Evaluating Electric Vehicle Infrastructure in New Hampshire

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Executive Summary

This analysis seeks to determine how the State of New Hampshire can best support electric vehicle (EV) charging infrastructure through appropriate policies and prudent investments and benefit the State's overall economy. New Hampshire has already done extensive work assessing EV charging infrastructure needs through their Electric Vehicle Charging Stations Infrastructure Commission (Commission) and has participated with other Northeast states in developing a *Northeast Corridor Regional Strategy for Electric Vehicle Charging Infrastructure.* This analysis aims to supplement those efforts with answers to specific questions asked by the New Hampshire Department of Business and Economic Affairs.

EVs produce very low pollutant emissions at the point of operation (primarily limited to particulate matter from tire and road abrasion), and with the relatively clean electricity grid in New Hampshire they produce far fewer emissions overall even when accounting for the generation of electricity. Medium- and heavy-duty EVs are particularly clean when compared to older diesel vehicles. If the vehicles can be primarily charged off-peak (accomplished through time-of-use pricing or time-of-use incentives), then *all* ratepayers, not just the EV owners, will benefit from downward pressure on electricity rates as utilities achieve greater utilization of their assets.

The EV market in the U.S. has grown at an annual rate of roughly 40 percent since 2012, corresponding to a doubling of market share every two years. While EVs represented about 2 percent of vehicle sales in New Hampshire in 2018, this share will grow as additional models become available, familiarity increases, and charging infrastructure expands. Establishing a robust charging infrastructure will not only serve the needs of New Hampshire drivers, but will sustain New Hampshire's tourism industry as EV drivers from surrounding states realize they can visit the Granite State's mountains, lakes, forests, towns, and beaches.

Destination charging is crucially important for New Hampshire residents and visitors alike. Mountain roads in winter are some of the most challenging trips EVs will take. Installing direct current fast charging (DCFC) along these routes and Level 2 charging at destinations such as ski slopes and hotels will keep New Hampshire at the center of winter recreation tourism as the EV market grows.

The economic case for installing EV charging infrastructure is in the money EV drivers spend at local businesses while charging, and not from the money spent on electricity at the charging station itself. Charging a car is not the same as fueling at a gas station. Drivers generally stop for longer periods of time to charge but do not have to supervise their vehicle while it is charging. This economically benefits nearby businesses as EV drivers stop for a meal, do some sightseeing, or shop while their car charges.

It is challenging to make an economic case for EV charging as a stand-alone business. Successful business models recognize the economic benefit to the site host and, where possible, leverage other sources of funding.

One such source of funding is the Volkswagen Settlement, with which New Hampshire can make considerable investments in EV charging infrastructure. New Hampshire utilities propose a plan to use approximately 40 percent of the funds for a network of DCFC. An array of stakeholders contacted during our research support this plan. We recommend that the remaining funds also be allocated to support residents, businesses, and municipalities in installing EV charging infrastructure. Investing the settlement money now will encourage greater EV adoption, enable a superior business case for private investment in EV charging infrastructure, and lead to greater cumulative emission reductions over time.

Technology will continue to evolve. As long as due diligence is performed on the specific proposals for funding, investments made now will offer greater benefits than investments made two years from now and assert New Hampshire as a state where the growing number of EV drivers will be supported with EV charging infrastructure. With proper planning and engineering, EV charging sites developed today with the available funding can be "future-proofed" to a degree, enabling future technology to build on, rather than replace, today's investments.

Stakeholders identified several policy changes that could further develop EV infrastructure in New Hampshire:

- The most common policy recommendation was approval of reasonable utility make-ready investments as necessary investments in the distribution system and therefore eligible for rate-basing. Make-ready investments include the utility infrastructure just up to the equipment:
- New Hampshire utilities have outlined a proposal for investment in DCFC that combines utility investments in make-ready infrastructure with a portion of the Volkswagen Settlement funding. This proposal is widely supported by stakeholders surveyed:
    - We propose numerous additional locations for DCFC and recommend that New Hampshire review and refine the proposed locations in this document with the Planning Division of the Office of Strategic Initiatives;
    - Some stakeholders have also noted that "shovel-ready" Level 2 charging infrastructure projects exist at the municipal level, awaiting the release of Volkswagen Settlement funding;
- There is broad support for revision of demand charge tariffs on DCFC. We note that this is a stakeholder recommendation and that tariff revisions are within the jurisdiction of the New Hampshire Public Utilities Commission and not any other State agency. We strongly recommend that any demand charge reform or relief should be applied to all DCFC;
- Adding an "EV-ready" component to building codes, particularly for multi-family housing and commercial buildings, will lower the overall cost of infrastructure deployment. This is a stakeholder recommendation, as the State does not have a position on EV-ready building codes.

These and other recommendations detailed in this report will reduce costs of installation and facilitate investment in EV charging infrastructure. **In some cases, the recommendations may require enabling legislation**. The other recommendations include:

Strategic Actions and Cross-Cutting Recommendations

- EV charging infrastructure investments should be "future-proofed" to the extent possibly by installing conduit and service capacity for future expansion;
- Grants and procurements for EV infrastructure should coordinate installation with planned parking lot resurfacing, electric improvements, or other work that would reduce the marginal cost of additional infrastructure;
- The Commission should review the NESCAUM model procurement rules, circulate any proposed rules for its New Hampshire procurements (such as through a Request for Proposals from OSI) to the stakeholder community for comment, and identify means to address compliance costs, perhaps with clarifying legislation if necessary.

Utility Actions

- Utilities should develop time-of-use pricing or non-tariff time-of-use incentives to encourage off-peak charging;
- Utilities should investigate the potential for demand response at workplace or municipal lot Level 2 EV charging, if additional demand response capability is desired;
- The New Hampshire Public Utilities Commission should identify any justifiable use cases where full utility ownership and responsibility of all capital costs may be warranted (such as environmental justice, low- and moderate-income communities, or rural high value but low traffic stations);
- Utilities should assess the potential for energy storage at public DC fast charging to provide multiple economic benefits including grid services and demand charge reduction;
- Utilities should develop and propose EV rebate programs, which not only helps adoption but provides the utility with insight into distribution needs.

Grants and Incentives

- The New Hampshire Office of Strategic Initiatives (OSI) should develop charging infrastructure incentives such as grants or rebates;
- OSI and the Department of Business and Economic Affairs (BEA) should develop a rural grant program for EV charging infrastructure;
- OSI and New Hampshire Department of Transportation (NHDOT) should develop voucher programs for replacement of medium- and heavy-duty vehicles with electric vehicles;
- All grants and procurements should apply not only to the electrical components of EV charging infrastructure but to necessary physical site features such as bollards (barriers to protect the chargers from impacts) and signage;
- All grants and incentives for workplace charging should apply to both Level 1 and Level 2 systems at workplaces, and not require that Level 1 stations be networked.

Government Properties

- State agencies and local governments should install EV charging at state and local facilities for public use, including high visibility state tourism locations such as the Statehouse:
- The Safety Rest Areas on state highways should be priority targets for DCFC (noting that many Interstate rest areas cannot host fueling infrastructure);
- Municipal park and ride lots should be priority targets for Level 1 and Level 2 EV charging to the extent possible under Federal law.

Supporting Destination Charging

- BEA and the local chambers of commerce should support New Hampshire's small businesses in executing site host agreements with charging network operators;
- Grant and incentive programs should support installation of destination charging at hotels;
- Local governments should request expansion of the Destination Electric program to their jurisdictions.

Expediting the Installation Process

- New Hampshire should establish, possibly through legislation, that EV charging is an accessory use that does not require separate zoning approval;
- The New Hampshire Department of Safety and other appropriate State agency partners should establish semi-annual training workshops and networking sessions for electricians, inspectors, planning departments, departments of public works, and regional field technicians to share best practices on permitting and inspection of EV charging systems;
- The New Hampshire Department of Safety should consider developing a program similar to Oregon's Minor Label Program, an inexpensive form of permit valid statewide for certain types of improvements;
- Each local government should designate one official to help fast-track permits and inspections;
- The Legislature should consider specifying that a multi-unit dwelling may not prohibit or unreasonably restrict the installation or use of an EV charging station in a homeowner's designated parking space.

Managing Winter Conditions

- Installers should consider snow-plowing patterns when locating EV charging systems within parking lots;
- In mountainous terrain and near winter recreation areas, DCFC should be spaced at distances 30-40 percent shorter than typical (every 30-35 miles rather than every 50 miles);
- Ski resorts should add a paragraph about on-mountain or nearby EV charging to their "Driving Directions" web pages.

Funding Sources

- The NHSaves program should include an EV charging infrastructure incentive;
- The New Hampshire Community Development Finance Authority's clean energy programs should include rebates or loans for EV charging infrastructure and equipment;
- The proposed State and Municipal allocations of the remaining Volkswagen Settlement funds should target transit fleets, workplaces, destination charging, multifamily housing, and public charging in metro areas (such as at municipal parking lots).

EV adoption is increasing in New Hampshire and in surrounding states. The expeditious investment of the available funds from the Volkswagen Settlement, combined with measures to streamline permitting, reform rates, and reduce barriers to private investment, can enable New Hampshire to support this trend and benefit from it. Actions now will lead to greater EV adoption, which will in turn further improve the case for private-sector investment.

1 Introduction

The State of New Hampshire recognizes the benefits EVs provide to the environment, economy, and drivers and seeks to increase the deployment of electric cars, trucks and buses. Neighboring states are expanding their EV charging infrastructure and increasing their EV market penetration. Drivers frequently travel between New Hampshire and neighboring states for business or tourism. If EV drivers can easily charge in New Hampshire, they will continue to visit and contribute to the local economy. Therefore, supporting EV charging infrastructure through appropriate policies and prudent investments will benefit the State's economy. New Hampshire looks to design its EV charging investments to encourage the investment of private capital in this infrastructure.

The New Hampshire Department of Business and Economic Affairs has commissioned this report to provide accurate, relevant, and objective information on the state of the EV market and options for expanding EV charging infrastructure.

1.1 Acronyms

BEV: A Battery Electric Vehicle has a battery and an electric motor; it does not have an internal combustion engine.

DCFC: Direct Current Fast Charging provides an EV with a large amount of power quickly, often 50 kW or more. These systems have a high capital cost but are very useful for EVs on long road trips.

EV: An Electric Vehicle can be either a BEV or a PHEV.

PHEV: A Plug-In Hybrid Electric Vehicle has both a gasoline engine and an electric motor and battery; it can run on either system, typically with a short (20-50 mile) all-electric range and a gas tank for longer trips.

ZEV: A Zero-Emission Vehicle including both EVs and hydrogen vehicles. California has specific regulatory standards to support ZEV deployment, and other states can adopt the ZEV requirements.

1.2 Report Methodology

This report supports the Department of Business and Economic Affairs' mission to develop strategies that attract, expand, retain and promote the adoption of new modes of transportation that impact local economies and climate change in a positive way. This plan is developed in the context of 2018 New Hampshire Senate Bill (SB) 517, which established the Electric Vehicle Charging Stations Infrastructure Commission (Commission) to make recommendations on:

- Developing ZEV technology and infrastructure, including the private and rental residence, business, and municipal installation of EV charging stations;
- The availability of high-speed charging stations and the role of proprietary technology in relation to their availability and use on public property;
- Developing EV charging stations, including high-speed charging stations, in state and federal highway corridors and at public transportation hubs and parking garages;
- Joining the Multi-State ZEV Task Force or forming an interstate compact for the development of EV charging station networks;
- Tax credit legislation for private, retail and workplace charging;
- Changes to state laws, rules, and practices, including building codes and New Hampshire Public Utilities Commission rules, to further the development of ZEV technology and infrastructure;

- Potential private, state, federal, and municipal funding sources, including grants, the Volkswagen Settlement and other settlement funds, and regional greenhouse gas (GHG) initiative funds;
- State agency workplace charging.

This report provides an analysis of the current and growing impact of the market for EVs related to personal cars and commercial vehicles. Its research and recommendations include:

- Stakeholder outreach and input from a broad spectrum of sectors both within New Hampshire and the surrounding states;
- EV infrastructure strategies developed by New Hampshire organizations or those from other states
- Models of successful EV infrastructure deployment;
- Partnership recommendations to improve and accelerate the State's charging infrastructure;
- Historical trends and forecasts.

1.3 Existing Legislation, Strategic Plans, and Initiatives

New Hampshire SB 517 establishes the Commission to make recommendations on many topics related to EV charging infrastructure. They have done extensive research on charging infrastructure needs. The Commission received a Gap Analysis of EV charging infrastructure, developed by MJ Bradley (Goetz, 2018). The New Hampshire Department of Environmental Services and the NHDOT noted the usefulness of this tool for New Hampshire (Ohler, 2019). We use this tool to develop our recommendations in Section 4.2.1.

The *Northeast Corridor Regional Strategy for Electric Vehicle Charging Infrastructure 2018 – 2021* (Kinsey et al., 2018), developed with input from the New Hampshire Department of Environmental Services, outlines numerous actions that states can take to expand charging infrastructure. The report includes recommendations for resolving overarching issues as well as for specific types of charging. We endorse those recommendations and reiterate a few key ones in the appropriate sections. We also offer more specific recommendations for the State of New Hampshire based on our stakeholder outreach.

New Hampshire SB 575, enacted in 2018, contains several provisions for EV charging infrastructure. It expands signage for EV charging stations, requires publicly-funded charging stations to be "open access," confirms that EV charging facilities are not regulated as utilities (even though they may sell electricity by the kWh), and requires the New Hampshire Public Utilities Commission to evaluate a number of rate design issues pertaining to EV charging infrastructure. NESCAUM has recently released model procurement requirements to ensure that publicly funded stations truly are "open access." These requirements are discussed in Section 3.2.8.

New Hampshire has also participated in the Transportation and Climate Initiative (TCI), coordinated by the Georgetown Climate Center. While New Hampshire has not yet committed to TCI's regional approach to cap GHG emissions from transportation, it remains a participant in the process with the option to join. This agreement would create revenue that could be used for investing in clean transportation infrastructure, through auctioning carbon allowances for the transportation sector. A fundamental economic principle behind this cap-and-invest program is that climate change impacts from carbon dioxide (CO2) have a negative impact on society. A cap-and-invest program can help reduce those emissions by fairly pricing the emissions in an open market and using the proceeds to invest in low-emission technologies, policies, and programs.

2 Adoption Rates, Trends, and Forecasts

The transportation sector is the largest source of U.S. GHG emissions, surpassing the power sector in 2015. As of 2016, cars and light-duty trucks were responsible for about 60 percent of transportation emissions. Medium- and heavy-duty vehicles, including tractor-trailers, large pickups and vans, delivery trucks, buses, and garbage trucks, predominantly run on diesel and produced about 23 percent of transportation emissions. However, emissions from medium- and heavy-duty vehicles have been on the rise nationally and will become a greater force still if left unchecked as e-commerce becomes increasingly prevalent; while GHG emissions from light-duty vehicles increased 14 percent from 1990 to 2016, GHG emissions from medium- and heavy-duty vehicles grew 85 percent over the same period (EPA, 2018).

In New Hampshire, transportation was also the largest source of GHG emissions, accounting for 42% of emissions in 2015 (NHDES, 2019). Emissions in this sector in 2016 were about 29% above 1990 levels, but 17% below the 2002 peak of 8.1 million metric tons of carbon dioxide equivalent ($MMTCO_2e$).

States have been most successful in increasing EV deployment where public and utility investments are structured, coordinated, and leverage private market investment.

Many states seek to increase EV adoption for climate mitigation and local air quality, and some have been successful. California exceeds other states' efforts in EV adoption for personal and commercial vehicles, as well as in bus fleets. The state has achieved the highest rates of EV adoption in the U.S. through a combination of policies and promotional activities including the ZEV regulation; consumer incentives (e.g., rebates for light-duty vehicles, vouchers for medium- and heavy-duty); extensive public EV charging infrastructure; greater model availability and marketing; access to high-occupancy vehicle lanes; and, progressive electric utility policies.

This report aims to evaluate the state of the EV market across four vehicle segments: Light-duty, commercial (i.e., medium-to-heavy-duty vans and trucks), public transit buses, and school buses, while describing the policies driving success in markets across the nation. The goal is to understand how urban and rural adoption rates differ and establish demographic trends to inform New Hampshire's development of EV infrastructure.

2.1 Electric Vehicle Overview

A variety of technology is available for EVs, though at present light-duty vehicles dominate the market while EV options for medium- and heavy-duty EVs have been slower to commercialization. As demand for EVs grows and battery technologies continue to mature, EV technologies will become increasingly viable to meet the needs of a broader range of drivers and fleets.

Model availability for light-duty EVs has been growing rapidly in recent years and promises to continue accelerating in the years ahead. Currently, there are 59 light-duty EV models—ranging from small two-door cars and sedans to full-size sport utility vehicles and minivans—available for purchase in the U.S. (AFDC, 2019a). As automakers electrify progressively greater shares of their car lineups, many more models are expected in coming years (Lambert, 2018; Estrada, 2017).

The medium- and heavy-duty EV technologies are not as advanced as light-duty EVs, but anticipated reductions in battery costs and the costs of producing EVs will increase the appeal of medium-duty and heavy-duty BEVs. Light-duty EVs, and medium- and heavy-duty EVs come with different levels of vehicle electrification (see Table 1).

Table 1: Different Levels of Truck and Bus Electrification (Gallo, 2016)

Truck & Bus Electrification Technology	Example	Average Peak Demand	Battery Size
Short Range PHEV	Volvo PHEV Class 8 Drayage Truck	10 kW	10 kWh
Work Truck PHEV	Odyne Advanced Diesel PHEV Truck	3.3 kW	14/28 kWh
Long Range PHEV	Efficient Drivetrain PHEV/CNG Class 4 Truck	up to 6.6 kW	40 kWh
Short Range PHEV	Proterra Fast Charge Catalyst	280 to 380 kW	53 kWh 131 kWh
Mid-Range BEV	Transpower Electric Drayage Drive	70 kW	215 kWh
Long Range BEV	BYD 40-ft Electric Transit Bus	Option 1 - 80 kW Option 2 200 kW	324 kWh

Charging equipment for EVs is classified by the rate at which the equipment dispenses power to charge a vehicle's onboard batteries. Currently, there are three levels of charging equipment available on the market: alternating current (AC) Level 1 Charging, AC Level 2 Charging, and DC fast charging, described in more detail in Section 3.1.

2.2 Light-Duty Passenger Vehicles

EVs are offered in a variety of technologies, each with aspects that serve different purposes. There are two main types of light-duty EVs: battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs).

In addition to charging from the electrical grid, these vehicles charge partially through regenerative braking, which generates electricity from some of the energy usually lost during braking. EVs have ranges from 80 to 250 miles, depending on the model. The charging time for these vehicles depends on the charging equipment and on the battery design, capacity, and state of charge. If the range and charging configuration for a BEV is insufficient to meet a driver's needs, a PHEV may be a better choice. These vehicles run on electricity for shorter ranges (6 to 50 miles), then switch to an internal combustion engine when the battery is depleted, providing greater total range and flexibility for some drivers. Powering vehicles at least partly with electricity reduces fuel costs, curbs petroleum dependency, and reduces tailpipe emissions.

The Union of Concerned Scientists (UCS) conducted a study of BEVs to determine their life cycle emissions compared to similar gasoline vehicles. The life cycle is determined by the raw materials to make the car through manufacturing, driving, and disposal or recycling of the BEV. UCS found that EVs are cleaner than combustion cars now and will become even cleaner as electricity is generated by increasing amounts of renewable energy (Nealer, Anair, and Reichmuth 2015).

2.2.1 State of Light-Duty EV Adoption

Light-duty EV sales are increasing in the U.S., owing to an increase in model availability, charging infrastructure, and the availability of rebates and incentives. Model availability has increased significantly in just 10 years; in 2008, there were 17 light-duty EV models available, only one of which was BEV, and some of which were only available for purchase in California. By 2018, 59 light-duty EV models were available (AFDC, 2019a). These vehicles offer much longer range and are now available at a wider range of price points than earlier EV models.

As of January 2019, there were roughly 1.1 million light-duty EVs on the roads in the United States. EVs were about 2 percent of the total light-duty vehicles sold in the U.S. (Hove and Sandalow, 2019). EV adoption tends to be the highest in major metropolitan areas on the West Coast, followed by Colorado and the Northeast. While California makes up just 12 percent of the U.S. population, it accounts for 50 percent of the new EVs purchased in 2017 (Lutsey, 2018), with an EV sales share in 2018 of 7.92 percent (Alliance of Automobile Manufacturers, 2019). New Hampshire had 1,123 new EVs registered in 2018, which represented 1.16 percent of all vehicle sales and a 42.5% increase over the 788 vehicles first registered in 2017.

The Institute for Electric Innovation and the Edison Electric Institute (IEI/EEI) project the U.S. EV fleet to reach 18.7 million vehicles in 2030. While it took eight years for automakers in the U.S. to sell the first one million EVs, IE and EEI project the next million EVs will be on the road by early 2021. IEI and EEI estimate annual EV sales to be roughly 1.4 million in 2025 (less than 10 percent of new vehicle sales) and 3.5 million vehicles in 2030 (more than 20 percent of sales) (Cooper and Schefter, 2018). Importantly, states in the Multi-State ZEV Task Force are phasing in progressively higher ZEV sales requirements, up to more than 15 percent by 2025. In 2018, the leading states for EV sales share were California, Washington, Oregon, Colorado, Hawaii, Massachusetts, and Connecticut (Alliance of Automobile Manufacturers, 2019). These states offer robust policies, including purchase rebates, to complement the federal rebate and support their clean transportation policy objectives. While Hawaii does not have an EV rebate or tax credit, it does have other measures such as utility-owned DCFC stations.

2.2.2 EV Charging Infrastructure

In the U.S., most charging occurs at home, but current and potential drivers express concern about the availability of public charging infrastructure. With rapid growth in model availability within the light-duty EV market comes the need for readily available charging infrastructure to support corresponding growth in EV sales. As of May 2019, there are only 113 public charging stations throughout New Hampshire, compared to 1,353 available charging stations throughout nearby New York State (AFDC, 2019b). Studies suggest the availability of public charging infrastructure is an important factor in a consumer's decision to purchase an EV. (Hardman et al., 2018). As of January 2019, there are 67,000 non-residential EV charging posts located at approximately 24,000 stations nationwide (Figure 1).

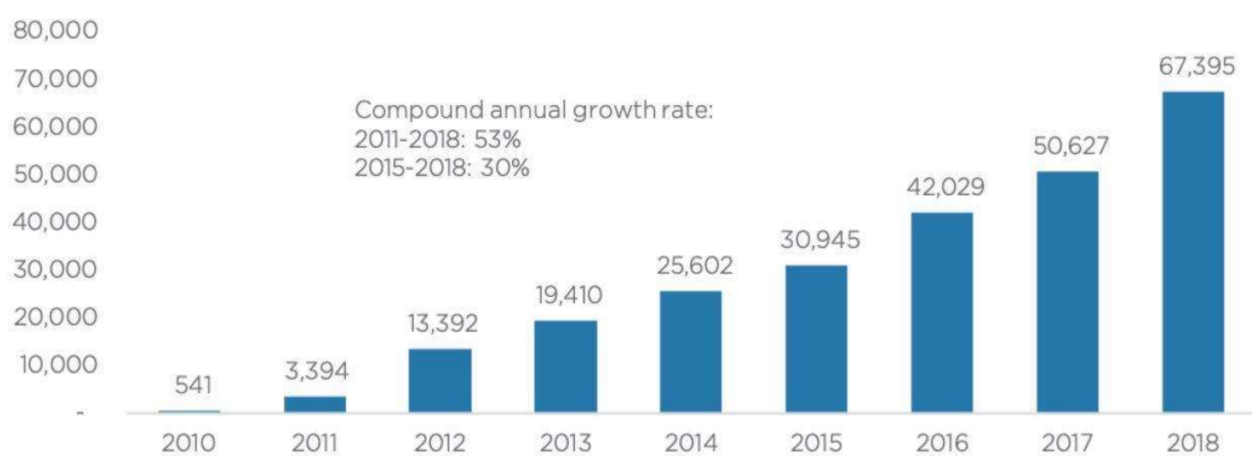


Figure 1:Number of charging posts at non-residential charging stations, U.S. 2011-2018 (AFDC 2019b).

EV infrastructure development faces numerous challenges. While more public charging infrastructure is required to support growth in EV sales, greater EV sales are required to support the business case for public charging infrastructure. The major impediment to widespread private charging infrastructure development is the economics of public charging stations, particularly fast charging sites. The costs include the equipment itself (with fast chargers costing tens of thousands of dollars); installation costs (including bringing sufficient power to the site and utility interconnection), and operating costs (particularly where demand charges apply and station utilization rates are likely to be low).

Investments in public charging infrastructure, such as by state and local governments, automakers, and electric utilities help to reduce “range anxiety,” or the concern among current and potential EV drivers whether electric technologies can reliably meet their needs.

State agencies offer funds for charging infrastructure in the form of grants, tax credits, and rebates. Currently, 17 states offer incentives reducing the cost of public Level 2 and DCFC for installers of the infrastructure (AFDC 2019c). Some cities include public EV charging projects in their budgets. For example, New York City plans to construct a DC fast charging hub in its five city boroughs and allocated $10 million in capital funding toward construction (de Blasio 2017).

Automakers like Tesla, BMW, General Motors, Nissan, and Volkswagen invested in public fast charging stations, either through proprietary networks or with network partners like ChargePoint and EVgo. Tesla has built a nationwide charging network with thousands of charging ports. Electrify America will spend $2 billion over 2017-2027 to deploy charging infrastructure and conduct other activities to support the EV market as part of the Volkswagen settlement with the U.S. Environmental Protection Agency.

Many utilities support charging infrastructure development through investment in EV chargers or upstream infrastructure, purchase incentives for charging infrastructure, or special electricity rates or voluntary rewards programs to encourage off-peak charging. California’s investor-owned utilities have the most robust investment programs for transportation electrification and are developing innovative EV rates (CPUC, 2019). In New York, Con Edison has a voluntary off-peak charging rewards program called SmartCharge NY (FleetCarma, 2019).

2.2.3 Policy

There are many policy drivers that can influence mass-market EV uptake, including but not limited to: State regulation, consumer rebates, access to carpool lanes on congested highways, extensive EV charging infrastructure, progressive electric utility policies, greater model availability and marketing, and continued growth of local EV promotions (Lutsey, 2018). Best practices for these policies are characterized below.

2.2.3.1 Regulations

California is authorized to promulgate motor vehicle emission standards more stringent than federal standards. Section 177 of the federal Clean Air Act authorizes other states to adopt California’s vehicle emission standards in lieu of the corresponding federal standards. Nine states have adopted the standards, which has led to the creation of the Multi-State ZEV Task Force, which guides initiatives to support the growth of the EV market in those states that have adopted California’s ZEV regulation. The ZEV regulation requires auto manufacturers to offer a specific number of ZEVs, including BEV, hydrogen fuel cell, and PHEV. Participating states include California, Connecticut, Maine, Maryland, Massachusetts, New Jersey, New York, Rhode Island, and Vermont (Hove and Sandalow, 2018). Colorado is in the rulemaking stage of adopting ZEV regulations.

2.2.3.2 Rebates

Government incentives such as purchase rebates, tax credits, and high occupancy vehicle (HOV) lane access for EVs have made EV adoption more attainable and attractive for consumers. Financial incentives reduce the initial purchase costs that tend to be higher than conventional vehicles. The Federal government offers EV purchasers a tax credit of $2,500 to $7,500 per vehicle, depending on battery size, available for the first 200,000 vehicles sold by each manufacturer, after which it begins to phase out for that manufacturer. Some states offer additional EV rebates to reduce the cost even further:

- **Massachusetts Offers Rebates for Electric Vehicles (MOR-EV)** is funded by the state's Executive Office of Energy and Environmental Affairs' Department of Energy Resources (MA DOER). The program offers rebates of $1,500 for fuel-cell and battery-EVs and $450 for zero-emission motorcycles;
- **Connecticut Hydrogen and Electric Automobile Purchase Rebate (CHEAPR)** program is a collaboration between the Connecticut Department of Energy and Environmental Protection (CT DEEP), Avangrid, Eversource, Connecticut Automotive Retailers Association, and the Center for Sustainable Energy. The program offers up to $5,000 for Connecticut residents who purchase or lease a new BEV, PHEV, or fuel-cell EV;
- **New York State's Drive Clean Rebate** offers point-of-sale rebates that vary based on the EPA-rated all-electric range of the car model. Vehicles with range greater than 120 miles are eligible for a $2,000 rebate, while those with electric range less than 20 miles (or MSRP >$60,000) are eligible for $500;
- **California's Clean Vehicle Rebate Project (CVRP)** offers $5,000 for fuel-cell EVs, $2,500 BEVs and the BMW i3 Rex, $1,500 PHEVs, and $900 for zero-emission motorcycles with funding from the California Air Resource Board (CARB) and Center for Sustainable Energy.

2.2.3.3 Workplace Charging

Workplace charging increases the convenience and affordability of driving electric for employees and demonstrates a company's leadership in adopting advanced clean technologies. Workplace charging can be especially meaningful in environments with a dearth of residential or public charging. For example, Charge to Work New York, an incentive-based workplace charging initiative, was developed to address low levels of EV adoption in and around New York City, where opportunities for home charging are lacking. Charge to Work New York, managed by CALSTART and funded by NYSERDA, offers rebates of $4,000 per port for workplaces to purchase EV chargers and $500 for the purchase or lease of a new EV by an employee of a participating business. This program encourages businesses in the metropolitan area to invest in charging infrastructure and encourages employees to consider EV adoption.

Currently, New Hampshire does not offer any state-sponsored incentives for the purchase of EVs or EV charging equipment. New Hampshire Electric Cooperative (NHEC) offers rebates for EV purchase and EV charger installation. It offers charging installation rebates of $300 per charger for residential customers and $2,500 per charger for commercial customers. Rebates of $1,000 are available for the purchase or lease of a new or used EV, and $600 for the purchase or lease of a new or used PHEV. NHEC also offers residential customers with EVs an off-peak electricity rate program. New Hampshire allows public utilities to consider whether to implement EV time-of-use (TOU) rates for residential and commercial customers. Utilities must consider whether implementing these rates would encourage energy conservation, optimal use of resources, and equitable rates for customers.

While some means of encouraging EVs may require legislation or regulation, there are also options that do not involve major statutory and/or administrative changes (e.g., voluntary programs such as workplace charging initiatives).

2.3 Commercial Vehicles

Medium-duty vehicles are excellent candidates for BEV technologies because they typically operate on a back-to-base drive cycle, travel a predictable daily distance, and maintain a low daily average speed and drive time. Similarly, some stop-and-go heavy-duty applications such as class 8 transit buses, yard tractors, and drayage trucks are good candidates for electric drivetrain technologies that harness regenerative braking. For medium- and heavy-duty vehicles, the vehicle energy efficiency of BEVs over conventional diesel vehicles is about 3.5 times greater at highway speeds and 5-7 times greater at lower speeds, where idling and coasting losses from conventional engines are highest (CARB, 2018a). Low-speed, frequent-idle duty cycle vehicles such as port yard tractors, drayage trucks (e.g., near dock, local, and refuse), delivery vans, urban buses, and delivery trucks are the best suited to realize the most efficiencies from electrification. Battery range limitations, battery costs, and energy recovery advantages associated with regenerative braking mean that electrification is more likely to happen for slower speed, shorter range vehicles first in the medium and heavy-duty market. Some medium- and heavy-duty trucks have onboard equipment—such as aerial platforms and digger derricks—that require the vehicle to be running to utilize the equipment. For instance, many utility fleets are switching to medium- and heavy-duty vehicles with electric power take-off (ePTO) that powers the onboard equipment for a utility bucket truck without needing to run the diesel engine.

Medium- and heavy-duty vehicles represent just under 5 percent of the vehicles on the road, but they account for about 24 percent of total transportation GHG emissions (BTS, 2019; and EPA, 2018). Trucks and buses also generate a large amount of localized, smog-forming air pollution that affects health, heightening risks of heart and lung diseases among other ailments (Heffling and O'Dea, 2018). Moreover, the impacts associated with medium- and heavy-duty vehicles accrue disproportionately on the most vulnerable populations, including low-income communities and communities of color that are most likely to be situated near highways, freight facilities, and ports, where truck and bus traffic is heaviest (Mikati et al. 2018; Kheirbek et al. 2017).

2.3.1 State of Commercial EV Adoption

The medium- and heavy-duty EV market is in its early stages. Technologies and solutions continue to be researched, developed, tested, and improved. Several nationwide fleets and transit agencies across the U.S. show serious interest and commitment to electrify buses, refuse trucks, delivery vans, drayage trucks, shuttle buses, yard hostlers, and utility trucks. The medium- and heavy-duty EV market may experience significant growth in the near term. Due to large-scale investments by electric transit bus manufacturers and cities' financial capacities to adopt medium- and heavy-duty EVs to meet their GHG and air quality goals, electric transit buses have the greatest near-term growth potential in the medium- and heavy-duty EV market.

Figure 2: FedEx Electric Delivery Van

FedEx Electric Delivery Vehicles
FedEx is expanding its fleet with the purchase of 1,000 Chanje V8100 electric delivery vehicles. FedEx is purchasing 100 of the vehicles and leasing the other 900 from Ryder Systems Inc. The vehicles will be deployed for commercial and residential pick-up and delivery services in the United States (see Figure 2).

Current EV technology has an overall positive return on investment over the lifetime of the vehicle, as shown by numerous demonstrations and studies. Future reductions in the costs of producing EVs will increase the appeal of medium- and heavy-duty BEVs alike. EV and near-zero-emission technologies are unlikely to completely replace internal combustion engines in the near future, as commercial vehicle fleets are accustomed to operating, fueling, and maintaining diesel trucks and may not be ready for electrification in all settings.

Incentive programs have supported most EV adoption for medium- and heavy-duty vehicles to date. California's Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP), the New York Truck Voucher Incentive Program (NYT-VIP) and Drive Clean Chicago (DCC) offer up-front voucher incentive funds for the purchase of medium- and heavy-duty electric and alternative fuel vehicles. California has paid for more than 1,200 ZEVs through HVIP since its beginning in 2009. California HVIP has paid $3.5 million in ePTO vouchers in several counties such as Los Angeles, Sacramento, San Diego, San Francisco, San Luis Obispo, and Yolo, from 2013-2017. NYT-VIP has provided $14.5 million to fund the purchase of 594 cleaner vehicles since 2014, 65 of which were all-electric ($5.7 million). Over a similar timeframe, DCC has funded 288 clean truck projects ($11.3 million), of which 49 ($5.8 million) were all-electric.

2.3.2 Infrastructure

Infrastructure challenges remain a major barrier to more wide-scale deployment of medium- and heavy-duty EVs. Given the size of the batteries on most medium- and heavy-duty EVs, chargers capable of delivering above 22 kW are essential even when charging in a depot to enable adequate overnight charging. As more consumers purchase EVs, governments and private companies are starting to invest more in highway chargers as well. Electrify America, for example, seeks to deploy 900 highway charging stations at intervals of 45-115 km.

Utilities play an important role in developing infrastructure for high level charging. In California, revenues from EV chargers outweigh the costs of delivering the electricity to chargers, as grid utilization increases owing to large sources of new load, which allows these investments to exert downward pressure on electricity rates (Frost, Whited, and Allison, 2019). In other areas, while infrastructure utilization rates remain low or modest, it can be difficult to earn a positive return on EV charging investments in the near term. Because utilities earn a regulated rate of return on assets, they are uniquely positioned to make necessary investments in EV infrastructure, including make-ready investments associated with bringing power to the interconnection point for EV charging. In May 2018, the California Public Utilities Commission (CPUC) made the largest-ever approval for utility transportation electrification programs, including more than $500 million for utilities in the state to invest in make-ready assets for medium- and heavy-duty EV fleets (CPUC, 2019).

Rate design and site host options offered by a utility will influence the deployment of DC fast charging. Because of their different load profiles, DC fast charging may require different rate options. For example, Portland General Electric, Southern California Edison, and Pacific Power have all proposed limits on demand charges or flat volumetric rates for EV charging. Utilities can also help maximize the benefits of EVs by providing information to customers about their loads and possible ways to reduce costs. Utilities can directly manage loads to avoid demand charges, install energy storage to help manage loads, encourage site development around known and existing customer bases, and at sites with excess grid capacity, to prevent under- or over-utilization, and place DC fast charging stations with existing large electricity users so that charging load is incremental rather than at a new meter. By facilitating the deployment of public electric charging stations, utilities can play an important role in reducing initial capital costs for EV fleet conversion and help realize the benefits of electric transportation sooner (Hledik & Weiss, January 2019).

2.3.3 Policy

Voucher programs offer point-of-sale rebates on the purchase (or lease) of EVs. Customers receive an immediate discounted price for the vehicle, while the vehicle manufacturer or provider seeks reimbursement from the voucher program administrator. Voucher programs in California, New York, and Chicago have been driving down the cost of medium- and heavy-duty EVs for customers.

HVIP launched in 2009, with collaboration from CARB and CALSTART. HVIP received $448 million in funding; $70.3 million from the State's Air Quality Improvement Program (AQIP); $370 million from the Greenhouse Gas Reduction Fund (GGRF); $4 million from the California Energy Commission, and $3 million in Air District Funding. The goal of this program is to accelerate the purchase of cleaner, more efficient trucks and buses in California. This program is helping build the market by reducing vehicle costs for truck and bus fleets looking to kick start electrification. To date, HVIP has paid 4,079 vouchers totaling $125 million.

New York Truck – Voucher Incentive Program (NYT-VIP) aims to accelerate the deployment of all-electric and alternative fuel vehicles for medium- and heavy-duty commercial fleets in New York. NYT-VIP is a partnership between the New York State Energy Research and Development Authority (NYSERDA), New York State Department of Transportation, New York State Department of Environmental Conservation, CALSTART, and the Center for Sustainable Energy. NYT-VIP disbursed 594 vouchers worth $14.5 million between 2014 and 2018. NYT-VIP will relaunch in mid-2019 with a mix of funding from the state's share of the Volkswagen Settlement Appendix D as well as from the State's Congestion Mitigation and Air Quality Improvement program. CALSTART has led technical assistance and marketing and outreach efforts for the duration of the program.

Drive Clean Chicago is a $14 million incentive program supported by CALSTART and funded through the Chicago Department of Transportation, with resources from the Federal Highway Administration's Congestion Mitigation Air Quality Improvement program. The funds are dedicated to three programs: Drive Clean Truck, Drive Clean Taxi, and Drive Clean Station. Driver Clean Truck – Voucher Program has about $11 million available for Class 2 to 8 all-electric hybrid truck and buses and drivetrain retrofits. To date, 288 truck vouchers have been paid through Drive Clean Chicago.

These examples illustrate the responsiveness of medium- and heavy-duty EV producers and commercial vehicle fleets to purchase incentives. With electrification of medium- and heavy-duty vehicles producing significant public health benefits, the states with robust and steady incentives for these technologies have become the leaders in medium- and heavy-duty EV technologies.

2.4 Public Transportation

Diesel fuel powers most U.S. transit buses, but electric bus adoption is growing through the collaborative efforts of transit agencies, electric utilities, and manufacturers, with support from voucher purchase incentive programs like HVIP and NYT-VIP. Diesel emissions cause local health effects including asthma, other respiratory illnesses, and cancers (WHO, 2012). Electric buses with zero tailpipe emissions significantly decrease exposure to localized criteria air pollutants. Electric transit buses also meet city and state goals to reduce GHG emissions. Replacing all diesel-powered transit buses and school buses with electric buses would avoid an average 7.3 million tons of GHG emissions annually (ANL, 2017).

The three main types of transit buses are full size (heavy-duty), articulated, and shuttle buses. Full size and articulated buses tend to run on a fixed route system, Bus Rapid Transit system, and a deviated fixed route system. Each of these routes are candidates for electrification but have different technological needs. Planners will need to consider the routes and make strategic decisions about the type or types of charging to install to balance vehicle operation requirements, power demand on the grid, and operational savings.

2.4.1 State of Electric Transit Bus Adoption

Electric buses sales have grown dramatically in recent years. In 2009, only 17 electric transit buses were operating in U.S. cities; by 2017, that number had grown to 568 (Casale and Manoney, 2018). As of August 2018, 1,650 battery-electric, zero emission buses operated by 139 transit agencies in the United States. California has 46 transit agencies with electric buses (CALSTART, 2018).

California electric bus total is the nation’s highest with 877 vehicles deployed; most states have adopted at least one electric bus (see Figure 3).

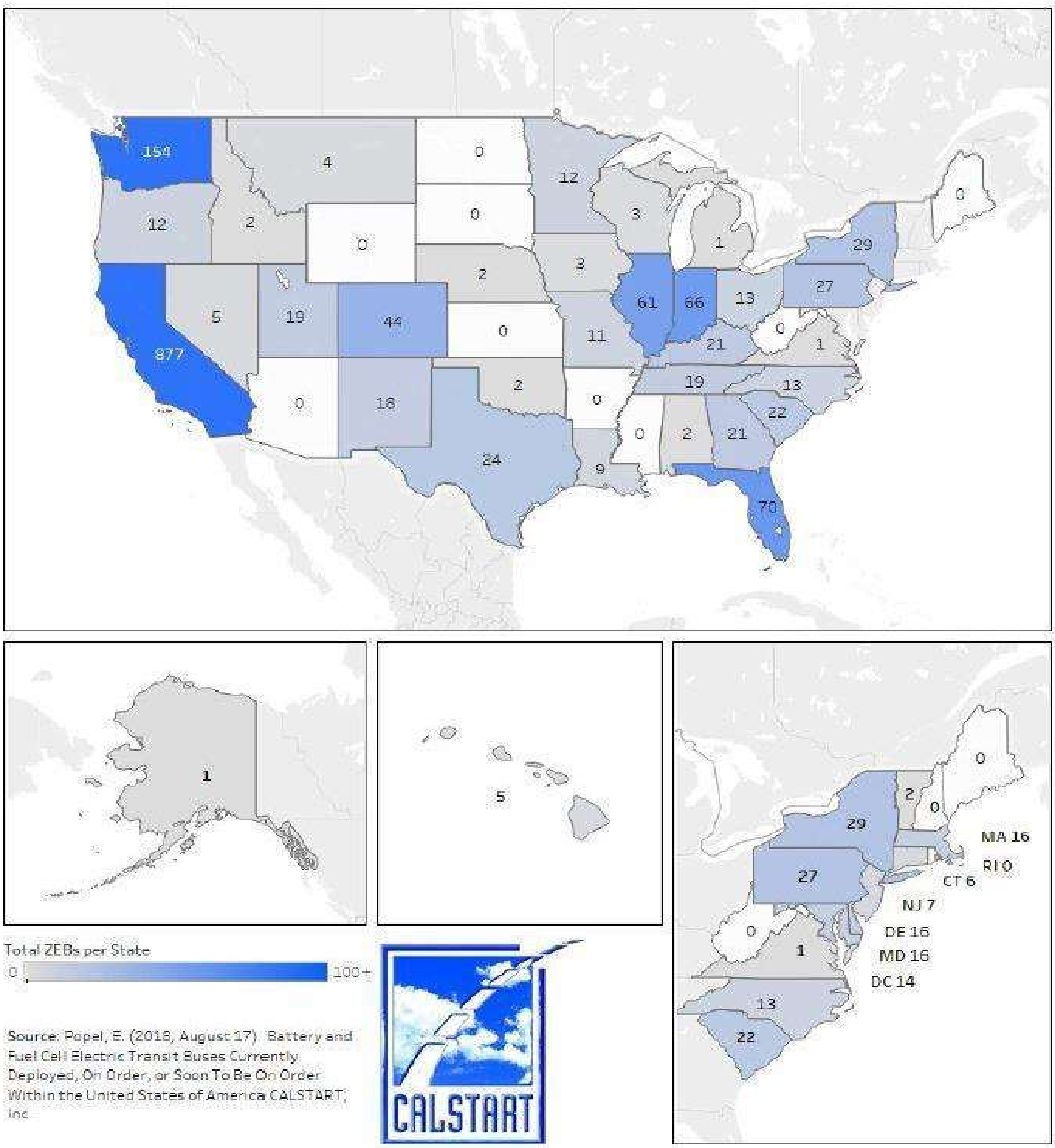


Figure 3: Battery and Fuel Cell Electric Transit Buses Currently Deployed, on Order, or Soon to Be on Order Within the U.S. (Popel, 2018).

2.4.2 Infrastructure

The two current methods of charging electric transit buses are on-route charging and depot charging. Vehicles charging on-route recharge their batteries while the bus is operating and carrying passengers. Electric transit buses that charge on-route may be designed with only enough battery capacity to meet a short driving range. On-route charging uses high power rates, which can be expensive due to associated high demand charges. Table 2 displays the trade-offs of on-route charging.

Table 2: On-route opportunity charging advantages and drawbacks (Gallo, Bloch-Rubin, Tomić, 2014).

Advantages	Drawbacks
Smaller bus battery size can reduce vehicle curb weight, potentially increasing vehicle efficiencies and can take up less space	Lower vehicle assignment flexibility as buses are dedicated to on-route charging infrastructure
Possibility to operate indefinitely without long interruption for charging	Demand charges can be high without energy storage
Smaller battery may be easier and less expensive to service and replace	Charging infrastructure costs can be high and grid connection complex
	Charging generally during daytime and thus on-peak
	Bus operation is not possible when grid power is not available

Depot charging allows electric transit buses to charge overnight while the vehicles are not in operation. Electric transit buses charging overnight are designed to meet the daily range of a conventional diesel bus. Thus, batteries must be sized to store enough energy to cover a traditional bus range, which may exceed 100 miles. Depot charging occurs at a lower power rate, which typically drastically reduces the costs of demand charges.

Table 3 presents the advantages and drawbacks associated with overnight or lower-power depot charging.

Table 3: Depot Charging Advantages and Drawbacks

Advantages	Drawbacks
Bus is designed to replace conventional diesel bus without accommodating on-route charging	Larger battery size can increase vehicle curb weight and could decrease passenger capacity
Charging is done generally at night and thus off peak	Longer charging time
Charging infrastructure costs can be lower	Decreased maintenance time while charging at night
Grid connection can be simpler and may not require grid upgrades	Grid impact if multiple buses need to charge at the same time and at the same location

Utilities may play a valuable role in designing infrastructure and financial incentives to help manage the electric loads and upfront costs of electric transit buses. Based on current utility efforts and consultations with various stakeholders, the Union of Concerned Scientists has developed a set of strategic, robust recommendations for designing utility programs for truck and bus charging (Houston, 2019).

Potential utility strategies for expanding charging infrastructure include:

- Make-ready: The utility invests in infrastructure by upgrading electrical panels, digging trenches, and laying wires, making sites ready for the EV charging to be installed;
- End-to-end utility ownership: The utility funds, owns, and operates all infrastructure, including the charger;
- Incentives: The utility offers incentives, either as full or partial rebates, to the site host for the cost of upgrading infrastructure, purchasing and installing the charger, or both;
- Financing: The utility pays the up-front costs of electrification and the customer repays the utility as a part of its regular utility bills.

2.4.2.1 Policy

To encourage the adoption of low-emission transportation, the Federal Transit Administration (FTA) provides grants to local public transit systems, including buses, subways, light rail, commuter rail, trolleys and ferries. FTA offers incentives for research, demonstration, and deployment projects involving low or zero emission public transportation vehicles to:

- Local, state, and federal governments entities;
- Public transportation providers;
- Private and non-profit organizations;
- Higher education institutions.

Funding opportunities include the Public Transportation Innovation Program and the Low or No Emission (Low-No) Vehicle Program.

Nashua, New Hampshire- Low-No Bus Purchase (GSCCC, 2018)

The Nashua Transit System received $1 million from the Low or No Emission Vehicle Program to purchase two hybrid diesel-electric buses. The BAE Systems buses will arrive in late 2019/ early 2020

In December 2018, CARB set a statewide goal for public transit agencies to transition entirely to zero-emission bus fleets by 2040 (CARB, 2018b). This was the first such regulation in the United States. The California Energy Commission is investing in charging infrastructure and technologies that are driving the transition to ZEVs in the state through the Alternative and Renewable Fuel and Vehicle Technology Program.

2.5 School Buses

School bus carriers collectively operate the largest transportation fleet in the United States. Each day, approximately 480,000 yellow school buses travel the nation's roads, roughly 2.5 times the size of all other forms of mass transportation combined (NSTA, 2013). In 2015-2016, approximately 55 percent of the 47 million children enrolled in public K-12 schools were bused to school at public expense (NCES, 2018).

2.5.1 State of Electric School Bus Adoption

According to the American School Bus Council, 95 percent of school buses are still powered by diesel. In comparison, only 60 percent of transit buses are powered by diesel. There are several factors that may help explain the lag in uptake of electric school buses relative to electric transit buses. The most significant barrier to electric school bus adoption is the higher upfront cost. Most school districts are resource-constrained and do not have the budget or administrative capacity to adopt a new vehicle technology. Electric school buses require new operating procedures, charging infrastructure, and new strategies for planning routes (Wallace-Brodeur, 2019). The expense of creating new transportation plans may be daunting for school districts. Transit agencies are comparative experts at planning bus routes and financing medium- and heavy-duty vehicles.

Electric school buses typically have lower annual operating costs than comparable diesel or gasoline school buses due to lower fuel and maintenance costs over the course of the bus's life, which tends to be about 12 to 16 years. They also benefit from more predictable energy prices than petroleum (Casale and Manoney, 2018). However, though the life-cycle cost of an electric school bus may be lower than equivalent gasoline- or diesel-powered buses, the savings are not as great as for transit buses because school buses typically drive fewer miles. The average school bus is typically in operation for 5.3 hours on a school day with an average driving distance of 32.2 miles, about half the miles driven as a transit bus (Duran and Walkowicz, 2013). Therefore, while electric school buses may cost less to operate, it takes longer to recoup the higher capital expense of purchasing an electric school bus than an electric transit bus.

Several drivers of electric school bus adoption have emerged in recent years, including:

- Emissions-related benefits. When considering bus emissions, school districts are typically most concerned with their students' exposure to diesel exhaust and the potential negative health effects associated with that exposure. Diesel exhaust may have an exacerbated impact on the health of children whose lungs are not yet fully developed (EPA, 2010);
- Operational costs savings. These are attractive to school districts that are conscientious of the total cost of vehicle ownership, given the funding and resource constraints that may impact many school districts;
- Grant and incentive programs. These are critical in helping school districts offset the higher upfront costs of electric school buses. Voucher incentive programs like the California Energy Commission School Bus Replacement program give school districts the opportunity to own and operate electric school buses without the burden of paying more for them;
- Demonstration programs. These can build awareness of and familiarity with the technology while helping catalyze the market and allowing time for upfront costs to drop (Wallace-Brodeur, 2019).

Demonstration Project - White Plains School District, New York

This demonstration project was one of several initiatives by Consolidate Edison, Inc (Con Ed) to support the development of a robust EV market in New York City and Westchester County. Con Ed is New York's largest electric utility based on the number of customers it serves. The project's goal was two-fold: provide clean, zero-emission mode of transportation for NY's school children and demonstrate vehicle-to-grid (V2G) capabilities of electric school buses (Plumer, 2018).

Con Ed, the New York State Energy Research and Development Authority (NYSERDA), and National Express shared the costs to purchase five electric school buses. National Express, owner and operator of the school buses for White Plains School District, received a $120,000 voucher per bus through the NYVIP that helped offset the higher upfront cost of each vehicle. Con Ed contributed an additional $100,000 per bus and was given access to use the buses to help power the grid in the summer, when school is out and the vehicles are sitting idle (Con Edison, 2018). In addition to funding for the buses, Con Ed and National Express helped cover the cost of charging infrastructure.

As a result of this funding, White Plains put five electric school buses on the road at the start of the 2018-2019 school year. The buses were manufactured by Lion Electric and operated for the school district by National Express, who also paid the energy costs required to run the buses. During the summer months, Con Ed paid National Express for the right to use the buses as a grid asset to help in periods of high demand.

Vehicle to grid (V2G) technologies and partnerships may make electric school buses more affordable and easier for school districts to adopt. V2G capability would allow electric school buses to feed electricity from their batteries into the power grid when they are not in use, earning additional revenue through grid services. In 2018, the California Energy Commission released $75 million in funding for an electric school bus replacement program that would require electric buses to be V2G capable.

2.5.2 Policy

California is a national leader with more than 150 electric school buses on the road and dedicated funding to replace diesel-powered school buses. The California Energy Commission's School Bus Replacement program began when SB 110 charged them with retrofitting or replacing old diesel school buses in disadvantaged and low-income communities. SB 110 appropriates up to $75 million to the program from The California Clean Energy Jobs Act, and the Alternative and Renewable Fuel and Vehicle Technology Program provides $13 million for charging infrastructure and workforce training and development opportunities for drivers and maintenance technicians (CEC, 2019).

Several states – including Vermont, Minnesota, Arizona, and Michigan – are also dedicating a portion of their Volkswagen Settlement mitigation funds towards new school buses, with some establishing specific funds for electric school bus models (Gerdes, 2018). In 2018, the Vermont legislature required that all spending in the first year of funding be used for EV charging infrastructure and replacement of diesel vehicles with all-electric vehicles. Advocates are seeking to extend this policy through the lifetime of the Settlement. Five electric school buses were purchased, in part, using rebates offered through the New York Truck Voucher Incentive Program (NYT-VIP), which supports New York's GHG and air quality pollutant reduction goals.

2.5.3 New Hampshire Electric School Bus Replacement Program

During the development of this report, New Hampshire announced an Electric School Bus Replacement Program. This Program will replace diesel school buses with electric school buses. It utilizes approximately $1,250,000 of Volkswagen Environmental Mitigation Trust funding. This amount is from a portion of the funds for "Public/Government Vehicles and Equipment," in this case replacing diesel buses with low- or zero-emission alternatives. It is separate from the $4.6 million that is available for EV charging infrastructure. New Hampshire is moving quickly on this, with proposals due by July 26, 2019. Grants under the Program *can* cover the costs related to the acquisition and installation of charging equipment specifically needed for the operation of these buses (White, 2019).

This represents an extraordinary opportunity to reduce emissions, improve public health, benefit children, and develop municipal familiarity with EV charging infrastructure.

2.6 Demographic Trends

2.6.1 Regions

The U.S. accounts for 40 percent of EV sales globally. These sales tend to be concentrated in several regions. Patterns of high EV adoption are found in cities and states with incentives and policies supporting EVs, including purchase incentives, support for charging infrastructure, and collaboration with electric utilities. Figure 4 illustrates the EV share of new U.S. vehicle registrations in 2017.

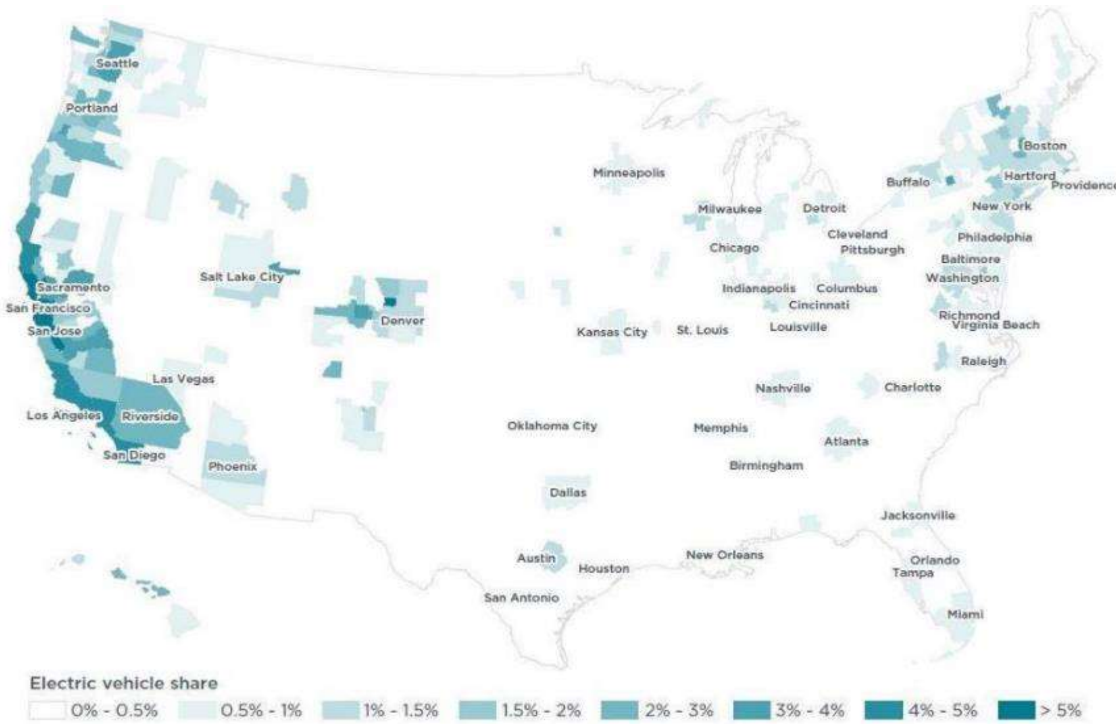


Figure 4: EV share of new 2017 vehicle registration by metropolitan area (Slowik and Lutsey, 2018).

EV market share is concentrated primarily in coastal metropolitan areas, consistent with the states that follow California's ZEV requirement. This policy requires automakers to sell EVs as an increasingly large percentage of total vehicle sales (C2ES, 2019). Figure 5 shows the underlying factors associated with EV uptake in 50 metropolitan areas. The most notable factors include charging infrastructure availability, multiple promotional activities, and light-duty EV model availability. Areas with the highest uptake tend to have the most charging infrastructure, many promotional activities, and high model availability.

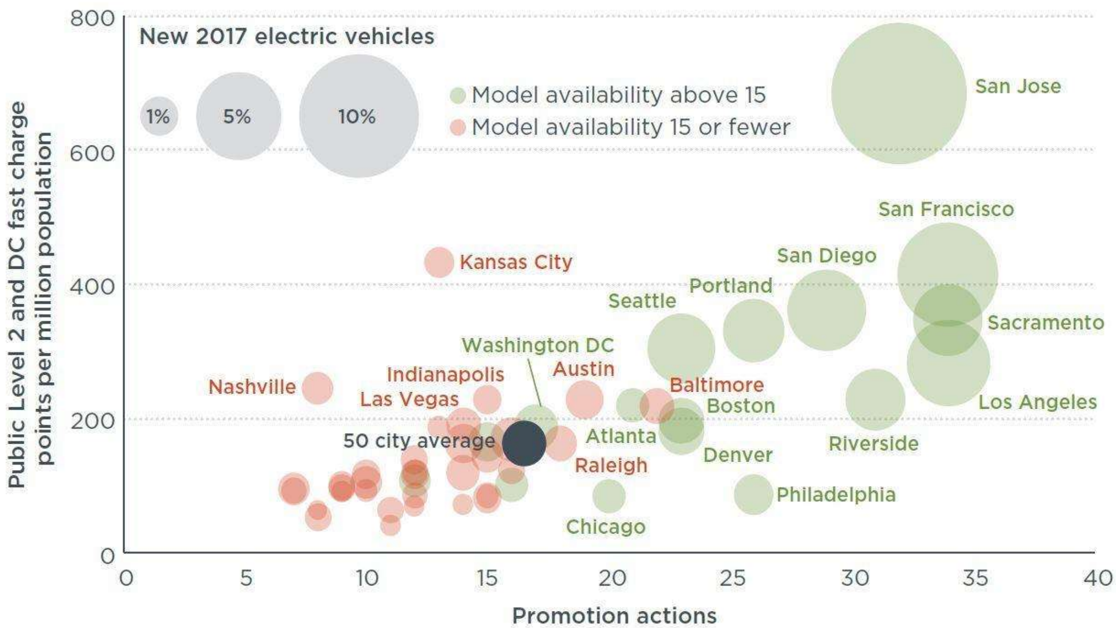


Figure 5: Public charge points, promotion actions, model availability, and EV uptake (Slowik and Lutsey, 2018).

2.6.2 Rural

Increasing incentives for rural and low- and moderate-income drivers will help overcome two of the most significant barriers for EV drivers – higher purchase price and range anxiety. Investing in rural charging infrastructure is crucial for addressing range anxiety because distances driven may be longer. However, residential charging may often be easier to install in rural areas. Outreach and education are essential in driving understanding how best to operate EVs to rural customers (Gatti, 2018).

States are making efforts to address rural regions, though uptake of EVs is not as rapid as in urban areas. Of the 21 counties considered rural in California, only one has utilized funds from the HVIP program. Mariposa County received $320,000 for the purchase of two Proterra battery-electric buses (California HVIP, 2019). New York has had better success. The NYT-VIP program has medium- and heavy-duty projects in several rural counties. Chautauqua, Erie, Lake Erie, Monroe, and Schenectady counties received a total of 7 vouchers (Table 4).

Table 4: NYT-VIP Vehicles Purchased by County and Manufacturer

Vehice Manufactrer	Albany	Chautauqua	Erie	Lake Erie	Manhattan	Monroe	Queens	Schenectady	Suffolk	Westchester	Total
Lion Bus										5	**5**
New Flyer					6						**6**
Orange EV		3	4	1		1		1			**10**
Proterra					6						**6**
Zenith	2				8		23		3	2	**38**
Total	**2**	**3**	**4**	**1**	**20**	**1**	**23**	**1**	**3**	**7**	**65**

3 Charging Infrastructure and Driver Behavior

The New Hampshire Department of Business and Economic Affairs asked how EV charging infrastructure would affect driver behavior when compared to the current landscape for gasoline refueling. How does charging an EV differ from fueling a conventional vehicle?

Very few owners of conventional vehicles have a gasoline station in their driveway, whereas most EV owners have a charger at home. In addition, charging a battery takes longer than filling up a gas tank, but the driver does not need to attend to the EV while it is charging. These differences affect the amount of charging infrastructure needed, the business model for EV charging, and the driver experience.

EV charging can be (and usually is) done overnight, or at work, or when the vehicle is otherwise not in use. Despite the advances in battery technology, over the next decade there will still be many EVs on the road that take significantly longer to charge than it takes to fill up a gasoline tank. This is not a problem for drivers who can charge at home and are willing to make a stop for lunch or sight-seeing on a long road trip. It does affect charging location selection, and it offers opportunities for businesses located near charging infrastructure.

EV charging generally costs less than fueling a gasoline vehicle. At the New Hampshire average residential electricity price of $0.20 per kWh (EIA, 2019), it costs about $2.00 to get the range provided by a gallon of gasoline. Due to higher capital costs and electricity demand charges, power from DCFC may not be consistently less expensive than gasoline, although fast charging represents a small fraction of a typical EV's charging on an annual basis.

Locating the EV chargers is also a different experience. Gas station signs are *prominent*. Signs on the highways and off-ramps alert drivers to the presence of fueling stations. Large signs at the stations are visible from a distance. EV chargers are far less visible. Most non-EV owners do not know how extensive the current infrastructure is, and so think that an EV will not suit their needs. While there is a need for more charging infrastructure, a considerable amount exists already.

Signage will educate non-EV drivers about the existence of the infrastructure. Once a driver has an EV, they typically use a smartphone app or in-vehicle navigation app to locate charging stations. Some vehicles, such as those manufactured by Tesla, integrate the navigation system with the charging network, the occupancy of the charging stations, the vehicle's state of charge, and the projected energy consumption along the route. Doing so will indicate to the driver the optimal locations to stop to charge and advise them on the duration of the charging stops. Vehicles that do not have this capability can still display nearby charging stations in their navigation systems, but they do not necessarily do so proactively. Third-party "trip planner" apps are a good solution for drivers in such cases.

Winter driving can pose challenges for EVs, as detailed below. They may in some cases only have half of their expected range. It is critical to educate new EV drivers on this fact. If they know it is 40 miles to their destination (where there is charging), and they have 75 miles of range, but temperatures are well below freezing, the drivers should know that the prudent course of action is to stop and "top off" at a public DCFC along the way, rather than risk running out of electricity. We recommend the development of materials for new EV drivers emphasizing the need to be conservative in estimating their remaining charge, especially in winter conditions.

3.1 Types of EV Charging

The most ubiquitous form of EV charging infrastructure is Level 1. This can be as simple as a 120-volt wall outlet rated for 15 amps. All EVs can accept Level 1 charging. The vehicle will regain about 2-5 miles of range per hour of charging. Overnight, it can generally restore most or all of the electricity consumed by a typical day's driving. The average light-duty vehicle based in urban New Hampshire travels about 30 miles per weekday; for suburban New Hampshire, it is 54 miles per weekday, and for rural New Hampshire 58 miles (Bureau of Transportation Statistics, 2018). At a workplace, it can restore a typical employee's commute over the course of a workday; more than 90 percent of U.S. employees commute less than 35 miles (Smith, 2016).

Level 2 charging uses a 240-volt outlet, typically a NEMA 14-50 type. This can restore approximately 25 miles of range per hour of charging at 40 amps of current. Some vehicles cannot accept this much current, and charge at a slower rate. Others can accept even higher levels. It might take approximately 1-2 hours to replenish a typical day's driving on Level 2 charging, though it could take several hours to fully recharge a battery that is very low.

Figure 6: J1772 Plug. Source: Plug In America

The J1772 standard is used for Level 1 and Level 2 charging on most EVs. A J1772 plug is shown in Figure 6. Tesla vehicles include an adapter to charge from a J1772 plug.

DCFC can charge EVs much more rapidly. A 50-kW fast charger can replenish 2-4 miles of range per *minute* of charging, while a 120-kW Tesla Supercharger can replenish about 5-7 miles of range per minute. Three primary connectors exist for DC fast charging. The Combined Charging System (CCS) is used by most automobile manufacturers from the United States, Europe, and South Korea. The CHAdeMo system is used by Japanese manufacturers, and Tesla offers an adapter as an option. Tesla maintains the Supercharger network, which its vehicles can use. Tesla has outlined the conditions for other manufacturers to use its stations, though to date there have been no such agreements established. DC fast connectors are shown in Figure 7.

Figure 7: DC fast charging Systems. Source: Plug In America.

The values of range regained per minute or hour are *estimates*, and depend on several factors:

- They refer to nominal range, which assumes relatively good driving conditions;
- Larger vehicles generally require more energy per mile, so will regain less range than smaller vehicles for the same amount of electricity supplied;
- The charging rate slows as battery capacity increases, so charging a vehicle from 20 percent to 30 percent will not take as long as charging from 80 percent to 90 percent;
- Driving behavior affects mileage, as does air resistance (such as from having a roof rack);
- There can be energy consumed *during* charging, such as from maintaining proper battery temperature.

3.1.1 Ultra-Fast Charging

Some companies are seeking to develop even faster EV charging to make public charging more like filling up at gas station. Faster charging requires more robust and sophisticated equipment, increasing capital costs. The higher power draw results in higher electricity demand charges. The battery must be capable of accepting a high charge rate, which increases vehicle cost. A battery technology breakthrough may enable affordable and durable batteries capable of accepting a charge rate of 350 kW. There are no vehicles in production that can accept 350 kW, although the Porsche Taycan and Audi e-Tron GT will reportedly have such capability.

The Porsche Taycan will have a battery of around 90 kWh (Lambert, 2019). At 350 kW, it would take about 10 minutes to supply the 54-kWh to bring it from 20 percent to 80 percent (not accounting for how the charging rate might taper as the state of charge increases). That would be enough for about 180 miles of travel. A driver could drive for 3 hours, stop for 10 minutes, and drive for another 3 hours. This would be close to the gas station experience. By comparison, a vehicle charging at 120 kW would need a half-hour stop, and one charging at 240 kW would need a 15-minute stop.

It is not reasonable to expect that by 2030 *all* EVs, or even most, will be charging at 350 kW. If a lower-cost EV can only accept 50 kW, there will be a market for such lower-cost EVs. These lower-cost EVs may include the EVs on the roads today, which could be on their second or third owners by that time.

There will be a need for EV charging infrastructure with a range of charging rates and corresponding prices. Rather than *all* DCFC at a station being 350 kW, some may be 50 kW and cost less to use. As a matter of safety, CCS connections will only supply what the vehicle can accept, so it is possible for a 50-kW car to plug into a 350-kW charger and limit the charger to supply power at 1/7 its nominal capacity. This would not be optimal, especially if cars that *can* use the full 350 kW are waiting to charge. Pricing the higher-powered charger at a higher rate will help it recoup its capital cost and demand charges while also ensuring that cars with a more limited charge rate are not occupying the high-powered systems unnecessarily.

It may be reasonable to, where feasible, increase the electrical, transformers and conduit to a size suitable for accommodating some ultra-fast chargers in the future, especially at the most heavily traveled corridors. Over-sizing the infrastructure upgrade to account for future expansion does carry an increased up-front capital cost. This determination should be made on a case-by-case basis.

3.2 EV Charging Behavior

Over 80 percent of EV charging occurs at home (Wood et al., 2017). For drivers with home and workplace charging, only about 3 percent of charging occurs at other locations such as public charging (INL 2015). In our survey, New England drivers of EVs most commonly reported that they used public charging less than once a month (30 percent of respondents). The second most common response was a few times a month (23 percent). The most common duration of public charging was “15-40 minutes”. These responses are shown in Figure 8 and Figure 9.

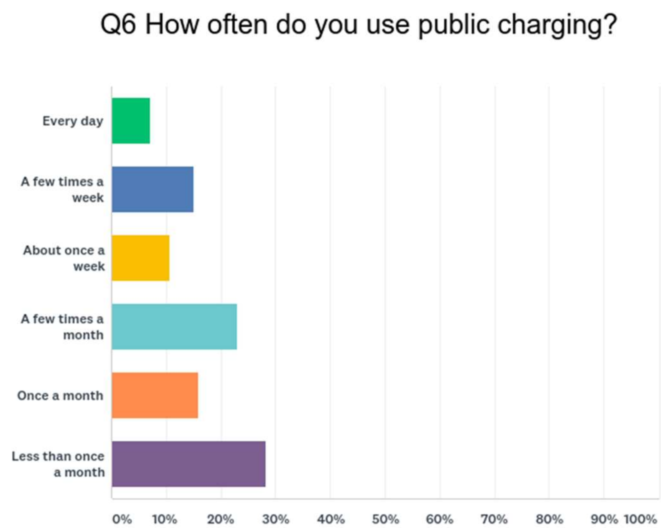


Figure 8: Frequency of Public Charging Visits. Source: Plug In America member survey.

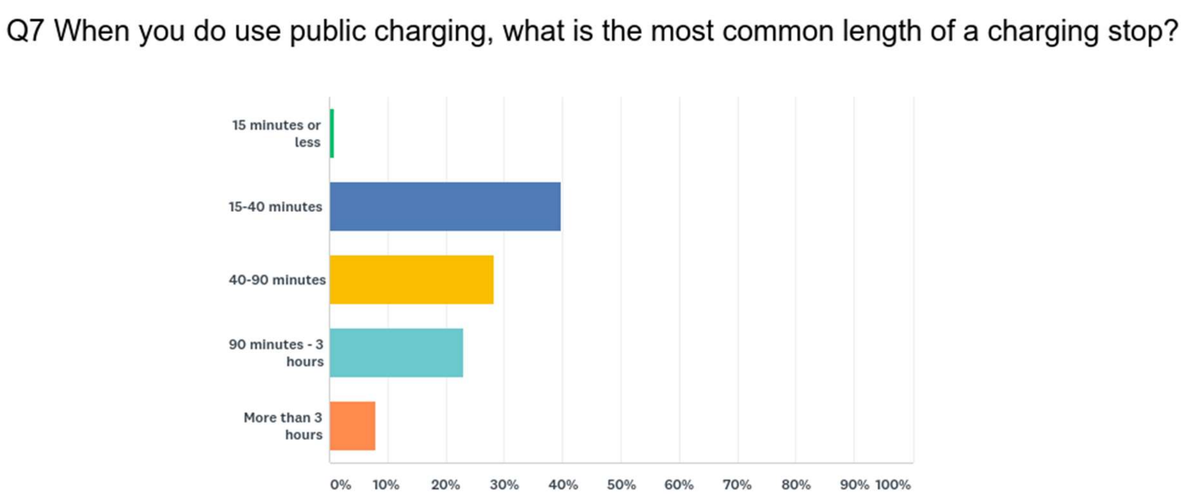


Figure 9: Duration of Public Charging Visits. Source: Plug In America member survey.

Because the charging rate of most vehicles tapers off as the state of charge increases, most drivers do not charge all the way to full when at a public charging facility. Nor is it recommended to let the battery get too low before charging. This is in part to keep the battery functioning well, and in part to guard against the risk of a given charging station not being operational upon the vehicle's arrival. Charging times are often expressed in the time required to charge 20 percent to 80 percent. The actual duration of charging visits represents a mixture of charging situations, often based on what else the driver is doing during that time.

When drivers do visit public charging, they patronize nearby businesses, as shown in Figure 10 and Figure 11.

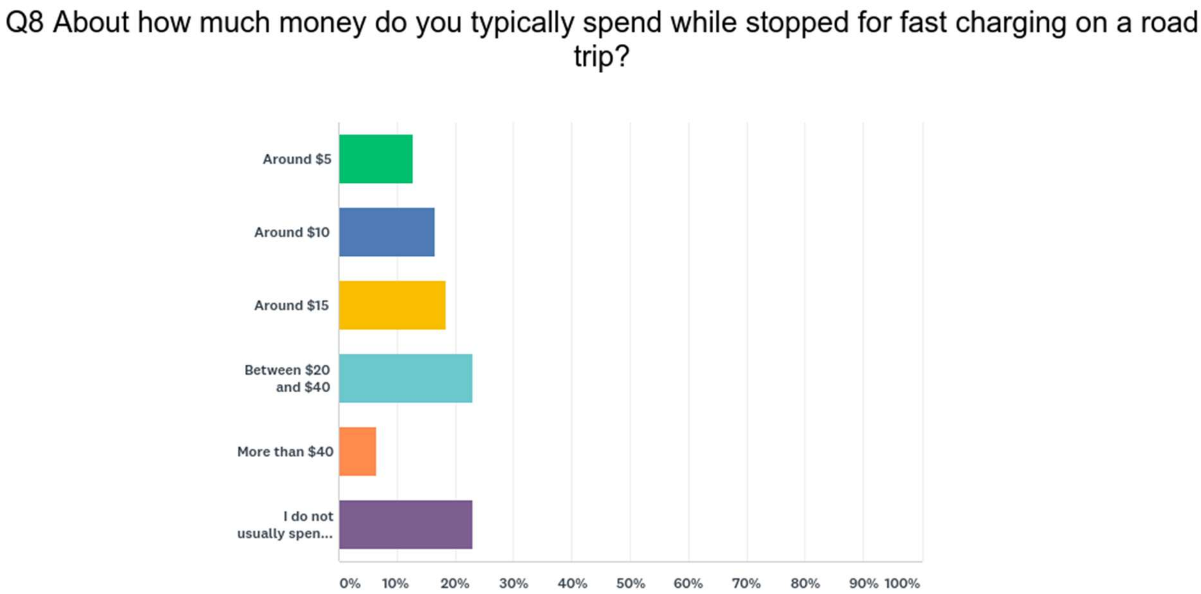


Figure 10: Typical spending at DC fast charging stops. Source: Plug In America survey.

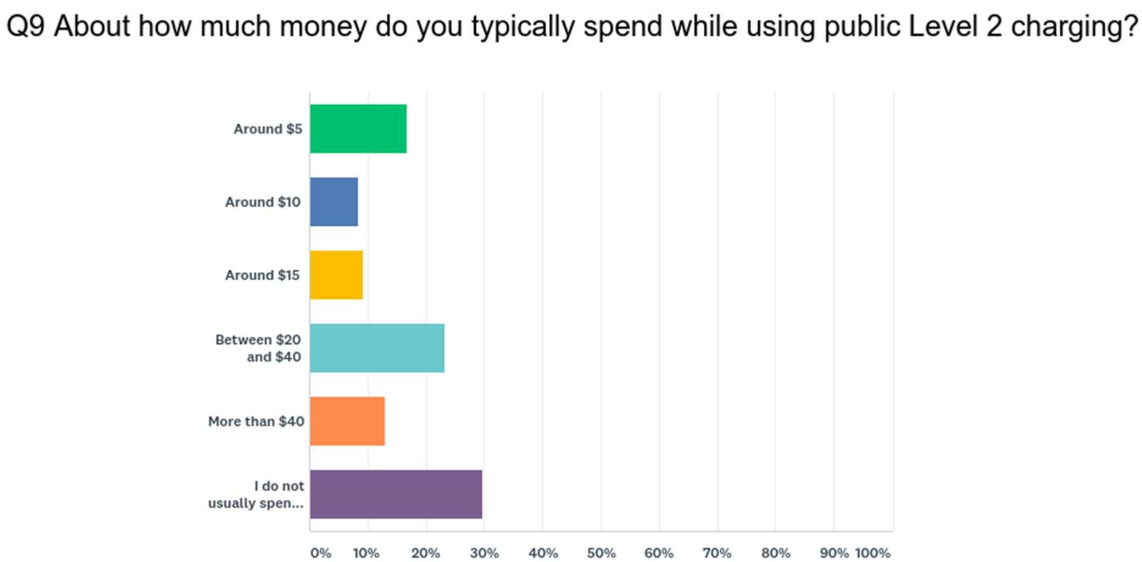


Figure 11: Spending at Public Level 2 Charging stops. Source: Plug In America survey.

About 70 percent of drivers typically patronized local businesses while using public Level 2 charging, and nearly 80 percent while using DC fast charging. Of those, the most commonly reported range of spending was between $20 and $40. This is an economic benefit to businesses located near EV charging systems.

3.2.1 The Charging Pyramid

The amounts of the different types of EV charging required can be represented by the EV Charging Pyramid, seen in Figure 12.

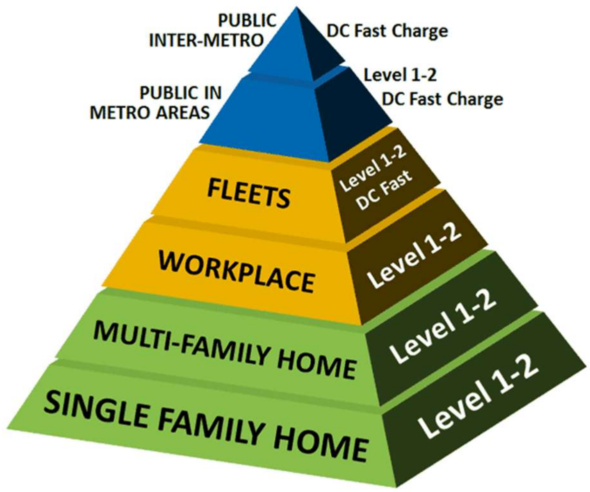


Figure 12: The EV Charging Pyramid. Developed by Ted Bohn, Argonne National Laboratory.

The levels of the charging pyramid indicate the charging ports needed for each type of charging, although the levels are not to scale. Rather, they indicate that the largest level will have the most charging ports, and the smallest level will have the least.

3.2.2 Single-Family Home Charging

The majority of EV charging happens at home. Currently, most EV drivers charge where they park, such as in a private garage. Even a standard 120-V outlet in a garage can charge an EV (at Level 1 charging), replenishing about 40-50 miles of range if the vehicle is parked for 12 hours at night. There are likely *tens of millions* of Level 1 EV charging locations at single family homes in the U.S. Every 120V outlet on a 15-amp circuit adjacent to a parking spot (with a Ground Fault Circuit Interrupter and outlet cover if in a location that is exposed to rain) can be a Level 1 EV charger. Most such outlets are never used for this purpose, but the potential exists.

Many EV drivers upgrade their home charging to Level 2. This is also a low-cost form of EV charging, with a Level 2 upgrade on the order of $1,000. A home Level 2 charger can have a higher peak demand than any other load in the home, typically at around 6.6-9.6 kW. It can be beneficial for the grid to delay this load until off-peak times. All EVs can schedule charging (even if just plugged into an ordinary outlet), and some EV charging stations also feature this capability. If the driver has an incentive to charge off-peak, such as lower electricity rate or a rebate, they may take advantage of this capability.

Specific locations on the grid may be strained by even a modest number of Level 2 chargers. Accordingly, the utility may find economic value in offering a rebate or incentive to EV drivers in exchange for knowledge of their vehicle and charging system. Doing so provides the utility with better information for planning its distribution upgrades, as well as contact information for their EV drivers for inclusion in off-peak charging programs, strategic plans, ride-and-drive events, or other programs.

The single-family home market is generally well-served by existing options for EV charging installation.

RECOMMENDATIONS FROM NESCAUM STRATEGY:

- States: Provide information about the benefits of home charging;
- Utilities: Guide customers through process of selecting and installing home charging;
- Utilities: Consider offering turnkey programs and other incentives for Level 2 EV charging at single family homes;
- Utilities: Offer variable (e.g., TOU) rates for residential customers;
- Utilities: Conduct outreach aimed at increasing residential EV charging.

OTHER RECOMMENDATIONS:

- Ensure that utility incentives for home EV charging are used to identify where the EV charging is being installed on their grid. Ensure that the utilities retain the contact information for EV drivers for future participation in load management programs or outreach events;
- Consider not only time-of-use pricing programs to encourage the home charging to occur off-peak, but also non-tariff time-of-use rebate programs.

3.2.3 Multifamily Charging

Those who do not have access to home charging are less likely to buy EVs. This is often the case for residents of multifamily homes, including condominiums and apartments (although some single-family homes do not have garages with outlets, and some multifamily homes do). Some residences do not have dedicated parking spots, and their owners must find street parking. Other residences have dedicated parking spots that do not have access to charging infrastructure. About 26 percent of the housing units in New Hampshire are in multifamily housing (U.S. Census Bureau, 2019).

Multifamily communities *can* install EV charging in their parking lots. This can be expensive if done as a retrofit. It is much less expensive when done with new construction. Building codes can require or encourage making provisions for EV charging when a new building is constructed. Building codes in some states require that a fraction of spaces be “EV Capable” and that some of those be “EV Ready”:

- An EV Capable parking spot has the raceway and the electrical panel capacity to allow for future installation of an EV charger;
- An EV Ready parking spot also has the dedicated branch circuit, circuit breakers, and other electrical components, though not necessarily an actual charging station.

Building codes requiring EV Capable or EV Ready parking spaces for multifamily housing have been passed in California and are under development in Massachusetts. Many municipalities have such requirements, and bills have been proposed at the state level in Connecticut, Vermont, Maryland, and Hawaii.

In general, coordinating the installation of EV charging with parking lot repaving (whether multifamily communities, commercial buildings, or municipal lots) will reduce costs. An important consideration for New Hampshire is snow removal and the potential for charging systems to be either buried or damaged during plowing. Plowing companies often have a fixed pattern for each property they cover. It is important to access this information and locate EV charging such that the systems will not be snowed in or struck by a plow (possibly protected by bollards or wheel stops).

Residences *without* any dedicated parking, where residents park on streets in “permit only” spots, are the most challenging use case for EV charging. One approach is to rely on DCFC combined with large battery sizes. Similar to a conventional vehicle, the driver would visit a charging location to “fill up,” rather than charging where they normally park.

Numerous EV installers and charging network operators commented on potential improvements to the permitting process. Many requested a determination that EV charging is an accessory use and does not require zoning approval. Other requests included the State providing information to local governments on the characteristics of EV charging systems and a model process for approving such projects, since local officials may not be familiar with the technology.

RECOMMENDATIONS FROM NESCAUM STRATEGY:

- States and Local Governments: Amend residential building codes to mandate make-ready charging infrastructure;
- Local Governments: Enact local EV ordinances requiring EV-ready parking spaces;
- States: Enact laws to provide multifamily residents with conditional rights to install EV charging;
- Utilities: Assist with electrical service upgrades and deployment of EV charging at multifamily communities;
- Utilities: Provide incentives to defray EV charging installation costs at multifamily communities;
- EV charging Providers /Automakers: Pilot innovative solutions to increase access to EVs at multifamily communities.

In addition, the recommendations for single-family housing such as TOU programs could apply.

OTHER RECOMMENDATIONS:

- Offer incentives for developers for multifamily housing that *exceeds* any requirements on EV-ready parking spaces;
- Utility programs to incentivize EV charging at multifamily communities should coordinate with the facilities’ scheduled parking lot resurfacing, electric improvements, or other work that would reduce the marginal cost of additional infrastructure;
- Consider snow-plowing patterns in locating EV charging systems;
- Establish that EV charging are “accessory use” and do not require zoning approval;
- Hold workshops or webinars to educate local governments on EV charging requirements and permitting approval;
- Consider legislation similar to California Civil Code 4745 and 6713. These specify that a multi-unit dwelling (such as a condominium) may not prohibit or unreasonably restrict the installation or use of an EV charging station in a homeowner’s designated parking space.

3.2.4 Workplace Charging

Workplace charging provides numerous benefits for EV adoption. Although most BEVs have a large enough battery to handle typical commutes, a commute of 50 miles each way could, in the winter, be difficult for a 200-mile BEV. Workplace charging alleviates this concern. And, PHEVs have shorter all-electric range, so workplace charging can allow far more driving in all-electric mode. As well, workplace charging leads to significant increases in EV adoption among the employees. Employees with access to workplace charging are *six times* more likely to own an EV than those who do not have workplace charging.

RECOMMENDATIONS FROM NESCAUM STRATEGY:

- States and Local Governments: Amend commercial building codes to mandate make-ready charging infrastructure;
- States: Prioritize workplace charging incentives among other EV charging incentives;
- States: Establish state workplace charging and fleet electrification mandates or goals and complementary reporting requirements;
- States: Conduct outreach to large employers to promote workplace charging;
- States: Organize events to secure and give high level recognition for corporate commitments for workplace charging and fleet electrification EV charging providers;
- EV charging Providers: Partner with states and sponsor corporate commitment events;
- Utilities: Provide workplace charging incentives, conduct outreach, install chargers and make-ready infrastructure, and optimize commercial customer load energy management plans;
- Sustainable Business Networks: Promote workplace charging and fleet electrification through outreach, recognition, award, and employer commitment programs;
- Workplace Charging Experts: Offer workshops, webinars and other educational materials.

OTHER RECOMMENDATIONS:

Many of our recommendations for multifamily communities also apply to commercial buildings. These include:

- Incentives for developers to *exceed* requirements on EV-ready parking spaces;
- Coordinate utility EV charging incentive programs with workplaces' scheduled parking lot resurfacing, electric improvements, or other work;
- Consider snow-plowing patterns in locating EV charging systems;
- Establish that EV charging are "accessory use" and do not require zoning approval;
- Hold workshops or webinars to educate local governments on EV charging requirements and permitting approval.

We also recommend that any state or utility incentives for workplace charging apply to both Level 1 and Level 2 systems at workplaces, and do not *require* that Level 1 stations be networked.

3.2.5 Fleet Charging

Fleet charging includes commercial vehicles, transit buses, and school buses. This sector is discussed in Sections 2.3, 2.4, and 2.5.

Make-ready for infrastructure and demand charge rate reform will be particularly important for fleet vehicles due to the need for DCFC and possibly ultra-fast charging for heavy-duty vehicles.

The New Hampshire Electric School Bus Replacement Program represents an excellent and important step in fleet electrification.

Other recommendations include:

- A voucher program for transit fleets, as discussed in Section 2.4;
- Education and outreach to fleet operators.

3.2.6 Public Charging

Public Level 2 charging is well suited for locations where drivers spend a few hours. These locations might include state or municipal parks, forests, and beaches; ski slopes; cinemas, stadiums, and entertainment venues; shopping centers; and restaurants. Such systems normally have either a cost per unit of time or unit of energy, or a time restriction on how long the vehicle can be parked there. Hotels are long-dwell-time locations that can utilize Level 2 charging, since a valet can move fully charged vehicles.

Public DC fast charging offer drivers an opportunity to charge from 20 percent to 80 percent in about half an hour to an hour, or “top off” in less time. This can be useful for restaurants, shopping centers, or grocery stores. However, DC fast charging carries a high capital cost and high demand charges, so a site host needs to consider the value provided by increased business. DC fast charging in metro areas can provide charging for EV drivers who do not have designated parking spaces.

Public Level 1 charging is not widespread. It can be appropriate for locations where vehicles spend many hours parked. They could include workplaces, commuter rail lots, or long-term airport parking. Offering an existing 120-volt outlet for EV charging, and requiring the driver to bring their own cord, can be a very low-cost method of providing Level 1 charging. Installing a system capable of collecting payment carries a higher capital cost and ongoing network costs.

Our survey found that drivers frequently patronized businesses near public chargers, whether Level 2 or DCFC, as shown above. Site hosts generally did not perceive this as an increase to their business, although this could be due to the relatively small number of EVs on New Hampshire roads.

The new Destination Electric program provides businesses throughout the Northeast with decals indicating their proximity to EV chargers. EV drivers can look on a website to see what New Hampshire businesses are near their next charging stop – and other visitors who are not EV drivers can gain awareness of the existing charging infrastructure. Participating businesses also receive a sheet of Frequently Asked Questions about their local charging system.

NESCAUM STRATEGY RECOMMENDATIONS:

- States: Fund or incentivize deployment of Level 2 EV charging at publicly-owned lots;
- States: Share lessons learned, data and business cases for deploying EV charging at privately owned lots;
- States: Fund or incentivize deployment of Level 1 and 2 EV charging at airports, train stations and transit centers;
- Local Governments: Incentivize private EV charging investment at publicly-owned lots;

- Charging Providers/Utilities: Deploy charging hubs near commuting travel corridors in metropolitan areas;
- Charging Providers/Utilities: Install DC fast charging at airports and train stations and strategically located charging hubs.

OTHER RECOMMENDATIONS:

Public Level 1 and Level 2 charging face many of the same considerations as workplace charging and multifamily charging. Accordingly, we recommend:

- Incentives for developers to *exceed* requirements on EV-ready parking spaces;
- Coordinate utility EV charging incentive programs with scheduled parking lot resurfacing, electric improvements, or other work;
- Consider snow-plowing patterns in locating EV charging systems;
- Establish that EV charging are "accessory use" and do not require zoning approval;
- Hold workshops or webinars to educate local governments on EV charging requirements and permitting approval.

Public DC fast charging systems have additional considerations. Most notably, demand charges can impose significant costs on such systems, and while utilization is low, they do not have the ability to recoup these costs. We recommend:

- Examine alternatives to demand charges for DC fast charging, such as shifting a larger amount of the cost recovery to time-of-use energy-based (kWh) charges;
- Assess the potential for energy storage at public DC fast charging to provide multiple economic benefits including grid services and demand charge reduction;
- Enforce regulations to prohibit non-charging vehicles from occupying DC fast charging parking spaces.

For all types of public charging in metro areas, we also recommend continued participation in and expansion of the Destination Electric program.

3.2.6.1 Inter-Metro Public Charging

Public inter-metro charging is "corridor charging," typically on highway rest areas or very near the highways. These are used by drivers on trips beyond their vehicles' range. With a 200-mile EV, a driver might travel for 3 hours, charge for 40 minutes, drive for another 2 hours, and then plug in at their destination.

Public inter-metro charging is essential EV adoption. A driver with adequate battery capacity and home charging might not *ever* need to use workplace charging, or public charging in their metro area, but they will likely need inter-metro charging at some point if they wish to travel more than their battery's range in a day.

In our survey, 79 percent of EV drivers who live in New Hampshire or visit fairly often said that additional DC fast charging along travel corridors would allow them to do significantly more electric driving. This was the most frequent response in our survey.

Because EV charging on road trips generally takes longer than filling a gas tank, there is an opportunity for businesses to serve the drivers. EV drivers can't necessarily choose to charge where they stop to get lunch on a long road trip – they get lunch where they stop to charge. This is the case *now*, when charging infrastructure is fairly limited. As charging infrastructure increases, drivers have more choices and will select the charger near the amenities they prefer.

A DCFC benefits the restaurants and shops that are within a short walk of it. Rural travel corridors are particularly important. The towns along Interstate 93 could be stops for drivers headed to Sherbrooke or Quebec. Towns along Route 16 might be stops for drivers headed to the ski slopes. The energy demand will be more frequent for those headed to the slopes for a few reasons, as detailed below. EV drivers will stop more often on those roads, even if there is a charger at the mountain.

The four major New Hampshire utilities (Eversource, Unitil, Liberty, and New Hampshire Electric Cooperative) have outlined a proposal to install DCFC along major travel corridors in New Hampshire using a portion of the funding from the Volkswagen Settlement, Appendix D. A total of $4.6 million of these funds are available for EV charging infrastructure. The plan is to use approximately $2 million of the funds for DCFC in 10-16 locations, each with 2-4 50-kW DCFC. The remainder of the funds would remain available for other EV charging investments. Example locations are shown in Figure 13.

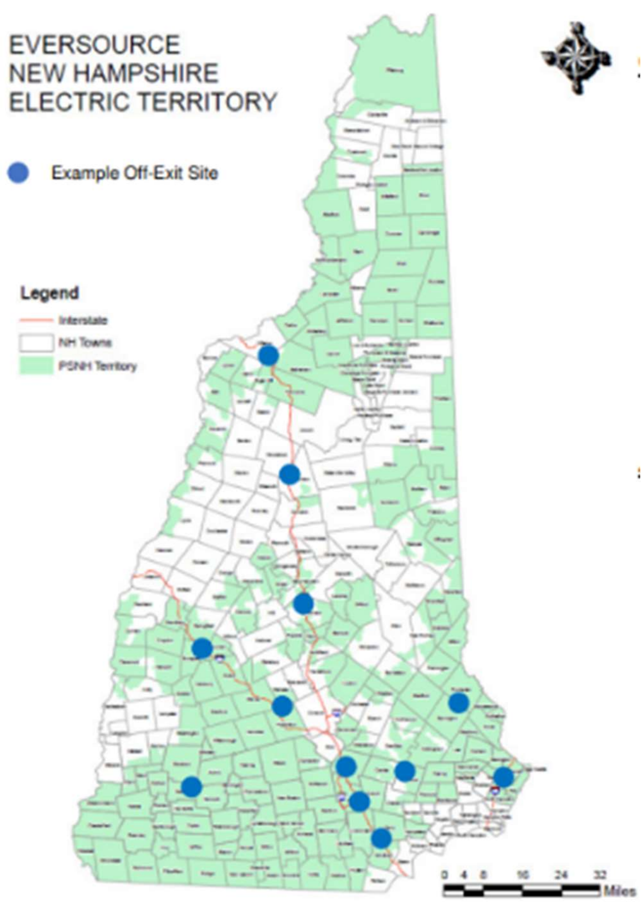


Figure 13: Example DCFC Sites in New Hampshire. Source: Eversource.

NESCAUM STRATEGY RECOMMENDATIONS:

- States: Target any funding for DC fast charging along corridors to fill gaps that may not attract near-term private or utility investment;
- States: Help identify sites or site owners to host DC fast charging along travel corridors;
- Utilities: Assist with DC fast charging site selection process;
- Utilities: Install, at a minimum, make-ready infrastructure to support EV charging deployment, especially where needed to fill gaps in travel corridors;
- Charging Providers: Expand investment in DC fast charging network along heavily traveled corridors.

OTHER RECOMMENDATIONS:

The utilities' proposal to spend a portion of the Volkswagen Settlement, Appendix D funds on a system of DCFC is reasonable and will accelerate EV adoption in New Hampshire. We support OSI's plan to develop a Request for Proposals to allocate the Settlement funds for DCFC projects, with targeted installation by Summer 2020. Releasing these funds now will increase EV adoption, which will in turn improve the business case for third-party investment in charging stations.

While a large fraction of travel happens along the I-93 and I-89 corridors, we also recommended installing DCFC along other state and U.S. highways. These include Route 16, 302, and 3. Other appropriate locations mentioned by network operators and utilities include Route 2, 4, 9, 11, 25, 101 and 202. While the primary charging corridors are important, it is also important that a prospective EV driver in New Hampshire be able to look at a map of the state and realize they potentially *could* go anywhere – even if they do not often take U.S. 3 to Pittsburg. And, it is important that rural areas not be left out of the economic development benefits of EV charging infrastructure. In Northern New Hampshire, U.S. 2 and 3 should be a priority, with Lancaster providing an opportunity to serve drivers on both highways.

We provide additional recommendations on DC fast charging locations in Section 4.2.1 of this report.

3.2.7 Destination Charging

Destination charging is not specifically included in the Charging Pyramid but can be vital for New Hampshire. It can include Level 2 public charging in metro areas but can also include systems in rural areas, such as the mountains, forests, and lakes. About 40 percent of New Hampshire's population lives in rural areas (U.S. Census Bureau, 2012). If there is no charging at a destination, then an EV driver is generally limited to those destinations within half their vehicle's range from their home or the nearest DC fast charging (after accounting for driving conditions). With charging at the destination, they do not have to keep half the battery "in reserve" and can visit destinations further away.

In our survey, 78 percent of EV drivers who live in New Hampshire or visit fairly often said that additional rural destination charging (such as at ski resorts, state parks, and hotels) would allow them to do significantly more electric driving. This was the second most frequent response in our survey. Hotels are an excellent option, and many drivers in our survey would be willing to pay $5-10 more per night for a hotel with EV charging. Many would pay more, as shown in Figure 14.

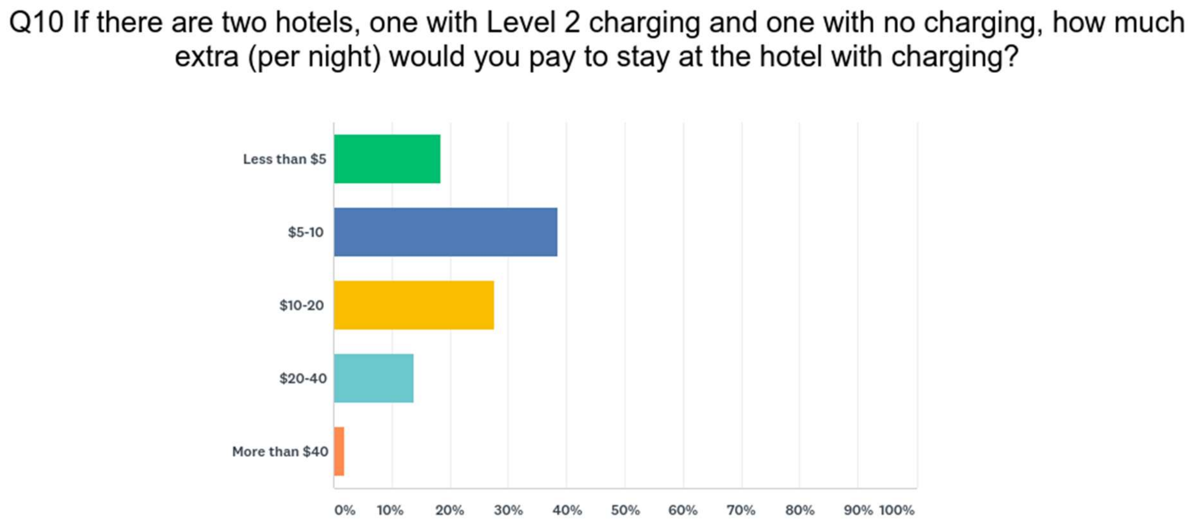


Figure 14: Willingness of survey respondents to pay extra for a hotel with EV charging. Source: Plug In America survey

EV drivers offered a range of suggestions for where additional charging would be most useful, with ski resorts commonly mentioned as well as specific winter recreation towns such as North Conway. These are shown in Figure 15.

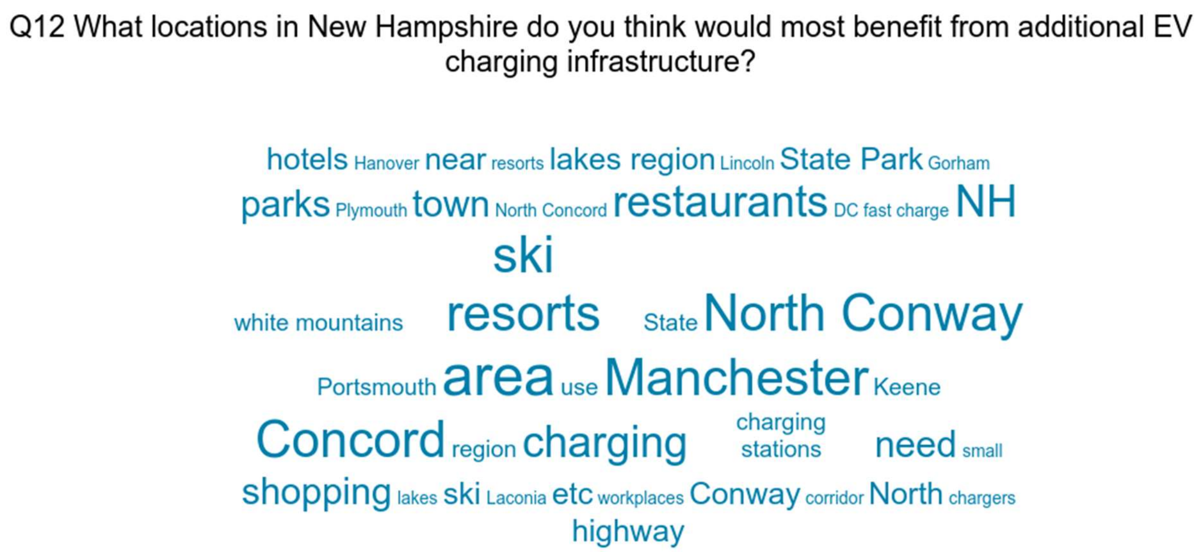


Figure 15: EV Driver Suggestions on Optimal Charging Locations. Source: Plug In America survey.

NESCAUM STRATEGY RECOMMENDATIONS:

- States: Identify key destination locations to encourage EV charging investment in these areas;
- States: Fund or incentivize Level 2 EV charging in publicly-owned lots at popular destinations;
- Local Governments: Incentivize deployment of EV charging at publicly-owned lots in popular destinations;
- EV charging Providers: Install DC fast charging along highly traveled destination corridors and charging hubs at popular destinations;
- EV charging Providers: Consider site design that includes battery storage where beneficial.

OTHER RECOMMENDATIONS:

Destination site hosts generally expressed an interest in having EV charging, but frequently pointed to the capital cost as a barrier and requested grants or rebates. They generally found electricity costs to be in line with expectations.

Charging network providers offered different business models. Some considered it optimal for a third party to own and operate the charger, while others preferred the site host to own and operate the charger. We recommend that grant programs be open to both business models.

3.2.7.1 Ski Resorts

New Hampshire's mountains are major destinations, drawing visitors from all over New England and the Mid-Atlantic. Winter recreation trips pose some challenges for EVs. The energy demand is increased in the winter by the need to run heaters – unlike internal combustion engines, electric motors do not produce enough waste heat to warm the cabin. The regenerative braking of EVs does not function as well when the battery is cold, so if it is parked overnight in a cold environment the vehicle will not effectively replenish the batteries when braking until the battery warms up. Driving uphill consumes more energy. Snowy roads have a higher coefficient of rolling friction, requiring more energy. Finally, any sort of a roof rack or roof box will increase the drag coefficient, making the vehicle less aerodynamic and requiring more energy.

This means that winter recreation resorts are excellent locations for EV charging. EV drivers will pick the slopes they can reach. As a rule of thumb, a driver might expect the vehicle to need about twice as much energy as normal in these conditions, possibly more with very adverse conditions. Therefore, the vehicle's range is roughly halved. If the resort is 50 miles from the nearest DCFC, the driver of an EV with nominal 240-mile range (perhaps only 100 miles effective range in bad conditions) is unlikely to make that trip. Even accounting for some regeneration of energy on the descent from the mountain back to the charger, it's too risky. However, if the mountain had an EV charger on site, the driver could visit that slope in confidence. If planning a multi-day trip, a lodge with an EV charger would be ideal.

A Level 2 charger can replenish about 25 miles of range per hour of charging, so a skier visiting the slopes for a day could be fully charged by the time they are ready to leave. Numerous Level 2 stations can be installed for the same cost as a DCFC and would be able to serve multiple vehicles simultaneously.

A lodge could have Level 2 charging for guests. Even those just visiting the restaurant could benefit, getting back 50 miles over a 2-hour dinner. This would be about 13 kWh, costing the lodge under $2 (at New Hampshire's average commercial electricity rate of $0.13/kWh). That would seem to be a cost worth paying to attract additional dinner guests. If the electricity is simply given away, the station itself can be cheaper and would have fewer potential points of failure.

Level 1 charging is not recommended for very cold environments. It is possible to lose electricity while plugged in to Level 1 charging during extreme cold; the vehicle may consume more energy to keep the battery warm enough to accept a charge than it receives. Still, level 1 charging is inexpensive and could work in a heated garage. For example, a lodge might allow guests who do not have need of their vehicle (such as if there is a shuttle to the mountain) to plug into a simple wall outlet and get back about 100 miles of range per day. Guests who do need their vehicles during their stay would be better served by Level 2 charging.

Winter recreation is seasonal. Investments with a high capital cost, such as EV charging stations, want high utilization. There are visitors to New Hampshire’s mountains in the spring, summer, and fall which will ensure that there are at least some visits to the charging stations year-round. It would be advantageous if the ski resorts’ charging stations were accessible year-round.

Considering the impacts of winter driving on energy consumption, we recommend that charging along the non-Interstate routes leading to the slopes (e.g., Route 16, 302) have DCFC every 30-35 miles (see Section 4.1.4). New EV drivers may not fully realize the impacts of adverse conditions on their vehicle’s range, so increased frequency of charging infrastructure is vital to ensure that no driver is stranded. Education of EV buyers in New Hampshire should emphasize the importance of leaving a margin of safety when planning trips in winter conditions and stopping to charge before the battery gets too low.

Ski resorts can highlight nearby charging spots on the “Driving Directions” sections of their web pages. For example, a ski resort might have a section similar to this:

> “EV Drivers: We have Level 2 chargers at the mountain! On the way, you can stop at the fast chargers in North Conway (if coming from the south) or Gorham (if coming from the north).”

This would encourage drivers to charge up on their way, and alert non-EV drivers to the fact that they would be able to travel to this mountain if they were to switch to an EV.

3.2.8 Consumer Protection and Open Access

Any charging infrastructure supported by public funds must follow the requirements of SB 575. NESCAUM has recently released model rules for grants and procurement for public charging (Kinsey, O’Grady, and Way, 2019) that are more specific than the principles in SB 575. The model rules were developed through a process that included webinars and a workshop convened by Plug In America.

The model rules include different requirements for DCFC than for public Level 2 stations. Public Level 2 charging is generally a convenience, not a necessity. While it is important to ensure that drivers can access these stations, the charging companies have an incentive as well in ensuring that their stations are used. By contrast, a DCFC can be a true necessity, and the hardship imposed on a driver unable to charge can far exceed the hardship to the charging network operator from the loss of potential revenue. This unequal situation warrants measures to protect the EV drivers.

NESCAUM’s model rules were released after our stakeholder outreach process for this report had concluded. We were not able to specifically ask stakeholders their opinions on these recommendations, although some had volunteered suggestions on the relevant topics. **We encourage New Hampshire to circulate any proposed requirements for procurements, such as under OSI’s Request for Proposals for DCFC, for comment. The State can identify means to address compliance costs, perhaps with clarifying legislation if necessary.**

The recommendations of NESCAUM are as follows:

Open Access: "The (grantee/recipient/contractor) must ensure that public electric vehicle charging stations are accessible by all drivers regardless of network memberships or subscriptions, and that consumers are not required to pay a subscription fee or otherwise obtain a membership in any network, club, association, or organization as a condition of using such public electric vehicle charging station; provided, however, that owners and operators of public electric vehicle charging stations may have separate price schedules conditional on a subscription or membership."

Comments: this is virtually identical to the language of SB 575. We endorse this with no reservation.

Payment Options: "For public DC fast charging stations that require payment, the (grantee/recipient/contractor) must ensure that such stations, at a minimum, are equipped with a credit card reader that allows users to pay using chip and tap credit and debit cards without incurring excessive fees, inconvenience or delays compared to other payment methods." As well, NESCAUM adds, "Note, however, that the language should be revisited periodically as markets, technology and consumer behavior evolve."

Comments: SB 575 says that stations must provide multiple payment options for public access, but does not specify what those payment methods must be. In California, SB 454 of 2013 imposed similar requirements, with a lengthy regulatory process by the CARB to define the specific regulations including acceptable payment methods. Some California stakeholders including Plug In America have supported CARB requiring credit card readers on *all* public EV chargers to enable near-universal access, including public Level 2 chargers and not merely public DCFC. As California is a market leader in EV adoption and policy, we recommend that New Hampshire revisit this area of payment option requirements once the California process is completed.

We note that NESCAUM's requirement for chip and tap credit card readers on public DCFC is a solution being adopted by Electrify America at its DCFC stations across the U.S.

Accessibility: "All public DC fast charging stations serving (designated) highway corridors must be publicly accessible year-round, 24 hours a day, 7 days a week (e.g., stations shall not be deployed in gated parking lots or fenced property that is closed to the public for any period of time). Charging station parking spaces must be clearly designated as reserved for EV charging and adequately lit from dusk to dawn."

Comments: We agree with NESCAUM that while it would be preferable for *all* public charging to be accessible 24 hours a day, it is imperative that this be the case for public DCFC.

Customer Service Support: "For all public EV charging stations, the (grantee/recipient/contractor) shall provide a customer support service number that is accessible to customers during hours of operation through a toll-free telephone number that is clearly visible and posted on or near the charging equipment to assist customers with difficulties accessing or operating the charging stations. The (grantee/recipient/contractor) must ensure that DC fast charge units are equipped with remote diagnostics and the ability to be "remote started." The customer support service must be capable of dispatching or otherwise providing services to address operational problems at the charging station. A customer who calls the toll-free number must get immediate assistance, including rebooting the system if necessary."

Comments: Cellular service can be limited in some rural areas, which might seem to pose a problem for a customer support number. We endorse this requirement, but note that in order for it to be effective, DCFC stations must be located in areas of strong and consistent cellular signal. This should not be a problem, as all DCFC stations should be networked in order to provide real-time operational status. Installations of DCFC may therefore also require installations of equipment to boost cellular reception.

Redundancy: "For public DC fast charging sites: At each project site, DC fast charging equipment must be networked and configured in one of the following ways: (1) at least two dual-cord protocol charging units per project site, each equipped with a CHAdeMO and a SAE CCS connector; or (2) at least two CHAdeMO chargers and two SAE CCS chargers per project site.
For public Level 2 sites: Each Level 2 site shall be equipped with a minimum of 2 J1772-compliant charging ports."

Comments: Two chargers per site is the *bare minimum* of redundancy acceptable. As EV adoption increases, such limited charging sites may be insufficient. Already, the six-stall Tesla Supercharger station at the Hooksett Rest Area can have a queue on Friday and Sunday afternoons. In heavily-traveled areas, redundancy is important because stations may be occupied. In sparsely-traveled areas (such as rural highways), redundancy is important because a motorist's life may be in peril if they are stranded in the winter. We strongly recommend that New Hampshire consider additional requirements in areas of concern. For example, 3-4 charging units per station may be appropriate, or a rural DCFC station may also have a Level 2 charger as a backup system. A Level 2 system will not provide a rapid charge on a road trip, but can keep a vehicle warm and charging if both DCFC units happen to be nonfunctional.

Uptime Requirements: "Each connector on each public DC fast charging station pedestal shall be operational at least 99 percent of the time based on a 24 hour 7-day week (i.e., no more than 1.7 hours of cumulative downtime in a 7-day period)." NESCAUM also "leaves states to decide uptime requirements for L2 chargers on a case-by-case basis."

Comments: This is an important recommendation. Again, DCFC units represent essential charging needs, not merely opportunity or convenience, and so reliability is paramount. If two connectors have independent chances of failure, and the uptime is 99 percent, then it would only be approximately 1 hour per year when both connectors are non-functional. However, it is not necessarily true that the chances of failure are independent. We endorse this recommendation, recommend it be supported by enhanced redundancy requirements in critical areas, and recommend that there be a means of enforcement of this uptime requirement. For example, the State could require charging network operators to post a bond guaranteeing their uptime. Or, it could evaluate future contracts and grants based on the uptime of existing systems. In either case, adverse consequences should only ensue if insufficient uptime were due to negligence on the installer's or charging station operator's part, and not due to problems in the utility system or force majeure events.

We do not have specific suggestions on uptime for public Level 2 charging. Procurement should not look only at the promised uptime of such stations, but on the installer's and network's track record of achieving such levels of operation.

Maintenance and Repair Obligations: “For all public electric vehicle charging stations, the (grantee/recipient/contractor), and any successor-in-interest, shall be responsible for operating and maintaining or causing a (sub-grantee/sub-recipient/subcontractor) to operate and maintain the charging station pedestals, and all ancillary equipment, including cables, awnings, canopies, shelters, and information display kiosks or signage associated with the charging stations, in good working order and in compliance with all manufacturer requirements and recommendations for a period of at least ___ years following the date when the charging station commences operation.” (The duration of the maintenance obligation is left to the discretion of individual states.) NESCAUM also notes, “In the Northeast region where snow is a common occurrence during winter months, inaccessibility due to accumulation of snow should not be excused, and an approved maintenance plan should include provisions for timely snow removal.”

Comments: Maintenance of public charging can be expensive, particularly in a climate with severe winters. A longer duration requirement will increase the cost of public charging installations but will reduce the long-term risk of non-functional stranded assets. We recommend that New Hampshire establish a tentative **five-year** maintenance requirement. We encourage selection of locations to anticipate long-term maintenance costs and vulnerabilities, to plan for typical patterns of snow removal in the parking lot, and to assess whether a longer or shorter duration maintenance requirement is appropriate.

DCFC Operation and Maintenance Plan Provision: “For public DC fast charging stations, the (grantee/recipient/contractor) must submit, for state approval, an operations and maintenance plan for all deployed DC fast chargers that ensures compliance with the 99 percent uptime requirement. The operations and maintenance plan shall provide for snow removal to ensure access during inclement weather and include a schedule for regular inspection and maintenance of each charging station and all ancillary equipment.

Comments: This is a necessary and prudent recommendation, and we endorse it.

Model Repair Provision: “For all public electric vehicle charging stations, the (grantee/recipient/contractor) shall initiate or cause a (sub-grantee/sub-recipient/subcontractor) to initiate the process for making any needed repairs within 24 hours following notice of a malfunction or other operational issue and shall complete repairs in accordance with the provisions of the approved operations and maintenance plan.”

Comments: This is a reasonable recommendation. Networked stations should be aware immediately of most malfunctions. Non-networked stations will not normally register a problem until one is reported by a driver.

Smart Phone App Operational Status Information: “All networked public EV charging stations are required to display real-time operational status on a smartphone application, either through a network-specific application or a third-party aggregator.”

Comments: We endorse this recommendation. Smart phones are very helpful for EV drivers, who can use them to find stations and pay for charging. Providing operational status (functionality and occupancy) enables drivers to plan trips with the knowledge that they will be able to reach their destination. It also provides a tool to readily measure the uptime of a charging station and alert charging networks or utilities to potential problems. We would *prefer* that operational data be provided such that third parties can aggregate the data into a single app, rather than a driver needing to switch between several apps while driving. However, with the development of roaming agreements between the various networks, it is to be hoped that they will effectively share data on operational status across their apps. We recommend consulting with the charging networks on this topic, and ascertaining if there should be a specific procurement requirement for open data.

Pricing Transparency: “For public electric vehicle charging stations that require payment, the (grantee/recipient/contractor) is responsible for making the following pricing information available to drivers in advance of each charging session either through a user interface that is legible both at night and in direct sunlight, or through another form of display on the charging station: the unit of sale (free, kWh, time, etc.), pricing per unit, any additional fees that may be assessed (e.g., fees associated with parking, dwell time surcharges, etc.); and, for DCFC stations only, the maximum power level of the station (when not sharing power) in kilowatts or equivalent units. A description of how the aforementioned requirements for pricing information will be met should be included with the application.”

Comments: We offer a qualified endorsement to this recommendation. It would be helpful for New Hampshire to establish greater clarity on whether a smartphone constitutes an adequate user interface for displaying payment information. For an EV charger without a built-in display, a lit sign at a public Level 2 charger in a municipal parking lot is not overly onerous. However, different regulatory requirements exist for signage of parking prices and for signage of fuel prices. Electric vehicle charging includes components of both. The Division of Weights and Measures should be consulted on signage requirements.

Revisiting these Requirements: NESCAUM notes, “The model provisions were developed against the backdrop of today’s market and should be revisited periodically as market penetration grows and conditions evolve over time.”

Comments: We strongly support this recommendation. Although we encourage the release of the Volkswagen Settlement funds as soon as feasible, there may be other funding sources for EV charging infrastructure in the future. Revising these requirements will ensure that future public funding of EV charging infrastructure is appropriate to technological and market conditions.

4 EV Charging Infrastructure Opportunities and Challenges

Today, EV driver surveys consistently show that more than 90 percent of drivers have access to charging at home (Carmax, 2017). This demonstrates the potential gap in charging needs is *outside the home* along New Hampshire's most traveled roads, and therefore where the majority of EV charging investment resources should be focused.

While most EV drivers charge their vehicles at home, in order to vastly increase percentage of EVs within the state there must be access to alternate charging methods for those without access to home charging.

4.1 Factors Affecting Charging Site Choices

4.1.1 Charging Speed & Parking Duration

Today, DCFC can *provide* about 150 miles of range per hour of charging, with some newer equipment capable of providing 75 miles of range within five minutes. Most vehicle makes and models can *accept* energy at an average rate of about 75 miles of range per hour (considering the tapering that occurs as the vehicle approaches full charge). Tesla vehicles, emerging commercial medium and heavy-duty EVs, and a few other models from other manufacturers can accept energy at the full 150-mile per hour rate.

To maximize cooperation with property and business owners, ensure that *expected* EV parking/charging durations match *existing* parking durations. This ensures that EV drivers' parking habits are consistent with business owner expectations. Based on the current vehicles and fast charging equipment, we suggest using a 30-60-minute parking duration as an underlying assumption when choosing potential sites for fast charging. Recent trends in vehicle batteries and charging equipment suggest that required EV-charging/parking durations may shorten over the next few years. This refers to *average* EV charging duration, as there will remain a mix of slower-charging and faster-charging vehicles. Shorter charging times could lead to additional candidate sites, where today's observed parking durations line up with those required for EV charging, by opening up possibilities for sites where parking durations tend to be less than 30 minutes (e.g., convenience stores and traditional liquid-fuel filling stations).

4.1.2 Accommodating Shorter Range Vehicles

Tesla vehicles accounted for about 80 percent of the light-duty BEVs sold in the U.S. in 2018. Tesla vehicles have range in excess of 200 miles (typically at least 240), and an extensive charging infrastructure (which accounts for part of the cost of the vehicles). The sales-weighted average of non-Tesla BEV battery range was 170 miles, with about 30 percent having range of 125 miles or less (author's calculations based on Loveday, 2019). In colder climates and seasons, range can be reduced by 30 to 40 percent, or more in extreme conditions.

To maximize charging and routing opportunities for EV drivers, while keeping the number of proposed locations to a manageable quantity, choose sites with distances between that are 50 miles or less.

4.1.3 Distance to Existing Electric Service

Another limiting factor in charging site selections is proximity to existing utility distribution infrastructure, such as transformers with the appropriate "secondary" voltage (120-480 VAC). Without such infrastructure, installation costs grow quickly. The Electric Power Research Institute found sites that require trenching, coring, boring, or poured foundations cost approximately 25 percent more than those that do not need such work (EPRI, 2013). In addition, sites that need new transformers and other related equipment can add another 15 percent. Early engagement with utility providers can help facilitate better siting decisions.

In order to minimize site-acquisition and installation costs, start with sites with relatively high concentrations of existing commercial operations, and ideally those with existing EV charging equipment.

4.1.4 Distance Between Charging Sites

To ensure that site-selection considers owners of both longer-range and shorter-range BEVs, **space DCFC sites at intervals of approximately 50 miles**, as Figure 16 illustrates. In mountainous terrain and near ski areas, space chargers at **distances that are 30-40 percent shorter (every 30-35 miles)**. This spacing provides a diversity of charging opportunities at intervals equal to, or less than, half the effective range of today's lower-range BEVs*, across the entire State.* Such a strategy supports New Hampshire residents and visitors to the State. Sites should be designed to accommodate multiple charging ports and with consideration for expansion of charging ports and increased charging capacity as demand grows. With proper planning in advance, the cost for expansion at existing facilities will generally be less expensive than development of new facilities.

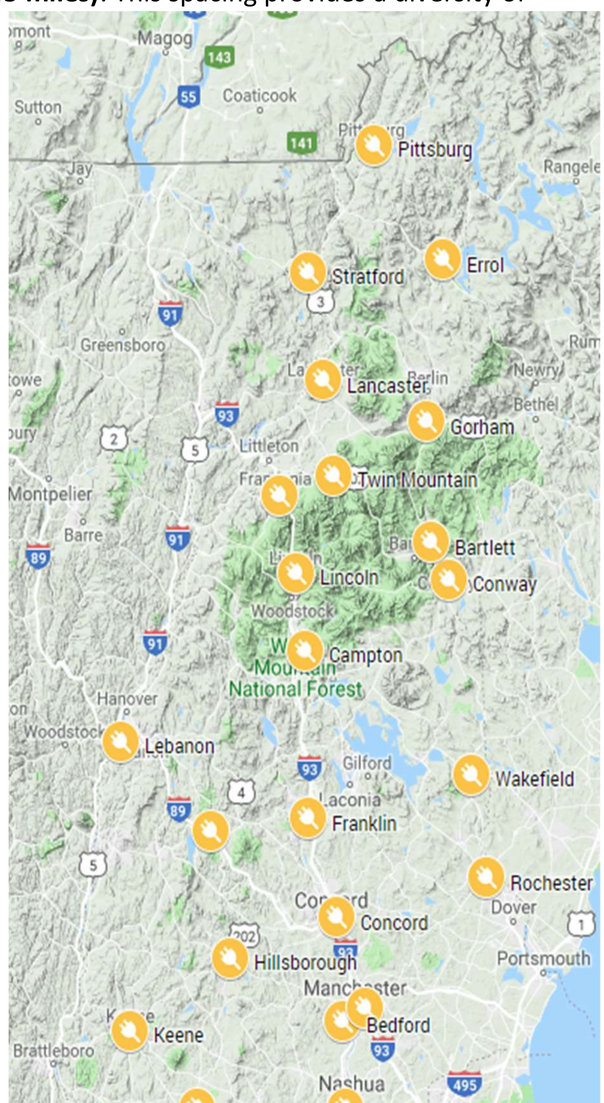


Figure 16: Identified Potential Charging Sites

For New Hampshire, 50-mile spacing between sites (and closer in mountainous areas) translates to 24 different locations across the State.

The locations shown in Figure 16 are chosen based on spacing, the intersection of major roads and, on characteristics conducive to charging (e.g. adequate parking, retail business with typical visitation durations consistent with a 30-45-minute stop, and existing electric distribution infrastructure).

The U.S. Department of Energy's Alternative Fuels Data Center maps (Figure 17 and Figure 18) show existing charging locations in New Hampshire. Figure 17 shows fast charging locations, and Figure 18 shows public Level 2 charging locations, appropriate for parking durations of 1-2 hours or more.

Since more than 90 percent of EV drivers have access to charging at home, and because medium and heavy duty EVs consume 2-4 times the energy per mile compared to light duty vehicles, this report focuses on Figure 17, DC *fast* *charging* opportunities *outside the home*, designed to support longer distance trips and intra-state or interstate travel by as broad a variety of vehicles as possible.

In Figure 17, the potential gaps in available charging service are in the North, East, and South/Central parts of the State. Stakeholders have noted that the DCFC in Lancaster, New Hampshire is at a seasonal campground. The station in Lincoln, New Hampshire is a Tesla Supercharger, as is the station in West Lebanon, New Hampshire. There are no year-round DCFC for non-Tesla vehicles in New Hampshire north of Concord. There are Level 2 chargers at many locations in the White Mountains and Northern New Hampshire, some of which could represent possible locations for DCFC with grants to defray the costs. Many of these are at small business site hosts that would not have the capital to install a DCFC; yet the cost here could be lower than at locations with no existing EV charging infrastructure.

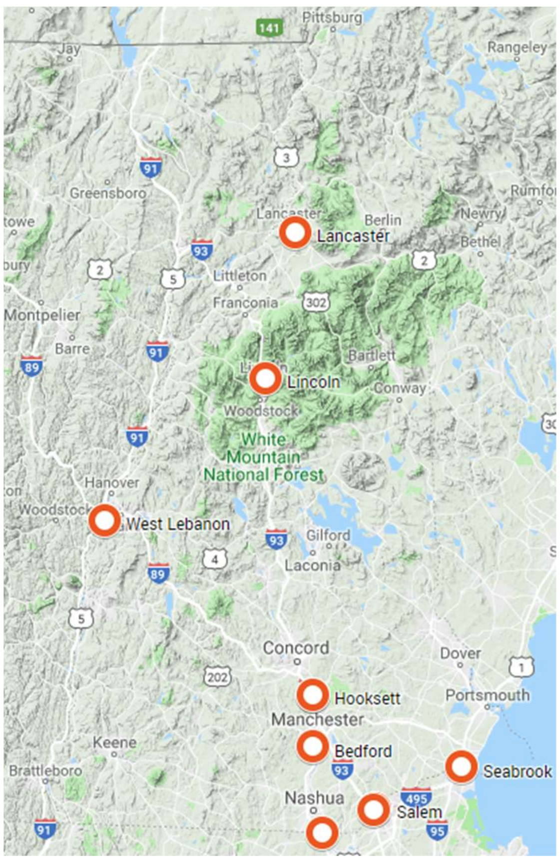


Figure 17: Existing DCFC in New Hampshire (CHAdeMO, CCS, Tesla)

9 New Hampshire locations (47 DCFC plugs)
Of these, 5 locations and 34 plugs are Tesla only

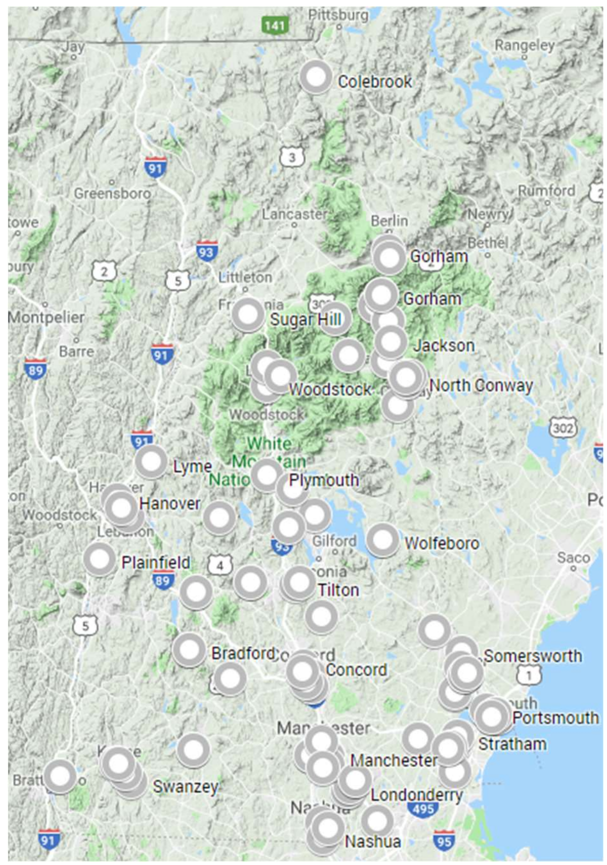


Figure 18: Existing Public Level 2 Chargers in New Hampshire

Some locations of existing Level 2 stations may be appropriate to upgrade to DCFC, with distribution capacity, amenities for drivers, and parking.

4.2 Choosing New Candidate Sites

The MJB&A GIS tool[1]

The MJB&A GIS tool focuses on freeway exits and other key highway and main road intersections ("exits") as possible locations for future infrastructure development.

The tool considers:

- Distance from each exit to nearest existing (public, non-proprietary) DCFC, and quantity of DCFC ports present;
- Number of commercial sites (gas stations and restaurants) within a mile of each exit;
- Population density by census tract and traffic volume on the freeway around each exit.

The interface is shown in Figure 19. Each location is assigned a cumulative score from 1 to 100 reflecting the suitability of that location for EV infrastructure development. This analysis was limited to areas near highway exits. We ran the model with assumptions heavily weighted toward the proximity of commercial activity (a factor the tool deems important to "Traveler Use" and "Resident Use").

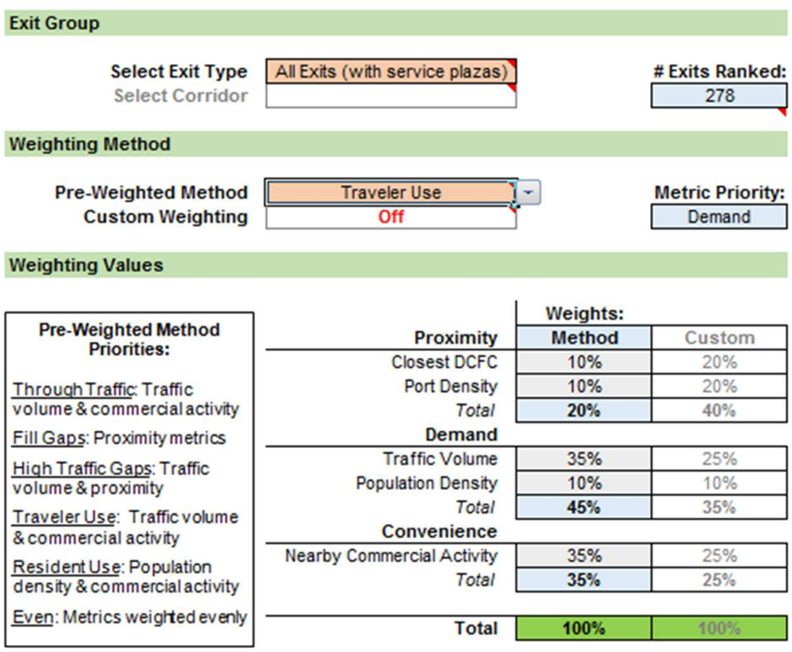


Figure 19: MJ Bradley & Associates GIS Tool Interface

Under these assumptions, the tool identifies exits consistently within a few miles of each other, all the way along all major highways (running North to South) in the Western part of the State.

Since these **results are too plentiful and closely spaced to provide value for defining a practical plan**, **we selected candidate locations using 30-50 mile spacing and considering the density and type of existing commercial locations.** These locations have sufficient electrical capacity, adequate parking, and businesses with visitor durations appropriate for DCFC.

4.2.1 Proposed Locations

Conducive locations in more populated areas are restaurants and retail stores. Parking durations here coincide with the needs of DCFC. In more remote areas, with fewer retail and restaurant establishments, we include post offices and churches. These alternative locations typically have ample parking and may represent controlling interests that are more amicable to hosting EV charging. As EV ownership and travel increase, the business case for operating a restaurant near even a rural DCFC will improve.

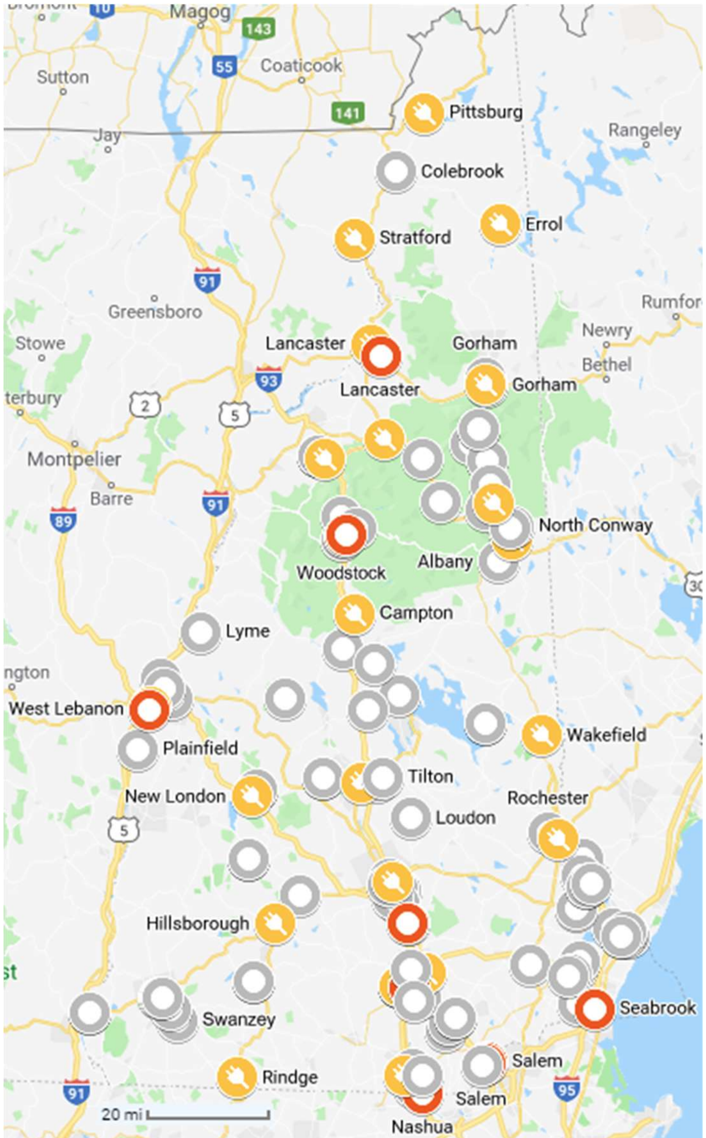
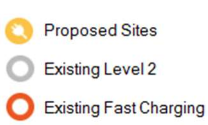


Figure 20: Existing DCFC and Proposed Sites



Note that although this Google Map review shows locations that appear conducive to EV charging (on or immediately adjacent to the highway) in each proposed city and town, this list is not meant to be exhaustive.)

We recommend a coordinated communications campaign, partnering with organizations such as local chambers of commerce to prioritize and outreach to potential EV charging site hosts.

For proposed DC fast charging sites, city centers were avoided in order to minimize exposure to exceptionally high-traffic and impacted parking areas (e.g. Bedford, on the South end of Manchester). Proposed sites within or near densely populated and/or high-traffic areas are more suited for Level 2 charging, at locations where parking durations are two hours or more (e.g., ski areas, schools and workplaces).

The following pages provide satellite imagery for specific city and town areas where conducive charging locations are found as shown in the map above.

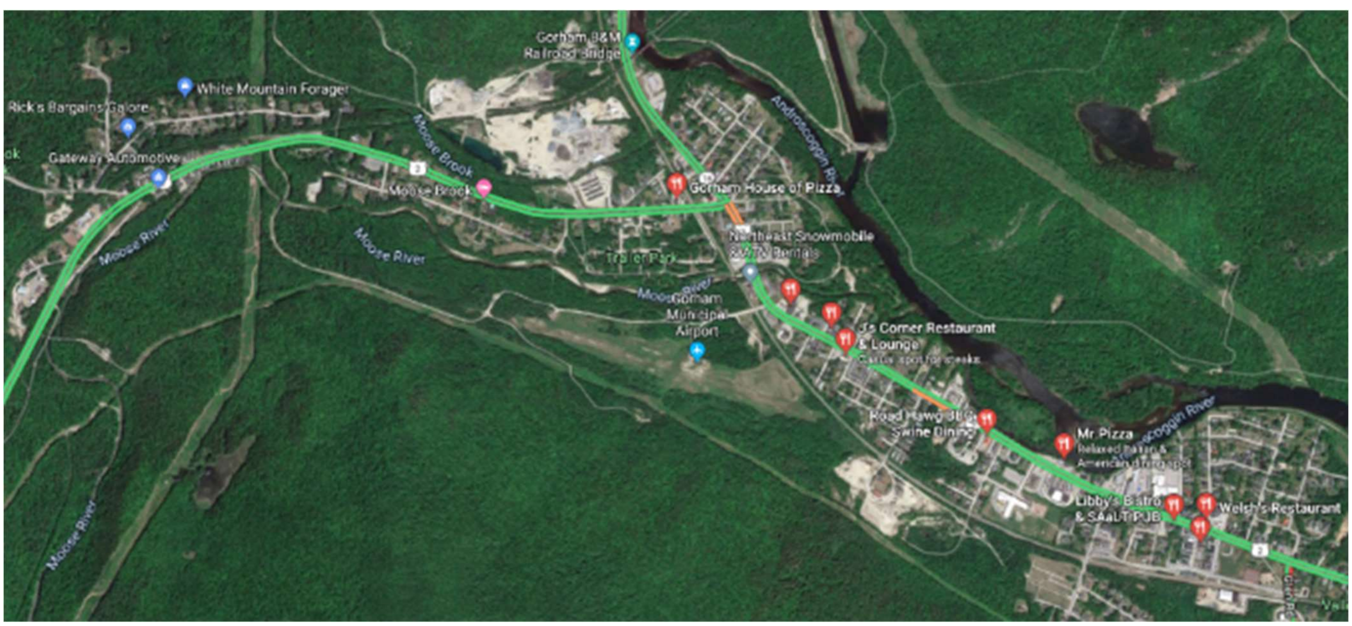
Pittsburg

Stratford

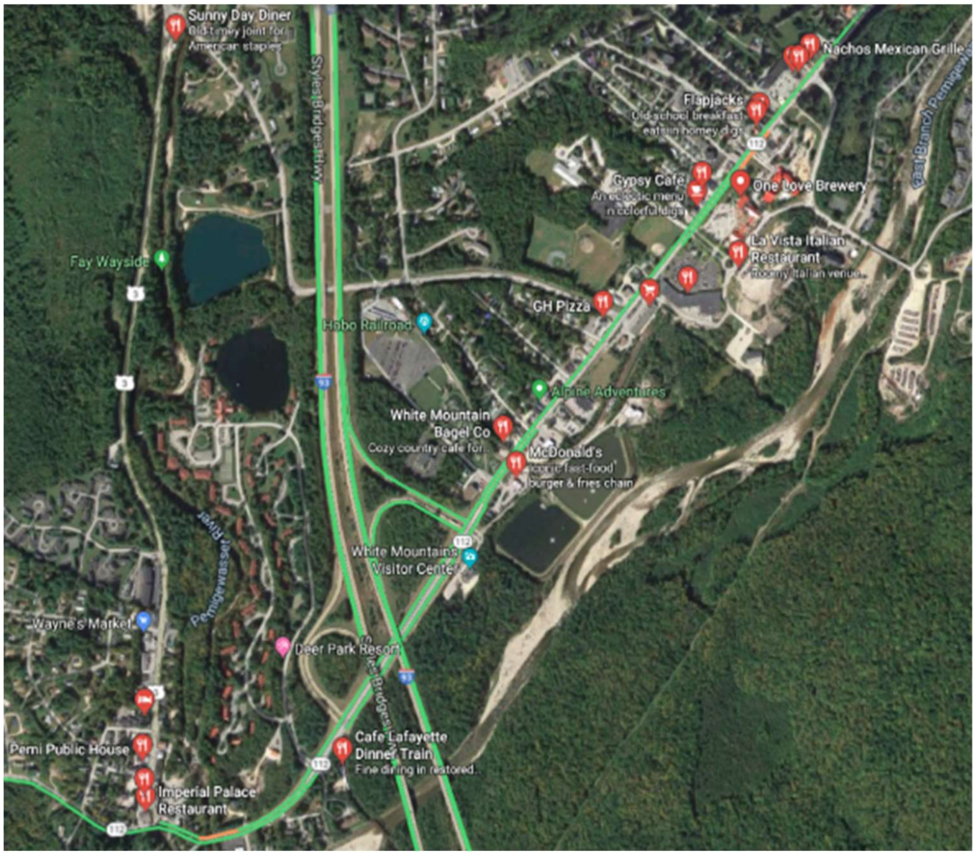
Errol

Lancaster

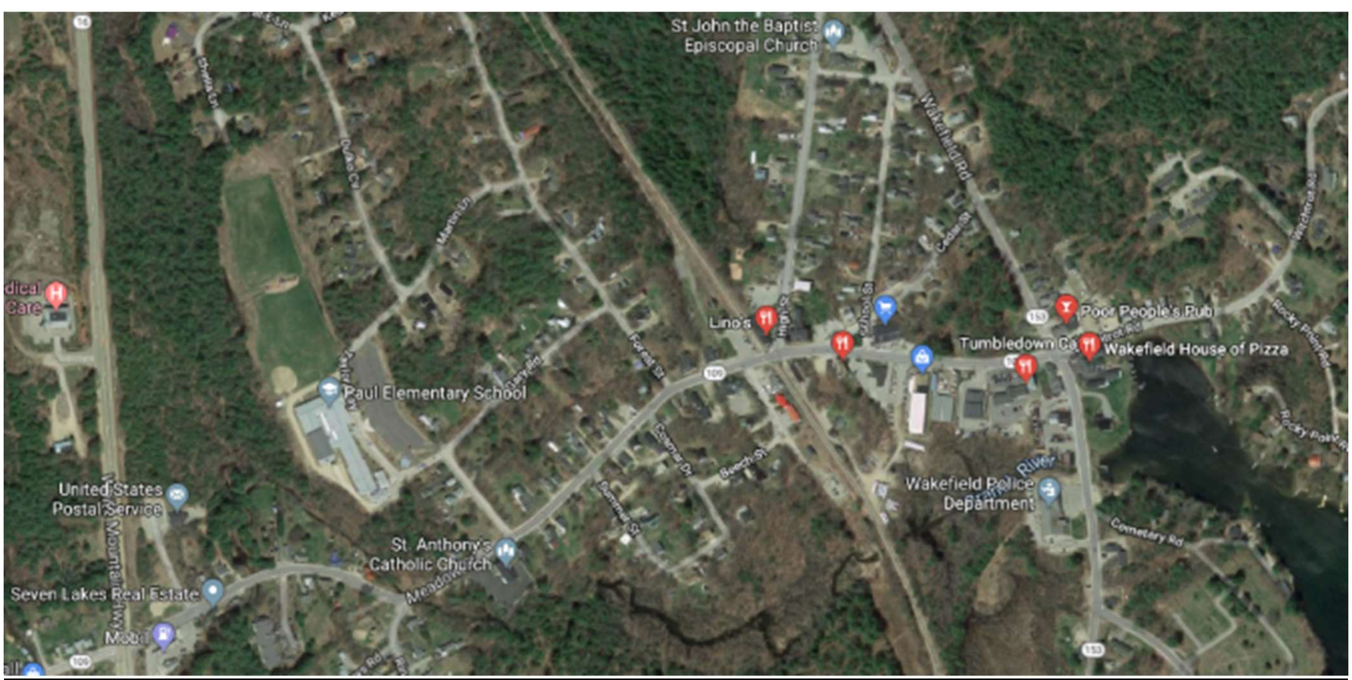
Gorham



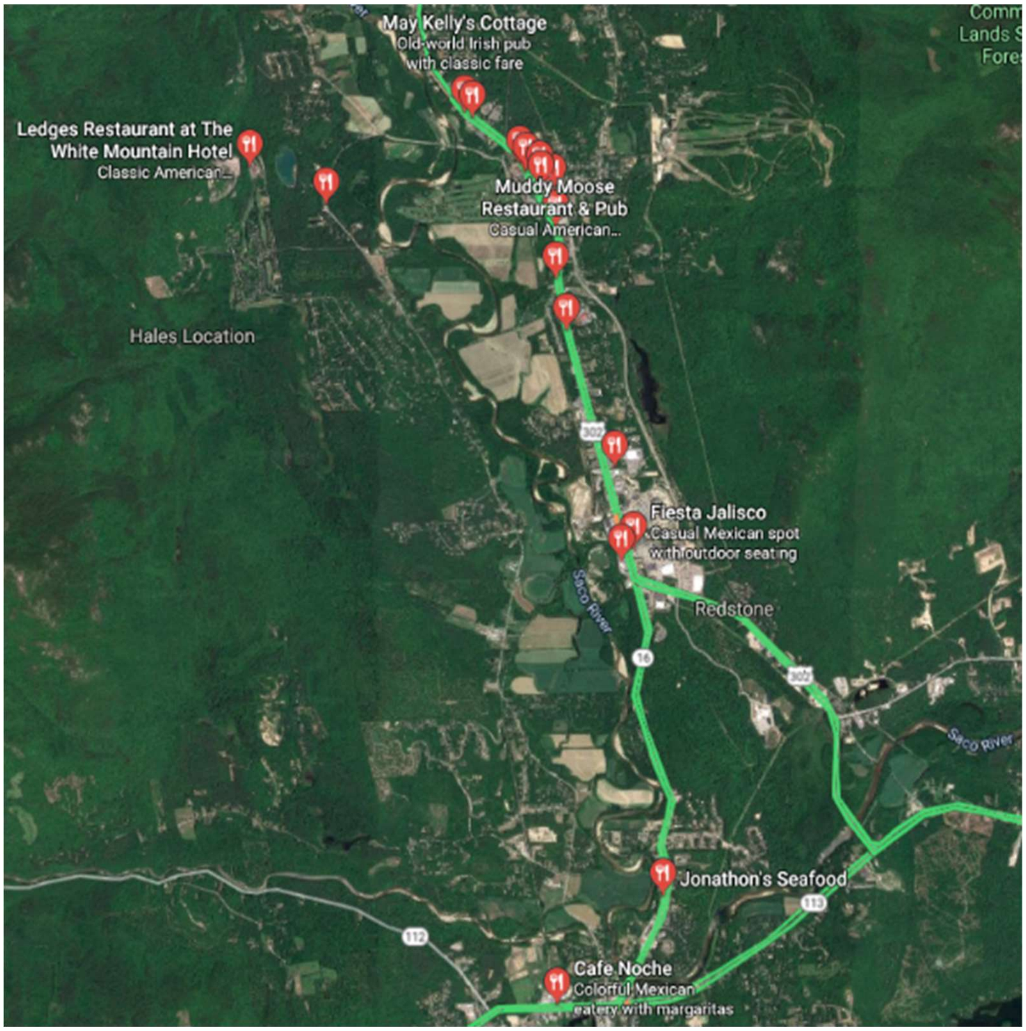
Lincoln



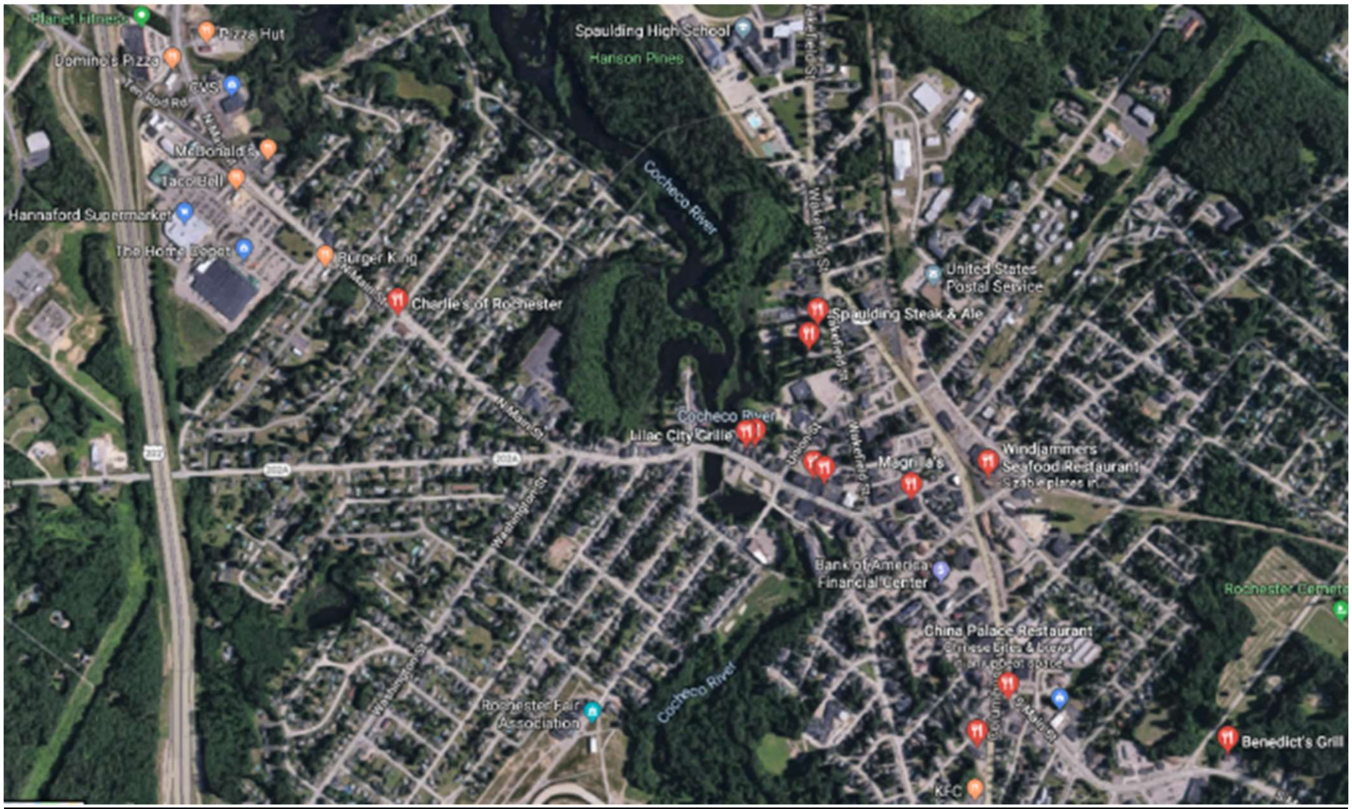
Wakefield



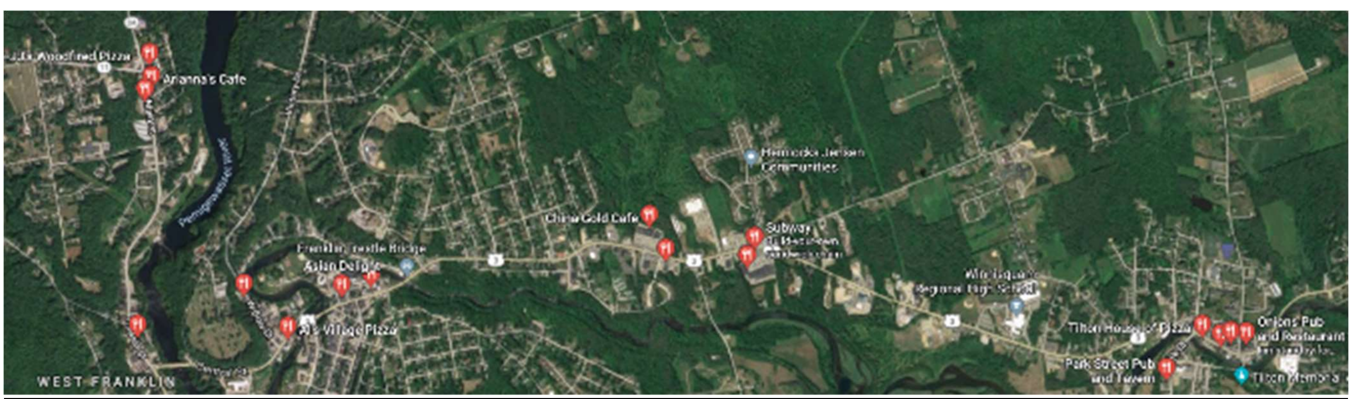
Conway/Redstone



Rochester



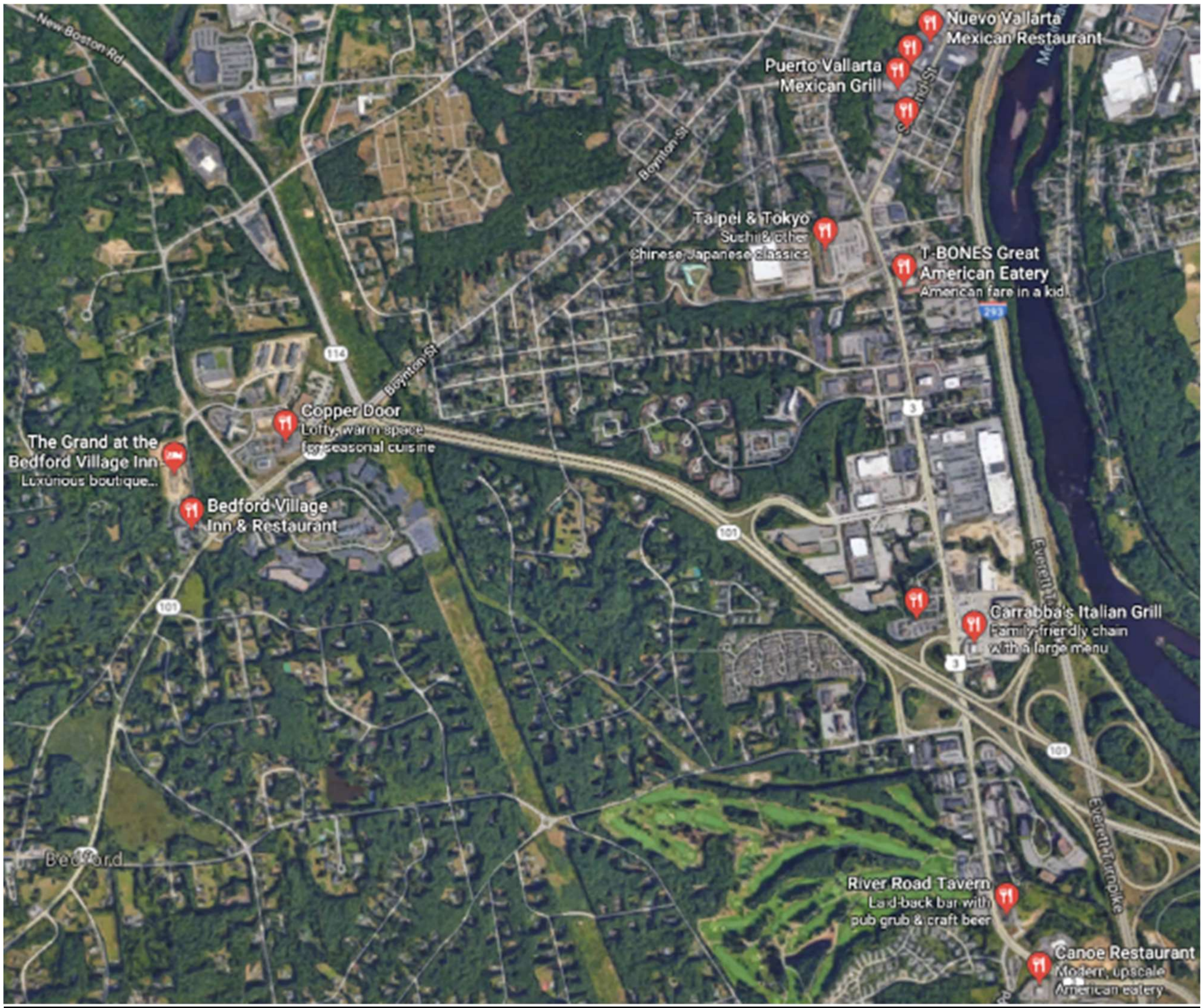
Franklin/Tilton



Concord


Smokeshow Barbeque
Market Basket
Panera Bread
Lowe's Home Improvement
Fort Eddy Plaza
L.L.Bean
Merrimack River
Wendy's
Hazen Drive
Airport Rd
Franklin Pierce Hwy
Buffalo Wild Wings
El Rodeo Mexican Restaurant
Homestyle fare in...
The Barley House
Gastropub fare, craft beer & buzzy digs
N Main St
Revival Kitchen and Bar
Classic bistro fare in a rustic setting
Siam Orchid Thai Bistro
Sal's Pizza
Pizza spot known for 3-pound pies
Vibes Gourmet Burgers
Willows Plant-Based Eatery
Casual vegan restaurant
South St

Manchester/Bedford



4.3 Recommended Infrastructure Strategies

- Review and refine the proposed locations in this document with the Planning Division of the Office of Strategic Initiatives, which leads the GIS Technical Advisory Committee, a subcommittee of the New Hampshire GIS Committee and leverage their participation in numerous state agency coordination activities related to land use planning, demographics, smart growth, recreation, floodplain management, land conservation, climate change, water resources, and community development:
    - In addition, the department provides information, data and guidance to assist decision-makers on issues pertaining to development, land protection, energy use and community planning. We guide the state's future growth through public policy development, education, research, and partnership building;

    - OSI operates several Energy Programs in partnership with both private and public entities to promote a sustainable, environmentally sound and least-cost energy future for New Hampshire: https://www.nh.gov/osi/energy/programs/vw-settlement.htm;
- Charging network operators have noted that they find it easier to engage with large companies that have numerous locations. While this will account for some EV charging infrastructure deployment, it is important to ensure that small and independent businesses also benefit. The State can work with local organizations such as chambers of commerce to provide such businesses with the information and expertise needed to navigate this process, as well as a point of contact for the charging network operators.

4.3.1 Selected Infrastructure Planning Tools and Information Resources

New Hampshire OSI	https://www.nh.gov/osi/planning/index.htm
New Hampshire Proposed Expenditure – Volkswagen Settlement Appendix D: Electric Vehicle Supply Equipment 15 percent ($4.6 million) – acquisition, installation, operation and maintenance of EV charging stations	https://www.nh.gov/osi/energy/programs/documents/osi-des-vw-public-information-sessions.pdf
Estimate number of charging units for each area	https://afdc.energy.gov/evi-pro-lite
New Hampshire electric system information	https://www.iso-ne.com/about/key-stats/maps-and-diagrams/
Volkswagen/Electrify America	https://www.electrifyamerica.com/charging-with-us
Electrify America Cycle 2 Investment Plan	https://elam-cms-assets.s3.amazonaws.com/inline-files/Cycle%202%20National%20ZEV%20Investment%20Plan%20-%20Public%20Version%20vF.pdf

5 Stakeholder Input

In partnership with the Department of Economic Affairs, the Department of Environmental Services, and other key stakeholders, outreach was performed via an online survey and interviews to the following sectors requesting their input to help shape this analysis:

- Charging Network Operators;
- EV Charging Installers;
- Fleet Operators;
- Site Hosts With EV Charging;
- Site Hosts Without EV Charging;
- Auto Dealerships;
- Auto Manufacturers;
- Utilities;
- EV Collaboratives;
- EV Drivers within New Hampshire;
- EV Drivers in States Surrounding New Hampshire.

Several common themes emerge from these conversations. Stakeholder input provides the basis for the following recommendations:

Allow utility make-ready investments: Make-ready programs are broadly supported; are consistent with established utility regulatory practice; are particularly important for rural locations (where the parking area may be far from the electrical service); and, are a proven success in other regions of the country. The New Hampshire Public Utilities Commission could solicit proposals for transportation electrification programs from the utilities that include a make-ready component. It could also clarify all other conditions under which utilities can rate-base necessary distribution improvements to serve the load of EV chargers.

Implement demand charge rate relief for DCFC: Numerous stakeholders point to demand charges as a barrier for installing DCFC. We support moving fast charging stations from demand charge tariffs while system utilization is low. Time-varying rates may be a better means of addressing systems impacts than kW-based demand charges. Pilot programs in Hawaii and Connecticut have removed demand charges for DC fast charging for five years. Pacific Power in Oregon removed the demand charges completely for now and installed a 10-year ramp to phase demand charges back in. The State of New York has implemented a program of rebates to DC fast charging systems to partially offset its demand charges; however, it does not apply to existing systems. We do not support this aspect of the New York program. We strongly recommend that any demand charge reform or relief should be applied to all DCFC.

Respect varying business models: We strongly recommend that any grant programs for destination charging, workplace charging, or public charging be applicable to a range of business models regarding EV charging ownership.

Study use cases for utility ownership: Utility ownership of the charging stations may be an appropriate solution in areas of environmental justice concerns, or in areas of low or moderate income. These areas could be underserved in the near term by the free market. In addition, we suggest that rural “linchpin” stations that see low traffic but are vital for occasional long-distance trips may be suitable for utility ownership. Potential EV buyers consider not only where they routinely do travel, but also where they *might* want to travel, regardless of how often they would actually do such trips. Such stations could have a value in EV adoption that is *not* reflected in their utilization.

Implement standards and requirements for publicly funded infrastructure: All publicly funded infrastructure should adhere to the requirements of SB 575. Regarding detailed specifications, the Northeast States for Coordinated Air Use Management (NESCAUM) released the document *Building Reliable EV Charging Networks: Model State Grant and Procurement Contract Provisions for Public EV Charging* (Kinsey, O'Grady, and Way, 2019). New Hampshire was a participant in the development of these standards. We *generally* endorse the findings of this document, but highlight the recommendations that states make modifications to suit their individual needs and circumstances and that the standards be revisited periodically (see Section 3.2.8 for more details).

It is important to install relatively inexpensive ESVE now, while acknowledging the technology is changing and evolving. It will take time to come to a consensus on technical standards and requirements. However, reliability is paramount. If non-functional stations were to result in stranded drivers, not only would the EV industry suffer, lives could be at risk (in winter conditions). Therefore, we encourage flexibility in technical requirements, coupled with firm requirements for redundancy and uptime guarantees.

Develop "EV-ready" building codes: Building codes for residential and commercial construction should require that all new construction include infrastructure to accommodate EV charging as this will reduce the costs of installing EV charging infrastructure. It is less expensive to include the charging infrastructure (at least the conduit and panel capacity, if not the actual charging station) at the time of construction.

Develop Time-of-use pricing or similar approaches: There are numerous means to encourage EV drivers to charge off-peak. Doing so will allow greater asset utilization by the utilities, enabling a substantial increase in kilowatt-hour sales with only moderate costs to serve this load. That will place downward pressure on electricity rates for all consumers. There can be whole-house time-of-use rates, EV-only time-of-use rates (with submetering), or non-tariff time-of-use incentives.

Provide charging infrastructure grants or rebates: Numerous stakeholders noted that the capital cost of charging systems can be a deterrent to site hosts. These costs can be defrayed with grants or rebates, using available sources of funding.

Develop best practices and expedite permitting: Stakeholders offered a number of suggestions on how to expedite inspection and permitting at the local level and outlined a role the State could play in education of local officials.

Stakeholder input particular to each sector is summarized below.

5.1 Charging Network Operators

Charging network operators provided substantial input and expressed a range of viewpoints. Due to their varying business models they differ as to which will be the most effective at expanding EV charging infrastructure.

Network operators that own and maintain charging stations on site hosts' properties encourage this ownership business model stating it provides greater reliability to both the site hosts and EV drivers. Those network operators that prefer the site host to own and maintain the chargers emphasize this model provides site hosts the flexibility to determine pricing and parking policies. Network operators' business models that focused on the deployment of DC fast charging emphasized the need for investment in chargers that provide drivers quicker refueling times, while those that focused on Level 2 charging noted such benefits as lower installation costs.

Respondents suggest that EV chargers capable of demand response or load management could also be funded through a rebate program as part of Demand Side Management activities. Workplace charging could be suitable for such a program, as those systems are generally used by a regular pool of drivers who can be informed about pending load curtailment a day in advance and plan their charging accordingly. Alternatively, a Southern California Edison pilot featured paid workplace charging in which the driver could select from three price options: a high price for a guarantee of no interruptions during a demand response event, a medium price for curtailing to Level 1 charging during such events, and a low price for curtailing to zero during demand response events (Ashley 2016). Public charging in municipal parking lots could also be used in this way. We recommend that New Hampshire investigate this potential if additional demand response capability is desired.

Respondents requested New Hampshire adopt building code policies for residential and commercial construction requiring all new construction include infrastructure to accommodate EV charging. Building codes are discussed further in Section 3.2.3.

Network operators noted specific areas of New Hampshire that would benefit from additional charging infrastructure, such as:

- Mountain regions;
- East of I-93 toward Maine;
- Northeast New Hampshire;
- Additional charging in the Concord area, where state highways and federal interstates converge;
- Interstates 89, 93, and 95;
- Highways 2, 4, 9, 16, 101, and 302, to which utility respondents added 3, 11, 25, and 202;
- Tourism destinations (e.g., parks, ski resorts, accommodations);
- Municipal and retail locations.

Regarding their site hosts customers, network operators said they can be motivated to install charging by several factors:

- Desire to attract new customers or tenants with a valuable amenity;
- Increased retail foot traffic and retain those customers for a longer period of time;
- Demonstrate sustainability leadership by showcasing emission reductions;
- Electrifying the site hosts' own fleet vehicles (particularly for municipalities);
- Assurance that the equipment will be used;
- Financial incentives or external investment to cover or offset costs.

Network operators select charging locations not only based on site hosts' interest, but also on:

- Driver travel patterns and proximity to retail and major travel corridors;
- Weather and elevation impacts on driving range;
- Range of vehicles on the road;
- Location of amenities that would be a good experience to charge for 30+ minutes (e.g., restrooms, food, security, WIFI);

- Development, utility upgrade, and operating costs;
- Adequate parking capacity;
- Safety;
- Visibility and ease of access;
- Community engagement.

It is often easier for network operators to execute a few agreements with larger companies that own or manage multiple properties, rather than executive many individual agreements with small businesses. A major property management firm mentioned as a partner in EV infrastructure deployment has most of its properties in Southern New Hampshire. While this partnership is helpful, it would be unfortunate if independent small businesses and those in Northern New Hampshire were excluded from the economic benefits of hosting EV charging infrastructure. We recommend that organizations such as BEA and the chambers of commerce seek ways to support New Hampshire's small businesses in executing these agreements, such as by providing information or model language.

Respondents suggest the State of New Hampshire consider:

- Tax incentives for charging infrastructure investment;
- Approving the ability of utilities to rate base charging infrastructure investments;
- Establishing that EV charging represents an accessory use and does not require separate zoning approval from the site host;
- Establishing an assertive state ZEV goal;
- Development of a robust statewide infrastructure plan incorporating the funds from the Volkswagen Settlement (Appendix D);
- Prioritize investment in high-use areas first;
- Address demand charges for DCFC, shifting a larger portion of the cost recovery onto time-of-use kilowatt-hour rates;
- Educate local jurisdictions on EV charging technology and best practices;
- Consider legislation similar to California's AB 1236, requiring an expedited permitting process;
- Develop best practices for local jurisdictions such as an EV permitting checklist and timeline.

Network operators agreed that demand charges pose difficulties for DCFC, particularly in the early stages of EV adoption when utilization is low and recommended:

- The PUC should develop rate designs that encourage off-peak charging;
- If necessary, utilities should increase or reorganize staffing to effectively collaborate with EV charging providers and provide information on grid capacity in a timely manner;
- The PUC should consider developing EV-only rates.

Charging network operators also had a range of opinions about the requirements imposed on publicly funded charging stations. They request clarification about what universal access entails in the context of SB 575 and what qualifies for multiple payment options. They recommend that New Hampshire not require credit card readers or display screens due to the increase in system costs. Other states, such as California with its SB 454 (2013), which is similar to SB 575, have addressed this issue. As well, the Northeast States for Coordinated Air Use Management has addressed the topic. The issue is further detailed in Section 3.2.8.

Network operators emphasized the need for utility programs that install infrastructure up to the charging station and rate reform. Stakeholders noted that utilities are ideally situated to ensure the associated new load of EV charging is incorporated in a safe, reliable, and efficient manner. Network operators note that utility make-ready line extension policies and regulatory approval of utility charging infrastructure programs installed up to the charging station equipment but not including it can effectively lower the cost of installing charging. Charging network operators offered Southern California Edison's "Charge Ready 2" program as an example of a well-designed make-ready program.

Respondents added that make-ready investments constitute extensions of the distribution infrastructure, and so are appropriate to include in the rate base. They noted that utilities have a powerful financial tool in rate-basing, being able to access low-cost capital with a long time horizon for recouping costs. They also noted that by doing so, utilities would put more EVs on roads across the U.S. and improve air quality for all.

5.2 Site Hosts

Site hosts offering EV charging, and those considering offering EV charging, submitted comments. The 23 respondents represented ski resorts, hotels, and restaurants. Approximately half offered a variety of charging levels and did not charge drivers to use them. These site hosts reported little problems with maintenance. Most of those who did not offer charging cited system cost as the reason.

All respondents offered suggestions that would encourage either the additional installation of chargers or for them to install chargers:

- Grants or rebates to reduce the cost of charging installation;
- A greater demand by drivers for their business to offer the service;
- The ability to charge EV drivers for electricity;
- Greater cooperation from installers to install in rural areas, said one lakeside bed and breakfast.

Given the importance of rural EV charging in ensuring complete coverage, this last experience stands out as problematic. The property owner wanted to have an EV charging station installed but was unable to find installers willing to do the work.

5.3 Auto Dealerships

Only two auto dealerships responded. One indicated problems obtaining EVs from certain manufacturers due to New Hampshire not participating in The ZEV Mandate, due to EVs allocated first to the states with these ZEV requirements. In some cases, manufacturers make just enough vehicles to meet these requirements.

One respondent noted that there is an interested population of EV buyers in the Seacoast area, with range anxiety alleviating as the potential buyers learn more about the vehicles' range and the charging infrastructure. The other recommended incentive programs for both EVs and chargers, stating such programs would encourage the installation of EV charging at their own property.

5.4 Utilities

Three New Hampshire utilities participated in the survey. One did not see a role for the State in encouraging EV adoption, and two recommended:

- The development of EV charging at state and local facilities for public use;
- Approval for utility make-ready infrastructure;
- Releasing the Volkswagen Settlement Funds for a network of DC fast charging stations.

The utilities also requested:

- Upfront provision of complete equipment specifications and land use issues (e.g., easements), through both cooperation from the installers or networks and a clearly defined process by the state;
- Installations that include extra conduit run to additional parking spaces to plan for future expansion;
- Move charging installation forward now with inexpensive chargers without waiting for a final consensus to emerge on every detail of technological requirements (whether payment options, displays, "smart charging" functionality, or standards and protocols).

The utilities expressed interest in electrifying their own fleets as soon as the necessary vehicles become available at reasonable prices. These include medium- and heavy-duty EVs, as well as all-wheel-drive light-duty cars, trucks and vans.

Utilities are interested in monitoring and determining potential impacts to the electric grid from the added loads at specific locations and upgrading service to ensure the continuity of safe and reliable service to customers. Utilities also noted only one New Hampshire utility allows the resale of electricity by charging station owners so they can charge by the kilowatt-hour; the New Hampshire Public Utilities Commission allows all utilities to offer this rate. Therefore, this should be a statewide offering.

Regarding DC fast charging rate design, utilities acknowledged that a balance must be found to ensure cost causation of added loads while providing just and reasonable electric rates to the charging station owner. One suggested integrating stationary storage with DCFC to reduce the impacts of demand charges.

5.5 Installers

Two EV charging infrastructure installers responded to the survey. Like the network operators, they emphasized the need for utility programs that install infrastructure up to the charging station as well as rate reform. Installers noted that site hosts are motivated to install charging by:

- The existence of utility make-ready programs;
- The existence of charging incentive programs (e.g., grants and rebates);
- Using the stations to demonstrate sustainability leadership;
- The presence of an EV Champion or advocate at their organization;
- Employees with EVs;
- Increased sales for businesses from customers with EVs.

Installers noted that municipalities would benefit from having a designated staff member to help fast-track permits and inspections. One proposed conducting semi-annual stakeholder training workshop and networking sessions focused strategically throughout the state, beginning with Concord, to establish the right formula and adding a city each month thereafter. Stakeholder attendees would be encouraged to also participate in events outside of their locale and act as testimonials to build momentum across the state. These workshops would include presentations to electricians, inspectors, planning departments, and departments of public works (DPWs), with break-out sessions to discover EV charging issues focused on that particular region that need solutions. The State of New Hampshire could then become a resource for best practices and frequently post the findings on their website.

Installers recommended utilities have regional field technicians attend these workshops, be designated the point of contact for EV charging infrastructure for that region and be empowered to make decisions to expedite the installation process. Installers noted that because EV charging installations are newer than other utility infrastructure projects, they often are passed to management, which prolongs the process and provides a poor customer experience for their customers. They also requested utilities provide adequate staffing for their EV teams, consider creative use of make-ready pilots that allow private installers access to projects, and prioritize funding for infrastructure.

Other permit streamlining recommendations focus on efforts to provide visibility to all municipalities of their neighboring city’s EV charging permitting costs to help bring them into parity, requiring infrastructure for charging to be included in new building codes, and providing incentives for public charging installations. Another recommendation is to consider a program similar to Oregon's Minor Label Program, which will help streamline and reduce permitting costs and code enforcement (Oregon Building Codes Division, 2019). The Minor Label is an inexpensive form of permit used for certain types of improvements and is valid anywhere in the state.

Installers had varying opinions on the requirements for charging stations, as one encouraged installing only networked chargers, while the other said stations with low utilization might warrant basic, non-networked charging that is free to EV drivers. Such non-networked stations could be replaced in the future as usage grows and justifies the cost of revenue collection. As well, networked stations may encounter problems in areas of unreliable cellular service, and another stakeholder noted that multiple municipalities have opposed a networking requirement. Both installers recommended flexibility in standards and requirements at this time. One advised against requiring credit card readers due the cost and risk of fraud by tampering with the magnetic strips and stealing driver credit card information.

Installers noted that the market is resolving roaming agreements and that this form of interoperability need not be mandated. In addition, one noted that the OCPP standard requiring driver membership to different networks is important but perhaps not currently worth the added cost in rural areas.

Installers advise that grants to support EV charging infrastructure should cover necessary site features such as bollards and signage.

They also proposed some innovative ideas, such as:

- A specific rural grant program as directed by the legislature;
- An EV charging infrastructure incentive in the NHSaves energy efficiency program;
- A series of EV charging workshops at relevant energy/sustainability events and across the state;
- Public EV charging at high visibility state tourism locations, such as the Statehouse.

5.6 Fleet Operators

We received nine survey responses, with respondents representing six different transit fleets and two freight delivery fleets. Responding transit fleets ranged from six light-duty vehicles to over 100 medium- and heavy-duty vehicles.

Transit buses are the most frequent fleet component, followed by light trucks. Public transit is the most common role, followed by student transportation.

Most vehicles in the fleets had daily routes under 120 miles, as shown in Figure 21, below:

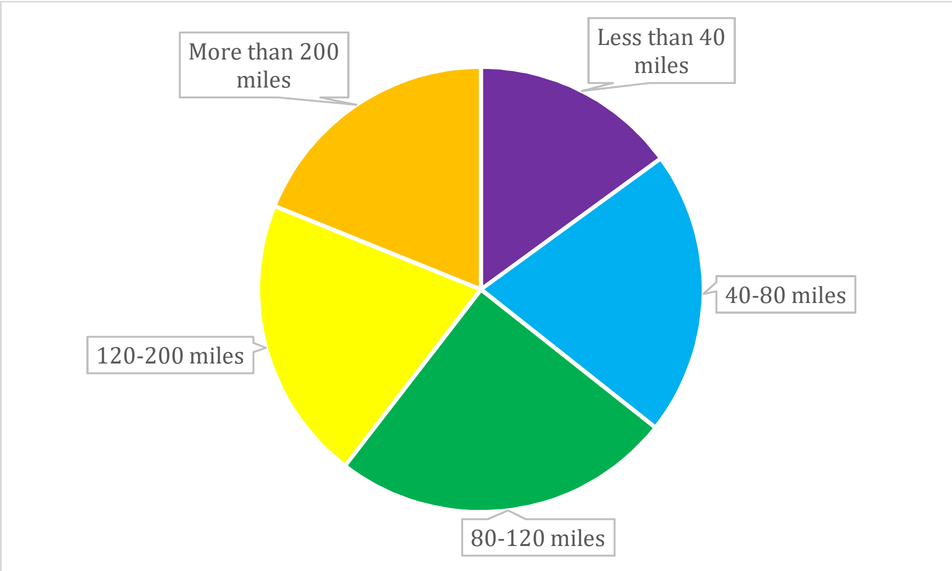


Figure 21: Daily Driving Demands of Fleet Vehicles. Source: CALSTART survey.

The vehicles averaged a top speed of 53 mph and averaged a maximum grade of 16 percent. All but one fleet noted that cost per mile was the most important factor in their decision-making.

Overall, many of the fleets seemed to be suitable candidates for electrification in the future. Most fleets reported at least 10 hours of dormancy per day for their vehicles, allowing charging with existing 50 kW DCFC given the mileage requirements.

Fleet operators report lack of model availability and economic barriers as the major obstacles to EV adoption. It was noted that the economics of school buses can be challenging given the low hours of operation. An electric bus costs more upfront, but can achieve lower costs per vehicle-mile. However, school buses only operate for about four hours a day for 180 days per year. We note that the economic value of pollutant reductions, especially around children, provides a sound rationale for public investment that could make the economics of electric school buses more favorable.

5.7 EV Drivers

EV drivers were the most numerous respondents to the survey, providing extensive comments reflected in Section 3, and specific recommendations as to where additional EV charging infrastructure would be useful. North Conway was the most commonly mentioned location. It should be noted that EV drivers to date represent early adopters and even so are still most likely found in areas with adequate public charging capability. Their geographic distribution may under-represent northern New Hampshire. The non-EV drivers who might adopt these vehicles in the future represent a much larger and more geographically diverse group.

5.8 Other Stakeholders

Other stakeholders, not included in the above categories, were contacted for interviews, rather than completing a survey. These stakeholders included auto manufacturers, EV collaboratives, regional planning organization officials, and local energy committees. They recommended:

- Including EV charging infrastructure and equipment tax credits or loan programs in the revisions to the New Hampshire Community Development Finance Authority's clean energy programs;
- Encouraging State and municipal fleets to lead the way in purchasing vehicles and installing EV charging available to the public;
- Releasing the Volkswagen Settlement Funds for shovel-ready projects in various locations, such as state-owned safety rest areas and municipal parking lots;
- Considering the possibility for limited cellular service to impact credit card functionality;
- Installing EV charging infrastructure with new construction, to keep the incremental cost low;
- Gaining insight into station reliability;
- Emphasizing hotels as priority site hosts for destination charging;
- Highlighting, promoting, and giving credit to builders making EV-ready developments such as multifamily housing;
- Establishing partnerships and collaborations with third parties;
- Locating EV charging at State-owned Park & Ride facilities, especially underutilized ones.

6 Conclusion

The EV market is growing in New Hampshire, and in the surrounding states that support New Hampshire businesses. EVs will reduce air pollution in New Hampshire and reduce emissions of GHGs. They also offer an economic boon for local businesses near charging infrastructure.

Across each vehicle segment—light-duty, commercial medium- and heavy-duty, public transit buses, and school buses—EV adoption is accelerated by incentives, infrastructure solutions, and policy support. Light-duty vehicles have seen the most robust uptake in California and Northeast states, where there is relatively extensive EV charging as well as steady financial incentives and ZEV sales requirements. Commercial vehicles are breaking through in California, New York, and Chicago where voucher programs are bringing down the purchase cost of vehicles for fleets. Transit agencies are utilizing multiple coordinated funding sources to electrify their fleets, which improves air quality and the health of their communities. Electric school bus deployments have succeeded through partnerships with local governments and utilities.

Coastal and metropolitan regions have had much more success than rural regions in EV adoption due to the increased availability of incentives. Rural regions have the need and ability to adopt EVs, but it requires public, private, and utility investment.

The most immediate source of funds for EV charging infrastructure is the Volkswagen Settlement, Appendix D (Breyer 2016). Utilities have proposed to spend a portion of these funds on DC fast charging infrastructure. This investment will spur EV adoption; greater EV adoption will spur investment by charging companies, site hosts, and others in meeting vehicle charging needs. That will in turn spur additional growth in EV adoption. The funds should therefore be allocated as soon as possible through a Request for Proposals from OSI. In addition to the utility plan, some municipal partners have noted “shovel-ready” projects awaiting the release of these funds. OSI has announced its intentions to include a State Allocation, a Municipal Allocation, and a School Bus Allocation. This would be a suitable use for the remaining funds. We recommend that the State and Municipal allocation target transit fleets, workplaces, destination charging, multifamily housing, and public charging in metro areas (such as at municipal parking lots).

The Congestion Mitigation and Air Quality (CMAQ) program represents another potential funding source for EV charging. The deadline for Letters of Intent for 2019 projects was June 7, 2019; the program is also funded for 2020 so there will be additional funding possible in that year. The program may be renewed in future years. CMAQ funding requires the involvement of the Regional Planning Organization.

Reasonable and prudent utility investment in EV charging infrastructure is warranted under existing regulatory practice. To the extent that EV charging infrastructure leads to increased revenue to the utility, it is reasonable to make the necessary investments to serve that load. A relatively small investment in infrastructure for public DC fast charging can lead to a much larger increase in residential electricity consumption for EV charging, as the infrastructure enables EV adoption. The large induced demand at the residential level (mostly off-peak) places downward pressure on rates for all ratepayers, including those who do not own EVs. “Thus, utility investments in public charging infrastructure should be thought of as investments in load growth similar to line extensions, even though a portion of the incremental revenue from investments in public charging accrues from home charging.” (Jester, 2018)

Other possible funding options include a Federal infrastructure bill, which could include a grant program to the states for EV charging infrastructure. The State of New Hampshire may also include funding for EV charging infrastructure along highways in its next 10-year highway plan.

Regional stakeholder feedback reveals a community in New Hampshire that is excited about and engaged with EV charging infrastructure deployment, with many excellent suggestions to offer. Based on this feedback, best practices implemented across the U.S., and the authors' expertise, we offer the following key recommendations to support EV charging infrastructure through appropriate policies and prudent investments. These recommendations are not the policy of the State of New Hampshire, the Office of Strategic Initiatives, the Department of Business and Economic Affairs, or any other New Hampshire state agency.

1. Fully, and expeditiously, fund the utilities' plan for installing DCFC at 10-16 sites across New Hampshire;
2. Authorize utility investment in make-ready infrastructure for EV charging systems and develop rate structures and programs to encourage off-peak EV charging. This will place downward pressure on rates for *all* ratepayers;
3. Develop EV-ready building codes for new residential construction, particularly multi-family housing, and for new commercial construction. This will lower costs, compared to installing charging stations after buildings are constructed;
4. Evaluate, modify, and apply the principles for consumer protection developed by the Northeast States for Coordinated Air Use Management (NESCAUM) to grants and procurements for EV charging infrastructure, to ensure the goals of SB 575;
5. Develop a plan to temporarily alleviate the disproportionate impact of demand charges on DCFC economic viability during the early adoption period while utilization is low, possibly shifting a greater portion of the cost recovery to time-of-use energy-based rates;
6. Develop programs to allocate the remaining Volkswagen Settlement funds in grants or rebates for other types of EV charging infrastructure, such as to local governments for EV charging at municipal properties and parking lots; to site hosts who want to install destination charging (with a portion reserved for destination charging in rural areas); to companies deploying workplace charging or fleet charging, and to residential customers (with a portion reserved for multifamily housing);
7. Develop and implement a coordinated communications campaign, collaborating with organizations such as local chambers of commerce, to prioritize and conduct outreach to potential EV charging site hosts. Provide information to assist site hosts in executing agreements with charging networks and installers;
8. Support local governments in permitting and approving EV charging infrastructure, possibly through a regular series of workshop and networking events;
9. Establish an assertive state ZEV target, supporting, when possible, grants or rebates for EV purchases, including light-duty, medium-duty, and heavy-duty vehicles;
10. Pay particular attention to the increased energy demands on of EVs in winter, supporting drivers with greater DCFC density along mountain roads; education and awareness about leaving a margin of safety; high reliability and redundancy standards for procurements and grants; consideration of snow removal patterns in parking lots; and, support for ski resorts in expanding and advertising charging infrastructure.

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