Bringing Electric Vehicles to Fruition Westchester County, New York

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Executive Summary

New York State, under Governor Andrew Cuomo's leadership, is dedicated to reducing greenhouse gas emissions by 40% from 1990 levels by 2030 and by 80% by 2050 to mitigate climate change. The Governor's plan, Reforming the Energy Vision (REV), relies on local municipality participation. The transportation sector is one of the primary avenues to achieve this ambitious goal as it represents 34% of the state's emissions. REV sees electric vehicles as the key to a cleaner transportation system. As such, multi-pronged programs under the monikers ChargeNY and Clean Fleets NY encourage electric vehicle proliferation.

Sustainable Westchester asked the Capstone team to analyze the evolving electric vehicle landscape and provide policy and infrastructure recommendations for both Sustainable Westchester and its constituent municipalities that encourage the use of electric vehicles in support of REV. The team was asked to assess the greenhouse gas impact of an increasing proportion of electric vehicles; review municipal funding opportunities and policies; and, explore how other cities approached electric car strategies.

From the research gathered, the team was asked to recommend areas where Sustainable Westchester can be most impactful and to create a "municipality toolkit" for its members to encourage electric vehicle use in their communities.

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I. Introduction

A. About the Client

Sustainable Westchester is a consortium of Westchester County local governments that facilitates effective sustainability initiatives, engages community stakeholders, and shares tools, resources and incentives to create healthy, vibrant and attractive communities. A small nonprofit, Sustainable Westchester was founded in 2013 as Northern Westchester Energy Action Consortium and Southern Westchester Energy Action Consortium joined forces.

For its member municipalities, Sustainable Westchester acts as an information hub, a lobbying force for political action and a facilitator of complex projects. Nearly all of Westchester's municipalities engage with Sustainable Westchester including all five cities and 17 towns and 19 of 22 villages covering 90% of the county's residents.[1]

Municipal resources devoted to sustainability issues vary from sustainability staff (two cities) to sustainability committees or advisory councils (the most common with 30 combined cities, towns & villages) to no segregated authority (mostly villages).

An example of a Sustainable Westchester initiative is the Municipal Solar Buyer Group Program, an economical and environmentally friendly project. Sustainable Westchester engaged a financing firm and solar equipment consultants to assist municipalities with solar installations on municipal properties. Participating municipalities benefit from expert counsel and aggregate pricing.

The Capstone team's secondary client is Sustainable Westchester's member municipality managers. The Capstone team's municipality toolkit is designed for them. Municipal managers are tasked to spend the community's tax dollars based on community preferences and cost-efficiency. Further, municipal leaders likely have broad responsibilities and have little time to delve deeply into any one topic.

Sustainable Westchester began an initiative to encourage electric vehicle (EV) use to coincide with New York State's ambitious goal to reduce greenhouse gas emissions by 40% from 1990 levels by 2030 and by 80% by 2050. Ron Kamen of Earthkind Energy was engaged to assist with this initiative and is the Capstone team's primary client contact.

[1] Sustainablewestchester.org, http://sustainablewestchester.org/about/member-municipalities/

B. The Case for Electric Vehicles in Westchester County

Westchester Resident Demographics

Westchester County has the demographic and political profile to be a leader in electric vehicle use. According to a market analysis by Experian Analytics,[2] electric vehicle purchasers have higher than average household incomes with nearly 21 percent having household incomes greater than $175,000. The analysis also found that electric car buyers tend to be under 56 years old (55 percent are between 36 and 55). As a comparison, the average purchaser of a Ford Focus was 46 years old with household income of $77,000. The average purchaser of a Ford Focus electric was 43 years old with household income of $199,000.

According to Census Reporter,[3] Westchester County's median household income is just over $86,000 (US household average is $53,775) with 18 percent of household income greater than $200,000 (more than double the US rate). Further, Westchester's median age is 40.5.

From a political standpoint, Westchester residents are likely purchasers of electric vehicles. Westchester is one of the country's most liberal counties[4] and a "Car Talk" survey of 10,000 listeners conducted prior to the 2016 election found that 86% of electric car owners were Democrats.[5] Based on both demographic and political data, Westchester is a very good market for electric vehicles.

Westchester Electricity Grid Mix

Electric drive vehicles include hybrid electric vehicles (HEV's), plug in hybrid electric vehicles (PHEV's), and electric drive vehicles (EV's). They all use electricity as their primary fuel source or for increased efficiency rather than using gasoline. The U.S. Environmental Protection Agency categorizes such vehicles as zero-emission vehicles since they have no direct exhaust or emissions. The benefit of using these vehicles is a reduction in petroleum consumption. However, electricity production also contributes to air pollution.

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[2] "Consumers purchasing an electric vehicle are more affluent and younger than those purchasing a hybrid."Experian.com. Web. April, 22, 2014. https://www.experian.com/blogs/news/2014/04/22/consumers-purchasing-an-electric-vehicle-are-younger-and-more-affluent-than-those-buying-a-hybrid/

[3] "Westchester County, Census Data." Census Reporter.com. Web. ACS 2015 1-year https://censusreporter.org/profiles/05000US36119-westchester-county-ny/

[4] "America's top 20 most liberal-friendly counties." Daily Caller.com. Web. April 9, 2010. http://dailycaller.com/2010/04/09/americas-top-20-most-liberal-friendly-counties/

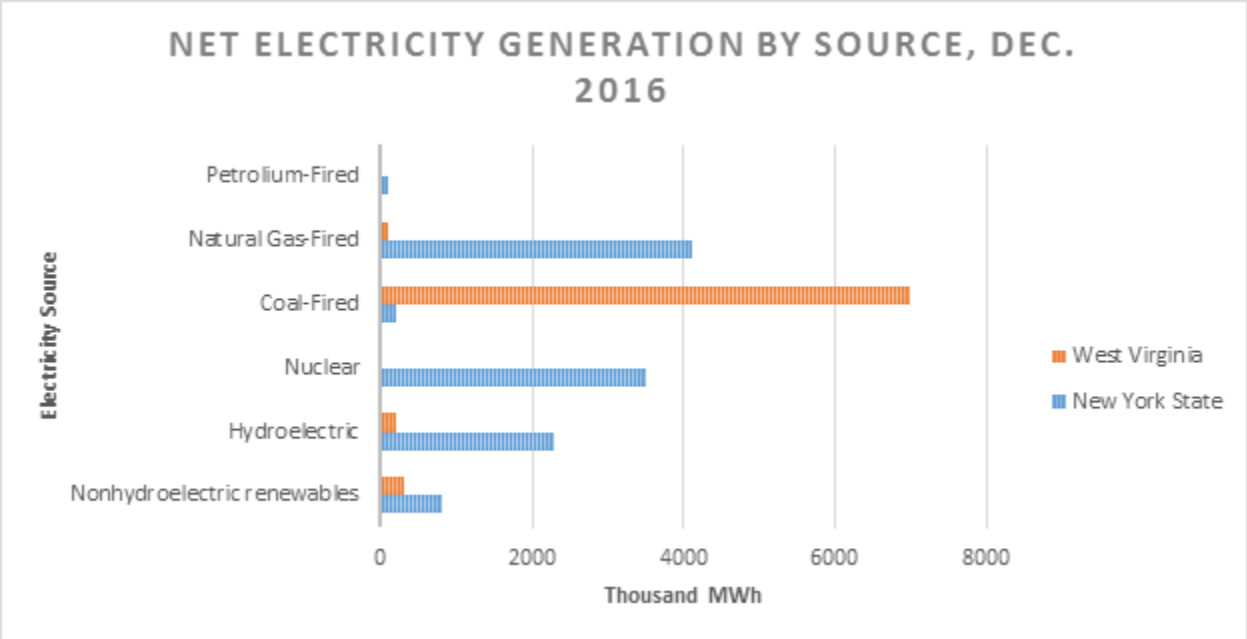
[5] "Does your ride predict your vote? CarTalk/BestRide Poll says 'yes'" BestRide.com. Web. 2016.http://bestride.com/news/entertainment/does-your-ride-predict-your-vote-the-car-talkbestride-poll-says-yes

There are two general classes of vehicle emissions namely: air pollutants which may result in smog, haze, or health problems and greenhouse gasses (GHG's) such as carbon dioxide and methane. Both categories of emissions can be evaluated on a direct basis and a "wheel to well" basis (from the vehicle to its energy source).

Electricity can be produced from a variety of energy sources, including oil, coal, nuclear energy, hydropower, natural gas, wind energy, solar energy and stored hydrogen. New York State's generation sources according to the data from the U.S. Energy Information Administration as of Nov 2016 consists mainly of natural gas (38%), followed by nuclear (32%), hydroelectric (19%) and then non hydro renewables (11%).[6]

Compared to West Virginia, a state that depends on coal for 94% of its electricity generation, New York is a relatively low carbon state. The expectation therefore is that New York State will yield a more positive electric vehicle benefit than would West Virginia. Figure 1 shows the vast differences in energy sources between New York State and West Virginia.

Figure 1: Net Electricity Generation by Source, Dec. 2016

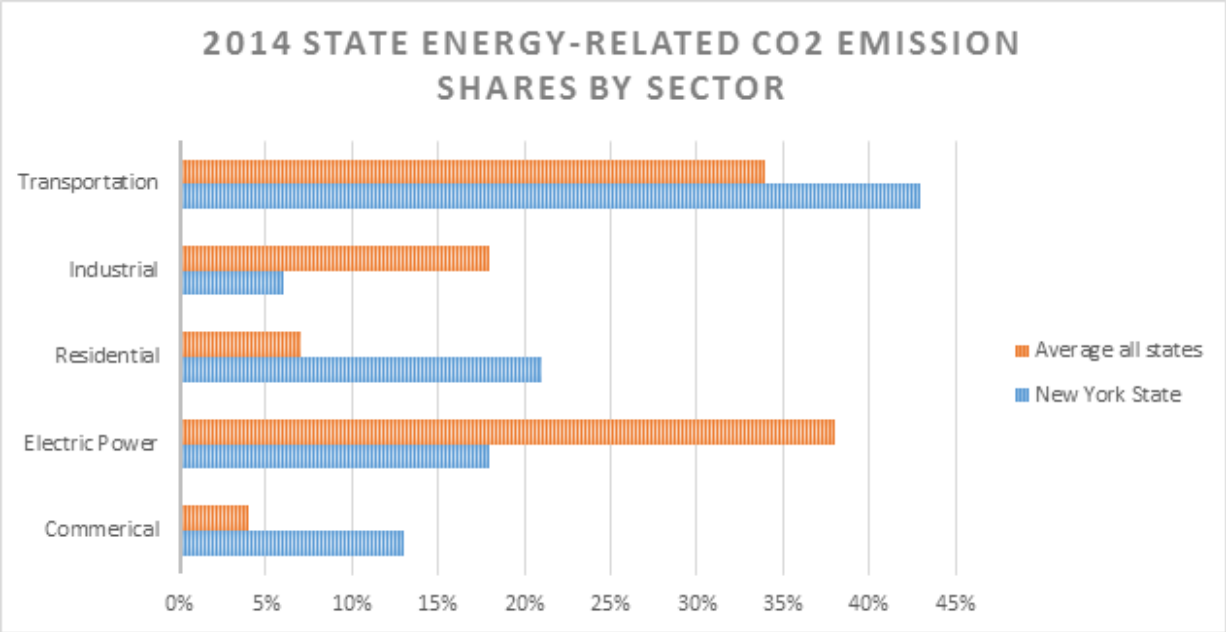


In 2010 New York State conducted a basic Tier 1 GHG emissions survey that served as a first draft of regional GHG emissions. The inventory was developed for the region and included Dutchess, Orange, Putman, Rockland, Sullivan, Ulster and Westchester

[6] "U.S. Energy Information Administration - EIA - Independent Statistics and Analysis." New York - State Energy Profile Overview - U.S. Energy Information Administration (EIA). N.p., n.d. Web. 08 Apr. 2017. www.eia.gov/state/?sid=NY#tabs-4>.

counties. The data was then supplemented with municipal level allocations for the villages and towns that populated the region. GHG emissions were estimated to be 26.5 million metric tons of carbon dioxide-equivalent ($MMTCO_2e$). The single largest source of GHG emissions across the region is transportation fuel consumption, which accounts for 11.9 million $MTCO_2e$, or 45 percent of regional emissions. Among the region's seven counties, over 38 percent of the regional total (about 10.2 $MMTCO_2e$), was allocated to Westchester County. This can be attributed to the county's large population and significant economic activity. Figure 2 shows the energy mix across all of New York State, indicating that transportation is again the dominant contributor to GHG emissions.

Figure 2: 2014 State Energy-related CO2 Emission Shares by Sector



This finding proves useful as it shows that that there is a consistency at both the county and wider state level. Policy prescriptions taken at the state level may have an effect at the county and vice versa given the findings of this study.

GHG Emission Reduction Estimates for Westchester County

The actual emission-reduction benefits associated with electric vehicles in a specific location are dependent on multiple factors, such as the electricity generation fuel mix, the time of day a vehicle is charging, and the vehicle type. Using a wide variety of methodologies and assumptions, numerous studies have investigated the impact of these different factors on emissions. A 2012 Union of Concerned Scientists (UCS) study concludes that emissions from electric vehicles are less than those of an average conventional vehicle, regardless of the mix of fuels used to generate the electricity on

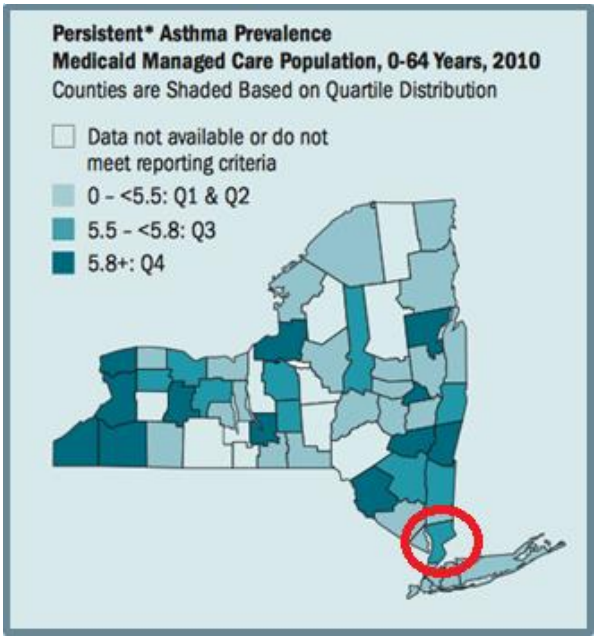
which they are charged.[7]

This paper uses New York State emissions data as presented in the Department of Energy's Alternative Fuel Data Center as the proxy for the conditions in Westchester County. See **Appendix A** for sources and assumptions used to calculate the annual emissions of an electric vehicle.

Using New York State's grid mix, average annual emissions for a conventional and an electric car were calculated. An electric vehicle adds 2,088 lbs. of CO_2e per year compared while a conventional gasoline vehicle adds 11,435 lbs. per year -- five times higher than an electric vehicle. The net carbon benefit of an electric vehicle replacing a conventional vehicle is 11,435 minus 2,088, or 9,347 lbs. of CO_2e.

Health Impacts

Figure 3: NYS Asthma Surveillance Summary Report Oct 2013



In addition to a reduction in GHG emissions there are health benefits that result from increased electric vehicle use. Various air pollutants, both inside and outside state and city boundaries, negatively impact the quality of life of New Yorkers. In the transportation sector, fine particulate matter, carbon monoxide, nitrogen oxide, and hydrocarbons produced from combustion engine vehicles damage lung tissue and lead to aggravated respiratory disease, such as asthma. With the rise of electric vehicles, air quality and cases of respiratory illnesses can significantly improve. In New York State, asthma among adults increased from 7.7% in 2000 to 9.7% in 2011 and was higher than the national average every year in between. During the same time period, the rate of emergency room visits and hospital discharge rates related to asthma is also above the

[7] Anair, Don, and Amine Mahmassani. 2012. State of Charge: Electric Vehicles' Global Warming Emissions and Fuel-Cost Savings across the United States. Cambridge, MA: Union of Concerned Scientists.
http://www.ucsusa.org/sites/default/files/legacy/assets/documents/clean_vehicles/electriccar-global-warming-emissions-report.pdf.

national average for all ages.[8]

The rise of respiratory illnesses increases health care costs. New York State's cost of asthma hospitalizations for 2011 was $660 million, a 61% increase since 2002. The average hospitalization cost was $17,954 in 2011, a 78% increase from 2002. Among New York State's Medicaid managed care population, more than $276 million was spent in 2010 for asthma- related services; or $1,109 per enrollee. [9]

When educating the general public on the benefits of electric vehicles, it is important to emphasize the impact zero emissions vehicles have on air quality, public health and health care costs. The New York State Department of Health aims to reduce the burden of respiratory illness on New Yorkers through better access to health care and cleaner air initiatives. Electric vehicles are one of many outlets to achieve this goal.

II. Municipal Considerations

A. Cost Barrier Overview

Cost is the most significant barrier to widespread acceptance of electric vehicles. Two other significant barriers are comfort with electric vehicle technology and easy access to charging stations. For planning purposes, municipalities need a better understanding of the timeline for electric vehicles to overcome the cost barrier and reach price parity.

The electric vehicle market today is based on early adopters who enjoy the latest technology or are keen to reduce emissions. The rate of mass adoption, expected to be similar to other emerging technologies, will be based on cost and cost is based on battery price.

For municipalities whose planning is on a ten, twenty or even fifty year time horizon, now is the time to set EVSE (charging stations) installation policies. Such policies include zoning and permitting to allow for simpler home installation and ESVE at gas stations; mandates on EVSE infrastructure in new commercial and multi-family residences; and, incentives for workplace EVSE stations.

Total Cost of Ownership

Despite the health and GHG benefits electric vehicles provide, a higher purchase price

[8] New York State Asthma Surveillance Summary Report, New York State of Health, Octorber, 2013 https://www.health.ny.gov/statistics/ny_asthma/pdf/2013_asthma_surveillance_summary_report.pdf
[9] Ibid

dissuades potential purchasers. The 2017 manufacturer's suggested retail price (MSRP) for a conventional Toyota Camry starts at $23,070 while the Nissan Leaf starts at $30,680.[10] Consumer rebates are available to help equalize costs. Consumers can receive up to $7,500 through a federal tax credit and $2,000 from a New York State rebate.

However, operating costs for an electric vehicle are lower mainly due to using electricity as fuel rather than gas. According to a 2015 NerdWallet report,[11] Toyota Camry's gas cost over five years is $7,000 while a Nissan Leaf's electricity cost over five years is $2,750.

Maintenance for electric vehicles is also less expensive as there are fewer moving parts, fewer fluids (including oil) to change. A 2015 NerdWallet report estimated five-year maintenance cost for a Toyota Camry at $2,846 while the Nissan Leaf was $2,403.

Overall, if purchase price rebates are available, the Nissan Leaf's purchase price and five-year operating costs total $26,333 while the Toyota Camry's total $32,916.

Lessons Learned: Importance of Electric Vehicle Cost Offset, Georgia

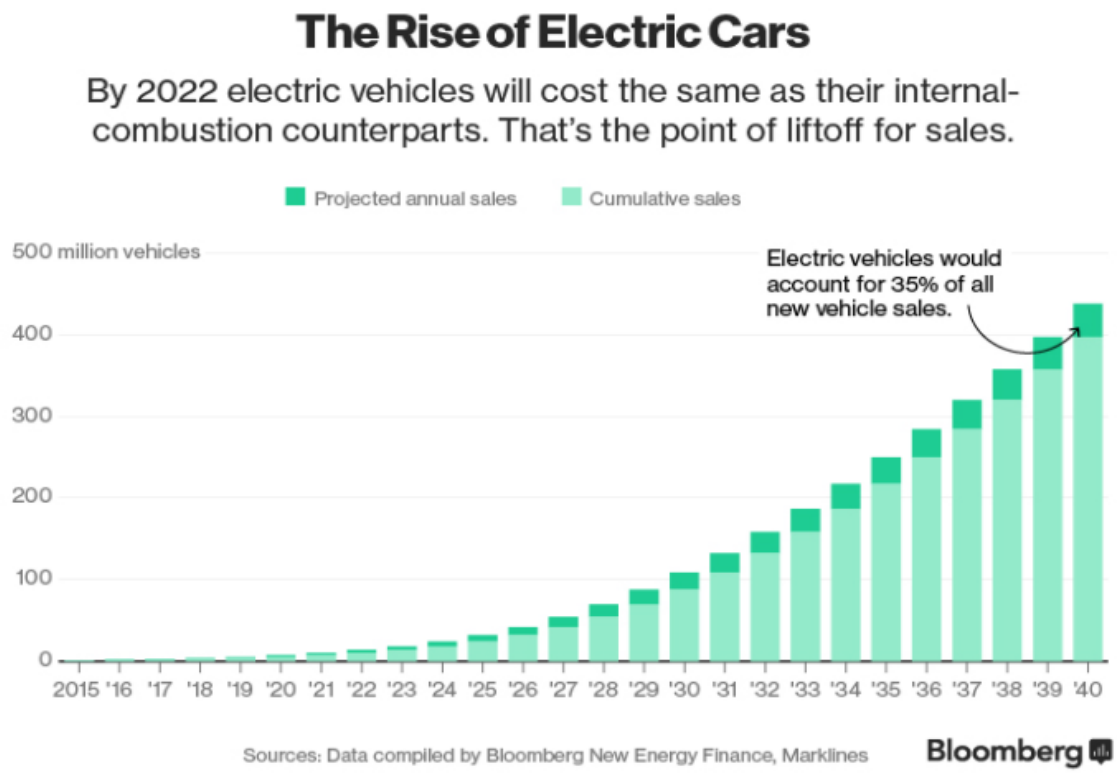
In Georgia, electric vehicle registration has dropped 90 percent since the summer of 2015. That summer, two years after Georgia was named a leader in electric vehicle proliferation, the state saw the sharpest decline, with 1,426 registrations in July to just 242 in August. Georgia had previously given a $5,000 tax credit to electric vehicle purchasers. Conservative state lawmakers in rural stretches of the state did not approve the bill because many felt it only benefited electric vehicle drivers in Atlanta and other urban areas. Instead, the state imposed a $200 registration fee in 2015 after discontinuing the credit.

Reaching Price Parity

The lithium-ion battery represents one-third of an electric vehicle's cost. Over the next few years, it is expected that battery costs will come down dramatically. Battery costs have already decreased from $1,000 per kWh in 2010 to $350 in 2015 and are expected to decrease further to $120 by 2030. A Chevy Bolt's battery is 60 kWh.

[10] Google search by model & year
[11] Chu, Jeffrey. "Electric vehicles vs gas hybrid cars: A comparison of maintenance, fuel, insurance and other costs." NerdWallet.com. Web. September 15, 2015.

Figure 5: Estimated Increase of Electric Vehicle Sales from 2015 - 2040



In 2015, roughly 460,000 electric cars were sold, less than one percent of global sales. This was a 60 percent increase from 2014, the same increase as Ford Model T sales in the 1910's. Bloomberg New Energy Finance predicts price parity for electric vehicles by 2022, just five years away. At that point, electric car sales will grow significantly.[12] Electric vehicles are predicted to account for 20 percent of new purchases in 2027 and 35 percent in 2040.

B. Electric Vehicle Technology Learning Curve

Consumers rely on their vehicle's safety, reliability and performance. Although electric vehicle technology is not new, mass market manufacturing and adoption of electric vehicle technology is. Electric vehicle technology is rapidly evolving and little understood. Battery driving range and charging time is a particular concern for consumers. Various charging levels provide different rates of charge with faster chargers being considerably more expensive to install and operate. Battery technology is exponentially improving, leading to longer driving ranges at lower costs.

[12] Randall, Tom. "Here's how electric cars will cause the next oil crisis" Bloomberg.com. February 25, 2016. Web. https://www.bloomberg.com/features/2016-ev-oil-crisis/

Consumers can feel more comfortable with electric vehicles through outreach and education. Municipal fleets also play a role by familiarizing consumers with electric vehicles. Dealerships too play a critical role by assuring consumers of the vehicle's reliability.

C. Electric Grid Overview

There is speculation that the electric grid cannot handle increased demands from electric vehicles. While electric vehicles do present a new demand for electricity, a survey of the available literature seems to indicate that even large increases in electric vehicle sales will not necessarily require the addition of new electric generation capacity or substantial upgrades to existing transmission and distribution infrastructure.

Electric demand rises and falls depending on time of day and time of year. Electric production, transmission and distribution must have the capacity to meet peak demand at all times. In the United States on average 50% of the generation capacity is used 100% of the time. More importantly for only 5% or about 400 hours per year more than 90% of capacity is used. As a result, electric vehicles will create little or no need for additional capacity, as long as they charge predominantly during off-peak times when the electric load on the system is at a minimum.

D. Gasoline Tax Overview

As the number of electric vehicles grows, states face declining revenues from gasoline and diesel taxes, generally funding transportation infrastructure States have begun to implement alternative revenue streams. For example, electric vehicle owners in Colorado must pay an annual fee of $50. Similarly, in Nebraska, the Department of Motor Vehicles imposes a fee of $75 on any vehicle powered by a source other than motor fuel when the vehicle is registered and annually thereafter. Electric vehicle owners in Georgia must pay an annual license tax of $200.

E. Consumer Use Patterns

Understanding consumer charging and use patterns can help municipalities anticipate future changes in infrastructure needs. The Plug-in Electric Vehicle Owner Survey is administered in California by the Center for Sustainable Energy and the California Air Resources Board to understand consumer trends in the electric vehicle market.[13] The survey uncovered differences in purchasing motivation for owners of different models

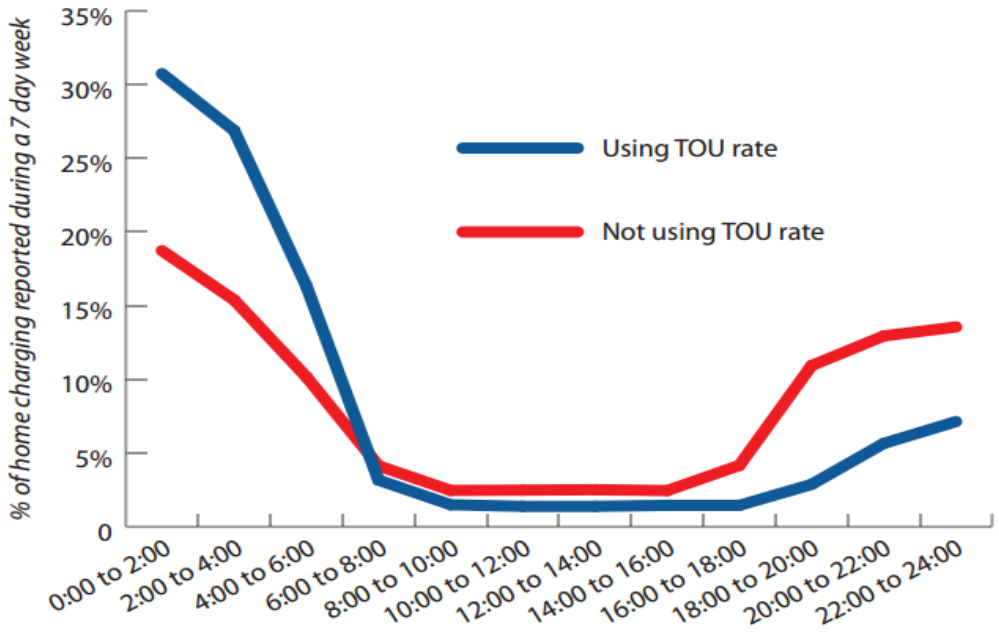
[13] "Plug-in Vehicle Owner Survey." California Clean Vehicle Rebate Program, Web. February 19, 2014. cleanvehiclerebate.org/eng/vehicle-owner-survey/feb-2014-survey

and a 14% increase in availability of charging infrastructure at workplaces since 2012. The average use of survey respondents was 29 miles per day.

Survey respondents consisted of 57% Nissan Leaf, 17% Chevrolet Bolt and 22% Toyota Prius owners. Leaf drivers claimed environmental impact as the main reason for purchase, while Prius and Bolt drivers sighted HOV lane access and fuel savings respectively. 59% of respondents said having HOV lane access was of high importance in their decisions to purchase an electric vehicle.

While the availability of infrastructure has improved since the previous survey, 71% of respondents expressed dissatisfaction with public charging infrastructure. 64% of respondents installed level 2 chargers at home and less than half of respondents had access to workplace charging. As expected, the majority of in home charging owners charged their vehicles overnight during off-peak hours. Consumers are taking advantage of time-of-use (TOU) rates that encourage off-peak charging when available by programming their electric vehicles to charge after midnight.

Figure 4 Charging Behavior of Owners on a TOU Rate vs. Non-TOU Rate[14]



In a separate study conducted by the U.S. Department of Energy, it was found that consumers use public charging stations for 45 minutes longer than necessary, limiting the

[14] "Plug-in Vehicle Owner Survey. "California Clean Vehicle Rebate Program, Web. February 19, 2014. cleanvehiclerebate.org/eng/ vehicle-owner-survey/feb-2014-survey

availability for other consumers.[15]

Charging cost, convenience and range anxiety are the top three factors considered when consumers decide when to charge their vehicle. The least important considerations were environmental impact and grid impact, a surprising find given that owners cited environmental benefits among the highest motivators for purchasing an electric vehicle. This discrepancy may indicate a lack of awareness of environmental impacts of when and how vehicles are charged.

III. Rolling Out an Electric Vehicle Plan

Municipalities have many avenues from which to encourage electric vehicle proliferation including zoning and permitting, municipal fleets and electric vehicle supply equipment.[16]

Zoning and permitting is an area where municipalities have jurisdiction. To encourage electric vehicles, municipalities amend building codes, permitting and parking and zoning ordinances. Municipalities also identify key sites for charging stations, guide public and private parking lot adaptation and standardize signage.[17] For example, by categorizing residential charging stations as "minor work," homeowners have less expensive, simpler permitting. Inspections can be handled by an electrician rather than a municipal inspector and property taxes are not affected. Other helpful elements include an online application, installation guidelines, load calculators and a utility notification process. More zoning adaptations include adding EVSE as an acceptable installation, setting criteria for design and accessibility,

[15] U.S. Department of Energy. Web April 23, 2017 https://www.smartgrid.gov/files/B3_revised_master-12-17-2014_report.pdf

[16] More detailed resources are available at NYSERDA (www.nyserda.ny.gov) and TCI (www.transportationandclimate.org).

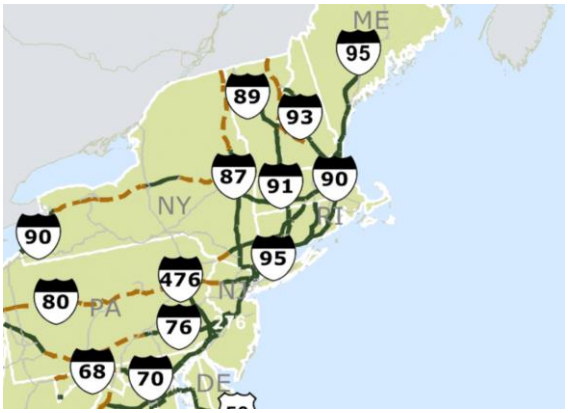
[17] Climate Smart Communities Webinar. Energetics: EVSE Permitting, Zoning, Parking, Best Practices and Opportunities. Department of Environmental Conservation. Web. 2014. http://www.dec.ny.gov/docs/administration_pdf/toolkitev.pdf

and incenting infrastructure in new developments (multi-residential housing, commercial buildings, parking).

Parking lots are a key area for electric vehicle plans. Standardized signage is needed to inform drivers of charging and parking rules. Laws are established to ticket or tow parked vehicles that are not using the charge port. Incentives include giving electric cars parking priority or waiving parking fees and HOV lane use.

Municipal partnerships or the federal government use zoning to encourage alternative fuel corridors along major highways to make long distance electric vehicle use viable for commercial and consumer transportation. In January 2017, The US Department of Transportation designated a network of 55 highways across 35 states as the first "alternative fuels corridors." The roads will have signage to alert drivers of alternative energy stations. The Federal Highway Authority will work with state and local municipalities and the private sector to install charging/fuel stations. The designated roads relevant for Westchester are I-87 from New York City to Lake George; I-95 from Washington DC to Augusta, Maine and I-84 from Middletown, NY to the Connecticut-Massachusetts border. Opportunities to encourage electric vehicle use will arise for Westchester municipalities along these major arteries.

Figure 3: Alternative Fuel Corridors



Fleets are another area where municipalities impact electric vehicle use. Many municipalities have mandated that its new fleet purchases, where possible, are electric vehicles. Apart from reduced emissions and air pollution, clean fleet use is a public endorsement for residents and "test drive" for municipal workers.

Municipalities can also encourage commercial fleets to purchase electric vehicles through recognition and low-cost incentives. Examples are dealer rebates, media events or other promotions featuring dealers or corporations with electric fleets and low-cost financing for commercial fleets.

A. Electric Vehicle Supply Equipment (Charging Station) Primer

Apart from cost, the largest barrier to electric vehicle growth is the small number of charging stations currently available to consumers. For mass adoption of electric vehicles, charging stations need to be numerous and as visible as gas stations. Municipalities can help overcome this barrier by installing EVSE themselves or mandate installation by commercial entities. The three types of charging stations are Level 1, Level 2 and Level 4/High-speed.

> *Level 1:* These are lowest cost and slowest charging stations. They are typically used for municipal fleets with some public access, installed in municipal parking lots and are free of charge. They are also used for residential installations.
>
> *Level 2:* These charging stations are more expensive and faster than Level 1. They are typically installed for commercial use but are also installed in residences. The commercial stations are sited close to commuter hubs and business centers for consumers to conveniently charge during work hours. They may be fee-based.
>
> *Level 4/High-speed:* These charging stations are many times more expensive than Level 1 or Level 2 but charge within 30 minutes. This charging station may be installed for municipal use but is more likely found along major transportation arteries. They are fee-based and typically installed through an EVSE provider such as ChargePoint or EV Connect.

Public charging stations present difficult questions regarding ownership and cost-allocation. There are several options for structuring ownership and cost-recovery. Among the most common are:

- Owned by a government entity, with the costs borne by tax-payers or by electric vehicle users;
- Owned by a regulated utility, with the costs shared by all utility ratepayers or allocated specifically to electric vehicle owners who use the stations; and/or,
- Owned by private entities not subject to retail price regulation with or without a profit-share arrangement with the municipality.

Lessons Learned: Infrastructure in Boulder, Colorado

The City of Boulder initially expected to install 40 charging stations by mid-2012. Despite this goal, only five were installed for public use and seven for city fleet use. The installation costs ran much higher than expected. Boulder's fleet manager said that in order to run electrical lines from the South Boulder Recreation Center to the desired charger location across the parking lot, more than 100 feet of concrete needed to be dug up and then replaced. The materials and labor for the concrete work cost more than $21,000, not including the cost of the charger itself, plus more for contracting assessments and project management. Charging station placement has been among the biggest challenges for the city to overcome.[18]

Lesson Learned: Work the ancillary costs such as wiring, demolition and construction and extra time needed to prepare a site for a charging station into the budget.

B. Funding Initiatives

New York State programs are administered through the New York State Department of Environmental Conservation (Nancy Welsh ZEVrebate@dec.ny.gov), New York Power Authority (John Markowitz john.markowitz@nypa.gov) and New York State Energy Research and Development Authority (NYSERDA). Other contacts are Pamela Hadad Hurst at DEC (pamela.hadadhurst@dec.ny.gov) or Anna Eckstein-Burns at OGS (Anna.Eckstein-Burns@ogs.ny.gov). Funding opportunities change with each budget cycle and may have limited availability. It is recommended that municipal planners contact agencies during their planning.

Westchester County and many other municipal governments across the state require that fleet purchases meet high fuel efficiency targets usually available only through plug-in vehicles. An exception is made for vehicle types that are not yet available as plug-in or for emergency vehicles. New York State has many funding programs.

Clean Energy Communities

Clean Fleets, part of the Clean Energy Communities Program at NYSERDA (cec@nyserda.gov) offers municipalities 50 hours of free on-demand technical assistance and a step-by-step toolkit. By installing a charging station or purchasing an electric vehicle for its municipal fleet, the municipality has completed one of four actions to be

[18] Nowicki, April "Boulder's Electric Vehicle Future". Web 8 April 2017. https://www.greentechmedia.com/articles/read/Boulders-Electric-Vehicle-Future

named a Clean Energy Community and apply for a grant up to $250,000.

Zoning Upgrades

Zoning, permitting and building code changes are the building blocks for electric vehicle proliferation. For example, California requires new multi-family residential and commercial developments to install a minimum number of charging stations in parking areas. Through NYSERDA, New York State encourages such changes with up to $5,000 in funding to support a community's zoning changes.

Municipal Charging Stations

DEC had a grant program for municipalities to offset the costs of publicly available charging stations expiring on March 31, 2017. (The 2017 New York State budget specifics were not available at the time of this writing.) This funding supports infrastructure projects for public charging and/or fueling of vehicles that meet the clean energy standard. Municipalities must submit a separate application for each facility.

The grant allowed municipalities to receive rebates up to $8,000 per port or $32,000 per pedestal for Fast Charge infrastructure; up to two years to fulfill grant requirements. This is 80% of the estimated baseline cost; the municipality must match 20% of grant the amount.

New York Power Authority has ongoing programs to assist municipalities with financing electric vehicle infrastructure including:

- Competitive Solicitation: NYPA has completed a competitive solicitation that municipalities can utilize through NYPA's Energy Efficiency Program. The contract includes hardware, software and installation services.
- Self-install option: For municipalities planning to use in-house staff to install EVSE, NYPA can supply the necessary hardware and software.
- Five year loans with low interest rates: NYPA finances prospective EVSE projects through five years loans with low government to government interest rates. In addition, customers can use DEC funding to pre-pay the NYPA loan and avoid interest expenses.

Municipal Fleet Support

In 2016, DEC offered a grant program to help fund municipal purchase or lease (minimum of 36 months) of clean vehicles. Municipalities received rebates up to $5,000 for vehicles with an electric range greater than 50 miles and up to $2,500 for vehicles with an electric range between 10-50 miles. (The 2017 New York State budget specifics were

not available at the time of this writing.)

New York Power Authority offers zero-interest financing over a three-year term to support low emission vehicle purchase.

The Office of General Services together with DEC prepares a bid for interested municipalities and state agencies for zero-emission vehicles. April, 2017 marks the second such bid. The bid has a set of generic minimum standards to allow bids from many sources. In 2016, the Chevy Bolt won the RFP. Through the bid, municipalities received an 11% discount.

Rebates & Consumer Incentives

New York State encourages electric vehicle purchases through a $2,000 rebate (available April 1, 2017) and a property tax credit on charging station costs, high occupancy vehicle (HOV) highway lane access; and a 10 percent discount on EZPass tolls ("Green Pass"). Initiatives other states offer include marketing campaigns and engaging dealerships (Vermont has financial incentives). Oregon permits biennial registration for electric vehicles and offers rebates for home charging infrastructure. California gives residents a rebate to retire vehicles that fail the smog test ("cash for clunkers") and another to a less polluting vehicle.

Utility Incentives

Con Edison, a utility in the metropolitan New York area, offers residents a reduced price for off-peak charging. To deepen the incentive, in April 2017 Con Edison will roll out SmartCharge,[19] an off-peak electric vehicle charging incentive program. Con Edison was directed by New York State to create the program to increase system efficiency and decrease system peak demand.

SmartCharge Rewards™

- $50 in rewards for signing up for SmartCharge New York.
- $5 per month in rewards for charging in the Con Edison Service Territory and maintaining the C2 installed in the vehicle.
- 5 cents per kilowatt for charging during off-peak hours year around (12 midnight – 8 am).
- $20 per month for no summer peak charging (2 – 6pm weekdays, June 1 – September 30).

SmartCharge, available to all electric vehicle owners who charge with Con Edison, deploys a cellular-enabled, connective car technology called the C2 that collects

[19] "Electric Vehicle Charging Rewards." Con Edison. N.p. n.d. Web. coned.com/en/save-money/rebates-incentives-tax-credits/rebates-incentives-tax-credits-for-residential-customers/electric-vehicle-rewards

data at no cost to the electric vehicle owner. The C2 is easily installed in the on-board diagnostics port of the vehicle and can view their analytics on an interactive web portal. Rewards based on their charging behavior. Con Edison estimates that program participants can earn up to $340 per year in rewards.[20]

State Funding Across the US

Colorado

Colorado established a comprehensive tax rebate policy for electric vehicles owners purchasing for the first time. The new tax credit is a flat $5,000 for passenger vehicles and goes up to $20,000 for fleet trucks.[21] To utilize the tax credits, lenders or vehicle financing entities provide a $5,000 cash rebate to vehicle purchasers up front and exchange the tax credits they receive from the government. This reduces the vehicle price at purchase.

California

According to California Environmental Protection Agency, California residents get up to $7,000 rebate by purchasing or leasing a new, zero emission electric vehicles.[22] Additionally, in 2016, the California Energy Commission approved approximately $9 million of grants to four specific companies, including ChargePoint and EV Connect, to install DC fast chargers on major state freeways and highways.

Private sector funding to build electric vehicle infrastructure is growing in California as well. The three major privately owned utility companies plan to spend $200 million to build charging stations in various locations from apartments to workplaces.[23] This is part of a $1 billion initiative to be raised over the next five years to help the state of California meet its electric vehicle target.[24]

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[20] "Con Edison program paying rewards for smart electric vehicle charging." Morningstar.com. N.p. April 17, 2017. morningstar.com/news/marketwired/MWR_urn:newsml:marketwired.com:20020408:2017041711G135967-001_US/con-edison-program-paying-rewards-for-smart-electric-vehicle-charging.html

[21] Reifer, Samantha. "Understand Colorado's New Electric Vehicle Tax Credit", CEO Policy & Research Team. Web. June 8, 2016, www.refuelcolorado.com/market-developments/clean-cities/ understand-colorados-new-electric-vehicle-tax-credit

[22] California Clean Vehicle Rebate Project, Web. N.d cleanvehiclerebate.org/eng.

[23] "Energy Commission Funds Electric Vehicle Chargers along Major State Routes Also Continues to Fund Research to Bring Clean Energy Technologies to Market." California Energy Commission. Web. , April 13, 2016, http://www.energy.ca.gov/releases/2016_releases/2016-04-13_ev_chargers.html

[24] St. John, Jeff. California Utilities Seek $1B to Build Out Electric Vehicle Infrastructure." Green Tech Media. Web. January 24, 2017. /www.greentechmedia.com/articles/read/ california-utilities-seek-1b-to-build-out-electric-vehicle-infrastructure

IV. Case Studies

A. New York State

City of Rochester, Monroe County (Genesee Region)

Population: 209,802[25] (2015)
Median Income: $30,960
Estimated Electric Vehicles (Fleets): 41 EVs[26]

From the flour mills along the Genesee River to the birth of Kodak and Xerox, Rochester was built on industry. Yet as new technologies emerged and old industries faded, its population decreased leaving the city with the remnants of a once-booming industrial economy.

In 2013, Rochester became part of Clean Cities, a U.S. Department of Energy program to reduce U.S. dependence on petroleum. With $228,000 in hand, Rochester partnered with Genesee Region Clean Communities (a nonprofit), Energetics (a consulting firm providing expertise and project management) and ChargePoint (a ESVE supplier) to install 24 charging stations at seven centrally located parking lots and garages. This team composition is typical for municipal electric vehicle plans.

Rochester residents have embraced the charging stations. According to NYSERDA, Rochester's charging stations are utilized more than in any other city in New York State.[27] Charging stations are utilized 11.2% of the time for an average 3.3 charges per week, 50% more than the next closest city.

Charging station locations determined usage and therefore value to the public. Rochester's workplace charging stations at universities, medical campuses and commercial parking lots have high usage rates. Sites for overnight or all-day parking like multi-family dwellings, hotels and commuter parking lots also saw significant use.

Retail location-based charging stations averaged the highest number of charging events per week, but these were mostly short events where the vehicle was only plugged in for about one hour. Charging stations in urban and suburban settings had more frequent

[25] "Quick Facts: City of Rochester" U.S. Census Bureau. N.d. Web. www.census.gov/quickfacts/table/INC110215/3663000,36
[26] "Electrical Vehicle Charging Station Implementation Plans for the Upstate New York I-90 Corridor." NYSERDA. N.p., Aug. 2016. Web.
[27] "Rochester goes green with electric vehicle grant" Rochester First. Web. N.d. www.rochesterfirst.com/news/local-news/rochester-goes-green-with-electric-vehicle-grant/510897376

use than in a rural setting. However, rural charging stations were used once per week on average and provided more electricity per charge event than suburban stations. This indicates their value.

Not surprisingly, free charging stations had twice the usage as charging stations that charged a fee. However, the "fee" stations saw longer connections that consumed more energy per charge.

In March 2017, Governor Cuomo announced that Rochester will be part of a pilot program to expand its charging station infrastructure, provide community engagement and educate residents and business about electric vehicles.[28] The goal is to demonstrate how developing an electric vehicle ecosystem can increase electric vehicle adoption and prepare a community for long-term electric vehicle growth. The program will be managed by three contractors: Energetics, CalStart and EV Connect. Thus, the Rochester EV Deployment Community will create replicable models for other New York communities to use for accelerating electric vehicle adoption.

City of Buffalo, Erie County

Population: 258,071[29]
Median Income: $31,918
Estimated Electric Vehicles (Fleets): 71 EVs

Buffalo is not new to electric vehicles. While it did not last long, the Buffalo Electric Vehicle Company (1912-1915) was the country's first electric vehicle manufacturer. Nearly 100 years later, electric vehicles have made a comeback. Today, Buffalo is among the state's leaders in electric vehicle and plug-in hybrid vehicle ownership according to the New York State Department of Motor Vehicles data.

Buffalo partnered with Energetics (a consulting and project management firm), Capital District Clean Communities (a nonprofit), and Capital District Transportation Committee (a team of local leaders). Buffalo currently has 25 public charging ports at SUNY-Buffalo, the Buffalo Zoo, and Buffalo Niagara Medical Campus. Additionally, the Buffalo Niagara International Airport has three charging stations with two ports on Level 1 in the daily/hourly parking garage.

Usage rates for Buffalo's charging stations are lower than Rochester's. Moreover, Erie County (Buffalo) has nearly as many public charging stations as Monroe County

[28] "City, NYSERDA celebrate Earth Day by unveiling new electric vehicle charging stations." Web. April 22, 2014. www.cityofrochester.gov/article.aspx?id=8589960953
[29] US. Census Bureau. "Quick Facts: Buffalo city" N.d. Web. www.census.gov/quickfacts/table/AGE135215/3611000

(Rochester), yet Monroe County has more than three times as many electric vehicles. This data suggests the complexity of encouraging electric vehicle sales and how results can differ from county and county.[30]

Lessons Learned: Rochester vs. Buffalo

According to NYSERDA, grants funded the installation of 64 charging ports in and around Erie County and 43 ports in and around Monroe County. Despite this funding pattern, 2016 data shows that even though Erie County had more infrastructure, overall charging use was 60% higher in Monroe County. Our research indicates that the approach to charging deployment plays a more important role in encouraging electric vehicle adoption than the number of stations.

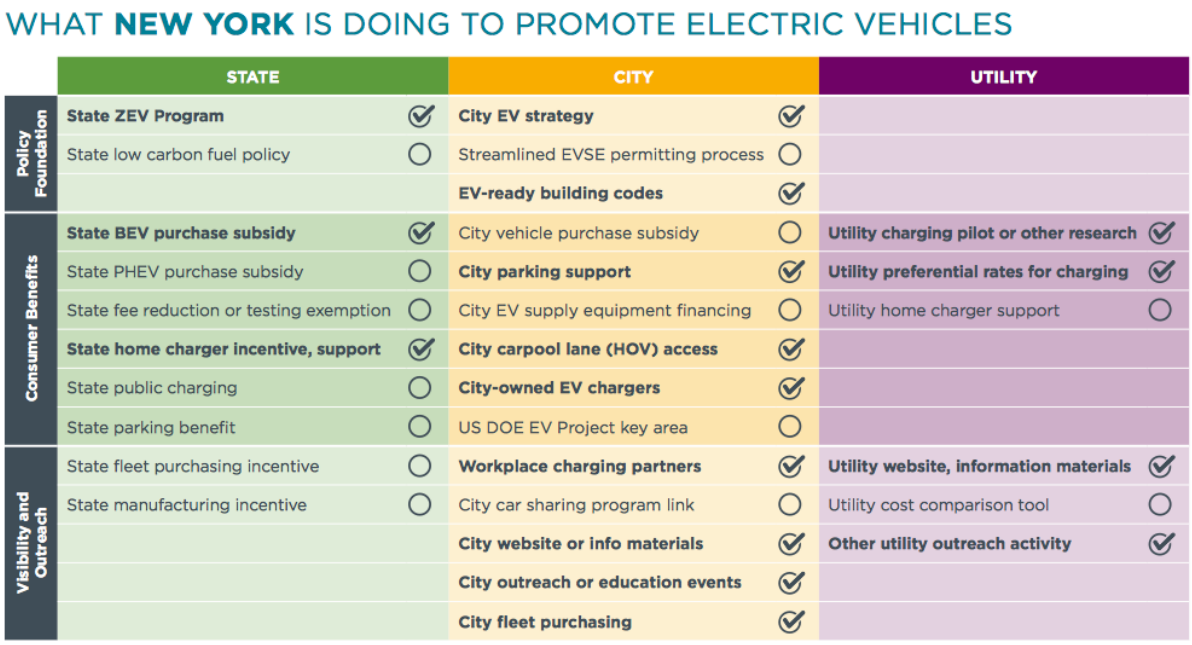
Rochester installed its 24 charging stations in high-traffic, centrally located parking facilities. Buffalo's charging stations are not as visible or easily accessible to the public. Rochester's charging stations were well-maintained while Buffalo's were often inoperable.

Charging stations are better utilized near workplaces, residential buildings, hospitals, universities and commuter hubs.

[30] NYSERDA. Charge NY. Review of New York State Electric Vehicle Charging Station Market and Policy, Finance and Market Development Solutions. N.p., Oct. 2015. Web. 28 Jan. 2017.

New York City

The New York City metropolitan area compares favorably in its electric vehicle promotion initiatives according to the International Council on Clean Energy (ICCE)'s 2015 U.S. City Electric Vehicle Profile having implemented 16 of ICCE's 30 key state, city and utility initiatives. Please note that "City" in this survey refers to New York City. Westchester municipalities have initiated fewer initiatives. This ranks the New York City metropolitan areas as eighth among the 25 largest cities. The area's electric vehicle sales are average at 16th in the ranking, however charging station infrastructure lags with New York City ranking 25th.[31]



B. Other North American Cities and States

Austin, TX

Population: 931,830
Median Income: $57,689
Estimated Electric Vehicles: 3,000+

When most people think of Austin, TX, country music, technology, and good bar-be-que might come to mind. Over the last decade, Austin has focused on advanced technology

[31] "2015 U.S City Electric Vehicle Profile Project." International Council of Clean Energy. N.p. n.d. theicct.org/sites/default/files/info-tools/EV_Cities_profiles_LR/NewYork_CityEV_2015.pdf

and electric vehicles with the goal of becoming the U.S. automotive capital. In June 2011, there were less than three dozen cars in Austin. When Austin Energy began a program called Austin EV Everywhere in 2012, charging stations doubled in and around the city in four years to over 250 charging stations. According to Austin Energy, there will likely be 200,000 electric vehicles in Austin by the end of this decade.

With Austin Energy, any charging stations within the Plug-In Everywhere network are charged on 100% renewable energy from Austin Energy's GreenChoice Program. For $4.17 a month, electric vehicle owners can plug in at any charging station in Austin.[32] In addition to low costs, Austin Energy developed a showcase for sustainable transportation in downtown Austin called Electric Drive. Electric Drive has a DC fast charger that charges cars in minutes and level 2 charging stations for electric vehicle drivers who wish to spend time downtown and charge their vehicles simultaneously.[33]

To help drivers who wish to charge at their home, Austin Energy offers up to a $1,500 rebate towards the hardware and installation of a level 2 charger. There are also rebates for electric bikes, scooters and motorcycles as an additional way to promote electric vehicle adoption. Austin Energy is also focusing infrastructure efforts on multifamily condo and apartment properties. Over 40 apartment and condo complexes are now electric vehicle ready with level 2 charging stations.

Many companies around Austin are creating electric vehicle ready parking garages. Semiconductor company AMD is one of the largest corporate charging providers in Austin with 30 electric vehicle charging stations on its campus. Not only does AMD provide charging stations, it pays for EV Everywhere monthly subscriptions. Austin Energy rebates pay for up to $4,000 per charging stations to help offset the cost.[34] In addition to partnering with businesses to provide infrastructure, Austin uses music festival SXSW to promote electric vehicle adoption among younger generations.

Raleigh, NC & Project Get Ready

The Rocky Mountain Institute (RMI), an independent nonprofit organization that leads the effort on efficient use of natural resources, began Project Get Ready in conjunction with several partners and advisors, to lead the transition to electric vehicles. The program

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[32] Austin Energy. Web http://austinenergy.com/wps/portal/ae/green-power/plug-in-austin

[33] Austin Energy, Press Release.Web https://austinenergy.com/wps/portal/ae/about/news/press-releases/2017/ae-launches-electric-drive/!ut/p/a1/jZDBTsMwEES_hUOOjrcOpYGbG1AIJUQcCG4ulRu2iaXUjmy3EXw9qbgAaqF7W-2bWc3QigpaablXjfTKaNkd9upqBSxm9wmwLJ2xGHiazBfT8mlynbMRWH4HirviFrKyKHmxSCBNojP1J4bDf_

[34] KUT 90.5, Austin's NPR Station. "As Texas Stalls in Electric Car Infrastructure, Austin Prepares for a Surge in Drivers" Web http://kut.org/post/texas-stalls-electric-car-infrastructure-austin-prepares-surge-drivers

was created to help community stakeholders to work together to create an electric vehicle plan and provide a forum for communities and cities to exchange lessons learned, best practices and show their progress to automakers and businesses worldwide. Project Get Ready prioritizes action items for cities into two categories: "must have" action items for new cities, where a community should meet most items; and "nice to have" action items for cities and communities that have already seen success in electric vehicle implementation.[35-36]

The Research Triangle

Population: 2,211,022
Median Income: $56,910
Estimated Electric Vehicles: 3,000+
Average Daily Travel: 16 miles

Raleigh, North Carolina and The Research Triangle area, including Cary, Chapel Hill and Durham have emerged as leaders in electric vehicle deployment thanks to its partnership with Project Get Ready. With this partnership Raleigh reduced barriers to electric vehicle adoption by addressing building codes, electrical codes and city ordinances related to signage, parking and fees for charging. The city also streamlined the permitting and inspections process for EVSE installation for consumers, businesses and fleets.

Project Get Ready assisted in assembling an interdepartmental team to take on issues such as streamlining the EVSE permitting and installation process. The team includes representatives from several city departments, including transportation, sustainability, development services, permitting, administration and public affairs, as well as private organizations Triangle Clean Cities Coalition, Duke Energy and Advanced Energy advisors. They developed five key objectives applicable to any city getting ready to roll out a plan for electric vehicles:

- Facilitate stakeholder working groups in resolving issues related to electric vehicles;
- Educate consumers on electric vehicles;
- Establish convenient and grid-friendly electric vehicle charging infrastructure;
- Develop relationships with electric vehicle and component manufacturers and ensure vehicle availability in local market; and,
- Explore opportunities for economic development related to electric vehicles.

[35] Rocky Mountain Institute. Web http://www.rmi.org/project_get_ready
[36] Please visit http://www.rmi.org/project_get_ready for the full list in these two categories and to download the EV City Casebook.

Much of Raleigh and The Research Triangle's success in electric vehicle deployment have been attributed to the participation of key stakeholders. Each city evaluated its needs individually and devoted a significant amount of time, funds and resources to the deployment of electric vehicles with the help of local non-profits.

Similar to Austin, TX, a utility, Duke Energy, is a key partner for Raleigh's electric vehicle initiative. Duke Energy assists in infrastructure research, customer support, stakeholder education and utility fleet implementation. By the end of 2014 the city operated more than 40 electric vehicles in its fleets, including Chevy Bolts, Nissan Leafs, Ford Fusion Energis and Tesla Roadsters. Additionally, the city created the "Greater Triangle Plug-In Electric Vehicle Readiness Plan" that takes into account survey results distributed to key stakeholders and recommends readiness actions for the entire community.

Colorado

The State of Colorado has a total of 423 electric stations with 976 public charging outlets. In an effort to improve air quality and encourage deployment of electric vehicles across Colorado, the Regional Air Quality Council (RAQC) and Colorado Energy Office (CEO) teamed up to create the Charge Ahead Colorado program. The program gives consumer friendly information and resources on financial support for electric vehicles and EVSE. The program has awarded funding to local municipalities and nonprofit organizations. Each organization funds 80% of the costs for EVSE.

Colorado currently gives consumers up to $13,500 in in-state and federal tax credits, including $5,000 off at the time of purchase.

The Denver International Airport (DIA) currently has 10 level 1 charging stations at the airport. DIA will add 10 more charging stations for electric vehicles at its public parking garages, doubling the total available for airport passengers. The charging stations will be free for use by anyone who pays to park in the garages and will be compatible with most electric and plug-in hybrid vehicles. A Charge Ahead Colorado grant covered $31,300 of the $66,100 cost of that installation.

Boulder residents can receive discounts on their purchases of electric vehicles through EV Benefits Boulder County, a program that is sponsored by the cities' Sustainability Division in partnership with the county's municipalities. With up to $12,000 in federal and tax incentives, on top of the program's $8,000 discount on a 2016 base model Nissan Leaf, consumers can buy a new car for about $12,000.

Vancouver, British Columbia, Canada

Vancouver has supported electric vehicle charging infrastructure in building codes since 2009 when the city first brought electric vehicles into their municipality fleet. By 2012, the number of electric vehicles in the city fleet grew to 17, not including electric bikes and scooters used by staff to travel to meetings. The city currently has 31 electric vehicles in its fleet with plans to grow by at least 115 by 2020. Over 78 public level 2 charging stations are available along with 24 city charging stations for fleets.

Vancouver's Renewable City Strategy, approved in March 2015, commits to derive 100% of its energy from renewable sources by 2050 and reduce greenhouse gas emissions at least 80% below 2007 levels. Achieving this goal will require a transition to electric vehicles. Vancouver is prepared to install the necessary electric vehicle infrastructure to support a transition to renewably-powered transportation. The plan's outlines a requirement to meet the following three factors:

- Accessibility: Improved access charging infrastructure
- Affordability: Reduced cost barriers to electric vehicle uptake
- Economic Opportunity: Develop a market large enough to support private sector operation of electric vehicle charging infrastructure

Vancouver coordinates its electric vehicle infrastructure efforts through a task force. A training crash course, referred to as a "quick start," was given to task force managers on electric vehicle charging requirements, technologies and potential configurations in building construction. A further training was given on installing hydro meters in city-owned buildings to track electric vehicle charging.

V. Recommendations

The Capstone team's recommendations are based on Sustainable Westchester's role as an information hub, a lobbying force for political action and a facilitator of complex projects.

As an information hub, Sustainable Westchester can facilitate consumer and dealer education. For consumers, Sustainable Westchester can hold electric vehicle education sessions at libraries and provide takeaway materials on the benefits of electric vehicle ownership. Other consumer marketing recommendations are an informational poster on Metro-North rail platforms and an informational sticker applied to charging stations. Depending on the venue, information can include the typical barriers to purchase such as installing a home charging station, mileage capacity, vehicle power and charging station availability; vehicle ownership costs, rebates and incentives and technology overview.

For dealers, Sustainable Westchester can educate them on ownership costs of electric vehicles and rebates and incentives available to purchasers and provide takeaway brochures educating their customers. Sustainable Westchester can give the most successful dealers recognition by giving them a framed certificate to hang in their showroom and asking them to participate in consumer information sessions.

Sustainable Westchester can use its political strength to advocate for initiatives that increase electric vehicle use. Such initiatives include a requirement that municipal fleets (at all government levels) purchase electric vehicles in available vehicle categories and that new parking lot spaces contain a minimum of 20 percent charging stations and that existing parking lots convert at least 20 percent of spaces by 2027. (According to Bloomberg New Energy, by 2027, 20 percent of new car sales will be plug-in vehicles.) An important change is for utilities to amend demand pricing so that entities with fast chargers are not penalized with a higher demand charges.

As a facilitator of complex projects, Sustainable Westchester can partner with experts to assist member municipalities with their electric vehicle proliferation plans. The Capstone team found that engaging experts was the common factor for success in our case studies. Similar to Sustainable Westchester's solar initiative, an electric vehicle initiative partnership includes planning and implementation experts and technology providers.

For example, NYSERDA, for its 2017 initiative, contracted with Energetics, EV Connect and CalStart to create outreach campaigns and ESVE implementation plans for the state's

largest cities. Energetics and CalStart provides strategic planning; project management; metrics and performance models; and communications and outreach. EV Connect is one of the leading charging station providers along with ChargePoint.

The Capstone team recommends that Sustainable Westchester creates similar partnerships to assist its member municipalities. The following are areas where Sustainable Westchester can engage with knowledgeable partners:

- EVSE Planning and Installation: Engage a partner such as an EVSE manufacturer to assist municipalities and commercial property owners with EVSE siting and installation. This will relieve these entities of the hurdle of assessing EVSE providers and provide a level of oversight they may find useful.
- Municipal fleets: Engage a consultant to create a tool to help municipalities track their fleet and evaluate electric vehicle replacement. Fleet data includes model year, annual mileage, use pattern (local, long distance, urgent). The tool, along the lines of NYSERDA's Watt Plan, would then assess which vehicles have comparable electric vehicle models and provide the highest operating cost savings.
- Funding assistance: Engage a consultant to reach out to municipalities to remind them of funding or other municipal opportunities and assist them with applications.

For its member municipalities, the Capstone team produced a "municipality toolkit." The toolkit explains electric vehicle technology basics, building an electric vehicle proliferation plan and funding sources. Its goal is to help municipalities break down the barriers to electric vehicle proliferation such as understanding new technology, costs and access to refueling stations.

The toolkit recommends that municipalities amend zoning and permitting regulations to simplify home charging station implementation. To provide ubiquitous access to refueling, the Capstone team recommends that municipalities mandate ESVE installation in new commercial and residential developments; encourage ESVE in workplaces and install ESVE in commercial centers. The team also recommends that municipal fleets are replaced as soon as practicable as they provide as an example to residents of electric vehicle viability.

The team further recommends that municipalities take advantage of support available through New York State agencies (NYSERDA, DEC and NYPA) and through Sustainable Westchester.

Appendices

Appendix A

The following sources and assumptions were used by the Alternative Fuel Data Center to show electricity sources and calculate the annual vehicle emissions for a conventional, hybrid electric, plug-in hybrid electric, or all-electric vehicle.

Parameter	Value	Source
Pounds of CO2e per gallon of gasoline	23.5	Full fuel cycle (well to wheels) greenhouse gas emissions (GHG) factors derived from GREET 2015. Results in CO2 equivalents (model available at http://greet.es.anl.gov)
National average electricity GHG/kWh	1.21	Energy Information Administration, Electricity Net Generation, Open Data, API http://www.eia.gov/opendata/qb.cfm?category=1
Electricity fuel mix	varies	Energy Information Administration, Electricity Net Generation, Open Data, API http://www.eia.gov/opendata/qb.cfm?category=1
Conventional vehicle mpg	24.3	CAFÉ Standard
HEV mpg	44.4	Sales weighted average of 2016 model year vehicles with sales in 2015: 2015 sales from "U.S. HEV Sales by Model" (http://www.afdc.energy.gov/data/vehicles.html); MPGs from 2016 Fuel Economy Guide (https://www.fueleconomy.gov/feg/)
PHEV mpg	37.9	Sales weighted average of 2016 model year vehicles with sales in 2015: 2015 sales from "U.S. Plug-in Electric Vehicle Sales by Model" (http://www.afdc.energy.gov/data/vehicles.html); MPGs from 2016 Fuel Economy Guide (https://www.fueleconomy.gov/feg/)
PHEV kWh/mi	0.367	Sales weighted average of 2016 model year vehicles with sales in 2015: 2015 sales from "U.S. Plug-in Electric Vehicle Sales by Model" (http://www.afdc.energy.gov/data/vehicles.html); MPGs from 2016 Fuel Economy Guide (https://www.fueleconomy.gov/feg/)
PHEV all electric range	33	Sales weighted average of 2016 model year vehicles with sales in 2015: 2015 sales from "U.S. Plug-in Electric Vehicle Sales by Model" (http://www.afdc.energy.gov/data/vehicles.html); MPGs from 2016

		Fuel Economy Guide (https://www.fueleconomy.gov/feg/)
EV kWh/mi	0.32	Sales weighted average of 2016 model year vehicles with sales in 2015: 2015 sales from "U.S. Plug-in Electric Vehicle Sales by Model" (http://www.afdc.energy.gov/data/vehicles.html); MPGs from 2016 Fuel Economy Guide (https://www.fueleconomy.gov/feg/)
Percentage of PHEV annual miles driven on electricity	55%	Estimate based on the current industry standard, SAE J2841 (available in http://avt.inel.gov/pdf/EVProj/EVProjectUtilityFactorBolt.pdf *(PDF)*), assuming the PHEV all-electric range is 33 miles.
Average annual vehicle mileage (miles)	11,824	Transportation Energy Data Book #34 (http://cta.ornl.gov/data/download34.shtml), Table 8.1; Total vehicle miles traveled divided by vehicles in operation, 2013

Appendix B

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Note: All websites were accessed between January 28-April 21, 2017.

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