APRIL 2024

Adapting zero-emission vehicle incentives for a mainstream market

Alexander Tankou, Dale Hall, and Peter Slowik

The International Zero-Emission Vehicle Alliance is a network of leading national and subnational governments demonstrating their deep commitment to accelerating the transition to zero-emission vehicles within their markets and globally. Its members include Austria, Baden-Württemberg, British Columbia, California, Canada, Chile, Connecticut, Costa Rica, Germany, Maryland, Massachusetts, the Netherlands, New Jersey, New York, New Zealand, Norway, Oregon, Québec, Rhode Island, Switzerland, the United Kingdom, Vermont, and Washington. The members collaborate through discussion of challenges, lessons learned, and opportunities; hosting events with governments and the private sector; and commissioning research on the most pressing issues in the ZEV transition.

Acknowledgments

This work was conducted for the International Zero-Emission Vehicle Alliance by the International Council on Clean Transportation (ICCT). The authors thank Chang Shen and Gaurav Dubey for reviewing an earlier version of the report. Hussein Basma provided analysis and important insights on heavy-duty vehicle costs. We also extend our appreciation to the members of the International Zero-Emission Vehicle Alliance, who provided key input on policy activities and reviewed an earlier version of the report. Their review does not imply an endorsement and any errors are the authors' own.

secretariat@zevalliance.org | www.zevalliance.org

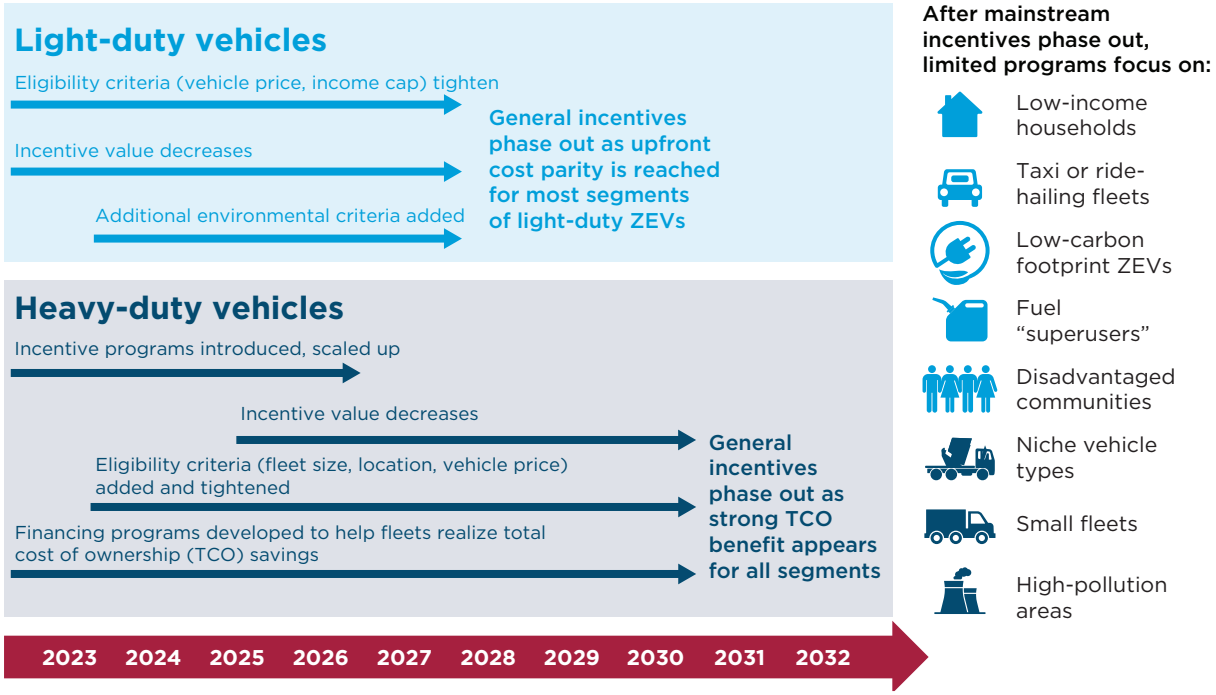
Executive summary

Zero-emission vehicle (ZEV) sales continue to grow around the world and are entering the mainstream market in many countries, spurred by government fiscal and regulatory policy alongside technological advances. Financial incentives for the purchase of ZEVs represent an important policy lever and have been offered in every major ZEV market. Effectively designing ZEV incentives depends on many factors like local demographics, transport needs, and political considerations, and incentive policies have evolved as the ZEV market expands and changes.

This research summarizes the past and present status of financial incentive programs for light-, medium-, and heavy-duty ZEVs in leading markets, with a particular focus on the national and subnational governments of the International ZEV Alliance. The paper examines the value of incentives for general ZEV buyers, as well as eligibility constraints like restrictions on vehicle price or purchaser income. It also explores the growing number of more targeted incentive programs open only to specific consumers or vehicle applications. Based on these trends, the paper discusses how these incentives could be used to maximize the environmental benefits of the ZEV transition and make the ZEV market more equitable.

Based on this research, Figure ES1 shows a roadmap for how incentives could evolve into the early 2030s. The figure shows a potential evolution of incentives for zero-emission light-duty vehicles (top, in light blue) and heavy-duty ZEVs (bottom, in dark blue). Arrows show how incentives can be reduced and adapted until reaching the point when incentives may not be necessary to drive the transition. As mainstream incentives are phased out, more targeted programs can be created for specific vehicles or consumers, as shown on the right.

Figure ES1 Pathways for the evolution of ZEV incentives from 2023 until the early 2030s for leading markets



This research suggests the following conclusions on the role of incentives in markets where ZEVs are increasingly reaching the mainstream:

Most governments with high ZEV sales offered incentives in 2023, but eligibility restrictions and phase-down schedules are increasingly common for passenger vehicle incentives. All ZEV Alliance governments offer some form of incentives or tax discounts for light-duty ZEVs. Out of the 22 markets assessed, 16 offer rebates or tax credits of $1,000–$5,000, which help to overcome the remaining ZEV upfront price premium. The others offer lower tax rates for ZEVs in some applications. However, many governments are reducing incentive values and tightening eligibility requirements; some markets like the United Kingdom and California have ended financial incentives for most buyers of new ZEVs. In contrast, the heavy-duty market is at a much earlier stage, and most governments as of 2023 are creating and expanding their incentive programs to support continued market growth.

First-owner total cost of ownership (TCO) parity with combustion engine vehicles, over a period of 5 to 6 years, will be reached for most light-duty ZEVs in the mid-2020s and most heavy-duty ZEVs by 2030. Reductions in purchase and operating costs for ZEVs are continuing due to improved battery technology, economies of scale, and lower fueling and maintenance costs. The exact timing of TCO parity varies by geography, segment, and range. BEVs are expected to have lower total costs over a 6-year first ownership period—compared to their combustion engine counterparts—by 2025 for 300-mile range light-duty cars, crossovers, SUVs, and pickup trucks, and by 2030 for most heavy-duty segments. The upfront purchase-price gap is expected to persist roughly 4 years longer, with 300-mile range light-duty BEVs reaching upfront price parity in the 2028–2029 time frame. Because purchasers of light-duty ZEVs typically emphasize upfront price over running costs, incentives could be sustained at least until TCO parity for first owners is reached, and ideally until upfront price parity is reached, as budgets allow. As vehicle costs fall, incentives can be phased down for mainstream customers and targeted toward specific consumer groups and vehicle segments.

Targeted incentives with selective eligibility criteria can maximize environmental benefits and make the ZEV market more equitable. To plan the next phase of incentive programs, several governments have launched more targeted incentives—such as those prioritizing low-income drivers or small commercial fleets—to ensure that ZEVs and their benefits are more accessible to the people who need them most. Governments may also design incentives to maximize the near-term environmental benefits of ZEVs, such as channeling incentives to high-mileage drivers and applications or requiring sustainability criteria for the vehicles and their energy supply. Incentives for scrapping older, high-polluting light- and heavy-duty vehicles can accelerate air quality improvement in heavily impacted communities.

Funding ZEV incentives via polluter-pays mechanisms and linking them to regulations can minimize government outlays and promote financial sustainability. Limited government budgets have led to incentive programs being frequently exhausted or modified. Connecting the design of ZEV incentive programs to national ZEV strategies and targets can ensure that incentives are durable enough to create market growth while limiting government outlays and the temporary exhaustion of program funds. Similarly, creating dedicated revenue streams for incentives—including taxes on polluting vehicles, differentiated tolling programs such as zero-emission zones, or low-carbon fuel standards—can improve financial stability and accelerate the overall decarbonization of the sector.

Contents

Introduction and background

As of the end of 2023, almost 30 million light-duty battery electric vehicles (BEVs) had been sold worldwide, primarily in China, Europe, and North America, compared to only 1 million in 2016 (EV-Volumes, n.d.). The medium- and heavy-duty electric vehicle market is at an earlier stage; about 900,000 zero-emission buses and 100,000 zero-emission trucks have been sold through late 2023, mostly in China (EV-Volumes, n.d.). For emissions from the transportation sector to remain on a path aligned with the goals of the Paris Agreement, ZEV sales of all types will need to continue to grow rapidly.

The early transition to ZEVs has been driven by policy to overcome several barriers. The regions with the most mature ZEV markets have typically implemented actions across five key areas: 100% ZEV targets, binding regulations, financial incentives, infrastructure, and stimulating consumer demand (Hall et al., 2021). Financial incentives are especially important in the early stages of the market to help consumers overcome ZEV's higher upfront costs compared to internal combustion engine alternatives.

As governments enact policies to achieve their ZEV sales targets, they seek to design incentive programs that balance the competing objectives of rapidly increasing ZEV sales, minimizing budgetary impacts, promoting a just transition, and avoiding unnecessary subsidies. As ZEV prices fall due to increased production and economies of scale, reduced battery costs, and technological improvements, the core rationale for incentives is diminished. However, market growth does not happen equally across all demographics, geographies, or vehicle segments, while incentives can be used to reduce disparities. At the same time, the total outlay for incentives increases as ZEV uptake grows, making them more costly to sustain. Evidence also shows that consistency and stability in incentive design increase their effectiveness, indicating that superfluous changes should be avoided (Yang et al., 2016). These dynamics suggest the need for adapting incentive programs alongside market growth and also highlight the challenges in balancing these competing demands.

This paper seeks to identify best practices and provide recommendations on how to adapt financial incentives for ZEVs to the growing market in a way that promotes financial sustainability and an equitable transition. It builds upon previous work conducted by the International ZEV Alliance (Slowik & Lutsey, 2016; Yang et al., 2016). While many of these papers' findings remain relevant, the ZEV market has changed in important ways; most notably, global sales of new light-duty electric vehicles (including plug-in hybrids) increased from 1.1% in 2016 to 21% in the first three quarters of 2023 (EV-Volumes, n.d.). The role of incentives has likewise evolved. This paper incorporates updates on global policy developments and new evidence on vehicle cost trends. The scope considers incentives for light-duty vehicles (cars, vans, and light trucks), as well as medium- and heavy-duty vehicles (focusing on commercial trucks).

This paper begins by assessing the values of financial incentives from 2016 to 2024 in select leading jurisdictions. Next, we examine opportunities to target incentives toward specific user groups and objectives, highlighting examples and evidence of effectiveness where possible. The paper then catalogs the types and levels of financial incentives available for ZEVs in International ZEV Alliance markets in 2023. Finally, the paper presents an analysis of how vehicle price, market progress, and polluter-pays principles can be used to modify incentives for light-duty and heavy-duty ZEVs as the market continues to develop. This leads to recommendations for governments in designing financial policies to support the ZEV market at each stage of the transition.

Types of financial incentives

Governments have several options to provide financial incentives for ZEV purchases. The specific mode of incentive implemented typically depends on political and legal factors, in addition to policy aims. Financial incentives considered in this report include the following types of policies:

- **Up-front purchase bonus**: The incentive value is deducted from the cost of the vehicle at the point of sale, reducing the purchase price of the vehicle.
- **Cash rebate**: The incentive provider will refund the value of the incentive after the vehicle has been purchased and delivered.
- **Income tax credit:** The incentive is provided as a credit against annual taxes for the year in which the vehicle was purchased. This may require the purchaser to have tax liability greater than the purchase amount and also delays receipt of the incentive.
- **Vehicle tax, sales tax, or value-added tax (VAT) discount**: The incentive waives or reduces taxes—based on purchase price or other factors like mass, footprint, emissions, and engine power—that otherwise would have been paid.

This report does not consider other forms of incentives (i.e. on-road incentives) such as free parking, exemptions from tolls, or access to bus or carpool lanes. It also does not consider incentives for charging infrastructure or incentives for the manufacturing of ZEVs or their components. Several studies suggest that such policies are associated with higher ZEV uptake (Jenn et al., 2020; Narassimhan & Johnson, 2018). However, analysis of their relative benefits and impacts is outside of the scope of this paper.

Although also not the focus of this paper, there are opportunities to make ZEVs cost-competitive by ending subsidies for fossil fuels and increasing taxation on internal combustion engine (ICE) vehicles. The International Monetary Fund estimates that global direct subsidies for fossil fuel consumption in 2022 exceeded $1.3 trillion (Black et al., 2023). However, implicit subsidies, including undervaluing the environmental and health-related externalities and foregone tax revenue, were almost 4 times greater at $7.54 trillion. The unvalued externalities of fossil fuels in the transport sector impose a great toll on society: a 2021 study focused on the United States estimated the public health and climate social costs of on-road transport to be $184 billion annually (Zelasky & Buonocore, 2021). Furthermore, several studies indicate that fossil fuel subsidies are regressive and mostly benefit higher-income households (Coady et al., 2015; Moayed et al., 2021). Ending fossil fuel subsidies, therefore, provides an opportunity to reallocate financial resources towards cleaner transport systems.

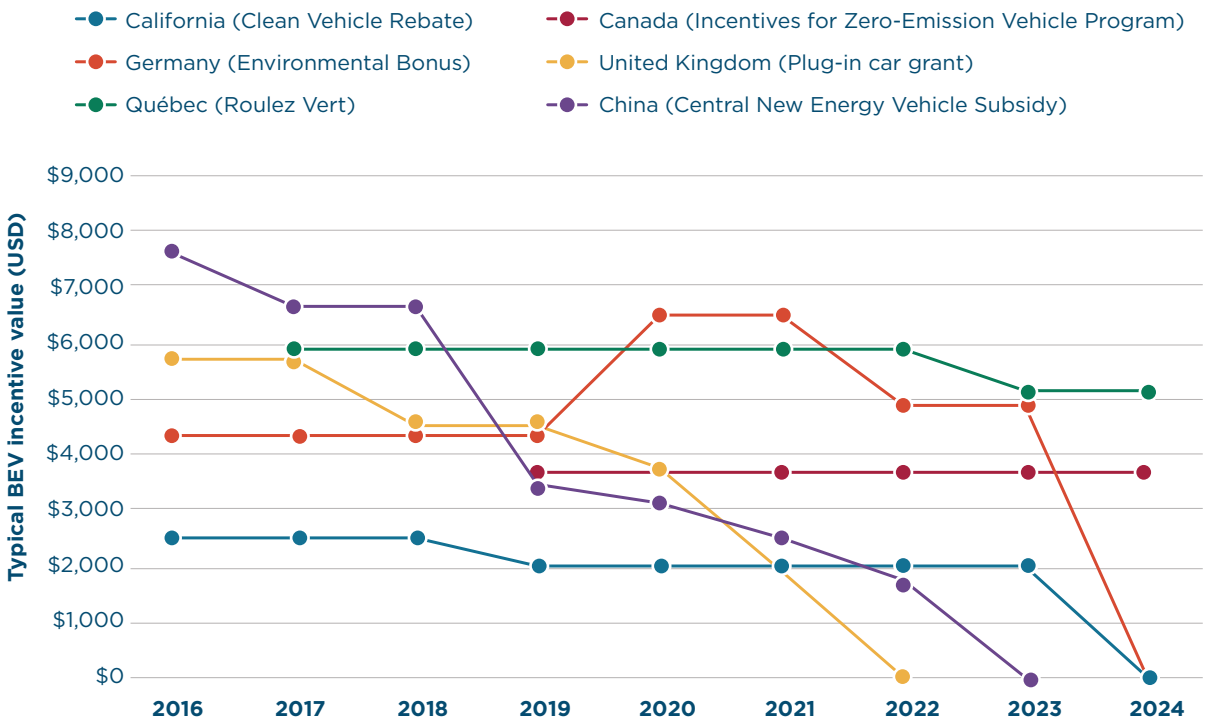
Historical evolution of financial incentives

Light-duty zero-emission vehicles

As of 2024, nearly every jurisdiction with strong ZEV market development has offered financial incentives at some point in their ZEV transition. Figure 1 below shows how the value of incentives for new BEVs have changed since 2016 in six markets: California, Germany, Québec, Canada, the United Kingdom, and China. These jurisdictions are among the leading EV markets in terms of sales or sales share as of 2023. Figure 1 displays the maximum BEV incentive value for the given year for buyers of a private car. It does not consider enhanced incentive values or bonuses that are

sometimes attributed to specific consumer groups like low-income or disadvantaged communities. Incentive values are in U.S. dollars and based on November 2023 exchange rates.

Figure 1 Values of incentives for BEV cars in six selected markets, 2016–2024



Sources: Center for Sustainable Energy (2018); Williams & Pallonetti (2020); Government of Canada (n.d.); Cui et al. (2017); Cui & Hui (2022); China, State Council of the Ministry of Finance (2020); China, State Council of the Ministry of Finance (2021); European Automobile Manufacturers' Association (2017); Germany, Federal Government (2020a); Germany, Federal Government (2020b); Germany, Ministry for Economy and Climate Protection (n.d.); United Kingdom, Office for Low Emission Vehicles (2016); Carwow (2022); Roberts (2022); Frontier Economics (2022); Transport Canada (n.d-a)

Figure 1 shows BEV incentive values decreased across the majority of the selected jurisdictions, although the trend is not universal. In Germany, the value of the incentive was increased in November 2019 from €4,000 ($4,274 USD) to €6,000 ($6,410 USD), motivated by the government's target of registering 7–10 million electric vehicles by 2030 (Government of Germany, 2020b). However, its value was reduced to €4,500 for 2023, reflecting accelerating demand for electric cars. At the end of 2023, the incentive was removed completely due to budget shortfalls (Germany, Federal Office for Economic Affairs and Export Control, 2023). In Canada, the Incentive for Zero-Emissions Vehicles (iZEV) Program was first introduced in 2019 with an incentive that has remained at up to $5,000 CAD ($3,650 USD) since its launch. The program was extended until March 31, 2025, or until available funding is exhausted (Transport Canada, 2022). In the United Kingdom, the value of the plug-in car grant incentive steadily decreased beginning in 2016 before being completely withdrawn for individuals in June 2022 (Roberts, 2022). The complete withdrawal of the plug-in car grant was informed through analysis indicating that the grant's influence on EV uptake had lessened as the light-duty EV market matured. The government found that incentive efforts could have greater influence if targeted toward company cars, vans, trucks, and wheelchair-accessible electric vehicles (Frontier Economics, 2022; United Kingdom, Office for Zero Emission Vehicles, consultation, 2023).

Evaluation of light-duty incentives

Several studies have assessed the link between financial incentives and ZEV uptake. A study of the 50 largest metropolitan areas in the United States in 2017 found a correlation between financial incentive value and electric vehicle uptake (Slowik & Lutsey, 2018). Financial incentives were determined to be one of the most important policies in differentiating electric vehicle uptake in cities in China (Yao et al., 2022). A similar relationship has been observed by comparing cities across Europe (Wappelhorst et al., 2020) and globally (Hall et al., 2019), where the regions with the highest ZEV uptake tend to have more generous incentives, although these studies do not control for confounding variables.

Studies have also been conducted to assess the impact of specific incentive policies through surveys and market analysis. A survey of more than 2,882 consumers across 11 U.S. states found that 30% cited the federal tax credit as influential in their purchase of a plug-in electric vehicle (Tal et al., 2018). Based on a survey of over 14,000 electric vehicle buyers in California, Jenn et al. (2020) found that the U.S. federal tax credit and the California rebate were the most important factors influencing purchase decisions. In New York, a survey-based study found that about 3,400 consumers out of a total of 5,000 surveyed were able to buy an electric car because of the Drive Clean Rebate program (New York State Energy Research and Development Authority [NYSERDA], 2022a and 2022b).

In Europe, a retrospective analysis of the plug-in car grant in the United Kingdom from 2011 to November 2021 found that it "had an important impact in building demand for electric cars in the market" and that about 90,000 electric car purchases could be attributed solely to the grant (Frontier Economics, 2022). In Germany, the Environmental Bonus introduced in 2016 contributed to the purchase of more than 820,000 electric vehicles with a total investment of €3.5 billion as of 2022 (Germany, Federal Government, 2022). Similarly, in China, a study found that city-level incentive programs supported the acquisition of about a quarter of new EV sales from 2008 to 2018 (Zheng et al., 2022). Additional evaluations of incentive programs are ongoing, but the available literature suggests that incentives can be effective in driving the ZEV market forward.

Heavy-duty zero-emission vehicles

In the United States, California pioneered financial incentives to stimulate the zero-emission truck market through the Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP) in 2009 (California Air Resources Board, 2022a). The program supports the transition of commercial fleets towards cleaner medium- and heavy-duty vehicles with vouchers that reduce the upfront purchase price up to $120,000 (California Air Resources Board, n.d.-c). As of January 2022, HVIP has directly supported more than 60% of the zero-emission truck sales in California (California Air Resources Board, n.d.-b). Other U.S. states have followed suit, including New York and Massachusetts, where incentives of up to $385,000 and $90,000 are provided, respectively (NYSERDA, n.d.-a; Massachusetts Department of Energy Resources & Center for Sustainable Energy, n.d.-b). In 2022, Canada launched the Incentives for Medium- and Heavy-duty Zero-Emission Vehicles Program (iMHZEV), which provides a rebate of up to CA$150,000 for battery electric or CA$200,000 for fuel cell trucks or coaches (Transport Canada, 2023b). In the first 14 months of operation, the program provided funding to about 1,200 medium-duty and 200 heavy-duty ZEVs (Transport Canada, 2023a).

In Europe, several countries have incentive programs for zero-emission medium- and heavy-duty zero-emission vehicles. The Plug-in Van and Truck Grant in the United Kingdom, introduced in 2012, first focused on vans and was extended to trucks in 2016 (United Kingdom Government,

n.d.-a). As of 2023, the program provides a maximum grant of £25,000 for the purchase of a large low-emission truck (weighing over 12 tonnes) (United Kingdom Government, n.d.-b). Germany opened its first round of applications for businesses and other institutions to apply for zero-emission commercial vehicle incentives in 2021 (Germany, Federal Ministry for Digital and Transport, 2021a). In the Netherlands, the AanZET program, announced in 2022, provides businesses up to €131,900 for the purchase of a zero-emission heavy truck (Netherlands Enterprise Agency, n.d.-a). The same year, the Austrian government announced a new funding opportunity to encourage commercial fleets to purchase zero-emission buses; the funding was extended to vans and trucks in 2023 (Austria, Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology, 2022). The funding covers 80% of the additional costs for vehicles and 40% of infrastructure investment costs. Table 1 below summarizes existing medium- and heavy-duty vehicle incentive programs across a selected number of jurisdictions. In each of these programs, both public and private fleets are eligible.

Table 1 List of medium- and heavy-duty incentive programs in selected jurisdictions in 2023

Jurisdiction and program	Type of incentive	Segment covered	Value	Enhanced incentive for small fleets	Enhanced incentive in disadvantaged communities	Source
Austria – EBIN and ENIN incentive programs	Grant	N1,N2, N3 and M3	80% of the additional costs for vehicles	**No**	**No**	Austria, Climate and Energy Fund (2023a)
British Columbia – CleanBC Go Electric Rebates	Rebate	Class 2B-8	Up to $150,000 CAD	**No**	**No**	Rebates (n.d.)
California – HVIP	Voucher	Trucks and buses	Up to $120,000	**Yes**	**Yes**	California Air Resources Board (n.d.-c)
Canada – iMHZEV	Rebate	Class 2B-8	Up to $200,000 CAD	**No**	**No**	Transport Canada (n.d.-b)
China – Vehicle and vessel tax reduction	Tax reduction	Heavy-duty vehicle	Full tax exemption for ZEVs	**No**	**No**	China, Ministry of Finance (2018)
France – Écosystèmes des véhicules lourds électriques	Grant	Trucks (N2 and N3) and road tractor and coaches	Up to €150,000	**No**	**No**	France, Ministry of Economics and Finance (2023a)
Germany – KsNI	Grant	N1, N2, N3	Up to €450,000	**No**	**No**	Germany, Federal Logistics and Mobility Office (2021b)
Massachusetts Offers Rebates for Electric Vehicles – MOR-EV	Rebate	Class 2B-8	Up to $90,000	**No**	**No**	Massachusetts Department of Energy Resources & Center for Sustainable Energy (n.d.-b)
Netherlands – AanZET	Rebate	N2 to N3 trucks	Up to €131,900	**Yes**	**No**	Netherlands Enterprise Agency (n.d.-a)
New Jersey – Zero Emission Incentive Program	Voucher	Class 2B-8	Up to $175,000	**Yes**	**Yes**	New Jersey Economic Development Authority (n.d.)
Québec – Écocamionnage	Rebate	Class 2-8	Up to $175,000	**No**	**No**	Québec Ministry of Transport and Sustainable Mobility (2023)
United Kingdom – Plug-in van and truck grant	Grant	N2 to N3 trucks and vans	Up to £16,000 for N2 trucks; up to £25, 000 for N3 trucks	**No**	**No**	United Kingdom Government (n.d.-a)

Approaches for designing targeted incentive programs

As light-duty ZEVs move closer to cost parity with combustion engine vehicles in many markets, governments are increasingly replacing or supplementing their mass-market incentive programs with more targeted incentives to guide ZEV sales to specific consumer groups. Targeted incentives may be designed to advance environmental goals (e.g., maximizing GHG reductions or improving air quality in polluted areas) as well as social goals (e.g., accelerating uptake among low-income or underserved populations). This section identifies categories of targeted incentives and provides examples, as well as evidence of their effectiveness, where available.

Incentives for advancing environmental and climate goals

The greenhouse gas and air quality benefits of ZEVs depend on their usage profile and the vehicles they replace. Governments are therefore interested in incentivizing the uptake of ZEVs in applications where they will have the greatest emission benefits for the lowest cost. Some of these applications are described below.

Super-users. Combustion-engine vehicles contribute different amounts of greenhouse gas emissions according to their efficiency and annual distance driven. In California, the top 10% of light-duty vehicle drivers in terms of gasoline consumption account for 28% of total consumption, and therefore carbon dioxide (CO_2) emissions, whereas the bottom 50% account for approximately 23% of gasoline consumption (London et al., 2023). If these high-fuel-consumption drivers switch to ZEVs at an accelerated rate, road transport emissions would drop more quickly than if all drivers adopted ZEVs at the same rate. This indicates an opportunity to provide incentives targeted toward drivers with high fuel consumption or with funding proportional to gasoline use displaced.

No such incentives are currently in existence, but a few U.S. states are exploring the option. Developments in Vermont appear the furthest along: A bill passed by the Vermont legislature in 2023 allows electric utilities to provide incentives for purchasing electric vehicles with an emphasis on individuals using more than 1,000 gallons of gasoline or diesel per year (Giles, 2023). Burlington Electric Department is designing a program targeted at super-users with the intention to launch the incentives in 2024. California is considering similar bills, but programs are not yet under development (Zero-Emission Vehicle Incentive Programs, 2023). The Washington State Legislative Committee proposes several approaches to encourage super-users to switch to EVs (Joint Transportation Committee, 2023). These include a scrappage incentive program whose value is determined by the amount of fuel consumption displaced. Although greater annual mileage can improve the value proposition of owning an electric vehicle more than lower annual mileage (International Energy Agency, 2022; Basma et al., 2023), reducing the upfront cost of purchasing these vehicles could still further accelerate uptake in this group.

The demographics of super-users vary across jurisdictions, meaning that incentive policies designed to reduce the use of fossil fuel may or may not promote more equitable adoption of ZEVs. In California, for example, super-users skew slightly lower income than average for drivers at large, while in the state of Washington, the highest gasoline-using drivers are higher income than average (London et al., 2023; Joint Transportation Committee, 2023). Encouraging super-users to adopt EVs, therefore, requires understanding the specific barriers to purchasing an EV, which may not necessarily be related to cost. Indeed, other barriers like the lack of charging infrastructure or limitations in model availability and range may be equally or more important than the upfront cost. For example, the Washington State study found that super-users are not less knowledgeable about

EVs than other drivers but are concerned that the electric versions of the preferred vehicle models do not perform as well as their conventional counterparts for uses like towing or hauling (Joint Transportation Committee, 2023). This indicates areas for additional research and targeted policy to overcome barriers to switching to ZEVs for high-energy-consumption applications.

Taxis and car-sharing fleets. Taxis and car-sharing fleets tend to have high annual mileage and fuel consumption. These vehicles also typically operate in urban areas where health concerns from air quality may be especially critical. Furthermore, because such vehicles carry many passengers every day, introduction of ZEVs into these fleets has the potential to expose many more people to ZEV technology. For these reasons, several governments have targeted incentives for taxis, in some cases alongside regulations requiring faster ZEV uptake.

There are numerous examples of incentives for zero-emission taxis at the national, regional, and city levels. The UK government, despite ending the plug-in car grant applicable to all zero-emission cars, offers incentives of up to £7,500 or 20% of the vehicle's purchase price (whichever is lower) for the purchase of a new wheelchair-accessible zero-emission taxi (United Kingdom Government, n.d.-b). The state of Baden-Württemberg, Germany, offers incentives of €3,000 for electric taxis and car-sharing vehicles (Baden-Württemberg Ministry of Transport, 2023). Austria offers incentives of €2,000 for ZEVs used in social institutions, driving schools, and car sharing, as well as taxis (Austria, Climate and Energy Fund, 2023a). In Scotland, interest-free loans are provided to drivers or companies for the purchase of electric taxis or private-hire vehicles ("Switched on taxis loan," n.d.). Several cities like Hamburg, Germany, and Amsterdam in the Netherlands, initially provided incentives for electric taxis, which have been phased out as the market has grown.

Individual zero-emission car-sharing programs have also received government support. The BlueLA system with 100 BEVs operating in Los Angeles, California, received funding from California's cap and trade system (Shared-Use Mobility Center, 2019). In Canada, car-sharing companies may receive incentives for up to 50 vehicles per year under the iZEV program, compared to 10 vehicles for other types of companies (Transport Canada, 2023a).

In some markets, ride-hailing services—also known as transportation network companies or private-hire vehicles—fill a similar role to taxis and could be incentivized under the same logic. However, dedicated government incentive programs for ride-hailing vehicles are not common as of early 2024. These services are subject to less regulation than taxis. Vehicles may also be used for personal use, making incentives harder to administer and evaluate.

Scrappage. Older vehicles tend to be less fuel efficient and have higher air pollutant emissions due to less sophisticated emissions control technologies. A study of vehicles in two U.S. states found that the oldest 11% of vehicles accounted for 50% of total light-duty nitrogen monoxide pollution (Bernard et al., 2020). Replacing these oldest vehicles with ZEVs would, therefore, provide far greater benefits in terms of pollution. For this reason, many governments offer additional incentives for the purchase of a ZEV when scrapping an older, heavily polluting vehicle.

Since lower-income drivers are more likely to drive older cars, incentives paired with scrappage also provide equity benefits. For example, California's Clean Cars 4 All program offers up to $9,500 for low-income drivers who turn in an old car and purchase a new ZEV. The program was originally available only in specific districts with high air pollution but is being expanded statewide following early program success (California Air Resources Board, 2023). These programs have also been offered for medium- and heavy-duty vehicles, which tend to have disproportionate air quality

impacts. In New Jersey, the Zero Emission Incentive Program can offer a grant of up to $175,000 for a new zero-emission truck with the scrappage of a model year 2009 or older vehicle (New Jersey Economic Development Authority, n.d.). Eligible applicants include businesses and government agencies; a bonus is offered for applicants located in disadvantaged communities.

Table 2 summarizes a selection of programs providing ZEV incentives for those scrapping older vehicles. These programs vary widely in scope, with some attaching additional eligibility requirements.

Table 2 Examples of ZEV incentive programs with bonuses for scrapping old vehicles

Jurisdiction	Vehicle categories	Eligibility criteria	Value	Source
California – Clean Cars 4 All	Passenger cars	Income restriction; resident of air pollution control districts	up to $12,000	California Air Resources Board (2023)
Greece – Green Taxis	Taxis	Vehicles with Euro 5 or older emission standards	€5,000	Government of Greece (n.d.).
Italy – Ecobonus	Passenger cars	Income restriction; car emission level restrictions	Up to €7,500	Italy, Ministry of Business and Made in Italy (n.d.)
New Jersey – Zero Emission Incentive Program	Medium- and heavy-duty trucks	Scrappage mandatory if vehicle replaced is model year 2009 or earlier	Up to $175,000	New Jersey Economic Development Authority (n.d.)
New York City – Clean Trucks Program	Medium- and heavy-duty trucks	Must be located in or near Industrial Business Zone	$55,000–$185,000	New York City Department of Transportation (n.d.)
New York State – Voucher Incentive Program	Heavy-duty trucks	Only new Class 4–8 battery and fuel cell trucks can be purchased	Up to $220,000	New York City Department of Transportation (n.d.)
Vermont – Replace Your Ride	Passenger cars	Income restriction	Up to $5,000 for a new or used vehicle	Vermont, Agency of Transportation (n.d.)

Although scrappage programs have been widely implemented and studied for air quality and economic impacts, there is less research on their effectiveness in driving increased ZEV sales. A 2022 modeling analysis focused on the United States suggests that tying a purchase incentive to a requirement to scrap an older gasoline car would reduce the number of drivers taking advantage of the incentive; specifically, an incentive of $5,000 without a scrappage requirement would see the same number of induced EV sales as an incentive of $13,000 with a scrappage requirement (Ankney & Leard, 2022). This may serve as an effective tool for reducing the number of incentives distributed over time, along with the associated cost, while accelerating the retirement of the existing combustion engine fleet, but it entails a trade-off in terms of boosting EV sales more generally.

Carbon footprint incentive. A few governments are tailoring their incentive programs toward electric vehicles with the lowest carbon footprint. In Germany, as of January 2023, PHEVs are no longer eligible for the Environmental Bonus due to their larger greenhouse gas emissions when

operating compared to battery electric or fuel cell vehicles (Germany, Federal Government, 2022). The Clever Fueren (Drive Smart) incentive program in Luxembourg is linked to energy consumption. For individuals, the program provides an incentive of up to €8,000 for a passenger electric car purchased or leased by December 31, 2024, with electricity consumption of less than 180 Wh/km. To accommodate large families, individuals who are part of a household of at least five people can purchase a larger vehicle and still qualify for the full €8,000 value. The full €8,000 value can also be received for the purchase or lease of a new electric car with energy consumption not exceeding 200 Wh/km and maximum net propulsion power not exceeding 150 kW. If any of the criteria described above are not met, the incentive is reduced to €3,000 (Government of Luxembourg, 2022).

France offers the bonus écologique (ecological bonus) incentive for vehicles that meet a minimum environmental score, which is assessed through four criteria: production, assembly, battery type, and transport and logistics. For 2024, the incentive effectively sets a requirement that the production carbon footprint be below 14.75 tonnes (Mathieu, 2023). The government estimated that this measure could reduce France's carbon footprint by an average of 800,000 CO_2-equivalent tons per year (France, Ministry of Economics and Finance, 2023b). As of late 2023, the Italian government is studying a similar structure for its EV incentive program (Fonte & Guillaume, 2023).

Incentives can also be used to encourage the purchase of electric vehicles and fueling with renewable energy. In Austria, all incentives are available only to consumers or fleets that charge or refuel their ZEV with electricity or hydrogen certified as renewable. To enforce this requirement, private consumers must submit a Confirmation of Electricity Use from Renewable Energy Sources from a certified provider, their home electric utility, or from a charging station that supplies 100% renewable energy. Similarly, companies, local authorities, and associations must submit proof of their use of a certified renewable energy supplier, a contract for charging authorization if the charging event occurs mostly in public charge points, or an invoice if the electricity is produced by an owned asset, such as wind turbines or solar panels (Austria, Climate and Energy Fund, 2023a; Austria, Climate and Energy Fund, 2023b).

Incentives for advancing social and equity goals

As with many new technologies, early ZEV uptake has not been consistent across populations. Data from multiple markets, including Germany, California, and the United Kingdom, indicate that those purchasing ZEVs generally tend to have higher incomes and education levels than other new-car buyers (Wappelhorst et al., 2023; ICF, 2022). Limiting access to the benefits offered by ZEVs—in terms of local air quality and operation costs—may perpetuate the inequalities existing in the transportation system for lower-income and disadvantaged communities (American Lung Association, 2023; McCormack, 2023). For these reasons, governments have created incentive programs specifically designed to make ZEVs more accessible and affordable to certain segments of the population underrepresented in the early stages of the ZEV transition.

Lower-income consumers. Despite the potential for savings on fuel, maintenance, and total cost of ownership, the current higher purchase price of ZEVs often makes them inaccessible for lower-income drivers. As a result, governments are increasingly conditioning eligibility for incentives on income. Several U.S. states offer supplemental rebates for lower-income buyers, including Pennsylvania ($3,000 for lower-income buyers versus $2,000 generally) and Oregon ($7,500 versus $2,500, pending additional funding for 2024) (Pennsylvania Department of Environmental Protection, n.d.-b; Oregon, Department of Environmental Quality, n.d.). The California Clean Vehicle Assistance Program provides an incentive of up to $7,500 USD for a BEV or fuel cell electric vehicle

and $7,000 for a PHEV for households with less than or equal to 300% of the U.S. federal poverty level ("Helping individuals access affordable clean vehicles," n.d.). France provides an additional incentive for lower-income purchasers of new ZEVs—up to €7,000 compared to €5,000 for those with higher incomes—although the maximum incentive is capped at 27% of a vehicle's purchase price, making it less valuable for more affordable models (Wappelhorst et al., 2023).

Although evaluation is ongoing, California's experience offers some evidence that targeted incentives can influence the demographics of the ZEV market. In 2017, California began offering an increased rebate through the Clean Vehicle Rebate Program for low-income ZEV purchasers. From 2017 to 2020, the share of new ZEV buyers with household incomes under $100,000 who received the incentive increased from 27% to 34% (as compared to 44% for new car buyers in California broadly), showing that the ZEV market is broadening in terms of income (Williams, 2023). Those receiving the increased rebate under the program had lower incomes, were less likely to be White, and were less likely to own their home than new car buyers in California on average. This indicates that the early incentive modifications intended to expand the market and reach new consumers appear to be effective.

Actions to achieve equity goals can also be considered by jurisdictions that have a carbon tax or emission trading scheme. These mechanisms aim to decouple economic growth from greenhouse gas emissions either by placing a tax on any products or services that produce greenhouse gas emissions or by placing a cap on the amount of emissions within the jurisdiction. In the transport sector, for example, these mechanisms will increase the price of gasoline or diesel, which will disproportionally impact lower-income drivers who spend a higher share of their income on vehicle-related costs like fuel (Bauer et al., 2021). In jurisdictions with emissions trading schemes (like in the EU), the cost of fossil-fuel-based energy for transport will increase and, therefore, add a financial burden on lower-income populations. To mitigate this effect, there are ongoing discussions about using the proceeds of such a program to fund a "climate premium" that would help lower-income drivers transition toward cleaner technologies. The climate premium could take the form of grants that enable low-income drivers to afford clean vehicles and, therefore, be less subject to the higher cost of diesel (Germany's Federal Ministry for Economic Affairs and Climate Action, consultations, 2023).

Incentives for used ZEVs. Another important consideration for lower- and middle-income consumers is the used ZEV market, which provides opportunities for more affordable ZEVs due to their faster depreciation rates compared to conventional vehicles (Tankou et al. 2021). Nonetheless, some used ZEVs could still present a cost premium over similar used combustion engine vehicles and, therefore, may not be affordable for lower-income purchasers in the near term. To make ZEVs more accessible for drivers who may otherwise only be able to afford used combustion engine vehicles, some governments provide incentives for ZEVs purchased on the second-hand market. These incentives do not directly accelerate the transition of the on-road vehicle fleet to zero emissions because these vehicles have already entered circulation; however, such programs may indirectly increase interest in purchasing new ZEVs by providing security regarding the residual value of the vehicles.

Table 3 presents an overview of incentive programs for second-hand light-duty ZEVs across IZEVA jurisdictions. These incentives are categorized according to their mode of distribution, their value for BEVs and PHEVs, and whether they include restrictions on the age and mileage of the vehicle. The table also indicates whether the programs allow double counting, i.e., whether a ZEV that came with incentives for its initial purchase may also be the subject of incentives for subsequent purchases.

Table 3 Overview of used ZEV rebate and grant programs across IZEVA jurisdictions

Jurisdiction and program	Type of incentive	Used BEV	Used PHEV	Vehicle age restriction	Usable at point of sale	Lease option	Allows double counting
California – Clean Vehicle Assistance Program	Grant	Up to $7,000	Up to $7,000	**No**	**Yes**	**Yes**	**Yes**
Connecticut – CHEAPR	Rebate	Up $3,000	Up to $1,125	**No**	**Yes**	**Yes**	**Yes**
Costa Rica – Law No. 9518	Tax exemption	Full tax exemption for BEVs less than US$30,000	Not eligible	Less than 5 years old	**Yes**	**No**	**Yes**
Massachusetts – MOR-EV	Rebate	$3,500	Not eligible	**No**	**Yes**	**Yes**	**No**
Netherlands – SEPP	Rebate	$2,000	Not eligible	**No**	**Yes**	**Yes**	**Yes**
New Jersey – Sales and Use Tax Act	Sales tax exemption	BEV discounted at 6.625%	Not eligible	**No**	**Yes**	**Yes**	**Yes**
Oregon – Charge Ahead Rebates	Rebate	$5,000	$5,000	**No**	**Yes**	**Yes**	**Yes**
Rhode Island – DRIVE	Rebate	$1,000	$750	**No**	**Yes**	**Yes**	**Yes**
Québec – Roulez Vert	Rebate	CA$3,500	Not eligible	1 to 4 years old	**Yes**	**No**	**No**
Washington	Excise tax credit incentive	up to $16,000		**No**	**Yes**	**Yes**	**Yes**

Sources: "Helping individuals access clean affordable vehicles" (n.d.); Connecticut Department of Energy and Environmental Protection (n.d-a); Ley No. 9518 (2018); Germany, Ministry for Economy and Climate Protection (n.d.); Massachusetts Department of Energy Resources & Center for Sustainable Energy (n.d.-b); Netherlands Enterprise Agency (n.d.-b); "Save money on your EV and charger," (n.d.); Oregon, Department of Environmental Quality, (n.d.); Rhode Island, Office of Energy Resources (n.d.); Government of Québec (n.d.); Washington, State Department of Revenue (n.d.)

Table 3 shows that just under half of the governments within the International ZEV Alliance offer incentives for used EVs. These incentives typically apply to both BEVs and PHEVs and offer values ranging from $1,500 to $7,000. It is also worth noting that, in most cases, the used EV incentive can be applied to a lease. This could be particularly advantageous for lower- to middle-income consumers by allowing them lower monthly payments when compared to a scenario where the EV is purchased (Barry, 2023). In jurisdictions such as Costa Rica, Germany, and Pennsylvania, only used EVs of a certain age or mileage qualify for the incentive. A few jurisdictions, including Germany, Massachusetts, and Québec, do not allow double counting. This means that if the buyer of

a new EV received an incentive, the vehicle will not qualify for the used EV incentive program when it is sold again. While allowing double-counting could lead to greater government expenditures, it could help bring the upfront cost of used ZEVs to parity with similar combustion engine vehicles more quickly and, therefore, make these vehicles a more appealing option for lower-income buyers. It could also make the programs simpler to navigate by making more second-hand ZEVs eligible for the incentive.

Pollution-burdened areas. Some communities are disproportionately exposed to air pollution, among other environmental concerns. In the United States, governments refer to these communities through different interpellations, including disadvantaged, overburdened, or environmental justice areas, and they also typically experience limited access to social and economic opportunities. To reduce air pollution exposure within these communities, some jurisdictions provide enhanced incentives to encourage fleets to purchase medium- and heavy-duty ZEVs. In New York, for example, the Truck Voucher Electric Program provides a maximum voucher value of $220,000 for battery electric school buses located within 0.5 miles (approximately 1 kilometer) of a designated disadvantaged community area (New York State Energy Research and Development Authority, n.d.-a). In Massachusetts, the MOR-EV Trucks program provides a voucher of up to $90,000 for class 8 trucks, and an additional value of 10% can be granted if the vehicle operates more than 50% of the time within an environmental justice area (Massachusetts Department of Energy Resources & Center for Sustainable Energy, n.d.-b).

Small, independent commercial fleets. Small commercial business fleets with fewer financial resources compared to larger fleets are less able to participate in the ZEV transition without financial support (Gurman, 2021). A survey conducted in 2022, focusing on fleets operating 25 or fewer trucks in the United States and Canada, identified the total cost of ownership, insufficient government support, and upfront cost as key barriers to purchasing a zero-emission truck (Brito, 2022).

A small but growing number of jurisdictions are addressing the concerns of small fleets through their incentive programs for zero-emission medium- and heavy-duty vehicles. This includes the AanZET program in the Netherlands, which offers enhanced incentives for purchasing a van, small truck, or tractor-trailer for small fleets (Netherlands Enterprise Agency, 2023). For tractor-trailers, for example, small fleets can receive an incentive of €131,900, which is 81% higher than the amount offered for larger fleets (€72,700). Other IZEVA jurisdictions that have considered a similar approach include California, where small fleets can receive double the incentive that larger fleets qualify for, and New Jersey, where small fleets receive a 25% increase above the standard voucher value (California Air Resources Board, n.d.-a); New Jersey Economic Development Authority, n.d.).

Other financial instruments are also being deployed to further accommodate small commercial fleets. In California, for example, the Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project includes the Innovation of a Small e-Fleet (ISEF) program, which proposes solutions such as flexible leases, short-term rentals, or truck-as-a-service to fleets with 20 or fewer trucks (California Air Resources Board, 2022b).

Incentive design and targeted approaches in ZEV Alliance jurisdictions

As the economics of the ZEV transition evolve, governments have instituted a range of incentive programs that consider budgetary constraints and local priorities. The 22 national and state governments of the International ZEV Alliance have used a sustained mix of policy programs to grow their ZEV markets. These policies represent a snapshot of incentives offered as of the start of 2024 in jurisdictions with ZEV sales near or above the global average.

Table A1 in the appendix catalogs the incentive policies for light-duty ZEVs in the ZEV Alliance jurisdictions, including the types of eligibility restrictions (e.g., income limit or vehicle price cap) and targeted programs (e.g., scrappage bonuses) available in these markets. As of the start of 2024, 21 out of 22 IZEVA jurisdictions offered financial incentives for private zero-emission passenger cars purchased by a typical middle-income buyer. Most of these programs take the form of grants or rebates, ranging from $1,500 USD to $5,000 USD per EV. Some jurisdictions administer incentives through tax exemptions, which can provide a strong incentive to purchase a ZEV rather than a combustion vehicle.

Although not a comprehensive global assessment, this review of light-duty incentive programs in 22 leading governments provides some insights into the prevalence of different specialized incentives. Seven jurisdictions offer enhanced incentives for lower-income consumers, six have incentives for taxi fleets, three have scrappage programs, and four have an income-cap eligibility requirement. To manage public financial resources more effectively and make incentive programs more durable, the majority of the governments studied have set a price cap for eligible vehicles ranging from $40,000 to $70,000 USD. Austria is the only jurisdiction studied that proposes a carbon footprint-based incentive (as described earlier in this report). As of the end of 2023, Germany, Maryland, Massachusetts, and New Jersey have excluded PHEVs from their programs. Germany made this decision based on evidence of higher real-world emissions from PHEVs (Germany, Federal Government, 2022). In addition to private cars, businesses are typically eligible for light-duty ZEV incentives in the programs studied.

Table 4 provides examples of several incentive design features incorporated in light-duty incentive programs in ZEV Alliance jurisdictions. These include eligibility restrictions for incentives; bonuses for priority groups; and tax incentives for vehicle purchase, ownership, and corporate use. The incentive programs listed were selected to illustrate possible design options and are not meant to identify policies as the best example within their category.

Table 4 Examples of incentive design features implemented by International ZEV Alliance governments

Category	Incentive characteristic	Government	Description	Reference
Eligibility restriction	Vehicle price cap	Canada	Base model must be under CA$55,000 for cars and $60,000 for pickup trucks, vans, and SUVs; trims of up to $10,000 above these limits allowed	Transport Canada (n.d-c.)
	Income limits	British Columbia (Canada)	Full incentive available for individuals with income below CA$80,000; no incentive available for individuals with income above $100,000	BC Hydro. (n.d.)
	Renewable energy requirement	Austria	To receive €5,000 incentive, purchasers must certify that they have a contract for 100% renewable electricity to charge the vehicle	Austria, Climate and Energy Fund (2023a)
Priority groups	Disadvantaged community bonus	Connecticut	Extra $2,000 for ZEV purchased by low-income resident or resident of an environmental justice community	Connecticut Department of Energy and Environmental Protection (n.d.-b)
	Higher incentive for priority fleet	Baden-Württemberg (Germany)	€3,000 for ZEV purchased for taxi or car-sharing fleet	Baden-Württemberg Ministry of Transport (2023)
		Canada	Car-sharing fleets may claim up to 50 incentives annually, as opposed to 10 for other businesses	Transport Canada (n.d.-c)
Tax incentive	Purchase tax discount	Norway	ZEVs pay 25% value-added tax only on share of price above NOK 500,000 (US$47,000); previously exempted from all VAT until 2022	Norwegian EV Association (2023)
	Operation tax discount	Chile	ZEVs pay no annual circulation tax for first 2 years, 75% discount for years 3–4, and 25% discount for years 5–6 after purchase	Ley Núm 21505 (2022)
	Company car benefit	United Kingdom	ZEVs and long-range PHEVs pay 2% benefit-in-kind tax; ICE cars pay 15%–37%	United Kingdom Government (n.d.-b)

Principles for adapting incentives over time

As this review of incentives in leading markets demonstrates, governments have frequently changed the value of incentives as well as the eligibility criteria in response to market conditions and financial pressures. Policymakers making such changes typically seek to balance the needs of a dynamic market within a limited budget while avoiding creating confusion for consumers. This section offers strategies for adapting incentives in a predictable and evidence-based way, building on recent research and observed best practices, which can be applied to light-duty and medium- and heavy-duty ZEV incentive programs. These include aligning incentive values to the premium in ZEV cost, using bonus-malus systems to make programs revenue-neutral, and connecting incentive phase-out timelines to ZEV targets and regulations. These principles can be applied together or separately and can be tailored to different jurisdictions' vehicle markets and taxation systems.

Alignment with ZEV price premium

Continued improvements in battery and electric vehicle technologies, along with reduced prices, lead to key questions about how quickly EVs will reach upfront price parity with conventional vehicles and about the optimal timing and design by which financial incentives can be phased down. At the same time, as EV volumes proliferate, governments may face questions about when incentive programs become too costly and how long they are needed to sustain market growth.

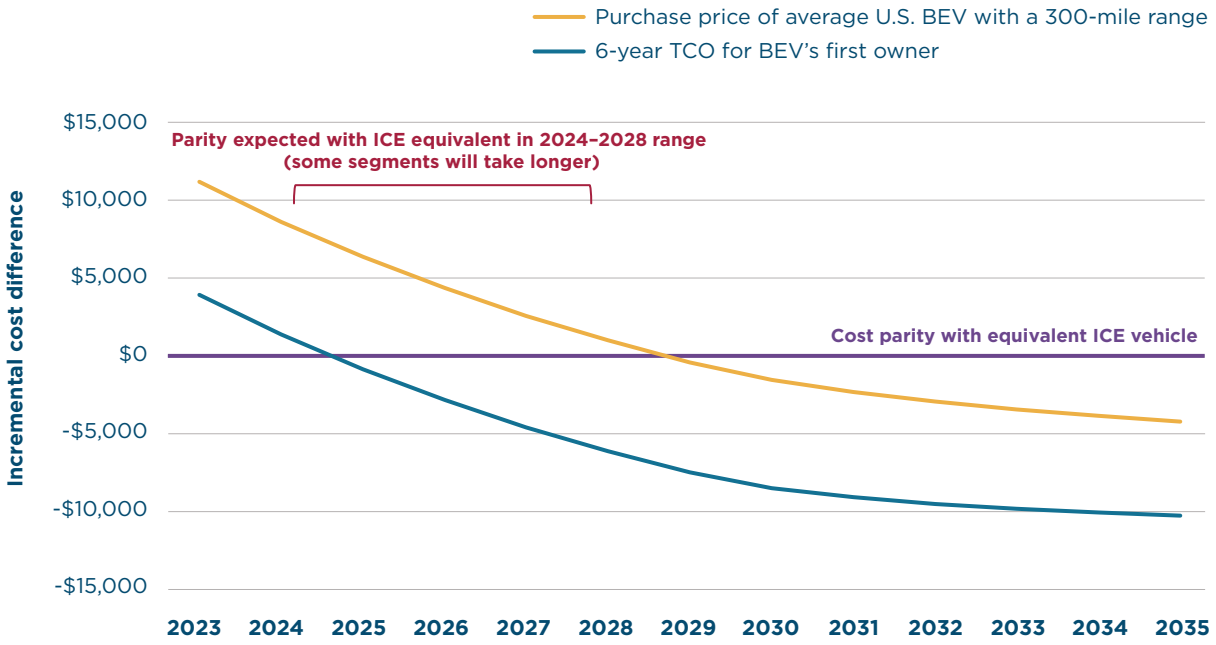
Because purchase incentives work to overcome the higher upfront cost of EVs, a detailed analysis of the expected timing of purchase price parity can potentially inform government decision-making for their incentive programs. In addition, analyzing the relative electric and conventional vehicle operating costs for first owners is also important to understanding the value proposition for prospective electric vehicle buyers. In this paper, total cost of ownership (TCO) is used to denote all costs for the first owner of a new vehicle (including purchase and financing, fueling or charging, maintenance, and relevant infrastructure) over 6 years for light-duty vehicles and 5 years for heavy-duty vehicles; it does not represent costs over the entire lifetime of the vehicle.

Light-duty ZEVs

A 2022 ICCT study analyzed average BEV, PHEV, and conventional vehicle prices in the United States for cars, crossovers, SUVs, and pickup trucks from 2022 through 2035 (Slowik et al., 2022). The first-owner TCO assessment considered a 6-year ownership period and included fuel and maintenance costs, taxes, and costs for home charging equipment for EVs. Based on a detailed bottom-up vehicle component-level cost analysis, the study found that purchase price parity will be achieved before 2030 for BEVs with up to 300 miles of range in all light-duty vehicle classes and that first-owner 6-year cost of ownership parity is reached several years before initial upfront purchase price parity.

Figure 2 shows the average incremental upfront and ownership costs for average new 300-mile range BEVs compared to their combustion counterparts, based on Slowik et al. (2022). The average BEV values represent a new sales mix of cars (27%), crossovers (35%), SUVs (23%), and pickup trucks (15%) that is consistent with the share of new U.S. light-duty vehicle sales of model year 2020. The figure shows new 300-mile range BEV cost parity with combustion engine counterparts is expected around 2024 based on a 6-year TCO, while cost parity for the initial upfront purchase price is expected around 2028. Not shown: 300-mile range electric cars and crossovers are projected to reach price parity 1 year earlier than the average results shown here, while 300-mile range pickup trucks are modeled to reach upfront price parity about 1 year later (see Slowik et al., 2022). Also not shown: shorter-range 200-mile BEVs are projected to reach price parity about 2 years sooner than 300-mile range BEVs, while 400-mile BEVs tend to reach parity about 2 years later.

Figure 2 Incremental cost difference for purchasing and owning a BEV in the United States versus an equivalent combustion engine vehicle



Falling battery and electric vehicle costs and the prospect of upfront price parity provide governments an opportunity to consider reducing or phasing out purchase incentives. Although there are other market barriers to widespread electric vehicle uptake, achieving cost competitiveness on a first-owner or upfront purchase-price basis means that incentives are no longer needed to tip the consumer economic value proposition in favor of EVs.

As they balance competing financial and political objectives, some governments may align their programs with parity on a first-owner total cost of ownership basis, while others on an initial upfront purchase price basis. Though not extensive, research in the United States and Europe identified a tendency for consumers to not sufficiently consider future fuel costs when choosing a new vehicle (Gillingham et al., 2019; Nicolle, 2022; National Academies of Sciences, Engineering, and Medicine, 2021). This suggests that timelines to phase down incentives would ideally be extended to align with purchase price parity, rather than total cost of ownership, to steer purchase decisions for consumers that undervalue fuel savings.

Heavy-duty ZEVs

Medium- and heavy-duty ZEVs are subject to similar dynamics in terms of upfront cost and TCO, although these markets are at a much earlier stage, particularly for the largest truck segments. In contrast to light-duty vehicles, where BEVs are the dominant zero-emissions technology, there are still multiple technology pathways in play for heavy-duty ZEVs, which may see cost parity at different points for different applications.

Basma and Rodríguez (2023) assessed vehicle cost trends and TCO for heavy-duty vehicles in Europe. The study looked at applications ranging from medium-duty urban delivery to long-haul cross-border tractor-trailer trucks and considered eight powertrain/fuel options: diesel, e-diesel, battery electric, hydrogen fuel cell, hydrogen ICE, hydrogen-diesel dual fuel ICE, hydrotreated vegetable oil biofuel, and biogas. For alternative fuel vehicles, the TCO also includes capital costs associated with charging or refueling infrastructure, which are amortized into the fuel costs.

Figure 3 shows the projected 5-year first-owner total cost of ownership (left) and purchase price (right) for zero-emission tractor-trailer trucks traveling up to 1,000 km per day, relative to the diesel equivalent, for new trucks of model years 2023 to 2035. Three different technologies with zero tailpipe CO_2 emissions are shown: battery electric, hydrogen fuel cell, and hydrogen internal combustion engine. The results show the average costs across Europe; the TCO in some regions will be higher or lower than this average depending on fuel costs and driving patterns. Previous analysis suggests that TCO parity for battery electric trucks, without incentives, will take place 4 to 5 years later in the countries with the most challenging TCO case (Germany and Italy) than the countries with the best TCO case (Netherlands and France) within Europe (Basma et al., 2021).

Figure 3 Incremental cost difference for purchasing and owning a ZEV tractor-trailer in Europe versus an equivalent diesel truck

This research illustrates that the cost differential for zero-emission trucks is more complex than for cars, owing to the greater variety in segments, use cases, and technology options. However, in broad terms, TCO and upfront cost parity is expected to take place later for heavy-duty than for light-duty vehicles. Battery electric long-haul trucks in Europe are expected to reach TCO parity with diesel around 2026 on average but will not see upfront cost parity until after 2035. Hydrogen fuel cell trucks are expected to reach TCO parity in about 2035, assuming a sharp reduction in the retail price of hydrogen fuel, whereas hydrogen ICE trucks are not expected to reach TCO or upfront price parity prior to 2035.

The long-haul tractor-trailer trucks depicted in Figure 3 are among the most challenging segments to transition to ZEVs in terms of upfront and running costs; most other commercial truck segments will be less costly to shift to zero emissions. Basma and Rodriguez (2023) indicate that light-, medium-, and heavy-duty regional battery electric trucks with a maximum daily driving distance of 300 km had a lower average 5-year TCO than diesel in 2023. Heavy-duty trucks with a maximum daily range of 500 km are projected to achieve TCO parity several years earlier than the case shown in Figure 3. Particularly when considering the disproportionate emissions contributions of the largest truck segments, this suggests that incentives would be sustained for long-haul tractor-trailers for a longer time than for shorter-range light- and medium-duty trucks and vans. Some niche vocational vehicles, such as for construction and industry, may also take longer to become cost-competitive due to their unique power needs and low scale of production; these vehicles could be candidates for more sustained funding. Governments may choose to apply a similar logic for light-duty vehicles and maintain subsidies for larger and longer-range vehicles that reach cost parity later.

Funding incentives sustainably with polluter-pays principle

Bonus-malus programs, also referred to as feebates, enable fund programs to be managed in a fiscally neutral way while also discouraging purchases of inefficient, polluting vehicles. Such programs operate by imposing a fee (or malus) on new vehicles proportionate to their CO_2 emissions, which generates revenue to support an incentive (bonus) for purchasing or leasing low- or zero-emission vehicles. The fee placed on conventional vehicles creates a disincentive for purchasing conventional vehicles, while the bonus makes ZEVs more affordable and attractive. Feebate programs can be designed to be financially self-sustaining, with no net impact on public finances, or revenue-generating, although the bonus and malus amounts and thresholds may have to be adjusted on a regular basis. In 2023, such mechanisms were in operation in France, New Zealand (since discontinued), Sweden, and Singapore (Wappelhorst, 2022).

Because bonus-malus programs provide their own revenue source, they may be better insulated from short-term budgetary pressures and provide stability for the mid-term transition to ZEVs. This could help jurisdictions meet longer-term ZEV targets in the 2030s, at which point light-duty EVs will likely have upfront cost parity. A feebate would also allow for ongoing stimulation of the EV market beyond the point of cost parity to ensure that ZEV targets are met.

There are other options for funding ZEV incentives through polluter-pays mechanisms. For example, the low-carbon fuel standard in California provides credits for low-carbon fuels, including electricity used for ZEVs, which can be sold on a marketplace. Four utilities in California used the revenue generated from these credits to provide incentives for ZEVs, including for purchases of used ZEVs and drayage trucks, and for help financing truck purchases for small fleets (California Public Utilities Commission, n.d.). Incentives could also be funded by carbon taxes or cap-and-trade programs in jurisdictions where they exist. Because ownership costs are an important factor in vehicle purchase decisions, particularly within the heavy-duty sector, carbon taxes or fees targeted toward the most polluting vehicles could have a positive influence on ZEV uptake, regardless of whether the

revenues generated are invested in ZEV incentive programs. Imposing additional costs without offering a bonus for ZEVs could be more politically challenging and potentially be regressive, particularly for drivers and businesses that rely on vehicles and have limited access to capital, suggesting a complementary role for targeted financial support programs.

Tolling programs that charge higher rates for ICE vehicles and low- or zero-emission zones in cities could act as an ongoing incentive for ZEV drivers while also generating revenues that could fund other ZEV programs. However, such programs may burden low-income drivers, suggesting that these revenues could be used to promote broader access to lower-cost ZEVs, particularly for disadvantaged communities and small fleets.

Connecting incentives to regulations to limit expenditures

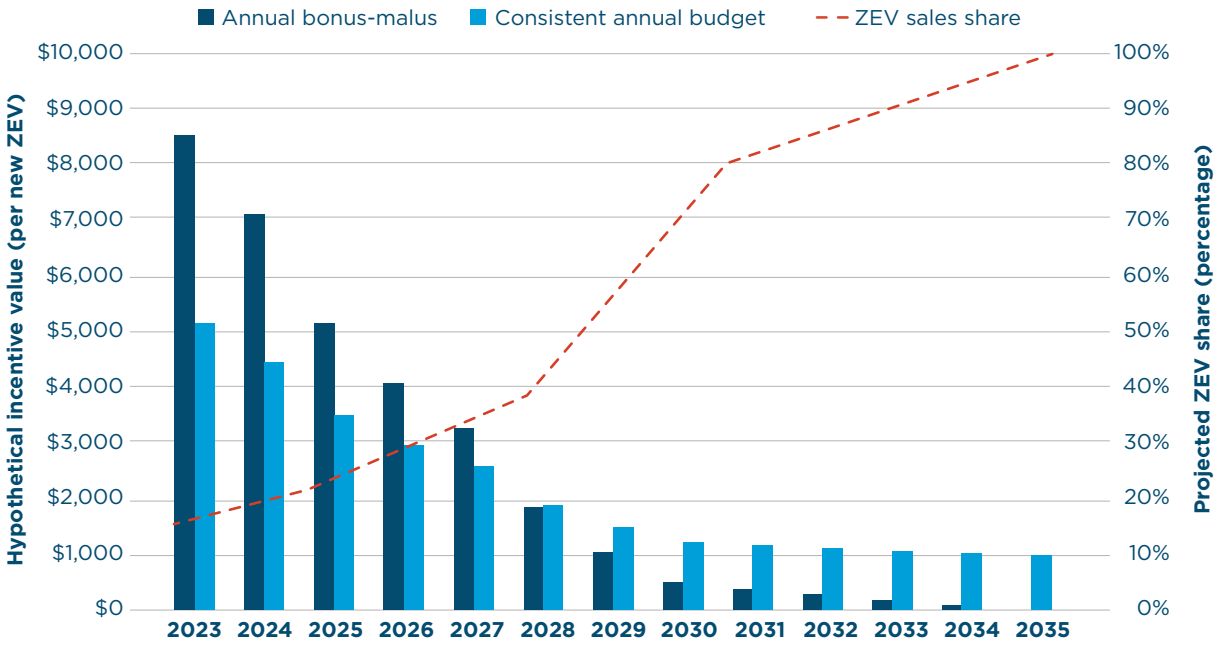
In addition to using incentives as efficiently as possible, governments are also motivated to keep incentive program budgets consistent and predictable. This is a challenge in early market stages when ZEV uptake can grow rapidly from a low baseline; incentive program funding has been exhausted earlier than expected. However, as the ZEV market has matured, many governments have set annual benchmarks or binding regulations for ZEV sales. This represents a different paradigm for the economics of the ZEV transition and the planning of complementary policies.

It remains to be seen if or how newly introduced sales regulations may impact pricing as manufacturers continue to increase supply, particularly when elevated interest rates impact the overall affordability of EVs. There is some evidence that ZEV regulations support economies of scale that help bring down the costs of batteries and other ZEV components, resulting in savings for consumers and a cycle of market growth (Slowik et al., 2022). On the other hand, it is possible that individual manufacturers may struggle to meet targets in a jurisdiction and thus choose to reduce overall vehicle sales and increase prices to compensate, leading to higher prices for specific models in the near term. Regardless of these dynamics, the greater predictability in ZEV market development afforded by such regulations can help in forecasting and planning overall incentive expenditures while also providing additional support for the early market.

Figure 4 provides an example of how incentive values could be gradually reduced in alignment with increasing ZEV sales shares in the United Kingdom. The targets in the United Kingdom's ZEV mandate for cars are used for this analysis as a proxy for the potential pace of ZEV uptake in a market committed to reaching 100% ZEV sales in 2035. For simplicity, this analysis also assumes that total new car sales remain constant over the 2023–2035 period.

Two scenarios are considered. The annual bonus-malus scenario assumes that incentives are funded through a bonus-malus model, where every non-ZEV sold would contribute US$2,000 to a fund that would be redistributed for ZEV incentives within that same year. Because the number of non-ZEVs sold each year declines, the bonus value per vehicle declines sharply in this scenario from over $8,500 in 2023 to $500 in 2030. The second scenario, a consistent annual budget, assumes the same total amount of funds as in the first scenario but these funds are allocated equally over each of the 13 years. The incentive per ZEV declines as the number of ZEVs sold each year increase. When compared to the bonus-malus scenario, this results in lower incentives in the earlier years ($5,100 in 2023) but higher in later years ($1,200 in 2030).

Figure 4 Example of two incentive-funding scenarios designed to reach a 100% ZEV sales share target



No jurisdictions have yet tied ZEV incentive values directly to sales requirements, but several jurisdictions have connected incentives to regulations and market milestones. New Zealand created its Clean Car Rebate bonus-malus scheme in 2022 alongside its Clean Car Standard CO_2 regulation. To ensure that the rebate scheme remained self-financing, the rebates and fees were regularly updated as the standards pushed emissions from new vehicles downward. In the July 2023 update, rebates for BEVs decreased from NZ$8,625 to NZ$7,015 while fees for highly polluting vehicles were increased (New Zealand Transport Agency, 2023). The bonus-malus system was canceled in late 2023 under a new government, although the Clean Car Standard remains in effect (New Zealand Transport Agency, 2023).

The government of the Netherlands aims for all new cars to be ZEVs by 2030. Each year, incentives can be modified depending on whether ZEV uptake is above or below the government's forecasts toward its 2030 target, as well as data on EV prices and technical specifications (Kok et al., 2022). In 2022, the following modifications to incentives were made: the maximum discount available for taxes on EVs registered to businesses was reduced, subsidy values for privately purchased ZEVs were gradually reduced over 2022 to 2024, and subsidies were set to phase out in 2025 rather than 2026. At the same time, the budget for private ZEV incentives was increased to enable more consumers to claim the incentive.

Such programs illustrate the potential to update incentives in line with changing market conditions to encourage consistent market growth and protect government budgets. However, making frequent adjustments can increase uncertainty for consumers and supply chains alike. This illustrates the benefit of pairing incentive design with binding annual sales requirements or purchase requirements for fleets, to provide confidence and stable market development.

Conclusions and recommendations

This research points to the following conclusions on the role of financial incentives in growing the light- and heavy-duty ZEV market over the coming decade.

In many markets with high ZEV sales shares, incentives for zero-emission cars are trending downward, while incentive programs for zero-emission trucks are expanding. As the light-duty ZEV market has grown, governments have adjusted their zero-emission car incentive programs with a general view toward gradually reducing incentive value, tightening eligibility, and targeting challenging segments. Leading markets like China, the United Kingdom, and California have ended or announced the end of some mainstream incentive programs. However, the pattern is not universal: for example, the United States has announced its intention to continue incentives until 2032. The heavy-duty market is at a much earlier stage, and most governments as of 2023 are creating and expanding their incentive programs with no stated timelines for their eventual phase-out.

For light-duty ZEVs, 6-year total cost of ownership parity is rapidly approaching, and upfront price parity is expected in the late 2020s, indicating a timeline for phasing down incentives for the mass market. Despite the uncertainty and short-term fluctuations triggered by high interest rates, supply chain issues, and the introduction of new regulations, ZEV prices continue to decline. Some segments of cars and vans are already cheaper to own and operate over a 6-year period due to their ongoing fuel and maintenance savings; remaining segments are expected to reach 6-year TCO parity in the mid-2020s. However, upfront price parity is expected somewhat later in the late 2020s as underlying technologies continue to improve. Evidence suggests that drivers tend to prioritize upfront price above running costs. Therefore, to encourage consistent market growth, incentives (potentially declining in value) could be sustained at least until TCO parity for the first owner is reached, and ideally until upfront price parity, where budgetary conditions allow.

Medium- and heavy-duty ZEVs are declining in cost, but diverse market needs and higher costs suggest that incentives may need to be more nuanced and put in place for longer. The variety of vehicle sizes and duty cycles means that the range of 5-year TCO parity for heavy-duty ZEVs will be wider than for light-duty ZEVs, and upfront price parity may not take place until well into the 2030s, particularly for the heaviest segments. However, because fleet operators are sensitive to ownership costs, it may be sensible to phase down incentives for medium- and heavy-duty ZEVs as first-owner TCO parity is reached, although costs for infrastructure, grid maintenance, and staff training should also be considered.

As broad incentives decline, governments may use more targeted programs to make the ZEV transition more equitable and maximize environmental benefits. Even as incentive programs are phased down for mainstream consumers, more targeted incentives with tightened eligibility criteria can shape the development of the ZEV market. For example, governments can offer incentives exclusively for low-income drivers, or for small fleets of commercial vehicles, to ensure that ZEVs and their benefits flow to those who were left out of the first phases of the ZEV transition. Governments may also design incentives to maximize the near-term environmental benefits of ZEVs, such as by directing ZEVs to high-mileage drivers and applications, or by offering incentives only for vehicles meeting specific sustainability criteria. Some provisions, like larger incentives with requirements to scrap older, polluting vehicles, may further both environmental and social goals.

Linking incentives to ZEV regulations or targets and using polluter-pays funding mechanisms can provide greater certainty for consumers, manufacturers, and governments. Incentive programs have been successful in boosting ZEV uptake, but limited government budgets and inconsistent availability of ZEVs have led to programs being frequently exhausted or modified. Designing ZEV incentive programs as a part of EV strategies, ideally alongside binding ZEV targets, can allow for greater predictability in incentive cost and durability. Linking incentives to targets could also enable governments to gradually reduce the value and tighten eligibility for incentives as the market expands, ensuring that limited funds are prioritized to high-priority groups when they are most needed.

While this work identifies important lessons on the design of financial incentives, it also points to opportunities for additional research relevant to the TCO for ZEVs. Beyond purchase price or depreciation, the TCO for BEVs is also influenced by the cost of charging and the capital cost of charging infrastructure. Further research could explore opportunities for policies to reduce these costs and could attempt to determine the relative benefit of subsidizing charging infrastructure compared to ZEVs. Furthermore, in the interim period between TCO parity and upfront cost parity with combustion engine vehicles, additional work is needed to evaluate scalable financing models and whether regulatory changes are needed to enable the widespread use of these models for increasing ZEVs in fleets. A similar analysis may be useful for informing policy around other vehicle segments not discussed in this report, like 2- and 3-wheelers and vocational vehicles.

Finally, making ZEVs cost-effective compared to conventional vehicles is necessary but not sufficient by itself to accomplish the ZEV transition at the pace required to meet climate targets. A complete ZEV transition also requires the availability of attractive ZEV models across many segments, brands, and applications; convenient charging infrastructure at homes, workplaces, and public settings; and awareness about ZEVs' benefits and capabilities. With the right mix of well-designed, predictable incentives, regulations, and complementary policies, a smooth and just ZEV transition and its myriad benefits remain within reach.

References

American Lung Association. (2023). *Driving to clean air: Health benefits of zero-emission cars and electricity.* https://www.lung.org/clean-air/electric-vehicle-report/driving-to-clean-air

Ankney, K., & Leard, B. (2022). *Should electric vehicle purchase subsidies be linked with scrappage requirements?* Resources for the Future. https://media.rff.org/documents/WP_22-13.pdf

Austria, Climate and Energy Fund. (2023a). *Leitfaden E-Mobilität für Betriebe, Gebietskörperschaften und Vereine – Jahresprogramm 2023.* [Guideline e-mobility for companies, local authorities and clubs – Annual program 2020]. https://www.klimafonds.gv.at/wp-content/uploads/sites/16/Leitfaden_EMob_Gewerbe_2023.pdf

Austria, Climate and Energy Fund. (2023b). *Leitfaden E-Mobilität für Private – Jahresprogramm 2023*. [Guideline e-mobility for private individuals – Annual program 2023]. https://www.klimafonds.gv.at/wp-content/uploads/sites/16/Leitfaden_EMob_Private_2023.pdf

Austria, Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology. (2022). *Klimafreundlicher Güterverkehr: Start der Förderungen für emissionsfreie Nutzfahrzeuge*. [Climate-friendly freight transport: Start of subsidies for emission-free commercial vehicles]. BMK Infothek. https://infothek.bmk.gv.at/klimafreundlicher-gueterverkehr-start-der-foerderungen-fuer-emissionsfreie-nutzfahrzeuge/

Baden-Württemberg Ministry of Transport. (2023). *Wir fördern ihre E-Fahrzeuge* [We promote your e-vehicles]. https://vm.baden-wuerttemberg.de/de/politik-zukunft/elektromobilitaet/foerderung-elektromobilitaet/e-fahrzeuge

Barry, K. (2023, September 1). Leasing an electric car may be a better deal even after Ford and Tesla price cuts. *Consumer Reports*. https://www.consumerreports.org/money/car-financing/why-leasing-an-electric-car-is-a-better-deal-a8470317219/

Basma, H., Buysse, C., Zhou, Y., & Rodríguez, F. (2023). *Total cost of ownership of alternative powertrain technologies for class 8 long-haul trucks in the United States.* International Council on Clean Transportation. https://theicct.org/publication/tco-alt-powertrain-long-haul-trucks-us-apr23/

Basma, H., & Rodríguez, F. (2023). *A total cost of ownership comparison of truck decarbonization pathways in Europe.* International Council on Clean Transportation. https://theicct.org/publication/total-cost-ownership-trucks-europe-nov23/

Basma, H., Saboori, A., & Felipe, R. (2021). Total cost of ownership for tractor-trailers in Europe: Battery electric versus diesel. International Council on Clean Transportation. https://theicct.org/publication/total-cost-of-ownership-for-tractor-trailers-in-europe-battery-electric-versus-diesel/

Bauer, G., Hsu, C.-W., & Lutsey, N. (2021). *When might lower-income drivers benefit from electric vehicles? Quantifying the economic equity implications of electric vehicle adoption.* International Council on Clean Transportation. https://theicct.org/publication/when-might-lower-income-drivers-benefit-from-electric-vehicles-quantifying-the-economic-equity-implications-of-electric-vehicle-adoption/

BC Hydro. (n.d). *Electric vehicle incentives in B.C.* Retrieved March 14, 2024, from https://electricvehicles.bchydro.com/incentives/EV-incentives-in-BC#SCRAP-IT

Bernard, Y., Dallmann, T., Tietge, U., Badshah, H., & German, J. (2020). *TRUE U.S. database case study: Emissions distributions by vehicle age and policy implications*. International Council on Clean Transportation. https://theicct.org/publication/true-u-s-database-case-study-emissions-distributions-by-vehicle-age-and-policy-implications/

Black, S., Liu, A. A., Parry, I. W. H., & Vernon, N. (2023). *IMF fossil fuel subsidies data: 2023 Update* (Working Paper 2023/169). International Monetary Fund. https://www.imf.org/en/Publications/WP/Issues/2023/08/22/IMF-Fossil-Fuel-Subsidies-Data-2023-Update-537281

Brito, J. (2023). *No fleet left behind: Barriers and opportunities for small fleet zero-emission trucking*. International Council on Clean Transportation. https://theicct.org/publication/small-fleet-ze-trucking-oct22/

California Air Resources Board. (2022a, March 30). *California Air Resources Board and CALSTART reopen incentives for clean trucks and buses* [Press release]. https://ww2.arb.ca.gov/news/california-air-resources-board-and-calstart-reopen-incentives-clean-trucks-and-buses

California Air Resources Board. (2022b, July 8). *New pilot program to help small trucking fleets transition to zero-emission technologies* [Press release]. https://ww2.arb.ca.gov/news/new-pilot-program-help-small-trucking-fleets-transition-zero-emission-technologies

California Air Resources Board. (2023, August 21). *California's clean vehicle rebate program will transition to helping low-income residents* [Press release]. https://ww2.arb.ca.gov/news/californias-clean-vehicle-rebate-program-will-transition-helping-low-income-residents

California Air Resources Board (n.d.-a). *Innovative small e-fleet update: Flexible zero-emission truck funding for small fleets with 20 trucks and fewer*. https://californiahvip.org/news/innovative-small-e-fleet-update/

California Air Resources Board. (n.d.-b). *Impact.* https://californiahvip.org/impact/

California Air Resources Board. (n.d.-c). *Implementation manuals.* https://californiahvip.org/im/

California Public Utilities Commission. (n.d.). *Low-carbon fuel standard.* Retrieved January 11, 2024, from https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/infrastructure/transportation-electrification/charging-infrastructure-deployment-and-incentives/low-carbon-fuel-standard

Coady, D., Flamini, V., & Sears, V. (2015). *The unequal benefits of fuel subsidies revisited: Evidence for developing countries.* International Monetary Fund. https://www.imf.org/en/Publications/WP/Issues/2016/12/31/The-Unequal-Benefits-of-Fuel-Subsidies-Revisited-Evidence-for-Developing-Countries-43422

Carwow. (2022, July 13). *Plug-in car grant (PiCG) explained.* Carwow Ltd. https://www.carwow.co.uk/blog/government-plug-in-grant

Center for Sustainable Energy. (2018). *California Clean vehicle rebate project: Final report fiscal year 2015–2016* (Prepared under Grant G-15-LCTI-01 for the California Air Resources Board). https://cleanvehiclerebate.org/sites/default/files/attachments/CVRP_FY2015-16_FinalReport.pdf

China, Ministry of Finance. (2018, July 10). 财政部、税务总局、工业和信息化部、交通运输部关于节能新能源车船享受车船税优惠政策的通知 [Notice of the Ministry of Finance, the State Administration of Taxation, the Ministry of Industry and Information Technology, and the Ministry of Transport on the preferential policies for energy-saving and new energy vehicles and vessels to enjoy vehicle and vessel tax]. Guangdong Provincial Department of Finance. http://czt.gd.gov.cn/shuishou/content/post_4135763.html

China, State Council of the Ministry of Finance. (2020). 关于进一步完善新能源汽车推广应用财政补贴政策的通知. [Notice on further improving the fiscal subsidy policy for the promotion and application of new energy vehicles.] https://www.gov.cn/zhengce/zhengceku/2020-12/31/content_5575906.htm

China, State Council of the Ministry of Finance. (2021). 关于2022年新能源汽车推广应用财政补贴政策的通知.[Notice on the fiscal subsidy policy for the promotion and application of new energy vehicles in 2022.] https://www.gov.cn/zhengce/zhengceku/2021-12/31/content_5665857.htm

Connecticut Department of Energy and Environmental Protection. (n.d-a). *CHEAPR—Eligible used vehicle incentive amounts*. Retrieved March 14, 2024, from https://portal.ct.gov/DEEP/Air/Mobile-Sources/CHEAPR/CHEAPR---Used-Eligible-Vehicles

Connecticut Department of Energy and Environmental Protection. (n.d-b). *CHEAPR.* Retrieved March 14, 2024, from https://portal.ct.gov/DEEP/Air/Mobile-Sources/CHEAPR/CHEAPR---Home

Cui, H., & He, H. (2020). *China announced 2020–2022 subsidies for new energy vehicles.* International Council on Clean Transportation. https://theicct.org/publication/china-announced-2020-2022-subsidies-for-new-energy-vehicles/

Cui, H., Yang, Z, & He, H. (2017). *Adjustment to subsidies for new energy vehicles in China.* International Council on Clean Transportation. https://theicct.org/publication/adjustment-to-subsidies-for-new-energy-vehicles-in-china/

European Automobile Manufacturers' Association. (2017). *Interactive map—Electric vehicle incentives per country in Europe (2017)*. https://www.acea.auto/figure/interactive-map-electric-vehicle-incentives-per-country-in-europe-2017/

EV-Volumes. (n.d). *EV Data Center* [subscription database]. https://www.ev-volumes.com/

Fekete, H., Kuramochi, T., Roelfsema, M., den Elzen, M., Forsell, N., Höhne, N., Luna, L., Hans, F., Sterl, S., Olivier, J., van Soest, H., Frank, S., & Gusti, M. (2021). A review of successful climate change mitigation policies in major emitting economies and the potential of global replication. *Renewable and Sustainable Energy Reviews*, *137*, 110602. https://doi.org/10.1016/j.rser.2020.110602

Fonte, G., & Guillaume, G. (2023, October 2). *Italy weighs auto incentive scheme to cut Chinese EV price advantage – sources.* Reuters. https://www.reuters.com/business/autos-transportation/italy-weighs-auto-incentive-scheme-reduce-chinese-ev-price-advantage-sources-2023-10-02/

France, Ministry of Economics and Finance. (2023a). *Première relève pour l'appel à projets « Écosystèmes des véhicules lourds électriques ».* [First request for the call for projects "ecosystems of heavy electric vehicles"]. https://www.entreprises.gouv.fr/fr/actualites/aides-et-financement/premiere-releve-pour-l-appel-projets-ecosystemes-des-vehicules-lourds-electriques

France, Ministry of Economics and Finance. (2023b). *Achat d'un véhicule: comment fonctionne le bonus écologique?* [Purchasing a vehicle: How does the ecological bonus work?] https://www.economie.gouv.fr/particuliers/bonus-ecologique#

Frontier Economics. (2022). *OZEV portfolio-level retrospective evaluation: An evaluation of the plug-in vehicle grant, electric vehicle homecharge scheme, and workplace charging scheme.* Commissioned by UK Department for Transport. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1082401/ozev-portfolio-level-retrospective-evaluation.pdf

Germany, Federal Government. (2020 February 19). *So funktioniert der neue Umweltbonus.* [This is how the new environmental bonus works.] https://www.bundesregierung.de/breg-de/schwerpunkte/klimaschutz/umweltbonus-1692646

Germany, Federal Government. (2020, September 22). *Climate-friendly transport*. https://www.bundesregierung.de/breg-en/issues/climate-action/climate-friendly-transport-1795842

Germany, Federal Government. (2022, December 23). *Nicht weniger fortbewegen, sondern anderns.* [Not moving less, but rather differently]. https://www.bundesregierung.de/breg-de/schwerpunkte/klimaschutz/nachhaltige-mobilitaet-2044132

Germany, Federal Office for Economic Affairs and Export Control. (2023). *Die Förderung des Absatzes von elektrisch betriebenen Fahrzeugen (Umweltbonus) ist ausgelaufen* [The promotion of the sale of electrically powered vehicles (environmental bonus) has expired]. https://www.bafa.de/DE/Energie/Energieeffizienz/Elektromobilitaet/Neuen_Antrag_stellen/neuen_antrag_stellen.html

Germany, Federal Logistics and Mobility Office. (2021a). *Richtlinie über die Förderung von leichten und schweren Nutzfahrzeugen mit alternativen, klimaschonenden Antrieben und dazugehöriger Tank- und Ladeinfrastruktur für elektrisch betriebene Nutzfahrzeuge (reine Batterieelektrofahrzeuge, von außen aufladbare Hybridelektrofahrzeuge und Brennstoffzellenfahrzeuge)* [Directive on the promotion of light and heavy commercial vehicles with alternative, climate-friendly drives and the associated refueling and charging infrastructure for electrically powered commercial vehicles (pure battery electric vehicles, externally chargeable hybrid electric vehicles and fuel cell vehicles)]. https://bmdv.bund.de/SharedDocs/DE/Anlage/G/richtlinie-KsNI.html

Germany, Federal Logistics and Mobility Office. (2021b*). Förderung von Nutz- und Sonderfahrzeugen mit klimaschonenden Antrieben und dazugehöriger Tank- und Ladeinfrastruktur.* [Promotion of utility and special vehicles with climate-friendly drives and associated tank and charging infrastructure]. https://www.balm.bund.de/DE/Foerderprogramme/KlimaschutzundMobilitaet/KSNI/KSNI.html

Germany, Ministry for Economy and Climate Protection. (n.d.). *FAQ Elektromobilität.* [FAQ Electric mobility]. Retrieved March 14, 2024, from https://www.bmwk.de/Redaktion/DE/FAQ/Elektromobilitaet/faq-elektromobilitaet-01.html

Giles, A. (2023, June 8). *Burlington is trying electric vehicle incentives targeted at gasoline "superusers."* Vermont Public. https://www.vermontpublic.org/local-news/2023-06-08/burlington-is-trying-electric-vehicle-incentives-targeted-at-gasoline-superusers

Gillingham, K. T., Houde, S., & van Benthem, A. A. (2021). Consumer myopia in vehicle purchases: evidence from a natural experiment. *American Economic Journal: Economic Policy*, *13*(3), 207–238. https://doi.org/10.1257/pol.20200322

Government of Canada, (n.d.). *Statistics on the Incentives for Zero-Emission Vehicles (iZEV) Program.* Retrieved March 14, 2024, from https://open.canada.ca/data/en/dataset/42986a95-be23-436e-af15-7c6bf292a2e1

Government of Greece, (n.d.). Πράσινα Ταξί Πρόγραμμα επιδότησης επιβατηγών οχημάτων δημόσιας χρήσεως (Ε.Δ.Χ.). [Green taxis: Subsidy program for passenger vehicles for public use (E.D.X.)]. Retrieved March 14, 2024, from https://prasinataxi.gov.gr/

Government of Luxembourg. (2022). *Applying for a subsidy for the purchase of an electric or hybrid vehicle as a natural person.* Guichet.lu information portal. https://guichet.public.lu/en/citoyens/aides/transport/transports-individuels/deduction-mobilite-durable-2019.html

Government of Québec. (n.d.). *Amount of the financial assistance for a used electric vehicle*. Retrieved March 14, 2024, from https://www.quebec.ca/en/transports/electric-transportation/financial-assistance-electric-vehicle/used-vehicle/rebate-amount

Gurman, R. (2021). *Taking commercial fleet electrification to scale: financing barriers and solutions.* CALSTART. https://calstart.org/taking-commercial-fleet-electrification-to-scale-financing-barriers-and-solutions/

Hall, D., Cui, H., & Lutsey, N. (2019). *Electric vehicle capitals: Showing the path to a mainstream market.* International Council on Clean Transportation. https://theicct.org/publication/electric-vehicle-capitals-showing-the-path-to-a-mainstream-market/

Hall, D., Xie, Y., Minjares, R., Lutsey, N., & Kodjak, D. (2021). *Decarbonizing road transport by 2050: Effective policies to accelerate the transition to zero-emission vehicles.* https://theicct.org/publication/zevtc-effective-policies-dec2021/

Helping individuals access affordable clean vehicles. (n.d.). Clean Vehicle Assistance Program, Beneficial State Foundation and California Air Resources Board. https://cleanvehiclegrants.org/

ICF. (2022). *Environmental justice impacts of zero emission vehicles.* International Zero-Emission Vehicle Alliance. https://zevalliance.org/ej-zevs-jan23/

International Energy Agency. (2022). *Electric vehicles: Total cost of ownership tool.* https://www.iea.org/data-and-statistics/data-tools/electric-vehicles-total-cost-of-ownership-tool

International Energy Agency. (2023). *Global EV outlook 2023: Policy developments.* https://www.iea.org/reports/global-ev-outlook-2023/policy-developments

International Monetary fund. (n.d.). *Climate change: Fossil fuel subsidies.* https://www.imf.org/en/Topics/climate-change/energy-subsidies

Italy, Ministry of Business and Made in Italy. (n.d.) *Ecobonus — L'incentivo per la mobilità sostenible.* [Ecobonus — the incentive for sustainable mobility]. Retrieved March 14, 2024, from https://ecobonus.mise.gov.it/ecobonus

Jenn, A., Lee, J. H., Hardman, S., & Tal, G. (2020). An in-depth examination of electric vehicle incentives: Consumer heterogeneity and changing response over time. *Transportation Research Part A: Policy and Practice*, *132*, pp. 97–109. https://doi.org/10.1016/j.tra.2019.11.004

Joint Transportation Committee, Washington State Legislature. (2023, June 20). *Encouraging high consumption fuel users (HCFU) to use electric vehicles* [Study presentation]. https://leg.wa.gov/JTC/Pages/HCFU.aspx

Kok, R., Spijker, B., & van Zyl, S. (2022). *Achtergrondrapport modelactualisatie Carbontax 2022* [Background report on model update of carbon tax 2022]. Revnext. https://www.pbl.nl/sites/default/files/downloads/revnext-2022-achtergrondrapport-modelactualisatie-carbontax-2022-5046.pdf

Ley No. 9518, Incentivos y promoción para el transporte eléctrico [Law No. 9518, Incentives and promotion for electric transport]. (2018). Costa Rican Legal Information System. http://www.pgrweb.go.cr/scij/Busqueda/Normativa/Normas/nrm_texto_completo.aspx?nValor1=1&nValor2=85810

Ley Núm 21505, Promueve el alamacenamiento de energía eléctrica y la electromovilidad. [Law No. 21505, Promoting electric energy storage and electromobility]. (2022). National Library of Congress of Chile. https://www.bcn.cl/leychile/navegar?idNorma=1184572

London, J., Metz, M., Rosler, P., & Dietrich, T. (2023). Gasoline superusers 2.0: Supporting gasoline-burdened families' transition to evs to maximize climate and equity benefits. Coltura. https://coltura.org/gasoline-superusers-2-report/

Maryland, Motor Vehicle Administration. (n.d.). Titling—Excise Tax Credit for Plug-in Electric Vehicles. Retrieved March 14, 2024, from https://mva.maryland.gov/vehicles/Pages/27300-71T.aspx

Massachusetts Department of Energy Resources & Center for Sustainable Energy. (n.d.-a). *Cars: Overview.* Retrieved March 14, 2024, from https://mor-ev.org/cars-overview

Massachusetts Department of Energy Resources & Center for Sustainable Energy. (n.d.-b). *Trucks: Class 3–8*. https://mor-ev.org/trucks-3-8

Mathieu, L. (2023, December 14). *France's eco-bonus shows how we can promote cleaner made-in-Europe EVs. Transport & Environment.* https://www.transportenvironment.org/discover/frances-eco-bonus-shows-how-we-can-promote-cleaner-made-in-europe-evs/

McCormack, R. (2023, May 18). *What low- to moderate-income consumers think about evs and ev charging.* Center for Sustainable Energy. https://energycenter.org/thought-leadership/blog/what-low-moderate-income-consumers-think-about-evs-and-ev-charging

McGovan, J. (2023, July 18). *German govt's 2030 target of 15 million e-cars unlikely to be met as orders drop—industry. Clean Energy Wire.* https://www.cleanenergywire.org/news/german-govts-2030-target-15-million-e-cars-unlikely-be-met-orders-drop-industry

Moayed, T., Guggenheim, S., & von Chamier, P. (2021). *Regressive subsidies to progressive redistribution: The role of redistribution and recognition in energy subsidy reform.* Pathfinders for Peaceful, Just and Inclusive Societies, Center on International Cooperation, New York University. https://cic.nyu.edu/resources/from-regressive-subsidies-to-progressive-redistribution-the-role-of-redistribution-and-recognition-in-energy-subsidy-reform/

Narassimhan, E., & Johnson, C. (2018). The role of demand-side incentives and charging infrastructure on plug-in electric vehicle adoption: Analysis of US states. *Environmental Research Letters, 13*(7), 074032. https://doi.org/10.1088/1748-9326/aad0f8

National Academies of Sciences, Engineering, and Medicine. (2021). *Assessment of technologies for improving light-duty vehicle fuel economy 2025-2035*. The National Academies Press. https://doi.org/10.17226/26092

Netherlands Enterprise Agency. (n.d.-a). *Aanschafsubsidie Zero-Emissie Trucks (AanZET)* [Zero-emission purchase grant]. Retrieved October 30, 2023, from https://www.rvo.nl/subsidies-financiering/aanzet https://zoek.officielebekendmakingen.nl/stcrt-2022-11166.html

Netherlands Enterprise Agency. (n.d.-b). *Veelgestelde vragen SEPP* [Frequently asked questions SEPP]. Retrieved Month, day, year, from https://www.rvo.nl/subsidies-financiering/sepp

New Jersey, Department of Environmental Protection. (n.d.) *Sales and use tax exemption.* Retrieved March 14, 2024, https://dep.nj.gov/drivegreen/sales-and-use-tax-exemption/

New Jersey Economic Development Authority. (n.d.). *NJ ZIP: New Jersey zero-emission incentive program.* https://www.njeda.gov/njzip/

New York City Department of Transportation. (n.d.). *Cleaner trucks for a greener New York City.* https://www.nycctp.com/

New York State Energy Research and Development Authority (NYSERDA). (n.d.-a). *Truck Voucher Incentive Program.* Retrieved March 14, 2024, from https://www.nyserda.ny.gov/All-Programs/Truck-Voucher-Program

New York State Energy Research and Development Authority (NYSERDA). (n.d.-b). *How the Drive Clean Rebate Works.* Retrieved March 14, 2024, from https://www.nyserda.ny.gov/All-Programs/Drive-Clean-Rebate-For-Electric-Cars-Program/How-it-Works

New York State Energy Research and Development Authority (NYSERDA).(2022a). *Drive clean rebate adoption survey: 2021 results*. https://www.nyserda.ny.gov/-/media/Project/Nyserda/Files/Publications/Research/Transportation/23-09-NYSERDA-Drive-Clean-Rebate-Adoption-Survey-2021-Results---acc.pdf

New York State Energy Research and Development Authority (NYSERDA).(2022b). *Drive clean rebate adoption survey: 2020 results*. https://www.nyserda.ny.gov/-/media/Project/Nyserda/Files/Publications/Research/Transportation/23-08-NYSERDA-Drive-Clean-Rebate-Ownership-Survey-2020-Results--acc.pdf

New Zealand Transport Agency. (2023). *Clean car programme.* https://www.nzta.govt.nz/vehicles/clean-car-programme/

New Zealand, Transport Agency. (n.d.). *Clean Car Discount.* Retrieved March 14, 2024, from https://www.nzta.govt.nz/vehicles/clean-car-programme/clean-car-discount-ended-on-31-december-2023/

Nicholas, M., & Wappelhorst, S. (2020). *Regional charging infrastructure requirements in Germany through 2030.* International Council on Clean Transportation. https://theicct.org/publication/regional-charging-infrastructure-requirements-in-germany-through-2030/

Nicolle, A. (2022a). *Are consumers myopic? Evidence from handset and mobile services choices*. SSRN. https://doi.org/10.2139/ssrn.2706391

Norwegian EV Association. (2023). *Norwegian EV policy: Norway is leading the way for a transition to zero emission in transport.* https://elbil.no/english/norwegian-ev-policy/

Oregon, Department of Environmental Quality. (n.d.). *How the EV Rebate Program works.* Retrieved March 14, 2024, from https://www.oregon.gov/deq/aq/programs/pages/applying-for-ev-rebate.aspx

Pennsylvania, Department of Environmental Protection. (n.d.-a). *Alternative fuel vehicle rebate program guidelines.* Retrieved March 14, 2024, from http://www.depgreenport.state.pa.us/elibrary/GetFolder?FolderID=42716

Pennsylvania Department of Environmental Protection. (n.d.-b). *Alternative fuel vehicle rebates for consumers.* https://www.dep.pa.gov:443/Citizens/GrantsLoansRebates/Alternative-Fuels-Incentive-Grant/pages/alternative-fuel-vehicles.aspx

Québec, Ministry of Finance. (2022). *Budget 2022-2023.* http://www.budget.finances.gouv.qc.ca/budget/2022-2023/

Québec Ministry of Transport and Sustainable Mobility. (2023). *Programme écocamionnage.* [Ecotrucking program]. https://www.transports.gouv.qc.ca/fr/aide-finan/entreprises-camionnage/aide-ecocamionnage/Pages/aide-ecocamionnage.aspx

Rebates. (n.d.). CleanBC Go Electric, administered by the Fraser Basin Council Society for the British Columbia Ministry of Energy, Mines and Low Carbon Innovation. Retrieved March 14, 2024, from https://www.goelectricotherrebates.ca/rebate

Rhode Island, Office of Energy Resources. (n.d.). *EV Programs.* Retrieved March 14, 2024, from https://drive.ri.gov/ev-programs

Roberts, G. (2022). *Plug-in car grant for electric vehicles pulled by government.* Fleet News. https://www.fleetnews.co.uk/news/latest-fleet-news/electric-fleet-news/2022/06/14/plug-in-car-grant-for-electric-vehicles-pulled-by-government

Save money on your EV and charger. (n.d.). Charge Up New Jersey, administered by the Center for Sustainable Energy for the New Jersey Board of Public Utilities. Retrieved March 14, 2024, from https://chargeup.njcleanenergy.com/

Sierzchula, W., Bakker, S., Maat, K., & van Wee, B. (2014). The influence of financial incentives and other socio-economic factors on electric vehicle adoption. *Energy Policy, 68,* pp. 183–194. https://doi.org/10.1016/j.enpol.2014.01.043

Shared-Use Mobility Center. (2019). *Electric and equitable: Learning from the BlueLA carsharing pilot.* https://learn.sharedusemobilitycenter.org/overview/case-study-electric-and-equitable-learning-from-the-bluela-carsharing-pilot-los-angeles-ca-2019/

Slowik, P., & Lutsey, N. (2016*). Evolution of incentives to sustain the transition to a global electric vehicle fleet.* International Council on Clean Transportation. https://theicct.org/publication/evolution-of-incentives-to-sustain-the-transition-to-a-global-electric-vehicle-fleet/

Slowik, P., & Lutsey, N. (2018). *The continued transition to electric vehicles in U.S. cities.* International Council on Clean Transportation. https://theicct.org/publication/the-continued-transition-to-electric-vehicles-in-u-s-cities/

Slowik, P., Isenstadt, A., Pierce, L., & Searle, S. (2022). *Assessment of light-duty electric vehicle costs and consumer benefits in the United States in the 2022–2035 time frame.* International Council on Clean Transportation. https://theicct.org/publication/ev-cost-benefits-2035-oct22/

Tal, G., & Nicholas, M. (2016). Exploring the Impact of the federal tax credit on the plug-in vehicle market. *Transportation Research Record, 2572*(1), 95–102. https://doi.org/10.3141/2572-11

Tal, G., Lee, J. H., & Nicholas, M. (2018). *Observed charging rates in California* (Research report UCD-ITS-WP-18-02). Institute of Transportation Studies, University of California, Davis. https://escholarship.org/uc/item/2038613r

Tankou, A., Lutsey, N., & Hall, D. (2021). *Understanding and supporting the used zero-emission vehicle market.* International Council on Clean Transportation. https://theicct.org/publication/understanding-and-supporting-the-used-zero-emission-vehicle-market/

Transport Canada. (2022, April 22). *Minister of Transport announces the expansion of the Incentives for Zero-Emission Vehicles Program* [News releases]. https://www.canada.ca/en/transport-canada/news/2022/04/minister-of-transport-announces-the-expansion-of-the-incentives-for-zero-emission-vehicles-program.html

Transport Canada. (n.d-a). *iZEV program statistics.* Retrieved March 14, 2024, from https://tc.canada.ca/en/road-transportation/innovative-technologies/zero-emission-vehicles/light-duty-zero-emission-vehicles/izev-program-statistics

Transport Canada. (n.d-b). *Medium- and heavy-duty zero-emission vehicles*. Retrieved March 14, 2024, from https://tc.canada.ca/en/road-transportation/innovative-technologies/zero-emission-vehicles/medium-heavy-duty-zero-emission-vehicles

Transport Canada. (n.d-c). *Incentives for zero-emission vehicles.* Retrieved March 14, 2024, from https://tc.canada.ca/en/road-transportation/innovative-technologies/zero-emission-vehicles/incentives-zero-emission-vehicles-izev?utm_campaign=tc-zev-hub-ongoing&utm_medium=doormat-link&utm_source=zev-hub-incentives-page-en&utm_content=izev-program-light-duty-vehicles

United Kingdom Government. (n.d.-a). *Plug-in Van and Truck Gra*nt. Retrieved March 14, 2024, from https://www.find-government-grants.service.gov.uk/grants/plug-in-van-and-truck-grant-1

United Kingdom Government. (n.d.-b). *Low-emission vehicles eligible for a plug-in grant*. Retrieved March 14, 2024, from https://www.gov.uk/plug-in-vehicle-grants

United Kingdom, Office for Low Emission Vehicles. (2016). *New Plug-in Car Grant Levels from March 2016.* https://www.gov.uk/government/publications/plug-in-car-grants-changes-to-grant-level-march-2016

Vermont, Agency of Transport. (n.d.). *Statewide Vehicle Incentive Programs.* Retrieved March 14, 2024, from https://vtrans.vermont.gov/climate/incentives

Switched on taxis loan (n.d.). Find Business Support, operated by Scottish Enterprise. Retrieved March 14, 2024, from https://findbusinesssupport.gov.scot/service/funding/switched-on-taxis-loan

Wappelhorst, S., Hall, D., Nicholas, M., & Lutsey, N. (2020). *Analyzing policies to grow the electric vehicle market in European cities.* International Council on Clean Transportation. https://theicct.org/publication/analyzing-policies-to-grow-the-electric-vehicle-market-in-european-cities/

Wappelhorst, S., Morrison, K., & Wilkens, M. (2023*). An equitable transition from combustion engines to battery electric vehicles: Theoretical framework and status in Germany.* International Council on Clean Transportation. https://theicct.org/publication/equity-german-transport-april23/

Wapplehorst, S. (2022). *Incentivizing zero- and low-emission vehicles: The magic of feebate programs.* International Council on Clean Transportation. https://theicct.org/magic-of-feebate-programs-jun22/

Washington, State Department Revenue. (n.d.). *Tax incentive programs*. Retrieved March 14, 2024, from https://dor.wa.gov/taxes-rates/tax-incentives/tax-incentive-programs#922

Williams, B.D.H. (2023). Assessing progress and equity in the distribution of electric vehicle rebates using appropriate comparisons. *Transport Policy*, 137, 141–151. https://doi.org/10.1016/j.tranpol.2023.04.009

Williams, B., & Pallonetti, N. (2020). *CVRP 2020 data brief: Vehicle replacement* [Presentation]. Clean Vehicle Rebate Project, administered by the Center for Sustainable Energy for the California Air Resources Board. https://cleanvehiclerebate.org/sites/default/files/attachments/2020-CVRP-Vehicle-Replacement-Data-Brief_2022-06.pdf

Yang, Z., Slowik, P., Lutsey, N., & Searle, S. (2016). *Principles for effective electric vehicle incentive design.* International Council on Clean Transportation. https://theicct.org/publication/principles-for-effective-electric-vehicle-incentive-design/

Yao, X., Ma, S., Bai, Y., & Jia, N. (2022). When are new energy vehicle incentives effective? Empirical evidence from 88 pilot cities in China. *Transportation Research Part A Policy and Practice, 165,* 207–224. https://doi.org/10.1016/j.tra.2022.09.003

Zelasky, S. E., & Buonocore, J. J. (2021). The social costs of health- and climate-related on-road vehicle emissions in the continental United States from 2008 to 2017. *Environmental Research Letters, 16*(6), 065009. https://doi.org/10.1088/1748-9326/ac00e3

Zero-Emission Vehicle Incentive Programs: Gasoline Superusers, AB 1267, California Legislature 2023-2024 Regular Session. (2023). https://legiscan.com/CA/text/AB1267/id/2750718

Zheng, X., Menezes, F., Zheng, X., & Wu, C. (2022). An empirical assessment of the impact of subsidies on EV adoption in China: A difference-in-differences approach. *Transportation Research Part A: Policy and Practice, 162,* 121–136. https://doi.org/10.1016/j.tra.2022.05.020

Appendix

The governments of the ZEV Alliance have adopted a wide variety of programs to make zero-emission passenger vehicles less costly. These programs, as they existed on January 1, 2024, are summarized in Table A1. Although tax discounts were not the focus of this research, they are included in this table as they represent an important incentive in some markets, particularly in Europe. In contrast, some U.S. states have adopted extra fees for zero-emission vehicles, typically assessed on an annual basis, to contribute to government budgets in lieu of fuel taxes; these are indicated in red. For the tax discount columns, "N/A" indicates that this form of tax is not levied by that government. Unless otherwise noted, the incentives apply only to BEVs and FCEVs. Finally, due to funding limitations, some of the programs listed below may be temporarily unavailable.

Table A1 Passenger car ZEV incentives in ZEV Alliance jurisdictions

	Private car incentives			Approaches for targeted incentive				Vehicle tax and fee discounts			Source
Jurisdiction	Program	Incentive value	Vehicle price cap	Income cap	Low-income bonus	Taxi / car sharing	Scrappage	Purchase tax discount	Annual tax/fee discount	Company car tax discount	
Austria	E-mobility for private individuals 2023	BEV: €5,000 PHEV: €2,500	€60,000	No	No	Up to €2,000	No	Exempt from fuel consumption/ pollution tax (NoVA)	Exempt from engine-related insurance tax	VAT exemption (20%); exempt from benefit-in-kind tax; tax allowance up to 15% of EV investments	Austria, Climate and Energy Fund (n.d.)
Baden-Württemberg	State Initiative III Market Growth Electric Mobility BW	BEV: €1,000	€65,000	No	No	€3,000 (taxi, car sharing)	No	N/A	N/A	N/A	Baden-Württemberg Ministry for Transport (n.d.)
British Columbia	CleanBC Go Electric	BEV: Up to CA$4,000 PHEV: Up to $2,000	CA$55,000 (cars), CA$70,000 (SUVs, trucks)	Up to CA $100,000	Highest rebates for incomes below CA$80,000	**No**	No	Used ZEVs exempt from 12% sales tax	No	N/A	BC Hydro (n.d.)
California	Clean Cars 4 All – new program to be revealed in 2024	Up to $7,500	TBD	TBD	TBD	N/A	Up to $12,000, only for low-income households	No	$100 additional fee	N/A	California Air Resources Board, 2023
Canada	iZEV, temporary enhanced first-year capital cost allowance rate	BEV and PHEV: Up to CA$5,000	CA$55,000 (cars) –$60,000 (pickups, vans, and SUVs) and trims of up to $10,000 above these limits allowed	No	No	Temporary enhanced first-year capital cost allowance rate	No	No	N/A	No	Transport Canada (n.d.-c)
Chile	Law No. 21,505, Mi Taxi Eléctrico	No	No	No	No	Up to CLP $16,000,000, in select regions	No	No	BEV, PHEV annual road tax exemption (2 years), discount (6 years)	N/A	Ley Núm 21505 (2022)
Connecticut	CHEAPR Standard and CHEAPR Rebate +	BEV: $2,250 PHEV: $750	No	Yes	Extra $2,000 for BEV and $1,500 for PHEV	No	No	No	Reduced biennial registration fee of $38 vs. $120	N/A	Connecticut Department of Energy and Environmental Protection (n.d-b)

Jurisdiction	Private car incentives			Approaches for targeted incentive				Vehicle tax and fee discounts			Source
	Program	Incentive value	Vehicle price cap	Income cap	Low-income bonus	Taxi / car sharing	Scrappage	Purchase tax discount	Annual tax/fee discount	Company car tax discount	
Costa Rica	Law No. 9518	N/A	No	No	No	**Yes**	No	Full tax exemption on BEV	Substantial discount on annual circulation tax	N/A	Ley No. 9518 (2018)
Maryland	Excise Tax Credit for Plug-in Electric Vehicles	BEV: Up to $3,000	$50,000	No	No	No	No	No	No	N/A	Maryland, Motor Vehicle Administration (n.d.)
Massachusetts	MOR-EV standard and MOR-EV +	BEV: $3,500	$60,000 for new car, $40,000 for used car	Yes	Yes	No	No	No	No	N/A	Massachusetts Department of Energy Resources & Center for Sustainable Energy (n.d.-a)
Netherlands	SEPP	BEV and PHEV: €2,950	From €12,000 to a maximum €45,000	No	No	No (private individual only)	No	Exempt from registration tax	No road tax until 2025; 75% discount in 2025	17% reduction in benefit-in-kind tax	Netherlands Enterprise Agency (n.d.-b)
New Jersey	Charge Up New Jersey	BEV: Up to $4,000	$45,000 for full incentive, $55,000 for partial incentive	No	No	No	No	No	No	N/A	"Save money on your EV and charger" (n.d.)
New York	Drive Clean Rebate	BEV and PHEV: Up to $2,000 (depending on electric range)	$42,000	No	No	No	No	No	No	N/A	New York State Energy Research and Development Authority (n.d-b)
Norway	Tax exemption	N/A	500,000 NOK	N/A	N/A	No	No	Reduced purchase tax and exempt from VAT	No	No	Norwegian EV Association (2023)
Oregon	Standard Rebate and Charge Ahead Rebate	BEV and PHEV: Up to $2,500	$50,000	Yes	Extra $5,000	Eligible to business	No	No	$0.019/mile or $115 additional annual fee	N/A	Oregon, Department of Environmental Quality (n.d.)
Québec	Roulez vert program	BEV: Up to CA$7,000 PHEV: Up to CA$5,000	CA$65,000	No	No	Eligible to business	No	No	Exempt from additional fee for luxury vehicles	N/A	Government of Québec (n.d.)
Rhode Island	DRIVE, DRIVE + and DRIVE Fleet	BEV: Up to $1,500	$60,000 for new vehicle; $40,000 for used vehicle	Yes	Yes	No	No	No	N/A	N/A	Rhode Island, Office of Energy Resources (n.d.)
United Kingdom	Plug-in Taxi grant	N/A	N/A	N/A	N/A	20% discount, up to £7,500 for ultra-low emission taxis	No	No	No	75%–95% discount on benefit-in-kind tax	United Kingdom Government (n.d.-b)
Vermont	Incentive program and Replace Your Ride program	BEV: Up to $5,000 PHEV: Up to $3,000	$50,000	$150,000 household	50% of incentive available over threshold	No	Up to $5,000	No	No	N/A	Vermont, Agency of Transport (n.d.)
Washington	Excise tax credit	N/A	New BEV: $45,000 Old BEV: $30,000	N/A	No	No	No	Exempt up to $16,000 in sales tax	$150 additional annual fee	N/A	Washington, State Department Revenue (n.d.)

Notes: VAT = value-added tax. All currency in USD unless otherwise specified.

www.zevalliance.org