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CADMUS

Maine Clean Transportation Roadmap

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Glossary of Terms

Glossary of Terms

ACC II	Advanced Clean Cars II. ACC II is a proposed California regulation that requires increasing numbers of zero emission light-duty vehicles be sold by automakers.
ACT	Advanced Clean Trucks. California regulation that requires increasing numbers of medium- and heavy-duty vehicle sales be zero emissions.
BEV	Battery electric vehicle. A vehicle powered exclusively by electricity (such as a Nissan LEAF).
CCS	Combined charging system. This is a DC fast charging standard supported by Volkswagen, General Motors, BMW, Daimler, Ford, FCA, Tesla, and Hyundai.
CHAdeMO	This is a DC fast charging standard developed in Japan that goes up to 62.5 kW, originally supported by Nissan, Mitsubishi, and Fuji Heavy Industries (which manufactures Subaru vehicles). Toyota later supported the standard as well, and Tesla sells an adapter allowing its vehicles to use CHAdeMO chargers.
CMP	Central Maine Power Company.
CO	Carbon monoxide.
DCFC	Direct-current (DC) fast charging equipment. DCFCs are sometimes called DC Level 3 (typically 208/480V AC three-phase input) and enable rapid charging of an electric vehicle.
EV	Electric vehicle. A vehicle powered, at least in part, by electricity. Unless otherwise noted, the term “EV” in this Roadmap refers to all plug-in vehicles and includes BEVs and plug-in hybrid electric vehicles (PHEVs; defined below). The term “EV” is synonymous with “plug-in electric vehicle” (PEV).
EVSP	Electric vehicle service provider. An EVSP provides connectivity across a network of charging stations. Connecting to a central server, they manage the software, database, and communication interfaces that enable operation of the station.
FCEV	Fuel cell electric vehicle.
GHG	Greenhouse gas. Gases that trap heat in the atmosphere, such as carbon dioxide, methane, and nitrous oxide.
HEV	Hybrid electric vehicle. A vehicle powered by an internal combustion engine in combination with an electric motor that uses energy stored in batteries. These vehicles rely on regenerative breaking rather than plugging into off-board electricity.
ICEV	Internal combustion engine vehicle. A vehicle that combusts fuel, such as gasoline or diesel, for power.
kW	Kilowatt. A unit of power.
kWh	Kilowatt-hour. A unit of energy.
LDVs	Light-duty vehicles. Vehicles with a gross vehicle weight rating below 8,500 pounds, which aligns with Class 1 to Class 2a vehicles.
MHDVs	Medium- and heavy-duty vehicles. Vehicles with a gross vehicle weight rating above 8,500 pounds, which aligns with Class 2b to Class 8 vehicles.
MMT	Million metric tons.

$MMTCO_2e$	Million metric tons of carbon dioxide equivalent.
MUD	Multi-unit dwelling. Also called “multi-family dwellings,” these are apartments, condominiums, and group quarters. The other major housing category used in this Roadmap is single-family homes.
NH3	Ammonia.
NOX	Nitrogen oxides.
PHEV	Plug-in hybrid electric vehicle. A vehicle powered by electricity or an internal combustion engine.
PM10/2.5	Particulate matter.
SO2	Sulfur dioxide.
TCO	Total cost of ownership.
US DOE	United States Department of Energy.
VIUS	Vehicle Inventory and Use Survey.
VMT	Vehicle miles traveled.
VOC	Volatile organic compounds.
ZEV	Zero-emission vehicle.

Executive Summary

The State of Maine is leading on climate action among peer states. In its 2020 *Maine Won't Wait* Climate Action Plan, the state lays out a bold set of strategies to reduce greenhouse gas (GHG) emissions by 45% by 2030 and 80% by 2050 and achieve carbon neutrality by 2045, and its progress toward achieving these goals is real. For example, since 2019 the number of battery electric and plug-in hybrid electric vehicles **increased by 90% to 5,577 vehicles** and the number of public charging stations **increased by 62% to 265 stations.** [1] The electricity that powers these vehicles continues to be cleaner as the state makes progress toward achieving its requirement of 80% renewable energy by 2030.[2] Further, the state and regional partners continue to explore new approaches for providing public transportation efficiently and effectively, including innovative solutions in rural Maine, and in 2021 spent **$11.55 per capita on public transit.**

This **Clean Transportation Roadmap**—a specific action of *Maine Won't Wait*—identifies the policies, programs, and regulatory changes needed to continue decarbonizing Maine's transportation sector in coming years. The work was conducted in 2021 by researchers at Cadmus and E2Tech, with oversight from a steering committee composed of state agency staff. An external advisory group provided technical input for the modeling, analysis, and recommendations.

Maine's transportation sector produced **54% of statewide, fossil-fuel GHG emissions** in 2017, or approximately 8 million metric tons of carbon dioxide equivalent ($MMTCO_2e$). Decarbonizing the transportation sector is a challenge with over 1 million vehicles on the road and thousands of off-road vehicles, aircraft, and marine vessels. Light-duty cars and trucks are the source of **approximately 60% of total sector GHG emissions**. Given the cost and scarcity of low-carbon fuels, the light-duty vehicle (LDV) fleet must achieve near-zero emissions in the aggregate by 2050 for Maine to achieve its 2050 GHG goal. Medium- and heavy-duty surface vehicles produce the next largest segment of sector emissions—**approximately 27% in 2017**—and must similarly be decarbonized but with a greater variety of fuels and at a pace sensitive to the needs of the business community in Maine.

Although multiple strategies could reduce emissions to near-zero levels, deployment of electric vehicles (EVs) appears to be the most important, technologically ready strategy for almost all modes, due to comparatively low fuel cost, high drive-train efficiency, and sustained falling costs of batteries. As a result, EVs represent the largest focus of this Clean Transportation Roadmap. Yet, increasing the adoption of EVs faces several constraints. In the near-term (probably the next two years), EV adoption will be constrained due to global supply chain issues, insufficient diversity of makes and models, higher upfront costs of EVs relative to comparable vehicles, and low inventory of used vehicles. By the mid-2020s, these constraints are expected to ease.

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1 Maine Climate Council (2021) https://www.maine.gov/future/sites/maine.gov.future/files/inline-files/MaineWontWait_OneYearProgressReport_SinglePgs.pdf

2 State of Maine (2021) https://www.maine.gov/energy/initiatives/renewable-energy/renewable-portfolio-standards

This roadmap also highlights strategies to reduce vehicle miles traveled (VMT) and shift travel away from personal automobiles. These strategies include pricing strategies, infill development, transit expansion, telecommuting, and bicycle and pedestrian infrastructure.

Because of the long planning horizon necessary for the design and construction of infrastructure projects, the Maine Department of Transportation (MaineDOT) advanced several new initiatives prior to the publication of this roadmap. These include rewriting the state's Complete Streets Policy, hiring a consultant to prepare transit bus electrification plans for select Maine transit agencies, updating the Statewide Strategic Transit Plan, and relaunching the Go Maine initiative in partnership with the Turnpike Authority. Maine's efforts to increase the availability of high-speed broadband internet service through the establishment of the new Maine Connectivity Authority will also yield transportation emissions reduction dividends as will the new Legislative Commission to Increase Housing Opportunities by Studying Zoning and Land Use Restrictions and the significant inclusion of federal resources via the American Recovery Plan Act (ARPA) and the Infrastructure Investment and Jobs Act (IIJA).

Additional policy interventions are necessary to accelerate a transition toward a decarbonized transportation sector while minimizing unintended consequences, stranded investments, and socioeconomic inequities. This roadmap, a first attempt at a plan for this transition, focuses on the strategies needed before 2025, although longer-term considerations are also discussed.

Policy Recommendations

Through its analysis, Cadmus developed a set of recommended new programs for state government, local governments, utilities and their regulator, and Efficiency Maine Trust, as listed in Table 1. This work was aided by E2Tech, which facilitated a statewide stakeholder engagement process. These recommendations will help direct consumers, businesses, and government agencies toward cleaner transportation options. Each recommended policy is associated with a goal and a rationale.

Table 1. Cadmus Recommendations for New Programs

	Program	Goal	Rationale
State-or Efficiency Maine Run Programs	**Advanced Clean Cars II**	Increase EV Adoption	• If implemented, programs will have profound impact on GHG emissions from the transportation sector. • Sends clear, long-term signal to automakers to increase deliveries of EVs. • Historically, EV market share has been roughly twice as high in states that follow California emission regulations (Section 177 states), illustrating effectiveness of vehicle sales requirements.[3]
	Advanced Clean Trucks		
	Public DCFC Incentive and/or Ownership	Expand Charging Network	• Cadmus analysis using MA3T model suggests expanding public fast chargers by 15% in 2030 boosts EV sales by 7% in 2030 relative to business-as-usual. • Academic literature clearly demonstrates positive relationship between DCFC access and EV sales.[4]

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[3] Center for American Progress (CAP; Cattaneo, Lia). June 2018. "*Plug-In Electric Vehicles: Evaluating the Effectiveness of State Policies for Increasing Deployment*". https://cdn.americanprogress.org/content/uploads/2018/06/06140002/EVreport-5.pdf

[4] For example, see review by Hardman, Scott. 2019. "Understanding the impact of reoccurring and non-financial incentives on plug-in electric vehicle adoption – A review." *Transp. Res. A Policy Pract.* 119, 1-14. https://phev.ucdavis.edu/wp-content/uploads/reoccurring-incentives-literature-review.pdf

	Program	Goal	Rationale
	Multi-Unit Dwelling (MUD) L2 Charger Incentive Program	Expand Charging Network	• Availability of charging in MUDs unlocks latent demand for EVs.[5] • 21% of Maine households are in MUDs (buildings with 2+ households).[6] • MUD households have approximately 50% lower household income in Maine than households in single-family homes.[7] • Cadmus analysis in MA3T model shows that enabling access to charging at MUDs is more impactful on EV sales than providing charging for single-family homes.
	Expanded Low-Income EV Incentive Program with L2 Charger	Incentivize Clean Vehicles	• EV rebate programs with a low-income component reduce free-riders and potentially increase cost-effectiveness.[8] • Low-income households have the largest transportation-related health burden of any group.
	Cash for Clunkers Program	Incentivize Clean Vehicles	• Removes high polluting vehicles, creating potential benefit to low-income households, which are most burdened by transportation emissions. • One of few programs capable of increasing turnover of vehicle stock. • Program requires equitable design—for example, in the 2009 federal CARS program participants were higher income than average used car buyers,[9] though lower income than average new car buyers, and only 1% of subsidies went to individuals in the bottom 50% of income.[10]
	Medium- and Heavy-Duty EV Incentive	Incentivize Clean Vehicles	• Incentives will help reduce the cost differential of ZEV MHDVs for fleet owners • Electrifying MHDVs is critical for meeting Maine's 2030 and 2050 GHG goals.[11]
	Marketing and Awareness Campaign	Education & Awareness	• Ensures public has concise, accurate information on clean transportation modes, incentives, and technologies. • Provides technical assistance to stakeholders in need.

5 DeShazo, J.R. 2019. "Overcoming Barriers to Electric Vehicle Charging in Multi-unit Dwellings: A Westside Cities Case Study" https://innovation.luskin.ucla.edu/wp-content/uploads/2019/03/Overcoming_Barriers_to_EV_Charging_in_MUDs-A_Westside_Cities_Case_Study.pdf

6 Only 19% when including Group Quarters. Data from US Census (2019) American Community Survey, 5-year Survey. https://data.census.gov/

7 Data from US Census (2019) American Community Survey, 5-year Survey. https://data.census.gov/

8 DeShazo, J. R., T. L. Sheldon, and R. T. Carson. 2017. "Designing Policy Incentives for Cleaner Technologies: Lessons from California's Plug-In Electric Vehicle Rebate Program." *Journal of Environmental Economics and Management* (84): 18–43. https://doi.org/10.1016/j.jeem.2017.01.002

9 Parker, T. & Gayer, E. Cash for Clunkers: An Evaluation of the Car Allowance Rebate System. Tech. Rep. (2013). https://www.brookings.edu/research/cash-for-clunkers-an-evaluation-of-the-car-allowance-rebate-system/

10 Miller, K. S., Wilson, W. W. & Wood, N. G. Environmentalism, Stimulus, and Inequality Reduction Through Industrial Policy: Did Cash for Clunkers Achieve the Trifecta? *Economic Inquiry* **58**, 1109–1128 (2020). https://doi.org/10.1111/ecin.12889

11 State of Maine (2020) Maine Won't Wait, Climate Action Plan. https://www.maine.gov/future/sites/maine.gov.future/files/inline-files/MaineWontWait_December2020.pdf

	Program	Goal	Rationale
Local Programs	**EV-Ready Building Codes**	Expand Charging Network	• EV-ready and EV-capable building codes are critical for reducing the cost of future charging installation on the customer side. • Estimates show that electric vehicle supply equipment (EVSE) installation costs increase by two[12] to six[13] times if a parking space is made EV-ready after construction compared to during construction.
	Transit Village to Encourage Transit Oriented Development (TOD)	VMT Reduction & Mode Shift	• Reduces VMT, boosts transit ridership, and reduces need for traditional road infrastructure.
	Bicycle & Pedestrian Investment	VMT Reduction & Mode Shift	• Ensures prioritization of nonmotorized modes. • Facilitates support of emerging micro-mobility technologies, such as e-bikes and e-scooters.
	Marketing and Awareness Campaign	Education & Awareness	• Ensures public has concise, accurate information on clean transportation modes, incentives, and technologies.
Utility or Efficiency Maine Programs	**Demand Charge Relief**	Expand Charging Network	• Cadmus analysis of CMP rates suggests demand charges account for between 34% and 70% of total costs for a 50 kW DCFC station and between 24% and 62% of total costs for a 350 kW DCFC station. • Critical for corridor charging, certain fleets, and sites with many plugs. • In a tariff analysis, Rocky Mountain Institute shows that reducing or eliminating demand charges can promote a more conducive business environment for the public DCFC market.[14]
	Utility-Side Make-Ready Infrastructure	Expand Charging Network	• Removes key barrier to expanding charging infrastructure, following California and New York programs.[15,16]
	Time Of Use (TOU) Rates	Incentivize Clean Vehicles	• Supports demand response and efficiency of grid. • Lowers operating cost of EVs.
	Marketing and Awareness Campaign	Education & Awareness	• Ensures public has concise, accurate information on clean transportation modes, incentives, and technologies.

Funding Recommendations

The roadmap also explores the magnitude and timing of investment needed between 2022 and 2025 for charging infrastructure and for an expanded low- and moderate-income (LMI) EV rebate. As shown in Table 2, the estimated investment for these programs increases over time as EV adoption grows. Note that the investments in Table 2 are typically shared between government, the business community, homeowners, and other entities. DCFC charging and LMI EV rebates are the two most critical programs

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12 Great Plains Institute (GPI; McFarlane, B. D., M. Prorok, and T. Kemabonta). 2019a. "Analytical White Paper: Overcoming Barriers to Expanding Fast Charging Infrastructure in the Midcontinent Region." https://scripts.betterenergy.org/reports/GPI_DCFC_Analysis_July_2019.pdf

13 California Electric Transportation Coalition (CalETC; DoVale K., E. Kamei, C. Kido, and E. Pike). 2019. *Plug-In Electric Vehicle Infrastructure Cost Analysis Report for CALGreen Nonresidential Update.* https://caletc.com/assets/files/CALGreen-2019-Supplement-Cost-Analysis-Final-1.pdf

14 Rocky Mountain Institute (RMI) (2019). https://rmi.org/wp-content/uploads/2017/04/eLab_EVgo_Fleet_and_Tariff_Analysis_2017.pd

15 NRDC (2021) https://www.nrdc.org/experts/miles-muller/ca-approves-new-rules-support-ev-charging-infrastructure

16 NY (2021) https://jointutilitiesofny.org/ev/make-ready

for the State of Maine to fund, based on experience in other states. See notes below the table for more detail about how the estimates were calculated.

Table 2. Annual Investment Needed for Charging Infrastructure and Expanded LMI EV Rebate Program

(Values in bold are in millions $2021. Numbers in parentheses are new plugs or EVs rebated)[a,b]

	2022	2023	2024	2025
Public L2 Charging [c]	**$4.1M** (200 plugs)	**$4.9M** (247 plugs)	**$5.5M** (291 plugs)	**$6.0M** (334 plugs)
Public DCFC Charging [c]	**$7.7M** (55 plugs)	**$10.6M** (77 plugs)	**$14.4M** (104 plugs)	**$17.6M** (132 plugs)
Residential L1 Charging [d]	**$0.4M** (1045 plugs)	**$0.5M** (1269 plugs)	**$0.6M** (1474 plugs)	**$0.6M** (1664 plugs)
Residential L2 Charging [d]	**$1.8M** (1568 plugs)	**$2.2M** (1903 plugs)	**$2.6M** (2212 plugs)	**$2.9M** (2495 plugs)
LMI New EV Rebate [e]	**$6.4M** (853 EVs)	**$7.0M** (1028 EVs)	**$7.5M** (1203 EVs)	**$7.7M** (1377 EVs)
LMI Used EV Rebate [e]	**$4.6M** (1139 EVs)	**$6.0M** (1655 EVs)	**$7.7M** (2320 EVs)	**$8.8M** (2996 EVs)
Total	**$25.0M**	**$31.2M**	**$38.2M**	**$43.7M**

Table notes:

[a] Future EV population associated with estimates in this table use the ACC II Lower/Upper Bound scenarios. See the *Outlook: Transportation Electrification* chapter for more information on scenarios.

[b] The LMI EV Rebate estimates are aligned with California LMI EV Rebate levels. However, the rebate values will likely require year-to-year adjustments in per-vehicle incentive to achieve the desired uptake.

[c] Public charger refers to publicly accessible chargers (as opposed to chargers at workplaces, apartment complexes, hotels, etc.). The number of new Level 2 and DCFC charging plugs are estimated by multiplying the EV population by ratios of plugs/EVs from the EVI-Pro Lite tool. Ratios are given in Table 10. Assumed per-plug costs are in Table 9. Costs in this table are the net present value (NPV) of costs and revenues associated with the station over the assumed 10-year life of equipment and assumed 30-year lifetime of make-ready infrastructure. A 4% discount rate is used. Costs include customer-side make-ready, station installation, equipment, revenue from drivers, electricity (using CMP commercial tariff including demand charges), maintenance, warranty, and networking costs. Station revenues are $0.25 per kWh for Level 2 plugs and $0.37 per kWh for DCFC plugs. Assumed utilization of stations aligns with current utilization in Maine and increase over time.

[d] Number of new residential charging plugs are estimated using ratios of existing residential plugs / EVs and applying an assumed gradual shift over time toward slightly greater public charging. Ratios are given in Table 10. Assumed per-plug costs are in Table 9. These costs reflect costs at a detached, single-family home rather than a multi-unit dwelling (MUD). A program to fund MUD charging should be funded separately. See Note c for assumptions on discount rate and equipment lifetime. Costs include customer-side make-ready, station installation, equipment, maintenance, and warranty (and networking costs for L2 chargers).

[e] New and used EV rebate assumptions are described in the *Clean Vehicle Funding* chapter and assume rebates are available only to households with income under $50,000 per year. New and used EV rebates start at $7,500 and $4,000 per vehicle in 2022, respectively, and decline over time to $5,500 and $3,000 per vehicle by 2025, respectively. In alignment with the new and used car market, households earning $50,000 or less are assumed to be 21% of the new EV market and 52% of the used EV car market.

The State of Maine has limited existing funding for charging infrastructure and EV rebates:

- **$8 million** available for charging infrastructure through its Fiscal Year 2026 from the *Maine Jobs & Recovery Plan*.[17]
- **$19 million** available for charging infrastructure through 2025 the federal *Infrastructure Investment and Jobs Act (IIJA)* formula funding to Maine for charging infrastructure.
- **$3.75 million** for EV rebates and **$1.25 million** for qualified low-income EV rebates from the New England Clean Energy Connect stipulation and the potential for an additional **$8 million** for charging infrastructure over four years. The $3.75 million will likely be fully used by June 2022.

Clearly, existing funding sources are insufficient to meet the funding needs described in Table 2. For example, if the State of Maine funds only new DCFC charging, it would need **$7.7 million** in 2022 and **$17.6 million** in 2025. Fully funding and distributing rebates under the LMI EV Rebate program would require an additional **$11.0 million** in 2022 and **$16.5 million** by 2025**.** Together, these programs exceed

[17] Maine fiscal year runs from July 1 through June 30. The values in Table 2 are for calendar year.

existing funding. The IIJA's **$2.5 billion** of competitive grant funding for charging infrastructure could help partially fill the funding gap. A fair share allocation of this $2.5 billion based on Maine's population would imply approximately **$10 million**. Additionally, Maine could develop a new funding source, such as a clean fuel standard, road user charge (or VMT tax), gas tax, carbon mechanism, and/or vehicle feebate program. These options are briefly described in the *Clean Vehicle Funding* chapter.

Table 2 does not include these five cost categories that may require public funding support in the future: (1) electricity distribution system expansion; (2) installation of chargers at multi-unit dwellings (MUDs); (3) installation of MHDV chargers; (4) installation of workplace charging; and (5) MHDV rebates.

Future Research

Finally, during the development of this roadmap, several new knowledge gaps and research needs arose. Table 3 summarizes future research opportunities.

Table 3. Recommendations for Future Research

Opportunities for Future Research	Description
Zero-Emissions MHDV Roadmap	In support of the implementation of programs such as Advanced Clean Trucks (ACT), develop a MHDV roadmap and corresponding stakeholder group that focuses on charging needs, funding, duty cycles, range, timeline on vehicle availability, and costs of electric and other zero-emissions MHDVs. Also, the MHDV roadmap could examine the feasibility of "lead by example" programs with zero-emissions MHDVs.
Make-Ready Mapping	Develop a publicly available ArcGIS map that shows areas suitable for fleet charging without a need to upgrade the local distribution system. Such a map could be especially important for electric MHDV fast chargers as well as for charging providers looking to site new stations.
Tourism Study	Maine's GHG inventory counts emissions from all fuel purchased in the state, including from tourists. Yet, relatively little data exist about how much fuel is purchased by in-state versus out-of-state drivers. The State of Maine should conduct a study to investigate opportunities and barriers for lowering emissions from out-of-state drivers. Such a study could also examine the feasibility of programs that increase EV penetration among tourists through rental cars and/or other incentives and fees.
Case Studies on Rural Transit and/or Electrification	Develop case studies on jurisdictions (in or outside of Maine) that have successful electric micro-transit or rural transit programs that simultaneously increase access and decarbonize transportation.
Loan Loss Reserve Program for EVs	Loan Loss Reserve (LLR) programs provide loan loss coverage to financing partners such as local and regional banks and credit unions. LLR programs, often used in clean energy financing, are a form of credit enhancement that can be constructed to offer below-market-rate terms to increase participation by low-income consumers, who often have poor or limited credit to access financing of a vehicle. Program could be modeled after New York's LLR program or California's Clean Vehicle Assistance Program (CVA Program).
Government Fleet Electrification	Develop a study of costs and feasibility of fleet electrification within state, local, and utility-owned vehicles. Estimate costs of charging infrastructure and vehicles. Additionally, study reimbursement options for drivers who park at home overnight and charge.
School Bus Electrification Study	Conduct an analysis of feasibility, power supply, duty cycle, market availability, and other factors related to school bus electrification in Maine. Coordinate with ongoing research by The Nature Conservancy and the Vermont Energy Investment Corporation (VEIC).
Emergency Management Plans	Identify opportunities through state planning processes to ensure that future energy assurance or emergency management plans consider high penetrations of vehicle electrification and the impacts of necessary infrastructure. This could include events such as natural disasters, mass evacuations, and prolonged grid blackouts.

Introduction

Purpose

The purpose of the Clean Transportation Roadmap is to identify the policies, programs, and regulatory changes needed to meet the state's emissions reduction targets for the transportation sector. Maine's recently updated climate action plan, entitled *Maine Won't Wait*, targets an 80% reduction in emissions by 2050. The transportation sector is responsible for 54% of the state's emissions, so reductions in this sector are critical to reaching this target. To coordinate the state's emissions reduction efforts in the transportation sector, the Governor's Office of Policy and the Future (GOPIF) and the Governor's Energy Office (GEO), in coordination with Efficiency Maine Trust, the Maine Department of Transportation (MaineDOT), and the Maine Department of Environmental Protection (DEP) commissioned Cadmus to develop a clean transportation roadmap for Maine. This roadmap integrates key findings from Cadmus's modeling of the transportation sector through 2050, with a particular focus on 2025 and 2030. It also explores the relative contributions of electrification, vehicle miles traveled (VMT) management, and system efficiencies in achieving the desired greenhouse (GHG) emission reductions.

Audience

This roadmap is intended to help inform Maine's transportation policy and investments as the state pursues the emissions reduction targets identified in its four-year climate action plan, *Maine Won't Wait*. To that end, the primary audience for this roadmap are the decision-makers in Maine's institutions who shape the state's transportation system, but stakeholders outside of these institutions may also benefit from this analysis of Maine's current and future transportation system.

Overview

This roadmap describes several complementary strategies to achieve the emissions targets laid out in *Maine Won't Wait*. To contextualize recommendations, the roadmap provides an overview of the status of the transportation system in Maine and the policies currently in effect to promote sustainable transportation. Electrification of the transportation sector has been identified as the most effective strategy for near-term emission reductions, so particular attention is paid to electric vehicles (EVs) and charging infrastructure. This roadmap characterizes the existing EV market and provides insight into trends impacting EV adoption. Using a suite of modeling tools and scenarios, the roadmap forecasts light-, medium-, and heavy-duty EV adoption along with the required number of chargers to support different adoption rates. Associated cost and revenue projections are also provided for chargers.

In addition to electrification, strategies to reduce VMT must be employed to meet Maine's emissions targets. The roadmap explores the VMT reduction potential of VMT pricing strategies, infill development, transit expansion, bicycle and pedestrian infrastructure, transportation demand management, and telecommuting policies. To accomplish electrification and VMT reduction objectives, the roadmap identifies current sources of funding, anticipated gaps in funding, and future funding requirements. The roadmap also discusses potential regulatory drivers behind the transition to sustainable transportation, parties responsible for policy implementation, and areas for further research. *Appendix A. Roadmap Development Process* provides an overview. In parallel to the roadmap, MaineDOT initiated several RFPs to address its role in VMT reduction. These include GO MAINE, a ridesharing program, the Statewide Strategic Transit Plan, the Transit Bus Electrification Plan, and an Active Transportation Plan.

Transportation Sector Overview

This section provides an overview of the transportation sector in Maine, with high-level descriptions of emissions, miles-traveled, policies, and vehicle mix.

Current Status

In 2017, the transportation sector was responsible for 54% of Maine's total CO_2 emissions, generating 8.0 $MMTCO_2e$.[18] The sector's share of total emissions has risen over time; in 1990 it was responsible for just 44% of total CO_2 emissions. However, as shown in Figure 1,[19] transportation sector emissions in Maine have been relatively stable between 1990 and the latest GHG inventory year of 2017. The increase in the transportations sector's share of the total is due to emissions reductions in other sectors, primarily the industrial sector.

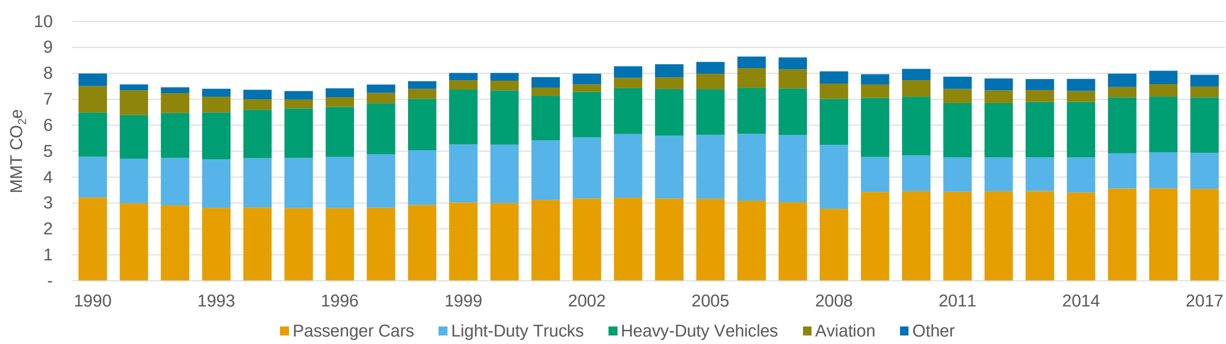

Figure 1. Maine's Transportation Sector GHGs, Million Metric Tons of CO_2e

Passenger cars are responsible for an outsized proportion of the sector's emissions, contributing 43% of the total. Combined with light-duty trucks, the two categories make up 60% of all emissions for the sector. Light-duty vehicles are responsible for the highest percentage of total emissions. Table 4 summarizes the on-road vehicle fleet in Maine. As shown, light-duty vehicles account for 90% of all VMT and 91% of the total vehicle population.

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18 Eighth Biennial Report on Progress toward Greenhouse Gas Reduction Goals, Maine Department of Environmental Protection, https://www.maine.gov/dep/news/news.html?id=1988154

19 Figure uses emission inventory data provided by Maine Department of Environment (DEP). "Other" category includes motorcycles, locomotives, boats, and other.

Table 4. Summary Statistics of Maine's On-Road Vehicles, 2017[20]

Source Type Name	Annual VMT	Vehicle Population	Average Miles Per Year Per Vehicle
Motorcycles	137,400,011	48,822	2,814
Light-Duty Vehicles	13,447,638,869	1,130,500	11,895
Buses	105,791,087	4,313	24,528
Single Unit Trucks	619,618,704	51,083	12,130
Combination Trucks	632,669,639	8,122	77,896
Total	**14,943,118,310**	**1,242,840**	

Maine drivers also prefer SUVs over sedans, which reflects a national trend toward larger vehicles. According to a national survey,[21] consumers list cargo space, 4WD/AWD capability, and safety as the top reasons for their SUV purchase. The Chevrolet Silverado, Ford F-150, and GMC Sierra pickup trucks are the three most popular vehicles in Maine. Light trucks and SUVs make up 62% of Maine's entire light-duty vehicle fleet. Given the increasing popularity of SUVs over smaller cars, the overall fuel economy of Maine's vehicle fleet remains unchanged for the last five years.[22] In addition to differences among vehicle types, VMT also varies widely by geography. Figure 2 breaks down VMT by county.

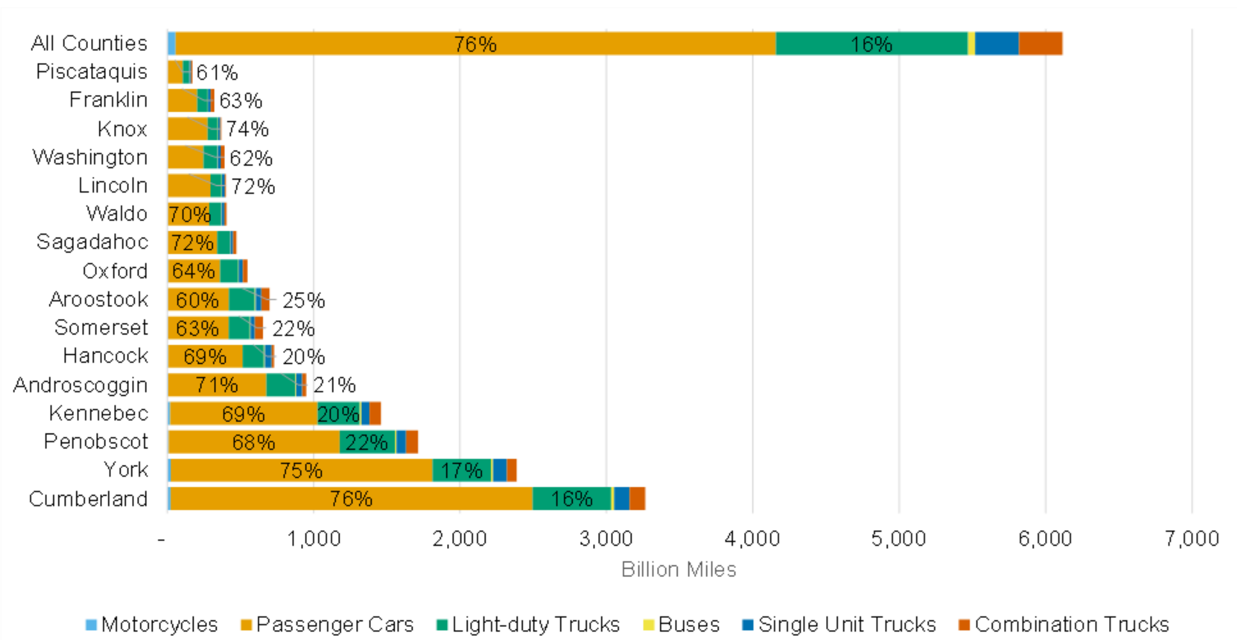

Figure 2. VMT by County and Vehicle Category

Unsurprisingly, the five most populous counties (Cumberland, York, Penobscot, Kennebec, and Androscoggin) also have the highest VMT. However, the correlation between population and VMT does not hold true for the remaining eleven counties. For example, Hancock and Somerset counties have

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20 Maine Department of Environment (DEP). Accessed November 2021. https://www.maine.gov/dep/air/mobile/vehicle-data.html

21 J.D. Power. 2017 Auto Avoider Study. https://www.jdpower.com/business/press-releases/jd-power-2017-auto-avoider-study

22 Rubin et al. 2021. Electric, Hybrid and High Fuel Efficiency Vehicles: Cost-Effective and Equitable GHG Emission Reductions in Maine. https://digitalcommons.library.umaine.edu/mcspc_transport/3/

higher VMT than Aroostook and Oxford counties, despite having relatively lower populations. This deviation is likely due to the greater number of road miles in larger, less populated counties.

Figure 3 shows the growth of EVs in Maine over time relative to other Northeast states.[23] Maine had an EV sales share among new vehicles of 1.4% in 2019, 1.6% in 2020, and 3.7% as of the first two quarters of 2021. A list is provided in *Appendix C. EV Sales by State by Year*.

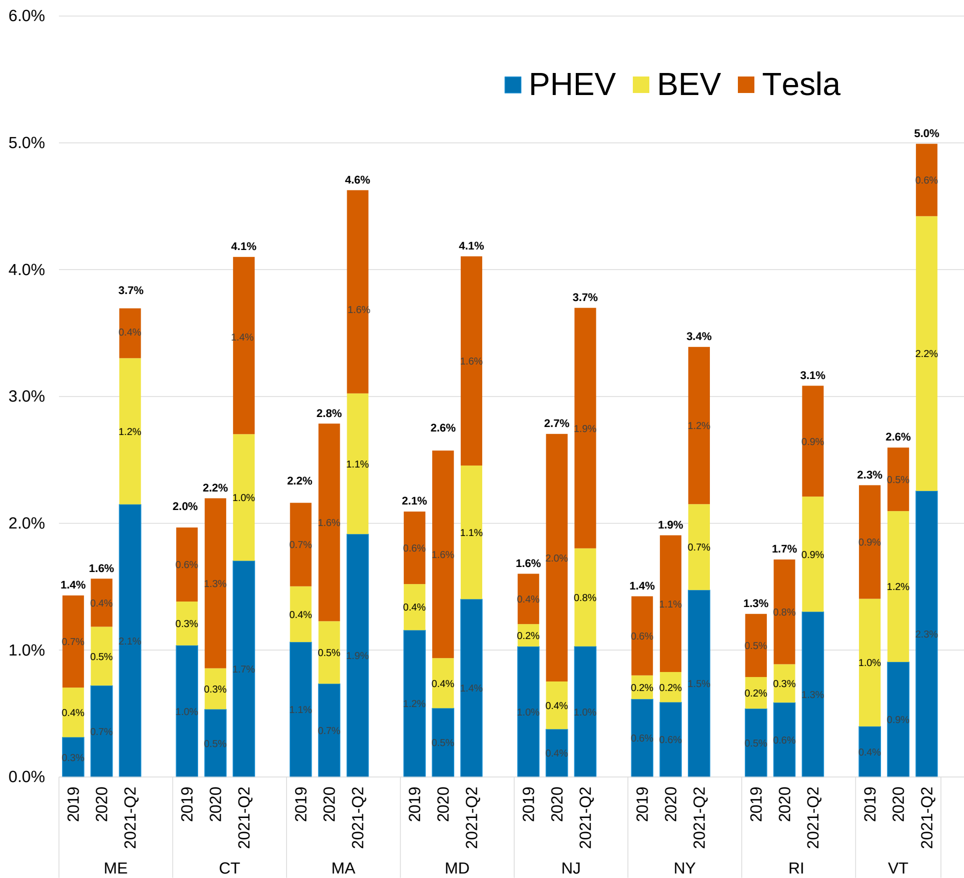

Figure 3. EV Sales Share of ALL Light-Duty Sales (%)

The Northeast States for Coordinated Air Use Management (NESCAUM) calculates the sales shares in Figure 3 by dividing the number of newly registered EVs (owned and leased) by the total number of new vehicles registered in a given year (regardless of the model year of the vehicles being registered). According to NESCAUM's methodology, the sales shares include only passenger cars and passenger trucks and excludes motorcycles and light commercial trucks.

In addition, vehicles that are registered in one state and then re-registered in a second state are only counted as being registered in the first state of registration. For example, if an EV is originally registered in Massachusetts then resold in the secondary market in Maine, the EV counts toward Massachusetts sales. This likely dampens Maine's actual EV registrations since many of the state's used EVs are

23 NESCAUM. 2021. Summary statistics provided by Jeremy Hunt, NESCAUM from IHS Markit/Polk data.

purchased at auctions in other states and sold at Maine dealerships.[24] Note, NESCAUM's methodology differs slightly from the goal of 219,000 EVs on the road in *Maine Won't Wait*. This goal includes light commercial trucks up to 10,000 pounds (in addition to passenger cars and passenger trucks).

As with other states that have adopted California's emissions standards (otherwise known as Section 177 states), EV sales shares in Maine are rising over time, though at different proportions for plug-in hybrid electric vehicles (PHEVs)[25] and battery electric vehicles (BEVs),[26] collectively referred to as EVs in this roadmap. As shown by the light blue bars in Figure 3, sales of Tesla EVs account for a smaller share of total EV sales in Maine compared to other Section 177 states. PHEV sales comprise a higher percentage of total EV sales in Maine relative to other Section 177 states.

Maine is also one of the first states in the country to pursue ferry electrification, as discussed below.

Electric Ferries: *Maine State Ferry Service and Casco Bay Lines*

MaineDOT and the Maine State Ferry Service are under contract for construction of the first commercial diesel-electric hybrid vehicle ferry on the east coast of the United States. The $18 million ferry is under construction at Senesco Marine in Rhode Island and expected to be operating in Maine waters in 2023. With its onboard stored battery power, the ferry will be capable of all electric zero-emission operations at slow speed operation and during loading and discharge of passengers. In addition to the reduction in CO_2 emissions and diesel costs over the lifetime of the vessel, passengers and workers will benefit from lack of diesel engine exhaust, noise, and vibrations during the periods of electric operation. The 155-foot vessel, capable of carrying 23 vehicles and up to 250 passengers, will employ BAE System's HybriGen Assist electric hybrid maritime technology. MaineDOT is also providing funding for the design of a replacement ferry for its Lincolnville-Islesboro route with the intent to implement full or mostly electric propulsion—including onshore charging facilities.

Similarly, Casco Bay Island Transit District—also known as Casco Bay Lines (CBL)—is actively pursuing an electric ferry project. CBL maintains a fleet of five vessels and operates year-round passenger, vehicle, and freight service to six unbridged islands in Casco Bay. Using federal, state and local funding, CBL will soon begin construction on a new car ferry, equipped with a state-of-the-art diesel electric hybrid propulsion system, to service Peaks Island. The electric portion of the hybrid propulsion system will serve as the primary means of operation with diesel generators as the backup. This existing vessel is 34 years old, operates on a two-mile route up to 17 times daily and is in port for approximately 15 minutes between most trips. When evaluating the configuration of the propulsion system, CBL considered six criteria: capital cost, operating costs, survivability, reliability, GHG emission reductions, and experience of customers. The new ferry plans to use an automated rapid charging system to recharge a 900 kWh battery using a 1.4-megawatt (MW) charger at the pier in Portland. The propulsion system will reduce emissions and noise while shoreside and reduce CBL's overall operational costs.

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[24] Discussions between the authors and Tim Archambault, Adam Lee, and Tim Seymour in September 2021.

[25] A vehicle powered by electricity or an internal combustion engine, such as a Chevy Bolt.

[26] A vehicle powered exclusively by electricity, such as the Nissan LEAF.

Current Policies

Maine's climate action plan *Maine Won't Wait* seeks to galvanize the state's decarbonization activities, save people in Maine money, and advance equitable access to climate benefits for everyone in Maine. The plan includes the following key targets for the transportation sector:

- **Electric vehicles.** 41,000 EVs on the road by 2025 and 219,000 by 2030.
- **Vehicle miles traveled.** A 10% reduction in light-duty VMT by 2025, a 20% reduction by 2030, and a 4% reduction for heavy-duty VMT by 2030.

Maine has already laid a foundation of clean transportation policies and programs, including these examples of key state-level policies and programs:

- Executive Order 36, **An Order to Advance Clean Transportation Solutions in Maine,** calls for a Clean Transportation Roadmap (this document) to be completed by December 31, 2021.
- The **Maine Climate Council**, established on June 26, 2019, by Governor Mills and the State Legislature. The council was tasked with development of a four-year plan to put Maine on a trajectory to reduce emissions by 45% by 2030 and 80% by 2050. The council delivered this plan, entitled *Maine Won't Wait*, to the governor on December 1, 2020. A key strategy identified in the plan is the accelerated adoption of EVs.
- Efficiency Maine Trust's **Electric Vehicle Rebate program** provides up to $2,000 for a new BEV and up to $1,000 for a new PHEV. To be eligible for a rebate, vehicles must have a total manufacturer suggested retail price (MSRP) of $50,000 or less. The program also tiers incentive level by income category, providing up to $5,500 for households that qualify to receive assistance through the Maine Low Income Home Energy Assistance Program (LIHEAP). The program also provides up to $2,500 for used vehicles for low-income residents and offers a comprehensive outreach and marketing initiative to raise awareness about the benefits of EVs.
- Efficiency Maine Trust's **initiative to expand EV charging infrastructure** across the state has received funding primarily through the **VW settlement and NECEC settlement** and includes installation of DCFC and Level 2 chargers. To date, the initiative has expanded Maine's DCFC network across the state, with funds awarded for 28 DCFC plugs at 14 locations. On a parallel timetable, the initiative has worked to improve local access and destination charging with publicly available Level 2 chargers, awarding grants for 178 Level 2 plugs at 59 site locations.
- Efficiency Maine Trust's **demand management pilot program** is intended to shift EV charging to off-peak hours. Efficiency Maine Trust is preparing to expand this program statewide.
- The **American Rescue Plan Act**, which directed $4.6 billion to the state of Maine, earmarked $3.6 billion for specific purposes. The remaining $1 billion was allocated through the **Maine Jobs and Recovery Plan (MJRP)**, in which Governor Mills prioritized $8 million for expanding public EV charging. The MJRP also allocated $5 million for workforce transportation pilot programs to support shared transportation options and increased access to work opportunities.
- Legislative bill **LD 1494,** which Governor Mills signed into law in June 2019, increases Maine's renewable portfolio standard (RPS) to 80% by 2030 and sets a goal of 100% by 2050. The obligation for 2021 requires that 45% of Maine's electricity come from renewable sources. The

bill also required the Maine Public Utilities Commission (MPUC) to procure long-term contracts for new clean energy generation.

Local governments in Maine are also active in clean transportation policies. For example, the Greater Portland Council of Governments (GPCOG) administers a set of policies designed to incentivize nonmotorized transportation and a shift to public transit. GPCOG is leading an effort to craft a **Complete Streets Policy** to be adopted by the Portland Area Comprehensive Transportation System (PACTS); the policy will require multimodal facilities in all road projects. GPCOG also developed **Transit Tomorrow**, a 30-year strategic plan for enhancing public transportation in the Greater Portland region. GPCOG's **Connect 2045** Project focuses on all modes of travel (including transit, freight, bicycles, and pedestrians) and will guide transportation investments over the next 25 years. To help accelerate the adoption of EVs, GPCOG hosts **Drive Electric Maine**, a statewide EV stakeholder group working to grow workplace charging, engage utilities, and attract business, consumer, and tourist investment.

Public Utility Commission Filings: Rates

Maine's utilities are responding to the growth in EVs. In February of 2020, the Maine Public Utilities Commission (MPUC) approved a Central Maine Power (CMP) pilot two-part demand rate called B-DCFC. The rate was designed to reduce the economic risk for DCFC installations. According to CMP, the rate was modeled to save DCFC station providers over 40% off their delivery costs. In 2020, the one eligible and participating DCFC station saved over 40% of its electricity delivery costs.

In addition, in 2021 the MPUC issued an order for transmission and distribution utilities in Maine to propose rate schedules to support the installation and sustainable operation of new and existing non-residential EV charging stations.[27] Cadmus's review of the November 2021 utility filings from CMP and Versant Power is included in the *Outlook: Transportation Electrification* chapter of this roadmap.

Finally, as directed by the legislature, the MPUC issued a second inquiry in 2021 for transmission and distribution utilities in Maine to propose rate schedules to support the installation and sustainable operation of several climate-friendly technologies, including residential EV chargers.[28] Given the rate submission timeline of December 1, 2021, these proposals are not included in Cadmus's review.

Several federal programs are also available to advance clean transportation in Maine. The **federal electric vehicle tax credit** provides a maximum $7,500 tax rebate for eligible vehicles. The U.S. Environmental Protection Agency's Diesel Emission Reduction Act (**DERA**) and the Federal Aviation Administration's Voluntary Airport Low Emissions Program (**VALE**) provide grants for low-emission technologies. The Environmental Protection Agency's **SmartWay Program** helps fleet operators measure, benchmark, and improve freight transportation efficiency. In addition, Maine actively participates in the Federal Highway Administration's **Alternative Fuel Corridor** designation program. As

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27 Maine PUC. "Procedural Order (EV Rate Schedules)." September 2021. https://mpuc-cms.maine.gov/CQM.Public.WebUI/MatterManagement/MatterFilingItem.aspx?FilingSeq=112223&CaseNumber=2021-00198

28 Maine PUC. "Commission initiated investigation into transmission and distribution utility rate design to promote state policies". September 2021. https://mpuc-cms.maine.gov/CQM.Public.WebUI/Common/CaseMaster.aspx?CaseNumber=2021-00325

of September 2021, Maine has three corridors designated as corridor-ready[29] and two corridors designated as corridor-pending.[30] Corridor-ready status requires DCFC stations spaced a minimum of every 50 miles.[31] Recent funding provided in the federal Infrastructure Investment and Jobs Act (IIJA) is provided in the *Clean Vehicle Funding* chapter of this roadmap. And as of the publication of this roadmap, additional federal funding and supporting initiatives are actively being considered by Congress.

Equity and Listening Sessions

The transportation system in the United States has a legacy of inequity directed toward disadvantaged, underrepresented, and historically excluded communities. Inequity can exhibit itself in several ways. For example, low- and moderate-income households spend higher portions of their income on transportation than do high-income households. In the Northeast, households with a before-tax income of less than $15,000 per year spend 11% of their income on fuel, maintenance, and repairs while those with an income of $200,000 per year spend 1%.[32]

Further, national data suggest that residents of disadvantaged communities are disproportionately impacted by transportation emissions, as they tend to live closer to emissions sources.[33] Wang et al. (2015) show that 25% of vehicles on the road contribute more than 90% of certain health-related air pollution.[34] These high emitters tend to be the oldest vehicles on the road and are more often driven by low-income households. In Maine, households with incomes under $50,000 drive vehicles with an average age of 12.9 years whereas households with income above $125,000 per year drive vehicles with an average age of 7.2 years.[35] Households making under $50,000 make up 65.8% of all households in Maine, greater than the U.S. average of 60.3%.[36]

Relatively little information is available about how people of different income levels travel in Maine. Data on the commute mode to work from the American Community Survey, collected before the COVID-19 pandemic, show that nearly 90% of people drive personal vehicles to work, although this fraction

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29 **I-295**: Between South Portland and West Gardiner at the intersection of I-295/I-95; **US-2**: Between Skowhegan and Farmington; **SR-27**: Between Gardiner and Farmington

30 **US-2**: Between Newport and Skowhegan; and between Farmington and Evans Notch (ME/NH border); **SR-27**: Between Boothbay and Gardiner; and between Farmington and the ME/Canada border

31 Note that these programs are evolving with the new Biden Administration and may look different in the near future.

32 U.S. Bureau of Labor Statistics. "Table 3104. Northeastern region by income before taxes: Average annual expenditures and characteristics, Consumer Expenditure Survey, 2018-2019." https://www.bls.gov/cex/2019/CrossTabs/regbyinc/xregnne.PDF

33 Gurram, S, et al. 2019. "Equity pollution exposure to low income groups." *Computers, Environment and Urban Systems,* vol. 75, 2019, pp. 22-34.

34 Wang, J. M., C.-H. Jeong, N. Zimmerman, R. M. Healy, D.K. Wang, F. Ke, and G. J. Evans. 2015. "Plume-based analysis of vehicle fleet air pollutant emissions and the contribution from high emitters." *Atmospheric Measurement Techniques*, (8): 2881–2912. https://amt.copernicus.org/preprints/8/2881/2015/amtd-8-2881-2015.pdf

35 Federal Highway Administration. 2017. "2017 National Household Travel Survey." https://nhts.ornl.gov

36 U.S. Census Bureau, American Community Survey. Accessed November 2021. https://www.census.gov/programs-surveys/acs/microdata.html

varies by household income. The highest fraction of individuals who drive-to-work is in the third income quartile of households making $71,000 to $110,000 per year. The highest income quartile (above $110,000 per year) are the most likely to work from home and least likely to walk and take transit. The lowest income quartile households (below $39,000 per year) are nearly four times as likely to take transit to work than households in other income quartiles.

To explore insights on clean transportation among people in underrepresented groups, the writers of this roadmap conducted 19 listening sessions during the fall of 2021. Interviewees represented industries and groups within Maine who face economic, social, or operational challenges to shifting to clean transportation fuels, vehicles, and modes.

Table 5. Listening Session Groups

Category	Number of Listening Sessions
Trucking or Fleet Operator or Package Delivery	2
Vehicle Maintenance Shops	1
Rural Transit Operator	1
Forestry	1
Refuse Truck Operator	2
Overburdened, Disadvantaged, and/or Vulnerable	6
Condo/Apartment Developer or HOA	3
Tourism Industry	3

Among the various insights gained during these listening sessions, two common questions emerged about the transition to electric vehicles. These questions are addressed below.

What are the emissions impacts from the source of electricity for EVs?

Electric vehicles, powered by a battery instead of an internal combustion engine (ICE), do not produce tailpipe emissions. To determine the total emissions of an EV, it is important to consider the source of electricity generation. Maine's Renewable Portfolio Standard (RPS) requires a minimum of 48% of electricity supplied in the state in 2022 to be sourced from renewable generators. The state's Renewable Portfolio Standard (RPS) will continue decarbonizing the electricity grid, requiring 80% renewable consumption by 2030 and a goal of 100% renewable consumption by 2050.

Due to the lower carbon intensity of electricity generation in Maine, driving an EV today will have a lower emissions impact than a vehicle with an ICE. A light-duty gasoline vehicle in Maine produces over 11,000 pounds of CO_2 equivalent on an annual basis. A light-duty EV in Maine is estimated to produce only 852 pounds of CO2 equivalent, or 92% less overall emissions than a gasoline vehicle. With such a low carbon intensity for electricity production, EVs in Maine are estimated to produce 77% lower GHG emissions than the national average for EVs. These calculations account for emissions on a well-to-wheel basis, which includes impacts related to fuel production, processing, distribution, and use.[37]

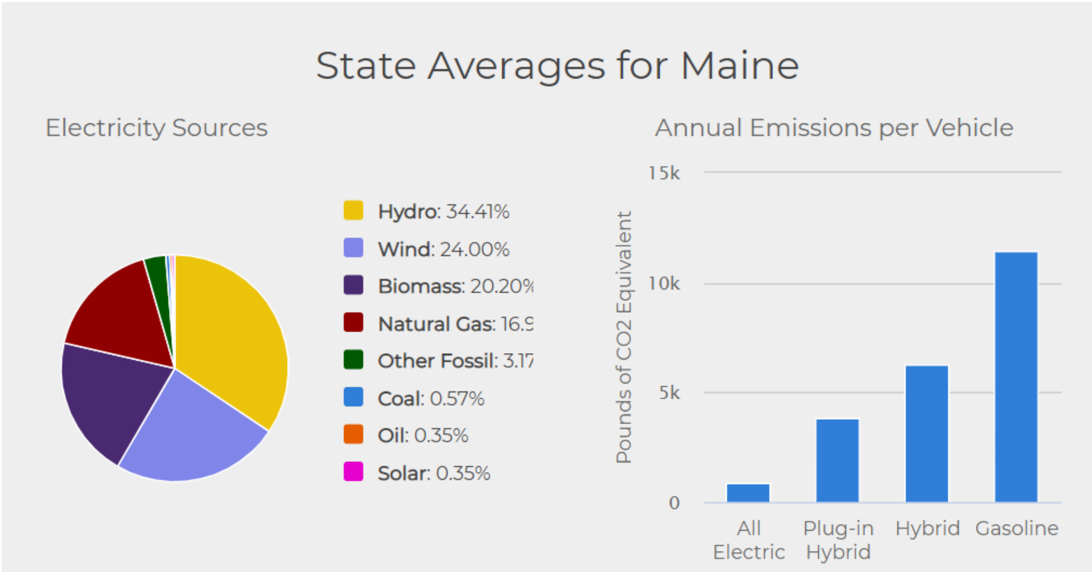

Figure 4. Well-to-Wheel Emissions for LDV in Maine (Source: AFDC)

What are the emissions impacts of EV production?

Production of an EV can be thought of as the production of the necessary raw materials, the manufacturing of component parts, and the vehicle assembly process. EV production can be more emissions-intensive than an ICE vehicle due primarily to the lithium, cobalt, and copper requirements for battery manufacturing.[38] Though EV production can be higher-emitting, total well-to-wheel emissions, or emissions over the entire lifecycle of the vehicle, are lower for EVs than ICE vehicles, as seen in Figure 5. The overall lower emissions impact of EVs can be attributed to much lower impact from operational use and maintenance over the lifetime of the vehicle. In addition, as the source of electricity becomes increasingly powered by renewable energy generation, the environmental impact of EV operation decreases over time.[39]

Acknowledging the environmental impact of EV production, the EV supply chain is innovating to ensure well-to-wheel EV emissions continue to decline. Improvements in manufacturing are underway to ensure that the impacts from the battery production and the end of life, including the collection, recycling, energy recovery and disposal of the vehicle and batteries, are less emissions intensive. For example, EV battery manufacturers are pursuing new technologies, such as sodium-ion and solid-state batteries, to improve energy density,

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37 U.S. Department of Energy. AFDC. "Emissions from Hybrid and Plug-In Electric Vehicles." Accessed November 2021. https://afdc.energy.gov/vehicles/electric_emissions.html

38 Union of Concerned Scientists. "EV Battery Recycling." Published February 2021. https://www.ucsusa.org/resources/ev-battery-recycling

39 Hill et al. "Determining the environmental impacts of conventional and alternatively fueled vehicles through LCA." Ricardo Energy & Environment. Published July 2020. https://ricardo.com/news-and-media/news-and-press/ricardo-delivers-major-european-report-on-the-lifecycle-impacts-of-road-vehicles

reduce costs, and rely less on limited critical materials.[40] As the EV market continues to grow, the market for these innovations also matures.

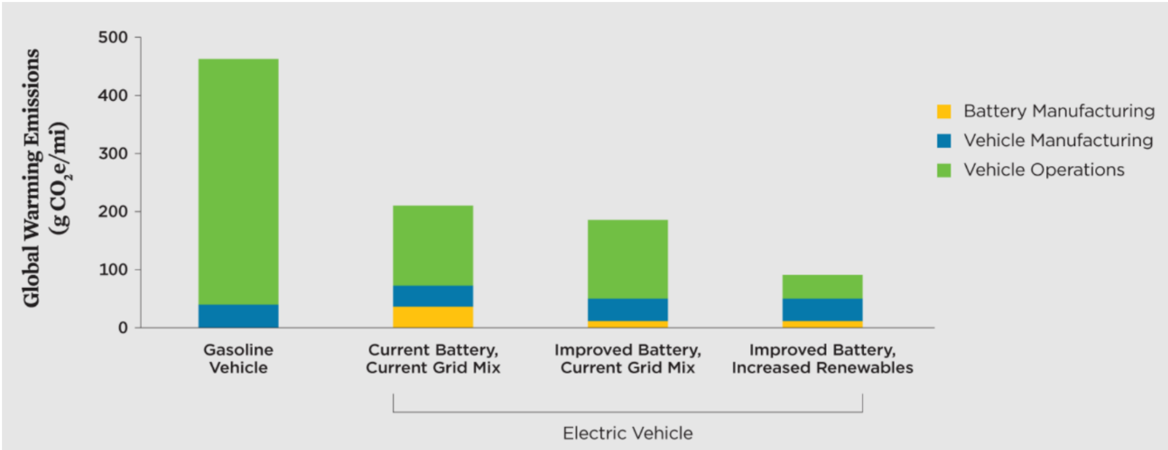

Figure 5. Mine-to-Wheel Life Cycle Emissions of EVs (Source: Union of Concerned Scientists)

[40] Kane, M. " CATL Unveils First-Generation Sodium-Ion Battery". *Inside EVs.* Published July 2021. https://insideevs.com/news/523413/catl-unveils-sodium-ion-battery/

Market and Technological Trends

This chapter explores recent market and technological trends related to electric vehicles, charging infrastructure, electric bikes and scooters, and transportation network companies.

Electric Vehicles

Electric Vehicle Availability

Statewide EV sales growth is constrained by a lack of the pickup trucks, vans, and SUVs preferred by most Maine drivers. As of 2021, Mainers could purchase 43 different EV models—28 PHEVs and 15 BEVs. Across the United States, California has the most availability of EV models, with 65 total PHEV and BEV models, while Montana has the fewest, with 21 total PHEV and BEV models.[41] According to an interview with three Maine auto dealerships, this discrepancy in availability is driven purely by the demand for EVs and the respective strategy by the automakers.[42] Figure 6 is a snapshot of the light-duty vehicle stock in Maine across vehicle categories.

- The far-left bar shows the breakdown of the entire light-duty vehicle stock. Sports utility vehicles, vans, and pickup trucks comprise nearly two-thirds of all light-duty vehicles.[43]
- The second from left bar shows the breakdown of all EVs on the market in Maine, highlighting the lack of pickup trucks.
- The third bar shows the breakdown of all EVs eligible for the Efficiency Maine Trust rebate, with an even larger share of vehicles in the sedan category likely due to the maximum purchase price of $50,000 for the rebate.
- The far-right bar shows the breakdown of EVs on the market expected in 2024.

Overall, Figure 6 demonstrates the misalignment between the types of vehicles driven by people in Maine and the types of EVs offered. Specifically, the lack of electric pickup trucks acts as a constraint on the market. However, it is worth noting that the bars for “All LDV’s in Maine” and “All EVs on the Market by 2024” are not directly comparable. For example, a single model of an electric truck (e.g., the Ford F-150 Lightning) could satisfy all 21% of the pickup segment in Maine. By 2024, if automakers meet their target delivery dates, 7% of EVs on the market will be pickup trucks (see far right bar). As of this writing, Rivian has begun initial deliveries of its R1T pickup truck, and the Ford Motor Company has announced that deliveries of the F-150 Lightning will start in the spring of 2022.

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41 Atlas Public Policy. 2020. “EVHub dashboard.” https://www.atlasevhub.com/materials/state-ev-sales-and-model-availability/

42 Discussions between the authors and Tim Archambault, Adam Lee, and Tim Seymour in September 2021

43 Rubin, Jonathan, Kathryn Ballingall, and Erin Brown. 2021. *Electric, Hybrid and High Fuel Efficiency Vehicles: Cost-Effective and Equitable GHG Emission Reductions in Maine.* https://digitalcommons.library.umaine.edu/cgi/viewcontent.cgi?article=1002&context=mcspc_transport

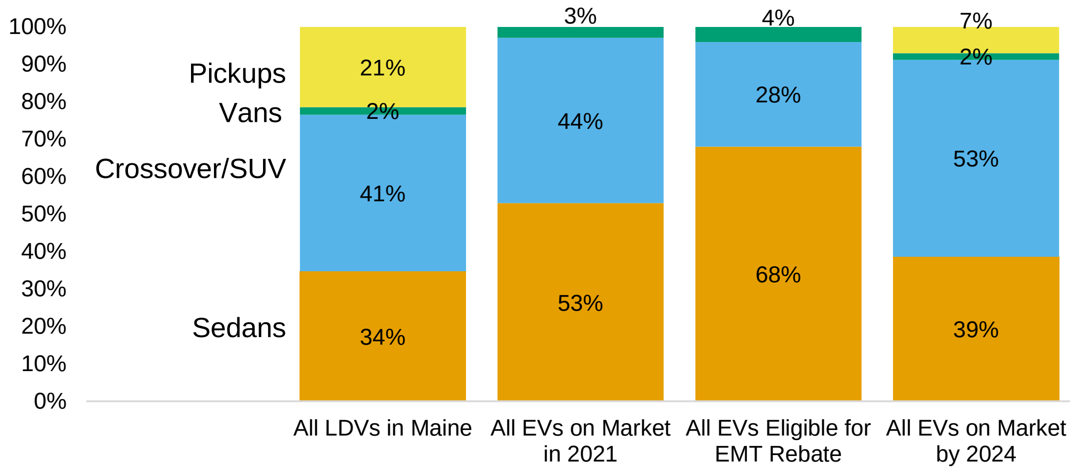

Figure 6. Breakdown of Light-Duty Vehicles in Maine

Electrification Costs

Consumers typically compare the cost of EVs and internal combustion engine vehicles (ICEVs) by their upfront retail cost or their total cost of ownership (TCO), which includes the upfront cost, fuel and maintenance costs, vehicle disposal cost, and ancillary costs such as home charger costs. Upfront costs of EVs are still currently higher than similar ICEVs comparable vehicles, while the TCO is close or even favorable for EVs.[44]

Several interrelated trends are changing the costs of the EV market:

- **Battery pack cost declines.** The costs of manufacturing EVs are dropping rapidly due to technological advances and economies of scale in the vehicle supply chain. In particular, costs of manufacturing battery packs continue to decline, as shown in Figure 7. Since 2010, the average cost of battery packs worldwide has declined by more than 50%. Battery pack costs account for approximately a quarter to a third of the cost of a BEV, depending on the all-electric range.

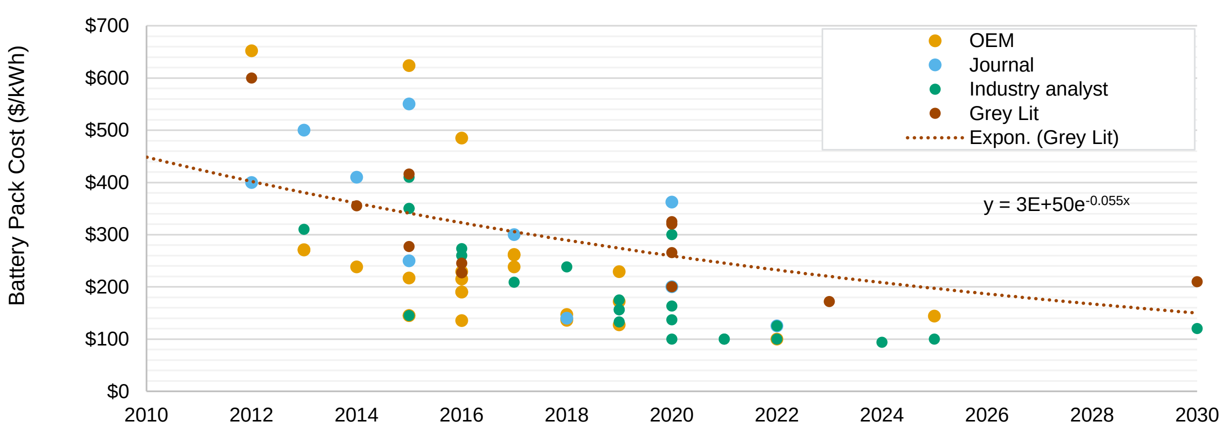

Figure 7. Battery Cost Estimates ($/kWh)

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44 International Council on Clean Transportation (ICCT; Lutsey, Nic, and Michael Nicholas). 2019. *Update on EV costs in the United States through 2030.* https://theicct.org/publications/update-US-2030-electric-vehicle-cost

- **Energy density of battery packs.** According to Bloomberg New Energy Finance's EV Outlook 2021, energy density has been improving at 7% per year in recent years.[45]
- **Emerging electricity rate designs.** Most of Maine's residents are serviced by CMP or Versant Power. Both utilities have time-of-use (TOU) rates available to customers, which provide a lower cost per kWh during off-peak hours. However, only a small percentage of customers typically take advantage of these rates. According to CMP's 2019 EIA-861 filing, 1% of its residential customers take advantage of TOU rates. Uptake is particularly low when a TOU program is a voluntary opt-in program. A survey of EV drivers who received the Maine EV rebate found that only 8% of residential customers used TOU rates. On the other hand, Lawrence Berkeley National Laboratory found robust evidence that opt-out programs produce substantially higher enrollment rates (93% to 98%), without affecting program retention patterns.
- **Increasing all-electric range.** Automakers are increasingly expanding all-electric range for EVs. For example, the weighted average all-electric range of EVs in California has shifted from about 150 miles in 2014 to 275 miles in 2021.[46]
- **MSRPs have stayed relatively steady.** Despite declining battery pack costs and improving energy densities, the MSRP of EVs has stayed relatively stable in recent years. However, two vehicle categories, BEV and PHEV SUVs, have seen steady declines in cost. This is mainly due to the availability of less expensive SUVs joining more expensive luxury models (namely, the Tesla Model X) in recent years. Figure 8 provides the average MSRP of EVs in Maine between 2015 and 2020 by vehicle category.[47]

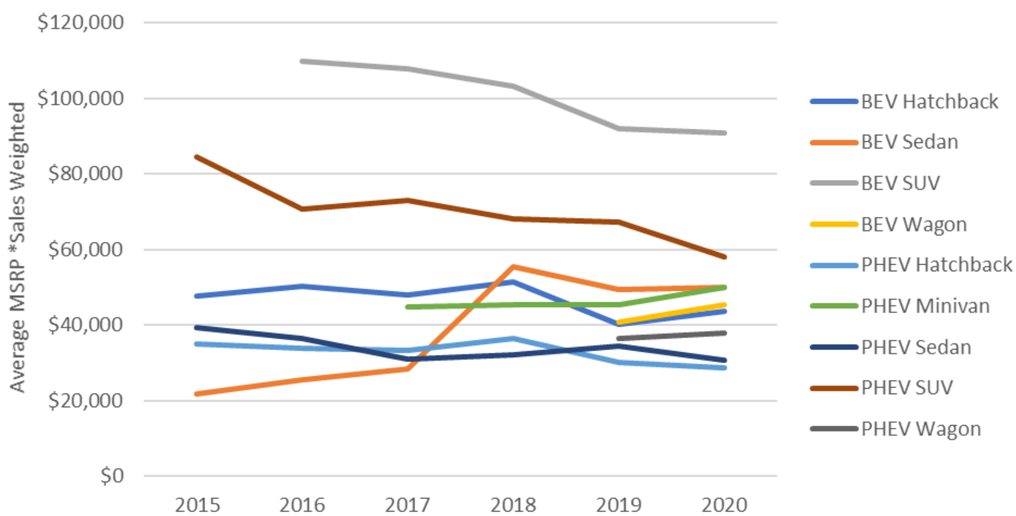

Figure 8. Average MSRP of EVs Sold in Maine by Vehicle Category.

45 BNEF (2021) EV Outlook. https://about.newenergyfinance.com/electric-vehicle-outlook/

46 California Air Resources Board. 2021. "Advanced Clean Cars (ACC) II Workshop." https://ww2.arb.ca.gov/sites/default/files/2021-08/ACC%20II%20August%202021%20Workshop%20Presentation.pdf

47 Analysis *by University of Maine, Kathryn Ballingall, Research Associate, Margaret Chase Smith Policy Center, based on July 2020 BMV data*

Recent estimates suggest light-duty BEVs are expected to reach cost parity on a TCO basis between 2022 and 2025, depending on the vehicle's all-electric range, size category, duty-cycle, and charging location.[48] Researchers estimate that upfront vehicle price parity will lag TCO parity by two to five years.[49] Nonetheless, consumers' attitude toward constraints on charging access, limited public charging availability, long charge times, and range anxiety will contribute to the persistence of ICEV sales. Some of these concerns have already been addressed by technology development. For example, many EVs can travel 200 to 300 miles on a charge[50] and charge to 80% in 20 to 30 minutes using a DCFC station.[51]

The MHDV subsector exhibits similar trends to the LDV subsector, although TCO and upfront cost parity is a few years further away for most vehicle categories.[52] Even when electric MHDVs reach parity with conventional MHDV on a TCO basis, adoption by fleets will be challenging for some segments. Fleets are often constrained in their capital budgets and are disinclined to take a risk on a new technology. Further, many MHDV segments require high power charging (i.e., 50 kW or higher) to serve the full array of use cases. This requires a local electricity distribution system that can handle the higher power demands. In particular, the most challenging fleet vehicles to electrify will be those with high daily mileage requirements, heavy payloads, minimal downtime for charging, and/or depots without access to high power charging. The public sector in other states is addressing these challenges with a variety of programs, including paying 80% to 100% of the chargers and/or distribution system upgrades (i.e., make-ready),[53] providing incentives for the upfront cost of vehicles,[54] providing free advisory services for fleet electrification,[55] and providing all-inclusive charging-as-a-service to fleets.[56]

Maine's Suitability for Electric Vehicles

According to data from the 2017 National Household Travel Survey, the average daily miles driven in private cars is 33 miles for Maine's urban residents and 30 miles for rural residents.[57] Nationally, average daily mileage is 30 miles. Figure 9 shows the distribution of average daily miles across urban and rural

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48 International Council on Clean Transportation (ICCT); Lutsey, Nic, and Michael Nicholas. 2019. *Update on EV Costs in the United States through 2030*. https://theicct.org/publications/update-US-2030-electric-vehicle-cost

49 Ibid.

50 U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy. Accessed November 2021. https://fueleconomy.gov/feg/evtech.shtml

51 Plug in America, "What is DC fast charging for electric vehicles?". Accessed November 2021. https://pluginamerica.org/dc-fast-charging-for-electric-vehicles/

52 International Council on Clean Transportation (ICCT); Hall, Dale, and Nic Lutsey. 2019. https://theicct.org/publications/zero-emission-truck-infrastructure

53 State of New York (2021). Make-Ready Program. https://jointutilitiesofny.org/ev/make-ready

54 State of California (2021) HVIP Program. https://californiahvip.org/

55 National Grid (2021) Fleet Advisory Services. https://www.nationalgridus.com/ev-fleet-hub/Get-Started/Fleet-Advisory-Services-Program

56 Sacramento Municipal Utility District (2021). https://www.smud.org/-/media/Documents/Corporate/About-Us/Board-Meetings-and-Agendas/2021/Oct/2021-10-19-Finance-and-Audit-Exhibit-to-Agenda-Item-1---Ed-Hamzawi.ashx

57 Rural and urban classifications based on US Census classification. Average daily miles calculated using vehpop file and applying household weights to BestMile variable.

drivers in Maine and the national average. The figure demonstrates that, on a typical day, most Maine drivers drive less than the range of modern EVs.

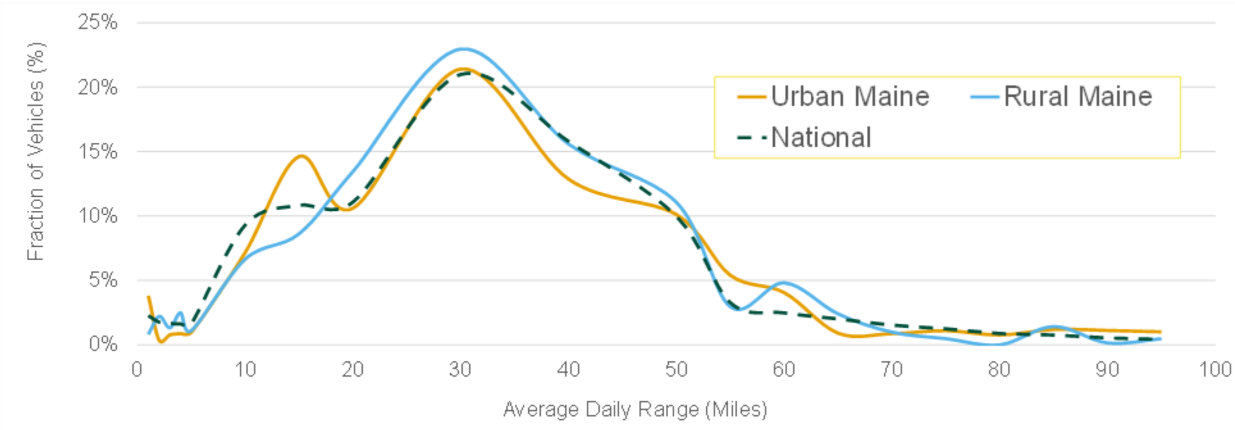

Figure 9. Average Daily Miles in Maine and in the U.S. (U.S. Census, 2017)

Note, Figure 9 shows average daily range only and therefore does not capture the distribution of miles across a given year for a given individual. This distribution is critical to market uptake of EVs because consumers tend to purchase EVs based on their maximum daily range needs, not average daily range.[58,59] Without telematics or GPS data, it is impossible to characterize these maximum daily range needs. However, we know that nationally, 95% of all trips taken are under 30 miles—well within the range of EVs.[60]

In addition, nearly 80% of households in Maine have two or more cars, further nullifying the range concern.[61] Previous studies in other parts of the United States find that most individual EV drivers need to recharge during the day for at least some days per year. For example, a study used Atlanta, Georgia, GPS data in 455 vehicles to calculate that a BEV with a 200-mile range would meet 21% of the sample's daily range needs all the time, 35% of the sample if drivers are willing to be inconvenienced two days per year, and 60% if drivers are willing to be inconvenienced six days per year.[62] In this study, inconvenienced means the driver's daily range needs were not met by the BEV with a 200-mile range. Said in another way, 60% of the sample required only overnight charging to complete all trips made 359 days out of the year.

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58 Franke et al (2013), What drives range preferences in electric vehicle users?, Transport Policy, Volume 30, 2013, Pages 56-62, https://doi.org/10.1016/j.tranpol.2013.07.005

59 Pearre, N.S., Kempton, W., Guensler, R.L., Elango, V.V., 2011. Electric vehicles: how much range is required for a day's driving? Transp. Res. Part C Emerg. Technol. 19, 1171–1184. http://dx.doi.org/10.1016/j.trc.2010.12.010

60 Oak Ridge National Laboratory, Popular Vehicle Trips Statistics. Accessed November 2021. https://nhts.ornl.gov/vehicle-trips

61 U.S. Census Bureau, American Community Survey. https://www.census.gov/programs-surveys/acs/

62 Pearre, Nathaniel, Willett Kempton, Randall Guensler, and Vetri Elango. 2011. *Electric vehicles: How much range is required for a day's driving?* https://www.sciencedirect.com/science/article/abs/pii/S0968090X1100012X?via%3Dihub

Impact of Cold Weather

Maine's climate is characterized by cold, snowy winters and mild summers. Mean annual winter temperatures range from 25 degrees Fahrenheit (°F) in the far south to less than 15°F in the northern and interior portions of the state. Mean annual summer temperatures range from near 60°F in the far north to near 70°F in the south.[63] Maine has many regions where the temperature during winter drops under 0°F for stretches of days or weeks.

Cold weather impacts EV battery performance, especially when the vehicle is parked outside and not plugged into the grid, and requires increased energy for heating the cabin of the vehicle.[64] A study led by the Norwegian Automobile Federation estimated that EVs lose approximately 20% of their range in winter conditions in Norway compared to test cycle ranges.[65] However, the U.S. Department of Energy (DOE) also notes that gasoline vehicles lose as much as 33% of fuel economy in temperatures under 20°F. Another study conducted in Norway estimated that winter fast charging lowers the average charging power by 24% relative to summer charging.[66] This is because the onboard battery management system limits the charging rate in cold conditions to avoid detrimental effects on the battery cells.[67]

The vehicle telematics firm, Geotab, provides an interactive tool that allows the user to understand the impact of temperature on EVs.[68] The tool is based on real-world data collected from 4,200 EV drivers. In the worst-case conditions at -4°F, EVs can lose up to 50% of their rated range (e.g., if a vehicle is rated at 250 miles, the vehicle would have an effective range of 125 miles). Figure 10 provides curves of the average, 90th percentile and 10th percentile of range impacts across all 4,200 EVs in the study. As shown, 70°F provides the highest range across temperatures.

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63 NOAA National Centers for Environmental Information, State Climate Summaries, Maine. Accessed November 2021. https://statesummaries.ncics.org/chapter/me/

64 Jaguemont, Joris, Loic Boulon, Yves Dube, and Francois Martel. 2016. "Thermal Management of a Hybrid Electric Vehicle in Cold Weather." *IEEE Transactions on Energy Conversion,* 3 (31). https://www.researchgate.net/publication/301307242_Thermal_Management_of_a_Hybrid_Electric_Vehicle_in_Cold_Weather

65 Veihjelp. March 12, 2020. "20 Popular EVs Testing in Norwegian Winter." https://www.naf.no/elbil/aktuelt/elbiltest/ev-winter-range-test-2020/

66 Figenbaum, Erik. 2017. "Perspectives on Norway's Supercharged Electric Vehicle Policy." *Environmental Innovation and Societal Transitions* (25): 14–34. https://doi.org/10.1016/j.eist.2016.11.002

67 Motoaki, Yutaka, and Matthew G. Shirk. 2017. "Consumer Behavioral Adaptation in EV Fast Charging through Pricing." *Energy Policy* (108): 178–183. https://doi.org/10.1016/j.enpol.2017.05.051

68 GEOTAB. 2021. "Temperature Tool for EV Range." https://www.geotab.com/fleet-management-solutions/ev-temperature-tool/

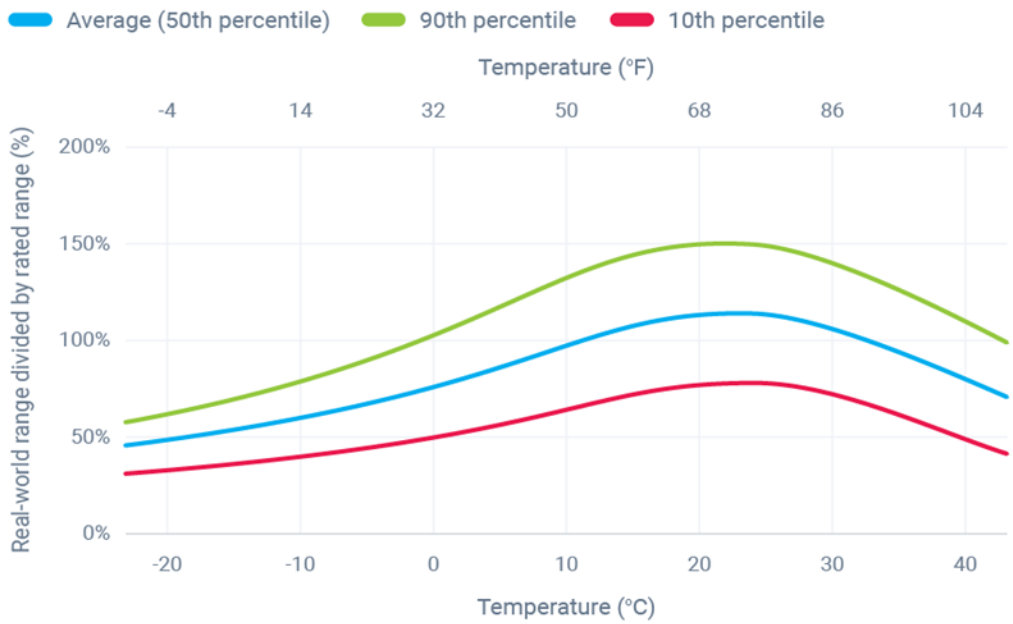

Figure 10. Impacts of Temperature on EV range for 4,200 real-world EVs Measured by GEOTAB.

Because about two-thirds of range impacts are due to cabin heating in cold conditions,[69] many of the emerging technologies focus on using heated seats and onboard heat pumps that lower the auxiliary loads. Some EVs also have battery heaters that prevent damage to the battery in extreme cold. The impact of cold weather temperature on EV range in the southern and coastal regions of the state is likely to be less significant than in less populous northern regions of the state. In addition, Maine's average summer temperature of 70°F represents the "sweet spot" for EV range, where lithium-ion batteries operate at their greatest efficiency.

Auto Dealerships and Electric Vehicles

Auto dealerships play an important role in EV ownership. According to a survey of Maine EV rebate recipients administered by Efficiency Maine Trust,[70] 61% of respondents said they were "very satisfied" or "satisfied" about the level of knowledge of the sales staff at the dealership on the Efficiency Maine EV rebate. However, most EV buyers had already decided on their EV purchase before going to the dealership. In fact, 92% of EV owners were already "very sure" or "pretty sure" they wanted an EV when they arrived at the dealership to purchase a vehicle. The other 8% were "on the fence" or "completely undecided."

In interviews, Maine auto dealers report that the majority of used EVs in Maine are purchased from out of state at auctions primarily within New England, which suggests the used EV population in the rest of New England is an important determinant of used EVs in Maine. National statistics show that 66% of all

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[69] US Department of Energy. 2021. "Fuel Economy in Cold Weather." https://www.fueleconomy.gov/feg/coldweather.shtml

[70] Survey results private via email by staff at Efficiency Maine Trust, August 2021.

vehicle sales are used vehicles—a number that has been relatively steady since 1990.[71] In 2021, inventories of EVs were 50% to 75% lower than normal in Maine due to a variety of supply chain issues in the automotive industry and greater consumer interest in EVs.[72] Auto dealers receive EVs from the manufacturers and with approximately one month of warning about the number of EVs being shipped.[73]

Tourism Industry and Electric Vehicles

Maine drew an estimated 46 million day and over-night tourists in 2019.[74] However, restrictions on non-essential travel due to the COVID-19 pandemic drastically decreased the number of tourists to just slightly over 12 million visitors in 2020. According to publicly available cell phone data analyzed by University of Maine, out-of-state Maine tourists are primarily residents from Massachusetts (16% of visitors) and New Hampshire (14% of visitors).[75] The peak tourist season in Maine is from July to September, with numbers in September spiking due to the Labor Day holiday and decreasing thereafter.[76] To reach Maine, 86% of tourists used some form of personal vehicle.[77] The tourism industry could help catalyze EV deployment in Maine through several routes, such as increasing the state's EV demand via purchases by rental car companies and increasing the use and buildout of publicly accessible charging infrastructure, especially in tourism destinations.

With the exception of Hertz,[78] traditional car rental agencies are still not a major buyer of EVs, but they could become one in the next decade. The peer-to-peer carsharing platform, Turo, allows anyone to list an EV on their website for others to rent.[79] The authors of this report confirmed that some EVs were available in Maine's urban areas on Turo. The general lack of EVs in rental agencies is likely tied to return on investment. Past research clearly shows that these EVs offer lower profitability for rental agencies compared to ICEVs because they cannot meet the range needs of all potential tourists and therefore sit idle (without a renter) for longer periods of time.[80]

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71 Bureau of Transportation Statistics. "New and Used Passenger Car and Light Truck Sales and Leases." Accessed November 2021. https://www.bts.gov/content/new-and-used-passenger-car-sales-and-leases-thousands-vehicles

72 Lee Automotive (Lee, Adam). September 2021. Personal communication.

73 Ibid.

74 Maine Office of Tourism. 2019. https://motpartners.com/wp-content/uploads/2020/06/2019-MOT-Annual-Visitors-Research.pdf

75 Ballingall, Kathryn, Jonathan Rubin, Sheldon Green, Peter O'Brien. 2020. *ACTime Report*. The University of Maine Margaret Chase Smith Policy Center.

76 Ibid.

77 Milliken, Maureen. 2021. "Promising numbers spell reason for optimism, Maine Tourist industry members told." *MaineBiz,* May 4. https://www.mainebiz.biz/article/promising-numbers-spell-reason-for-optimism-maine-tourist-industry-members-told

78 Hertz. 2021. "Hertz Invests in Largest Electric Vehicle Rental Fleet and Partners with Seven-Time Super Bowl Champion Tom Brady to Headline New Campaign." https://ir.hertz.com/2021-10-25-Hertz-Invests-in-Largest-Electric-Vehicle-Rental-Fleet-and-Partners-with-Seven-Time-Super-Bowl-Champion-Tom-Brady-to-Headline-New-Campaign

79 See https://turo.com/

80 Homem de Almeida Correia, Goncalo, and Raquel Filipa Gonçalves Santos. 2014. "Optimizing the Use of Electric Vehicles in a Regional Car Rental Fleet", *Transportation Research Record*. https://doi.org/10.3141/2454-10

Publicly accessible charging infrastructure is a second potential approach to harnessing tourism to spur EVs in Maine. Tourists who drive EVs have a higher reliance on publicly accessible charging stations than other EV drivers, particularly stations along highways and at tourist destinations. Other jurisdictions have purposely built charging networks to serve tourists. For example, the State of Colorado funded 66 DCFC charging stations in strategic locations to serve EV owners in remote mountain regions. Popular destinations to consider as potential sites for EV chargers are Maine's parks, beaches, and coastal towns. Acadia National Park currently has two publicly available EVSEs and the National Park Service has installed 160 public chargers at other national parks in the United States. Recently, Efficiency Maine Trust announced seven new grants to place DCFCs across the state, including near Acadia National Park.[81] In addition, Efficiency Maine Trust's Triennial Plan identifies destination locations as a priority investment segment for both DCFC and Level 2 charging in coming years.[82]

Electric Vehicle Charging Infrastructure

Maine's EV charging network has grown steadily since 2012. Today, there are 417 publicly accessible Level 2 plugs and 131 publicly accessible DCFC plugs. In Figure 11, the map on the left shows locations of new, publicly accessible chargers in Maine. The figure includes only the stations reported to the DOE's Station Locator tool and likely underestimates the number of chargers at office parking. The map on the right shows the priority locations for future chargers under Efficiency Maine Trust's Triennial Plan.[83, 84]

Publicly accessible charging stations in Maine are concentrated in the state's southeast region. Northern and Northeast Maine have large spatial gaps between chargers. Figure 11 shows the publicly accessible charging locations in Maine as of November 2021. The maps include all stations registered with the DOE's Alternative Fuel Data Center and all stations funded with grants from Efficiency Maine. Additionally, stations located in Quebec and New Brunswick are not shown. Efficiency Maine Trust, in partnership with the Maine Department of Transportation, is currently expanding the charging infrastructure in the state to fill in spatial gaps, particularly in the northern regions of the state.

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81 Staff. 2021. "High-speed EV charger network to extend eastward to Acadia." *MaineBiz,* June 4. https://www.mainebiz.biz/article/high-speed-ev-charger-network-to-extend-eastward-to-acadia

82 Efficiency Maine Trust. 2021. https://www.efficiencymaine.com/docs/N_EV-Initiatives_Targets-and-Priorities-for-Future-Funding-Sources.pdf

83 Ibid.

84 The right side of Figure 11 includes Tesla superchargers as currently available Level 3. Tesla has indicated plans to make its superchargers compatible with CCS plugs within the next year.

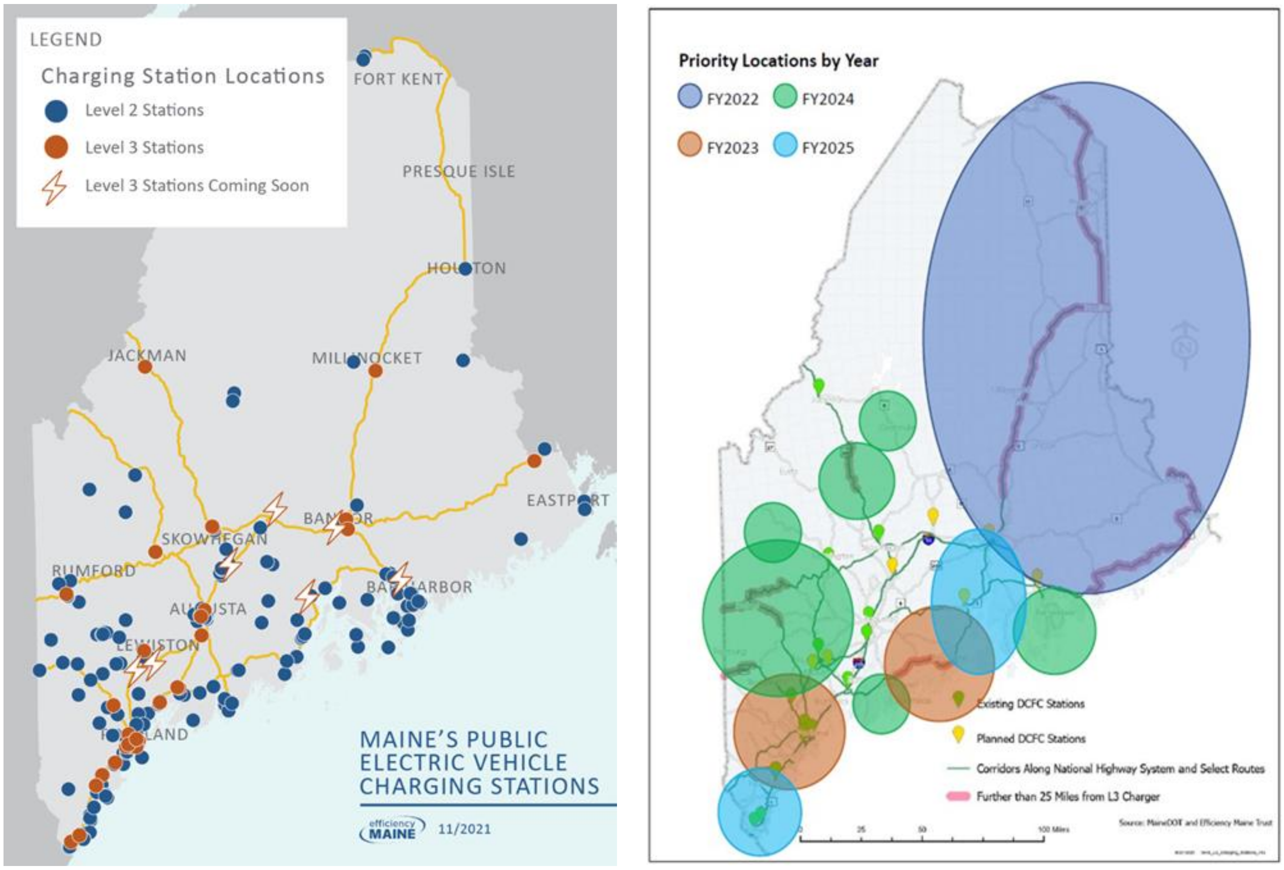

Figure 11. Locations of Publicly Accessible and Planned Chargers in Maine (Left). Priority Locations for Future Chargers by Fiscal Year (Right).

At the time of this writing, Maine had five alternative fuel corridors, designated by the Federal Highway Administration. The purpose of the program is to add visibility to sections of the National Highway System that can sustain long-distance travel for alternative fuel vehicles, allowing states to signpost corridors as such once they are approved.[85] The FHWA designates corridors corridor-ready or corridor-pending depending on the spacing of refueling stations. For example, EV-Ready corridors require charging stations to be located no greater than 50 miles apart[86] and no greater than five miles off the highway, while EV-Pending corridors have some charging stations but not at the right frequency or locations to meet the corridor-ready standard.[87]

Electric Bikes and Electric Scooters

The popularity of electric bikes and scooters has exploded in recent years. According to a report by the World Economic Forum (WEF), sales of e-bikes in the U.S. grew by 145% in 2020 compared to 2019.

85 Federal Highway Administration. 2021. *Federal Funding is Available for Electric Vehicle Charging Infrastructure On the National Highway System*.

86 FHWA will allow spans of greater than 50 miles on a case-by-case basis.

87 Ibid.

Additionally, 130 million e-bikes are expected to be sold globally between 2020 and 2023, making e-bikes the most popular EV.[88] Likewise, electric scooter sales grew by 190% in 2020 compared to 2019.[89] The City of Portland has been exploring opportunities for bike share since 2012, beginning with a bike share feasibility study. In August 2021, the city selected Tandem Mobility to plan and operate a bike share system with a target launch date of summer 2022.[90] The initial program will include 50 e-bikes and 150 pedal bikes dispersed throughout Portland.[91]

Transportation Network Companies

Another rapidly growing element of the modern transportation system, transportation network companies (TNCs), are having a significant impact on emissions. As of 2018, Uber had accumulated more than 10 billion trips globally, with Lyft coming in at 1 billion trips.[92] Both Uber and Lyft operate in the state of Maine. The Union of Concerned Scientists (UCS) estimates a non-pooled ride-hailing trip generates about 47% greater emissions than does a private car trip in a vehicle of average fuel efficiency.[93] This increase is largely due to deadheading, or the period when a TNC driver is without a passenger.

Prior to the COVID-19 pandemic, TNCs were offering pooled rides, which essentially eliminated their climate-disadvantage. However, social-distancing requirements put these programs on hold. Vehicle electrification represents another solution to these increased emissions, and major TNC providers Uber and Lyft have committed to transitioning to 100% electric fleets by 2030.[94] In the near term, TNC providers are looking to roll out EVs through rental programs, where TNC drivers pay a single fee to cover a vehicle rental, insurance, and maintenance. In the longer term, TNCs are focusing on policy advocacy (including better EV rebates), Level 2 charging in multi-unit dwellings (MUDs), and greater access to DCFC in urban areas. TNCs cite a lack of education and awareness about EVs, higher upfront costs, and a lack of access to financing for low- and moderate-income drivers as the biggest barriers to adoption for their drivers.[95]

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88 Deloitte. "Technology, Media, and Telecommunications Predictions 2020." Accessed November 2021. https://www2.deloitte.com/content/dam/insights/us/articles/722835_tmt-predictions-2020/DI_TMT-Prediction-2020.pdf

89 NPD Group. "Electric Bike Market Size." Accessed November 2021.

90 City of Portland, Maine. Bicycle & Pedestrian Planning. Accessed November 2021. https://www.portlandmaine.gov/1750/Bicycle-Pedestrian-Planning

91 News Center Maine, Portland Planning Dept Interview. Accessed November 2021.

92 Union of Concerned Scientists. "Ride-Hailing's Climate Risks." Accessed November 2021. https://www.ucsusa.org/sites/default/files/2020-02/Ride-Hailing%27s-Climate-Risks.pdf

93 Ibid.

94 Lyft. "The Path to Zero Emissions: 100% Electric Vehicles by 2030." Accessed November 2021. https://legacy-assets.eenews.net/open_files/assets/2020/06/18/document_ew_02.pdf. https:/www.uber.com/us/en/about/sustainability/

95 Cadmus conversation with a TNC provider on 10/28/21

Outlook: Transportation Electrification

This chapter examines potential trajectories of transportation electrification in Maine in the next decade, with a focus on the years 2021 to 2025. The chapter provides projections on the number of new EVs and chargers, and the associated costs of chargers. Appendix D provides the methodology.

Advanced Clean Cars II and Advanced Clean Trucks Regulations

The most important regulatory driver in the electrification of Maine's light-duty vehicles in the next two decades will be through Advanced Clean Cars II (ACC II) standards, which have been adopted in California and are expected to be adopted in Maine in 2022. Adoption of ACC II will require vehicle manufacturers to deliver increasing fractions of zero emissions vehicles to Maine—starting at 20% to 30% in 2026, hitting 49% to 70% in 2030, and reaching 100% by 2035. Where exactly Maine will fall within these ranges depends on the manufacturers' use of pooling,[96] historical, and environmental justice (EJ) credits under the program. Note that manufacturers are nearly assured to use historical credits, which drops the maximum 2026 and 2030 percentages to 24% and 56%, respectively. More information on ACC II is available on the California Air Resources Board (CARB) website at Link.

The Advanced Clean Trucks (ACT) regulation is also under active consideration in Maine and has a similar requirement, applicable to manufacturers of Class 2b through Class 8 trucks. If adopted, the regulation will require manufacturers to sell zero emission vehicles for up to 55% of Class 2b to Class 3 trucks, 75% of Class 4 to Class 8 straight trucks, and 40% of truck tractor sales by 2035. More information on ACT is available on the CARB website at Link.

Both ACC II and ACT place the obligation on vehicle manufacturers, not consumers. This means manufacturers must establish electric vehicle pricing strategies and advertising campaigns that ensure they meet the requirements.

Exceeding the required sales percentages in the ACC II and ACT standards will be challenging. Vehicle manufacturers typically have a three- to five-year planning horizon for setting up new supply chains and retooling factories for new models. Manufacturers are currently making the decisions and investments that will impact the early years of these two standards.

Regardless of manufacturers' actions, the State of Maine can maximize its EV population by creating strong policies and incentives that simultaneously attract a variety of EV models to choose from and investment in the infrastructure to support them while easing the transition for households and businesses. Note also that the requirements in ACC II and ACT relate to new vehicles. The State of Maine could accelerate uptake by importing used electric vehicles from out of state.

[96] Pooling means meeting credit requirements in one state by delivering EVs to another state.

Projections of EVs

Four scenarios project light-duty EV adoption in Maine to the year 2035. Figure 12 shows new vehicle registrations on the left and EV stock on the right. The scenarios are defined as follows:

- **Maine Won't Wait Targets** uses the central EV adoption curves in the *Maine Won't Wait* Climate Action Plan. This curve aligns with Maine's EV adoption targets for 2025 and 2030.
- **ACC II Upper Bound** assumes automakers exactly comply with the maximum number of required EV deliveries in Maine set by the California Air Resources Board. The curve goes through 26% in 2026 and 60% in 2030. Assumes no use of pooling or environmental justice (EJ) credits.
- **ACC II Lower Bound** assumes automakers use the maximum available flexible credits (i.e., historical, pooled, and EJ) to comply with the ACC II regulation in Maine. The curve goes through 17% in 2026 and 44% in 2030.
- **Annual Energy Outlook (AEO) 2021 Reference Case** uses the Energy Information Administration's AEO 2021 Reference Case. The curve accounts for currently enacted federal programs such as the fuel economy standards but does not account for any current or planned state-level policies.

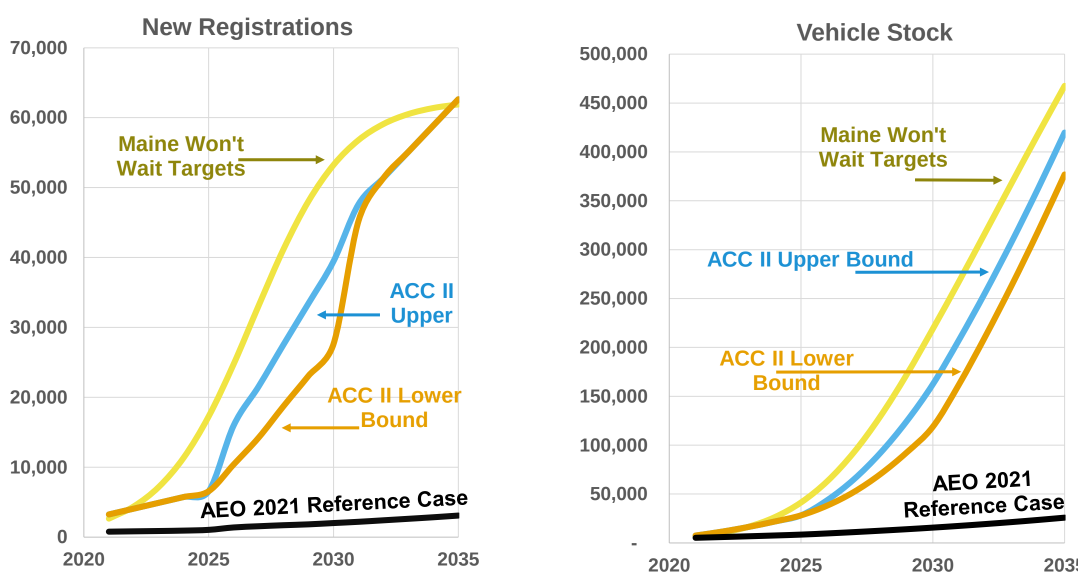

Figure 12. Scenarios for Light-Duty EV Deployment in Maine, New Registrations (left), Stock (right)

The scenarios in Figure 12 illustrate four widely different outlooks of the future. The *Maine Won't Wait* curve is the adoption needed to meet the state's GHG targets, under current assumptions about the ability of other sectors (buildings, industry, etc.) to decarbonize. The two ACC II curves provide estimates of what automakers will be mandated to deliver to Maine after adoption of the standard. Given the lack of historical evidence of automaker compliance, Cadmus sees these two curves as the most likely path toward vehicle electrification. The AEO 2021 Reference Case provides a far more pessimistic outlook and would require no additional action by Maine or other states. Note that the California Air Resources

Board plans to conduct a mid-term review of the ACC II regulation in 2030 and could adjust the requirements in that year.

Medium- and heavy-duty zero emissions vehicle adoption is also anticipated to rise in coming years (Figure 13). The two scenarios are the targets from *Maine Won't Wait* and the ACT regulation. The figure on the left shows the percentage of new vehicle registrations that are zero emissions, with electric being the most likely near-term technology. The figure on the right breaks down vehicle categories under the ACT regulation. Note that ACT is assumed to begin (at the earliest) in model year 2026.

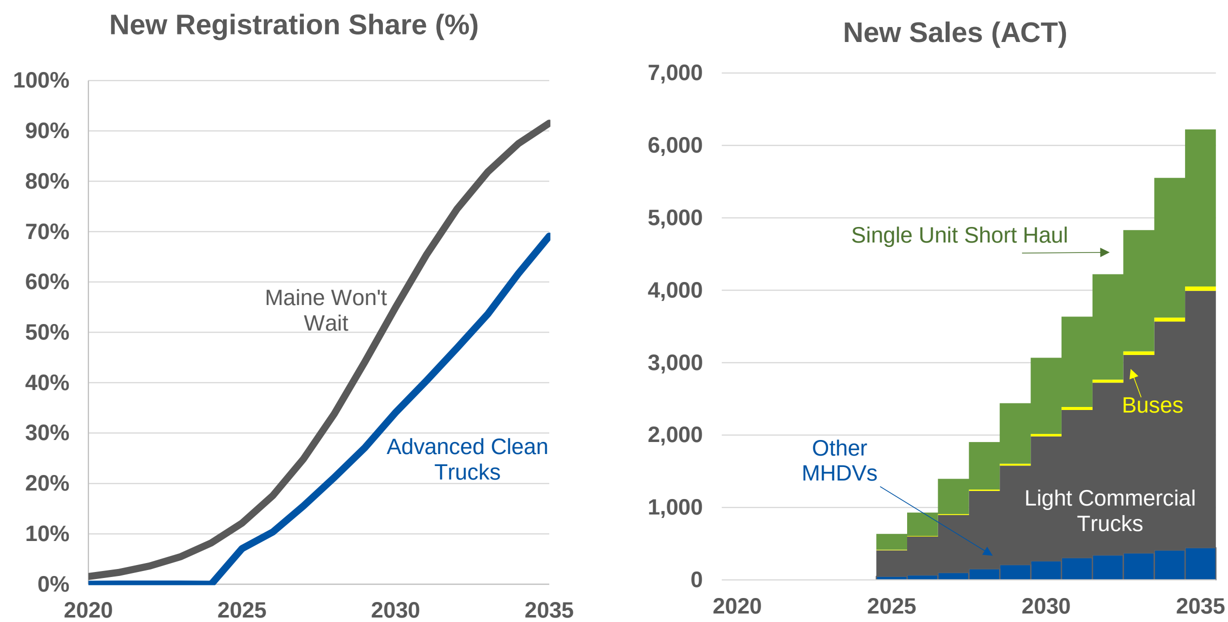

Figure 13. Scenarios for Medium- and Heavy-Duty EV Deployment in Maine, New Registration Share (left), New Sales (right)

Projections of New Chargers

Table 6 provides the assumed ratios of plugs per EV required to support a given population of light-duty EVs. The methodology behind development of these ratios is provided in Appendix D. Using these ratios, Cadmus estimated the number of new plugs per year as shown in Figure 14. Note these ratios change slightly over time based on literature that demonstrates that home charging will diminish in importance in the future because a greater proportion of EV owners will not have access to the necessary electrical equipment.[97] Although not shown in a figure, electric MHDVs are anticipated to have a ratio close to 1.0 plugs per vehicle, based on the small amount of evidence of charging behavior among electric MHDVs.[98]

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97 Ge et al. (2021) There's No Place Like Home: Residential Parking, Electrical Access, and Implications for the Future of Electric Vehicle Charging Infrastructure. https://www.nrel.gov/docs/fy22osti/81065.pdf

98 For example, the vehicles in the California Priority Review Projects had ratios close to 1 charger per vehicle. https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/sb-350-te/california-te-prp-final-evaluation-report-presentation_compressed.pdf

Table 6. Needed Ratio of Plugs per Light-Duty EV[99]

Vehicle Category	Actual in 2021[100]	2021	2022	2023	2024	2025
Residential Level 1	0.34	0.34	0.34	0.33	0.32	0.32
Residential Level 2	0.52	0.52	0.51	0.50	0.49	0.48
Public Level 2	0.09	0.06	0.06	0.06	0.06	0.06
Public DCFC: 50-100 kW	0.027	0.0136	0.0151	0.0165	0.0177	0.0191
Public DCFC: 100-300 kW	0.0001	0.0001	0.0002	0.0002	0.0002	0.0003
Public DCFC: 300+ kW	0.0000	0.0000	0.0000	0.0000	0.0002	0.0002

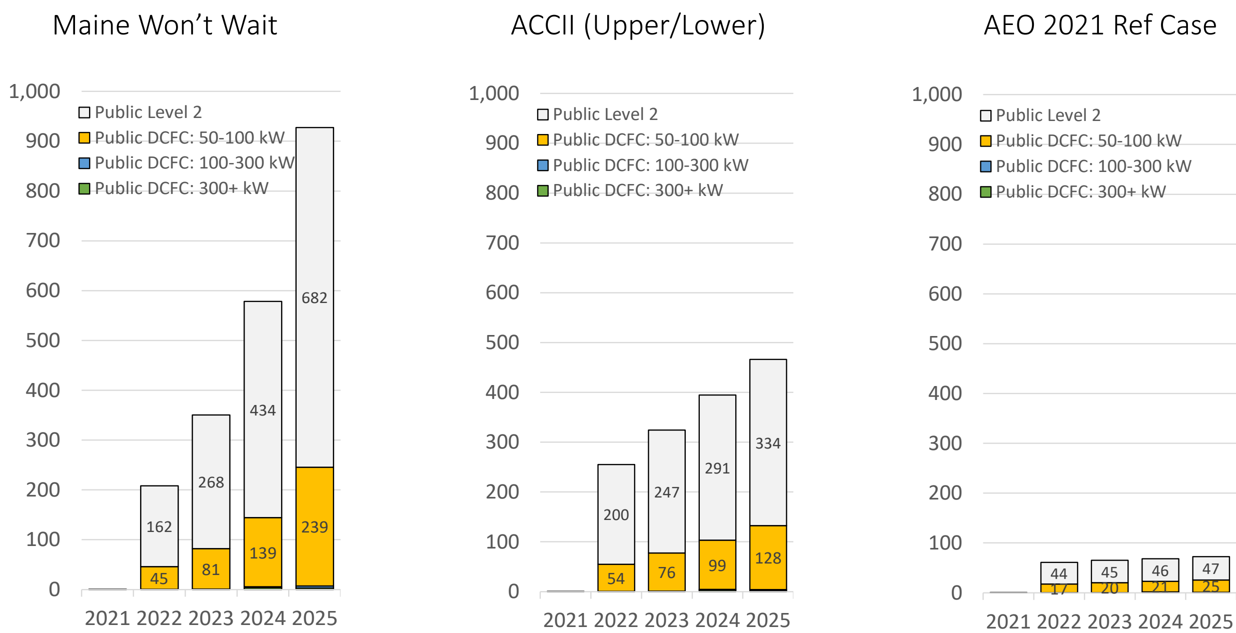

Figure 14. New Plugs Needed to Support Given EV Population

Charging Infrastructure Economics

In this section, Cadmus uses its financial model to estimate costs per plug for Public Level 2 and DCFC 50-100 kW charging stations in Maine. These estimates are intended to illustrate how costs vary in Maine along two dimensions—station utilization and plug count per site.

The next two figures depict all costs and revenue streams from the perspective of a site host who owns and operates the charger, pays electricity fees to the utility, and collects fees from drivers who use the station. The modeling does not include government incentives or revenues generated from non-charging activities (e.g., increased sales of food at a convenience store). All costs and revenues are discounted and placed in a net present value (NPV) for new chargers built in 2020 (and lasting to 2030)

99 For simplification, the ratios in this table are applicable to both BEVs and PHEVs. A plug refers to a single pedestal charger. Note some pedestals have multiple plugs (e.g., a CCS and CHADeMO). This case would only be counted as a single plug.

100 Actual data column calculated using data from the U.S. Department of Energy's Alternative Fuels Data Center (AFDC) website.

and in 2030 (and lasting to 2040). An NPV of $0 is a common threshold used to assess whether an investment makes financial sense. CMP electricity tariffs are used for electricity costs. Other assumptions are documented in *Appendix E. Methodology for Projecting Charger Costs*.

Station Utilization

Utilization, measured in number of charging sessions per day, is a critical factor in the economics of public charging. High utilization plugs are typically found in urban environments or along high-traffic corridors, while low utilization plugs are more common in rural, remote areas. With utilization, per-plug electricity consumption increases, resulting in higher electricity charges for the station owner but also higher revenue received from drivers. As shown in the left panel of Figure 15, high utilization Public Level 2 plugs come close to NPV=$0 for stations built in 2020, whereas low utilization plugs do not approach NPV=$0 in 2020 or 2030. On the other hand, DCFC are unprofitable even at high utilization rates in 2020 and in 2030. This suggests a need to reform the demand charges. Electricity charges represent the largest cost to site hosts.

Plug Count Per Site

Costs of charging also vary based on the number of plugs per site. The largest number of DCFC plugs at a site in Maine is the Electrify America station in Scarborough that has eight plugs on four pedestals. Other sites mostly have one to two plugs per site. Figure 16 shows the estimated 10-year per-plug costs at high-plug count (HPC) sites (10 plugs per site) and low-plug count (LPC) sites (two plugs per site) beginning in 2020 and 2030. Both HPC and LPC sites assume the same level of utilization on a per-plug basis, which increases from 2020 to 2030. HPC sites allow for fixed costs, such as make-ready costs, fixed electricity charges, and site lease costs to be spread across more plugs. As a result, HPC sites are generally more cost-effective than LPC sites, all else being equal. However, HPC also run the risk of underutilization if the stations are overbuilt.

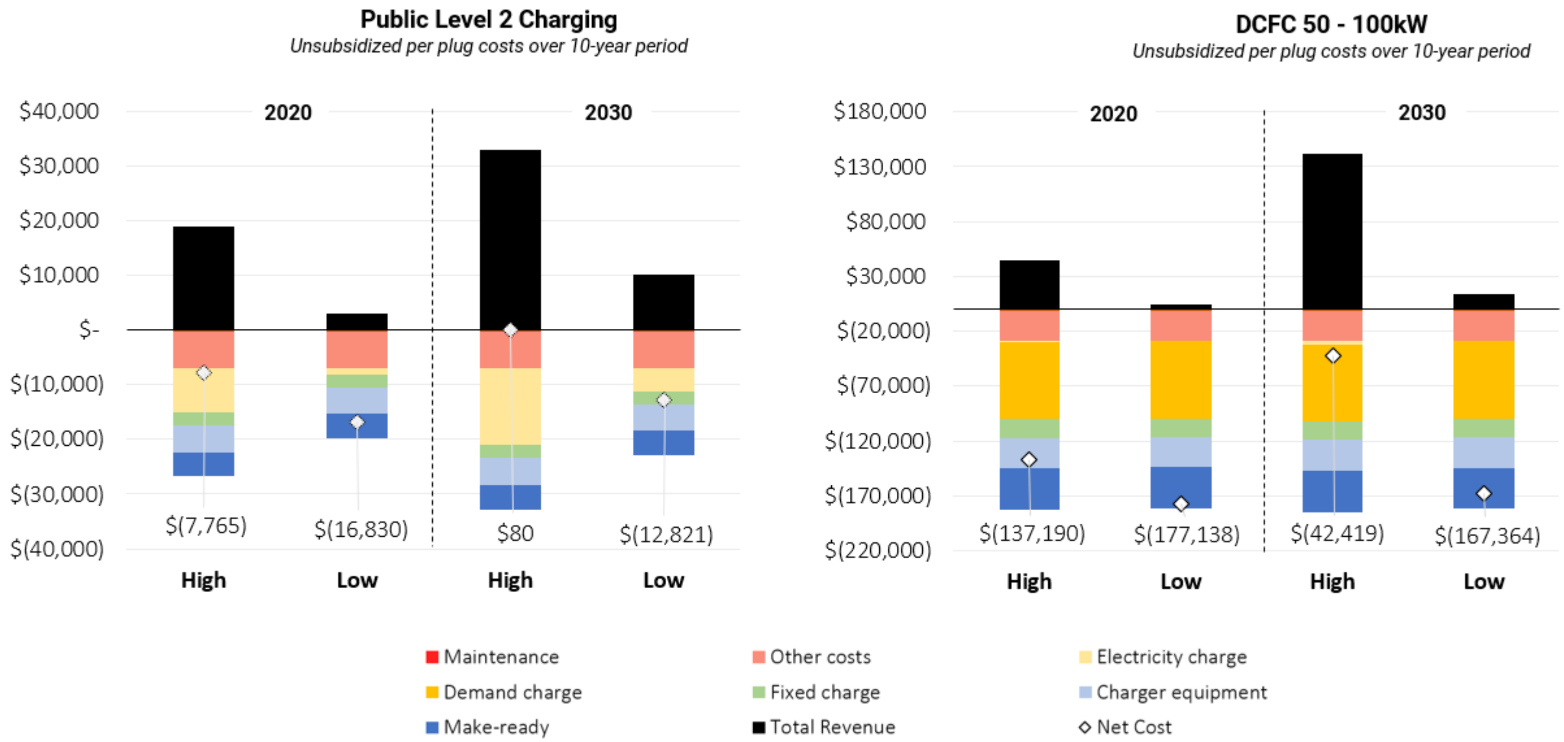

Figure 15. High versus Low Utilization Station Costs and Revenues

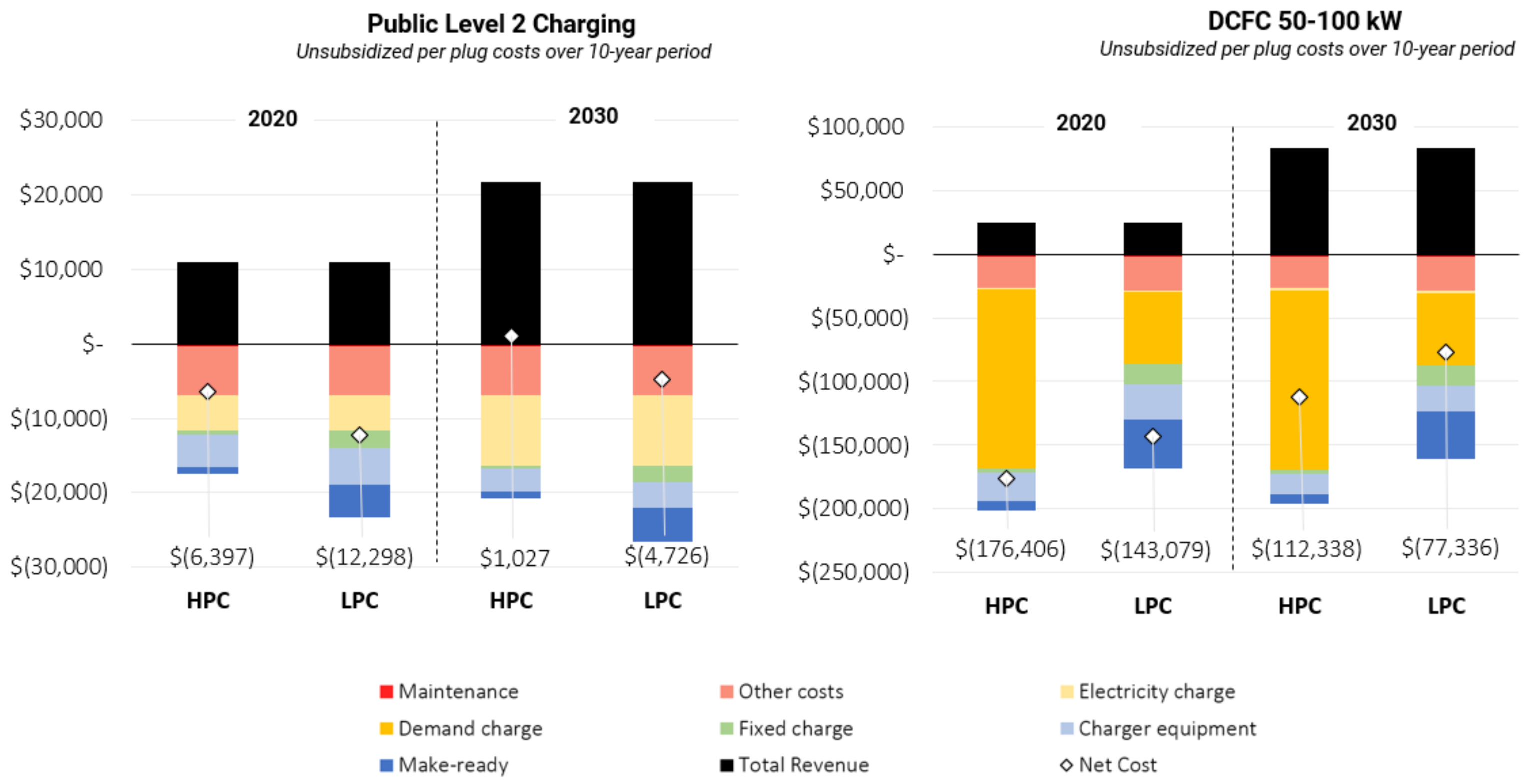

Figure 16. High Plug Count (HPC) versus Low Plug Count Stations (LPC) Costs and Revenues of Public L2 and DCFC Plugs

Rate Design

In September of 2021, as directed by the State Legislature, the MPUC issued an order for transmission and distribution utilities in Maine to propose rate schedules to support the installation and sustainable operation of new and existing non-residential EV charging stations.[101] Cadmus reviewed the November 2021 utility filings from CMP and Versant Power.

CMP has proposed expanding the eligibility of its B-DCFC rate to all DCFCs including those installed prior to 2020. CMP observed that the currently piloted B-DCFC rate provided over 40% savings on transmission and delivery costs for the sole participant in the program.[102] CMP also proposed creating a new electric public transit tariff applicable to transit buses, school buses, and ferries. Finally, its proposal included updating the marginal costs under current TOU periods for all EV chargers using the Residential Load Management Service (A-LM) rate. Versant Power has proposed making residential TOU rates available to Maine Public District customers, which would include residential and small business customers with Level 2 charging stations.

In addition, Versant Power proposed modifying rates for DC fast charging, utilizing a similar methodology to CMP's piloted B-DCFC rate.[103]

These proposed rates offer price signals to discourage charging during periods of peak energy demand, potentially reducing associated demand charges for customers. As demand charges can be the largest cost component for DCFC, improved utility rate design can accelerate market development. Additionally, TOU rates are well-aligned for residential Level 2 charging use cases. Returning home at the end of the day, EV users can charge their vehicles overnight when electricity demand is low. This rate structure is increasingly common as 48% of investor-owned utilities (IOUs) offer residential TOU rates.[104] Rochester Gas & Electric, an Avangrid company, provides a calculator to show how customers can save on EV charging using its TOU rate.[105]

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101 Maine PUC. "Procedural Order (EV Rate Schedules)." September 30, 2021. https://mpuc-cms.maine.gov/CQM.Public.WebUI/MatterManagement/MatterFilingItem.aspx?FilingSeq=112223&CaseNumber=2021-00198

102 Central Maine Power Company. "CMP EV Rates Filing." November 1, 2021. https://mpuc-cms.maine.gov/CQM.Public.WebUI/MatterManagement/MatterFilingItem.aspx?FilingSeq=112623&CaseNumber=2021-00198

103 Versant Power. "Versant Power Comments and Rate Schedules." November 1, 2021. https://mpuc-cms.maine.gov/CQM.Public.WebUI/MatterManagement/MatterFilingItem.aspx?FilingSeq=112619&CaseNumber=2021-00198

104 Hulburt, D., et al. "Electric Vehicle Charging Implications for Utility Ratemaking in Colorado: Utility EV Pilots and Rates." NREL. Accessed Nov 2021.

105 RG&E. "Enroll to Save on EV Charging." Accessed December 2021. https://rge.chooseev.com/tou/

Modeling EV-specific rate impacts on electricity costs

Charging cost scenarios were modeled using a non-TOU (base) electricity rate structure. Cadmus analyzed recent November 2021 utility filings and compared the B-DCFC rate piloted by CMP with the August 2021 base rate. As seen in Figure 17, the B-DCFC rate resulted in a 45% decrease in total electricity costs for a DCFC 50-100 kW plug over a 10-year period. EV-specific rate design, such as were proposed in the November 2021 filing, has the potential to improve the economics of EV charging in Maine.

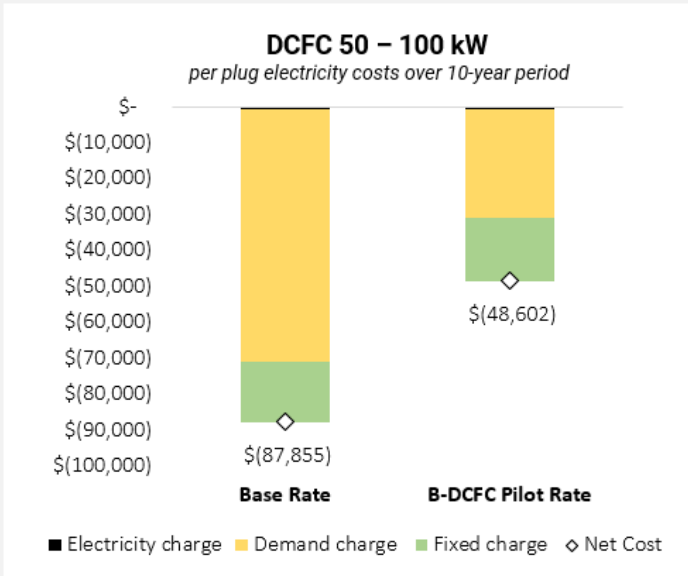

Figure 17. Electricity Costs of CMP B-DCFC Pilot vs Base Rate

Load Impact of Electric Vehicles

Growth in EVs raises questions related to the costs associated with expanding electricity generation, transmission, and distribution. Some estimates suggest these costs could be substantial if vehicle charging is unmanaged. For example, Lawrence Berkeley National Laboratory (2019) conducted an analysis of 3,000 residential electricity feeders in Northern California and estimated that 60% of the feeders would exceed their maximum load limit if every household on the feeder owned one EV and charging was unmanaged.[106] With centralized managed charging, however, peak demand would increase only by an estimated 8%.

Light-duty EVs are typically found in residential clusters, as both demographics and peer pressure are key factors when buying an EV.[107] Electric MHDVs may pose an even larger challenge to the electrical distribution system than light-duty EVs, particularly when several vehicles are charging at once. Infrastructure must be appropriately sized on both the utility and customer sides of the meter to

106 Coignard et al. 2019. Will Electric Vehicles Drive Distribution Grid Upgrades? https://ieeexplore.ieee.org/document/8732007

107 University of Hawaiʻi Economic Research Organization (UHERO; Wee, Sherilyn, Makena Coffman, and Sumner LaCroix). June 2, 2017. “The Role of Policy and Peers in EV Adoption.” https://uhero.hawaii.edu/the-role-of-policy-and-peers-in-ev-adoption/

accommodate high power charging. The length of time and the upgrades involved for several different distribution system upgrades depends on the type of upgrade. Fleet managers, most of whom are not electric grid experts, must commit significant time and financial resources to secure the necessary technical studies, design work, and equipment installations. Overall, installing electric MHDV chargers is a substantial cost compared to installing light-duty EV chargers, operating costs are less predictable, and demand charges make a larger cost impact.

However, EVs also represent an opportunity to expand utility revenues and increase grid flexibility. A study by Synapse on 2012 to 2017 load in California found that EVs put a downward pressure on utility rates because new utility revenues from EVs are greater than the utility's costs of expanding the distribution system, for both standard utility rates and TOU rates.[108] This study was conducted when relatively few EVs were on the road.

More recent work suggests that the impact of EVs on the grid varies. Boston Consulting Group conducted a study in 2019 for a utility with an initial system capacity of 12 gigawatts, baseline electricity sales of about 40 million megawatt-hours (MWh), and wholesale prices that range from roughly $23 per MWh during off-peak times to $34 per MWh during peak periods.[109] The authors found that—in the worst case, without managed charging—utilities will need to invest between $1,700 and $5,800 in grid upgrades per EV through 2030, the same order of magnitude as the increased revenue from electricity sales. This worst-case scenario translates to 1.4 cents per kWh change from an assumed baseline rate of 11 cents per kWh. Similarly, forthcoming work by Cadmus and Nexant in New York State shows the worst-case unmanaged charging scenario with adoption of the ACC and ACT standards translates to an increase in rates of 0.9 cents per kWh by 2050. The authors find managed charging scenarios result in no change in rates by 2050.

This roadmap does not measure cost impacts from distribution system upgrades other than assigning a simple "make-ready" multiplier on plugs. A full study would require a distribution system, capacity expansion model that accounts for increased sizing of transmission and distribution lines as well as increases in load from other sectors, such as buildings.

Figure 18 shows the total electricity load from light-duty vehicle electrification, in megawatt-hours, forecasted in Maine. In reality, right sizing the grid necessitates a more detailed understanding of when and where the load will appear. Note that the figure shows only the load growth associated with LDVs and assumes EVs drive 12,000 miles per year,[110] require 0.34 kWh per mile, have 10% electricity losses at the charger, and experience 7% losses along the transmission and distribution lines.

Charge management measures, such as a TOU rate and smart charging, are beneficial to electricity rates because they flatten the load throughout the day. Data on the impact of charge management

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[108] Frost et al. 2019. Electric Vehicles Are Driving Electric Rates Down. https://www.synapse-energy.com/sites/default/files/EVs-Driving-Rates-Down-8-122.pdf

[109] Sahoo et al. 2019. https://www.bcg.com/publications/2019/costs-revving-up-the-grid-for-electric-vehicles

[110] Rubin et al. 2021. *Electric, Hybrid and High Fuel Efficiency Vehicles: Cost-Effective and Equitable GHG Emission Reductions in Maine.* Draft white paper provided from University of Maine. https://digitalcommons.library.umaine.edu/mcspc_transport/3/

interventions for public chargers is very limited; however, given the current understanding of charging behavior, most flexible load will exist in the residential market because vehicles are stationed at home longer than at other locations in their daily duty cycles.[111] In more urban areas, where access to residential charging may be limited, public charging will become more prevalent and mechanisms to manage that load will need to be developed.

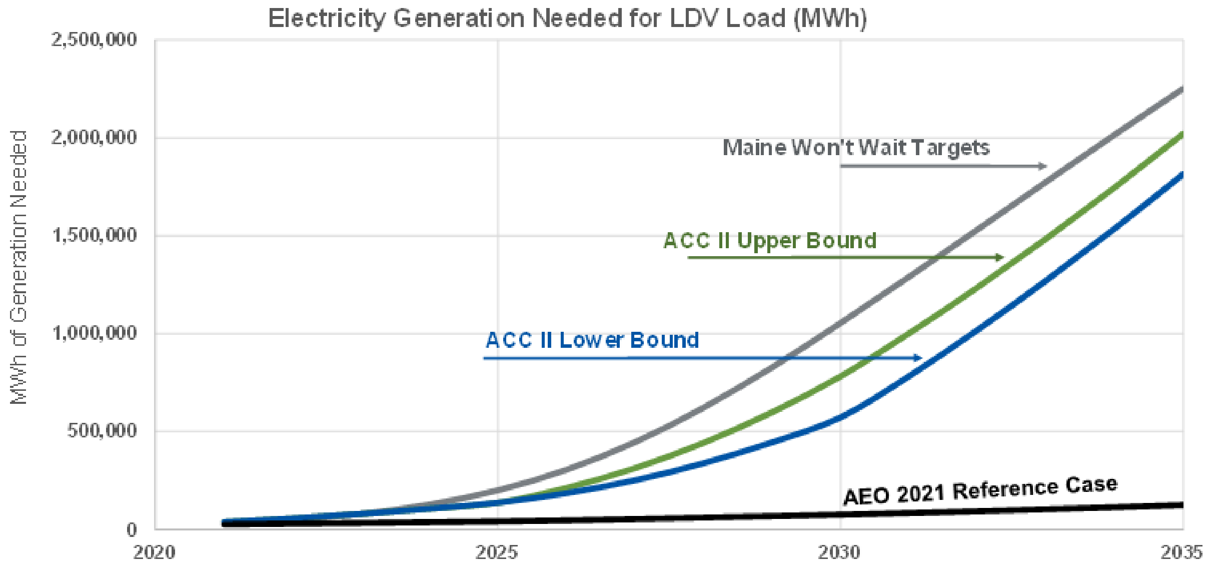

Figure 18. Total Transportation Electrification Load from Light-Duty Vehicles, by Scenario Outlook: Management of Vehicle Miles Traveled

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111 Szinai, Julia K., Colin J. R. Sheppard, Nikit Abhyankar, and Anand R. Gopala. January 2020. "Reduced Grid Operating Costs and Renewable Energy Curtailment with Electric Vehicle Charge Management." Energy Policy (136): 111051. https://www.sciencedirect.com/science/article/pii/S030142151930638X

Outlook: Management of Vehicle Miles Traveled

Though transportation electrification is widely seen as the most impactful strategy on GHG emissions,[112] investments in transit, bike and pedestrian infrastructure, smart growth, and livable communities have meaningful benefits for quality of life and public health while also lowering emissions.[113] The *Maine Won't Wait* Climate Action Plan sets aggressive VMT reduction targets, with goals to reduce light-duty VMT 10% by 2025 and 20% by 2030. The state is also targeting a 4% reduction in heavy-duty VMT by 2030. As of 2019, the average Maine personal vehicle traveled approximately 12,000 miles per year, less than the national average of just over 14,200 miles per year. Residents and visitors in Maine traveled a total of 14.8 billion miles in 2018.[114]

Disruptions and lockdowns caused by COVID-19 resulted in reductions in travel activity both in Maine and across the country. As shown in Figure 19, VMT plunged in March of 2020 then slowly recovered through the summer and fall. In 2021, VMT has generally hovered below 2019 levels but has picked up slightly at the end of November, with a gain of 0.9% over 2019 levels.

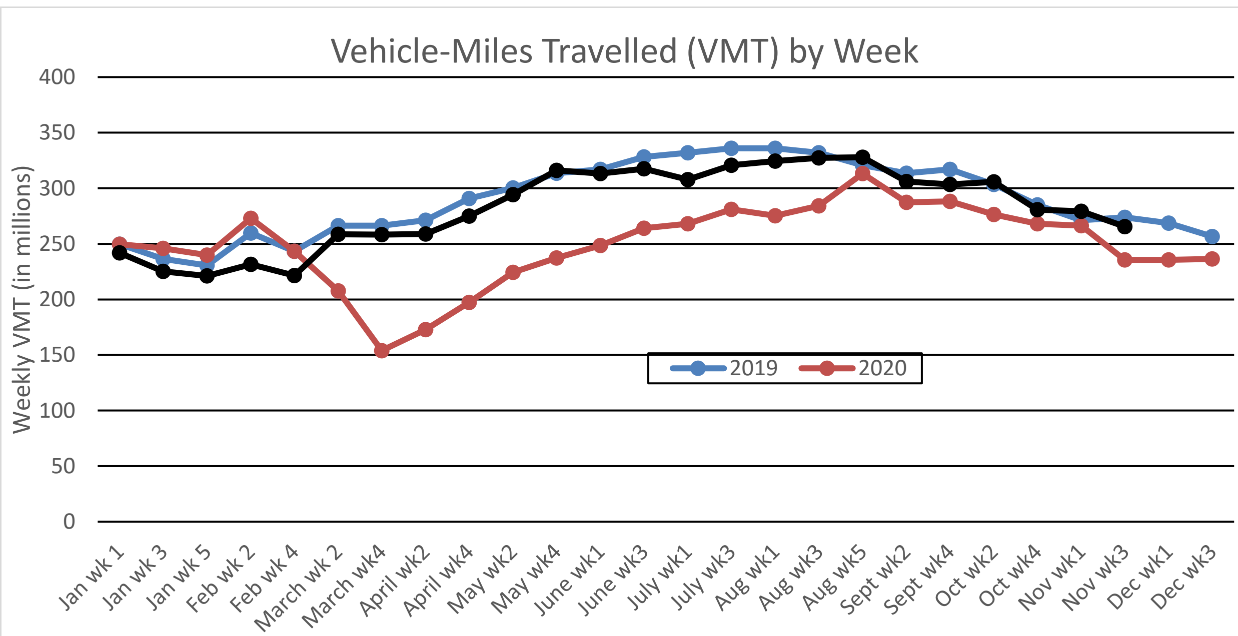

Figure 19. Vehicle- Miles Travelled by Week in Maine

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112 State of Maine GOPIF. 2020. "Assessing the Impacts Climate Change May Have on the State's Economy, Revenues, and Investment Decisions", https://www.synapse-energy.com/sites/default/files/ERG_MCC_AssessingImpactsClimateChangeMaine_Summary_20-019.pdf

113 Guo et al. 2010. "An economic evaluation of health-promotive built environment changes." Preventative medicine Volume 50, https://doi.org/10.1016/j.ypmed.2009.08.019

114 USDOT Bureau of Transportation Statistics. 2020. https://www.bts.dot.gov/sites/bts.dot.gov/files/states2020/Maine.pdf

Despite the disruption by the pandemic, Maine's Long-Range Transportation Plan projects a steady rise in VMT as population and incomes rise.[115] Policies for reducing VMT should focus on shifting to more VMT-efficient modes, reducing trip lengths, and/or reducing discretionary travel. Better transit service, defined as more accessible, affordable, and cleaner transit options, and higher parking costs are examples of strategies designed to shift the mode of travel to more VMT-efficient modes. Mixed-use development and other land development policies typical of smart growth are examples of strategies designed to shorten trip lengths. Teleworking and other policies that use technology to replace physical travel are examples of strategies that reduce discretionary travel. The most effective VMT management policies address all three aspects of VMT—mode of travel (mode choice), trip length (trip distribution), and forgone trips (trip generation).

Pricing Strategies

The assessment of fees can be an effective strategy to influence transportation system user behavior. The most common pricing strategies are fuel taxes, tolls, and mileage-based fees. These fee schemes generate revenue for maintenance of the transportation system and aim to reduce VMT per person.

Fuel Tax

All 50 states and the federal government rely primarily on fuel taxes to fund road maintenance and expansion. The State of Maine levies a $0.30 per gallon charge on gasoline and a $0.31 per gallon charge on diesel fuel. These rates have remained unchanged since 2013.[116] Many states have not raised rates according to inflation and find that the funds that are raised are insufficient to cover infrastructure needs as VMT increases faster than fuel consumption.[117] In response, states including Massachusetts, Rhode Island, North Carolina, and Vermont have passed legislation to link fuel taxes to inflation. A 2017 national poll found that 78% of Americans would support a $0.10 gas tax increase, if revenues funded road maintenance.[118] Indeed, in Maine, Article IX, Section 19 of the Maine Constitution requires that state fuel tax revenues be used for the reconstruction, maintenance, and repair of public highway and bridges and for the state enforcement of traffic laws.

Many studies have examined the relationship between fuel price, fuel consumption, and VMT. Results from these studies show that changes in fuel costs have relatively small impacts on how much gasoline people consume, especially in the short-term, with estimates of gasoline price elasticity ranging from

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115 Maine's Statewide Long-Range Transportation Plan 2008-2030, MaineDOT, https://www1.maine.gov/mdot/publications/docs/plansreports/connectingmainefulldocument.pdf

116 State of Maine Department of Administrative and Financial Services, Fuel Tax Rates. https://www.maine.gov/revenue/taxes/fuel-tax/rates

117 Byars et al. 2017. "State-Level Strategies for Reducing Vehicle Miles of Travel", University of California, https://escholarship.org/uc/item/8574j16j

118 Agrawal, A. W., and H. Nixon. 2017. What Do Americans Think about Federal Tax Options to Support Public Transit, Highways, and Local Streets and Roads? Results from Year Eight of a National Survey. http://works.bepress.com/hilary_nixon/37/

between -0.02 to -0.1.[119] In other words, an increase in gasoline price from $3.00 per gallon to $3.50 per gallon (an increase of approximately 15%) decreases gasoline consumption by only 0.3% to 1.5%. This pattern of behavior is the result of auto-centric land-use patterns, where transportation system users have few good alternatives to the automobile. Unsurprisingly, studies also suggest higher fuel prices result in greater transit ridership.[120]

Mileage-based Fee

An annual vehicle tax or fee that is proportional to the vehicle-miles traveled by the vehicle is a tool for directly managing VMT. Also called a road user charge, a VMT fee is a tax on the number of miles traveled by a vehicle. It is potentially among the most effective strategies for managing VMT, because it affects all three legs of the VMT management stool (mode choice, trip length, and number of trips). Benefits of a mileage-based fee can include immediate changes in behavior, easy adjustability for changing conditions, and the use of proceeds to address equity impacts and other agency goals. Equity can be incorporated by separating users into groups (vehicle classes and weight groups) and separating road facilities into classes. These breakdowns can ensure closer alignment between costs being incurred and revenue being generated.[121]

In structuring this policy mechanism, VMT fees may be applied to all vehicles or may be applied in different ways to certain vehicle types (like trucks) or to certain operating conditions (like an automated vehicle or ride-hail vehicle not carrying passengers) and may be administered annually, quarterly, or on a pay-as-you-go basis. Several states are exploring VMT fees to address the issue of declining revenue from fuel taxes as the fuel economy increases. These VMT fees are marketed as a simple switch from a "pay-per-gallon" to a "pay-per-mile" option that follows a "user pays" principle for infrastructure funding. Such a system allows the state to receive revenue from hybrid and electric vehicles that contribute less or no gas taxes but still cause wear and tear on the road.

Several states are exploring VMT fees through pilot or volunteer-based programs. The State of Oregon's OReGO program, launched in 2015, enrolls volunteer light-duty passenger vehicles. The OReGO program was created by Senate Bill 810 in 2013, making Oregon the first state to establish a VMT fee program after conducting several pilot studies between 2005 and 2012. Volunteer participants pay 1.8 cents per mile and receive a credit for the fuel tax they pay. As an incentive for participation, the state provides a credit for fuel tax and remote emissions testing or reduced registration fees for drivers of EVs. Revenue is directed to the State Highway Fund. The first phase was limited to 5,000 vehicles, and the program was opened to an unlimited number of personal vehicles in 2019 (still on a voluntary basis).

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119 Circella et al., 2014, California Air Resources Board, "Impacts of Gas Price on Passenger Vehicle Use and Greenhouse Gas Emissions", https://ww2.arb.ca.gov/sites/default/files/2020-06/Impacts_of_Gas_Price_on_Passenger_Vehicle_Use_and_Greenhouse_Gas_Emissions_Policy_Brief.pdf

120 Maghelal, P. (2011). Investigating the relationships among rising fuel prices, increased transit ridership, and CO2 emissions. Transportation Research Part D: Transport and Environment 16(3), 232-235. https://doi.org/10.1016/j.trd.2010.12.002

121 Volovski et al., FUNDING FOR HIGHWAY ASSET CONSTRUCTION AND MAINTENANCE: SUSTAINABLE ALTERNATIVES TO THE TRADITIONAL GAS TAX, https://www.irf.global/wp-content/uploads/Matthew-Volovski-Funding_for_Highway_Asset_Construction_and_Maintenance-Sustainable_Alternatives_to_the_Traditional_Gas_Tax.pdf

In addition, the I-95 Corridor Coalition, consisting of members across 16 eastern states, completed a study that looked at how a multi-state VMT system would function.[122] The study concluded that states should be able to cooperate across boundaries yet remain autonomous when implementing VMT fee programs.

Tolls

Most states, including Maine, have tolling programs. Travelers on the Maine Turnpike are charged a user fee through E-ZPass, an automated toll collection system that relays a vehicle's entry and exit location. Fees are based on vehicle class and distance traveled on the turnpike. The first rate increase in nine years occurred on November 1, 2021, when E-ZPass rates were raised by 4%. Other states are beginning to link tolling rates with inflation. For example, the State of Florida is using the Consumer Price Index to adjust its tolling fees. Metropolitan planning organizations (MPOs) are also beginning to incorporate road pricing into long-range transportation plans.[123]

Infill Development

Infill development involves building on vacant or underused lands in alignment with existing development patterns. Policies encouraging infill development reduce VMT in a few different ways. Infill development reduces trip lengths (through higher-density, mixed-use development) and encourages the shifting of travel to more VMT-efficient modes through improved transit and active transportation (bike and pedestrian) infrastructure. Placing residences, jobs, schools,[124] and retail establishments closer together reduces the distance needed to travel to work or to shop and increases the proportion of trips made by walking.[125] Higher-density developments reduce the walking distance to access transit, where transit is available, and provide the higher levels of ridership needed to support efficient transit service.[126]

Though the authority for land use and development decisions typically rests with municipalities, states can also influence land use. To encourage municipalities to conduct comprehensive land use planning, the State of Maine allows only municipalities with a completed comprehensive plan to pass certain types of zoning ordinances.[127] Maine also requires that transportation decisions follow specific state

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122 RAND Corporation. "Mileage-Based User Fees for Transportation Funding", pp. 13. http://www.rand.org/content/dam/rand/pubs/tools/TL100/TL104/RAND_TL104.pdf

123 U.S. Department of Transportation, (2011). Congestion Pricing A Primer: Metropolitan Planning Organization Case Studies. Washington, DC: Federal Highway Administration, Office of Operations. https://ops.fhwa.dot.gov/publications/fhwahop15036/ch3.htm

124 Schlossberg et al., "Effects of Urban Form and Distance on Travel Mode", Journal of the American Planning Association, Vol. 72, https://pages.uoregon.edu/schlossb/articles/schlossberg_school_trips.pdf

125 Saelens et al., 2010, Built Environment Correlates of Walking: A Review, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2921187/

126 Puget Sound Regional Council, 2015, "Transit-Supportive Densities and Land Uses", https://www.psrc.org/sites/default/files/tsdluguidancepaper.pdf

127 Pacyniak et al., 2012, State-Level Programs and Policies Supporting Sustainable Communities within TCI Jurisdictions, https://www.georgetownclimate.org/files/report/report-tci-state-level-programs-policies-supporting-sustainable-communities.pdf

policies, including reduction of reliance on foreign fuels and consistency with the state's growth management principles.[128] Municipalities that have received a state certification for a comprehensive plan or growth management program receive preference for state grants.[129] Though these rules apply only to a limited number of municipalities and circumstances, they are appropriate examples of state influence over land-use decisions, even in a strong home rule state like Maine.

A planned state-level initiative to encourage infill development is MDOT's Village Partnership initiative (VPI), which will use state and local funds to reinvest in village centers and could be well placed to take advantage of existing and forthcoming federal funding opportunities. Through the program, MDOT will work with municipalities to make investments in lower-speed areas where people meet, shop, and do business. Special emphasis is placed on expanding the area's bicycle and pedestrian infrastructure. An objective of the program is to bring businesses and other services closer to where people live and reduce the number of miles traveled to obtain goods and services.

Other states have taken a variety of approaches to achieve infill development goals. To promote dense development near transit connections, Connecticut offers significant zoning flexibility through the Smart Growth Zoning Overlay District Act. In California, MPOs are required to develop sustainable community strategies in parallel with regional transportation plans, which has resulted in significant infill development in areas served by transit.[130] New Mexico allows landowners to use transfer development rights (TDR), through which landowners can sell development rights from their land to an entity that uses those rights to increase the density of a development at a different location.[131] In 2022, the Legislative Commission to Increase Housing Opportunities in Maine by Studying Zoning and Land Use Restrictions is also anticipated to recommend policies to the State Legislature that would support regulations or incentives for increased housing density for future development in Maine.

Transit Expansion

Increasing public transportation investment was identified as a key goal in the *Maine Won't Wait* plan. Maine's per-capita funding was $11.55 for public transportation in 2019 and include state funds for the Maine State Ferry Service, GO MAINE, and the Northern New England Passenger Rail Authority, which had not been designated in previous years. Including these offers a more accurate representation of the state's total public transportation funding level.[132]

Several initiatives are already underway in Maine to improve public transit. MDOT is currently updating its Statewide Strategic Transit Plan (SSTP), with a target completion date of December 2022. The update

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128 Sensible Transportation Policy Act, ME. REV. STAT. tit. 23, § 73 (2011)

129 ME. REV. STAT. tit. 30-A, § 4349-A(3-A) (2011)

130 California Air Resources Board. Sustainable Communities. Accessed November 2021. https://www.arb.ca.gov/cc/sb375/sb375.htm

131 Santa Fe County, Transfer of Development Rights (TDR) Program. Accessed November 2021. https://www.santafecountynm.gov/growth_management/planning/tdr

132 Colorado Department of Transportation. Transit Projects and Grant Information. Accessed November 2021. https://www.codot.gov/programs/transitandrail/transit/transit-grant-programs

process will also look at potential integration of nontraditional transit models, ridesharing, vanpools, and partnerships with employers. Important outcomes will include an implementation plan and a five- to 10-year targeted investment plan that supports the overall goals and direction of the SSTP. An important element of the SSTP is to examine unmet needs and identify efficiencies and innovations in delivering appropriate levels of transit service, particularly in rural areas and to underserved cohorts in different regions of the state. The SSTP will look at approaches in other states and recommend pilot projects to improve efficiency and effectiveness.

The SSTP update will also incorporate expansion of the GO MAINE program, identified as another key transit priority in *Maine Won't Wait*. GO MAINE is an online portal that matches rides for commuters and encourages other modes of travel outside of single-occupancy vehicles. MDOT recently became the lead agency for GO MAINE and is partnering with the Maine Turnpike Authority and a consultant to expand and relaunch the program in 2022. Goals for the expanded program include serving as a one-stop statewide platform for travelers to connect to green alternatives quickly and easily; offering a complete trip planner that allows travelers to go from origin to destination safely and efficiently across modes and providers; reducing single-occupancy vehicle trips, VMT, and GHG emissions; increasing participation and engagement of key stakeholders to promote the program and develop appropriate incentives; incorporating flexibility to integrate into other statewide transit efforts; and prioritizing underserved communities.

Such state-sponsored ride-matching programs are an increasingly popular VMT management strategy. Connecticut CTrides and Delaware Rideshare offer ride-matching, vanpool services, and information on travel resources for commuters across the state. The Drive Less Save More program in Oregon aimed to raise awareness about alternative modes of transportation and was reported to have reduced 21.8 million vehicle road miles by 2009.[133]

U.S. and global transit agencies are recognizing the need to operate transit systems more holistically. Mobility-as-a-service (MaaS) integrates multiple transportation options through an on-demand service and an integrated payment platform. For example, a rural or suburban resident might use an app to call a ride-hail pick-up from home to a transit station, board a bus to downtown, then use a bikeshare to get to the destination. Numerous MaaS pilot projects are currently being deployed across the country.

MaineDOT contracted with the University of Maine's Margaret Chase Smith Center to prepare a white paper, "Rural Public Transportation and Maine: Review of State Best Practices," authored by Eric Brown and Jonathan Rubin in 2021. The paper highlights the Vermont Agency of Transportation's

Transit Electrification

MDOT's forthcoming Transit Bus Electrification Plan will assist select transit providers in Maine with transitioning a portion of their bus fleets to electric or hybrids vehicles. Electrification plans will examine route lengths, available technologies, electrical capacities, emissions impacts, and total cost of ownership (TCO) for participating agencies.

133 Get there Oregon, formerly "Drive Less Save More". https://getthereoregon.org/

several pilot projects and ongoing efforts to improve transit in a similar rural state. Efforts include consolidation of public transit providers, cooperation between public transit providers, the feasibility of micro-transit, ride to wellness, and a pilot program for recovery and job access rides.

MaineDOT is currently looking at a number of these initiatives with particular focus on the feasibility of micro-transit, rides to wellness, recovery rides, and workforce access. An example is the Move PGH pilot offered by the City of Pittsburgh, Pennsylvania, through which residents use an app to pay for bus fare, rent scooters and bikes, and find someone to carpool with in a single transaction, even if a trip crosses multiple modes.[134] MDOT is exploring options for automated fare payment systems that may operate across agencies, general transit feed specification systems that map fixed-route and on-demand transit service, and automated vehicle location—all of these make the transit system more accessible and encourage ridership.

Telecommuting

Teleworking is a transportation demand management (TDM) measure that encourages employers to allow (or encourage) employees to work from home, which reduces the need to commute to and from work and in turn reduces VMT and GHGs.[135] Restrictions and closures caused by COVID-19 boosted the transition to telework. According to the U.S. Bureau of Labor Statistics, 33% of U.S. workers worked from home because of the pandemic during May and June 2020. The percentage of workers telecommuting declined in the fourth quarter of 2020 but remained at 22%.[136] For comparison, in 2017 and 2018 only 13% of wage and salary workers had teleworking arrangements.[137]

Telework focuses on trip reduction. Of the three legs of the VMT stool, trip reduction is the most effective way to reduce VMT,[138] because it reduces the need for the trip in the first place. A study conducted by the California Air Pollution Control Officers Association (CAPCOA) suggests a 1% to 6% per-capita VMT reduction in daily commute trips for workers allowed to telecommute just 1.5 days per week.[139] States can encourage teleworking through lead-by-example initiatives, whereby the state is the first adopter for policies that it desires to see adopted by other public and private sector entities. Along

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134 Pittsburg Mobility Collective (PMC). https://move-pgh.com/

135 Carlson et al., "Impacts of VMT Reduction Strategies on Selected Areas and Groups", https://www.wsdot.wa.gov/research/reports/fullreports/751.1.pdf

136 U.S. Bureau of Labor Statistics. "Teleworking and lost work during the pandemic". Accessed November 2021. https://www.bls.gov/opub/mlr/2021/article/teleworking-and-lost-work-during-the-pandemic-new-evidence-from-the-cps.htm

137 Frazis,et al., "Who telecommutes? Where is the time saved spent?" BLS Working Paper 523, April 2020, https://www.bls.gov/osmr/research-papers/2020/ec200050.htm.

138 Choo et al., 2005, Does telecommuting reduce vehicle-miles traveled? An aggregate time series analysis for the U.S., https://link.springer.com/article/10.1007/s11116-004-3046-7

139 California Air Pollution Control Officers Association, Quantifying Greenhouse Mitigation Measures, 2010. http://www.capcoa.org/wp-content/uploads/2010/11/CAPCOA-Quantification-Report-9-14-Final.pdf

with many other states in response to COVID-19, Maine has instituted a comprehensive telework policy for state employees.[140]

Telework can also expand opportunities for rural residents, provided they have adequate internet connectivity. The U.S. Office of Personnel Management (OPM) reports that 16% of Maine's workforce currently telecommutes.[141] Expanding this percentage will require greater access to broadband, which remains a challenge across rural communities in the United States. In Maine, one in 10 homes does not have access to broadband.[142] In response, Maine seeks to deploy high-speed broadband to 95% of homes by 2025 and 99% by 2030. The state will be able to use $129 million in federal funding from the American Rescue Plan and $21 million from unallocated federal funds to expand access to high-quality broadband.[143] The state is also projected to receive at least $100 million in additional allocated funds for broadband through the federal Infrastructure Investment and Jobs Act and an opportunity to compete for other competitive funding.

Bicycle and Pedestrian Infrastructure

To promote mode shift to active transportation options, Maine needs to make the transportation system safer. This can be accomplished by funding projects that promote safety, changing engineering standards to accommodate all modal users, and incorporating the needs of all users on traditional transportation projects.

Some states support active transportation by providing grants to local governments. For example, California's Active Transportation Program (ATP) consolidates federal and state transportation programs into a single funding stream that enables active transportation infrastructure, plans, and education.[144] North Carolina has also brought multiple funding streams under one umbrella through the North Carolina Bicycle and Pedestrian Planning Grant Initiative.[145]

MaineDOT funds active transportation in several ways. Through the federal Transportation Alternatives Program grant, all transportation capital projects are eligible for bike and pedestrian improvements; other grant initiatives allow a 50/50 municipal/state share for a municipality to make active transportation improvements to state-owned infrastructure. MaineDOT has also updated its Engineering

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140 State of Maine. Executive Branch Baseline Telework Policy. Accessed November 2021. https://www.maine.gov/governor/mills/sites/maine.gov.dafs/files/inline-files/Executive%20Branch%20Baseline%20Telework%20Policy%2008%2026%202021.pdf

141 U.S. Office of Personnel Management. "Telework Trends". Accessed November 2021. https://www.telework.gov/reports-studies/telework-trends/#DataByLocation

142 State of Maine. "Maine Won't Wait", pg. 65. Accessed November 2021. https://climatecouncil.maine.gov/future/sites/maine.gov.future/files/inline-files/MaineWontWait_December2020.pdf

143 State of Maine. "The Maine Jobs & Recovery Plan". Accessed November 2021. https://www.maine.gov/covid19/maine-jobs-and-recovery-plan

144 California Department of Transportation. "Active Transportation Program". Accessed November 2021. https://dot.ca.gov/programs/local-assistance/fed-and-state-programs/active-transportation-program

145 North Carolina Department of Transportation. "Bicycle & Pedestrian Planning Grant Initiative". Accessed November 2021. https://www.nc.gov/services/bicycle-pedestrian-planning-grant-initiative

Instructions on Crosswalk Policy to promote safer design and construction of crosswalks and pop-up projects to allow communities to test narrowing lanes, reducing parking, and creating safer pedestrian access. It has also partnered to give away rapid flashing beacons to municipalities that take a class on safe crosswalks.

MaineDOT has historically spent $5 to $7 million annually on bicycle and pedestrian programs and infrastructure. However, this figure does not include bicycle and pedestrian facilities that are part of paving, bridge, and larger projects nor does it include bicycle and pedestrian studies.

Statewide bicycle and pedestrian plans provide guidelines, strategies, and performance metrics to support active transportation projects. Oregon, Washington, Minnesota, Massachusetts, North Carolina, and Virginia have all created such plans, and Maine is in the process of developing its own Statewide Active Transportation Plan (SATP). Maine's SATP will lay out the vision and goals for active transportation in the state, assess current programs and practices, and identify implementable strategies. The SATP will also examine key corridors for trail-until-rail, a program that would develop nonmotorized paths along unused rail lines while reserving the rail lines for future use by rail operators.

Complementary to the SATP, MaineDOT is updating its official Complete Streets policy. The goal of a Complete Streets policy is to design and operate transportation infrastructure to better serve all users, especially pedestrians, bicyclists, and transit passengers, who are often underserved by traditional roadway design. Complete Streets can be an effective VMT management strategy because it promotes alternative travel modes and encourages travelers to switch to more efficient modes (bike, walk, transit), thereby reducing VMT per capita. A review of national studies by CAPCOA suggests that the VMT per-capita reduction would be 1% to 2% for areas with Complete Streets.[146]

MaineDOT's updated Complete Streets policy will include both a design guide and an external policy. The design guide will provide MaineDOT engineers and consultants with a suite of street treatments to enhance the safety and comfort of nonmotorized users and will be compiled based on best practices from leading cities and more rural areas. To increase transparency, the guide will also assist engineers in documenting why particular design elements were chosen over others. The external policy will provide guidance on public involvement and ways in which equity will be addressed during the design of road projects. The update will also expand the scope of Complete Streets considerations, requiring that smaller road projects, even repaving projects, consider Complete Streets principles.

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[146] California Air Pollution Control Officers Association, Quantifying Greenhouse Mitigation Measures, 2010. http://www.capcoa.org/wp-content/uploads/2010/11/CAPCOA-Quantification-Report-9-14-Final.pdf

Clean Vehicle Funding

Current funding sources for Maine's clean transportation system include the American Rescue Plan Act (ARPA), Volkswagen Settlement, and Infrastructure Investment and Jobs Act (IIJA) as well as state and local sources such as state-issued bonds and the New England Clean Energy Connect (NECEC) settlement. Because of the challenge of isolating and quantifying every funding source, this roadmap focuses on funding for charging infrastructure and EV rebates.

Currently, the State of Maine has the following funding available:

- **$8 million** for charging infrastructure through its Fiscal Year 2026 from the *Maine Jobs & Recovery Plan*.[147]
- **$19 million** for charging infrastructure through 2026 from the federal *Infrastructure Investment and Jobs Act (IIJA)* formula funding to Maine.
- **$3.75 million** for EV rebates and **$1.25 million** for qualified low-income EV rebates from the New England Clean Energy Connect stipulation and the potential for an additional **$8 million** for charging infrastructure over four years. The $3.75 million will likely be fully used by June 2022.

In addition, Maine is eligible to compete with other states for up to $2.5 billion in funding for chargers in the IIJA as well as for other funding summarized on the White House fact sheet.[148] If $2.5 billion were allocated to states based on the relative size of the population, Maine would receive $10 million. The federal Build Back Better bill would increase the EV tax credit from a maximum of $7,500 to $12,500 per vehicle and remove the 200,000 vehicle cap (per manufacturer) in the current tax credit.[149]

Funding Needs for Charging Infrastructure

Figure 20 shows the annual estimated investment needed for residential chargers and public chargers for 2022 and 2025. Funding levels increase over time as the state's EV population grows. Estimates in this figure use cost assumptions described in *Appendix E. Methodology for Projecting Charger Costs*. The estimated number of plugs are based on the ACC II curves shown earlier in Figure 12. The ACC II curves were chosen as a central, most-likely curve, and are identical to the year 2025. Values in this figure do not necessarily reflect the State of Maine's needed investment since homeowners, businesses, and other entities in Maine should play a part in installing charging equipment and paying for its operation.

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147 Maine fiscal year runs from July 1 through June 30. The values in Table 2 are for calendar year.

148 White House (2021) https://www.whitehouse.gov/wp-content/uploads/2021/08/MAINE_Infrastructure-Investment-and-Jobs-Act-State-Fact-Sheet.pdf

149 White House (2021) https://www.whitehouse.gov/briefing-room/statements-releases/2021/10/28/president-biden-announces-the-build-back-better-framework/

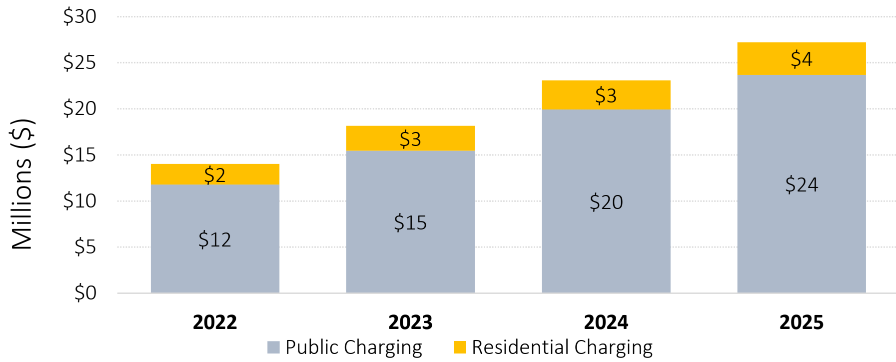

Figure 20. Funding Needs for New Residential and Public Charging

Funding Needs for Low-Income Vehicle Rebate

This section presents a proposal for the design of an expanded low-income EV rebate program and an estimate of the state funding needed to support such a program. Currently, Maine's EV rebate for income-qualified households provides up to $5,500 for a new EV and $2,500 for a used EV. Rebate programs that target low-income households reduce free-riders (people who would have purchased an EV even without an incentive), thereby potentially improving the program's cost-effectiveness.[150]

Figure 21 shows the income distribution of new EV buyers, all new car buyers, and all used car buyers.[151] Historically, EV buyers have had higher income levels than the general population. As shown in the top bar, over 50% of survey recipients in the EV rebate program indicated they came from households that earn more than $100,000 per year.[152] Maine's current low-income EV rebate has had few participants in comparison to the overall program. Thus, higher incentive levels are likely needed to increase uptake.

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150 DeShazo, J. R., T. L. Sheldon, and R. T. Carson. 2017. "Designing Policy Incentives for Cleaner Technologies: Lessons from California's Plug-In Electric Vehicle Rebate Program." *Journal of Environmental Economics and Management* (84): 18–43. https://doi.org/10.1016/j.jeem.2017.01.002

151 Data for the New EV buyers is from Maine's EV rebate survey, provided by Efficiency Maine Trust. Data for the New Car Buyers and Used Car Buyers is from the National Household Travel Survey. Note that New Car Buyers is for all of the United States, whereas the Used Car Buyers is specific to Maine. There was a lack of data in the New Car Buyers for a Maine specific graphic.

152 EMT Survey of EV Rebate Program participants

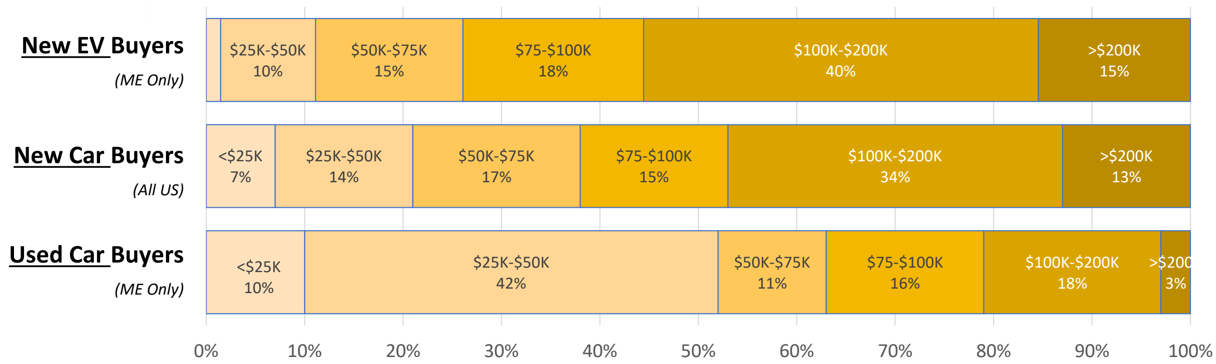

Figure 21. Income Distribution of New EV Buyers, New Car Buyers, and Used Car Buyers

An alternative program design could adjust the incentive level until uptake of the rebate matches the income distributions in the rest of the car market. Suppose the State of Maine wants to incentivize clean vehicle purchases in households with an annual income below $50,000 per year. To match the income distribution in the bottom two bars in Figure 21, the EV rebate would need to be sufficiently high to ensure that 21% of new EVs and 52% of used EVs were purchased by households making less than $50,000 per year.

Cadmus made the simplifying assumption that a $7,500 EV rebate on a new vehicle and a $4,000 EV rebate on a used vehicle will induce sufficient demand to achieve this goal. Figure 22 illustrates a program design for a low-income rebate program. The line graph along the top shows the assumed decreasing per-vehicle incentive over time. The two bar graphs below the line graph show the necessary annual funding for new EVs (left) and used EVs (right). Overall program funding for such a program would require $11 million to $28.8 million per year.

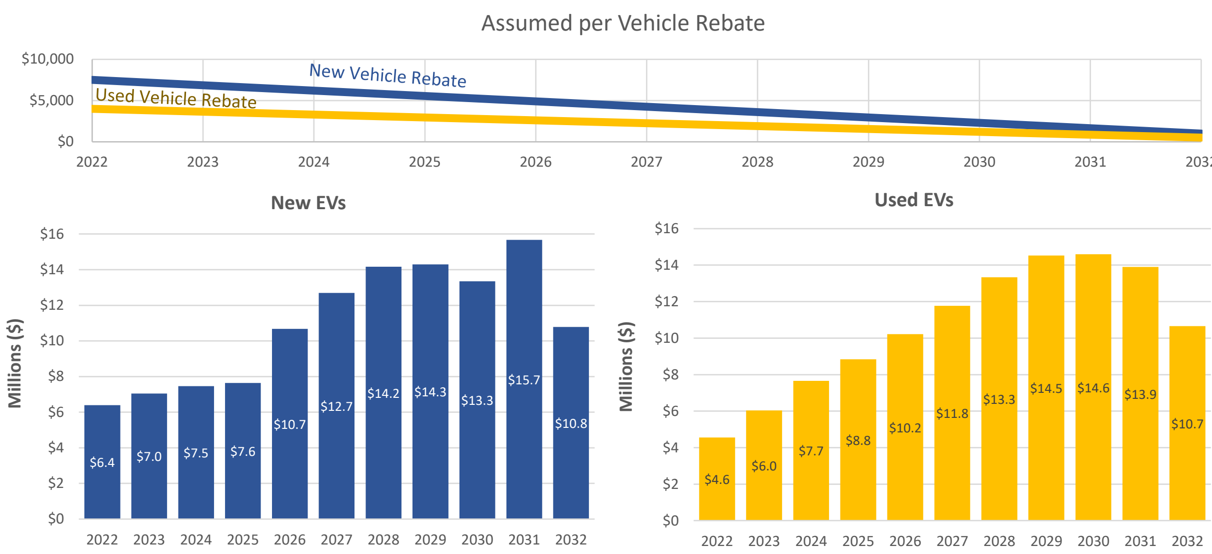

Figure 22. Example Program Design for Low-Income Rebate Program

Other Potential Funding Needs

Several potential future costs are not included in the estimates presented above:

Electricity distribution system expansion is a future cost described in the

- Load Impact of Electric Vehicles section above. A full study of such costs would require a capacity expansion model that accounts for increased sizing of transmission and distribution lines as well as increases in load from other sectors such as buildings.
- **Installation of chargers at multi-unit dwellings (MUDs)** will become an increasingly important element of EV charging. Efficiency Maine Trust released an RFP in 2021 to fund MUD chargers (and other chargers) up to $4,000 per plug for networked chargers and $2,000 per plug for non-networked chargers.
- **Installation of workplace charging**, including installation and equipment, is a relatively small cost compared to other costs described above. Workplaces are increasingly adding Level 1 and Level 2 chargers as an employee benefit.
- **Installation of MHDV chargers** is estimated to cost $20 million per year in the early years of the Advanced Clean Truck (ACT) regulation. These costs would escalate as the adoption of electric MHDVs increases.
- **MHDV rebates.** Vehicle rebates would likely be needed to help defray the incrementally higher upfront costs of MHD EVs.

Recommendations

This chapter provides a set of recommendations that will catalyze Maine's clean transportation sector. The recommended new programs in Table 7 show strong evidence of their impact from the analytical modeling and experience in peer jurisdictions. Of these new programs, ACC II and ACT are the most critically important in terms of impact on GHG emissions. Assuming they are adopted and remain unchanged in the future, these two programs together can lead to large reductions in transportation sector GHG emissions. Cadmus' work for the State of New York shows that these two programs alone can result in approximately 60% to 70% reduction in GHG emissions in the state's transportation sector by 2050. Many other programs listed in Table 7 can smooth the rapid transition needed and help toward distributing benefits in an equitable manner.

Table 7. Cadmus Recommendations for New or Expanded Programs

	Program	Goal	Rationale
State-or Efficiency Maine Run Programs	**Advanced Clean Cars II** **Advanced Clean Trucks**	Increase EV Adoption	• If implemented, programs will have profound impact on GHG emissions from the transportation sector. • Sends clear, long-term signal to automakers to increase deliveries of EVs. • Historically, EV market share has been roughly twice as high in states that follow California emission regulations (Section 177 states), illustrating effectiveness of vehicle sales requirements.[153]
State-or Efficiency Maine Run Programs	**Public DCFC Incentive and/or Ownership**	Expand Charging Network	• Cadmus analysis suggests expanding public fast chargers by 15% in 2030 boosts EV sales by 7% in 2030 relative to business-as-usual. • Academic literature clearly demonstrates positive relationship between DCFC access and EV sales.[154]
State-or Efficiency Maine Run Programs	**Multi-Unit Dwelling (MUD) L2 Charger Incentive Program**	Expand Charging Network	• Availability of charging in MUDs unlocks latent demand for EVs.[155] • 21% of Maine households are in MUDs (buildings with two or more households).[156] • MUD households have approximately 50% lower household income in Maine than households in single-family homes.[157] • Cadmus' analysis shows that enabling access to charging at MUDs has more impact on EV sales than providing charging for single-family homes.

153 Center for American Progress (CAP; Cattaneo, Lia). June 2018. *Plug-In Electric Vehicles: Evaluating the Effectiveness of State Policies for Increasing Deployment.* https://cdn.americanprogress.org/content/uploads/2018/06/06140002/EVreport-5.pdf

154 For example, see review by Hardman, Scott, 2019. "Understanding the impact of reoccurring and non-financial incentives on plug-in electric vehicle adoption – a review." *Transp. Res. A Policy Pract*. 119, 1–14. https://phev.ucdavis.edu/wp-content/uploads/reoccurring-incentives-literature-review.pdf

155 DeShazo, J.R., Overcoming Barriers to Electric Vehicle Charging in Multi-unit Dwellings: A Westside Cities Case Study, https://innovation.luskin.ucla.edu/wp-content/uploads/2019/03/Overcoming_Barriers_to_EV_Charging_in_MUDs-A_Westside_Cities_Case_Study.pdf

156 Only 19% when including Group Quarters. Data from US Census (2019) American Community Survey, 5-year Survey. https://data.census.gov/

157 Data from US Census (2019) American Community Survey, 5-year Survey. https://data.census.gov/

	Program	Goal	Rationale
	Expanded Low-Income EV Incentive Program with L2 Charger	Incentivize Clean Vehicles	• EV rebate programs with a low-income component reduce free-riders and potentially increase cost-effectiveness.[158] • Low-income households have the largest transportation-related health burden of any group.
	Cash for Clunkers Program	Incentivize Clean Vehicles	• Removes high-polluting vehicles, creating potential benefit to low-income households that are most burdened by transportation emissions. • One of few programs capable of increasing turnover of vehicle stock. • Program requires equitable design. For example, in the 2009 federal Car Allowance Rebate System (CARS) program, participants had higher income than average used car buyers,[159] though lower income than average new car buyers, and only 1% of subsidies went to individuals in the bottom 50% of income.[160]
	Medium- and Heavy-Duty EV Incentive	Incentivize Clean Vehicles	• Many fleet operators are ill-equipped to pay premium for electric MHDVs. • Electrifying MHDVs is critical for meeting Maine's 2030 and 2050 GHG goals.[161]
	Marketing and Awareness Campaign	Education & Awareness	• Ensures public has concise, accurate information on clean transportation modes, incentives, and technologies. • Provides technical assistance to stakeholders in need.
Local Programs	**EV-Ready Building Codes**	Expand Charging Network	• EV-ready and EV-capable building codes are critical for reducing the cost of future charging installation on the customer side. • Estimates show that EVSE installation costs increase by two[162] to six[163] times if a parking space is made EV-ready after construction compared to during construction.
Local Programs	**Transit Village to Encourage Transit Oriented Development (TOD)**	VMT Reduction & Mode Shift	• Reduces VMT, boosts transit ridership, and reduces need for traditional road infrastructure.
Local Programs	**Bicycle & Pedestrian Investment**	VMT Reduction & Mode Shift	• Ensures prioritization of nonmotorized modes. • Facilitates support of emerging micro-mobility technologies, such as e-bikes and e-scooters.
Local Programs	**Marketing and Awareness Campaign**	Education & Awareness	• Ensures public has concise, accurate information on clean transportation modes, incentives, and technologies.

158 DeShazo, J. R., T. L. Sheldon, and R. T. Carson. 2017. "Designing Policy Incentives for Cleaner Technologies: Lessons from California's Plug-In Electric Vehicle Rebate Program." *Journal of Environmental Economics and Management* (84): 18–43. *https://doi.org/10.1016/j.jeem.2017.01.002*

159 Parker, T. & Gayer, E. Cash for Clunkers: An Evaluation of the Car Allowance Rebate System. Tech. Rep. (2013). http://www.brookings.edu/$/sim$/media/research/files/papers/2013/10/cashforclunkersevaluationgayer/cash_for_clunkers_evaluation_paper_gayer.pdf

160 Miller, K. S., Wilson, W. W. & Wood, N. G. Environmentalism, Stimulus, and Inequality Reduction Through Industrial Policy: Did Cash for Clunkers Achieve the Trifecta? *Economic Inquiry* **58**, 1109–1128 (2020). https://doi.org/10.1111/ecin.12889

161 State of Maine (2020) Maine Won't Wait, Climate Action Plan. https://www.maine.gov/future/sites/maine.gov.future/files/inline-files/MaineWontWait_December2020.pdf

162 Great Plains Institute (GPI; McFarlane, B. D., M. Prorok, and T. Kemabonta). 2019a. "Analytical White Paper: Overcoming Barriers to Expanding Fast Charging Infrastructure in the Midcontinent Region." *https://scripts.betterenergy.org/reports/GPI_DCFC_Analysis_July_2019.pdf*

163 California Electric Transportation Coalition (CalETC; DoVale K., E. Kamei, C. Kido, and E. Pike). 2019. *Plug-In Electric Vehicle Infrastructure Cost Analysis Report for CALGreen Nonresidential Update. https://caletc.com/assets/files/CALGreen-2019-Supplement-Cost-Analysis-Final-1.pdf*

	Program	Goal	Rationale
Utility or Efficiency Maine Programs	**Demand Charge Relief**	Expand Charging Network	• The Cadmus analysis of CMP rates suggests demand charges account for between 34% and 70% of total costs for a 50 kW DCFC station and between 24% and 62% of total costs for a 350 kW DCFC station. • Critical for corridor charging, certain fleets, and sites with many plugs. • In a tariff analysis, Rocky Mountain Institute shows that reducing or eliminating demand charges can promote a more conducive business environment for the public DCFC market.[164]
	Utility-Side Make-Ready Infrastructure	Expand Charging Network	• Removes key barrier to expanding charging infrastructure, following California[165] and New York[166] programs.
	Time Of Use (TOU) Rates	Incentivize Clean Vehicles	• Supports demand response and efficiency of grid. • Lowers operating cost of EVs.
	Marketing and Awareness Campaign	Education & Awareness	• Ensures public has concise, accurate information on clean transportation modes, incentives, and technologies.

As demonstrated in the previous Clean Vehicle Funding chapter, current funding for EV chargers and vehicles is insufficient beyond fiscal year 2022 or 2023. To fill this gap, Maine could consider one or more funding mechanisms, as described here.

Potential Funding Mechanisms for Transportation Under Consideration in Other Jurisdictions

- **Federal competitive grant funding**. The federal IIJA provides $2.5 billion in competitive grant money for electric vehicle chargers. Other competitive grant opportunities could be leveraged for bicycle and pedestrian improvements. Maine should aggressively pursue this funding within the next year to ensure it receives its fair share.
- **Clean Fuel Standard (CFS)**. This program would regulate fuel providers. Current programs in other states require a 10% reduction in the average carbon intensity of each fuel provider over a 10-year period through a tradeable credits system. In its Interim Clean Energy and Climate Plan for 2030, Massachusetts has expressed interest in coordinating a Northeast CFS. Current programs exist in California, Oregon, British Columbia, and Quebec. New York is also considering adopting a program. CFSs are attractive because they accelerate carbon reductions and mitigate program costs by directing funding toward cleaner fuels rather than toward a general fund. A CFS uses a lifecycle emissions perspective, so it does not currently align with how Maine DEP measures emissions at the source.
- **VMT Tax**. This places a fee on miles driven. An Oregon pilot project demonstrated that a VMT tax reduced VMT by 11% to 12% for the same magnitude of gas tax, all else equal, simply because of

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164 Rocky Mountain Institute (RMI) (2019). https://rmi.org/wp-content/uploads/2017/04/eLab_EVgo_Fleet_and_Tariff_Analysis_2017.pd

165 NRDC (2021) https://www.nrdc.org/experts/miles-muller/ca-approves-new-rules-support-ev-charging-infrastructure

166 NY (2021) https://jointutilitiesofny.org/ev/make-ready

the psychological shift in paying for each mile. VMT tax is regressive and may require redistributing proceeds.

- **Gas Tax**. This is a fee on petroleum-based fuels. As with VMT tax, a gas tax is regressive and may require redistributing proceeds (e.g., through a low-income tax credit). Note that the Maine Constitution currently limits gas tax revenue to be used for road maintenance and enforcement of traffic laws; nevertheless, this mechanism may still effectively impact VMT.
- **Carbon Mechanism**. This fee on fuels is based on carbon intensity and provides a simple approach to generating revenue and lowering emissions. It is also a regressive tax. It will probably not have a large impact on VMT (0.2% for every 1% increase in fuel price).
- **Feebate**. Vehicles are incentivized based on level of emissions. EVs decrease in price and ICEVs increase in price. A feebate program is currently moving forward in New York State, though it has not yet been otherwise tested in the United States. This is a revenue-neutral policy to generate vehicle incentives.

Cadmus' work on this roadmap also highlighted knowledge gaps. Table 8 summarizes four urgent research needs for the State of Maine.

Table 8. Recommendations for Future Research

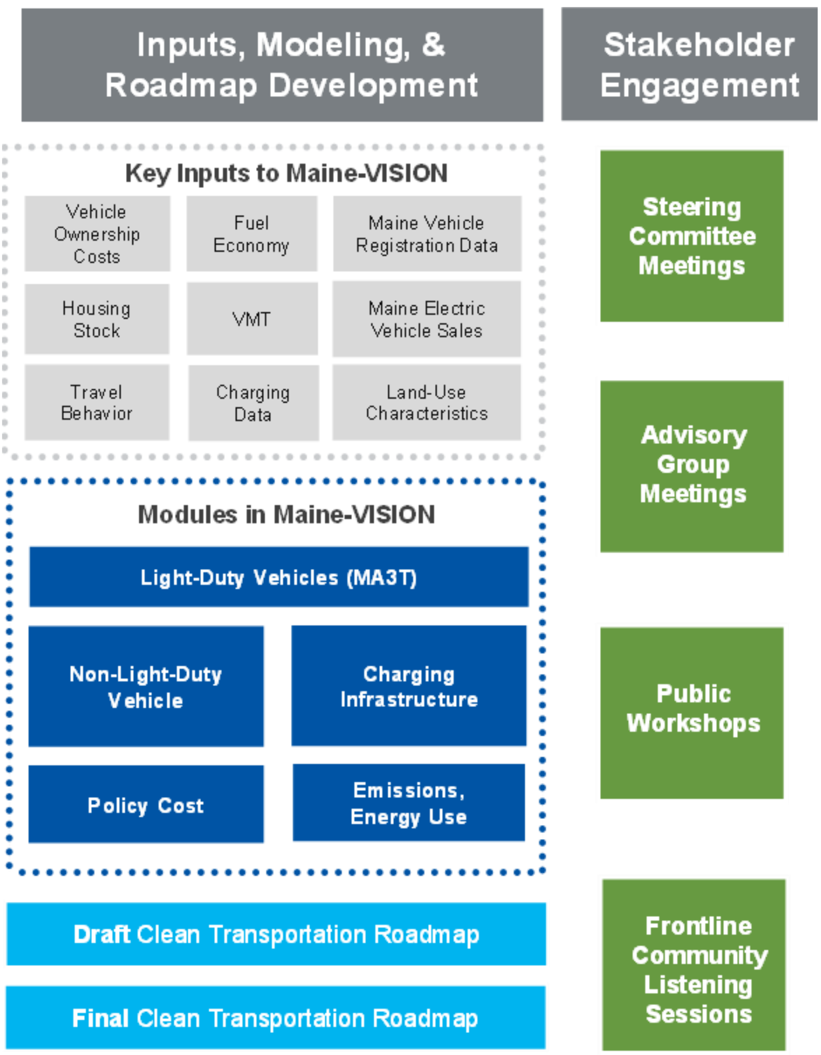
Opportunities for Future Research	Description
Zero-Emissions MHDV Roadmap	In support of the implementation of programs such as ACT, develop a MHDV roadmap and corresponding stakeholder group that focuses on charging needs, funding, duty cycles, range, timeline on vehicle availability, and costs of electric and other zero-emissions MHDVs. Also, the MHDV roadmap could examine the feasibility of lead-by-example programs with zero-emissions MHDVs.
Make-Ready Mapping	Develop a publicly available ArcGIS map that shows areas suitable for fleet charging without a need to upgrade the local distribution system. Such a map could be especially important for electric MHDV fast chargers as well as for charging providers looking to site new stations.
Tourism Study	Maine's GHG inventory counts emissions from all fuel purchased in the state, including tourists. Yet, relatively little data exist about how much fuel is purchased by in-state versus out-of-state drivers. The State of Maine should conduct a study to investigate opportunities and barriers for lowering emissions from out-of-state drivers. Such a study could also examine the feasibility of programs that increase EV penetration among tourists through rental cars and/or other incentives and fees.
Case Studies on Rural Transit and/or Electrification	Develop case studies on jurisdictions (within or outside of Maine) that have successful electric micro-transit or rural transit programs that simultaneously increase access and decarbonize transportation.
Loan Loss Reserve Program for EVs	Loan Loss Reserve (LLR) programs provide loan loss coverage to financing partners such as local and regional banks and credit unions. LLR programs, often used in clean energy financing, are a form of credit enhancement that can be constructed to offer below-market-rate terms to increase participation by low-income consumers, who often have poor or limited credit to access financing of a vehicle. Program could be modeled after New York's LLR program or California's Clean Vehicle Assistance Program (CVA Program).
Government Fleet Electrification	Develop a study of costs and feasibility of fleet electrification for state, local, and utility-owned vehicles. Estimate costs of charging infrastructure and vehicles. In addition, study reimbursement options for drivers who park at home overnight and charge.
School Bus Electrification Study	Conduct an analysis of feasibility, power supply, duty cycle, market availability, and other factors related to school bus electrification in Maine. Coordinate with ongoing research by The Nature Conservancy and Vermont Energy Investment Corporation (VEIC).

Opportunities for Future Research	Description
Emergency Management Plans	Identify opportunities through state planning processes to ensure that future energy assurance or emergency management plans take into account high penetrations of vehicle electrification and the impacts of necessary infrastructure. This could include events such as natural disasters, mass evacuations, and prolonged grid blackouts.

Appendices

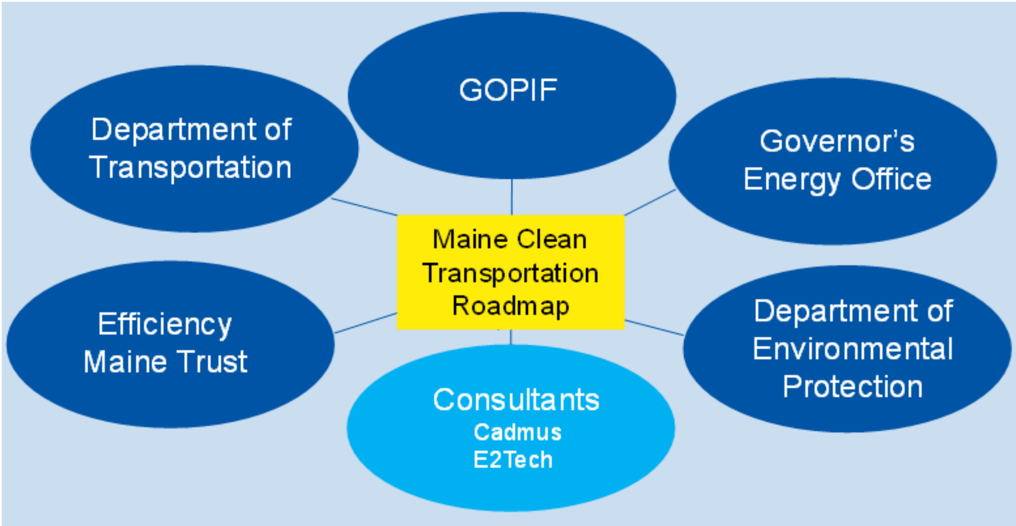
Appendix A. Roadmap Development Process

This roadmap was developed in 2021 by Cadmus, with the support of E2Tech for stakeholder engagement, and involved modeling, research, and stakeholder engagement. This figure shows the inputs, outputs to the modeling and roadmap development, and the stakeholder engagement that informed this document.



Roadmap Development Process Diagram

This figure shows the composition of the Steering Committee, which met on a biweekly basis throughout roadmap development in 2021.



Membership of Steering Committee

Other stakeholder input was provided by the following:

- **Advisory Group** provided technical input to consultants for modeling, analysis, and assessment.
- **Transportation Working Group (TWG)** helped identify and develop transportation sector strategies for the state's Climate Action Plan.
- **General Public** engaged through Transportation Working Group meetings.
- **Listening Sessions** involved interviews with members of three types of communities in Maine—housing management and development; overburdened, disadvantaged, and vulnerable groups; and fleet operators.

Appendix B. Relevant Literature

This table summarizes key literature related to clean transportation in the State of Maine.

Key Literature Related to Clean Transportation in Maine

Year of Publication	Document Type	Lead Author or Organization	Name of Document	Summary	Link
2021	Report	GOPIF	Lead by Example	Outlines strategies to curb state agencies' greenhouse gas emissions, transition state electricity use to 100% clean power by 2024, and purchase 100% electric vehicles for the state fleet by 2030.	Link
2021	Report	The Great Plains Institute & The Nature Conservancy	Maine Utility/Regulatory Reform and Decarbonization Initiative	Stakeholder recommendations to plan, build, and operate the electric grid that is needed to meet Maine's climate and energy requirements.	Link
2021	Summary Memo	MaineDOT	Battery Electric Bus Cold Weather Deployment Experience Informal Research Conducted by MaineDOT to Inform Transit Electrification Planning	A summary of findings from MaineDOT's informal research on Battery Electric Bus (BEB) experience with cold weather.	Available upon request
2021	RFP	MaineDOT	Maine Department of Transportation Request for Proposals: GO MAINE Program Management and GO MAINE 2.0 Relaunch	RFP for operational management for the GO MAINE program and plans to relaunch the GO MAINE 2.0 program.	Available upon request
2021	RFP	MaineDOT	MaineDOT Transit Electrification Plan	RFP for developing a plan to electrify Maine's transit buses.	Available upon request
2021	Summary Memo	Anastasia Hediger, Dan Mistro, and Lauren Trapani	NREL's AFDC Pro Lite Tool: Limitations and Recommendations for Use	Summary memo provides an overview of AFDC's Pro Lite Tool, including its limitations and recommendations for use.	Available upon request
2021	Report	Central Maine Power	Electric Vehicle Program Opportunities: Encouraging the Beneficial Electrification of Transportation"	Report provides an overview of electric vehicle program opportunities CMP can support and provide.	Available upon request

Year of Publication	Document Type	Lead Author or Organization	Name of Document	Summary	Link
2021	Academic Paper	U of Maine (Jonathan Rubin, et. al.)	Electric, Hybrid and High Fuel Efficiency Vehicles: Cost-Effective and Equitable GHG Emission Reductions in Maine	Detailed analysis of vehicle stock and fuel economy in Maine, GHG benefits of EVs, spatial distribution of vehicle ownership, and existing policies that support low-income and disadvantaged communities in Maine.	Link
2021	Academic Paper	U of Maine (Jonathan Rubin, et. al.)	Rural Public Transportation and Maine: Review of State Best Practices	Compares Maine's rural transit system with similar systems in other states.	Link
2021	Summary Memo	New Bridge Strategy + The Nature Conservancy	Key Findings Memo – Electric Vehicles in the Northeast Qualboard Among Small Town/Rural Voters	Results from 23-person online focus group consisting of rural residents of Maine, New Hampshire, and Vermont. The focus group aimed to gauge perceptions about electric vehicles from people who did not own or plan to own one.	Available upon request
2021	Summary Memo	Maine Climate Council	Maine Climate Council Equity Subcommittee Meeting: Summary of Recommendations"	Memo with bullet points of recommended actions in different topic areas such as transportation access or affordability.	Link
2021	Report	ISO-NE	Draft Transportation Electrification Forecast	ISO New England 2021 Final Transportation Electrification Forecast.	Link
2020	Report	GOPIF	Maine Won't Wait	Climate Action Plan released in December 2020 provides four overarching strategies and numerous actions to pursue the strategies.	Link
2020	Report	City of Portland	One Climate Future	Climate plan, vehicle electrification portions.	Link
2020	Briefing	ICCT	Update on electric vehicle adoption across U.S. cities	Briefing assesses the 2019 electric vehicle market in the United States as well as the policy actions by cities, states, and electric power utilities.	Link
2020	Report	Maine Department of Environmental Protection	Eighth Biennial Report on Progress toward Greenhouse Gas Reduction Goals	Report provides analyses on Maine's progress toward meeting GHG emission reduction goals.	Link
2020	Strategy Plan	Maine Climate Council	Maine Climate Council: Transportation Working Group	Transportation Working Group in Maine developed a package of strategy recommendations to increase climate change impacts and reduce Maine's transportation source GHG emissions.	Link

Year of Publication	Document Type	Lead Author or Organization	Name of Document	Summary	Link
2020	Report	Maine Executive Branch	Maine Climate Council Public Input Survey	Survey of 4,400 Mainers in the summer of 2020 on climate-related topics	Available upon request
2020	Report	Maine Department of Health and Human Services	2nd DRAFT Maine DHHS Transportation Program Evaluation	Report provides outcomes of independent assessment done as part of the evaluation for Maine DHHS's ongoing oversight of transportation programs.	Link
2020	Summary Memo	New Bridge Strategy + The Nature Conservancy	TNC Maine Mixed Mode Survey	Memo presenting survey results on TNC Mixed mode survey based on interviews.	Available upon request
2019	Report	NESCAUM	NE Corridor Regional Strategy for EV Charging Infrastructure, 2018-2021	Report provides guidance and recommendations to ensure strategic integration of public and private infrastructure investments to build out a charging network that will meet the region’s emerging needs.	Link
2015	Report	MaineDOT	Maine DOT: Strategic Transit Plan 2025	10-year comprehensive transit plan for the period 2015 - 2025 that will help MaineDOT prioritize service improvements, identify performance measures, and establish standards for responding to the need for transit services.	Link

Appendix C. EV Sales by State by Year

This table provides the sales of new Teslas, non-Tesla BEVs, PHEVs, and total light-duty vehicles by year and state for the Northeast Section 177 states. Data were provided by Jeremy Hunt at Northeast States for Coordinated Air Use Management (NESCAUM) and are derived from IHS Markit data.

Vehicle Sales by State, by Year

	State	Tesla	Non-Tesla BEVs	PHEVs	Total EVs	Total LDVs
2019	CT	963	570	1,710	3,243	164,844
	ME	483	260	208	951	66,459
	MD	1,853	1,179	3,752	6,784	324,152
	MA	2,278	1,522	3,680	7,480	346,036
	NJ	2,386	1,067	6,193	9,646	602,119
	NY	6,303	1,888	6,208	14,399	1,011,035
	RI	236	118	255	609	47,365
	VT	373	419	166	958	41,644
2020	CT	1,923	464	765	3,152	143,417
	ME	238	292	453	983	62,875
	MD	4,236	1,022	1,404	6,662	258,910
	MA	4,488	1,422	2,116	8,026	288,075
	NJ	9,708	1,871	1,872	13,451	497,253
	NY	9,438	2,079	5,161	16,678	875,329
	RI	352	129	250	731	42,639
	VT	188	446	340	974	37,498
2021 Q1 & Q2	CT	1,210	866	1,476	3,552	86,631
	ME	144	423	788	1,355	36,671
	MD	2,538	1,622	2,157	6,317	153,878
	MA	2,819	1,950	3,369	8,138	175,899
	NJ	5,355	2,183	2,906	10,444	282,384
	NY	6,431	3,515	7,649	17,595	518,884
	RI	226	235	337	798	25,873
	VT	123	467	486	1,076	21,551

Appendix D. Listening Sessions

Listening Session Groups

Category	Number of Listening Sessions
Trucking or Fleet Operator or Package Delivery	2
Vehicle Maintenance Shops	1
Rural Transit Operator	1
Forestry	1
Refuse Truck Operator	2
Overburdened, Disadvantaged, and/or Vulnerable	6
Condo/Apartment Developer or HOA	3
Tourism Industry	3

Appendix E. Methodology for Projecting Charger Costs and Counts

Charger Costs

Charger costs shown in Figure 15, Figure 16, Figure 17, and Figure 20, in the main report, were estimated using a tool originally developed by Andrew Burnham at Argonne National Laboratory and expanded by Cadmus for the State of Maine. Charger cost estimates use the following set of assumptions, which vary by charger type:

- Rated power of the charger
- Number of chargers per site
- Max grid power demanded at each site
- Charger efficiency
- Utilization (sessions per day)
- Charging time per sessions
- Revenue of stations (for public L2 and DCFC)
- Average session power

The charger types used in the analysis include residential Level 1, residential Level 2, public Level 2 in an outdoor surface lot, public DCFC located at an outdoor surface lot. Three power levels of DCFC were modeled including 50 to 100 kW, 100 to 300 kW, and 300+ kW.

The category labeled "other costs" shown in Figure 15 and Figure 16 include warranty costs, communications costs, and host site lease or access costs, where applicable. Revenue calculations assume charging station users pay $0.20 per kWh for Level 2 charging and $0.37 per kWh for DCFC. Modeling TOU electricity costs assumed a 0.24 coincident peak to non-coincident peak ratio based on assumptions provided in CMP's Rate Design Attachments "MGS IGS LGS DCFC Bill Compare" provided in the November 2021 filing.[167]

The model uses Central Maine Power Company (CMP) electricity rates, demand charges, and fixed charges. CMP supplied 78.2% of Maine's residential load and delivered 8.8 MWh of electricity in 2020 across all customer classes.[168] Based on charger power assumptions, rates for Level 2 Chargers were classified as Small General Service, DCFC 50-100kW and 100-300 kW were classified as Medium General Service, DCFC 300kW+ was classified as Intermediate General Service. A 1.4% discount rate was applied to calculate net present values.

Cadmus received input from Efficiency Maine Trust to create utilization scenarios based on plug usage in Maine. After determining a high and low scenario for 2020, Cadmus used an 11% annual growth rate to create projections for 2030. Maximum usage was capped at 16 hours per day per plug. Cadmus utilized

167 Central Maine Power Company. Accessed November 2021. CMP Rate Design Attachments.

168 Maine PUC. Accessed November 2021. Residential Electricity Rates.

the National Plug-In Electric Vehicle Infrastructure Analysis histogram "plug requirement variance between stations" to determine high and low plug count site scenarios.[169]

For aggregated charging costs through 2025, it is of note that public charging includes both Level 2 and DCFC plug projections. Costs associated with public charging include revenue from EVSE users as well as upfront and operational costs. Residential charging includes the costs of the charging equipment.

Table 9 shows the assumed cost per plug, by year, for costs for estimates in the Executive Summary in Table 2 and in Figure 20 in the main report.

Table 9. Average Per-Plug Costs Used in this Roadmap

Charger Type	2022	2025	2030	Costs Included
Residential Level 1	$380	$380	$380	*CAPEX, customer make-ready*
Residential Level 2	$1,169	$1,169	$1,169	*CAPEX, customer make-ready*
Public Level 2	$20,454	$18,096	$14,164	*CAPEX + customer make-ready +Electricity + Revenue*
Public DCFC: 50-100 kW	$138,570	$128,165	$110,825	*CAPEX + customer make-ready +Electricity + Revenue*
Public DCFC: 100-300 kW	$285,245	$263,580	$227,471	*CAPEX + customer make-ready +Electricity + Revenue*
Public DCFC: 300+ kW	$363,985	$330,788	$275,462	*CAPEX + customer make-ready +Electricity + Revenue*

Charger Counts

As noted in *Outlook: Transportation Electrification*, Cadmus estimated the number of charging plugs needed into the future using a variety of assumptions described below. Cadmus estimated the number of workplace, public Level 2, and DCFC chargers needed using the EVI-Pro Lite tool,[170] then developed a high and low plug scenario.

- **Assumptions in low plug count scenario.** Support for 86,566 EVs. Vehicle Mix: 20 mile range (8%), PHEV 50 mile range (8%), BEV 100 mile range (25%), BEV 250 mile range (59%). Partial support for PHEVs, 100% access to home charging.
- **Assumptions high plug count scenario.** Support for 86,566 EVs. Vehicle Mix - PHEV 20 mile range (8%), PHEV 50 mile range (8%), BEV 100 mile range (25%), BEV 250 mile range (59%). Full support for PHEVs, 70% access to home charging.

Table 10. Outputs from EVI-Pro Lite Tool

Charger Type	Low Plug Count Scenario	High Plug Count Scenario
Workplace L2	0.017	0.060
Public L2	0.012	0.043
DCFC	0.006	0.019
Total	**0.034**	**0.121**

[169] Wood, E. et al. "National Plug-In Electric Vehicle Infrastructure Analysis." National Renewable Energy Laboratory, Office of Energy Efficiency & Renewable Energy, Department of Energy. Page 34. September 2017.

[170] NREL (2021) https://afdc.energy.gov/evi-pro-lite

Using this output, the average of the low and high plug count scenarios is 0.065 plugs per EVs for workplace and public Level 2. The average of the DCFC ratios was 0.014. Note that the State of Maine already exceeds its needed DCFC ratio and is close to the needed public Level 2 ratio. In the future, we assume the ratio of total public plugs per EV increases by 1% per year. This increase aligns with recent literature that demonstrates that the importance of public charging will increase in importance over time.[171] Higher power charging is assumed to grow in importance among all DCFC over time. Here, Cadmus makes an assumption that the ratio of plugs to EVs (not the actual count) for 100 kW to 300 kW stations and 300+ kW stations will grow by 10% per year.

Ratios for residential plugs per EV were estimated using Efficiency Maine Trust's EV Rebate survey of approximately 250 EV drivers in Maine. In that survey, 35% of respondents stated they charged at home using a Level 1 charger, and 53% of respondents stated they charged at home using a Level 2 charger. The rest of the respondents (12%) stated they charged in public locations. Finally, the total number of chargers, by type, was estimated each year by multiplying the ratio of plugs per EVs by the number of EVs in a given scenario.

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171 Ge et al. 2021. *There's No Place Like Home: Residential Parking, Electrical Access, and Implications for the Future of Electric Vehicle Charging Infrastructure*. https://www.nrel.gov/docs/fy22osti/81065.pdf