profit partnership)</i>	Testing a portable charger that allows individuals to charge their EV from a standard outlet at a faster rate, simulating Level 2 charging.	<ul style="list-style-type: none"> Mobile charger technology
Sustainable Transportation Equity Project and California Air Resources Board (CARB) <i>(Government)</i>	Provide grants to communities to determine their needs and structure EV adoption programs accordingly.	<ul style="list-style-type: none"> Unique decision-making process

For example, lower-income and disadvantaged communities, including communities of color, are more likely to live in “charging deserts” without reliable access to charging.³⁹ **SparkCharge** pairs

technology and business model innovation to address this problem. The company develops mobile charging systems and provides a subscription-based charging service. For a fixed fee per month (\$25), the company will charge an individual's EV, wherever it is located, up to three times per week. The service is available in Dallas, Los Angeles, and San Francisco, including all neighborhoods within these cities. The convenience of such a model can appeal to a wide range of customers, regardless of whether they live within a charging desert.

Similarly, the California Air Resources Board (CARB) seeks to provide options for individuals who seek EV ownership but cannot install a Level 2 home charger and are unable to utilize existing incentives to receive a \$1,000 prepaid charge account for use at public charging stations. As part of this program, **Grid Alternatives and EVGo** are testing a new portable charger that plugs into a standard outlet but charges at a faster rate, which is comparable to Level 2 charging. Eligible EV owners receive the charger alongside the charging credit. Although it was developed to meet a distinct problem faced by low-income and disadvantaged consumers, this technology is equally useful to a broader class of EV drivers and can be used on properties that lack a fast charger.

Two businesses in our study take creative approaches to increasing the affordability of EVs. Since one of the major barriers to adoption is up-front cost, the creation of a viable used vehicle market for EVs could accelerate their uptake. Of course, secondary vehicle markets present other market failures such as asymmetric information between sellers and buyers—gaps that may be even more pronounced with EVs. Because EVs are an early stage technology, consumers buying used EVs are typically less knowledgeable about the technology and its performance than about conventional used cars. **Recurrent Energy** seeks to increase the accessibility of used EVs, as it monitors EVs in operation to develop statistics on the longevity and performance of different cars and battery types and packages this information into customer-facing reports on battery health, similar to the services provided by Kelley Blue Book. The start-up company, though motivated by equity, is creating a product that is useful for any budget-minded EV shopper.

Sway Mobility takes a different strategy to address affordability. The company develops small-scale car sharing programs for specific clients, with vehicle fleets as small as one EV. Sway's "micro-mobility" approach lowers the capital costs required to start a car-sharing program and allows organizations to provide low-cost transportation services to low-income or otherwise disadvantaged communities. Sway's early partnerships include a real estate developer of affordable and low- and moderate-income housing, the City of Oberlin, the Greater Cleveland Regional Transit System, the Center for Families and Children, and a workforce development organization for formerly incarcerated individuals. Though the company has found the strongest initial interest from socially minded partners, its unique approach may offer distinct advantages over traditional car-sharing programs—many of which have now faltered due to high entry costs and capital investment needed. It can also take advantage of recent competitor exits.

In the area of workforce development, **Charger Help** services, maintains, and fixes charging stations across 11 states. The company is distinctive along two dimensions. First, it utilizes an innovative process technology to manage and dispatch technicians efficiently. Second, it uses an inclusive approach to hiring, training, and retaining new technicians to develop a diverse workforce. For example, the company does not require a college or high school degree for its applicants. This commitment has allowed it to create a team that is ethnically and gender diverse. Given the scale of a workforce that would be needed if EVs were adopted at mass scale,

the insights generated by this company on effective workforce development may have broader implications for policies and programs to drive the EV transition.

Finally, the **Sustainable Transportation Equity Project**, administered by CARB, demonstrates a commitment to engage stakeholders and communities that CARB is targeting. In response to communities’ feedback, CARB changed the initiative to offer two tranches of grants: one for planning and capacity building by communities to conduct needs assessments and propose local solutions, and another for implementation. This approach allows flexibility in the creation of place-based solutions. CARB’s process innovation may serve as a best practice for other government agencies that seek to make decision-making more equitable.

RECOMMENDATIONS TO ACCELERATE PROGRESS

The unique approaches highlighted in the prior section illustrate how solutions that are designed for the least well-off have the potential to create benefits for a much broader section of society. They demonstrate that including a diverse group of customers in the early phases of adoption—and designing business and technological solutions to meet their needs—can help EV technology appeal more broadly in order to accelerate mass adoption.

Our research identifies several strategies through which equity considerations can be incorporated into future EV programs and policies, as shown in table 2. The second column of the table advances policy recommendations that would apply these strategies to federal EV programs. The subsections that follow provide further details, illustrated by supporting perspectives from our interviewees.

Table 2: Strategies and policy recommendations to accelerate progress in equitable EV adoption

Strategies to Advance Equity	Federal Policy Recommendations
<p>Prioritize communication and marketing. Gaining social acceptance is as essential to adoption as building infrastructure. Intentional communication—education, outreach, and marketing—by all actors can help achieve this goal.</p>	<p>Federal agencies covered by the Biden Administration’s Justice40 Initiative can use education and outreach as a part of their strategy to ensure that the benefits of EV programs reach disadvantaged communities.</p>
<p>Revisit assumptions and biases about early adopters. Individuals in marginalized communities can be early adopters, and real opportunities exist to serve these groups. Funders, investors, and public servants working on early adoption programs should reconsider their beliefs about who can become EV customers.</p>	<p>Federal programs administering grants can use community-centered decision-making processes so that spending reflects communities’ preferences and needs.</p>
<p>Design government programs to increase demand and maximize benefit. Limited funds should be used wherever they are needed most and avoid subsidizing transactions that would occur without government intervention. By focusing on equity, government programs can maximize the climate and social benefits per dollar spent.</p>	<p>The federal tax credit for an EV purchase can be revised so that it is refundable or eligible for carry forward. The federal government can also consider allowing the tax credit to apply to pre-owned EVs and programs to expand access to charging infrastructure; and incentives to offset the cost of home-panel upgrades needed for older homes to install charging equipment.</p>

Prioritize Communication and Marketing

Several industry practitioners we interviewed emphasized the importance of communication to make the adoption of EVs more equitable. Education, outreach, and marketing are essential to ensure that low-income and disadvantaged communities are engaged, aware, and able to fully benefit from EV technology and programs. This finding echoes the insight of scholars who describe adoption as fundamentally a process of information gathering. Knowledge about a technology that sparks its adoption can arise from either official (e.g., government, businesses) or unofficial (e.g., peers in one's social network) communication channels.⁴⁰

Including a diverse group of customers in the early phases of adoption—and designing business and technological solutions to meet their needs—can help EV technology appeal more broadly in order to accelerate mass adoption.

Two excellent examples of organizations that put this insight into practice are **EV Hybrid Noire** and **EV Noire**. The former is a grassroots network of diverse EV drivers and enthusiasts—spanning racial-ethnic, gender, age, immigrant, and sexuality categories—that engages with stakeholders to craft EV-friendly and -inclusive policies. The latter is a consulting company that works with institutional partners such as utilities, transit authorities, municipalities, and auto manufacturers to shape electrification plans and provide best practices for diversity, equity, and inclusion. Central to both organizations is an emphasis on “normalizing” EV adoption within diverse communities and tailoring communication about the technology. The work of these organizations emphasizes that such education, outreach, and engagement is as critical to achieving equitable adoption as installing infrastructure in marginalized communities.

Executive Order 14008, issued by President Biden in 2021, created the Justice40 Initiative, which aims to ensure that 40 percent of the benefits from federal climate-related investments are received by disadvantaged communities. Federal programs related to clean transportation and EVs fall within this initiative. To advance it, we recommend that federal agencies, such as the Department of Energy and Department of Transportation, explicitly consider education and outreach in their strategies to meet Justice40 goals in EV programs. By engaging disadvantaged communities directly, these programs can ensure that efforts to expand the benefits of EV programs reach their intended recipients.

Perspectives from Practitioners

Practitioners noted that if consumers' perceptions of EV technology differ from the actual capabilities of the vehicles, education can help bridge the gap. One interview subject expressed confidence that the majority of perceived barriers about EV technology fall into this category and can be solved through dealer and customer education (R1). Similarly, a second expressed that they view misperceptions as a larger barrier to adoption in low-income communities than technological limitations:

If you would have asked me a few years ago, I would say the technology was a problem because there weren't enough options. Now there are enough options. I would say, based on how much we talk to customers and also where we see barriers in customers making decisions around electric vehicles, it's largely an issue with the marketing and perceptions of electric vehicles in those communities and the lack of charging—both the real lack of charging and the perceived lack of charging (R2).

EV manufacturers have a strong role to play within this area. One participant emphasized the role of marketing, noting that a lack of focus within communities of color was a root cause of patterns of lower adoption. This interviewee argued that car manufacturers were not proactively marketing EVs to communities of color (R3).

Our interviewees further underscored the importance of peer role models in achieving equity in EV adoption. As a demonstration of this idea, one participant conveyed that, in their experience, diversity in workforce development can also lead to higher adoption (R8). The diverse employees hired by the interviewee's organization often purchased EVs after learning about and being exposed to the technology, and they became change agents within their communities, recommending the cars to others.

Revisit Assumptions and Biases About Early Adopters

Assumptions about the demographic and socioeconomic characteristics of early adopters can become self-fulfilling prophecies. Such casual biases about the types of individuals and communities that are likely to buy or use EVs may shape the design of corporate and government EV programs. Within the private sector, for example, these assumptions can affect the willingness of investors to back businesses that serve the distinct needs of low-income or marginalized communities. Within the public sector, they can determine the type of electrification that is prioritized within a given geographical area.

As Section 2 highlights, low-income and disadvantaged communities face overlapping and distinct barriers to adopting EVs, which can stifle the demand for the unique advantages the technology would provide these communities. Moreover, as demonstrated through the case studies provided in Section 4, many opportunities exist for businesses and other institutional actors to meet the potential demand in ways that amplify total social benefit and accelerate innovation.

The federal government should seek to create equitable decision-making structures that give communities a say over EV programs, and avoid top-down designs that weaken the programs' impact.

Our primary recommendation for the federal government—and one that was emphasized by several industry participants we interviewed—is to utilize community-centered decision-making processes when creating equity-focused grants and programs. Community-centered processes provide communities with greater control over the type of program that is implemented for a given budget. The approach prevents agencies from imposing solutions that may not reflect the needs or preferences of the communities that will be impacted by them, thereby decreasing their efficacy. The federal government should seek to create equitable decision-making structures that give communities a say over EV programs, and avoid top-down designs that weaken their impact.

The **Sustainable Transportation Equity Project** administered by the CARB, an innovative government program highlighted in Section 4, can serve as a model for federal agencies. The program was mentioned by several practitioners as a best-in-class example of community-directed program design. It allows communities to develop their own proposals for EV adoption and other transportation needs and provides seed funding for them to conduct needs assessments.

Perspectives From Practitioners

Two private-sector interviewees noted a connection between funders' willingness to finance projects and their assumptions about early adopters of EVs. For example, one highlighted that the ability to raise capital can be a barrier for programs that seek to serve marginalized or nontraditional communities. Banks see these communities as higher risk and often will not provide the up-front capital. This issue can be especially difficult for businesses that require high initial capital investments, such as purchasing a fleet of EVs (R3).

One start-up cofounder we interviewed, who focuses on creating access to EVs in low-income and marginalized communities, noted that other investors assumed that only areas with highly educated and high-income individuals were viable for their business model. In contrast, he and his cofounders believed there was demand for their service in the exact opposite types of communities (R7). The start-up's pilot projects, launched with small EV fleets and low up-front costs, are beginning to demonstrate the viability of the service within these overlooked communities—but convincing initial partners has been an uphill battle.

Within the public sector, an interviewee who has participated frequently in stakeholder meetings about EV programs, noted surprise at the way “equity” programs are designed, describing the dynamic as “[decision-makers] just kind of making assumptions and/or kind of being patronizing in terms of rolling out the technology without engaging ... with communities frequently and often. That really impacts the awareness and the way people might otherwise embrace the technology” (R4).

The interview subject further explained that these assumptions affect the design and efficacy of programs. An example is when public officials choose to electrify public buses instead of installing charging stations because they assume community members are unlikely to purchase EVs. Communities, the subject suggested, should be engaged directly and asked about their specific transportation needs and preferences (R4).

Supporting this recommendation, several participants noted that the transportation needs of communities are heterogeneous, and developing policy or technology solutions without their input runs the risk of imposing solutions based on erroneous assumptions, which can decrease the efficacy of the programs (R4, R9, R11, R12). One participant also cautioned against a focus on “policy-heavy” approaches, because any theoretical policy design is always changed during implementation (R12).

Interviewees recommended, at a minimum, that decision-makers, whether in government or business, speak with the communities they are trying to reach (R4). Two subjects framed this recommendation as being no different than normal customer research a company would undertake (R4, R8). One subject framed the best practices as simply to avoid top-down decision-making, center on the needs of the community, and hire from that community as well (R9).

Combine Equity and Decarbonization Goals in EV Policies

The urgency and necessity of addressing climate change, and the critical role that electrification of transportation plays in meeting that goal, justifies equity-based policy interventions to increase EV demand and maximize the benefit of limited public funds. Adopting this principle will accelerate innovation and speed up the pathway to mass adoption. A key justification within this line of reasoning is climate goals cannot be met if EVs are not adopted by everyone.

A clear way to apply this strategy at the federal level is to revise the tax incentive for EV purchases to allow more individuals at lower income levels to benefit from it. The EV provision in the Build Back Better Act that passed the House in 2021 includes an income cap that would exclude very high earners.⁴¹ However, it does not fully address the incentive's inequities, because it would remain nonrefundable and be without a carry-forward. Taxpayers with low federal tax liability would still be unable to claim it. Refundability of the federal EV tax credit emerged as a primary recommendation across practitioner interviews, and we recommend either refundability or carry-forward provisions be incorporated into the program.

In addition, states are experimenting with other equity-oriented changes in EV incentive design that can provide models for more innovative reforms of the federal tax credit (Appendix B). For example, at least five states now allow used EVs to qualify for purchase incentives. This structure can be critical to ensure that low-income consumers, who are not often able to afford the sales price of a new vehicle, will benefit from the program and be able to purchase lower-priced used EVs. Allowing the federal tax credit to apply to pre-owned EVs would have a similar effect.

The federal government should revise the tax incentive for EV purchases to allow more individuals at lower income levels to benefit from it.

Finally, the Build Back Better Act authorizes two grant programs to expand access to charging infrastructure, with a focus on underserved communities. The Zero-Emission Vehicle Infrastructure program would expand charging infrastructure located in rural or disadvantaged communities, while the Affordable Housing Access Program would do the same for charging infrastructure at affordable housing units. The bill also expands the Alternative Fuel Refueling Property tax credit for public charging infrastructure. These types of programs would aid renters, especially those living in multifamily units and other difficult-to-reach segments of the population, to gain greater access to charging infrastructure.

We recommend Congress and the administration adopt these policy proposals and consider an additional incentive for individuals to install charging infrastructure at their homes. Specifically, the federal government can consider a tax credit or direct assistance—with similar design considerations as previously outlined for the EV tax credit—for electrical panel upgrades in older homes. Such improvements can be cost-prohibitive for low-income individuals who are more likely to live in such dwellings. While many states and car manufacturers offer incentives to install charging infrastructure at homes, the cost of panel upgrades is excluded, with the exception of recent program reforms in California. Such a program would fulfill an important gap in federal EV policy.

Perspectives From Practitioners

One interviewee succinctly explained how decarbonization can motivate equity-focused, government intervention in EV adoption: “We can’t wait until it works for everybody, because climate is too urgent. We can’t wait until 30 years from now when there’s just dirt-cheap, used EVs everywhere because people are on generation four of their Tesla. Because if we wait that long, we’re in trouble” (R9).

This practitioner noted that a consideration of equity can also help ensure that public dollars are spent in an efficient manner. Public funding should not subsidize purchases of the new technology that would have been made anyway (i.e., in the absence of the incentive or subsidy), but should seek

to shift the marginal buyer: “[T]he idea of ... if you do have very limited public resources, you really need to be laser-focused on the transactions actions that would not have happened at all without those resources, to me, seems like good governance“ (R9).

Such a framing of “additionality” can allow those who are less well-off, and for whom an incentive can shift decisions and have higher marginal benefit, to gain priority over those with higher incomes for whom the incentive might be ancillary.

CONCLUSION

A focus on equity in clean energy innovation policy can help accelerate the pace of decarbonization and address ongoing disparities related to environmental justice and automobile emissions. Equity-focused EV policy can unlock new business models and changes in technology that achieve equity goals by addressing specific barriers faced by traditionally disadvantaged and marginalized communities. The coordinating set of strategies we propose—prioritize communication and marketing, revisit assumptions about early adopters, and design government programs to increase demand and maximize benefit—can guide the development of new equity-focused EV policies.

APPENDIX A: INTERVIEW METHODOLOGY

This analysis draws on semi-structured interviews with both thought leaders and program managers within the EV industry. We initially identified possible respondents via professional contacts and an extensive online search. Specifically, we searched for organizations and individuals that met one of two criteria: (i) experience implementing equity-focused businesses or programs within the EV space; or (ii) leadership of an initiative that addressed equity and EVs in an innovative way. After a round of initial interviews, we employed snowball sampling to identify additional interviewees based on the recommendations of our participants.

The semi-structured interviews focused on the themes of innovation and equity. We used separate instruments for the thought leaders and program managers; while there was significant overlap in content, the questions for thought leaders focused more heavily on general connections between energy innovation and equity, while the questions for program managers focused on the specific innovations and experiences encountered by each program. Interviews were conducted over Zoom and lasted between 45 and 60 minutes. We recorded all interviews and subsequently transcribed them to use for analysis.

Table 3 shows a summary of the 12 organizations represented by our interview participants. (Precise details are omitted to preserve confidentiality.) The organizations were roughly split between for-profit organizations and nonprofit or government entities. Six of the organizations were national in scope, with the remaining half representing organizations with regional operations. Most subjects were at a senior level within their organization, with several chief executive or “C-level” individuals participating.

Table 3: Summary of organizations interviewed

Organization Type	Geographic Scope	Survey Instrument	Citation Code
Car Manufacturer	National	Thought Leader	R1
Utility	California	Thought Leader	R2
Consulting	Primarily Midwest	Thought Leader	R3
Consulting/Nonprofit	National	Thought Leader	R4
Nonprofit	Primarily Pacific Northwest	Thought Leader	R5
Start-up	National	Program Manager	R6
Start-up	Midwest	Program Manager	R7
Business	National	Program Manager	R8
Nonprofit	National, but primarily California	Program Manager	R9
Government	Colorado	Program Manager	R10
Government	California	Program Manager	R11
Philanthropy	National	Program Manager	R12

APPENDIX B: COMMON STATE AND UTILITY POLICY DESIGNS

In addition to the creative approaches highlighted in the main text, a number of state governments and electric utilities have begun to actively incorporate equity into EV program and policy designs. Table 4 identifies the basic policy designs.

Table 4: State and utility policy approaches to address equity in electric vehicle adoption⁴²

Barriers Addressed	Program Approach	Examples
Up-Front Cost	Purchase incentive adder if individual is income-qualified	<ul style="list-style-type: none"> At least five states—California, Maine, Oregon, Pennsylvania, and Vermont—supplement a base EV purchase incentive for low-income individuals Some utilities, such as Green Mountain Power (VT) and Clark Utilities (WA), also offer income-qualified rebates
	Remove barriers to participation and use of existing incentives ⁴³	<ul style="list-style-type: none"> Colorado allows its state tax credit to be assigned at purchase Delaware, New Jersey, New York, and Vermont incorporate point-of-sale eligibility for incentives and partner with dealerships on rebate programs Stakeholders in California created a single application program, Access Clean California, to check eligibility across state and local incentive programs and decrease the difficulty of identifying and receiving incentives Some state and utility incentives, such as those in California, Maine, Oregon, Pennsylvania, and Vermont, allow used/pre-owned EVs to qualify for purchase incentives
Availability of Charging Infrastructure	Grants to install charging stations at multifamily and affordable housing units	<ul style="list-style-type: none"> At least nine states—California, Delaware, Hawaii, Maryland, Massachusetts, New Jersey, New York, Pennsylvania, and Rhode Island—offer specific grants or higher rebate levels for charging infrastructure at multi-unit dwellings, often using funds from the VW Settlement A number of utilities, such as Austin Energy (TX), Potomac Edison (MD), and Amaren (MO), offer generous incentives for multifamily property owners (up to \$10,000, \$20,000, and \$50,000, respectively)
	Allocative targets for infrastructure investment	<ul style="list-style-type: none"> An executive order in California (N-79-20) directs the Public Utilities Commission to accelerate deployment of charging infrastructure, especially in low-income and marginalized communities. Following this, San Diego Gas & Electric is targeting 50% of deployment of charging infrastructure in low-income communities in its “Power Your Drive” Phase 2 Program

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