Massachusetts Offers Rebates for Electric Vehicles (MOR-EV) Cost-Effectiveness Study

2014-2020 Program Results Summary

Prepared for the Massachusetts Department of Energy Resources (DOER)

February 25, 2022 – FINAL

LETTER FROM THE COMMISSIONER

The *MOR-EV Cost-Effectiveness Study* was commissioned to support the Baker-Polito Administration's continued efforts to reduce Greenhouse Gas Emissions (GHG) from the transportation sector as cost-effectively as possible.

As outlined in Section 95 of Chapter 142 of the Acts of 2019, passed by the Legislature and signed by the Governor, there included a provision for the Department of Energy Resources (DOER) to assess the cost-effectiveness of the MOR-EV program, and specifically to assess cost-effectiveness in terms of GHG reductions.

This study analyzes the cost-effectiveness of the MOR-EV Program at increasing electric vehicle adoption and reducing GHG emissions. It reviews the MOR-EV Program within the context and landscape of policies and programs across the country, and globally.

The study identifies opportunities for program revisions and supplemental transportation policies which may improve the financial sustainability, cost-effectiveness, and equity of vehicle electrification policies and programs in the future.

Following the release of this study, DOER will work with stakeholders and our partners in the legislature to implement recommendations from the report with the objective of maximizing the greenhouse gas benefits of limited funding, furthering equity goals, and placing the Commonwealth on a sustainable path to meeting our ambitious climate requirements.

Sincerely,

Patrick Woodcock

Commissioner

Massachusetts Department of Energy Resources

ACKNOWLEDGEMENTS

DOER Commissioner Patrick Woodcock would like to acknowledge the following people for their assistance in the analysis and development of this report.

Department of Energy Resources

Director of the Leading by Example Program, Eric Friedman

Deputy Director of the Leading by Example Division, Catie Snyder

Alternative Transportation Program Coordinator, Michelle Broussard

Synapse Energy Economics

Jennifer Kallay

Jackie Litynski

Courtney Lane

Patrick Knight

Jason Frost

EXECUTIVE SUMMARY

Massachusetts was one of the first states in the nation to set aggressive economy-wide goals to reduce greenhouse gas (GHG) emissions across the electricity, thermal, and transportation sectors and enact a suite of policies and practices to reach those goals. However, emissions from the transportation sector remain the state's foremost challenge in reaching its goal of net zero emissions in 2050; transportation is the largest source of GHG emissions, and its emissions continue to grow. GHG emission reductions are possible because of the transition from gasoline to electricity as a fuel source for vehicles, as electric powertrains are substantially more efficient than combustion engines. Furthermore, the emissions from electricity generation in New England are relatively low today and will continue to decline over time.

This report examines the cost-effectiveness of the Massachusetts Offers Rebates for Electric Vehicles Program (MOR-EV), which seeks to address to transportation sector GHG emissions. MOR-EV provides incentives to residents, businesses, and non-profits for the adoption of new battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs).

With seven years of MOR-EV performance data spanning several program design updates, in addition to insights on similar strategies and associated performance in other states and countries, ample information is available to inform the future direction of the MOR-EV Program. The report identifies key findings and opportunities to improve the design of the MOR-EV Program, as well as opportunities to potentially supplement the program with other efforts to accelerate transportation electrification.

MOR-EV was one of the first programs of its kind in the United States and the performance of the program to date offers many lessons learned. As with any new initiative, there are successful aspects of the program as well as opportunities for improvement. Three challenges of the current program are 1) financial sustainability, 2) cost-effectiveness, and 3) equity. These issues are high priorities for the next phase of the program, and the opportunities presented are focused on achieving these three priorities.

This section summarizes each priority area and outlines potential opportunities for improvement moving forward, ordered according to timing, from nearer term to longer term. Several opportunities address both financial sustainability and cost-effectiveness, so these program areas are combined.

FINANCIAL SUSTAINABILITY AND COST-EFFECTIVENESS

KEY FINDINGS

Free ridership is an important determinant of the cost-effectiveness of the program. Higher free ridership increases the dollars per ton of GHG reduced and reduces the benefit-cost ratio of the program. The current MOR-EV Program is challenged by high free ridership, meaning funds are being spent that are not necessary to obtain additional EV purchase. In addition, free ridership is higher for vehicles with higher purchase prices.

Increases in market adoption of electric vehicles (EVs) will strain the long-term financial sustainability of the program, to the point where the volume of incentives requested becomes too costly for the state to support within the current program construct. There may be less costly ways to influence the purchase of new EVs than direct customer financial incentive payments. For example:

- Reduction in purchase and ownership cost via tax and fee exemptions to provide financial support to consumers buying electric vehicles without requiring financial outlay from government entities.
- Education for customers, dealers, and vehicle salespeople is essential for influencing more consumers to consider an electric vehicle as their next vehicle purchase.
- Certain policies provide supplemental benefits that have value to consumers. Examples include polices that eliminate unnecessary operation and maintenance requirements such as emissions inspections, policies that provide for shorter drive times through priority access to routes with less traffic, and policies that provide for charging and access to parking spots in high demand locations.
- Penalties that disincentivize the purchase and operation of gasoline-fueled vehicles also play an important role in shifting vehicle preferences.

OPPORTUNITIES

1. Reduce the vehicle purchase price cap as early as next year: This is highly likely to improve financial sustainability and cost-effectiveness. Reducing the cap can improve program financial sustainability by reducing the overall percentage of EV sales eligible for participation. Reducing the cap can improve cost-effectiveness by reducing free ridership in the program and thus reduces the dollar per ton of GHG reduction and increases the program benefit-cost ratio. A cap that declines over time can continue to improve financial sustainability and cost-effectiveness as a greater share of new vehicles become EVs.

   To address some uncertainties customers face regarding incentive availability, the incentive amount and cap could be based on a publicly available and transparent schedule. This would ensure manufacturers, dealers, vehicle salespeople, and customers have advance notice of upcoming program changes and can plan accordingly.

   To ensure incentives of sufficient magnitude moving forward, the incentive and cap should consider projections of changes in federal incentives, increasing EV market share, and decreases in EV costs over time.

2. Limit PHEV incentive eligibility to only vehicle types without comparable BEV alternatives at reasonable price points: If implemented quickly, this is highly likely to improve financial sustainability and cost-effectiveness in the near term. This is key because PHEVs represent a substantial portion of overall program rebates and have a higher cost per ton of GHG reduction than BEVs.

3. Implement additional, targeted program outreach to influence consumers whose current vehicle, location, and behaviors result in higher emissions by 2023: This will improve the program's financial sustainability and cost-effectiveness. Targeted incentives to drivers of inefficient vehicles and high mileage drivers can increase financial sustainability by decreasing the overall pool of

eligible participants and/or decreasing the value of the incentive available to those outside of the high emissions targeted participant pool. Targeted incentives can increase cost-effectiveness by increasing the benefits provided by each participating vehicle. A carefully designed incentive structure can avoid the perverse incentive of encouraging people to drive more.

4. Align MOR-EV eligibility with other statewide programs over the longer term: This will both support the Commonwealth's decarbonization policies and improve financial sustainability and cost-effectiveness by ensuring spending is well coordinated and allocated to the initiatives that provide the greatest benefit for the cost. For example:
    a. Eligibility for solar and storage incentives could depend on first electrifying a participant's vehicle and/or building
    b. Applications from renters or condominium dwellers could trigger installation of on-site charging infrastructure; and
    c. Vehicle incentive eligibility could require household energy efficiency audits and installation of certain energy efficiency measures (e.g., Mass Save®), demand response program enrollment (e.g., ConnectedSolutions), and/or Clean Peak Energy Standard participation.

The more participants that take advantage of energy efficiency, demand response, and on-site solar generation paired with storage, in concert with vehicle electrification, the closer the state can get to its overall GHG emission reduction requirements.

EQUITY

KEY FINDINGS

MOR-EV was designed to remove some financial barriers to accessing EVs. Low- to moderate-income (LMI) consumers are less likely to participate in the MOR-EV Program to date due to the lower rate of new vehicle ownership among this demographic, the higher price of new vehicles as compared to used vehicles, and the higher upfront cost to purchase a new EV as compared to a gasoline-fueled vehicle. To improve equity and increase access to EVs among lower-income households, several changes will need to be considered.

Such inequitable access to MOR-EV incentives will need to be addressed to fulfill the program's goals without perpetuating existing social, environmental, or economic inequities.

The MOR-EV Program is, however, increasing the percentage of used vehicles that are EVs, which may eventually make EVs more available to lower income households. In addition, it makes new vehicle purchases more attractive which suppresses demand and therefore prices on used vehicle equivalents (used EVs).

OPPORTUNITIES

1. Reduce the vehicle purchase price cap as early as next year: This improves equity by ensuring more rebates are available for lower-cost new vehicles and a greater share of lower-priced new vehicles are EVs.
2. Consider the inclusion of separate incentives for LMI customers in future iterations of the MOR-EV Program: A number of other states have implemented additional LMI incentive efforts through a variety of means such as vouchers and separate rebate processes. It is recommended that any future MOR-EV Program design process include the evaluation of such measures for possible inclusion.
3. Rapidly develop awareness campaigns that target communities and consumers historically underserved by the MOR-EV Program to improve equity: Any such campaign should provide information on vehicle, charging infrastructure, and incentive availability (including state, federal, and other types of incentives). Improving dealer and vehicle salesperson program awareness in key geographies will also help with equity.
4. Implement additional program targeting by 2023 to reach consumers whose current vehicle, location, and behaviors result in higher emissions and to improve the program's equity. The incorporation of a geographic adder for the incentive can ensure the program addresses those residents living in rural areas that are further away from places of work or recreation, or residents living in environmental justice communities who are most affected by the health impacts of transportation-related pollution.
5. Revise the program over the next year to enable up-front provision of the incentive and/or structures to reduce monthly payments: This will improve equitable program access by enabling more of the LMI population to participate in the program. This feature would also improve the accessibility and immediacy of the incentive. For the existing program to provide an effective up-front incentive, it may require an intermediary debt-service to provide the incentive at time of purchase and then be subsequently reimbursed by the state. Over time, the state could offer a reduction in taxes or fees at the time of purchase. Such a tax and/or fee exemption could be revenue neutral with the addition of a luxury tax on new inefficient gasoline vehicle sales. In addition, point-of-sale incentives with a portion attributed to the customer and a portion to the dealer and/or salesperson in select geographies can help drive increases in EV market share in environmental justice communities.
6. Include used EVs or a guaranteed second sale to LMI customers: This would improve equity by expanding the pool of eligible EVs (potentially at a significantly lower price point) and/or guaranteeing used EVs are available for purchase by LMI customers.

   Some states provide additional incentives for the lease or purchase of used EVs. Since used EVs do not currently qualify for federal tax credits, additional program funding could be beneficial for improving access to EVs at even lower price points than new models. The inclusion of used EV incentives, and the parameters through which customers or vehicles are eligible for rebate access, are worth consideration as part of future MOR-EV Program design.

For the program to enable a second sale model would require changes to the eligibility criteria and participation requirements for Commercial Fleets, including adjustments similar in design to affordable housing deed restrictions as described under Chapter 40B, the Commonwealth's Affordable Housing Law. In the same way that homes are deed restricted to only be sold on to eligible residents, vehicles could be title restricted so they would only be sold on to LMI customers. This feature would improve EV availability by ensuring that vehicles are available exclusively to LMI customers.

Table ES-1 summarizes the opportunities and timing of the opportunities discussed above.

Table ES-1. Summary of Opportunities

Timing	Opportunities	Financial Sustainability	Cost-Effectiveness	Equity
Nearer Term (early 2022)	1. Reduce purchase price cap for eligibility	✓	✓	✓
	2. Limit PHEV incentive eligibility to vehicle types with no BEV alternatives at reasonable price points	✓	✓	
	3. Consider the inclusion of separate incentives for LMI customers			✓
	4. Increase accessibility through targeted awareness campaigns to dealers, vehicle salespeople, and customers in select geographies			✓
Mid Term (mid/late 2022)	5. Target incentives to consumers whose current vehicle, location, and behaviors result in higher emissions	✓	✓	✓
	6. Enable up-front incentive payment with the potential for a share of the incentive for the dealer/vehicle salespeople in select geographies			✓
Longer Term (2023+)	7. Make eligibility contingent upon participation in other programs	✓	✓	
	8. Include used EVs or a guaranteed secondary fleet program sale to LMI consumers			✓

The exact design of the program and incentives will depend on the level of EV market share the state desires over what timeframe, federal actions, and incentives for EVs over that period, and other transportation program funding needs and cost-effectiveness. The MOR-EV Program is only one tool in the state's transportation emission reduction toolkit; investments in other programs may help to reduce the number of drivers and/or the vehicle miles traveled by drivers. These outcomes are achievable through better public transportation, remote work, and more walkable and bikeable streets. Programs that achieve these outcomes may be more accessible to and have a larger impact on LMI households. By conducting similar cost-effectiveness analyses on its other program efforts and other strategies under consideration, Massachusetts can optimize its current programs and prioritize investments in programs that can reduce emissions at the lowest cost.

ACRONYMS AND DEFINITIONS

Acronym or Term	Definition
Accessibility	Incentives are easy to obtain by customers.
Availability	A variety of vehicle types (new and used), sizes, makes, models, customer types (e.g., residents, businesses, and municipal governments), and ownership models (purchases and leases) are eligible for incentives.
BCA	Benefit-cost analysis
BCR	Benefit-cost ratio
BEV	Battery electric vehicle
Certainty	Customers, manufacturers, and dealers can rely on and plan for incentives.
Clarity	The value of the incentive is easy to communicate to dealers and consumers.
CO_2	Carbon dioxide: one of the most important greenhouse gases linked to global warming and a minor component of Earth's atmosphere, formed in combustion of carbon-containing materials, in fermentation, and in respiration of animals and employed by plants in the photosynthesis of carbohydrates.
CSE	Center for Sustainable Energy
CUV	Crossover utility vehicle
Early adopters	Representing 13.5 percent of the population, these individuals openly share positive opinions, are followed by others, and have a high degree of trust and credibility among these followers.
Early majority	Followers of early adopters who represent 34 percent of the population.
Equity	Equity is the condition of fair and just inclusion into a society; equity will exist when those who have been most marginalized have equal access to opportunities, power, participation, and resources. In the context of broader EV adoption, EVs can result in lower total costs of ownership for drivers and reduced environmental externalities for all; incentives such as MOR-EV rebates can assist with alleviating higher capital costs of EVs and may contribute to more equitable access to EV purchases. Note that this definition of equity is nascent and likely to change over time.
EV	Electric vehicle
EV cost differential	The additional estimated cost to purchase an EV as compared to a similar gasoline vehicle, calculated by subtracting the average gasoline vehicle purchase price of $31,260[1] from the average purchase price of BEVs and PHEVs rebated through the MOR-EV Program.
FCEV	Fuel cell electric vehicle; FCEVs are vehicles powered by compressed hydrogen fuel that produces electricity.
Free rider	A person who would have purchased the EV without an incentive but received an incentive anyway.
FTC	Federal tax credit
GWSA	Global Warming Solutions Act
GHG	Greenhouse Gas
ICE	Internal combustion engine

[1] International Council on Clean Transportation (ICCT). 2019. Working Paper 2019-06. Available at: https://theicct.org/sites/default/files/publications/EV_cost_2020_2030_20190401.pdf

Acronym or Term	Definition
Immediacy	A purchase incentive is available to the consumer upfront, effectively reducing the cost at the point of sale.
Incremental EV cost	The additional estimated cost to purchase an EV as compared to a similar gasoline vehicle, less any relevant incentives.
Innovators	Representing 2.5 percent of the population, these people are open to exploring new ideas and technologies.
Laggards	Representing 16 percent of the population, these individuals will only adopt a new product or service when there are no alternatives.
Late majority	Skeptics who are not keen on change and will only adopt a new product or service if there is a strong feeling of being left behind or missing out. These individuals account for 34 percent of the population.
LDV	Light-duty vehicles. Vehicles that are primarily used to transport passengers and cargo (e.g., cars, CUVs, SUVs, vans, and pickup trucks).
LMI	Low- to moderate-income
Magnitude	The level of the incentive is adequate to influence vehicle purchase behavior.
Market share	The portion of a market controlled by a particular company or product.
MOR-EV	Massachusetts Offers Rebates on Electric Vehicles
MPG	Miles per gallon
MSRP	Manufacturer's suggested retail price
NO_X	Nitrogen oxides, namely nitric oxide (NO) and nitrogen dioxide (NO_2), that contribute to the formation of smog and acid rain and affect tropospheric ozone.
NSPM for DERs	National Standard Practice Manual for Benefit-Cost Analysis of Distributed Energy Resources
PHEV	Plug-in hybrid electric vehicle; PHEVs are vehicles powered using gasoline as well as electricity.
Participant BCA	A benefit-cost analysis from the perspective of the consumer participating in the program.
Participant cost	The price paid to purchase the vehicle, less any relevant incentives. In this analysis, relevant incentives include an estimate of the average federal tax credit available to BEV and PHEV purchasers and the average MOR-EV rebates for BEVs and PHEVs. It is important to note that this analysis assumes that all MOR-EV Program participants apply for the federal tax credit and receive the full amount for which they are eligible.
Participation	The number of individuals who received a MOR-EV rebate.
Participation rate	The proportion of total purchasers of EVs in the state who participate in the MOR-EV program.
$PM_{2.5}$	Particulate matter 2.5 are fine inhalable particles or droplets in the air that are two-and-one-half microns or less in width.
Program BCA	A benefit-cost analysis demonstrating the program cost-effectiveness.
Purchase price	The price paid to purchase the vehicle.
RGGI	Regional Greenhouse Gas Initiative
S-Curve	A mathematical function having a characteristic "S"-shaped curve or sigmoid curve which is a common way of mapping the transformation of the degree of market transformation for any new technology.
SO_2	Sulfur dioxide is the component of greatest concern out of the entire group of sulfur oxides (SO_X) and used as the indicator for the larger group of gaseous sulfur oxides (SO_X). Short-term exposures to SO_2 can harm the human respiratory system and make breathing difficult. SO_X can also react with other compounds in the atmosphere to form small particles.

Acronym or Term	Definition
SUV	Sport utility vehicle
TOU	Time of use
ZEM	Zero emission motorcycle
ZEV	Zero emission vehicle

CONTENTS

LIST OF FIGURES AND TABLES

INTRODUCTION

Massachusetts leads the nation with bold and transformative policies and practices to address climate change. Signed into law in 2008, the *Global Warming Solutions Act (GWSA)* established a statewide limit on greenhouse gas (GHG) emissions of 25 percent below 1990 levels for 2020 and 80 percent below 1990 levels by 2050.[2] In 2020, Governor Baker signed *An Act Creating a Next Generation Roadmap for Massachusetts Climate Policy*, further committing the Commonwealth to net zero emissions in 2050.[3] As of 2020, the transportation sector represents the highest source of GHG emissions in Massachusetts and emissions from the sector are growing.

One of the key strategies to reduce these emissions is to increase the deployment of zero emission vehicles (ZEV), such as battery electric vehicles (BEV) and plug-in hybrid electric vehicles (PHEV).[4,5] Launched in 2014, the *Massachusetts Offers Rebates for Electric Vehicles* (MOR-EV) program is an education and rebate program funded by the Massachusetts Department of Energy Resources (DOER) and administered by the Center for Sustainable Energy (CSE) to increase the number of ZEVs on roadways and reduce Massachusetts transportation sector GHG emissions.

This report investigates the cost-effectiveness of the MOR-EV Program from June 2014 through December 2020, provides a mid-year update on program trends in 2021, and identifies opportunities to improve MOR-EV moving forward.[6]

---

[2] An Act Establishing the Global Warming Solutions Act. Chapter 298 of the Acts of 2008, and as codified at M.G.L. c. 21N (Chapter 21N). Available at: https://malegislature.gov/laws/sessionlaws/acts/2008/chapter298

[3] Mass.gov. Press Release. Governor Baker Signs Climate Legislation to Reduce Greenhouse Gas Emissions, Protect Environmental Justice Communities. March 26, 2021. Available at: https://www.mass.gov/news/governor-baker-signs-climate-legislation-to-reduce-greenhouse-gas-emissions-protect-environmental-justice-communities

[4] PHEVs are not ZEVs but are zero emission capable.

[5] Mass.gov. Clean Energy and Climate Plan for 2020. Available at: https://www.mass.gov/service-details/clean-energy-and-climate-plan-for-2020

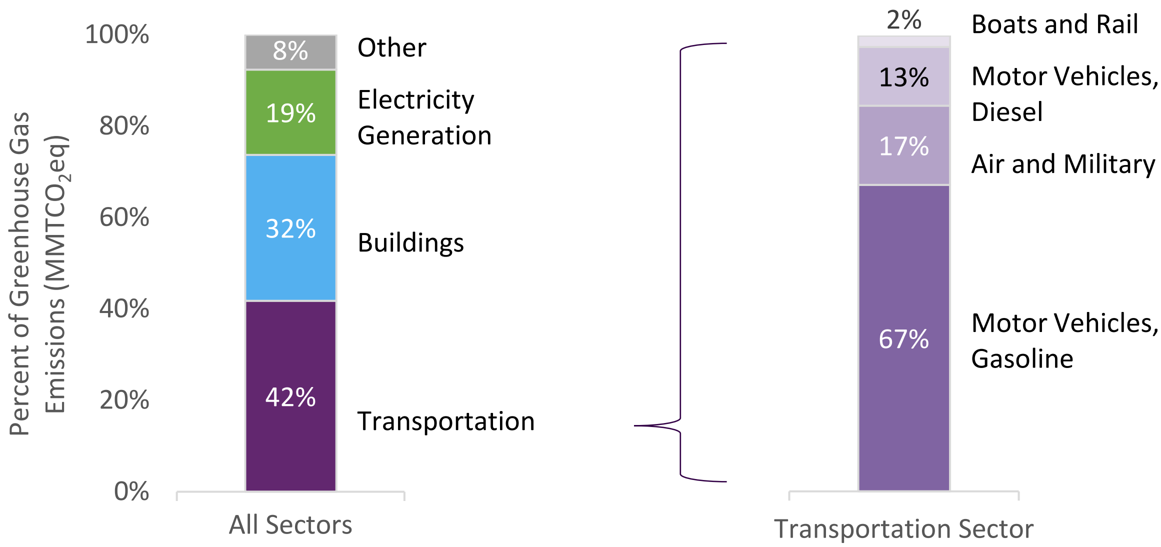
[6] "The department shall examine the programs, including, but not limited to, the cost-effectiveness of the programs in greenhouse gas emissions reductions, and report its findings to the joint committee on telecommunications, utilities and energy not later than January 1, 2022." Available at: https://malegislature.gov/Laws/SessionLaws/Acts/2019/Chapter142, Section 95

BACKGROUND

OVERVIEW OF VEHICLE EMISSIONS IN MASSACHUSETTS

Massachusetts' transportation sector is a key focus of state policy and programs as the sector emits more GHG emissions than any other sector. Figure 1 shows that GHG emissions from the transportation sector comprised 42 percent of total GHG emissions in 2017 or 30.5 million metric tons of CO_2 (MMTCO_2eq). Two-thirds of the transportation sector GHG emissions (20.3 MMTCO_2) are from gasoline-powered light-duty vehicles.

Figure 1. Economy-Wide and Transportation Sector GHG Emissions in Massachusetts

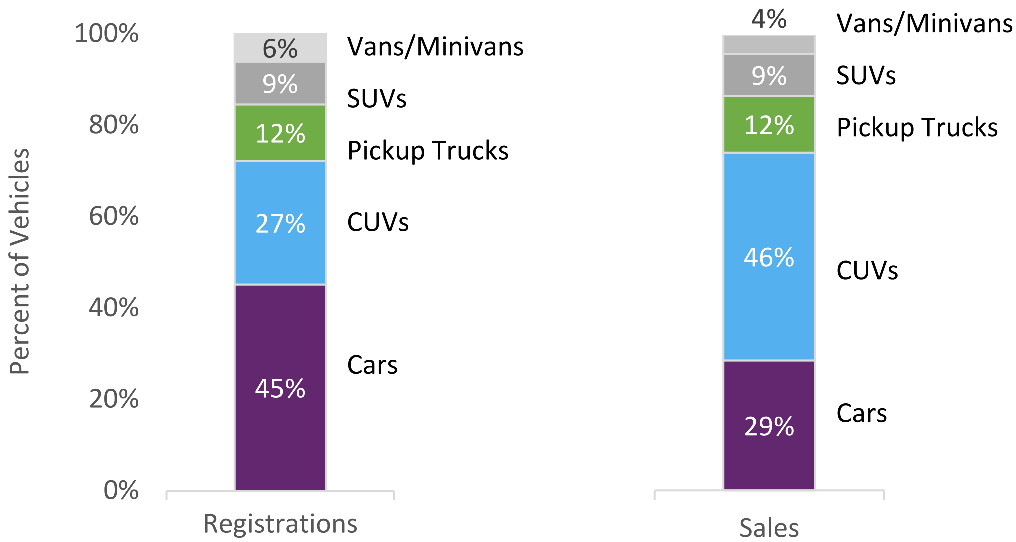


Sources:

1. *Appendix C of the Massachusetts Greenhouse Gas Inventory at: https://www.mass.gov/doc/appendix-c-massachusetts-annual-greenhouse-gas-emissions-inventory-1990-2017-with-partial-2018/download. 2017 is used as it is the latest year for which there is complete data.*
2. *Synapse calculations using EIA's State Energy Data System database at: https://www.eia.gov/state/seds/.*

There are approximately 5.4 million light-duty vehicles registered in Massachusetts. Light-duty vehicles are vehicles that are primarily used to transport passengers and cargo such as cars, crossover utility vehicles (CUVs), sport utility vehicles (SUVs), minivans, vans, and pickup trucks.[7] Figure 2 shows that cars make up the largest segment of the existing fleet. However, a growing share of light-duty vehicle sales are CUVs. These are lighter than SUVs and built on a car platform but are typically larger and have a lower fuel efficiency than cars. Most EV models are currently cars or CUVs, though more SUVs and truck models are launching in 2022.

Figure 2. Massachusetts Light-Duty Vehicle Registrations and Sales



Source: Alliance for Automotive Information. "Autos Drive Massachusetts Forward." Available at https://www.autosinnovate.org/resources/insights/ma.

[7] Today's available EVs are mostly light-duty vehicles.

The MOR-EV Program is designed to reduce GHG emissions in the transportation sector by influencing buyers to purchase an EV rather than a traditional gasoline-powered vehicle. Table 1 shows a representative range of annual GHG emissions for various vehicle efficiencies, fuel types, and miles driven.

Electrification provides an opportunity to substantially reduce emissions of all vehicle types. High mileage drivers of less efficient vehicles represent a significant portion of the opportunity for emissions savings. Also, while gasoline vehicle emissions are fixed over time, electric vehicle emissions will decline as the proportion of non-carbon emitting resources on the electricity grid increases.

Electrification provides an opportunity to substantially reduce emissions of all vehicle types. High mileage drivers of less efficient vehicles represent a significant portion of the opportunity for emissions savings. Gasoline vehicles driven 20,000 miles per year emit approximately 14,200 pounds (6.4 metric tons) of CO_2 annually, whereas BEVs driven the same distance generate grid emissions of approximately 4,700 pounds.* Also, while gasoline vehicle emissions are fixed over time, electric vehicle emissions will decline as the proportion of non-carbon emitting resources on the electricity grid increases.

Table 1. Annual Pounds of CO_2 Emitted by Vehicle Efficiency, Fuel Type, and Annual Miles Driven

Fuel Type	Vehicle Type	Avg Fuel Efficiency	CO_2 Emissions Rate	Annual Pounds of CO_2 Emissions for Various Annual Vehicle Miles Traveled		
				4,000	**12,000**	**20,000**
Gasoline	Pickup Truck	19.0 miles per gallon	19.5 lbs. CO_2/ gallon of gasoline	4,100	12,300	20,600
	CUV	27.5 miles per gallon		2,800	8,500	14,200
	Car	30.9 miles per gallon		2,500	7,600	12,600
Electricity	Car/CUV	3.3 miles per kWh	0.78 lbs. CO_2/ kWh *	900	2,800	4,700

Sources:

1. *CO_2 Emissions Rate for gasoline vehicles: U.S. Energy Information Administration (EIA) Carbon Dioxide Emissions Coefficients. Available at: https://www.eia.gov/environment/emissions/co2_vol_mass.php.*
2. *CO_2 Emissions Rate for electric vehicles: Avoided Energy Supply Cost Study. 2021. Table 80: Electric Grid Marginal Emissions rate, https://www.synapse-energy.com/sites/default/files/AESC%202021_20-068.pdf.*
3. *Average Fuel Efficiency for gasoline vehicles: U.S. Environmental Protection Agency (EPA). Automotive Trends Report. Figure ES-2. Production Share and Fuel Economy by Vehicle Type. Available at: https://www.epa.gov/automotive-trends/highlights-automotive-trends-report#Highlight2.*
4. *Average Fuel Efficiency for electric vehicles: 100 miles per 30 kWh for the 2018 Nissan Leaf in Loveday, Steven. U.S. News and World Report. What Is MPGe? July 05, 2018. https://cars.usnews.com/cars-trucks/what-is-mpge. The 2018 Nissan Leaf was selected as it represents the midpoint of the vehicles listed.*

**** Note: The marginal emission rate assumes that an EV is added to the grid with no corresponding changes in electricity composition, which is a conservative assumption as grid emissions are expected to decline over time.***

The aggregate emissions of the light-duty fleet of vehicles on Massachusetts roads is thus determined by a combination of the makeup of registered vehicles and the number of miles driven. The overall composition of the state's registered vehicles changes over time as new vehicles are purchased, old vehicles that no longer function or pass inspection are removed, and vehicles move in and out of state. Persuading new vehicle buyers to purchase an EV instead of a gasoline vehicle reduces future emissions from the transportation sector as vehicle purchases today determine the composition of the fleet for the vehicle's lifetime. Today's new vehicles are likely to be on the roads for the next 12 years or more.

BARRIERS TO PURCHASING AN EV

Customers may face barriers to purchasing an EV, including economic, technical, educational, and behavioral barriers as shown in Figure 3. Purchasing any new vehicle is a major financial decision for a consumer and addressing these real or perceived barriers can lead a consumer to purchase an EV instead of a gasoline-powered vehicle.

Figure 3. Real or Perceived Barriers to Purchasing an EV

Economic Barriers

- **Higher upfront costs** such as vehicle purchase price and home improvement costs
- **Cost uncertainty** about incentives, fuel, maintenance, battery replacement, and vehicle resale

Technical Barriers

- **Limited vehicles, chargers, and EV electric rate designs**
- **Battery recharging time and degradation**
- **Supply chain disruptions** including car and battery manufacturing

Educational Barriers

- **Low awareness of**:
  - EVs, EV incentives, and EV purchase prices
  - Fuel use/costs and emissions impacts/costs (electricity and gasoline)
  - Operational benefits of EVs (at-home refuelin, regenerative braking, quick acceleration)
  - Options for EV charging
- **Fear, uncertainty, or doubt about**:
  - Performance (range anxiety in general and in cold weather)
  - Safety including battery safety, safety during an accident, and low noise increasing accidents
- **Low dealer motivation resulting in**:
  - Lack of EV marketing
  - Uninformed dealers
- **More complex communications around:**
  - Increased electricity consumption and cost
  - Different units for gasoline (gallons) and electricity (kWh), meaning no direct comparison
  - Perception (in Massachusetts) that electricity is expensive while gasoline is cheap

Behavioral Barriers

- **Preference for** larger-sized vehicles, the latest and greatest products, meeting rare needs
- **Higher priority** on upfront purchase price than on longer-term operational and maintenance costs
- **Lack of interest** in new or different technology
- **Dislike of styling** prevalent in emerging vehicles
- **Apprehension about perceptions** of environmentally-friendly behavior
- **Aversion to change**
- **Brand loyalty**

Sources:

1. *National Research Council 2015. Overcoming Barriers to Deployment of Plug-in Electric Vehicles. Washington, DC: The National Academies Press. https://doi.org/10.17226/21725. Chapter 3. Understanding the Customer Purchase and Market Development Process for Plug-in Electric Vehicles.*
2. *Viola, F. Electric Vehicles and Psychology. Sustainability 2021, 13, 719. https://doi.org/10.3390/su13020719.*
3. *Crothers, B. Why Americans Don't Buy EVs. 2019. Forbes. https://www.forbes.com/sites/brookecrothers/2019/09/22/why-americans-dont-buy-electric-cars-hey-the-tesla-model-3-isnt-that-popular/?sh=45a99f2a37fd.*

MOR-EV PROGRAM PURPOSE AND DESIGN

MOR-EV provides rebates for the purchase or lease of BEVs, fuel-cell electric vehicles (FCEVs), and PHEVs with a purchase price below a certain threshold. The underlying objectives of MOR-EV include:

- increasing consumer awareness of EVs
- increasing consideration of EVs in new vehicle purchase decisions
- increasing EV sales
- reducing GHG emissions of the transportation sector
- improving air quality and associated health benefits
- enhancing vehicle fuel diversity and security
- promoting economic growth

The primary measure of success of the MOR-EV Program is associated with its influence on the number of EV purchases, as many of the other objectives are outcomes of an increased number of EV sales.

The design of MOR-EV evolved several times over the years. Detail on the four phases of the program is described below and summarized in Table 2.

Phase 1, from June 2014 until January 2016, included rebates of $2,500 for BEVs (including cars, CUVs, SUVs, and pick-up trucks), PHEVs with an onboard battery size of 15 kWh or more (referred to as PHEV Plus), and fuel cell electric vehicles (FCEV). Phase 1 also included rebates of $1,500 for PHEVs with an onboard battery of less than 15 kWh and $750 for fully electric zero emission motorcycles (ZEMs).

Phase 2, from February 2016 through December 2018, continued the rebate levels from Phase 1 for vehicles with a manufacturer's suggested retail price (MSRP) of less than $60,000. Vehicles with a MSRP greater than or equal to $60,000 received a reduced rebate of $1,000.

Phase 3, from January through September 2019, reduced the rebates from $2,500 to $1,500 for BEVs and FCEVs, and from $750 to $450 for ZEMs; it eliminated all rebates for PHEVs. The program did not provide rebates for any vehicles with a MSRP of $50,000 or higher. MOR-EV was then suspended from October through December 2019, during which time the program provided notice to potential participants that rebates would no longer be available. Rebates were ultimately provided to these EV purchasers, although these participants are all considered free riders in the analysis because they made the purchase decision with the understanding no rebate was available.

Phase 4, from January through December 2020[8], resumed the program at similar rebate levels as were offered in Phases 1 and 2 with two adjustments: (1) PHEV pluses received a $1,500 rebate instead of a $2,500 rebate (and were designated as eligible by having a range of 25 or more electric miles rather than based on onboard battery size) and (2) ZEM rebates concluded. Beginning June 25, 2020, commercial and

[8] Although MOR-EV continued past December 2020, this report focuses on 2014 through 2020 as 2020 is the last full year of actual data.

nonprofit fleets (including rental cars, company cars, and delivery vehicles) also became eligible to receive rebates.[9]

Table 2. Summary of MOR-EV Program Design Phases

		Phase 1: Initial program design		**Phase 2:** Reduced rebates for vehicles with high MSRPs			**Phase 3:** Reduced rebate values, PHEV ineligible, high MSRP ineligible	**Phase 4:** Resume Phase 1 rebate values modifications, no rebates for PHEVs with low e-range
Program Year		2014	2015	2016	2017	2018	2019	2020
Timeframe		Jun - Dec 2014	Jan 2015 – Jan 2016	Feb – Dec 2016	2017	2018	Jan - Sep 2019	2020
# of Months		7	13	11	12	12	9	12
Vehicle Types	FCEV	$2,500					$1,500	$2,500
	BEV	$2,500					$1,500	$2,500
	PHEV Plus >15kWh	$2,500					$0	$1,500
	PHEV <15kWh	$1,500					$0	$1,500
	ZEM	$750					$450	N/A
Rebate Eligibility Limitations	MSRP/ Purchase Price-Based	N/A		$1,000 for MSRP ≥ $60,000			Purchase price must be ≤ $50,000	
	Battery Capacity-Based	N/A		N/A			N/A	E-miles must be ≥ 25

Sources: Massachusetts Department of Energy Resources, Massachusetts Clean Cities Coalition, and Center for Sustainable Energy. 2021. Massachusetts Offers Rebates for Electric Vehicles. Available at: https://mor-ev.org/.

FEDERAL TAX CREDIT DESIGN

The Energy Improvement and Extension Act of 2008 established the Qualified Plug-in Electric Drive Motor Vehicle Tax Credit (or FTC) for EVs.[10] The FTC enables purchase of eligible new BEV or PHEV to offset

[9] Though not included in these results, MOR-EV added rebates for medium-duty and heavy-duty trucks in February 2021.

[10] Energy Improvement and Extension Act of 2008. Section 205. Available at: https://www.congress.gov/bill/110th-congress/house-bill/6049.

$2,500 to $7,500 in federal taxes owed if the vehicle meets certain criteria.[11] For BEVs, the maximum credit is $7,500. For PHEVs, the maximum credit varies based on battery capacity.

INCENTIVE DESIGN CONSIDERATIONS

A well-designed incentive is critical to achieving a program's objectives.[12] This section defines and describes seven best practices in incentive design, including: magnitude, clarity, immediacy, availability, accessibility, equity, and certainty. It also examines whether the MOR-EV rebate and federal tax credit (FTC) achieve these best practices.

Magnitude: An incentive is of sufficient magnitude when the level of the incentive is adequate to influence vehicle purchase behavior. Two main parties influence vehicle purchase behavior: customers and dealerships. While the MOR-EV rebate and the federal tax credit (FTC) may impact customer behavior and customer choices, importantly, both programs have little to no direct effect on a dealer's motivation to sell more EVs as the incentive is provided to customers and not dealers. There are two ways to examine the customer impact of the MOR-EV rebate and FTC. First, one can compare the incentives to the purchase price of the vehicle. Second, one can compare the incentives to the cost differential between an EV and a similar gasoline-fueled vehicle.

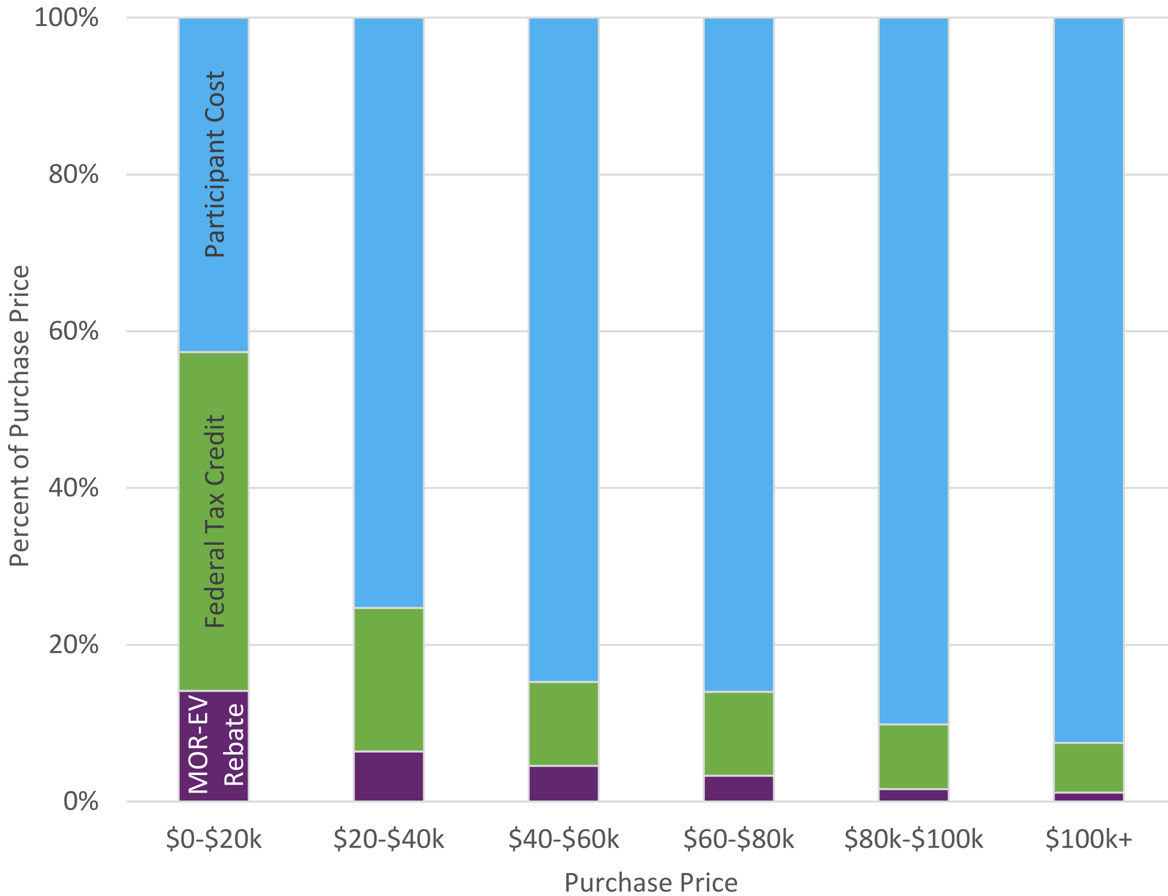
During Phase 4 of the MOR-EV Program, the rebate was $2,500 for BEVs and $1,500 for PHEVs. Figure 4 shows that MOR-EV incentives ranged from more than 14 percent of the price of a low-cost vehicle to 1 percent of the price of a high-cost vehicle. This analysis also estimates the average FTC of $6,000 is three times higher than the average MOR-EV rebate of $2,000. The FTC ranges from 43 percent of the price of a low-cost vehicle to 6 percent of the price of a high-cost vehicle. In summary, customers who take advantage of both the MOR-EV rebates and FTCs may receive $8,000 in incentives on average, representing 8 to 57 percent of the price of a vehicle. While the MOR-EV rebate and FTCs may be necessary for vehicles with lower purchase prices, it seems unlikely that these incentives are influencing the purchase of higher priced vehicles.

---

[11] Vehicles must be purchased after December 31, 2009, use a traction battery with at least four kilowatt hours (kWh) of capacity and an external plug-in source to recharge, have a vehicle weight rating no higher than 14,000 pounds, and meet emissions standards.

[12] National Research Council 2015. Overcoming Barriers to Deployment of Plug-in Electric Vehicles. Washington, DC: The National Academies Press. https://doi.org/10.17226/21725. Chapter 7. Incentives for the Deployment of Plug-In Electric Vehicles.

Figure 4. Incentives and Participant Cost as a Percent of Purchase Price



Sources:

1. *Participant Costs and MOR-EV Rebate: Center for Sustainable Energy. MOR-EV Application Data, Collected by the Center for Sustainable Energy from 2014-2021.*
2. *FTC: US Department of Energy and US Environmental Protection Agency. Federal Tax Credits for New All-Electric and Plug-in Hybrid Vehicles. Available at: https://www.fueleconomy.gov/feg/taxevb.shtml*

Notes:

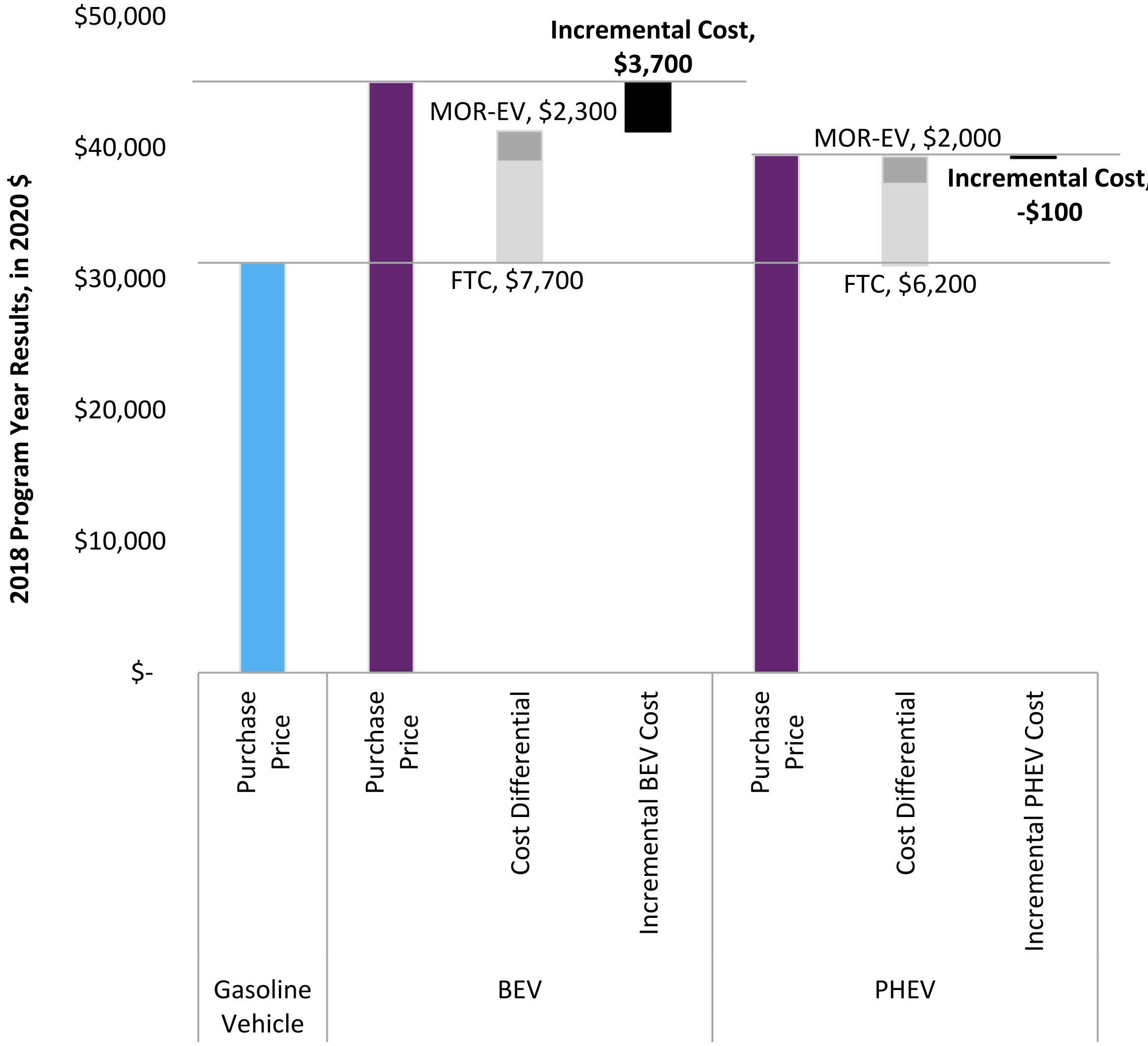
1. *Includes rebates for free riders.*
2. *Participant Cost = (Purchase Price) – (MOR-EV Rebate Received) – (Average Annual Maximum FTC for BEV or PHEV, as applicable)*
3. *This analysis assumes program participants received the maximum FTC available to them.*

Figure 5 shows that the incremental cost of a BEV is $3,700 and the incremental cost of a PHEV is -$100. In 2018, the average purchase price of a BEV was $45,000 whereas the average purchase price of a similar gasoline vehicle was $31,300. The average MOR-EV BEV rebate of $2,300 was 17 percent of the $13,800 cost differential for a BEV. Adding in the average FTC of $7,700 in 2020 dollars that was available to vehicles that are not Tesla and General Motors' Cadillac and Chevrolet models,[13] the incentives covered 73 percent of the cost differential for the BEV.

In 2018, the average purchase price of a PHEV was $39,500 whereas the average purchase price of a similar gasoline vehicle was $31,300. On its own, the average MOR-EV PHEV rebate of $2,100 was 25 percent of the $8,200 cost differential for a PHEV. With the average FTC of $6,200 included, the incentives covered $100 more than the cost differential for the PHEV.

[13] Note, the Federal Tax Credit is no longer available to EVs made by the two most popular manufacturers in MOR-EV, Tesla, and Chevrolet.

Figure 5. Incremental Costs to Purchase BEVs and PHEVs



Sources:

1. *Gasoline Vehicle, BEV, and PHEV Purchase Prices: International Council on Clean Transportation (ICCT). 2019. Working Paper 2019-06. Available at: https://theicct.org/sites/default/files/publications/EV_cost_2020_2030_20190401.pdf*
2. *BEV and PHEV MOR-EV Incentives: Center for Sustainable Energy. MOR-EV Application Data, Collected by the Center for Sustainable Energy from 2014-2021.*
3. *BEV and PHEV FTC Incentives: U.S. Department of Energy and U.S. EPA. Federal Tax Credits for New All-Electric and Plug-in Hybrid Vehicles. Available at: https://www.fueleconomy.gov/feg/taxevb.shtml*

Notes:

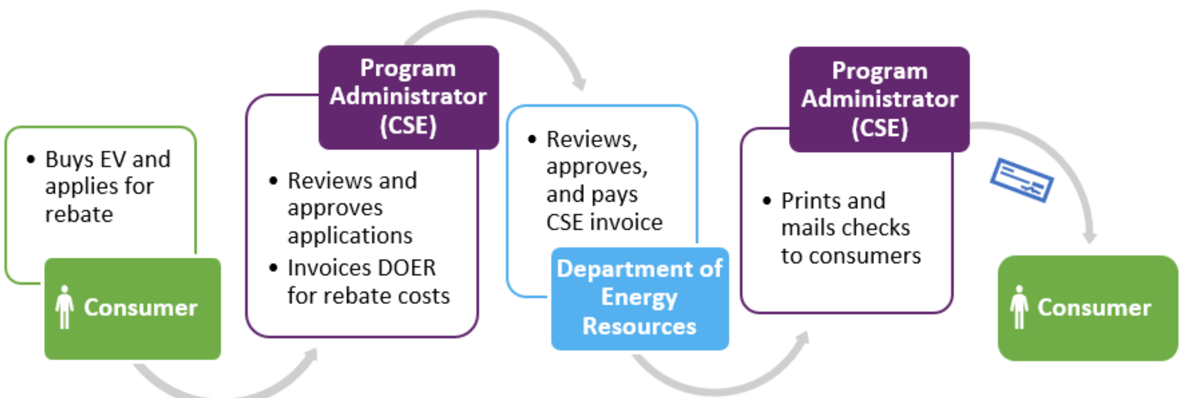
1. *The incremental cost is higher for vehicles without access to the FTC, which include two of the top-selling vehicles.*
2. *The incremental cost is the additional upfront cost to purchase an EV. The fuel savings experienced over the lifetime of the vehicle will offset these costs as described in the Cost-Effectiveness section later in this report.*

Clarity: Clarity means the value of the incentive is easy to communicate to dealers and consumers. As the MOR-EV incentive is a fixed value rather than a percentage, the amount is transparent and clear. The FTC is not as clear since the credit depends on how much the customer will owe in taxes next year, which they may not know at the time of vehicle purchase. For PHEVs, the credit amount further varies based on battery capacity.

A particular clarity challenge for MOR-EV is the $50,000 purchase price cap. Some EV models have configurations that are less than $50,000, while other configurations of the same model cost more than $50,000. With vehicle sales so close to the purchase price cap, there can be dealer and consumer uncertainty about whether the vehicle will be eligible for the rebate (as delivery fees, dealer markups, options, discounts, and sales can further complicate the matter).

Immediacy: Immediacy means a purchase incentive is available to the consumer upfront, effectively reducing the cost at the point of sale. The MOR-EV rebate is designed as a reimbursement incentive; Figure 6 illustrates the rebate process and the parties involved. Customers need to apply for the MOR-EV rebate, and can do so up to three months after purchasing or leasing and registering the vehicle. Rebate checks are mailed within 90 calendar days from the completion of the application.[14]

Figure 6. The MOR-EV Program Rebate Process



Source: Massachusetts Department of Energy Resources.

DOER is subject to state procurement laws, which effectively limits DOER to reimbursement contracts. An incentive paid at the time of purchase (using a method to quickly draw state funds or a third party willing and able to take short-term debt to float the incentive cost until it is paid by DOER) or an incentive available at the time of purchase (such as sales tax exemption), would be more effective.

[14] Massachusetts Department of Energy Resources. 2020. *Implementation Manual for the FY 2020-21 Massachusetts Offers Rebates for Electric Vehicles (MOR-EV) Program*. Available at: https://mor-ev.org/sites/default/files/docs/Implementation%20Manual%20for%20MOR-EV.pdf.

A concern with the purchase incentive delay associated with a reimbursement incentive process is that it is self-selecting for applicants with the least need for the incentive. Effectively, only consumers with the ability to float the incentive value for a few months can participate in the program. This concern may be assuaged by the fact that new vehicle purchases in general are often economically irrational decisions made by affluent constituents more likely to be able to float the incentive value (i.e., those unable to float $2,500 may not be those well suited to purchase a new vehicle).

The FTC can be an even longer wait for customers, as this incentive is provided after the customer files their federal taxes up to 12 months after vehicle purchase.

Availability: Availability means that a variety of vehicle types (new and used), sizes, makes, models, customer types (e.g., residents, businesses, and municipal governments), and ownership models (purchases and leases) are eligible for incentives. MOR-EV incentives are available for a variety of technologies and ownership models. However, the incentives have focused on new vehicles. Furthermore, the program limited participation to residents until mid-2020 when business and municipal government customers began to participate in the program. The FTC does not apply to used vehicles or business and municipal government purchases.

Accessibility: The MOR-EV incentive is a rebate, which requires customers to fill out an application form that is available online or by customer request through email or phone. The form requires additional time and effort to obtain, fill in, and submit; customers who wait too long may forget to apply for the rebate. Also, the rebate is mailed, so it can be mistaken for junk mail and thrown out.

The FTC suffers from similar issues, though the application is integrated as a component of the customer's federal tax filing rather than an additional separate process.

Equity: LMI households typically purchase lower cost vehicles, usually used vehicles, and own cars for longer periods of time.[15] These older vehicles require more maintenance and have a lower fuel efficiency than newer cars, leading to increased fuel costs.[16] For LMI populations, these fuel costs are disproportionately higher relative to their income as compared to higher-income households. Any cost-savings LMI households can reap from increased fuel efficiency will thus represent a higher percent of their income. Additionally, urban communities and LMI populations tend to be in areas with lower air quality due in part to transportation-related air pollution. Electrifying transportation can help reduce emissions and offer additional health benefits for these populations.

---

[15] Consumer Federation of America. *Trump Rollback of Fuel Economy Standards Will Ravage Low-Income Consumer Budget Saving at the Pump Important to All Consumers, but Especially Financially Challenged Consumers.* Press Release. December 19, 2018. Available at: https://consumerfed.org/press_release/trump-rollback-of-fuel-economy-standards-will-ravage-low-income-consumer-budget/

[16] Pendall, Rolf, Evelyn Blumenberg and Casey Dawkins. *What if Cities Combined Car-Based Solutions with Transit to Improve Access to Opportunity?* Urban Institute. June 22, 2016. Available at: https://www.urban.org/research/publication/what-if-cities-combined-car-based-solutions-transit-improve-access-opportunity

Incentives should be appealing to all customers, regardless of income, race, ethnicity, age, primary language, and housing type, among other characteristics. MOR-EV is designed to influence new vehicle purchase decisions, and new vehicles are mostly purchased by the affluent.[17] The rebates do not scale by income level, nor do they offset 100 percent of the upfront costs of a new electric vehicle. As a result, LMI residents may not be able to take advantage of the rebates.

Certainty: Certainty is when customers, manufacturers, and dealers can rely on and plan for incentives. While the MOR-EV Program has provided rebates for seven years, the incentive levels changed at several points and the program was suspended for three months in late 2019 due to funding shortages. All these changes may have resulted in customer uncertainty in the availability of incentives.

Although the FTC is subject to phase out, notice of the phase-out is provided upfront and ample time is provided for consumers to complete purchases before the phase out goes into effect. The MOR-EV Program faces a certainty challenge in the future, as EV sales will need to continue to accelerate for the state to achieve its net zero emissions goals. While the 2019 Supplemental Budget provided DOER with sufficient Regional Greenhouse Gas Initiative (RGGI) funds to maintain the program through 2020 and 2021, it is unclear how long RGGI funds will be sufficient to support a broadly available EV incentive.[18]

In summary, rebates are not provided at the point of sale and therefore require the customer to apply after purchase and registration, which takes additional time and effort and is less convenient.[19] While the design of the MOR-EV rebate is relatively simple and easy-to-understand, rebate eligibility is limited to residents who are new car buyers, and the low dollar amount relative to the purchase price may not be sufficient to sway a purchasing decision without a robust FTC in place. Low-income households may not be able to afford to purchase new vehicles and as a result, rebates are not available to this population. Lastly, program changes require press and education, which takes resources away from addressing barriers to EV adoption. A program that is designed with a built-in phase-out provides information about upcoming program changes to consumers upfront, for consideration as they plan their purchase.

OTHER FACTORS IMPACTING PROGRAM RESULTS

MOR-EV Program participation has been impacted by factors outside of DOER's control and influence, including free ridership, the availability of the FTC, the number and types of EVs, and the COVID-19 pandemic.

FREE RIDERSHIP

[17] *Low-income Americans Struggle to Afford Decade-Old Used Cars*. Dealer News Today. October 14, 2019. Available at: https://www.dealernewstoday.com/low-income-americans-struggle-to-afford-decade-old-used-cars/

[18] RGGI is the primary source of funding for the MOR-EV Program.

[19] It is important to note that a point-of-sale approach is likely to increase free-ridership, so long as the program is not targeted to those in need of the incentive.

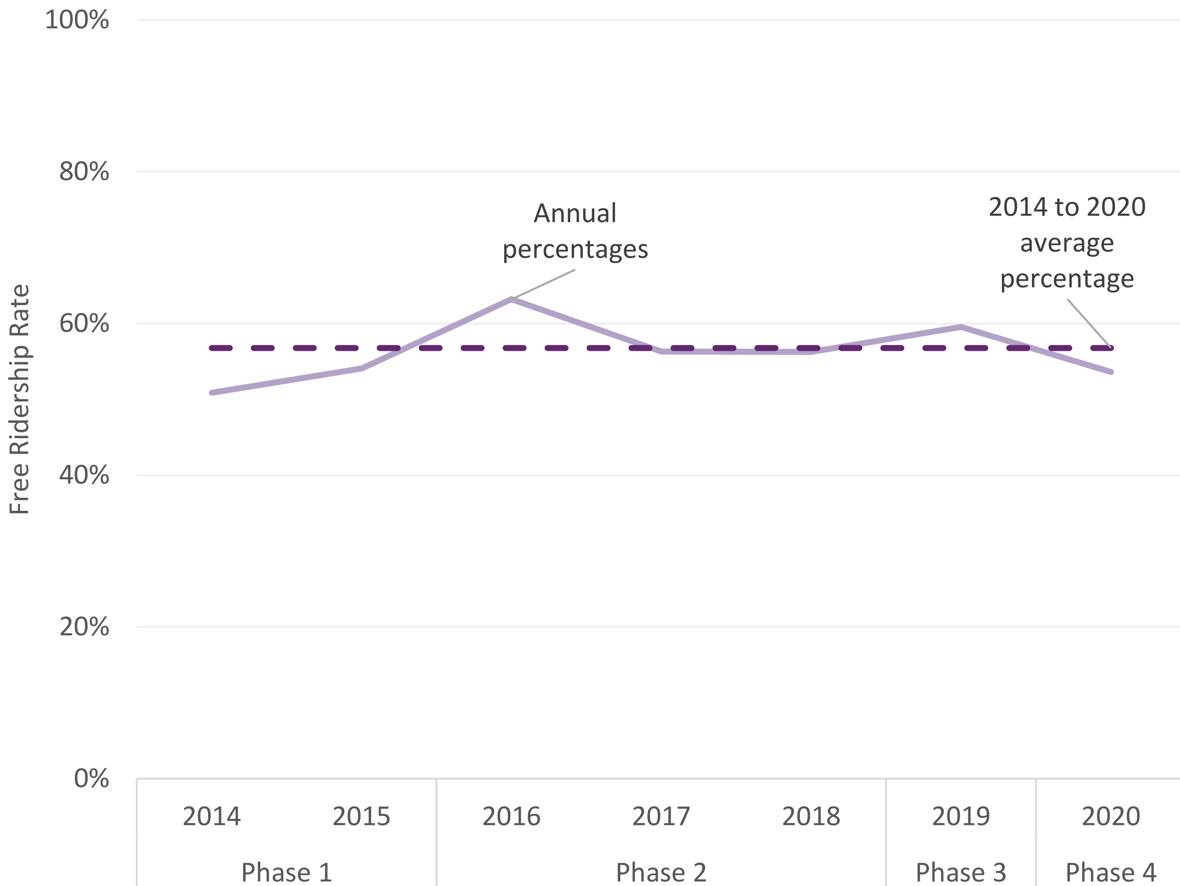
Free ridership under MOR-EV is influenced by two factors: the first is the purchase price of the vehicle, where a higher price is associated with higher free ridership. The second is the incremental cost of the EV, where a lower incremental cost is associated with higher free ridership. For example, PHEVs have a lower incremental cost—relative to gasoline-fueled vehicles—than BEVs (and a lower technological leap-of-faith) and thus a higher rate of program free ridership. The amount of time between purchase and rebate payment may also influence free ridership, where a longer and more complex incentive payment process is associated with lower free ridership.

This report identifies free riders according to MOR-EV participant survey results and vehicle purchase dates and includes the cost of rebates provided to free riders in the analysis. However, it excludes the benefits created from free rider vehicle operations from the analysis because the benefits would have occurred with or without the program.

Free riders were identified and removed from relevant analyses in one of two ways, depending on the data year. For Program Years 2014 to 2018 and 2020, the analysis relied on responses to a MOR-EV customer survey. Question 11 of a survey sent to all participants post-rebate asks: “Would you have purchased or leased your EV without the MOR-EV rebate?” If the participant responded “Yes” to this question, they were a free rider. Fifty-six percent of survey respondents replied yes to this question; this percentage was multiplied by the total number of participants to calculate a total number of free riders. The next step was to remove the benefits attributed to these free riders in these program years from the cost-effectiveness calculations.

For Program Year 2019, this analysis relied on application and survey data. From October to December 2019, no participants were expecting to receive the MOR-EV rebate because the program was suspended. As such, all program incentive applicants during this time were free riders and removed from the data using the date of purchase in their application. In addition, responses to survey question 11 were used to find a free ridership rate for the remaining 2019 participants. The resulting free ridership rate of 59 percent was multiplied by the remaining 2019 participants to calculate the free riders, and the benefits associated with these free riders removed from the 2019 program year. The solid purple line in Figure 7 shows the MOR-EV Program free ridership rates vary by year. The dashed purple line shows an average free ridership rate of 57 percent for 2014 to 2020. It is important to note that high free ridership rates may indicate there is an opportunity to improve the program design, but the EV purchases made by free riders still provide benefits such as GHG emissions reductions.

Figure 7. MOR-EV Program Free Ridership Rates, Average and Over Time

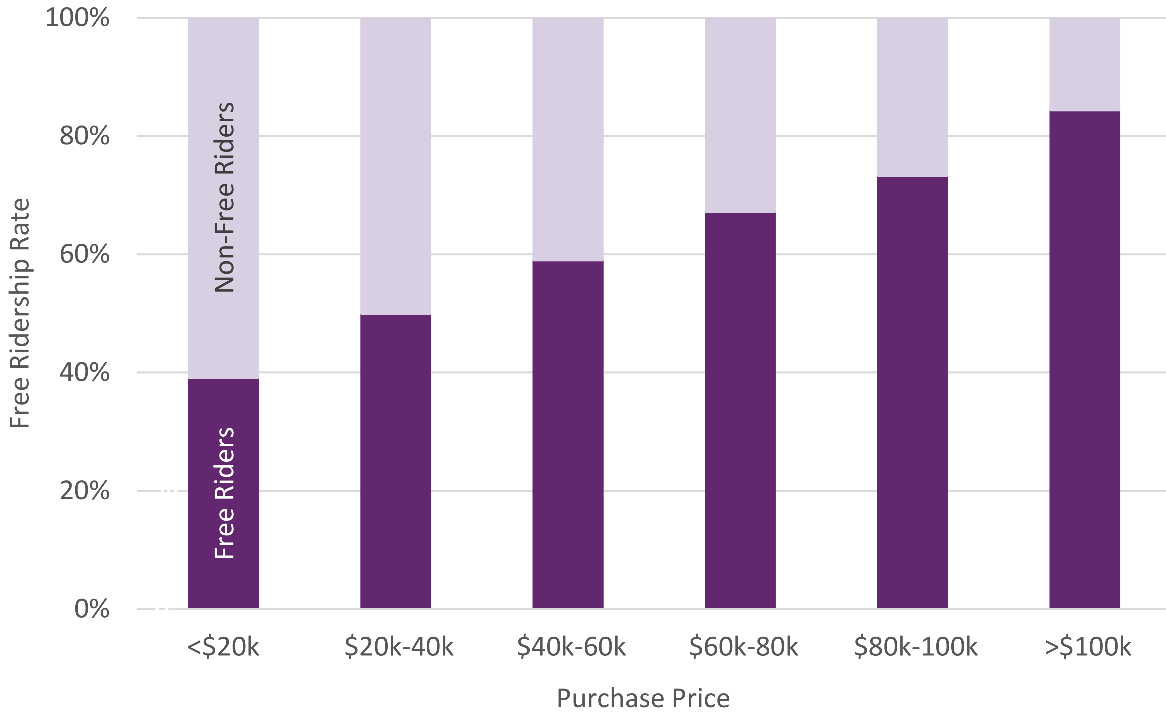


Source: Center for Sustainable Energy. MOR-EV Survey Data, Collected by the Center for Sustainable Energy from 2014-2021.

In summary, half of the individuals who applied for MOR-EV rebates would have made the EV purchase without the MOR-EV rebate. These individuals purchased BEVs that were approximately $14,000 more than gasoline vehicles and PHEVs that were approximately $8,000 more than gasoline vehicles. Many EVs were luxury vehicles with purchase prices of more than $50,000. Those who could afford to purchase a new, higher priced EV and chose to make that new vehicle purchase did not necessarily need the MOR-EV rebate to make that purchase.

Figure 8 shows that free ridership rates increase with higher purchase prices. Roughly 40 percent of program participants who purchased a vehicle with a price of up to $20,000 were free riders whereas more than 80 percent who purchased a vehicle with a price of $100,000 or more were free riders.

Figure 8. MOR-EV Program Free Ridership Rates by Vehicle Purchase Price



Source: Center for Sustainable Energy. MOR-EV Survey Data, Collected by the Center for Sustainable Energy from 2014-2021.

FEDERAL TAX CREDIT PHASE-OUT IMPACTS

The tax credit phases out at the beginning of the second calendar quarter after a manufacturer has sold 200,000 eligible vehicles. To date, the phase-out is in effect for all Tesla and General Motors' models. Tesla vehicles delivered from January to June 2019 received a credit of $3,750, from July to December 2019 received a $1,875 credit, and from January 2020 on received no credit. General Motors vehicles delivered from April to September 2019 received a $3,750 credit, from October 2019 to March 2020 received a $1,875 credit, and from April 2020 on received no credit. Tesla and Chevrolet are the two most popular brands bought by MOR-EV participants. They continue to supply the majority of BEVs that participate in MOR-EV, even following the complete phase-out of federal incentives.[20]

Table 3 shows the impact of the phase-out on the average FTC for BEVs over time. The average FTC for BEVs decreases from $7,500 prior to 2019, to $4,500 in 2019, to $1,900 in 2020.

[20] Eighty-three percent of BEV MOR-EV participants in 2021 purchased vehicles from these two manufacturers.

Table 3. Calculation of Average FTC

		2014-2018 Average	2019	2020	2014-2020 Average
BEVs	% MOR-EV Participants in Phase-Out	0%	65%	77%	22%
	Average FTC for Vehicles in Phase-Out	-	$2,900	$200	$1,500
	Average FTC for All Other Vehicles	$7,500	$7,500	$7,500	$7,500
	Average FTC	**$7,500**	**$4,500**	**$1,900**	**$6,100**
PHEVs	**Average FTC**	**$5,900**	**N/A**	**$5,300**	**$5,900**

Sources:

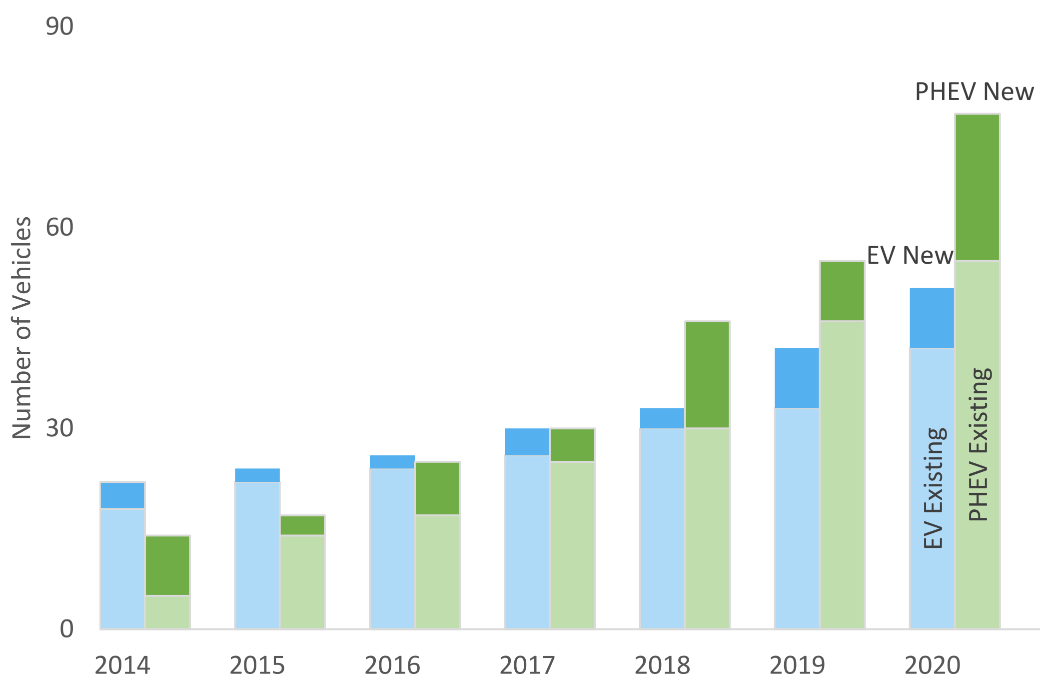
1. *Average FTC from Fueleconomy.gov. Federal Tax Credits for New All-Electric and Plug-in Hybrid Vehicles. Available at: https://www.fueleconomy.gov/feg/taxevb.shtml*
2. *% Vehicles in Phase Out from Center for Sustainable Energy. MOR-EV Application Data, Collected by the Center for Sustainable Energy from 2014-2021.*

Note: Includes free riders.

NUMBER AND TYPES OF ELECTRIC VEHICLES

The number and types of EVs available spur interest in EVs and purchase. Figure 9 shows 29 new EV models and 63 new PHEV models launched between 2014 and 2020. Fifty-one EV models and 77 PHEV models were available to customers by 2020, for a total of 128 EV options.

Figure 9. Number and Types of Electric Vehicles by Year



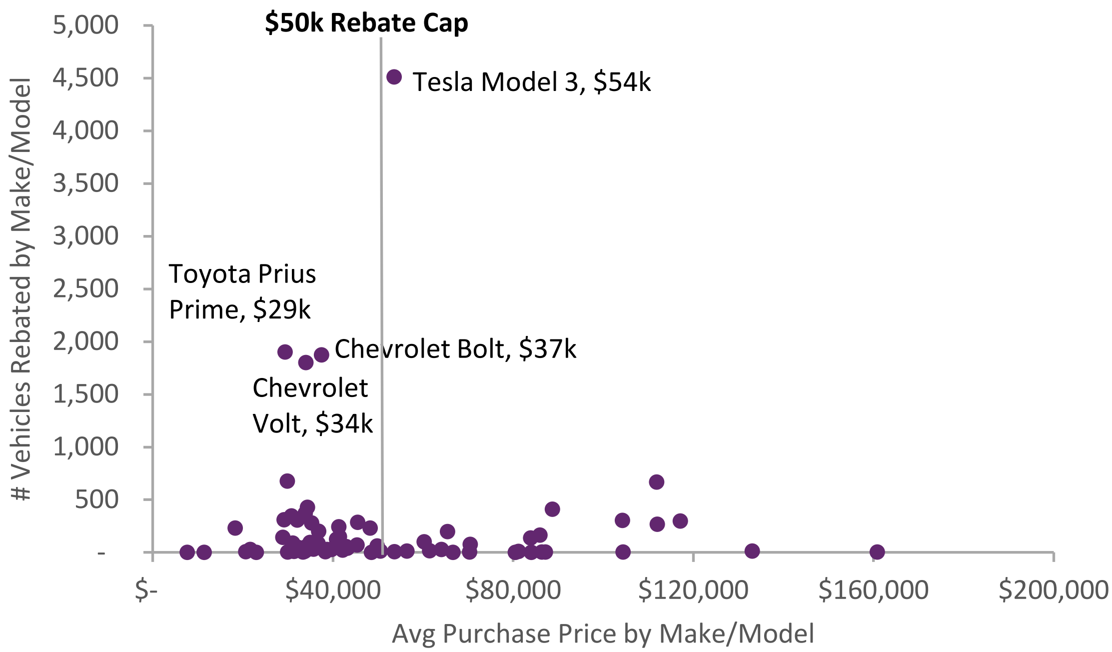
Source: Fueleconomy.gov. Federal Tax Credits for New All-Electric and Plug-in Hybrid Vehicles. Available at: https://www.fueleconomy.gov/feg/taxevb.shtml

Figure 10 shows the number of MOR-EV rebates issued for each vehicle make and model, ordered from lower purchase prices on the left to higher purchase prices on the right. The most popular vehicles rebated by the MOR-EV Program, with more than 1,500 rebates each, are:

- Tesla Model 3, EV, 2019 launch
- Toyota Prius Prime, PHEV, 2017 launch
- Chevrolet Bolt, EV, 2017 launch
- Chevrolet Volt, PHEV, 2011 launch

The most popular vehicles range in purchase price from $29,000 to $54,000.

Figure 10. Number of Vehicles Rebated and Average Purchase Price by Make and Model



Source: Center for Sustainable Energy. MOR-EV Application Data, Collected by the Center for Sustainable Energy from 2014-2021.

COVID-19 PANDEMIC

The COVID-19 pandemic altered driving and vehicle purchasing habits significantly from March through December 2020. As a result, 2018 and 2019 are the most recent, representative years of program performance for analysis of cost-effectiveness.

2014-2020 MOR-EV PROGRAM RESULTS

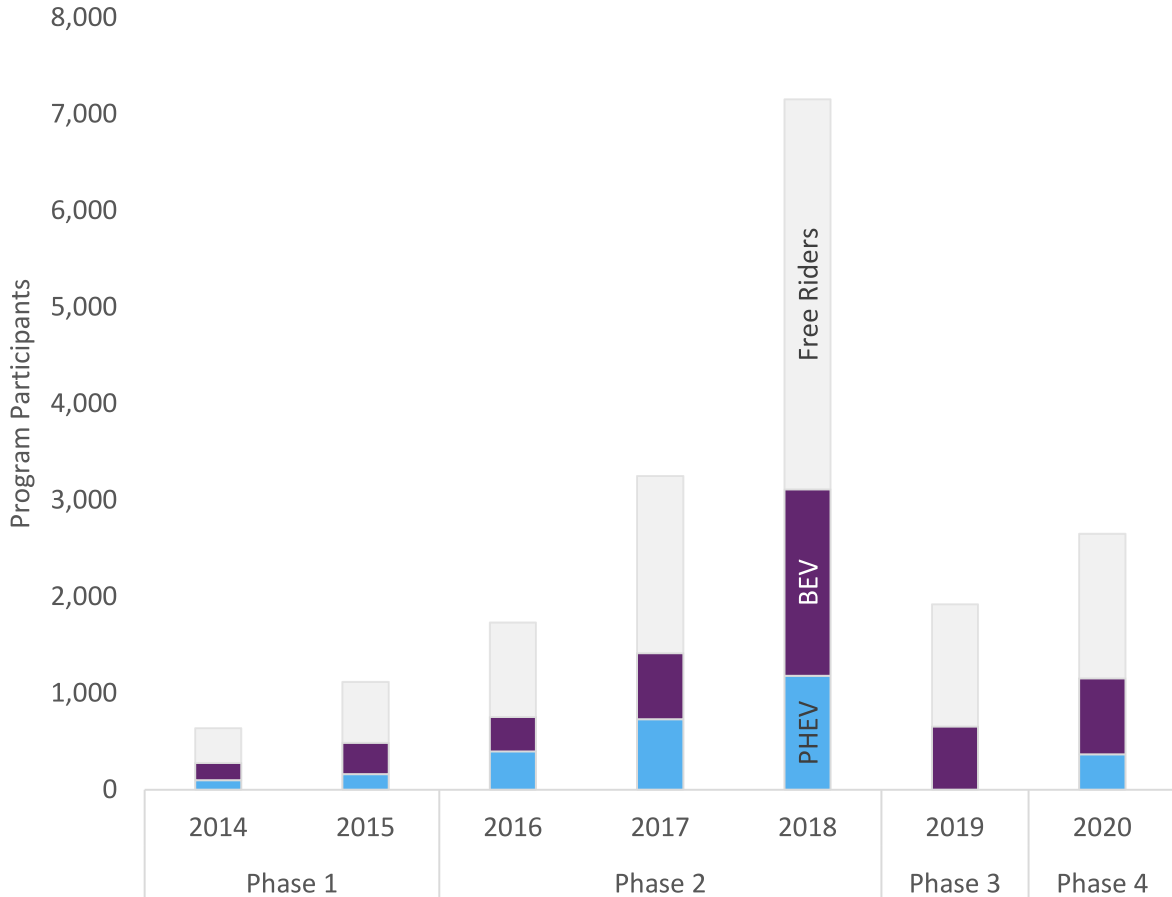
This section evaluates MOR-EV Program performance using several key metrics. It includes examination of participation, funding and spending, and cost-effectiveness. The following notes apply to all data presented throughout this section, unless otherwise stated.

- No participants purchased FCEVs during the program and therefore FCEVs do not show up in program results.
- Participants purchased 30 ZEMs and 17 of these were considered free riders. The small number of ZEMs were not included in the analysis.
- Applicants self-reported vehicle purchase price and there were 20 instances of vehicle purchase prices not listed or significantly understated. The average reported vehicle purchase price for the same make and model replaced this data.

PARTICIPATION

Participation is the number of individuals who received a rebate. Figure 11 shows the number of vehicle purchases rebated by the program, broken out by BEVs in purple and PHEVs in blue. The figure also shows free riders in grey. From 2014 to 2020, the program rebated 7,855 vehicle purchases which represent program participants. From 2014 to 2018, the number of program participants increased, reaching a peak in 2018. In 2019, program participation decreased due to the reduction in the BEV rebate, the elimination of the PHEV rebate, the elimination of rebates for vehicles with a purchase price of $50,000 and up, and the suspension of the program for the last quarter of the year. In 2020, the program reinstated rebates for both BEVs and PHEVs and participation began to increase slightly. However, the onset of the COVID-19 pandemic impacted participation from March 2020 on.

Figure 11. Program Participants and Free Riders

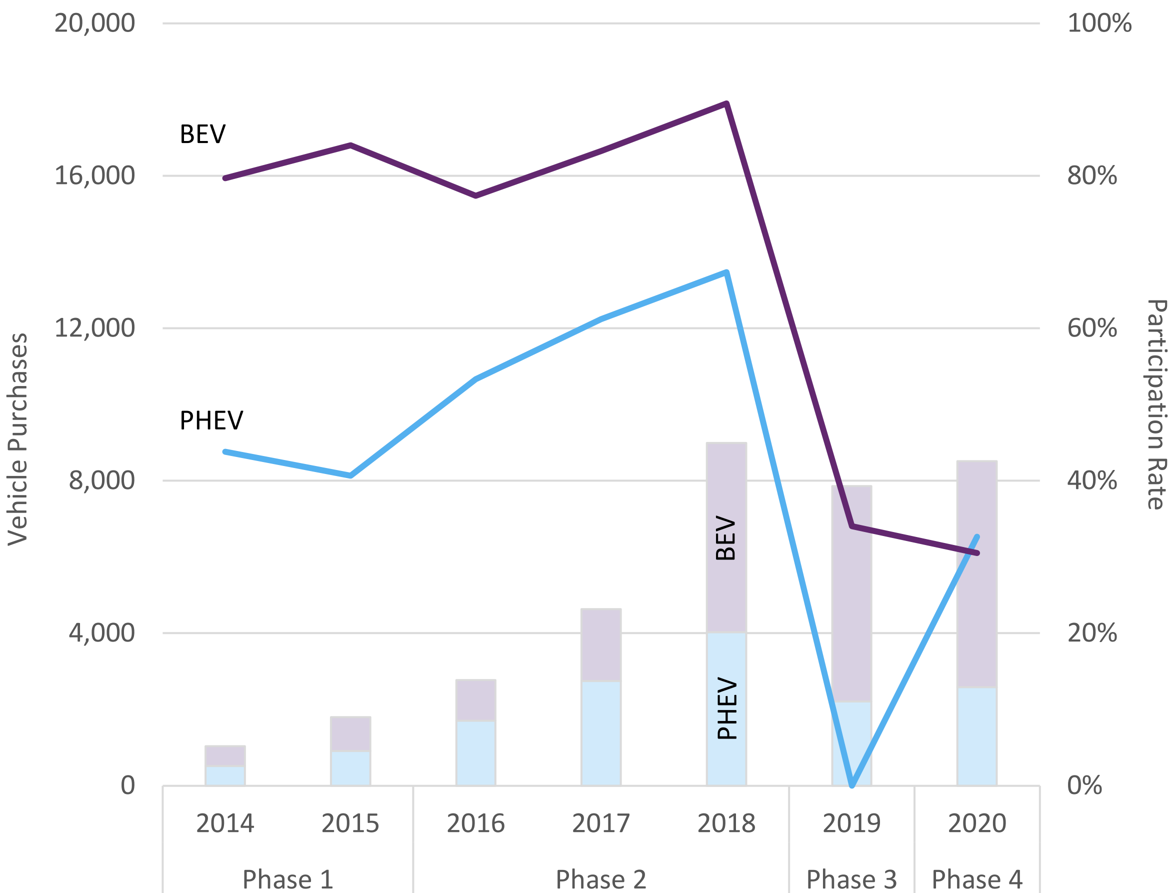


Source: Center for Sustainable Energy. MOR-EV Application Data, Collected by the Center for Sustainable Energy from 2014-2021.

Figure 12 shows the percent of BEV and PHEV purchasers in Massachusetts who applied for and received a MOR-EV rebate, referred to as the participation rate. The participation rate may indicate the extent to which the MOR-EV rebate influenced the vehicle purchase and the extent to which EV purchasers are aware of the MOR-EV Program. BEVs and PHEVs are shown by separate lines (in purple and blue). The purple and blue portions of the stacked columns below the lines show the total statewide purchases of BEVs and PHEVs (whether they participated in the MOR-EV Program) respectively. It is important to note that the participation rate calculation includes free riders. The participation rate rose from 2014 to a peak in 2018, at 89 percent for BEVs and 67 percent for PHEVs. Based on state data on BEV and PHEV purchases, calculations show that 10 percent of BEV purchasers and 30 percent of PHEV purchasers did not apply for the MOR-EV rebate due to either a lack of awareness or need.

In 2019, the participation rate declined to 34 percent for BEVs as rebate amounts decreased from $2,500 to $1,500 and 0 percent for PHEVs as the program eliminated rebates. In 2020, the PHEV participation rate rebounded to 33 percent for PHEVs nearly matching the 31 percent BEV participation rate. Though MOR-EV rebates declined in 2019 and 2020 due to changes in the rebate levels and the temporary suspension of the program, the figure shows that total statewide BEV and PHEV vehicle purchases remained strong, with the total number of purchases at 2018 levels. Importantly, PHEVs represented a greater proportion of EV purchases from 2014 to 2017, but BEVs became the predominant vehicle type purchased from 2018 on.

Figure 12. MOR-EV Participation Rate



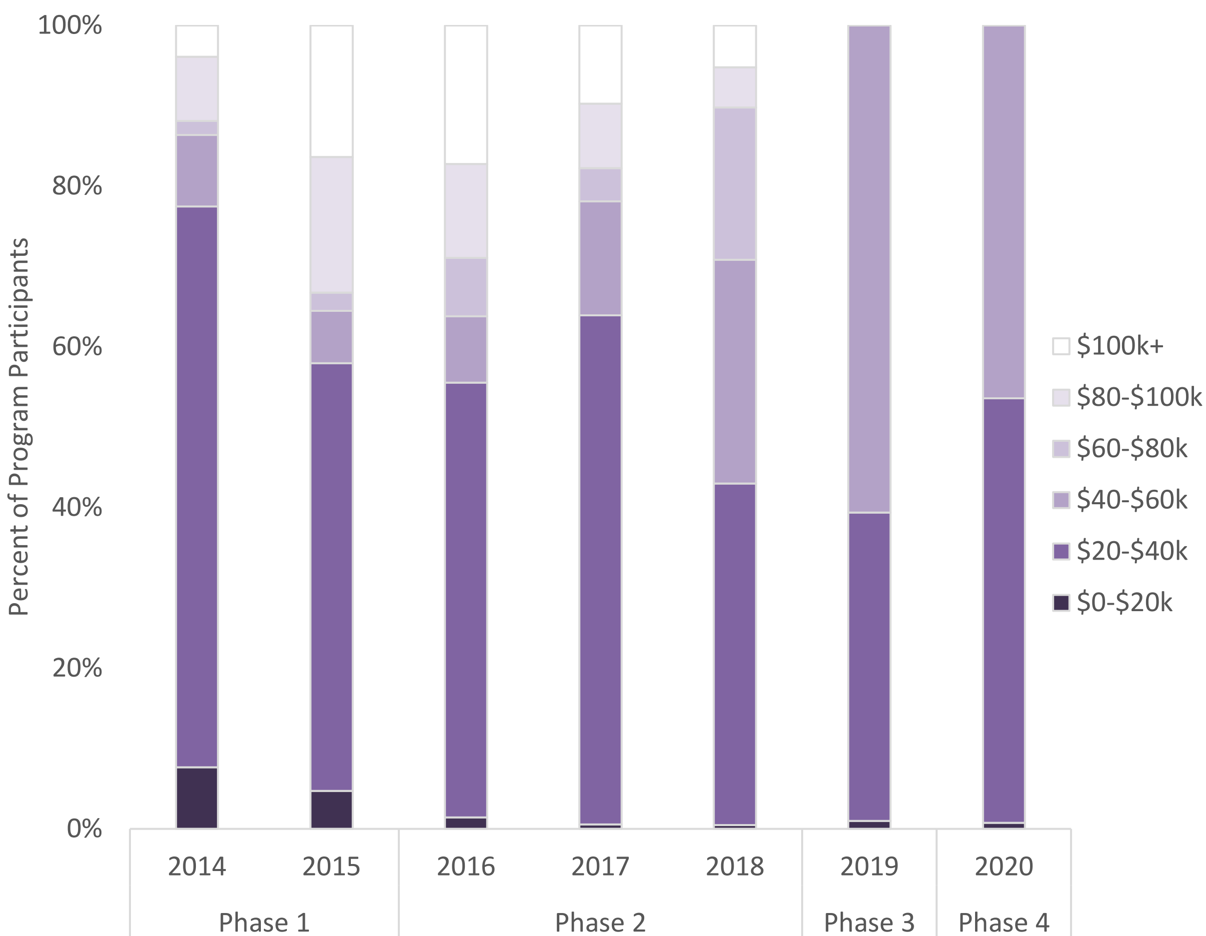
Sources:

1. *Total Massachusetts BEV and PHEV purchases were collected from the Alliance for Automotive Innovation at: https://www.autosinnovate.org/resources/electric-vehicle-sales-dashboard*
2. *MOR-EV Program Participation: Center for Sustainable Energy. MOR-EV Application Data, Collected by the Center for Sustainable Energy from 2014-2021.*

Note: The participation rate includes free riders.

Figure 13 shows the percent of program participants by five purchase price groupings. In general, the program rebated lower priced vehicles of up to $60,000 (shown towards the bottom by the darker shades of purple) more often than higher priced vehicles of $60,000 and up (shown towards the top by the lighter shades of purple). As expected, the proportion of lower priced vehicles rebated by the program increased with the 2016 reduction in rebates to $1,000 for vehicles with an MSRP of $60,000 and up and the 2019 elimination of rebates for vehicles with a purchase price of $50,000 and up. However, it is important to note that most EV makes and models are higher priced than gasoline-fueled vehicles. $40,000 to $60,000 vehicles are significantly higher cost than the average gasoline-fueled vehicle priced at roughly $30,000.

Figure 13. Percent of Program Participants by Vehicle Purchase Price

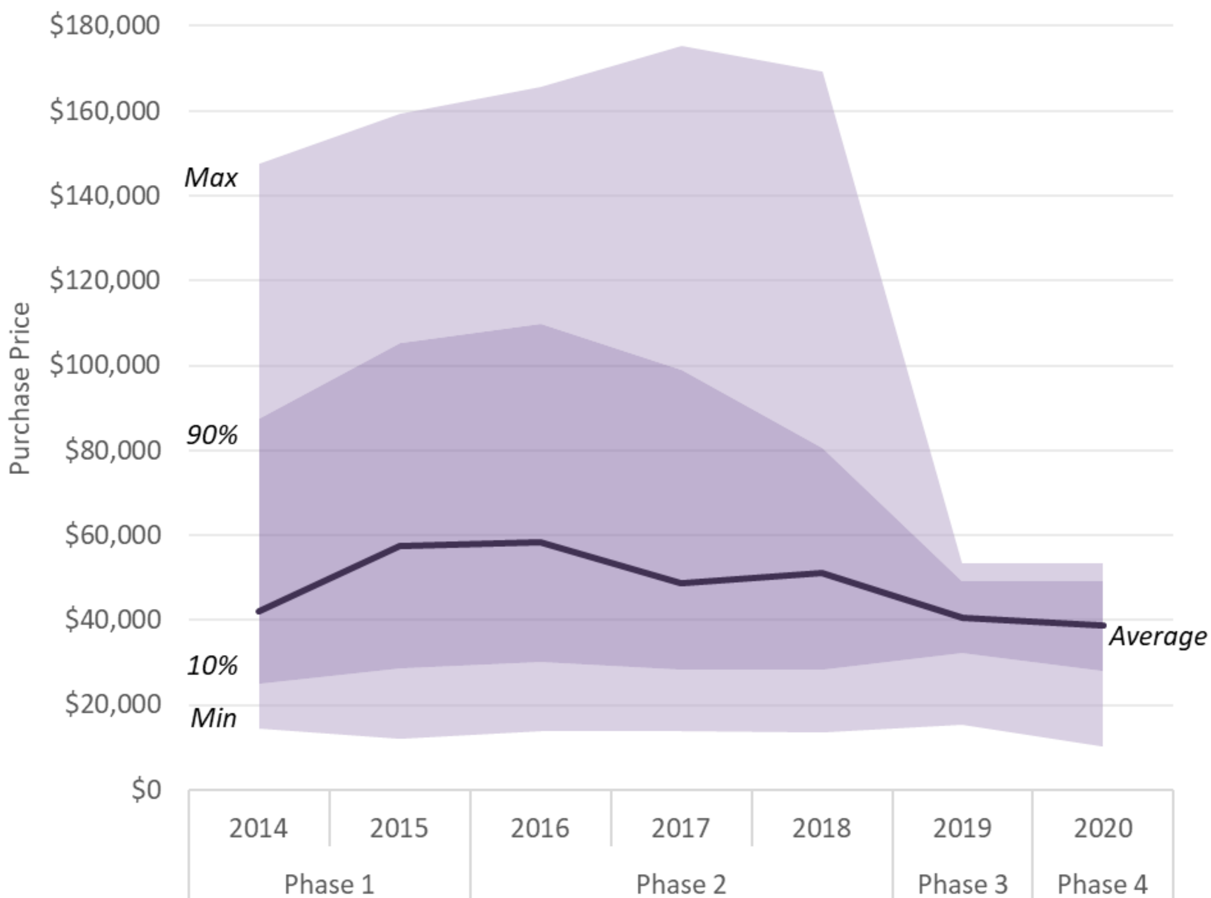


Source: Center for Sustainable Energy. MOR-EV Application Data, Collected by the Center for Sustainable Energy from 2014-2021.

Figure 14 shows the full range of vehicle purchase prices rebated in the MOR-EV Program. The light purple shading shows the highest and lowest 10 percent of purchase prices. The medium purple shading shows the middle 80 percent of purchase prices. The dark purple line shows the average purchase price. Over the lifetime of the program, the central 80 percent of rebated vehicles had a purchase price of $28,500 to $88,500. The average cost was $48,500.

Seven percent of vehicles with a purchase price of $100,000 to $175,000 received MOR-EV rebates. The 2019 purchase price cap of $50,000 was more effective at reducing rebate payments to program participants who did not need the rebates to purchase an EV than the reduced rebates for vehicles with a MSRP of $60,000 and up implemented in 2016.

Figure 14. Vehicle Purchase Price

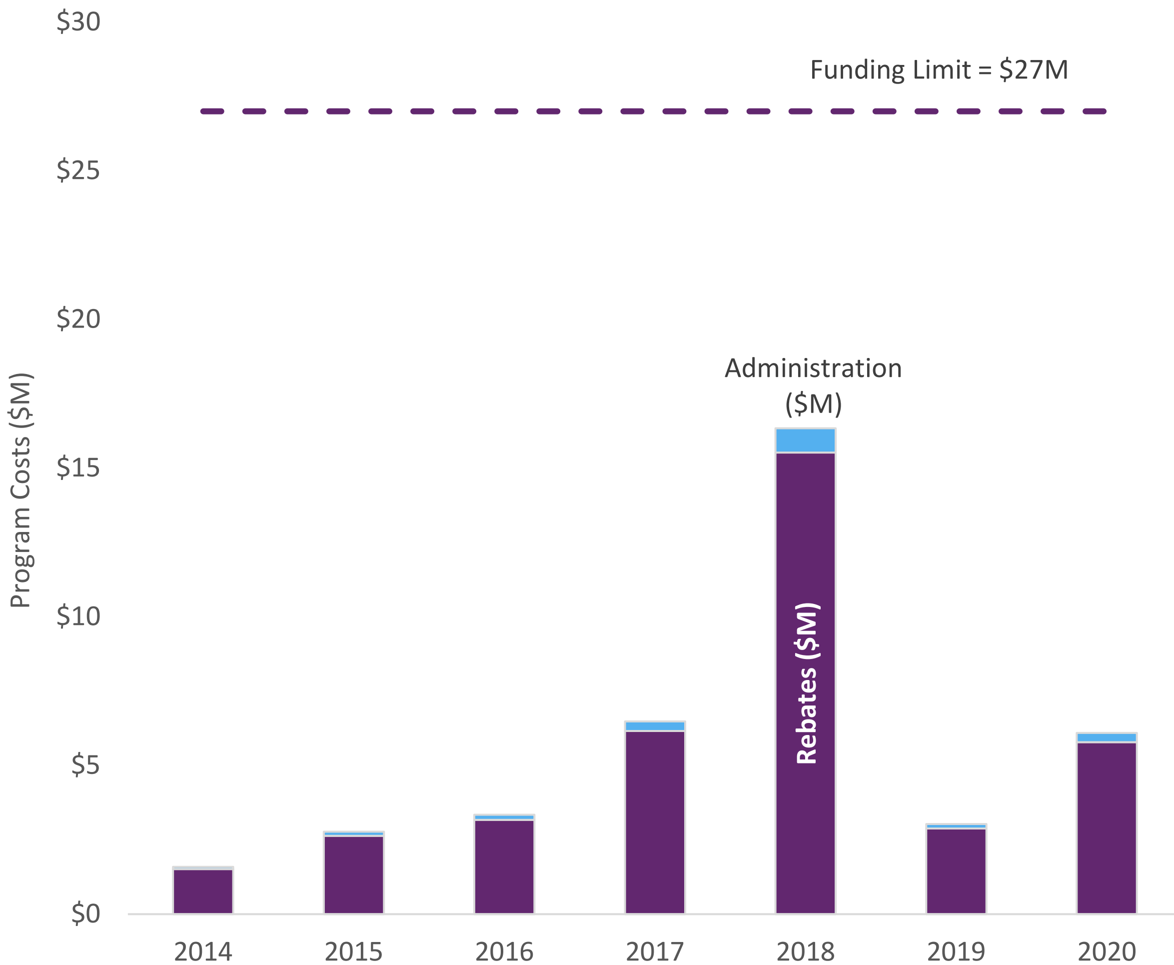


Source: Center for Sustainable Energy. MOR-EV Application Data, Collected by the Center for Sustainable Energy from 2014-2021.

FUNDING AND SPENDING

From 2014 to 2020, program spending totaled $39.7 million. Figure 15 shows program spending from 2014 to 2020, which ranged from $1.6 million in 2014 to $16.3 million at the program's peak spending in 2018.

Figure 15. Program Spending



Sources:

1. *Rebate Costs from Center for Sustainable Energy. MOR-EV Application Data, Collected by the Center for Sustainable Energy from 2014-2021.*
2. *Administration Costs from Massachusetts Department of Energy Resources*

Notes:

1. *Includes free riders.*
2. *Administration costs are 5 percent of total annual program costs.*

In recent years, the RGGI Auction Trust Fund provided $27 million in annual funding to support MOR-EV each year. Due to differing RGGI prices, number of allowances, and the varying needs of the different programs guaranteed some RGGI funding, actual RGGI fund allocations are uncertain and differ from RGGI commitments. In addition, program participation varied substantially. Due to reporting delays, the program administrator could not tell how much of the funding was spent until after rebate approval. While the program spending did not reach the annual program funding limit, program funding jumped significantly between 2017 and 2018 and exceeded the funding allocated to the program in 2018. In 2018, $10 million in RGGI proceeds were allocated to the MOR-EV Program, which was $6 million short of the program spending that year.[21] This misalignment between funding and spending led to the suspension of the program in 2019, which may have eroded customer confidence in the program and consideration of an EV for their next vehicle purchase. In 2020, program spending rebounded to 2017 levels.

COST-EFFECTIVENESS

This section examines the cost-effectiveness of the most recent representative program years (2018 and 2019) using two primary metrics. First, the cost of CO_2 emissions reduced by the program is calculated and compared to other transportation sector programs. Second, several different benefit-cost analyses are conducted to determine whether the benefits outweighed the costs from different program and participant perspectives. The cost-effectiveness incorporates free ridership by reducing the benefits of the program due to the reduced participation while holding the costs the same. As a result, higher free ridership increases the dollars per ton of GHG reduced and reduces the benefit-cost ratio of the program.

It is important to note that the replaced vehicle and driving behavior of the participant strongly influence the cost-effectiveness of the program. Emissions savings are a matter of whether the EV is replacing another vehicle, the fuel efficiency of the vehicle being replaced, the number of miles driven by the vehicle per year, and the number of years the vehicle will remain on the road. This analysis uses an average fuel efficiency improvement, average annual vehicle miles traveled, and average years driven to calculate the average cost-effectiveness for the program and the average participant. A range of cost-effectiveness values are possible based on vehicle characteristics as well as personal circumstances and behaviors, which can vary by the individual participant.

COST PER CO_2 EMISSIONS REDUCED

Table 4 shows that the MOR-EV rebate led to a net reduction in CO_2 emissions of 73,200 metric tons and 18,900 metric tons in 2018 and 2019, respectively. Using the costs from Figure 15, the analysis estimated that the cost-per-ton of the program was $231 per metric ton of CO_2 for Program Year 2018 and $162 per metric ton of CO_2 for Program Year 2019 in 2020 dollars. Critically, this number represents the cost of the program and the GHG reduction benefits.[22] Program Year 2019 was significantly less costly than Program Year 2018 due to lower rebates and the absence of PHEVs in the program. The analysis assumes that

[21] The Regional Greenhouse Gas Initiative: An Initiative of the New England and Mid-Atlantic States of the United States. *The Investment of RGGI Proceeds in 2018*. Published July 2020. https://www.rggi.org/sites/default/files/Uploads/Proceeds/RGGI_Proceeds_Report_2018.pdf

[22] All the program benefits are included below in the Benefit-Cost Analysis section.

PHEVs are not recharged frequently and therefore operate on gasoline 46 percent of the time.[23] As a result, CO_2 emissions from PHEVs are higher than emissions from BEVs.

Table 4. MOR-EV Program Cost per Metric Ton of CO2 Emissions Reduced

Program Year	Vehicle Type	CO_2 Reduction	MOR-EV Program Cost	Cost per Metric Ton of CO_2 Reduced
		Metric Tons	*2020 $M*	*2020 $/Metric Ton*
2018	BEV	54,600	11.0	201
	PHEV	18,600	6.0	323
	Total (Weighted Average)	73,200	16.9	231
2019	BEV	18,900	3.1	162
	PHEV	N/A		
	Total (Weighted Average)	18,900	3.1	162

CO_2 Emission Calculation Sources:

1. *Distribution Loss Factor: Avoided Energy supply Components in New England 2021 Report. Synapse Energy Economics. Page 332. Available at:* https://www.synapse-energy.com/sites/default/files/AESC%202021_20-068.pdf
2. *Vehicle Survivability: Davis, S.C. and R.G. Boundy. Transportation Energy Data Book: Edition 39. Table 3.15. Oak Ridge National Laboratory. April 2021. Available at:* https://tedb.ornl.gov/wp-content/uploads/2021/02/TEDB_Ed_39.pdf#page=92
3. *Percent PHEVs are Driven as Electric: Plotz, P., M. Cornelius, Y. Li, G. Bieker, P. Mock 2020. "Real-world usage of plug-in hybrid electric vehicles: Fuel consumption, electric driving and CO2 emissions." The International Council on Clean Transportation. Available at:* https://theicct.org/publications/phev-real-world-usage-sept2020
4. *Vehicle Miles Traveled: Federal Highways Administration, 2017 National Household Travel Survey. Available at:* https://nhts.ornl.gov
5. *Gasoline Vehicle MPG and CO_2 Emissions: US Environmental Protection Agency. Automotive Trends Report. 2020. Available at:* https://www.epa.gov/automotive-trends/explore-automotive-trends-data#SummaryData
6. *Marginal Grid Emissions Rates: Avoided Energy Supply Components in New England 2021 Report. Synapse Energy Economics. Table 80. Available at:* https://www.synapse-energy.com/sites/default/files/AESC%202021_20-068.pdf
7. *MPGe Conversion Factor: Environmental Protection Agency. 2011. New Fuel Economy and Environment Labels for a New Generation of Vehicles. Page 5. Available at:* https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P100BAV0.txt
8. *Electric Vehicle Efficiency: Jadun, Paige, Colin McMillan, Daniel Steinberg, Matteo Muratori, Laura Vimmerstedt, and Trieu Mai. 2017. Electrification Futures Study: End-Use Electric Technology Cost and Performance Projections through 2050. Golden, CO: National Renewable Energy Laboratory. NREL/TP-6A20-70485. Page 17. Available at:* https://www.nrel.gov/docs/fy18osti/70485.pdf

Other Sources:

9. *MOR-EV Program cost from Figure 15.*

[23] Plotz, P., M. Cornelius, Y. Li, G. Bieker, P. Mock 2020. "Real-world usage of plug-in hybrid electric vehicles: Fuel consumption, electric driving and CO2 emissions." The International Council on Clean Transportation. Available at: https://theicct.org/publications/phev-real-world-usage-sept2020.

Table 5 shows the cost per metric ton of CO_2 emissions reduced by the MOR-EV Program compared to other transportation sector GHG reduction programs in 2020 dollars. Ranges representing the costs for the other transportation sector GHG reduction programs are based on economic studies of implemented or considered policies. In Program Year 2018, MOR-EV cost $231 per metric ton of CO2 reduced. MOR-EV is less costly than other vehicle incentive programs that may offer higher incentives, such as *Cash for Clunkers* and other dedicated BEV subsidy programs.[24] MOR-EV is more costly than gasoline taxes, Federal Corporate Average Fuel Efficiency (CAFE) Standards, low-carbon fuel standards (such as the one in California), and incentives for biodiesel (such as the federal tax credit).

In Program Year 2018, MOR-EV cost $231 per metric ton of CO_2 reduced.

Table 5. Cost per Metric Ton of CO_2 Emissions Reduced by MOR-EV versus Other Transportation Sector Programs

Program	Cost per Metric Ton of CO_2 Reduced (2020 dollars)
Gasoline Tax	$19 – $49
Federal CAFE Standards	$50 – $321
Low Carbon Fuel Standards (such as California)	$104 – $3,004
Incentives for Biodiesel (such as the federal tax credit)	$155 – $259
MOR-EV BEV	$162 (*2019*) – $201 (*2018*)
MOR-EV Total	$162 (*2019*) – $231 (*2018*)
MOR-EV PHEV	$323 (*2018*)
Federal Cash for Clunkers Program (2009)	$280 – $435
Incentives for EVs (such as the federal tax credit)	$362 – $663

Sources:

1. *Gasoline tax, CAFE Standards, Low-carbon fuel standard, Biodiesel, and Cash for Clunkers from: Gillingham, Kenneth and James H. Stock. The Cost of Reducing Greenhouse Gas Emissions. Journal of Economic Perspectives. Volume 32, Number 4—Fall 2018—Pages 53–72. Available at:* https://pubs.aeaweb.org/doi/pdfplus/10.1257/jep.32.4.53
2. *MOR-EV PHEV, MOR-EV BEV, and MOR-EV Total from Table 4.*

[24] Cash for Clunkers was a 2009 U.S. government program that provided financial incentives to car owners to trade in their old, less fuel-efficient vehicles and buy more fuel-efficient vehicles.

BENEFIT-COST ANALYSIS

This section presents benefit-cost analyses (BCA) from the program and participant perspectives for the 2018 and 2019 program years. Program Year 2018 represents higher rebate levels and Program Year 2019 represents lower rebate levels for BEVs and the elimination of rebates for PHEVs.

The program BCA determines whether the benefits created by the MOR-EV Program outweigh the costs of administering the program. The results of this analysis can be used to determine whether the impact of the program design and incentive levels are creating the desired benefits. If the resulting benefit-cost ratio (BCR) is above 1.0, the program is cost-effective and creating more benefits than costs.

The participant BCA is from the perspective of the consumer participating in the program. The results of this analysis can be used to determine whether the benefits of purchasing an EV outweigh the costs for the consumer; the results provide useful insight into the rebate levels needed to make the purchase of an EV economic. If the resulting BCR is above 1.0, the rebate amount is sufficient to create a net benefit to consumers. If the BCR is lower than 1.0, the rebate level may not be high enough to motivate purchase of an EV.

OVERVIEW OF COSTS AND BENEFITS

The program and participant BCAs conducted for the MOR-EV Program use the principles outlined in the *National Standard Practice Manual for Benefit-Cost Analysis of Distributed Energy Resources* (NSPM for DERs).[25] The NSPM for DERs recommends conducting a BCA that includes all the benefits and costs related to the utility system as well as those that reflect a jurisdiction's specific energy policy goals. Tables 6 and 7 identify and describe the costs and benefits associated with the deployment of EVs in Massachusetts. The program BCA applies all the impacts, and the participant BCA uses a subset of these impacts as identified in the rightmost column of the table.

The costs and benefits are quantitative or qualitative impacts. Quantitative impacts are the monetized costs and benefits in the BCR. Qualitative impacts are costs and benefits not incorporated into the BCR, but considered, nonetheless.

[25] National Energy Screening Project. 2020. *National Standard Practice Manual for Benefit-Cost Analysis of Distributed Energy Resources*. (NSPM for DERs). Available at www.nationalenergyscreeningproject.org

Table 6. Summary of Costs

Type	Name	Description	Included in BCA	
			Program	Participant
Quantitative				
Utility System	Energy Generation	Cost to supply additional electricity load	✓	N/A
	Capacity	Cost to serve additional peak electricity demand	✓	
	Wholesale Market Price Effects	Increased wholesale prices due to increased electricity and capacity demand	✓	
	Renewable Portfolio Standard (RPS) Compliance	Increased electricity load leads to an increase in RPS requirements and compliance costs	✓	
	Transmission & Distribution (T&D)	Increased investment in infrastructure to address increasing load; this analysis assumed zero T&D costs related to EVs purchased in Program Years 2018 and 2019	✓	
Participant	Incremental EV Cost	Additional upfront cost to purchase an EV instead of a gasoline vehicle, minus the average MOR-EV rebate and estimated FTC	✓	✓
	Charging Equipment and Installation	Cost to participant to purchase and install a Level 2 charger	✓	✓
	Vehicle Charging	Cost to participant to charge the EV	N/A	✓
MOR-EV Program Administration	Rebates	Dollar value of rebate paid to participant	✓	N/A
	Administration	Five percent of total budget to administer the program	✓	
Societal	Federal Tax Credit	The estimated cost of the federal tax credit	✓	N/A
Qualitative				
Participant	Transaction Cost	Time spent researching EVs such as makes, models, and incentives	Not included in BCR	Not Included in BCR
	Operational Cost	Time associated with locating charging facilities and charging vehicles	Not included in BCR	Not Included in BCR
Societal	Foregone Gas Tax Revenues	Gas tax revenues not received from EV drivers due to their lack of gasoline consumption	Not included in BCR	Not Included in BCR

Table 7. Summary of Benefits

Type	Name	Description	Included in BCA	
			Program	Participant
Quantitative				
Utility System	N/A	N/A	N/A	N/A
Participant	Avoided Gasoline Cost	Reduction in gasoline consumption	✓	✓
	Avoided Maintenance Cost	Savings from lower maintenance costs associated with EVs	✓	✓
	Resale Value	Incremental resale value to first owner	N/A	✓
Societal	Avoided GHG Externality Cost	Social Cost of Carbon $128/short ton;[26] applied to both electricity and gasoline emissions	✓	N/A
	Avoided Health Impacts[27]	Avoided damages from NO_X, SO_2, and PM2.5 emissions	✓	
Qualitative				
Utility System	Improved Grid Utilization	Opportunity to increase utility system sales during hours when existing generators are not fully utilized, leading to reduced electricity rates	Not Included in BCR	Not Included in BCR
Societal	Market Transformation	Faster and broader adoption of EVs due to increased public awareness from more EVs on roadways	Not Included in BCR	Not Included in BCR
	Economic Development and Jobs	Increased spending EVs, reduced gasoline expenditures, and increased spending on electricity can lead to changes in job-years and state GDP	Not Included in BCR	Not Included in BCR
	Noise Reduction	Reduction in noise pollution from fewer gasoline vehicles on the road	Not Included in BCR	Not Included in BCR
	Reduced National Security Risk	Reducing the need for energy imports from foreign countries, thereby reducing national security risk and potentially decreasing defense funding	Not Included in BCR	Not Included in BCR

[26] After the publication of the 2021 AESC Study, the $128/ton was superseded by a $393/ton value for the social cost of carbon. Application of a higher social cost of carbon value would make the program more cost-effective.

[27] While not included in this study, it is important to note that VOC and NH3 emissions can make up a sizable proportion of health benefits. By including these benefits, the program BCA would be higher.

In addition to the benefits listed above, EVs can impact electric rates in several ways. When drivers switch from a gasoline vehicle to an EV, there is an increase in electricity sales. This in turn spreads out fixed utility costs over more kilowatt-hours (kWh), resulting in a lower per-unit cost of electricity for everyone. At the same time, EVs can create upward pressure on rates. A large increase in the number of EVs may eventually lead to the need for grid investments such as distribution or transmission upgrades or expansions. However, these costs can be mitigated if drivers are encouraged to charge their cars during times when there is less demand on the electric system. The overall impact of EVs can be a net reduction in electricity rates so long as the increased sales create more rate reductions than the increased costs to serve EVs. For example, a recent study focused on California found that EVs increased utility revenues more than they increased utility costs, leading to downward pressure on electric rates for EV-owners and non-EV owners alike.[28] While rate impacts should be assessed outside of a BCA, these benefits should be considered in evaluating the performance of the program.[29]

PROGRAM BENEFIT-COST ANALYSIS

The program BCA examines the aggregate impact of BEVs and PHEVs rebated in Program Years 2018 and 2019 and assesses the costs and benefits to the utility system, participants, and society over the 15 years that vehicles remain on the road. The program BCA includes costs related to administering the MOR-EV Program, those borne by consumers participating in the program, and those related to the impact of EVs to the utility system. This analysis includes the costs associated with free riders because they are costs related to the program. See below for a discussion of costs, followed by a discussion of benefits.

Costs

Program administration costs include the costs to plan and implement the program as well as the rebates given to participants. The participant costs include the incremental cost of the EV compared to a gasoline vehicle (reduced by the MOR-EV and FTC incentives) and the cost of purchasing and installing charging equipment at the home. The utility system costs account for the resulting increased electricity consumption each year.

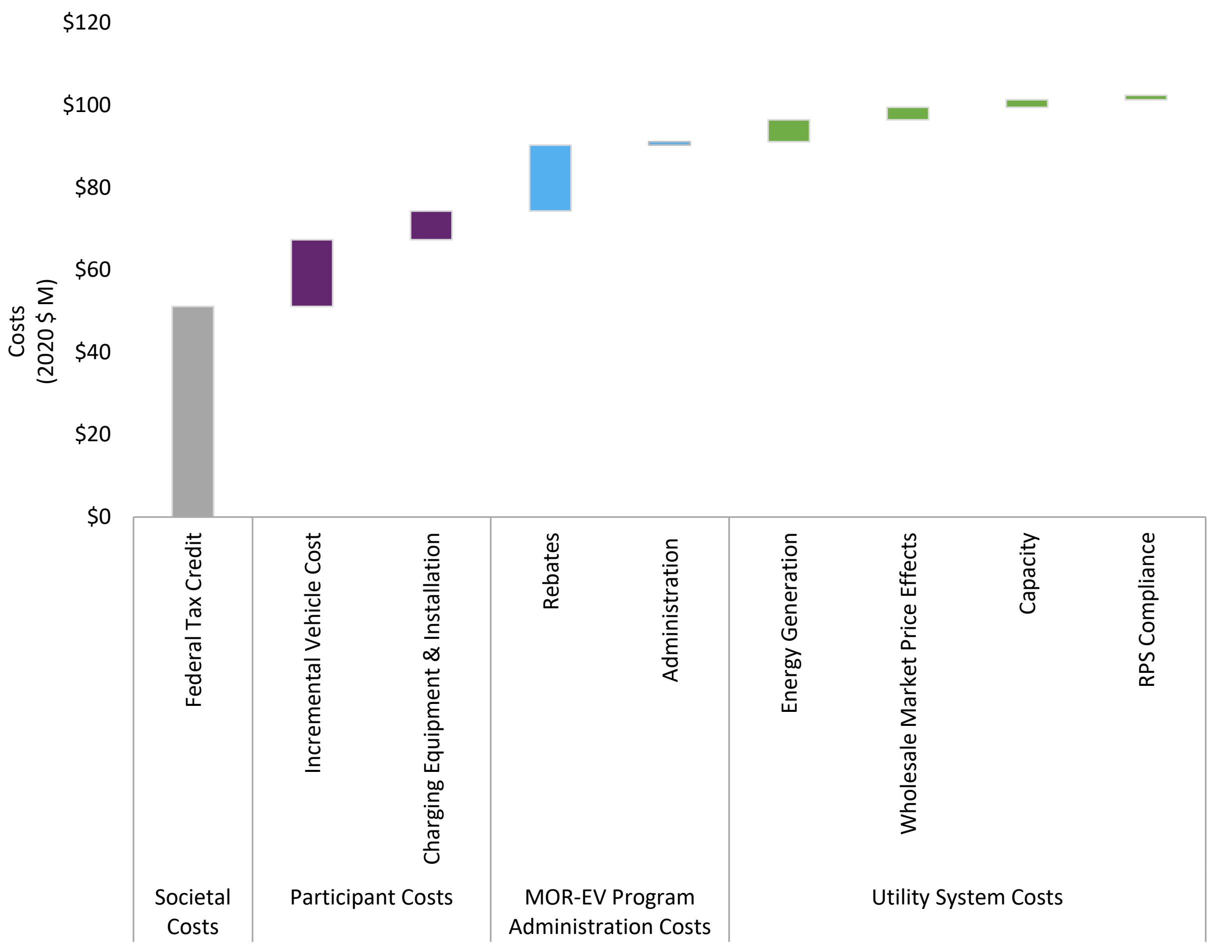
Figure 16 shows the 2018 program year participant, program administration, and utility system costs in 2020 dollars. The most significant costs of the program are the participant's incremental cost to purchase the EV and the cost of the rebates.

---

[28] Synapse Energy Economics. 2019. *Electric Vehicles Are Driving Electric Rates Down*, https://www.synapse-energy.com/sites/default/files/EVs-Driving-Rates-Down-8-122.pdf.

[29] National Energy Screening Project. 2020. *National Standard Practice Manual for Benefit-Cost Analysis of Distributed Energy Resources*. (NSPM for DERs). Available at www.nationalenergyscreeningproject.org

Figure 16. 2018 Program Year Costs (2020$ M)



Sources:

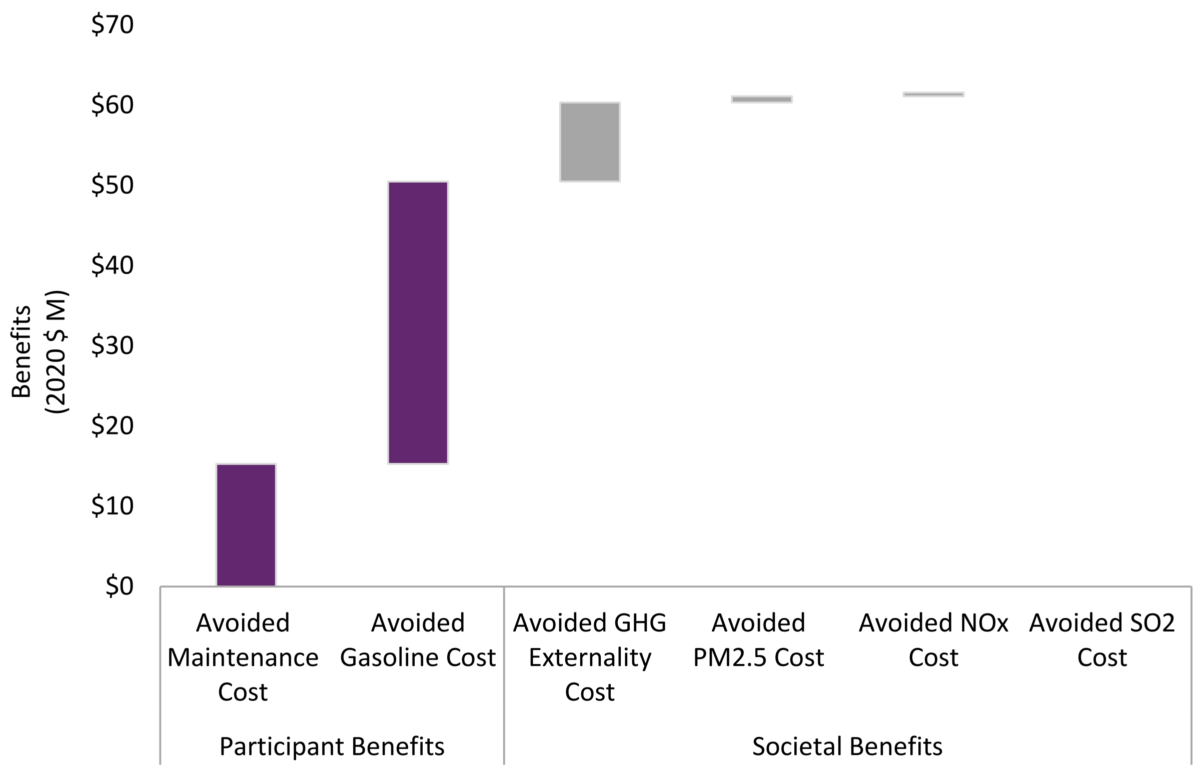
1. *Societal Costs: Synapse calculations based on Fueleconomy.gov. Federal Tax Credits for New All-Electric and Plug-in Hybrid Vehicles. Available at: https://www.fueleconomy.gov/feg/taxevb.shtml*
3. *Participant Costs: Synapse calculations based on the incremental upfront cost to purchase an EV instead of a gasoline vehicle based on prices from the International Council on Clean Transportation (ICCT) Working Paper 2019-06, minus the MOR-EV rebate cost and the FTC.*
4. *Rebate Costs from Center for Sustainable Energy. MOR-EV Application Data, Collected by the Center for Sustainable Energy from 2014-2021.*
5. *Administration Costs from Massachusetts Department of Energy Resources.*
6. *Utility System Costs: Synapse calculations based on Avoided Energy Supply Cost Study. 2021.*

Benefits

The program BCA includes benefits realized by participants and by society. This analysis excludes the benefits resulting from free riders because they are not directly attributable to the program. The participant benefits include gasoline and maintenance savings for an EV compared to a gasoline vehicle for each year of the vehicle's life. The societal benefits include the reduction in GHG emissions and health benefits from reduced nitrogen oxide (NO_X), sulfur dioxide (SO_2), and particulate matter (PM2.5). The societal benefits are calculated by taking the difference between the decrease in emissions from a reduction in the use of transportation fuels for gasoline-fueled vehicles and the increase in emissions from the electricity sector due to EV charging. The net impact is a reduction in emissions because transportation fuels emit more emissions than the region's electric grid. The benefits calculation accounts for the differences between BEVs and PHEVs. While BEVs run solely on electricity, research indicates that PHEVs run on electricity 54 percent of the time. This significantly reduces the benefits associated with avoided gasoline consumption and maintenance of these vehicles.

Figure 17 shows the 2018 program year participant and societal benefits in 2020 dollars. The most significant benefits of the program are the participant's avoided maintenance and fuel costs.

Figure 17. 2018 Program Year Benefits (2020$ M)



Sources:

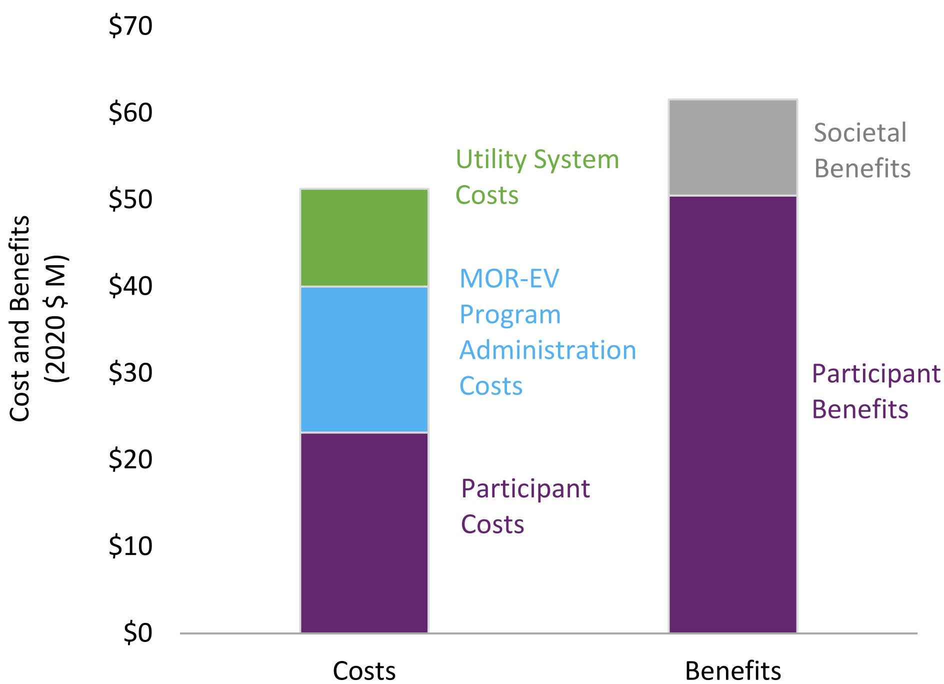
1. *Maintenance Costs: International Council on Clean Transportation (ICCT). 2019. Working Paper 2019-06. Available at: https://theicct.org/sites/default/files/publications/EV_cost_2020_2030_20190401.pdf.*
2. *Gasoline Costs: Actuals from Energy Information Administration (EIA) Massachusetts Gasoline and Diesel Retail Prices. Forecast from EIA Annual Energy Outlook 2020, Table 57. Components of Selected Petroleum Product Prices - New England. Price Components: Motor Gasoline: End-User Price: Reference case (converted to $/gallon).*
3. *GHG Externality Costs, NO_X, and SO_2: Avoided Energy Supply Cost Study. 2021.*
4. *PM2.5 Costs: EPA (2018) Estimating the Benefit per Ton of Reducing PM2.5 Precursors from 17 Sectors. Table 63.*

Benefit-Cost Ratio

This BCA assesses the net present value of the stream of costs and benefits over the lifetime of the EV. Figures 18 and 19 below show 2018 program year data; the discussion that follows shows 2019 program year data for comparison.

Figure 18 illustrates the costs and benefits by type including program administration, utility system, participant, and society and shows that the MOR-EV Program was cost-effective in 2018 with a BCR of 1.20.

Figure 18. Program BCA Costs and Benefits for Program Year 2018, without Federal Tax Credit Cost (2020$ M)



The FTC creates a benefit to participants by reducing the cost of purchasing an EV. However, this tax credit is not free and is part of federal taxes paid to the government. Therefore, this tax credit creates a societal cost. Including the cost associated with the FTC, the MOR-EV Program goes from being cost-effective with a BCR of 1.20 to not cost-effective with a BCR of 0.60 as shown in Figure 19.

Figure 19. Program BCA Costs and Benefits for Program Year 2018, with Federal Tax Credit Cost (2020$ M)

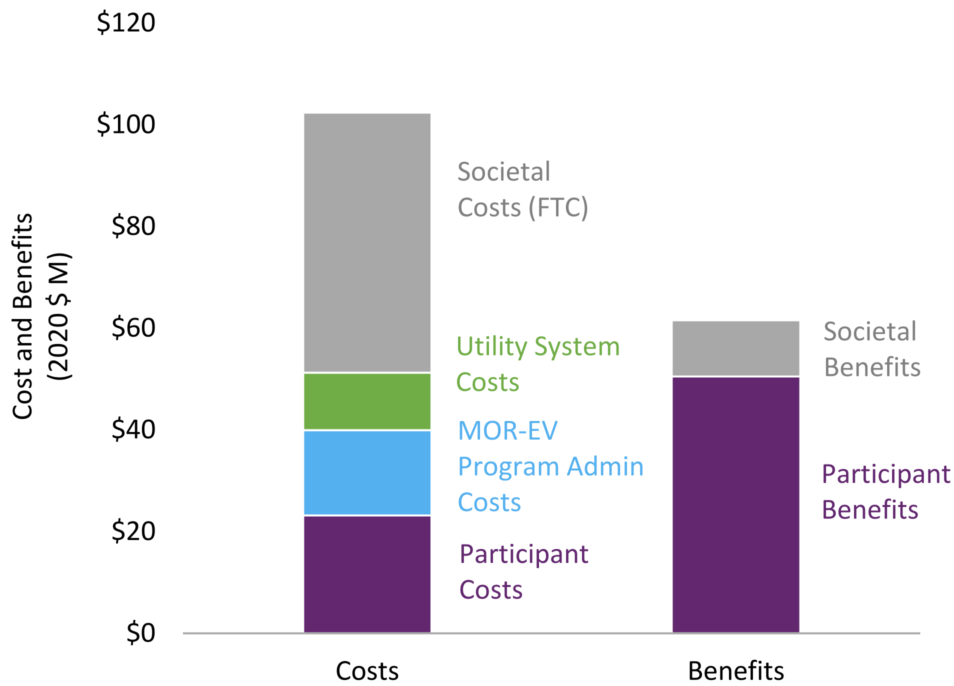


Table 8 summarizes the BCA results for the 2018 and 2019 program years without the cost of the federal tax credit. The MOR-EV Program was cost-effective in 2018 with a BCR of 1.20. Program Year 2019, while still cost-effective, had a lower BCR of 1.08. This is driven by the phase-out of the FTC for many BEV purchases in 2019, which increased participant costs.

Table 8. MOR-EV 2018 and 2019 Program BCA Results-BEVs and PHEVs, without Federal Tax Credit Cost (2020$ M)

Type		Impact	Program Year 2018		Program Year 2019	
			Total ($)	% of Total	Total ($)	% of Total
Benefits	Participant	Avoided Gasoline Cost	$35.2	57%	$10.7	57%
		Avoided Maintenance Cost	$15.3	25%	$4.7	25%
	Societal	Avoided GHG Externality Cost	$9.9	16%	$3.1	16%
		Avoided Health Impacts	$1.2	2%	$0.3	2%
	Total Benefits		**$61.6**	**100%**	**$18.8**	**100%**
Costs	MOR-EV Program Administration	Administration	$0.8	2%	$0.2	1%
		Rebates	$16.0	31%	$2.9	17%
	Participant	Incremental EV Cost	$16.2	32%	$9.7	56%
		Charging Equipment and Installation	$7.0	14%	$1.7	10%
	Utility System	Energy Generation	$5.3	10%	$1.6	9%
		Capacity	$1.8	4%	$0.4	2%
		Wholesale Market Price Effects	$3.1	6%	$0.6	4%
		RPS Compliance	$1.1	2%	$0.3	2%
		Transmission and Distribution	$0.0	0%	$0	0%
	Total Costs		**$51.3**	**100%**	**$17.5**	**100%**
Benefit-Cost Ratio			1.20		1.08	
Net Benefits			$10.3		$1.3	

Table 9 summarizes the BCA results for Program Years 2018 and 2019 for BEVs only, without the cost of the federal tax credit. Reduced incentives drove lower cost-effectiveness in Program Year 2019 as compared to Program Year 2018.

Table 9. MOR-EV 2018 and 2019 Program BCA Results–BEVs Only, without Federal Tax Credit Cost (2020$ M)

Type		Impact	Program Year 2018		Program Year 2019	
			Total ($)	% of Total	Total ($)	% of Total
Benefits	Participant	Avoided Gasoline Cost	$26.5	57%	$10.7	57%
		Avoided Maintenance Cost	$11.7	25%	$4.7	25%
	Societal	Avoided GHG Externality Cost	$7.4	16%	$3.1	16%
		Avoided Health Impacts	$0.9	0%	$0.3	2%
	Total Benefits		**$46.4**	**100%**	**$18.8**	**100%**
Costs	MOR-EV Program Administration	Administration	$0.5	1%	$0.2	1%
		Rebates	$10.3	26%	$2.9	17%
	Participant	Incremental EV Cost	$16.5	41%	$9.7	56%
		Charging Equipment and Installation	$4.9	12%	$1.7	10%
	Utility System	Energy Generation	$4.0	10%	$1.6	9%
		Capacity	$1.1	3%	$0.4	2%
		Wholesale Market Price Effects	$2.1	5%	$0.6	4%
		RPS Compliance	$0.9	2%	$0.3	2%
		Transmission and Distribution	$0.0	0%	$0	0%
	Total Costs		**$40.4**	**100%**	**$17.5**	**100%**
Benefit-Cost Ratio			1.15		1.08	
Net Benefits			$6.1		$1.3	

Table 10 summarizes the BCA results for Program Years 2018 and 2019 without the cost of the federal tax credit, for PHEVs Only. PHEVs are more cost-effective in Program Year 2018 than BEVs with BCRs of 1.39 and 1.15, respectively. This is primarily driven by the difference in the participant incremental EV cost of a BEV compared to a PHEV. The combination of the MOR-EV Program rebate and the FTC results in a negative incremental PHEV cost compared to a gasoline vehicle in 2018. After accounting for the program rebate and FTC, the cost of the PHEV is less than the cost of a gasoline vehicle. Even though PHEVs produce fewer societal benefits than BEVs due to potential continued usage of gasoline, the lower incremental EV cost more than offsets this factor.

Table 10. MOR-EV 2018 and 2019 Program BCA Results–PHEVs Only, without Federal Tax Credit Cost (2020$ M)

Type		Impact	Program Year 2018		Program Year 2019	
			Total ($)	% of Total	Total ($)	% of Total
Benefits	Participant	Avoided Gasoline Cost	$8.7	58%	N/A	
		Avoided Maintenance Cost	$3.6	24%		
	Societal	Avoided GHG Externality Cost	$2.5	17%		
		Avoided Health Impacts	$0.3	2%		
	Total Benefits		**$15.1**	**100%**		
Costs	MOR-EV Program Administration	Administration	$0.3	3%		
		Rebates	$5.6	52%		
	Participant	Incremental EV Cost	-$0.3	-3%		
		Charging Equipment and Installation	$2.1	19%		
	Utility System	Energy Generation	$1.3	12%		
		Capacity	$0.7	6%		
		Wholesale Market Price Effects	$1.0	9%		
		RPS Compliance	$0.3	2%		
		Transmission and Distribution	$0.0	0%		
	Total Costs		**$10.9**	**100%**		
Benefit-Cost Ratio			1.39			
Net Benefits			$4.2			

Table 11 summarizes the BCA results for Program Years 2018 and 2019 with the cost of the federal tax credit. The 2018 and 2019 MOR-EV Program years with the FTC added are not cost-effective, with BCRs of 0.60 and 0.72, respectively.

Table 11. MOR-EV 2018 and 2019 Program BCA Results-BEVs and PHEVs, with Federal Tax Credit Cost (2020$ M)

Type		Impact	Program Year 2018		Program Year 2019	
			Total ($)	**% of Total**	**Total ($)**	**% of Total**
Benefits	Participant	Avoided Gasoline Cost	$35.2	57%	$10.7	57%
		Avoided Maintenance Cost	$15.3	25%	$4.7	25%
	Societal	Avoided GHG Externality Cost	$9.9	16%	$3.1	16%
		Avoided Health Impacts	$1.2	2%	$0.3	2%
	Total Benefits		**$61.6**	**100%**	**$18.8**	**100%**
Costs	MOR-EV Program Administration	Administration	$0.8	1%	$0.2	1%
		Rebates	$16.0	16%	$2.9	11%
	Participant	Incremental EV Cost	$16.2	16%	$9.7	37%
		Charging Equipment and Installation	$7.0	7%	$1.7	7%
	Utility System	Energy Generation	$5.3	5%	$1.6	6%
		Capacity	$1.8	2%	$0.4	2%
		Wholesale Market Price Effects	$3.1	3%	$0.6	2%
		RPS Compliance	$1.1	1%	$0.3	1%
		Transmission and Distribution	$0.0	0%	$0	0%
	Societal	Federal Tax Credit	$51.1	50%	$8.8	34%
	Total Costs		**$102.4**	**100%**	**$26.2**	**100%**
Benefit-Cost Ratio			0.60		0.72	
Net Benefits			-$40.8		-$7.5	

PARTICIPANT BENEFIT-COST ANALYSIS

The participant BCA examines cost-effectiveness from the perspective of the consumer participating in the program. The participant BCA was conducted for all program participants combined and broken out by BEV owners and PHEV owners. Both the costs and benefits include free riders. This analysis assumes that the program participant will own the EV for a period of eight years, on average.[30]

Costs

The participant BCA includes costs associated with the purchase, ownership, and operation of an EV compared to a gasoline vehicle. This includes the incremental cost of the EV (reduced by both the MOR-EV rebate and the FTC), the cost of purchasing and installing charging equipment at the home, and the cost to charge the vehicle over the 8-year period of ownership.

The MOR-EV Program does not collect information on when and where participants charge their vehicles. The analysis assumes EV owners charge their vehicles at home 100 percent of the time. This assumption may overstate charging costs. EV drivers can sometimes charge for free or at a discounted rate at their workplace or at municipal lots. Also, time-of-use electric rates may become available in the next several years. These rates will enable EV owners to charge their cars for less at home during off-peak hours of the day when there is less demand on the electric grid.

Benefits

The participant BCA includes benefits related to operational savings over the ownership period of the EV and its resale value in Year 8. The most significant benefit is the reduction in gasoline costs over the ownership period, followed by avoided maintenance cost for an EV compared to a gasoline-fueled vehicle. The resale value was calculated by applying a depreciation rate to the initial price of an EV and a gasoline-fueled vehicle. The difference in the value of the gasoline-fueled vehicle to the EV in Year 8 equals the resale benefit to the original owner.

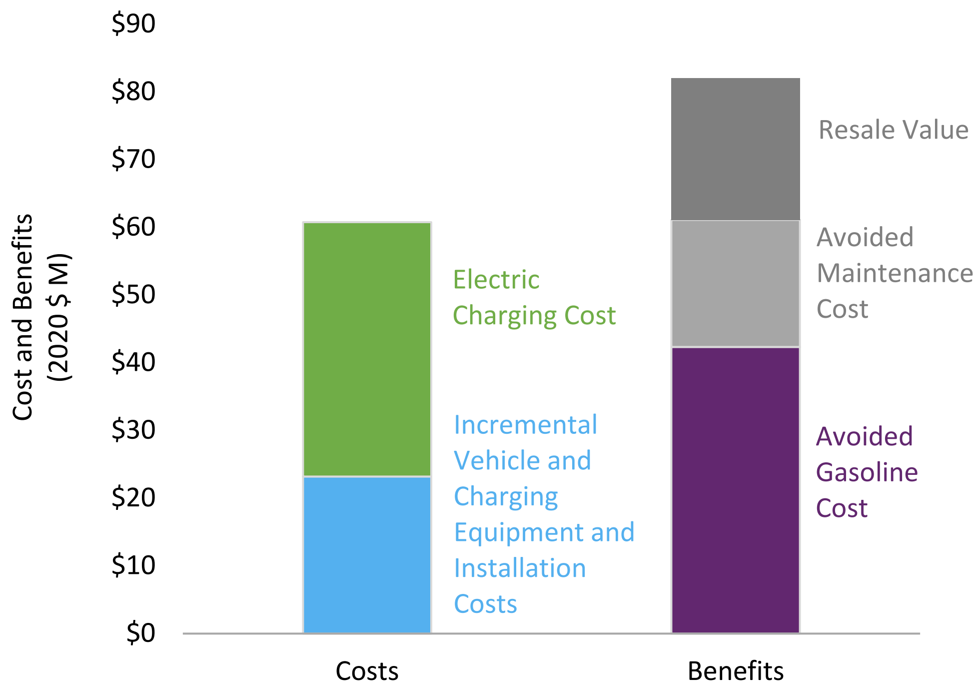
Benefit-Cost Ratio

Figure 20 shows the 2018 program year participant costs and benefits. The figure shows that the purchase was cost-effective for the participant, with a BCR of 1.35 in 2018. The purchase was even cost-effective for the participant without the resale benefit. The BCR is 1.07 in 2019, which is lower due to the phase-out of the FTC for most BEV purchases that results in an increased incremental vehicle cost.

---

[30] iSeeCars.com analyzed five million 5+ year-old vehicles sold by original owners between 2014 and 2018 and found that owners keep new cars for 8.4 years on average. See the *How Long People Keep Cars Study* for more information. Available at: https://www.iseecars.com/how-long-people-keep-cars-study

Figure 20. Participant BCA Costs and Benefits for Program Year 2018 (2020$ M)



Tables 12, 13, and 14 summarize the BCA results for Program Years 2018 and 2019 for BEVs and PHEVs combined, BEVs only, and PHEVs only. The program is cost-effective for all participants in both years. PHEVs are more cost-effective than BEVs in 2018, with BCRs of 1.90 and 1.23, respectively. There was no incentive offered for PHEVs in 2019.

Table 12. MOR-EV 2018 and 2019 Participant BCA Results – BEVs and PHEVs (2020$ M)

Type		Impact	Program Year 2018		Program Year 2019	
			Total ($)	**% of Total**	**Total ($)**	**% of Total**
Benefits	Participant	Avoided Gasoline Cost	$42.3	52%	$13.9	52%
		Avoided Maintenance Cost	$18.8	23%	$6.2	23%
		Incremental Vehicle Resale Value	$20.9	26%	$6.6	25%
	Total Benefits		**$82.0**	**100%**	**$26.7**	**100%**
Costs	Participant	Charging Cost	$37.6	62%	$12.0	48%
		Incremental EV Cost	$16.2	27%	$11.2	45%
		Charging Equipment and Installation	$7.0	11%	$1.7	7%
	Total Costs		**$60.7**	**100%**	**$25.0**	**100%**
Benefit-Cost Ratio			1.35		1.07	
Net Benefits			$21.3		$1.8	

Table 13. MOR-EV 2018 and 2019 Participant BCA Results – BEVs Only (2020$ M)

Type		Impact	Program Year 2018		Program Year 2019	
			Total ($)	**% of Total**	**Total ($)**	**% of Total**
Benefits	Participant	Avoided Gasoline Cost	$31.8	52%	$13.9	52%
		Avoided Maintenance Cost	$14.4	23%	$6.2	23%
		Incremental Vehicle Resale Value	$15.3	25%	$6.6	25%
	Total Benefits		**$61.5**	**100%**	**$26.7**	**100%**
Costs	Participant	Charging Cost	$28.6	57%	$12.0	48%
		Incremental EV Cost	$16.5	33%	$11.2	45%
		Charging Equipment and Installation	$4.9	10%	$1.7	7%
	Total Costs		**$50.0**	**100%**	**$25.0**	**100%**
Benefit-Cost Ratio			1.23		1.07	
Net Benefits			$11.6		$1.8	

Table 14. MOR-EV 2018 and 2019 Participant BCA Results – PHEVs Only (2020$ M)

Type		Impact	Program Year 2018		Program Year 2019
			Total ($)	% of Total	
Benefits	Participant	Avoided Gasoline Cost	$10.5	51%	N/A
		Avoided Maintenance Cost	$4.4	21%	
		Incremental Vehicle Resale Value	$5.6	27%	
	Total Benefits		**$20.5**	**100%**	
Costs	Participant	Charging Cost	$9.0	84%	
		Incremental EV Cost	-$0.3	-3%	
		Charging Equipment and Installation	$2.1	19%	
	Total Costs		**$10.8**	**100%**	
Benefit-Cost Ratio			1.90		
Net Benefits			$9.7		

2021-2022 MOR-EV PROGRAM SPENDING UPDATE

This section provides an update on projected 2021 and 2022 spending. No changes in MOR-EV Program design occurred during this period. Figure 21 shows actual monthly program spending from January 2020 through August 2021 and projected monthly program spending based on a linear trend of the actual data through 2022. Though there are significant month-to-month fluctuations in program spending, program spending grew at a linear rate in 2020 and this rate of growth is projected to continue in 2021 and 2022. If this growth in program spending proceeds as anticipated, the program will reach its average monthly RGGI funding allocation of $2,250,000 by the end of 2022.

Figure 21. 2020-2022 Monthly Program Spending Trend

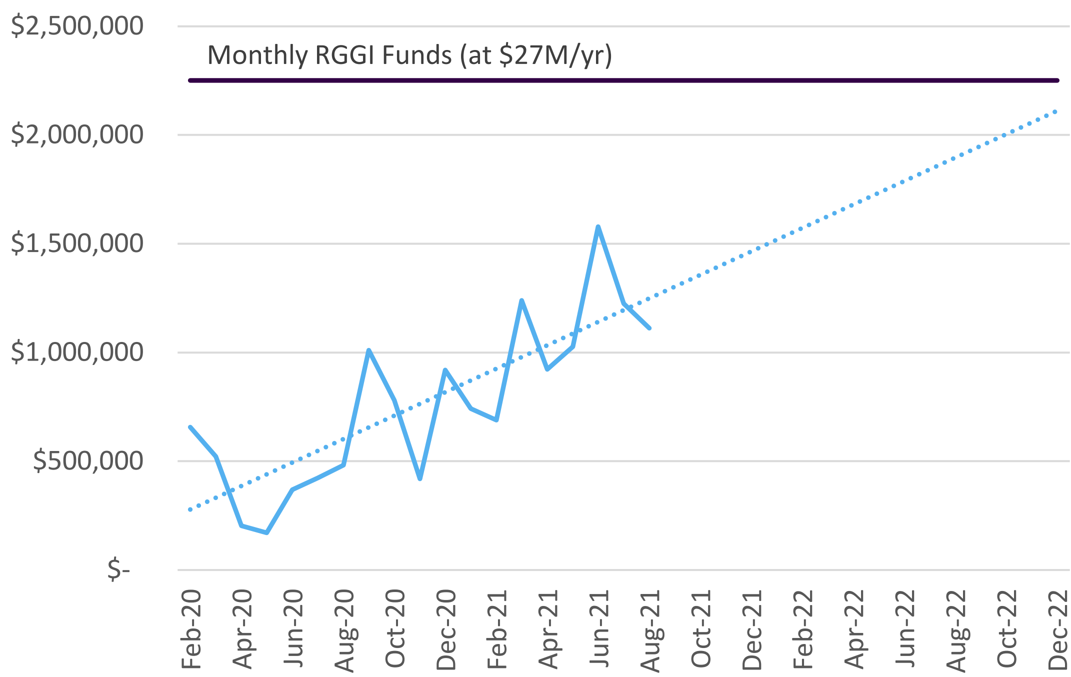
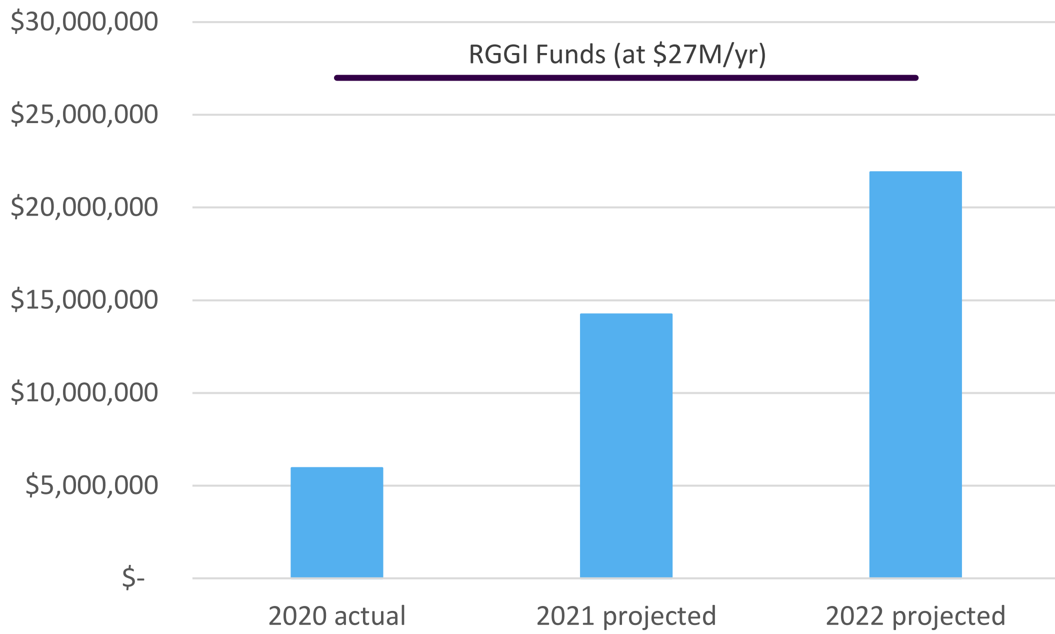


Figure 22 shows the anticipated annual progression in projected program spending for 2020, 2021, and 2022.

- In 2020, program spending rebounded to 2017 levels.
- 2021 spending rebounded to 2018 levels, which represent the peak of program activity to date.
- 2022 projected spending significantly exceeds 2021 spending and approaches the $27 million annual allocation in funding for the program.

Figure 22. 2020-2022 Annual Program Spending Trend



OTHER STATE EV PROGRAM RESULTS

The design and performance of EV incentive programs in other states can inform the MOR-EV Program design moving forward. Table 15 compares the MOR-EV Program design and performance in 2018 to programs in California, Connecticut, Delaware, New York, and Pennsylvania in 2019. Though provided, the MOR-EV Program design and performance in 2019 does not make for a good comparison to the other states due to the impact of the program suspension. These states have well-established EV programs and offer comparable performance metrics.

Program design and performance data from other states with EV rebate programs shows that designs are converging and best practices emerging. This section summarizes six program design trends including: eligible sectors, rebate levels, rebate caps, and incentives for dealers, low-income households, and buyers of used vehicles. This section also discusses performance based on an evaluation of five metrics including: total participants and spending, percent BEV and PHEV participants, average rebate per participant, and participation rate.

Key takeaways include the following:

1. MOR-EV served fewer markets than other states for many years. California, Delaware, and New York serve residential, business, and government markets. In 2021, MOR-EV expanded its eligibility to include the business and government markets in addition to the residential market.
2. California and Delaware offer fixed rebates like MOR-EV, but New York scales the rebate based on the battery capacity of the vehicle. Connecticut and Pennsylvania originally scaled their rebate but have since fixed their rebates.
3. The average MOR-EV rebate per participant is lower than in Delaware and California, but higher than in Connecticut, New York, and Pennsylvania. The MOR-EV rebate for BEVs and PHEVs is on the higher side overall. Delaware is the only state with a higher BEV incentive than MOR-EV, and New York and Pennsylvania offer higher PHEV incentives than MOR-EV. However, the average rebate for MOR-EV is lower due to higher uptake of PHEVs in Massachusetts compared to programs in most other states (except for New York).
4. Many states have rebate caps based on MSRP or purchase price. California is the only state with e-mile and income-based caps as well as an MSRP-based cap. The 2019 MOR-EV purchase price rebate cap is lower than in Delaware and New York (at $60,000) but higher than in Connecticut (at $42,000).
5. Three states (California, Connecticut, and Pennsylvania) offer additional low-income incentives.
6. One state, Connecticut, offers a used vehicle incentive for low-income customers only.
7. No state offers dealer incentives.
8. California is the largest program by far based on annual participation and spending. MOR-EV's 2018 program and the New York's 2019 program are the next largest programs. New York had

higher participation in 2019 but lower spending than MOR-EV due to lower average rebates per participant.

9. With an 80 percent participation rate, more Massachusetts EV buyers leverage state rebates than in other states.

Table 15. Summary of Other State EV Rebate Program Designs and Performance

State	Program Name	Program Year	Eligible Markets	Rebates		Rebate Caps	Dealer Incentive	LI Incentive	Used Vehicle Incentive	Participants	Total Spending ($M)	Participants by Vehicle Type (%)		Avg. Rebate per Participant ($)	Participation Rate (%)
				BEVs	PHEVs							BEVs	PHEVs		
MA	MOR-EV	2018	Res	$2,500	$1,500	$1,000 rebate for MSRP ≥ $60k	No	No	No	7,154	$16.3	62%	38%	$2,170	80%
		2019	Res	$1,500	$0	Purchase price ≤ $50k	No	No	No	1,923	$3.0	100%	-	$1,500	24%
CA	Clean Vehicle Rebate Project	2019	Res, Bus, Gov, Non-Profit	$2,500	$1,000	E-miles ≥ 20 MSRP ≤ $60k Income: $150k (single), $204k (head-of-household), and $300k (joint)	No	Add'l $2,000	No	69,140	$168.0	73%	27%	$2,405	47%
CT	CHEAPR	2019	Res	$500 - $2,000	$500 - $1,000	MSRP ≤ $42k	No	BEV: Add'l $2,000 PHEV: Add'l $1,500	LI Only BEV: $3,000 PHEV: $1,125	1,594	$2.6	75%	25%	$1,581	48%
DE	Clean Vehicle Rebate Program	2019	Res, Bus, Gov, Non-Profit, Education, Active-Duty Military	$3,500	$1,000	Purchase price ≤ $60k	No	No	No	570	$1.7	77%	23%	$2,882	69%
NY	Drive Clean Rebate	2019	Res, Bus, Gov	$500 - $2,000		$500 rebate for MSRP ≥ $60k	No	No	No	8,469	$13.7	54%	46%	$1,505	57%
PA	Alternative Fuel Vehicle Rebate Program	July 2018-June 2019	Res	$750 - $1,750		Purchase price ≤ $50k; $60k if BEV battery capacity > 65 kWh	No	Add'l $500	No	2,386	$3.8	83%	17%	$1,555	33%

Sources:

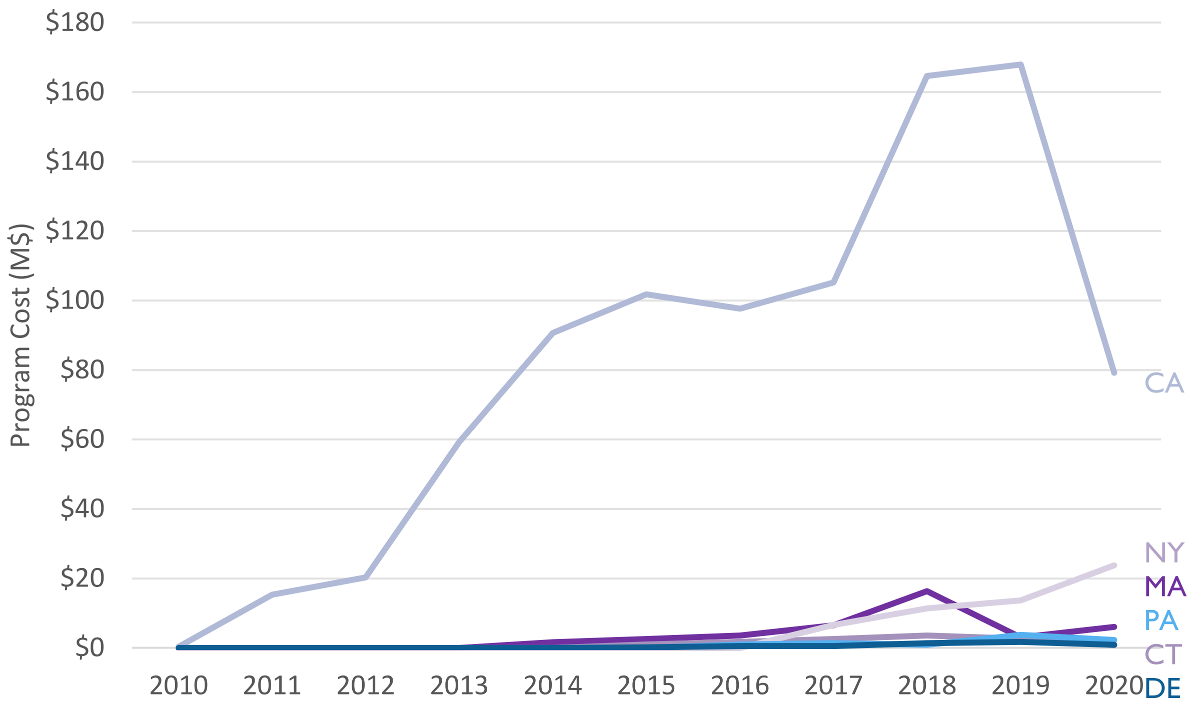
1. *MA: Massachusetts Department of Energy Resources, Massachusetts Clean Cities Coalition, and Center for Sustainable Energy. 2021. Massachusetts Offers Rebates for Electric Vehicles. Available at: https://mor-ev.org/.*
2. *CA: California Air Resources Board, California Climate Investments, and Center for Sustainable Energy. 2021. California Clean Vehicle Rebate Project. Available at: https://cleanvehiclerebate.org/eng.*
3. *CT: Connecticut Department of Energy and Environmental Program. 2021. Connecticut Hydrogen and Electric Automobile Purchase Rebate. Available at: https://portal.ct.gov/DEEP/Air/Mobile-Sources/CHEAPR/CHEAPR---Home.*
4. *DE: Delaware Department of Natural Resources and Environmental Control. 2021. The Delaware Clean Vehicle Rebate Program. Available at: https://dnrec.alpha.delaware.gov/climate-coastal-energy/clean-transportation/vehicle-rebates/.*
5. *NY: New York State Energy Research and Development Authority. 2021. Drive Clean Rebate for Plug-In Electric Cars. Available at: https://www.nyserda.ny.gov/All%20Programs/Programs/Drive%20Clean%20Rebate*
6. *PA: Pennsylvania Department of Environmental Protection. 2021. Alternative Fuels Incentive Grant Program (AFIG). Available at: https://www.dep.pa.gov/Citizens/GrantsLoansRebates/Alternative-Fuels-Incentive-Grant/Pages/default.aspx.*

Notes:

1. *The data in all states does not include FCEVs and ZEMs.*
2. *CA: "Gov" includes local, state, and federal government entities based in California.*
3. *PA: The state has a similar but separate grant program for education, non-profits, governments, and businesses to purchase EVs.*

Figure 23 shows the annual program spending for the states included in the table above. MOR-EV and Delaware's program launched in 2014, California in 2010, Connecticut and Pennsylvania in 2015, and New York in 2017. California's spending dropped to half of 2019 levels in 2020 but remains around four times higher than that of the next highest state.[31] New York's program outspent MOR-EV in 2019 and 2020.

Figure 23. Annual Program Spending by State



Sources:

1. *Rebate costs are based on the sources listed for Table 14.*
2. *MA: Meetings with the Massachusetts Department of Energy Resources. 2021.*
3. *CA: California Air Resources Board. 2020. Proposed Fiscal Year 20221 Funding Plan for Clean Transportation Incentives. Page 7. Available at: https://ww2.arb.ca.gov/sites/default/files/2020-11/proposed_fy2020-21_fundingplan.pdf.*
4. *NY: New York State Energy Research and Development Authority. 2021. Clean Energy Fund Investment Plan: Clean Transportation Chapter. Page 14. Available at: https://www.nyserda.ny.gov/About/Funding/Clean-Energy-Fund.*
5. *PA: Pennsylvania Department of Environmental Protection. 2021. Alternative Fuels Incentive Grant Program (AFIG). Available at: https://www.dep.pa.gov/Citizens/GrantsLoansRebates/Alternative-Fuels-Incentive-Grant/Pages/default.aspx.*

Note: Due to the absence of better data, the administration cost percentages used to find total program costs for Delaware and Connecticut are averages based on available data from Massachusetts, New York, and California.

[31] California had some program requirement changes that may have led to the decrease in spending in 2020. See: https://cleanvehiclerebate.org/eng/rebate-statistics, https://web.archive.org/web/20200407100728/https://cleanvehiclerebate.org/eng/faqs.

EV MARKET TRANSFORMATION

For any new technology, the degree of market transformation is assessed by examining changes in the rate of adoption over time. An s-curve, a mathematical function having a characteristic "S"-shaped curve or sigmoid curve, is a common way of mapping the sales transformation. Research has divided this shape into five segments with each segment categorized and defined globally as follows:

1. **Innovators** are a small group of people exploring innovative ideas and technologies. About 2.5 percent of the world population falls into this category.
2. **Early Adopters** represent 13.5 percent of the population. These individuals openly share positive opinions, are followed by others, and have a high degree of trust and credibility among these followers.
3. The **Early Majority** are followers of early adopters and represent 34 percent of the population.
4. The **Late Majority** are skeptics who are not keen on change and will only adopt a new product or service if there is a strong feeling of being left behind or missing out. These individuals account for 34 percent of the population.
5. **Laggards** comprise the remaining 16 percent of the population and will only adopt a new product or service when there are no alternatives.[32]

The rate of adoption for EVs is the percent of new car sales that are EVs or EV market share. Market share is the portion of a market controlled by a particular company or product.

Figure 24 shows current Massachusetts EV market share on a standard s-curve. In 2020, approximately 3 percent of new car sales were BEVs or PHEVs in Massachusetts, meaning that the state has just entered the early adopter phase. Fourteen states have adopted California's Low-Emission Vehicle (LEV) criteria pollutant and GHG emission regulations and Zero-Emission Vehicle (ZEV) regulations, including Massachusetts.[33] Eight of these states and Massachusetts are on the Multi-State Zero-Emissions Vehicle (ZEV) Task Force and require 15 percent of new vehicle sales to be zero emission vehicles by 2025.[34] Reaching those goals would mean that the states would be nearly entering the early majority phase by 2025.

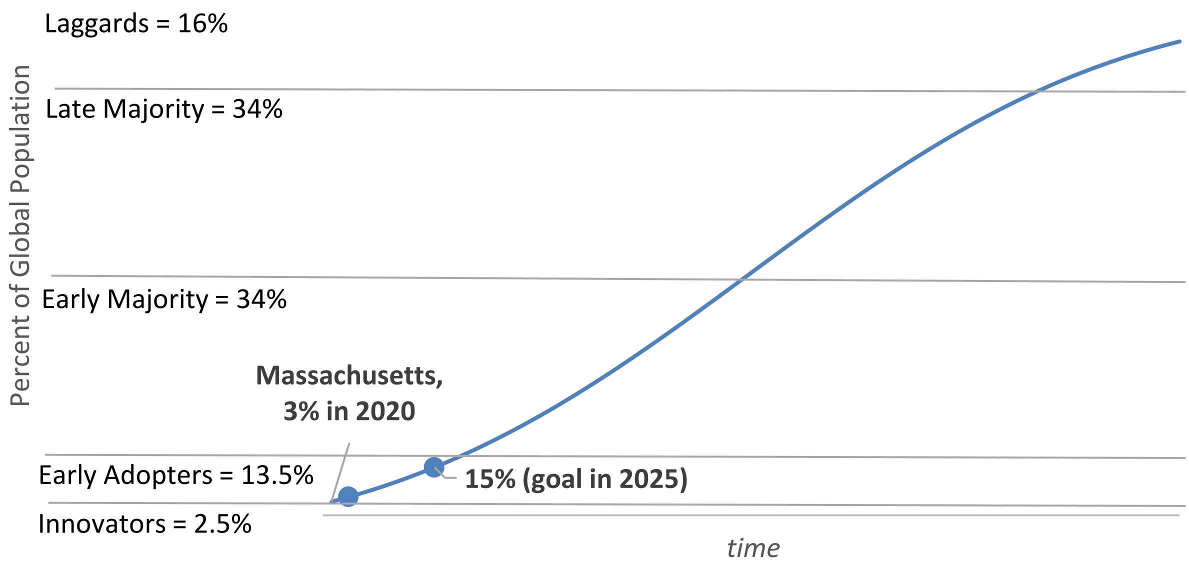
---

[32] Rogers, E.M. *Diffusion of Innovations*, 1st ed.; Free Press of Glencoe: New York, NY, USA, 1962.

[33] *States that have Adopted California's Vehicle Standards under Section 177 of the Federal Clean Air Act*. Available at: https://ww2.arb.ca.gov/sites/default/files/2019-03/177-states.pdf

[34] Laska, Alexander. *New Multi-State Plan Outlines Priority Actions for Increasing Zero-Emissions Vehicle Adoption*. July 06, 2018. Eno Center for Transportation. Available at: https://www.enotrans.org/article/new-multi-state-plan-outlines-priority-actions-for-increasing-zero-emissions-vehicle-adoption/

Figure 24. Massachusetts EV Market Share in 2020



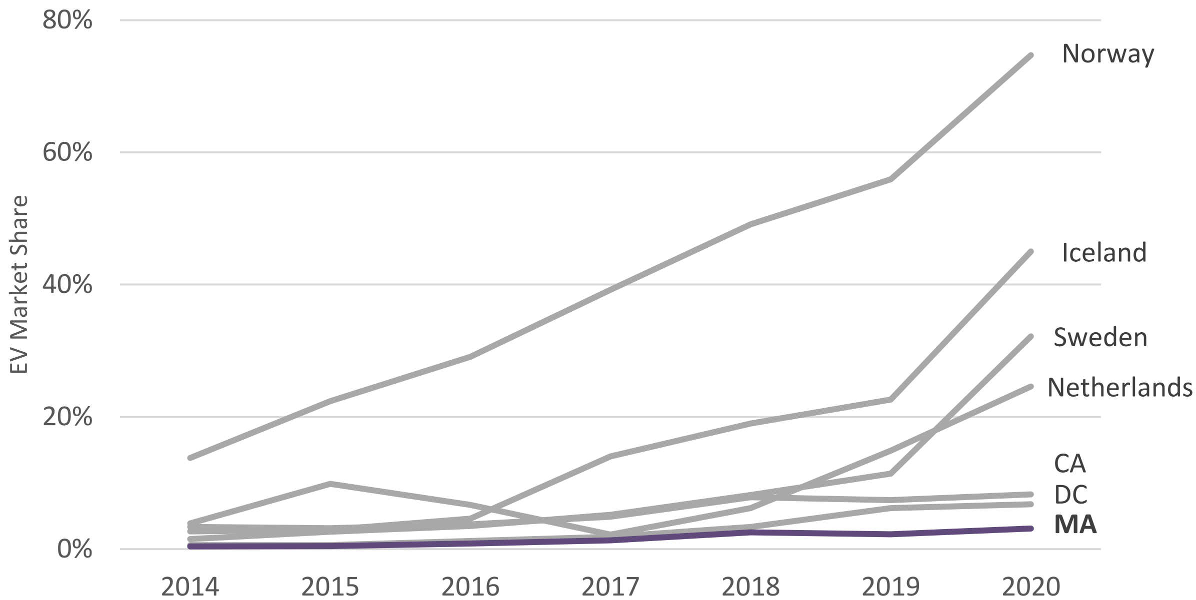
Sources:

1. *Market transformation segments from Rogers, E.M. Diffusion of Innovations, 1st ed.; Free Press of Glencoe: New York, NY, USA, 1962.*
2. *Massachusetts 2020 EV Market Share from Alliance for Automotive Innovation, Electric Vehicle Sales Dashboard, ATV Market Share, FCEVs, BEVs and PHEVs, https://www.autosinnovate.org/resources/electric-vehicle-sales-dashboard.*

Figure 25 compares EV market share growth in the top countries and U.S. states (including Massachusetts) from 2014 to 2020. Progress through each segment takes a different amount of time in different places, due to differing demographics, behaviors, policies, and practices. In Norway, the top country, EV market share rose from 14 percent in 2014 to 75 percent in 2020 and the country is on track to reach 100 percent by mid-2022.[35] In California, the top U.S. state, EV market share rose from 3 percent to 8 percent over the same period. Massachusetts increased from half a percent to 3 percent during that time, surpassing the U.S. average.

[35] Margeit, Rob. *Norway to hit 100 per cent electric vehicle sales early next year*. DRIVE. October 6, 2021. Available at: https://www.drive.com.au/news/norway-to-hit-100-per-cent-electric-vehicle-sales-by-next-year/.

Figure 25. EV Market Share Growth in the Top Countries and U.S. States, 2014 to 2020



Sources:

1. *An aggregated list of sources for each country in each year appears on Wikipedia, at: https://en.wikipedia.org/wiki/Electric_car_use_by_country, in the Market Share table titled "Passenger plug-in market share of total new car sales for selected countries and selected regional markets since 2013."*
2. *U.S. average, California, Massachusetts, and District of Columbia from Alliance for Automotive Innovation, Electric Vehicle Sales Dashboard, ATV Market Share, FCEVs, BEVs and PHEVs, https://www.autosinnovate.org/resources/electric-vehicle-sales-dashboard.*

ALTERNATIVE OR SUPPLEMENTAL EV INCENTIVE STRATEGIES

This section discusses alternative or supplemental EV incentive strategies (to statewide rebate programs like MOR-EV) employed in U.S. states and countries with higher EV market shares. Strategies in U.S. states are discussed first, followed by strategies in other countries.

Table 16 identifies five alternative or supplemental EV incentive strategies used in the 10 U.S. states with the highest EV market share including: vehicle purchase tax credits or exemptions, vehicle registration fee reductions or exemptions, state tax credits, emissions inspection exemptions, and electric utility time-of-use rates or EV charging credits. For comparison, the strategies are shown for two U.S. states with the lowest EV market share as well.

In general, there are a variety of EV incentive strategies employed in U.S. states and clear takeaways regarding which strategies are most successful at driving EV adoption are not evident in the available data.

- Half of the top 10 U.S. states have statewide rebate programs including California, Oregon, Vermont, New Jersey, and Massachusetts.[36] California, Oregon, and Massachusetts also have some utilities that offer time-of-use rates or EV charging credits.
- Instead of a statewide rebate program, Washington and New Jersey offer vehicle purchase tax exemptions. The District of Columbia offers a title excise tax exemption, a registration fee reduction, and its utility—PEPCO—offers a time-of-use rate.
- Colorado and Oklahoma offer state tax credits, which are more aligned with federal tax credits than statewide rebate programs like MOR-EV.
- Washington, Colorado, Massachusetts, and Nevada provide exemptions for EVs from emissions inspections requirements, which provide another form of cost savings.

Notably, Hawaii and Nevada do not offer many EV incentives but have high EV market shares relative to many other states. It is likely that factors such as demographics, vehicle fleet composition, geography, and gasoline prices, among others, are also playing a role in EV adoption in these states. However, the top states may offer one or more EV incentives whereas the bottom states may not offer an EV incentive, indicating that these incentive offerings help increase EV purchase consideration.

[36] Oregon, Vermont, and New Jersey's programs launched recently and therefore it is unclear if the impacts of those programs are fully reflected in the 2020 market share data.

Table 16. Alterative or Supplemental EV Incentive Strategies in the Top Ten and Bottom Two U.S. States

State		EV Market Share (2020)	Statewide EV Rebate Programs (Launch Date)	Alternative or Supplemental EV Incentive Strategies					
				Vehicle Purchase Tax Credits or Exemptions	Vehicle Excise Tax Credits or Exemptions	Registration Fee Reductions or Exemptions	State Tax Credits	Emissions Inspection Exemptions	Utility TOU Rates or EV Charging Credits
Top 10	CA	8.35%	X (2010)						x (Liberty, MCE, and Azusa)
	DC	6.19%			x	x			x (PEPCO)
	WA	5.53%		x				x	
	HI	5.29%							x (HECO)
	OR	5.25%	X (2018)						x (PGE)
	CO	4.17%					x	x	
	MA	3.13%	x (2014)					x	x (Eversource and Braintree Electric Department)
	VT	3.05%	x (2019)						
	NV	3.02%						x	x (NV energy)
	NJ	2.98%	x (2021)	x					
Bottom 2	ND	0.26%							
	OK	0.17%					x		

Sources:

1. *EV Market Share: Alliance for Automotive Innovation. 2021. "Electric Vehicle Sales Dashboard." Available at:* https://www.autosinnovate.org/resources/electric-vehicle-sales-dashboard.
2. *Statewide EV Program Rebate Program from* https://afdc.energy.gov/laws/state *(launch dates from individual program websites).*
3. *Other vehicle incentives from: https://afdc.energy.gov/laws/state.*

Table 17 identifies six alternative or supplemental EV incentive or gasoline vehicle penalty strategies used in the four countries with the highest EV market share including: vehicle purchase tax credits or exemptions, excise tax exemptions, annual insurance tax exemptions, company car tax reductions or deductions, gasoline vehicle tax penalties, and gasoline taxes.

As with the findings for U.S. states, there are a variety of EV incentive and penalty strategies employed in countries and clear takeaways regarding which strategies are most successful at driving EV adoption are not evident in the available data. It is likely that factors such as demographics, geography including the proportion of the population in urban areas, and gasoline and electricity prices, among others, also play a role in EV adoption in these countries.

- Sweden and the Netherlands introduced penalties for gasoline vehicles, in addition to incentives for EVs.
- All top countries have multiple EV incentives or gasoline vehicle penalties in place. The Netherlands has the most with six incentives or penalties.
- Vehicle purchase tax credits or exemptions and company car tax reductions or deductions are the most common form of incentives, with each one in use in three of the four countries.
- Norway and the Netherlands offer a combination of upfront, one-time incentives such as purchase tax credits or exemptions and annual, ongoing incentives or penalties such as gasoline taxes.

Table 17. Alternative or Supplemental EV Incentive or Gasoline Vehicle Penalty Strategies in the Top Four Countries

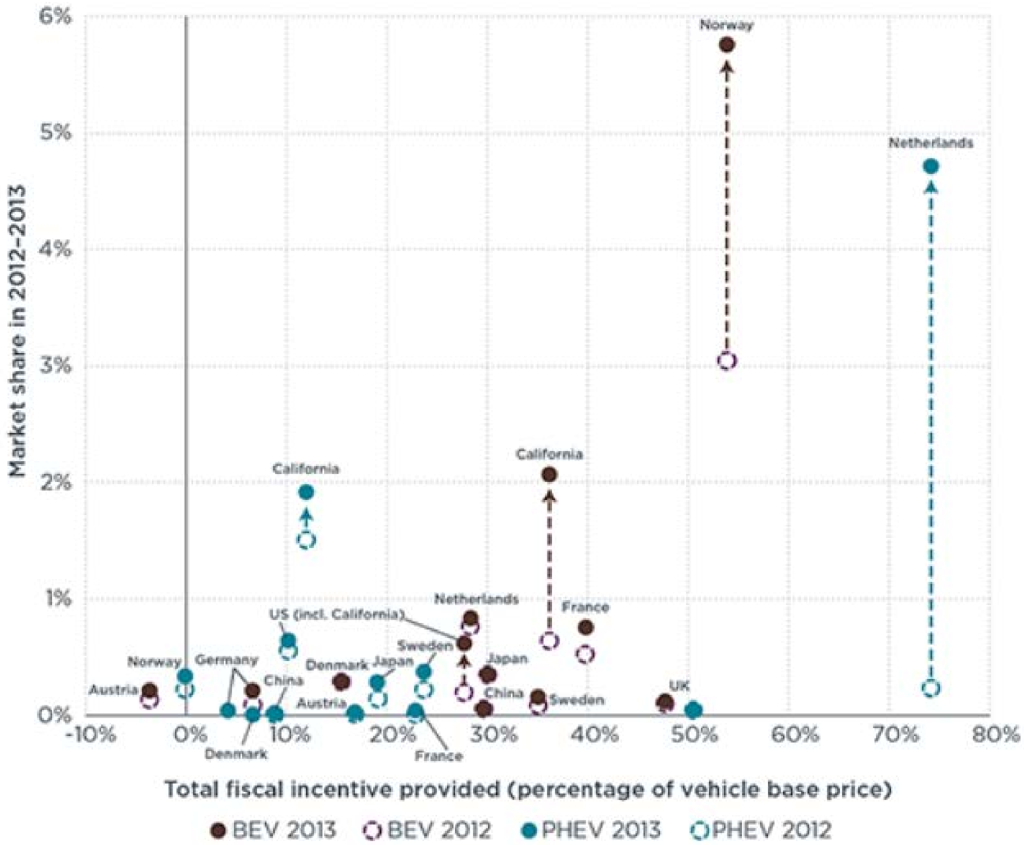
Country	EV Market Share (2020)	Country-wide EV Incentive Programs (Launch Date)	Alternative or Supplemental EV Incentive or Gasoline Vehicle Penalty Strategies					
			Vehicle Purchase Tax Credits or Exemptions	Excise Tax Exemptions	Annual Insurance Tax Exemptions	Company Car Tax Reductions or Deductions	Gasoline Vehicle Tax Penalties	Gasoline Tax
Norway	75%		x		x	x		
Iceland	45%		x	x				
Sweden	32%	x (2018)				x	x	
Netherlands	25%	x (2020)	x		x	x	x	x

Sources:

1. *Market share from table titled "Passenger plug-in market share of total new car sales for selected countries and selected regional markets since 2013", https://en.wikipedia.org/wiki/Electric_car_use_by_country.*
2. *Norway from https://blog.wallbox.com/norway-ev-incentives/.*
3. *Iceland from https://theicct.org/blog/staff/iceland-ev-market-201807.*
4. *Sweden from https://blog.wallbox.com/ev-incentives-europe-guide/#index_10.*
5. *Netherlands from https://blog.wallbox.com/ev-incentives-europe-guide/#index_11.*

Incentive levels are also playing a significant role in driving EV adoption, as the percent is significantly higher in some top countries than in Massachusetts. Figure 26 shows that BEV incentives were 28 percent in the Netherlands and Sweden and 54 percent in Norway in 2013, as compared to 20 percent for Massachusetts. The higher EV market share in some countries is due in part to more forms of incentives which sum to a higher total incentive value for EV adopters.

Figure 26. EV Incentive as a Percent of Vehicle Price by Country



Source: Mock, Peter and Zifei Yang. Driving electrification: A global comparison of fiscal policy for electric vehicles. The International Council on Clean Transportation. May 5, 2014. https://theicct.org/publications/driving-electrification-global-comparison-fiscal-policy-electric-vehicles.

FINDINGS

The MOR-EV Program can benefit from ample information to inform its direction, with seven years of MOR-EV performance data spanning several program design updates, along with insights on strategies and performance in other states and countries. Several areas have emerged as shortcomings of the current program construct and thus are higher priorities for the next phase of the program. These include: (1) financial sustainability, (2) cost-effectiveness, and (3) equity. This section summarizes these shortcomings and priorities moving forward.

1. Financial sustainability: The EV market continues to transform with the evolution of incentive structures, adoption of other supportive policies, expansion of EV options, and growth in exposure to and experience with EVs. Without program design changes, increased market adoption of EVs will strain the financial sustainability of the program. Funds to support the program will not be able to increase at the rate of EV adoption.

   In addition, many factors beyond finance influence the new car buying decision. Other states and nations are ahead of Massachusetts in percentage of new EVs sold due in part to complementary policies and practices. Education for customers, dealers, and vehicle salespeople is essential to influence more consumers to consider an EV as their next vehicle purchase. Policies which eliminate unnecessary operation and maintenance requirements (such as emissions inspections), provide for shorter drive times through priority access to routes with less traffic, and provide for charging and access to parking spots in high demand locations provide supplemental benefits that have value to consumers. Penalties which disincentivize the purchase and operation of gasoline-fueled vehicles also play an important role in shifting vehicle preferences.

2. Cost-effectiveness: Free ridership is an important determinant of the cost-effectiveness of the program. This BCA includes free rider participants in program costs but not in the benefits, reducing the cost-effectiveness of the program. Higher free ridership increases the dollar per ton of GHGs reduced and reduces the BCR of the program. The current MOR-EV Program suffers from high free ridership, meaning that this spending is not necessary to encourage the EV purchase. Also, free ridership is higher for vehicles with high purchase prices.

3. Equity: The MOR-EV Program is increasing the percent of used vehicles that are EVs, which may eventually make EVs more available to lower-income households. In addition, it makes new vehicle purchases more attractive, which suppresses demand and therefore prices on used vehicle equivalents (used EVs). However, LMI consumers are less likely to participate in the MOR-EV Program to date due to the higher price of new vehicles as compared to used vehicles, the higher price of EVs as compared to conventional vehicles (many of them are made by luxury vehicle manufacturers), and the additional cost to purchase a new EV as compared to a gasoline-fueled vehicle. A portion of the incentives were not reserved for lower-income households, nor has the program offered higher incentives for consumers with lower incomes.

OPPORTUNITIES

This section summarizes opportunities to evolve the program design to address the key findings. For each opportunity, this report identifies the opportunity's ability to address the three emerging program goals of financial sustainability, cost-effectiveness, and equity.

1. Reducing the vehicle purchase price cap is highly likely to improve financial sustainability, cost-effectiveness, and equity. Reducing the cap can improve program financial sustainability by reducing the overall percent of EV sales eligible for participation. Reducing the cap can improve cost-effectiveness by reducing free ridership in the program, which reduces the dollar per ton of GHG reduction and increases the program BCR. Reducing the cap can improve equity by ensuring more rebates are available for lower-cost new vehicles.

   To address some uncertainties customers face regarding incentive availability, the incentive amount and cap could be based on a publicly available and transparent schedule. This will ensure manufacturers, dealers, vehicle salespeople, and customers have advance notice of upcoming program changes and can plan accordingly.

   To ensure incentives of sufficient magnitude moving forward, the incentive and cap should consider projections of changes in federal incentives, increasing EV market share, and decreases in EV costs over time.

2. Limiting PHEV incentive eligibility to only vehicle types for which there are no BEV alternatives at reasonable price points is highly likely to improve financial sustainability and cost-effectiveness. PHEVs represent a substantial portion of overall program rebates, and their exclusion would decrease the number of rebates provided and thus improve the program's financial sustainability. A recent study found PHEVs drive more than half the time on gasoline. PHEVs have a higher cost per ton of GHG reduction than BEVs, and thus removal of PHEV eligibility would improve program cost-effectiveness.

3. Considering the inclusion of separate incentives for LMI customers will improve equity. Any future MOR-EV Program design process should evaluate measures from other states for possible inclusion, including vouchers and separate rebate processes.

4. Targeting awareness campaigns at historically underserved communities and consumers by the MOR-EV Program can improve equity. Any such campaign should provide vehicle, charging infrastructure, and incentive availability information (including state, federal, and other types of incentives). Improving dealer and vehicle salesperson program awareness in key geographies will also help with equity.

5. Further targeting the program to consumers whose current vehicle, location, and behaviors result in higher emissions can improve the program's financial sustainability, cost-effectiveness, and equity. Incentives targeted at drivers of inefficient vehicles and high mileage drivers can increase financial sustainability by decreasing the overall pool of eligible participants and/or decreasing the value of the incentive available to those outside of the high emissions participant pool. Targeted incentives can increase cost-effectiveness by increasing the benefits provided by each

participating vehicle. A carefully designed incentive structure can avoid the perverse incentive of encouraging people to drive more. The incorporation of a geographic adder for the incentive can ensure the program addresses those residents living in rural areas (further away from places of work or recreation) or in environmental justice communities (who are most affected by the health impacts of transportation-related pollution).

6. Revising the program to enable up-front provision of the incentive and/or structures to reduce monthly payments would improve equity by enabling more of the LMI population to participate in the program. This feature would also improve the accessibility and immediacy of the incentive. For the existing program to provide an up-front incentive, it would require an intermediary debt-service to provide the incentive at time of purchase and then be subsequently reimbursed by the state. Over time, the state could offer a reduction in taxes or fees at the time of purchase. Such a tax and/or fee exemption could be revenue neutral with the addition of a luxury tax on new inefficient gasoline vehicle sales. In addition, point-of-sale incentives with a portion attributed customer and a portion to the dealer and/or salesperson in select geographies can help drive increases in EV market share in environmental justice communities.

7. Aligning eligibility with other programs to support the Commonwealth's decarbonization policies can improve financial sustainability and cost-effectiveness by ensuring spending is well coordinated and allocated to the initiatives that provide the greatest benefit for the cost. For example:

    a. vehicle incentive eligibility could require household energy efficiency audits and installation of certain energy efficiency measures (e.g., Mass Save®), demand response program enrollment (e.g., ConnectedSolutions), and/or Clean Peak Energy Standard participation;

    b. applications from renters or condominium dwellers could trigger installation of on-site charging infrastructure; and

    c. eligibility for solar and storage incentives could depend on first electrifying a participant's vehicle and/or building.

    The more participants that take advantage of energy efficiency, demand response, and on-site solar generation paired with storage, in concert with vehicle electrification, the closer the state can get to its GHG emission reduction requirements.

8. Including used EVs or a guaranteed second sale to LMI customers: This would improve equity by expanding the pool of eligible EVs (potentially at a significantly lower price point) and/or guaranteeing used EVs are available for purchase by LMI customers. Some states provide additional incentives for the lease or purchase of used EVs. Since used EVs do not currently qualify for federal tax credits, additional program funding could be beneficial for improving access to EVs at even lower price points than new models. The inclusion of used EV incentives, and the parameters through which customers or vehicles are eligible for rebate access, are worth consideration as part of future MOR-EV Program design. For the program to enable a second sale model would require changes to the eligibility criteria and participation requirements for

Commercial Fleets, including adjustments similar in design to affordable housing deed restrictions as described under Chapter 40B, the Commonwealth's Affordable Housing Law. In the same way that homes are deed restricted to only be sold on to eligible residents, vehicles could be title restricted so they would only be sold on to LMI customers. This feature would improve EV availability by ensuring that vehicles are available exclusively to LMI customers.

CONCLUSIONS

MOR-EV was one of the first programs of its kind in the United States, and the performance of the program to date offers many lessons learned. As with any new initiative, there are successful aspects of the program as well as opportunities for improvement. Three areas of concern with the current program are financial sustainability, cost-effectiveness, and equity. These shortcomings are higher priorities for the next phase of the program and the opportunities presented here focus on achieving these three priorities.

Some opportunities for improvement can be implemented immediately. Others will take more time and may be more appropriate once the state achieves higher levels of EV adoption. For example, the opportunities identified to improve equity are a starting point; more can and should be done to improve equity in this program. As discussed above, this could include higher rebate amounts directed at LMI consumers and the expansion of the program to include used vehicles. Also note that private vehicle purchases are by their very nature an inequitable act, making achieving equity in this arena more challenging. A stakeholder forum on equity is needed to brainstorm these and other opportunities further and inform future action.

The exact design of the program and incentives will depend on the level of EV market share the state desires over what timeframe, federal actions and incentives for EVs over that period, and other transportation program funding needs and cost-effectiveness. The MOR-EV Program is one tool in the state's transportation emission reduction toolkit. Investments in other programs may help to reduce the number of drivers and/or the vehicle-miles traveled by drivers. These outcomes are achievable through better public transportation, remote work, and more walkable and bikeable streets. Programs that achieve these outcomes may be more accessible to and have a larger impact on LMI households. By conducting similar cost-effectiveness analyses on its other program efforts and other strategies under consideration, the state can optimize its current programs and prioritize investments in programs that can reduce emissions at the lowest cost.