Fully Charged:

How Utilities Can Help Realize Benefits of Electric Vehicles in the Northeast

Cover Photo: https://pixabay.com/en/rural-road-autumn-fall-foliage-981757/

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Executive Summary

Plug-in electric vehicles (EVs)[1] have the potential to provide wide-ranging benefits to the New England and New York region, complementing and enhancing existing state policies and programs. With the region's comparatively clean electric grid in relation to many parts of the country, electrifying transportation already produces significant climate and environmental gains. Presently, EVs in most of New England and New York achieve mile per gallon (MPG) equivalencies of between 79 to 135 MPG.[2] As Northeast states continue to reduce the carbon-intensity of electric generation in the region through programs like the Regional Greenhouse Gas Initiative (RGGI) and through increases to and extensions of renewable portfolio standards, the magnitude of these gains will only grow.

With thoughtful planning and integration, EVs can provide myriad additional benefits to electric customers, the electric system, and the broader regional economy. Beyond the significant climate benefits of decreasing oil consumption, electric vehicles produce no tailpipe emissions and, consequently, help to alleviate smog and other local air pollution burdens, which are particularly acute in the Northeast. New England and New York spend over $54 billion annually on petroleum-based transportation fuels[3] and decreasing oil consumption through increasing penetration of EVs keeps money in the region. Finally, with proper incentives for timely charging, EVs can benefit the electric system by helping to manage load, foster integration of renewables, and even lower electric rates.

It is critical for Northeast states to proactively engage the participation of utilities in order to accelerate the deployment of EVs and proactively manage the integration of EV load onto the grid. Public utilities are uniquely positioned to manage EV demand on the grid and to engage in large-scale, strategic and equitable siting of EV charging infrastructure. EVs can contribute to grid efficiency by load smoothing and shaping. They can also serve as a buffer to absorb intermittent power from renewable generation into the grid and transfer excess renewable generation into clean energy to power the transportation sector, thus achieving two goals simultaneously; incorporating renewables into the grid and providing clean transportation energy.

With the right policy design, utility support for transportation electrification is a cost-effective means to significantly lower barriers to EV adoption and maximize benefits of EVs to ratepayers, vehicle owners and operators, and society.

Building on a Progressively Cleaner Electric Sector

While Greenhouse Gas (GHG) emissions from electricity generation are declining in all regions of the U.S., emission rates in Northeast states are declining even more rapidly than the U.S.

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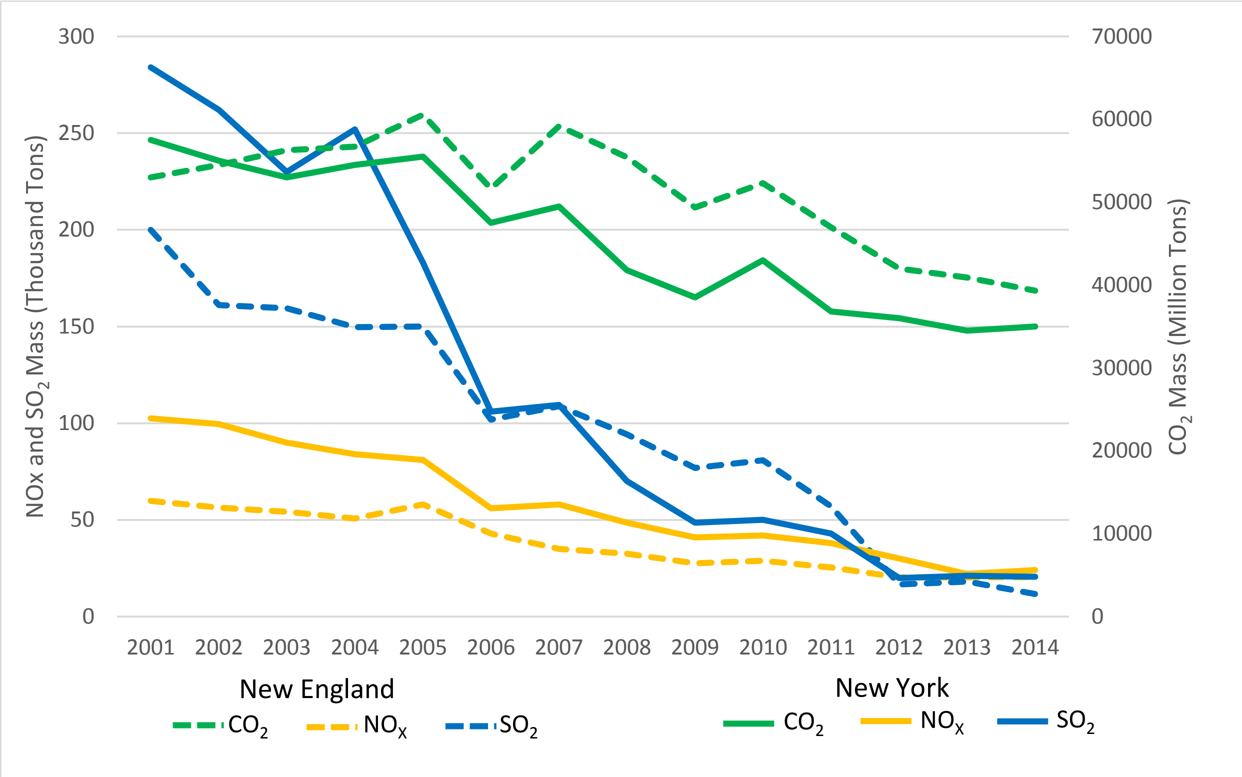
[1] Which include light-duty passenger plug-in hybrid electric vehicles and battery electric vehicles.

[2] With the exception of Long Island, NY where EVs get equivalent to 47 mpg on average. Union of Concerned Scientists (2015) *Cleaner Cars from Cradle to Grave: How Electric Cars Beat Gasoline cars on Lifetime Global Warming Emissions*. http://www.ucsusa.org/sites/default/files/attach/2015/11/Cleaner-Cars-from-Cradle-to-Grave-full-report.pdf

[3] J. Todd, J. Chen, and F. Clogston, (2012) *Creating the Clean Energy Economy: Analysis of the Electric Vehicle Industry,* 2013. Originally from U.S. Energy Information Administration. *Gasoline and Diesel Fuel Update*. Retrieved from http://www.eia.gov/petroleum/gasdiesel/, at 105.

average.[4] **Figure 1**, illustrates the decline of GHG emission rates from electricity generation in New England and New York between 2000 and 2014.[5,6]

Figure 1: New York and New England Emissions from Electricity Generation 2001-2014[7]



A robust clean power policy environment supports cleaner electricity generation in the Northeast (see **Appendix A**) through Renewable Portfolio Standards (RPS), Energy Efficiency Resource Standards, (EERS), Greenhouse Gas (GHG) emission targets, ZEV mandates, and participation in the region's carbon market, the Regional Greenhouse Gas Initiative (RGGI).

In addition to existing policies, initiatives are underway to further reduce emissions from the electric sector. Just this summer, New York State regulators approved a 50% Clean Energy Standard while legislators in Rhode Island increased the state's clean energy goals. The Massachusetts Legislature recently passed an energy bill that requires increasing amounts

> In the first part of this millennium, CO_2 emission rates from the electric sector decreased by 39% in New York and by 28% in New England. As emissions from electricity generation in the Northeast continue to decrease, the environmental benefits of EVs continue to grow.

[4] Electric Power Research Institute & National Resources Defense Council (2015) *Environmental Assessment of a Full Electric Transportation Portfolio, Volume 1: Background, Methodology, and Best Practices.* http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?productId=000000003002006875

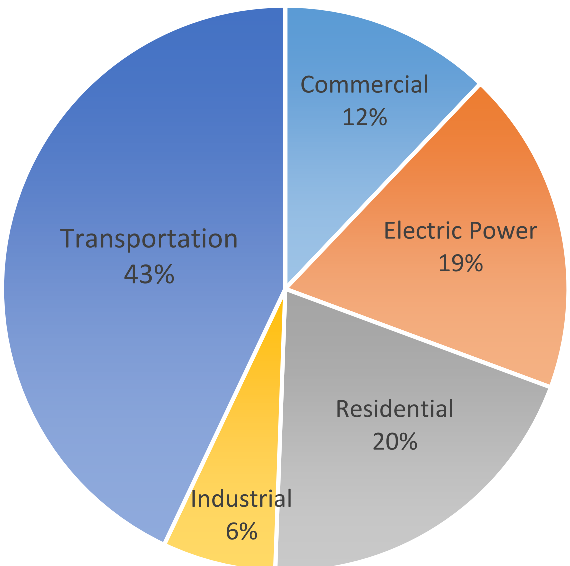
[5] http://www.nyiso.com/public/webdocs/media_room/press_releases/2015/Child_PowerTrends_2015/ptrends2015_FINAL.pdf

[6] http://www.iso-ne.com/about/key-stats/resource-mix

[7] http://www.nyiso.com/public/webdocs/media_room/press_releases/2015/Child_PowerTrends_2015/ptrends2015_FINAL.pdf http://www.iso-ne.com/about/key-stats/resource-mix

of power to be procured from clean, renewable energy. Connecticut, Massachusetts, and Rhode Island are working collectively to evaluate proposals and programs to procure large-scale clean energy. A 2016 program review of RGGI is also currently underway. Initiatives like these illustrate a policy and programmatic commitment to cleaner electric generation in the region.

Figure 2: 2013 CO_2 Emissions by Sector (New England and New York)[8]



As the electric sector becomes cleaner, the transportation sector emerges as the primary source of GHG emissions in the region. As indicated in Figure 2, the transportation sector in the Northeast emits more CO_2 than any other sector. Using electricity to power transportation will yield substantial benefits today. As the region continues to decarbonize the electric sector in compliance with existing and proposed policy commitments, these benefits will continue to grow.

Benefits of EVs

EVs are critical to meeting state, national, and global climate goals (see sidebar).[9] Electric sector scenario modeling in Northeast states found that converting light duty vehicles from gasoline to electricity will yield significant net benefits and is necessary to reach climate goals.[10] In addition to being a cost-effective investment for consumers, a large-scale shift to vehicle electrification will create a net increase in jobs and economic development, and will reduce reliance on foreign oil. With careful implementation, it will dramatically improve air

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[8] Source: http://www.eia.gov/environment/emissions/state/

[9] Williams et al., (2012) *The Technology Path to Deep Greenhouse Gas Emission Cuts by 2050: The Pivotal Role of Electricity*, Science at 54 (January 2012).http://deepdecarbonization.org/wp-content/uploads/2015/09/US_DDPP_Report_Final.pdf
Mark Z. Jacobson, Mark A. Delucchi, Guillaume Bazouin, Zack A. F. Bauer, Christa C. Heavey, Emma Fisher, Sean B. Morris, Diniana J. Y. Piekutowski, Taylor A. Vencilla and Tim W. Yeskooa. (2015) "100% clean and renewable wind, water, and sunlight (WWS) all-sector energy roadmaps for the 50 United States." *Energy & Environmental Science* 8, (2015) 2093–2117. https://web.stanford.edu/group/efmh/jacobson/Articles/I/USStatesWWS.pdf
International Energy Agency (2011) *Technology Roadmap: Electric and plug-in hybrid electric vehicles.* https://www.iea.org/publications/freepublications/publication/EV_PHEV_Roadmap.pdf
Sustainable Development Solutions Network (SDSN) and Institute for Sustainable Development and International Relations (IDDRI). (2014) *Pathways to Deep Decarbonization.* http://unsdsn.org/wp-content/uploads/2014/09/DDPP_Digit.pdf

[10] Synapse Energy Economics Inc. 2016. *The RGGI Opportunity 2.0: RGGI as the Electric Sector Compliance Tool to Achieve 2030 State Climate Targets*.

quality, reduce adverse health impacts, and lower greenhouse gas emissions, as well as provide opportunities and efficiencies for electric utilities.

CLIMATE AND ENVIRONMENTAL BENEFITS

The transportation sector in the Northeast is by far the largest source of GHG emissions in the region (Figure 2). Conversely, the electric sector in the Northeast is one of the cleanest in the U.S., powered by increasing amounts of renewable sources. Leveraging cleaner electricity in the Northeast into transportation fuel can yield substantial emissions reductions in the region. The Union of Concerned Scientists estimates that on average, an EV charging in the Northeast would achieve the greenhouse gas equivalent of 79-135 miles per gallon, well beyond double the average fuel efficiency of the national light duty fleet.[11,12]

The environmental benefits of EVs will continue to increase for several reasons. Manufacturers are building lighter, more efficient EVs. States continue to work toward achieving their renewable energy portfolio standards, air quality standards, and meeting their carbon market caps. As electricity generation shifts away from the use of coal, electricity as a fuel is becoming cleaner and the environmental benefits of EVs will continue to grow. The combination of decarbonizing the grid and transportation electrification has been shown to result in GHG emissions reductions as well as yield air quality benefits.[13]

THE ROLE OF EVS IN MEETING CLIMATE GOALS

Forecasts and studies consistently identify electrification of the transportation sector as a critical component of a future based on sustainable energy generation and consumption. An analysis of pathways to reduce greenhouse gas emissions by 80% from 1990 levels by Williams et al. found widespread electrification of direct fuel uses (such as gasoline in cars) was required to reach this policy goal. Roadmaps developed by a team of scientists to convert all energy uses for each of the 50 states to 100% wind, water, and sunlight by 2050 rely heavily on the electrification of the transportation sector to reduce reliance on oil and gas. At the global level, The International Energy Agency (IEA) energy scenarios rely on EVs making up over half of light duty vehicle sales by 2050 to achieve a 50% reduction in global energy-related CO2 emissions levels from 2005 levels. Research conducted by the Sustainable Development Solutions Network (SDSN) and the Institute for Sustainable Development and International Relations (ISDRI) identify the pathway to decarbonization as relying on three pillars: energy efficiency and conservation, decarbonization of electricity generation, and electrification of fossil fuel energy uses such as transportation.

[11] Union of Concerned Scientists (2015) *Cleaner Cars from Cradle to Grave: How Electric Cars Beat Gasoline cars on Lifetime Global Warming Emissions*. http://www.ucsusa.org/sites/default/files/attach/2015/11/Cleaner-Cars-from-Cradle-to-Grave-full-report.pdf Note: the Long Island region has a lower equivalent of about 47 mpg.

[12] US Department of Transportation, Bureau of Transportation Statistics, 2014: http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_statistics/html/table_04_23.html

[13] Electric Power Research Institute & National Resources Defense Council (2015) *Electrifying Transportation Reduces Greenhouse Gas Emissions and Improves Air Quality.*

ECONOMIC DEVELOPMENT BENEFITS

> An Oregon study found that every time a consumer in Oregon purchases an EV, local tax revenue increases by $426 and $1,503 over a ten-year period.
>
> – The Returns to Vehicle Electrification, Northwest Economic Research Center

Currently the transportation system in the Northeast is powered almost exclusively by fossil fuels that are imported from out of state and a portion of which are imported from out of the country. According to the U.S. Energy Information Administration, more than 80 percent of the cost of a gallon of gas immediately leaves the local economy.[14] In 2014, the Northeast states spent a combined $54.7 billion on petroleum-based transportation fuels (Table 1).[15]

Table 1: 2014 Petroleum Expenditures by State[16]

State	2014 Transportation Sector Petroleum Expenditure Estimates ($ millions)
Connecticut	$ 6,348
Maine	$ 3,598
Massachusetts	$ 11,611
New Hampshire	$ 2,782
New York	$ 27,363
Rhode Island	$ 1,647
Vermont	$ 1,380
Total	$ 54,729

Based on vehicle miles traveled in the Northeast, the light duty fleet in this region uses an estimated 8.5 billion gallons of gasoline annually, totaling $17 billion in consumer spending. In contrast, powering these miles with electricity would cost an estimated $10 billion.[17] A full switch to light-duty electric vehicles could put approximately $7 billion back into the regional economy each year.

AIR QUALITY AND HEALTH BENEFITS

Tailpipe emissions cause significant adverse health impacts including heart attacks, strokes, congestive heart failure, asthma, chronic obstructive pulmonary disease, cancer, reproductive and developmental harm, low birthweight of infants, autism spectrum disorder, and early death.[18] Researchers from MIT estimate that $PM_{2.5}$ from on-road pollution causes 52,800 premature deaths in the U.S. each year. In the Northeast states alone, 7,141 early deaths are attributed to $PM_{2.5}$ from tailpipe emissions each year.[19]

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[14] J. Todd, J. Chen, and F. Clogston, (2012) *Creating the Clean Energy Economy: Analysis of the Electric Vehicle Industry*, 2013. Originally from U.S. Energy Information Administration. *Gasoline and Diesel Fuel Update*. Retrieved from http://www.eia.gov/petroleum/gasdiesel/

[15] Ibid p.105.

[16] http://www.eia.gov/state/seds/sep_fuel/html/pdf/fuel_pr_pa.pdf

[17] These estimates sum annual vehicle miles traveled data for each state available from the Bureau of Transportation Statistics: http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/state_transportation_statistics/state_transportation_statistics_2011/html/table_05_03.html). We assumed that the light duty fleet accounted for 70% of total VMT. Gasoline costs were assumed to be $2 per gallon and electricity costs 18.44¢ (Energy Information Agency): https://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_6_a). Average vehicle efficiency (21.4 miles per gallon) was obtained from the Bureau of Transportation Statistics (http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_statistics/html/table_04_23.html) Electric vehicle efficiency is assumed to be 3.33 miles per kWh.

[18] U.S. EPA, Final Rulemaking for 2017-2025 Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards, EPA-420-R-12-901, 2012.

[19] Air pollution and early deaths in the United States. Part I: Quantifying the impact of major sectors in 2005. Fabio Caiazzo, Akshay Ashok, Ian A. Waitz, Steve H.L. Yim, Steven R.H. Barrett· Laboratory for Aviation and the Environment, Department of Aeronautics and Astronautics, Massachusetts Institute of Technology, 77 Massachusetts Avenue, Cambridge, MA 02139, United States, 31 May 2013.

Many of the Northeast states are struggling to achieve health-based air quality standards for ground-level ozone. While transported emissions from Midwestern states contribute significantly to the region's air quality challenges, in-region motor vehicle emissions also play a an important role, increasing concentrations of ozone precursors in urban areas with some of the worst air quality. EVs present an opportunity to reduce NOx emissions in critical locations.

All-electric vehicles have zero tailpipe emissions. Similar to the environmental benefits of EVs, health benefits of EVs are linked to electricity generation. Air quality improvement from transportation electrification will be most pronounced where the regional electricity generation mix is the cleanest and has the lowest proportion of coal and oil.

Heavy duty electric vehicles such as electric school buses and transit buses reduce diesel emissions in low-income urban neighborhoods and near schools resulting in public health benefits for those populations most susceptible to health impacts from diesel emissions: low-income populations and children.

ELECTRIC SYSTEM BENEFITS

A 2015 study by Lawrence Livermore National Laboratory found transportation to be the most wasteful energy sector (by percent). This is primarily due to the inefficiency of internal combustion engines, which generally convert only 17%-21% of the energy content of gasoline into propulsion. In contrast, an EV running on battery power is about three times more efficient and converts about 59%-62% of the energy it receives into motion.[20] Not only are EVs mechanically more efficient than internal combustion engines, they also have the potential to contribute to a more efficient electric system.

Because EVs are typically only on the road less than 5 percent of the time[21] [22] and are actively charging only about 20 percent of the time they are plugged into charging equipment,[23] they present utilities with a highly flexible and manageable load.

EVs also have the capacity to provide a "cushion" between electricity generation and use. The ability of EVs to charge their batteries when electricity generation is abundant and cheap, store this energy, and use this energy at a later time for transportation not only creates a more efficient grid, it also allows for greater integration of renewables which ultimately leads to a cleaner generating mix.

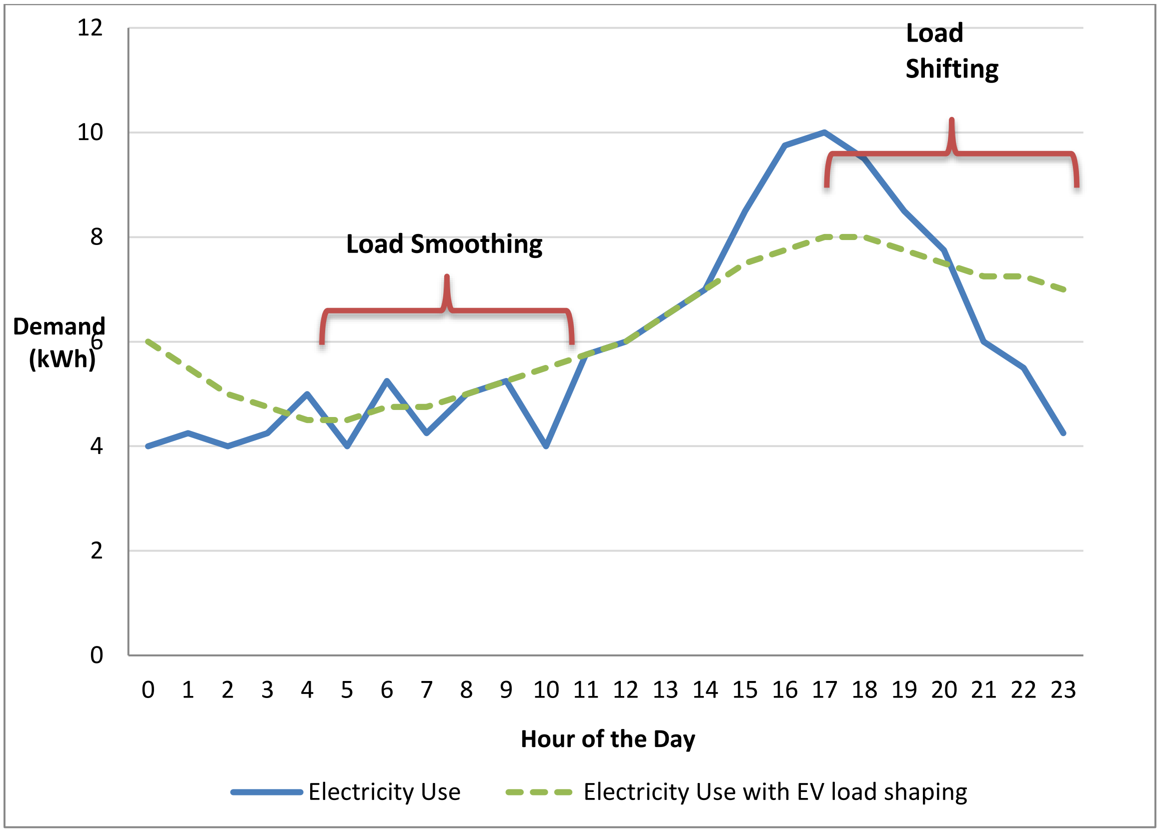
[20] https://www.fueleconomy.gov/feg/evtech.shtml

[21] Galus, Matthias D., Marina González Vayá, Thilo Krause, and Göran Andersson. "The Role of Electric Vehicles in Smart Grids." *Wiley Interdisciplinary Reviews: Energy and Environment* 2, no. 4 (2013): 384–400. doi:10.1002/wene.56.

[22] Kempton, Willett, and Jasna Tomić. "Vehicle-to-Grid Power Fundamentals: Calculating Capacity and Net Revenue." *Journal of Power Sources* 144, no. 1 (June 1, 2005): 268–279. doi:10.1016/j.jpowsour.2004.12.025. http://www.udel.edu/V2G/KempTom-V2G-Fundamentals05.PDF

[23] Langton, Adam, and Noel Crisostomo (2013) *Vehicle-Grid Integration: A Vision for Zero-Emission Transportation Interconnected throughout California's Electricity System*. Report prepared by California Public Utilities Commission, Energy Division. http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M081/K975/81975482.pdf.

Figure 3: Benefits of EV Load Shaping[24]



As electric utilities incorporate more wind and solar renewables into their generation portfolios, the flexibility of EV charging creates the opportunity to absorb excess intermittent generation and transfer it into the transportation sector. This essentially decouples generation and demand on the grid and allows EV charging to peak when generation cost is at its lowest point. This increase in grid efficiency coupled with a broader rate base (from additional EV load) reduces grid costs and puts downward pressure on rates.

With the expansion of the EV market in the Northeast, planning for EV load will become increasingly important to realize EV benefits. Careful management of EV load can increase grid efficiency by flattening the load curve and improving load factor (Figure 3). Both electricity prices and marginal emissions increase as utility loads approach peak use periods. Since the electric grid is designed to provide reliable electricity during peak demand, it rarely operates at capacity. Flattening electric load creates more efficient use of grid assets, thus lowering the cost per kWh of electricity. In addition, by incentivizing EV charging during off-peak hours, utilities can save money by securing energy at lower costs. As addressed in the consumer benefits section, these savings, in turn, can be passed on to ratepayers.

[24] Adapted from a schematic at Esource https://www.esource.com/ES-WP-18/GIWHs

CONSUMER BENEFITS

Many of the efficiencies that EVs can contribute to the grid also have the potential to benefit ratepayers. Electric infrastructure in the Northeast is underutilized as it is designed to meet peak load demand, which occurs only a few hours of each year.[25] The rest of the time the system has excess capacity that could be used to power the transportation sector.

EVs have the capacity to put downward pressure on rates through a number of mechanisms. Increasing electricity sales without increasing peak load is one of these. Improving load shape and grid efficiency is another.

If a consumer purchases an EV, the customer will pay the retail electric rate to charge the vehicle. The retail rate paid by the consumer will include an allocation of the utility's fixed costs as well as the cost of delivered energy. Each kWh sold by the utility covers a portion of the utility's fixed costs, so spreading these fixed costs over more kWh sales reduces the allocation per kWh, thus lowering the rate the utility needs to charge to recover fixed costs. One analysis for San Diego Gas and Electric included assumptions that 100% of the light duty fleet would be replaced with EVs and that no additional infrastructure would be needed because the load would fill valleys. In this scenario, short term Utility Cost of Service would be reduced by over 25%.[26]

EV OWNER/OPERATOR BENEFITS

In addition to the downward pressure on rates that are distributed among ratepayers, EVs low cost of ownership benefits individual owners and operators. The most notable benefit is a reduction in energy costs. Driving an EV instead of a comparable gasoline-powered vehicle will save hundreds of dollars on fuel costs each year. Electricity is also much less volatile in price and supply than oil-based petroleum. Figure 4 illustrates the price volatility of gasoline compared to the dollar/gallon equivalent of electricity. In all cases, a mile driven with electricity is less expensive than a mile driven with gasoline, but due to the fluctuations in gasoline prices, the net benefit of driving an electric vehicle can range from about 20 cents per gallon equivalent to nearly $3.00 per gallon equivalent.

Price shocks associated with petroleum are particularly difficult for low-income populations and those with fixed incomes. These households will have the most to gain from the price stability of using electricity as transportation fuel. All-electric vehicles require significantly less maintenance than gasoline-powered vehicles. Vehicles powered solely with electricity never need oil changes, transmission fluid, spark plugs, or mufflers. Brakes on EVs require less maintenance than on conventional cars since wear on the brakes is significantly reduced due to regenerative braking.[27] EV owners are likely to save between one and two thousand dollars on maintenance costs over the first 100,000 miles of vehicle use.[28]

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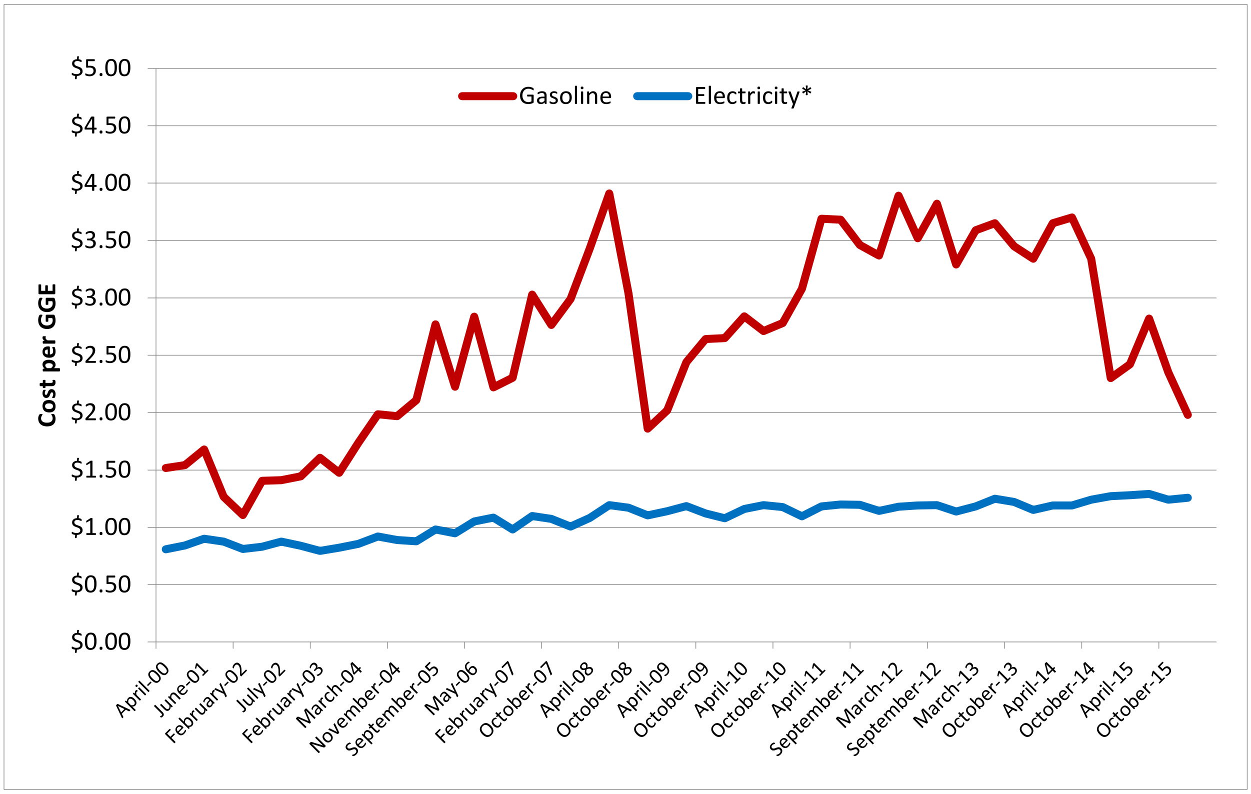
[25] Michael Kintner-Meyer, Kevin Schneider, & Robert Pratt (2007) *Impacts Assessment of Plug-in Hybrid Vehicles on Electric Utilities and Regional U.S. Power Grids*. https://www.ferc.gov/about/com-mem/5-24-07-technical-analy-wellinghoff.pdf

[26] Michael Kintner-Meyer, Kevin Schneider, & Robert Pratt (2007) *Impacts Assessment of Plug-in Hybrid Vehicles on Electric Utilities and Regional U.S. Power Grids*. https://www.ferc.gov/about/com-mem/5-24-07-technical-analy-wellinghoff.pdf

[27] http://www.evtown.org/about-ev-town/operating-costs.html

[28] http://insideevs.com/ev-vs-ice-maintenance-the-first-100000-miles

Figure 4: U.S. Average Retail Fuel Prices[29]



*Electricity Prices are reduced by a factor of 3.4 because electric motors are approximately 3.4 times as efficient as internal combustion

BENEFITS TO UTILITIES

For more than 100 years, the U.S. electric system has focused on providing safe, affordable, reliable electricity to power the nation. Recently, major changes like smart grid technologies, distributed energy resources, and renewables have begun challenging the status quo of the nation's electric system. The utility industry is adapting to these changes. Customers are no longer just consumers, but also partners in maximizing grid efficiency, resiliency, and reliability through programs like time-of-use rates, net metering, and demand response. If well implemented, new business models that include increased transportation electrification can benefit both utilities and customers.

The Edison Electric Institute, which represents all of the U.S. investor-owned electric companies, identifies transportation electrification as a "quadruple win" for electric utilities and society stating that electrification of the transportation sector provides an opportunity for load growth, economic opportunities, environmental opportunities, and opportunities for utilities to engage with consumers.[30]

Both investor-owned utilities and cooperative utilities have reached the conclusion that EVs are integral to their future. The National Rural Electric Cooperative Association has concluded

[29] www.afdc.energy.gov/data/
[30] Ibid.

that electric vehicles, "... represent a unique opportunity for co-ops to grow load and increase revenue in a way that is environmentally and socially acceptable."[31] These benefits for utilities are particularly important since electricity sales have stagnated over the last several years with sales falling in five of the last eight years.[32]

Utility Role in Planning and Implementation of EVs and Charging

Utilities have a unique and important role to fill in the planning and expansion of transportation electrification throughout the U.S. Utilities in several states including Missouri and Michigan are taking a leading role in the development of EV charging infrastructure. In order to accelerate the deployment of EVs and proactively manage the integration of EV load on the grid, it is critical for Northeast states to engage the participation of utilities. Utilities are situated as a primary point of contact for customer engagement, as a resource for charging information behavior and data, as the designer of rate structures and EVSE build-out, and as the promoter of equitable access beyond what markets are likely to provide.

An Electric Power Research Institute study reached the conclusion that, "...potential stresses on the electric grid can be fully mitigated through asset management, system design practices, and at some point, managed charging of Plug-in Electric Vehicles (PEVs) to shift a significant portion of load away from system peak."[33]

REGULATOR CHECKLIST TO SUPPORT EQUITABLE EV DEPLOYMENT

- ☐ Allow rate-basing of EV infrastructure, including low-income neighborhoods, at work places, and multi-unit dwellings
- ☐ Ensure that non-utility entities are allowed to operate charging stations without being regulated as a utility
- ☐ Allow public and private ownership of charging stations
- ☐ Encourage consistent pricing, signage, and connection equipment
- ☐ Develop a plan for EV infrastructure to address major travel corridors
- ☐ Adopt rates that maximize fuel savings and manage charging
- ☐ Encourage business partnerships and EV/renewable combinations
- ☐ Encourage utility-grade metering in charging equipment to support special EV rates
- ☐ Support load balancing, smart metering and Vehicle-to-Grid (V2G) pilot programs

Compiled from:
Natural Resources Defense Council Paper: Driving Out Pollution
New York State Grid-Interactive Vehicle Study: Roadmap

[31] Cooperative Research Network (2015) Plug-In Electric Vehicles and Electric Cooperatives: Volume 2: Managing the Financial and Grid Impacts of Plug-In Electric Vehicles. http://www.nreca.coop/wp-content/uploads/2015/06/managing_the_financial_and_grid_impacts_of_plugin_electric_vehicles.pdf
[32] http://www.eia.gov/todayinenergy/detail.cfm?id=25352
[33] Electric Power Research Institute. 2011. *Transportation Electrification: A Technology Overview.* http://tdworld.com/site-files/tdworld.com/files/archive/tdworld.com/go-grid-optimization/transportation-electrification.pdf

The successful integration of EVs with the grid depends on two factors: charging time and charging location. With the right policy design, utility support for transportation electrification can be cost effective, significantly lower barriers to EV adoption, and maximize benefits for all utility customers. While adoption of this nascent technology is in its early stages, appropriate planning will maximize the benefits of EV deployment while mitigating negative impacts on the grid.

EV LOAD MANAGEMENT

If EV charging is managed to occur during off-peak periods, new load from electric vehicles can be served by existing and often underutilized infrastructure.[34] A study by the Pacific Northwest National Laboratory suggests EV charging occurring during off-peak load hours could supply more than 70% of the energy for the U.S. light duty vehicle fleet (cars, vans, SUVs, and light trucks) without building additional generation or transmission infrastructure.[35]

One way to manage EV load is through rate design. Utility rate design can influence EV charging activity to maximize benefits to ratepayers and the grid. Because EVs offer interruptible and shiftable load, there are a number of rate design tools that utilities can employ to maximize the benefits of EVs within the distribution system.

More than 80% of vehicle charging takes place at home.[36] As a result, utilities should focus initial EV rate design efforts around residential rates. There are a number of pricing strategies that can be employed by utilities to modify EV charging behavior. Volumetric charges, tiered rates, demand charges, critical peak pricing and dynamic rates are all effective means of shaping load through rates.

In 2009, the U.S. Department of Energy funded the EV Project, a demonstration project to understand EV charging behavior. As part of this project, Idaho National Laboratory analyzed the data from approximately 8,700 EVs across the U.S. and found that price incentives substantially influence residential charging behavior. The study also found a strong correlation between the size of the price differential and likelihood of behavior change. EV drivers in San Diego meet 80 percent of their re-fueling needs during the "super-off- peak" period from midnight to 5:00 AM due to San Diego Gas and Electric's (SDG&E's) time-of-use rate which incentivizes charging during this time.

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[34] California Transportation Electrification Assessment Phase 1: Final Report.(2014) at 38; California Transportation Electrification Assessment Phase 2: Grid Impacts (2014) at 17.

[35] Pacific Northwest National Laboratory (2010) *The Smart Grid: An Estimation of the Energy and CO_2 Benefits,* U.S. Department of Energy. PNNL-19112. http://www.pnl.gov/main/publications/external/technical_reports/PNNL-19112.pdf

[36] Cooperative Research Network (2015) Plug-In Electric Vehicles and Electric Cooperatives: Volume 2: Managing the Financial and Grid Impacts of Plug-In Electric Vehicles. http://www.nreca.coop/wp-content/uploads/2015/06/managing_the_financial_and_grid_impacts_of_plugin_electric_vehicles.pdf

Figure 5: EV Project Electric Vehicle Charging Patterns With (San Diego and San Francisco) and Without (Los Angeles and Washington State) Time of Use Rates demonstrate the effectiveness of well-designed TOU rates.

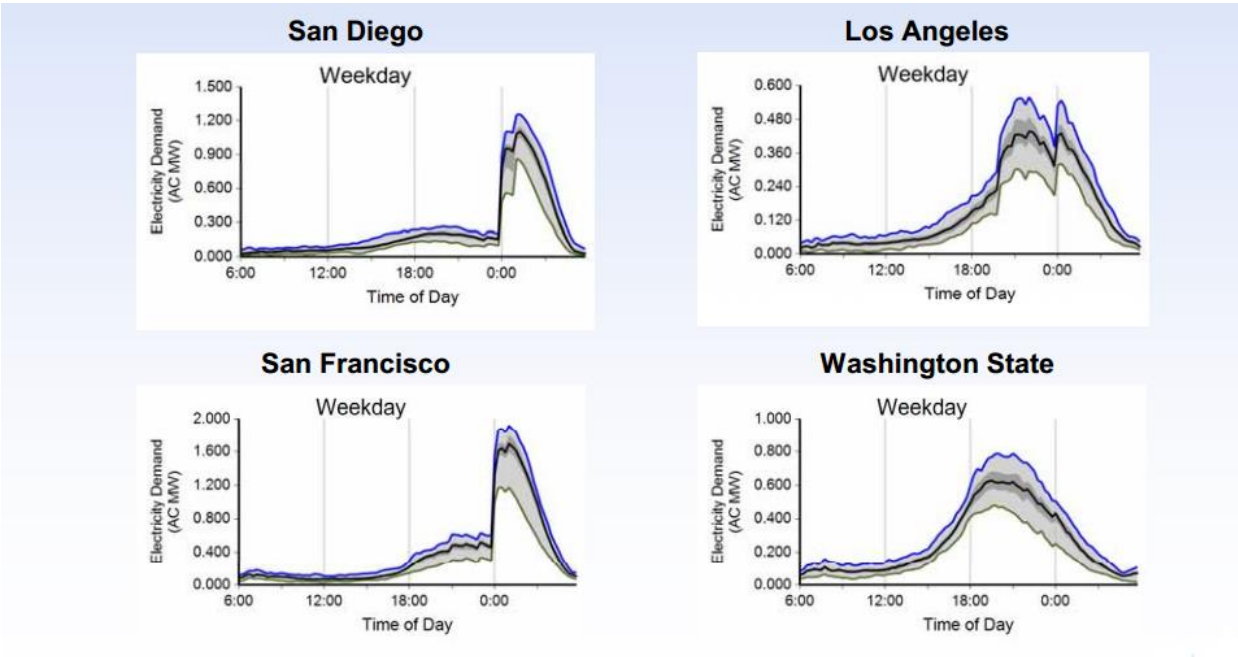

Figure 5 illustrates what a powerful tool TOU rates can be. In this diagram, San Diego and San Francisco have TOU rates that encourage off-peak nighttime charging. Los Angeles and Washington State did not have TOU rates during this time and illustrate the stark differences in charging times during the study. The importance of TOU rates in mitigating peak demand cannot be overstated. The EV Project found that in regions that did not offer TOU electricity rates, such as Nashville, Tennessee EV drivers would arrive home and begin charging their vehicles starting at 4:00 p.m. and peaking at 8:00 p.m. on weekdays. This EV peak corresponds with the existing summer peak (partly due to air conditioning) and illustrates that without planning and adequate rate incentives, EV charging can exacerbate peak demand.[37]

CHARGING STATION PLANNING AND DESIGN

The other important element that affects EVs' impact on the grid is the location of EV charging. The vast majority of EV charging taking place at a vehicle operator's residence. As such, the ability for vehicle operators to charge their EVs where they live is critical in a large-scale deployment of EVs. Reliability and availability of workplace charging is also critical

> A U.S. Department of Energy initiative to increase workplace charging found that employees with access to EV charging stations at work were twenty times more likely to drive a plug-in electric vehicle than the average worker.
>
> – U.S. DOE Workplace Charging Challenge Progress Update 2014: Employers Take Charge

to EV adoption. Workplace charging is another important factor for consumers in deciding whether to purchase an EV. Availability of workplace charging effectively doubles the range of the commute that can be made by a battery electric vehicle.[38] It improves consumer confidence and increases sales. In an increasing number of cases, businesses and commercial establishments offer EV charging to attract customers.

EQUITY CONSIDERATIONS

While cost-benefit analyses show that EVs save owners money over the long term, the upfront cost of an EV is out of reach for most low-income car buyers even with government incentives factored in. Another barrier of EV ownership by low-income drivers is the absence of charging infrastructure in multi-family housing areas. Multi-family units are often located in more concentrated development zones that often result in higher EVSE installation costs due to construction challenges such as concrete roads and sidewalks. Installation of additional meters, long distances between a customer's residential meter and their parking location, and the inclusion of other parties like property managers and homeowners associations add to the hurdles.[39]

Although there are barriers to EV adoption among low and moderate income households, these households also have the most to gain. Transportation costs make up a significant portion of American household budgets, second only to housing costs, and similar to other energy-related costs, the cost burden grows as income declines.[40] A 2012 report by the Center for Neighborhood Technology found that in the 25 largest metro areas, transportation costs averaged 13% of overall household income for above-median-income households but averaged 27% of annual income in moderate-income households. Through their lower cost of ownership, EVs provide a form of long-term energy relief for moderate and low income households, if the higher upfront cost barrier can be overcome.

Low-income households are most impacted by large fluctuations in energy prices. As illustrated in Figure 3, fueling a vehicle with electricity not only costs less, but avoids price shocks allowing for more dependable budgeting, more disposable income, and alleviating large price fluctuations. In addition, low and moderate income households are disproportionately impacted by air pollution and higher rates of respiratory disease, cancer, and heart disease. Low-income residents are also often limited in their housing options and tend to live in areas with the highest traffic and poorest air quality – which could be improved by transportation electrification.

Other opportunities for transportation electrification that will reach a more diverse population include the electrification of transit buses and the electrification of school buses, both having the added benefit of improving ambient air quality in areas of high population density. Zero-

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[38] Transportation Research Board and National Research Council (2015) Overcoming Barriers to Deployment of Plug-in Electric Vehicles. Washington, D.C.: The National Academies Press. Doi:10.17226/21725. http://www.nap.edu/read/21725/chapter/3

[39] California Plug-in Electric Vehicle Collaborative (201) *Plug-in Electric Vehicle Charging Infrastructure Guidelines for Multi-units Dwellings.* http://www.pevcollaborative.org/sites/all/themes/pev/files/docs/MUD_Guidelines4web.pdf

[40] Center for Housing Policy and Center for Neighborhood Technology. 2012. Losing Ground: The Struggle of Moderate Income Households to Afford the Cost of Housing and Transportation. http://www.cnt.org/resources/losing-ground/

emission electric transit buses, disproportionately benefit low-income urban communities because they operate in congested areas where air pollution is a problem.

Electric school buses have great potential to reduce GHG emissions, improve children's health and save schools money on both fuel and maintenance. Every school day, 25 million children in the United States climb aboard 480,000 school buses. Each year, these buses burn more than 800 million gallons of diesel fuel.[41] Fine particle pollution from diesel emissions is linked to serious health damages. Children are more susceptible to health risks from fine particle pollution because they are growing and because they have higher breathing rates. In addition,

CASE STUDY: CHARGE READY

One example of the importance of the utility role in transportation electrification is that of the recently approved Southern California Edison Pilot EV charging program, Charge Ready. In January 2016, the California Public Utilities Commission authorized the utility to spend $22 million to incentivize the deployment of approximately 1,500 EV charging stations. The pilot includes several important design elements illustrative of the key role of utilities in deployment. The pilot targets EVSE deployment in parking areas typically used for longer than 4 hours like workplaces, fleet spaces, multi-unit housing, and destination centers like hotels and sports venues. It covers electric infrastructure costs and installation as well as provides rebates to cover a percentage of the cost of the charging stations. Rebates are scaled to support charging station development in disadvantaged communities with rebates covering 100% the cost of charging stations for approved customers in disadvantaged communities, 50% of the cost of the charging stations in multi-unit dwellings, and 25% of the cost of charging stations in all other installations. Another element of the pilot is the utility's ability to gather charging data from the stations regarding charging behaviors and rate decisions. This information will inform future distribution planning, EVSE placement, and rate design. The Charge Ready pilot highlights the unique ability of regulated utilities to perform *all* of the following functions in a way that other entities are not able to. Only utilities supported by state regulators are in a position to have such a broad impact on EVSE deployment filling the following critical roles:

- Information and charging usage data gathering
- Market education and outreach
- Addressing infrastructure gaps
- System planning and integration
- Local job creation
- Equitable deployment including targeting the low-income market, the market that has the potential to benefit the most from as shift to EVs but is least likely to be served by private investors.

[41] Wargo, John, Ph.D., Children's Exposure to Diesel Exhaust on School Buses. 2002. Environment and Human Health, Inc., p. 10. and http://www.informinc.org/pages/research/sustainable-transportation/fact-sheets/118.html

studies in California and Connecticut show that children's exposure to harmful particulates on school buses may be higher *inside* the cabin of the school bus than outside of the bus. In some cases, particulate concentrations on school buses were 5-15 times higher than background concentrations.[42]

There is still much to be done to ensure that the benefits of transportation electrification reach low-income populations. The role of utilities is a critical component in ensuring equity in access to EVs and availability of EV charging, including expanding the rebates and car-sharing programs for low-income residents well beyond California. If utilities can rate-base charging infrastructure, with regulatory guidance, they can support what is best for the community and society. Private sector investors are likely to focus EV infrastructure in narrower, more affluent markets, which will leave low-income communities behind in achieving the benefits that EVs can provide.

Conclusion

Electric vehicles offer many potential benefits to ratepayers, the electric system, the environment, the economy and the health of residents in New York and New England. Electrification of the transportation sector combined with continued efforts to generate electricity using cleaner renewable energy, are critical elements in the states' ability to meet air quality, energy, and transportation goals.

New England and New York already have policies and programs in place to reduce GHG emissions in the electric sector. As a result of these endeavors, the Northeast electric system is one of the cleanest in the country. The successful, and continued, reduction of emissions from the electric sector provides an excellent opportunity to reduce transportation emissions though vehicle electrification.

The key to optimizing these benefits lies in the engagement of utilities and regulators in the thoughtful development of rate structures and careful placement of charging infrastructure. Particular challenges exist in providing equitable EV charging infrastructure to low income populations-the populations most burdened by volatile gasoline prices.

Utilities are in a unique position to address EV adoption and equity issues. For more than 100 years, the U.S. electric system has focused on providing safe, affordable, and reliable electricity to power the nation. As the main point of customer contact, utilities have access to important charging data, can build consumer engagement, can equitably distribute power resources, and can improve grid efficiency while creating a cleaner transportation sector in the Northeast.

[42] Wargo, John, Ph.D., Children's Exposure to Diesel Exhaust on School Buses. 2002. Environment and Human Health, Inc., p. 10.

Appendix A: Status of Transportation Electrification in the Northeast

Northeast states are taking steps to address energy, air quality, and climate issues. In recognition of the need to reduce emissions, each of these states has established greenhouse gas emissions targets, adopted renewable energy standards and participate in the Regional Greenhouse Gas Initiative carbon market. This section provides an overview of current and proposed policies and programs that contribute to cleaner electricity generation in the Northeast as well as policies supporting cleaner transportation.

Table A-1: State Energy, Emissions, and EV Policy at a Glance

State	GHG Emissions Reduction Goals	Renewable Energy Standard	Statewide Incentives			ZEV State	RGGI Participation	Trans. Climate Initiative
			EV	EVSE	Other			
Connecticut	✓	✓	✓	✓	✓	✓	✓	✓
Maine	✓	✓				✓	✓	✓
Massachusetts	✓	✓	✓	✓	✓	✓	✓	✓
New Hampshire	✓	✓		✓			✓	✓
New York	✓	✓	(✓)	✓	✓	✓	✓	✓
Rhode Island	✓	✓	✓		✓	✓	✓	✓
Vermont	✓	✓	(✓)		✓	✓	✓	✓

(✓) indicates that incentives for Vermont are limited and New York has incentives approved to begin in the fall of 2016.

Connecticut

Connecticut's 2013 Comprehensive Energy Strategy reiterates the state's greenhouse gas emissions goals. Established by the General Assembly in 2008, it requires greenhouse gas emissions reductions of 10% below 1990 levels by 2020 and 80% below 2001 levels by 2050. Connecticut is in the process of establishing a mid-term 2030 climate goal through its Governor's Council on Climate Change. Connecticut is one of the states currently involved in the New England Clean Energy RFP. In November of 2015, state agencies and electric distribution companies in Connecticut, Massachusetts and Rhode Island issued an RFP to procure clean energy and transmission in pursuit of state clean energy goals. Bids are currently being evaluated.

In its 2013 Comprehensive Energy Strategy, Connecticut calls for sufficient public electric vehicle charging stations to increase range confidence of EV owners in the state, with 100 additional charging locations recommended. Connecticut's Clean Cars Statute adopts the ZEV regulations which requires ZEVs to make up 15% of sales in CT by 2025.[43] In order to lead by example with cleaner state fleets, the state has committed funding from the Regional Greenhouse Gas Initiative (RGGI) for municipalities and state agencies to purchase and install EVs and charging stations with support of $15,000 per vehicle and $10,000 per dual head charger.[44] Consumers are able to receive a state EV incentive of up to $3,000 to purchase or lease an EV and EV dealers receive a sales incentive valued at 10% of the consumer amount.

Maine

Maine does not currently offer state incentives for EVs, but a distribution utility in Maine--Central Maine Power--previously offered EV incentives for non-profits of up to $5,000 toward the purchase of a plug-in electric vehicle and $2,500 toward the purchase of a level 2 or DC fast charge charging station. From a charging infrastructure perspective, the Governor of Maine and the Premier of Quebec recently announced plans to develop an EV charging corridor between Quebec and Portland to boost tourism activity in the region.[45]

Massachusetts

Massachusetts supports the transition to vehicle electrification through a number of policies and programs. The 2015 update of the Massachusetts Clean Energy and Climate Plan for 2020 states that meeting their 2050 emission limit will require powering the transportation sector largely with electricity. This transition will require new infrastructure, incentives, and sustained policy development over the 15–30 years it takes for the vehicle fleet to turnover.[46]

As part of the FY 2015 Massachusetts State Budget, a formal ZEV Commission was created. This Commission was tasked with filing an action plan based on findings of the electric vehicle task force and preparing a study recommending (at minimum) policies for further expanding access to electric and fuel cell vehicle infrastructure, encouraging the purchase and lease of electric and fuel cell vehicles, reducing the up-front costs associated with electric and fuel cell vehicle purchases, and identifying strategies for removing barriers to electric and fuel cell vehicle deployment.[47]

One way the Commonwealth has implemented a commitment to EVs is by designating funding to incentivize EV sales. Well over $5.5 million has been reserved or issued in rebates as part of the Massachusetts Offers Rebates for Electric Vehicles (MOR-EV) program.[48] Rebates of up to $2,500 for purchase or lease of zero-emission and plug-in hybrid light duty vehicles including zero emission motorcycles are offered statewide.

Transportation electrification has also been addressed at the utility regulation level in Massachusetts, resulting in the definition of the role of utilities with regard to EVs and EVSE. In December, 2013 the Massachusetts Department of Public Utilities opened an investigation into

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[43] http://www.ctenvironment.org/#!ct-electric-vehicle-coalition/c13ul
[44] http://www.ct.gov/deep/cwp/view.asp?a=2684&q=561884&deepNav_GID=2183
[45] http://www.pressherald.com/2016/03/09/maine-and-quebec-team-up-to-develop-electric-car-charging-network/
[46] http://www.mass.gov/eea/docs/eea/energy/cecp-for-2020.pdf
[47] The Massachusett Zero Emission Vehicle Commission and Mass Drive Clean Campaign http://www.mass.gov/eea/waste-mgnt-recycling/air-quality/ma-zero-emission-vehicle-commission-and-mass-drive-clean-campaign/
[48] https://mor-ev.org/

electric vehicles and electric vehicles charging.[49] The outcome of this investigation, captured in an August 4, 2014 Order (D.P.U. 13-182-A), indicates that the Department not only will allow, but encourages utility investment and cost recovery for research, development, and deployment efforts related to EVs and EV charging as part of an approved pilot or grid modernization plan.[50]

Massachusetts has also partnered with Connecticut and Rhode Island to issue the New England RFP for clean energy and transmission procurement. The three states, along with electric utilities in the states, are working together to pursue clean energy opportunities at economies of scale that would be beyond the scope of individual states.

New Hampshire

New Hampshire does not participate in the California ZEV program and hence has not signed on to the ZEV MOU, although it does participate in the Transportation and Climate Initiative[51]

New Hampshire's 10-Year State Energy Strategy includes a number of recommendations to support electric vehicles.[52] The recommendations include opening a Public Utility Commission docket on grid modernization in which electric vehicles would be an important consideration. According to the strategy, "Electric vehicles are an important part of New Hampshire's strategy to reduce reliance on imported fuels as the electric mix shifts to distributed renewable sources. They can provide significant cost savings to consumers as compared to traditional fuel vehicles, and with reduced emissions they provide local air quality and health benefits." In 2015, the New Hampshire PUC opened an investigation into grid modernization and is currently in the process of conducting working groups and collecting discovery information from utilities to assess current practices.[53]

Other recommendations from the plan include creating a strategic plan for EV charging infrastructure development and increasing consumer access to low-emission and zero-emission vehicles. The report also recommends the state participate in these programs to increase deployment of EVs and reduce transportation emissions in the state. The state's energy strategy suggests that EVs are the best near-term option for increasing the state's energy independence, "…as power generation shifts to locally produced clean energy."[54] One action proposed in the strategy is that New Hampshire could investigate using RGGI funds to provide rebates, and could ensure that charging infrastructure is exempt from the vehicle excise tax.[55]

In December of 2015, the NH PUC opened an order investigating the resale of electricity by EV charging stations which was triggered by a tariff amendment filed by Liberty Utilities. The utility stressed that an existing prohibition from reselling electricity from charging stations meant that charging station owners were required to charge by the hour, versus a per kWh rate. This

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[49] Commonwealth of Massachusetts, Department of Public Utilities D.P.U. 13-182. http://www.mass.gov/eea/docs/dpu/electric/13-182-order.pdf

[50] Commonwealth of Massachusetts, Department of Public Utilities D.P.U. 13-182-A at 13. http://web1.env.state.ma.us/DPU/FileRoomAPI/api/Attachments/Get/?path=13-182%2fORDER_13182A.pdf

[51] http://www.transportationandclimate.org/content/about-us

[52] https://www.nh.gov/oep/energy/programs/documents/energy-strategy.pdf

[53] https://www.puc.nh.gov/Regulatory/Docketbk/2015/15-296.html

[54] https://www.nh.gov/oep/energy/programs/documents/energy-strategy.pdf p.72

[55] Ibid p.55

configuration caused complaints about high charging costs, which the utility hoped to address. In March of 2016, PUC staff issued a recommendation that EV charging station operators be permitted to resell electricity for EV charging.[56]

New York

New York has a number of initiatives and policies in place to promote the EV market in the state. According to the State Energy Plan, "Building a cleaner, more efficient, and sustainable transportation system is a critical component of the State's energy strategy."[57] Initiatives like ChargeNY promote EV charging infrastructure by setting a goal of having 3,000 charging stations installed to support an expected 40,000 EVs on the road in New York by 2018.[58] One of the recurring themes of EV initiatives is leading by example with government fleet adoption of EVs. In 2016, several NY agencies are committed to ensuring that at least 50% of new, administrative-use vehicles will be ZEVs, including battery electric, plug-in electric hybrid, or hydrogen fuel cell vehicles.[59] At the city level, Mayor de Blasio announced last December an initiative called NYC Clean Fleet. The initiative calls for the City to procure at least 2,000 electric cars, making the largest municipal electric vehicle fleet in the country, and to reduce fleet emissions by 50 percent by 2025.[60]

New York also recently passed a budget that includes rebates for EVs that are expected to be available in late 2016 for purchasers of new EVs and plug-in hybrids. The incentive will be as high as $2,000 for a battery-only electric vehicle, a plug-in hybrid, or a fuel-cell vehicle and will be administered by New York State Energy Research and Development Authority (NYSERDA).[61] New York also offers the Electric Vehicle Voucher Incentive Fund (NYSEV-VIF), which supports the deployment of electric fleet vehicles by covering up to 80% of incremental cost over traditional internal combustion engine vehicles or up to $60,000 per vehicle.

Recent utility regulation developments in New York include the outcome of the Reforming the Energy Vision (REV) proceeding. A recent order was issued by the New York Public Service Commission adopting Distributed System Implementation Plan (DSIP) Guidance.[62] The Order provides guidance on utility roles regarding transportation electrification and specifically, EVSE deployment,

> "Coordinated statewide approaches by the utilities will directly contribute to market development and decreases in carbon emissions. In addition to new demand on the system resulting from PEV charging service, issues related to vehicle grid integration will have direct impact on utility operations and planning. Therefore, it is appropriate for the utilities to include consideration of EVSE deployment as part of the DSIP process."[63]

[56] http://www.puc.state.nh.us/Regulatory/Docketbk/2015/15-510.html
[57] http://energyplan.ny.gov/
[58] Ibid p. 106
[59] Ibid. p.107
[60] Press Release: Mayor Bill de Blasio, office of the Mayor of new York City. May 12, 2016
[61] http://www.eany.org/our-work/press-release/electric-vehicle-rebate-integral-reaching-ny%E2%80%99s-climate-and-clean-energy-goals
[62] https://www.energymarketers.com/Documents/rev_order_on_DSIP_filings.pdf
[63] Ibid at 26.

New York's Governor Andrew Cuomo issued an ambitious Clean Energy Standard requiring 50% of the state's energy to come from renewables by 2030. He directed state regulators to design a plan for reaching this goal. In January of 2016, the New York Department of Public Service published a white paper on attaining the Clean Energy Standard. On August 1, 2016, the New York Public Service Commission issued an order adopting this Clean Energy Standard.

Rhode Island

In its State Energy Plan, *Energy 2035*, 20 strategies are outlined to help the state reach its energy goals. Strategy #11, which is aimed at having 25%-40% of the vehicle market powered by alternative fuels, is to promote alternative fuel and electric vehicles. The strategy specifies, "Mature the market for alternative fuel and electric vehicles through ongoing efforts to expand fueling infrastructure, ease upfront costs for consumers, and address other barriers to adoption."[64] Steps are already in place in the state to support this strategy.

In 2013, Governor Lincoln Chafee announced that the Rhode Island Office of Energy Resources (OER) would use funds from the American Recovery and Reinvestment Act (ARRA) to purchase and install 50 electric vehicle charging stations around the state.[65] The recently introduced, Driving Rhode Island to Vehicle Electrification (DRIVE) incentive program, provides buyers of EVs incentives of up to $2,500. These incentives are funded by penalties collected for violations of environmental laws.[66]

Rhode Island has partnered with Connecticut and Massachusetts (and electric companies in all three states) to issue the New England Clean Energy RFP. By working together, the states hope to be able to procure clean energy and transmission more cost-effectively than they would be able to individually. The proposed bids are currently under review.

Vermont

Vermont was one of the original signatories of the ZEV MOU and is an active participant in the TCI. One of the goals of the state's updated Comprehensive Energy Plan is to electrify and increase the efficiency of light-duty vehicles. Transportation emissions make up more than half of Vermont's CO_2 emissions and that may increase as electricity in Vermont is increasingly generated from clean renewable resources. [67]

According to the EIA, in 2014, 27% of Vermont's net electricity generation was produced by renewable energy, including hydroelectric, biomass, wind, and solar resources.[68] In fact, all new electric generating capacity added to Vermont's grid in 2014 was solar-powered.[69] These factors contribute to a situation in which the benefits of transportation electrification are substantial. As a result, state energy goals call for a significant focus on transportation energy use.[70] Vermonters purchasing or leasing a new plug-in electric vehicle in 2016 are eligible for

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64 http://www.planning.ri.gov/documents/LU/energy/energy15.pdf
65 Ibid p 123
66 http://www.greencarreports.com/news/1102601_dirty-money-from-polluters-funds-clean-car-incentives-in-rhode-island
67 http://www.eia.gov/environment/emissions/state/analysis/pdf/stateanalysis.pdf (p.18)
68 http://www.eia.gov/state/print.cfm?sid=VT
69 Ibid.
70 https://outside.vermont.gov/sov/webservices/Shared%20Documents/2016CEP_Final.pdf

up to $1000 rebate for a limited number of incentives (200) administered through the Drive Electric Vermont program[71].

The 2015 passage of Vermont's Renewable Energy Standard includes an energy transformation category aimed at reducing fossil fuel use in Vermont and its associated GHG emissions. This unique approach incentivizes utilities to take measures to reduce energy use and its associated emissions by expanding energy savings outside of the electric sector. Examples of energy transformation include fuel switching from fossil fuels used in transportation or heating to electricity through EVs or heat pump technologies. The details of establishing the implementation guidelines for the energy transformation tier have recently been outlined in an order by Vermont's Public Service Board.[72]

[71] http://www.driveelectricvt.com/buying-guide/purchase-incentives
[72] http://psb.vermont.gov/docketsandprojects/electric/8550