EVS29 Symposium
Montréal, Québec, Canada, June 19-22, 2016

New York State EV Charging Station Deployment

Bryan Roy[1], Ziga Ivanic[1], Paul Windover[1], Adam Ruder[2], Matthew Shirk[3]

[1]*Energetics Incorporated; Clinton, NY and Columbia, MD; broy@energetics.com*

[2]*New York State Energy Research and Development Authority; Albany, NY*

[3]*Idaho National Laboratory; Idaho Falls, ID*

Summary

Over 600 Level 2 electric vehicle (EV) charging ports have been installed to support New York Governor Andrew Cuomo's Charge NY initiative, which is focused on supporting EV market development in New York State. These installations represent a wide range of business models and approaches for providing public charging to learn how different stations are used, including which types of locations are the most promising. EV charging station usage statistics based on various station attributes help determine where installing EV charging stations is a good investment.

Keywords: electric vehicle (EV), electric vehicle supply equipment (EVSE), charger, infrastructure, deployment

1 Introduction

The New York State Energy Research and Development Authority (NYSERDA) made financial grant awards in 2012 and 2013 to more than a dozen organizations to install Level 2 electric vehicle (EV) charging stations (also referred to as electric vehicle supply equipment [EVSE]) across the New York State. These installations support Governor Andrew M. Cuomo's ChargeNY initiative. The initiative set the goal of a state-wide network of up to 3,000 public and workplace charging stations to support up to 40,000 plug-in vehicles on the road by 2018. Since the program's inception in 2013, New York State has supported the installation of over 600 charging ports (bringing the state-wide total to more than 1,200), revised regulations to clarify charging station ownership rules, and supported research and demonstration projects on new EV technologies and policies.

At the end of 2015, there were 1,063 public Level 2 EV charging ports in New York State. Note that most charging stations have more than one charging port and some sites have multiple charging stations installed, so there are a lot fewer charging station locations than charging ports. NYSERDA-funded EVSE projects account for 628 of the 1,063 installed Level 2 EV charging ports. There are also 73 direct current (DC) fast charging ports in New York station.

The NYSERDA-funded EVSE projects represent a wide range of business models and approaches for providing public charging infrastructure. One NYSERDA program goal is to learn how the stations are used, including which types of locations and business models are the most promising. By doing so, NYSERDA is paving the way for future private sector charging station investment.

NYSERDA-funded EV charging stations were installed at 300 different locations throughout the state representing various venues. 20% parking lots or garages within New York City including both municipal and private; 16% are universities or colleges; 15% retail locations including several at Price Chopper

Supermarkets, Kohl's stores, and Chili's restaurants; 14% parking lots or garages outside of New York City including several municipalities such as the City of Rochester and Ulster County which each have around eight different sites; 13% are workplaces, both small and large; 6% are hotels; 4% are medical campuses; 4% are leisure destinations such as Niagara Falls, Bronx Zoo, Onondaga Lake Park, Museum of Innovation and Science in Schenectady, and Windham Mountain; 4% transit stations including airports and train stations; and 4% are multi-family apartments.

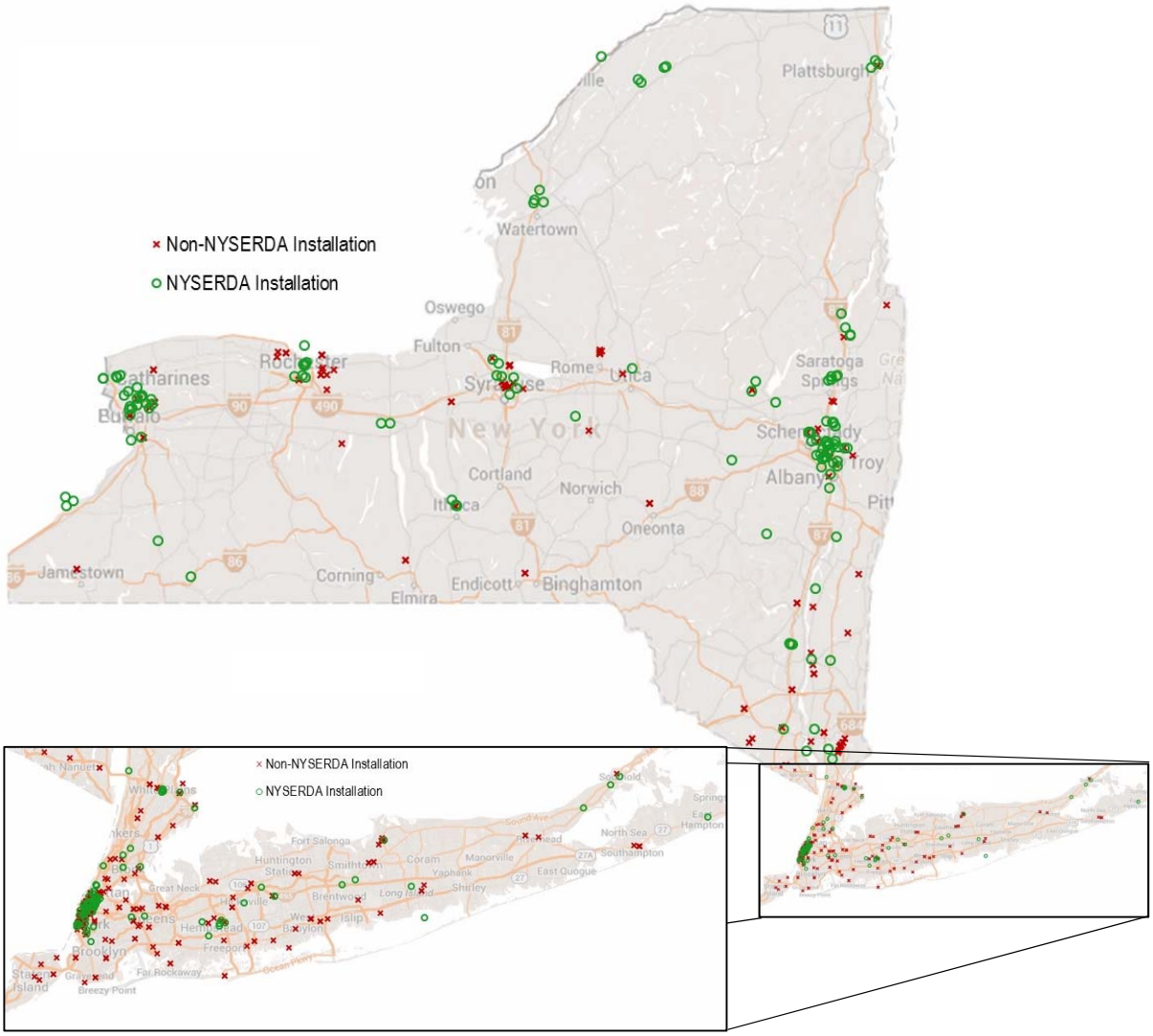

Figure 1. New York State EV Charging Stations

2 Data Collection and Analysis

Energetics Incorporated and Idaho National Laboratory have been collecting and analyzing data from the NYSERDA-funded EV charging stations to show usage statistics based on various station attributes. Energetics has also analysed and summarized EV ownership data from NYS Department of Motor Vehicle (DMV) registrations.

2.1 EV Charging Stations

Data analysis is conducted for various subsets of station characteristics including: access type, required payment, land use type, region, and venue. A charging event is defined as the period when a vehicle is connected to a charging unit, during which power is transferred. Between December 2012 and December 2015, the NYSERDA EV Charging Station Program funded the installation of 634 charging ports. Figure 2 shows the quarterly growth of installed charging stations through NYSERDA's program.

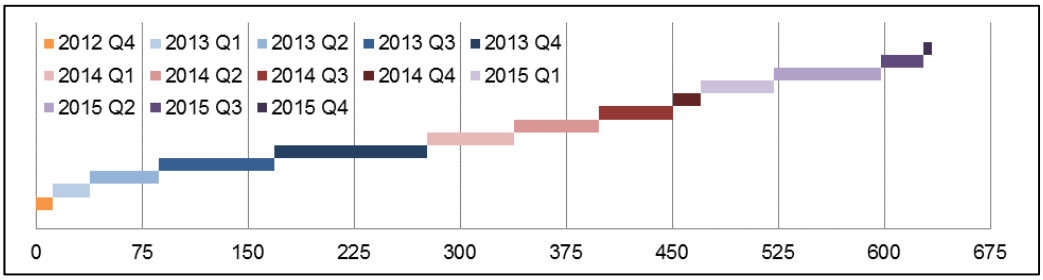

Figure 2. Growth in Installed EVSE Ports Supported by NYSERDA Funding

Data is collected for every charging port, which means that a charging station with two charging connections (a dual port station) was counted as two ports. EVSE access types are defined as follows:

- **Public** EVSE are available to any EV driver.
- **Limited** EVSE are installed specifically for, but may not necessarily be restricted to, a select group (e.g., employees, apartment building tenants, or hotel guests).

Table 1. 2015 Usage Statistics for NYSERDA-funded EVSE by Access Type

Access	Ports	Charge Events (CE)	Charge Events per day	Plug-in Time		Charging Time		% of Plug-in time charging	Total Energy (kWh)	Energy per CE
				Hours per CE	%	Hours per CE	%			
Public	435	31,814	0.23	3.6	3.5%	1.8	1.7%	50%	212,817	6.7
Limited	200	12,399	0.18	5.7	4.3%	2.3	1.7%	41%	98,236	7.9

As shown in Table 1, limited access stations are occupied much longer per charge event than public access stations (5.7 hours per charging event as compared to 3.6), but the average length of time a vehicle actually draws power from the charging port is fairly similar (2.3 hours per charge event for limited access stations as compared to 1.8 hours for public access stations).

In addition to the growth in number of deployed stations in the NYSERDA EV Charging Station Program over the past few years, there has also been a steady increase in the use of these stations in regards to both occupancy and dispensed electricity as shown on Figure 3.

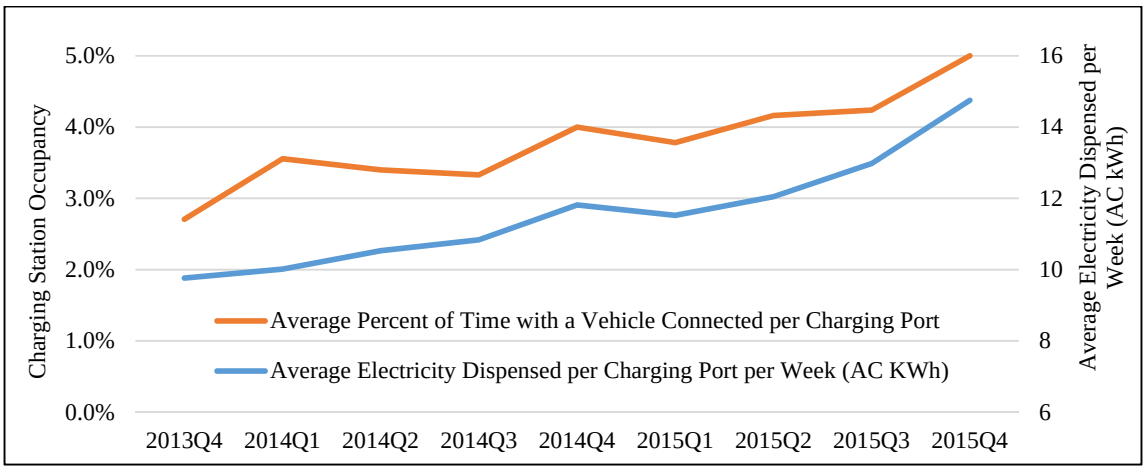

Figure 3. Growth in EV Station Occupancy and Electricity Dispensed Since the Fourth Quarter of 2013

EVs are likely connected to a charging station the entire time that they are in EV dedicated parking spaces. However, the vehicles only draw power until the battery pack is finished charging. The Charging Demand plot on Figure 4 shows the total electrical power used by all active NYSERDA-funded stations at different times of day. This data indicates the total electrical grid impact from EVs charging at NYSERDA-funded public stations. It is important to note that this data does not reflect all EV charging in New York State. Public charging stations that were not funded by the NYSERDA project and private home charging were not included in this analysis.

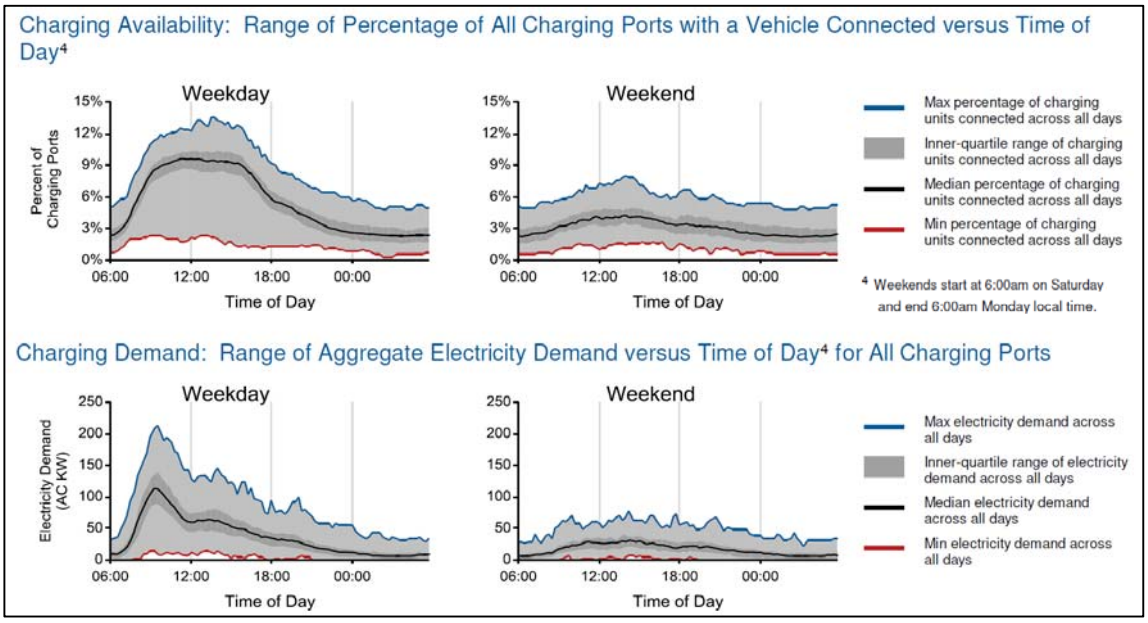

Figure 4. Charging Availability and Demand Plots for NYSERDA-funded Charging Stations

Also shown on Figure 4, the highest utilization of charging ports occurs during weekdays from 9 am to 4 pm which suggests that most EV drivers are plugging in to these stations while at work. The collective electricity demand for all charging stations installed through the NYSERDA EV Charging Station Program has a significant peak at the beginning of this period (9 am) when those EVs need to charge their batteries, but it falls off quite quickly, indicating that only a few hours of charging at level 2 are needed to fully recharge the vehicle's battery after the morning commute.

Free charging stations experience three times as many charging events per day as "for fee" stations which leads to a higher percentage of time a vehicle is plugged in at these stations. However, EVs that do connect to a station with a fee stay connected longer and draw more electricity per charge event. Note that the majority of the for fee stations are in New York City garages that have a higher than average use by Tesla EVs that charging stations throughout the rest of the state.

Table 2. 2015 Usage Statistics for NYSERDA-funded EVSE by Required Payment

Payment	Ports	Charge Events (CE)	Charge Events per day	Plug-in Time		Charging Time		% of Plug-in time charging	Total Energy (kWh)	Energy per CE
				Hours per CE	%	Hours per CE	%			
Free	527	41,688	0.25	4.0	4.1%	1.9	1.9%	46%	272,798	6.5
For Fee	108	2,525	0.07	6.4	1.9%	3.0	0.9%	47%	38,256	15.2

Further differences in usage patterns between free and for fee stations as shown on Figure 5.

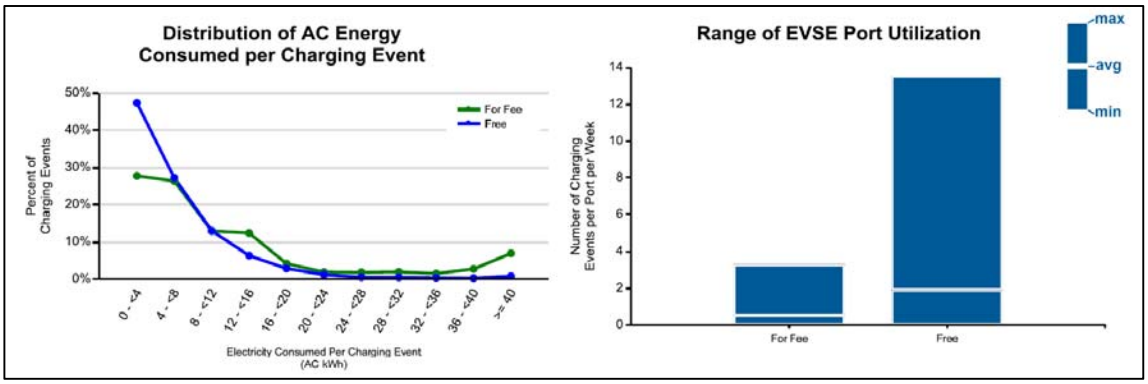

Figure 5. Charts Portraying the Differences in EVSE Usage Behavior by Required Payment

The line chart indicates a smooth trend for the free stations that has fewer charging events at increasing levels of energy dispensed, while for fee stations show a bump in the percentage of charging events dispensing 12-16 kWh as well as at 36-40 kWh and above 40 kWh. The bar chart displays the range of charging events per port per week which shows the difference between the most and least utilized ports as compared to the average for those charging stations. The free stations have a significantly broader range from the lowest to highest number of charging events per port per week.

In regards to the average percentage of time a vehicle is connected or drawing power per charging port, charging stations in urban setting see the highest amount of time in use, followed by those in suburban settings, then those in rural settings (see Table 3). Charging stations in urban and rural settings experience a wider range in length of charging time, while the majority of charging events in suburban settings are short durations (see Figure 6).

Table 3. Usage Statistics for NYSERDA-funded EVSE by Land Use Type

Land Use Type	Ports	Charge Events (CE)	Charge Events per day	Plug-in Time		Charging Time		% of Plug-in time charging	Total Energy (kWh)	Energy per CE
				Hours per CE	%	Hours per CE	%			
Suburban	325	26,178	0.25	3.2	3.3%	1.6	1.7%	50%	142,242	5.4
Urban	269	16,328	0.20	5.6	4.6%	2.4	1.9%	42%	154,623	9.5
Rural	41	1,707	0.10	4.3	1.8%	2.3	0.9%	53%	14,189	8.3

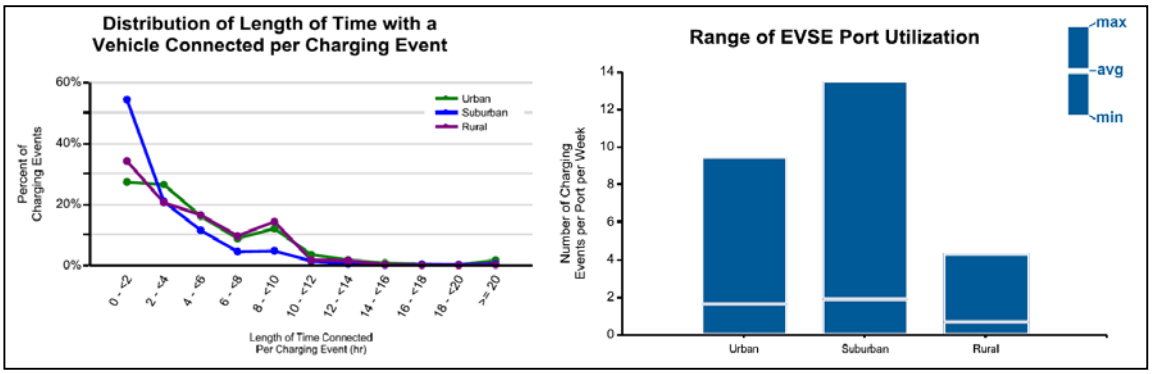

Figure 6. Charts Portraying the Differences in EVSE Usage Behavior by Land Use Type

NYSERDA-funded EV charging station were installed at various businesses, organizations, municipalities, and other settings which have been categorized and analysed within venue types listed on Table 4.

Table 4. Usage Statistics for NYSERDA-funded EVSE by Location Type or Venue

Location Type/Venue	Ports	Charge Events (CE)	Charge Events per day	Plug-in Time		Charging Time		% of Plug-in time charging	Total Energy (kWh)	Energy per CE
				Hours per CE	%	Hours per CE	%			
Parking Lot/Garage (NYC)	149	2,357	0.06	10.8	2.5%	3.8	0.9%	35%	49,790	21.1
University or Medical Campus	114	13,173	0.35	4.7	6.9%	2.1	3.1%	45%	95,899	7.3
Retail Location	95	11,877	0.41	1.2	2.1%	1.0	1.7%	83%	44,889	3.8
Parking Lot/Garage (non-NYC)	79	7,837	0.28	4.3	5.1%	1.8	2.1%	42%	48,107	6.1
Workplace	57	4,840	0.19	5.2	4.1%	2.5	2.0%	48%	33,353	6.9
Transit Station	64	886	0.06	6.2	1.5%	1.9	0.5%	30%	6,463	7.3
Hotel	36	867	0.07	5.0	1.5%	2.5	0.7%	50%	9,666	11.1
Leisure Destination	21	1,791	0.22	3.4	3.1%	1.9	1.7%	55%	11,353	6.3
Multi-Family	20	585	0.09	10.7	4.1%	3.7	1.4%	34%	11,534	19.7

Charging stations at universities or medical campuses have the highest occupancy rate due to a high average of charging events per week (3.1) and a longer average length of time each vehicle is connected per charge event (5.6 hours). Retail locations have a high average of charging events per week (3.5), but much shorter connection durations (1.2 hours). On the other hand, EVs stayed plugged in to stations at New York City garages and multi-family locations longer than at universities or medical campuses (10.9 and 10.7 hours respectfully), but their average number of charge events per week is much lower (0.8 and 1.1) so their overall occupancy also lower. Location types with similar vehicle parking patterns were grouped together in the charts on Figure 7, which shows some unique characteristics exhibited by certain venues, particularly the retail and leisure destination sites.

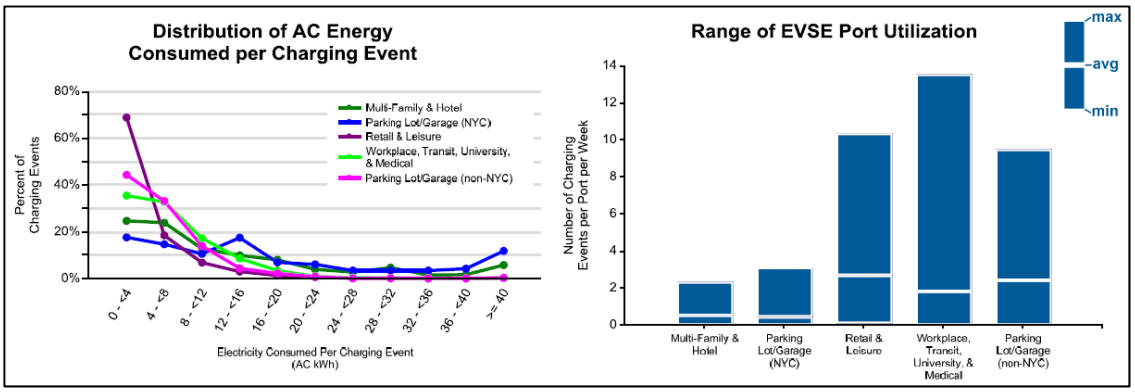

Figure 7. Charts Portraying the Differences in EVSE Usage Behavior by Location Type or Venue

Various EV charging stations use is illustrated on Figure 8 which plots the number of charging events and length of each charging event at different venues, resulting in varying levels of overall station occupancy.

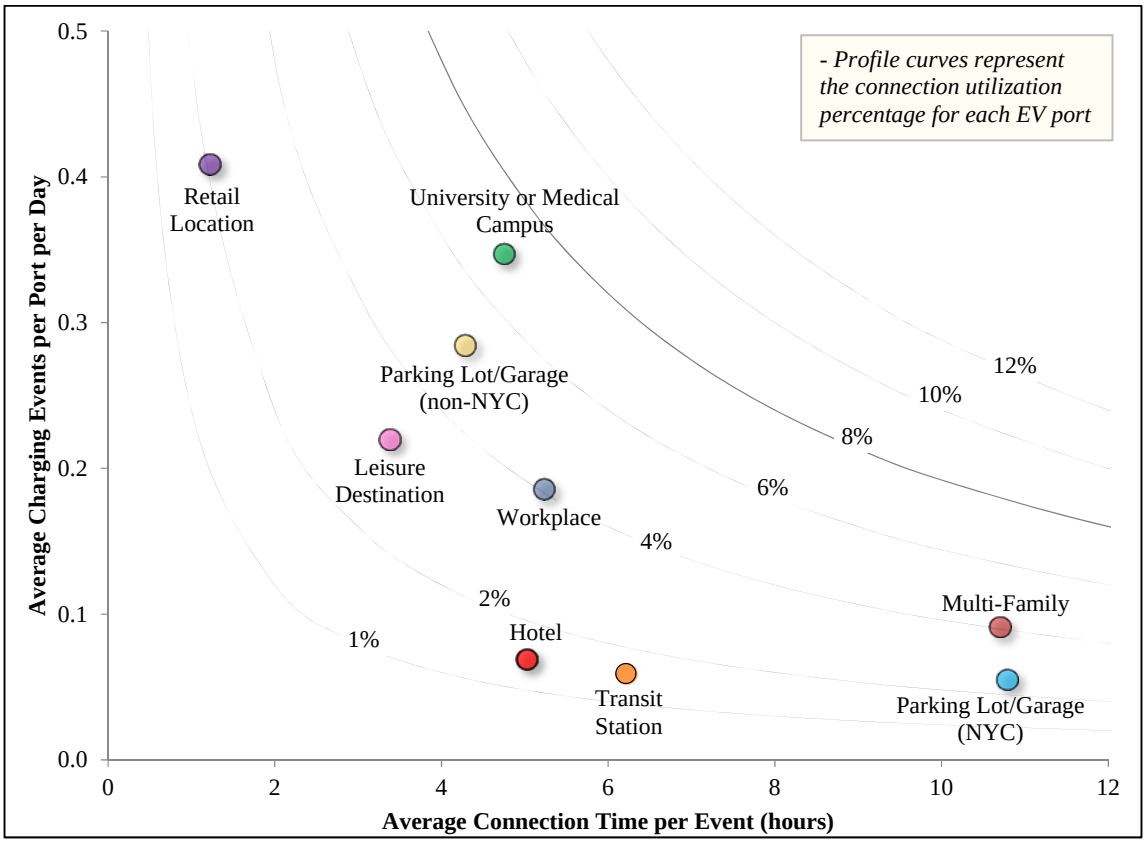

Figure 8. Comparison of Public EV Charging Station Usage by Location Type or Venue

2.2 EV Ownership

EV ownership in New York State has been increasing rapidly in the past couple of years as shown in Figure 9, using an analysis of DMV registration data. There are close to three times more plug-in hybrid electric vehicles (PHEV) registered in New York State than battery electric vehicles (BEV), but a variety of models are being offered and purchased for both technologies.

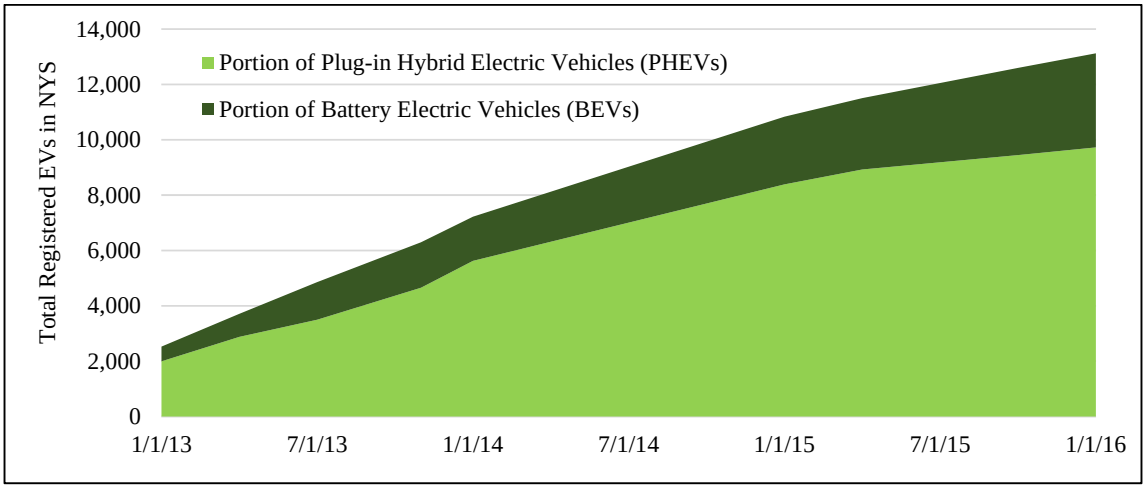

Figure 9. Growth in New York State EV Registrations

The Tesla Model S is the most popular BEV model, which along with the Nissan Leaf account for 84% of all registered BEVs (Figure 11).

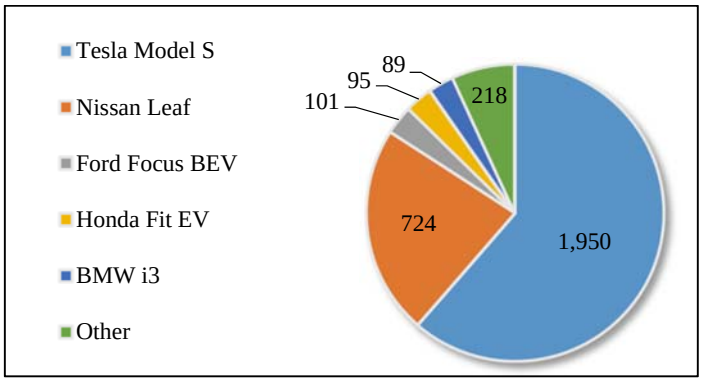

Figure 10. Vehicle Models Represented by the Battery Electric Vehicle Registrations in New York State

Figure 11 shows that the most registered PHEVs include the Toyota Prius Plug-in (41%), Chevrolet Volt (23%), Ford Fusion Energi (14%), and Ford C-Max Energi SEL (12%).

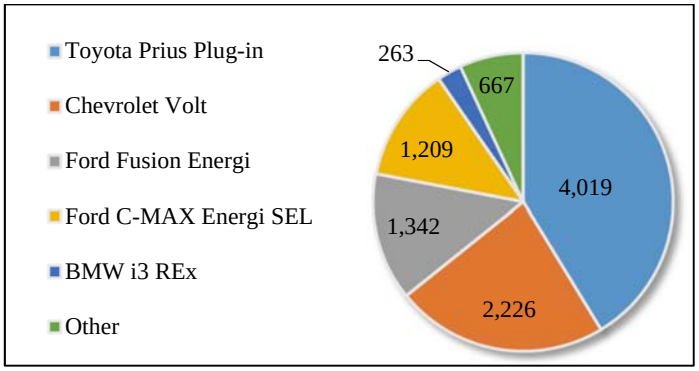

Figure 11. Vehicle Models Represented by the Plug-in Hybrid Electric Vehicle Registrations in New York State

Different parts of New York State have seen greater adoption of EVs as shown in Figure 12, but on average EVs still only account for 0.16% of all registered vehicles.

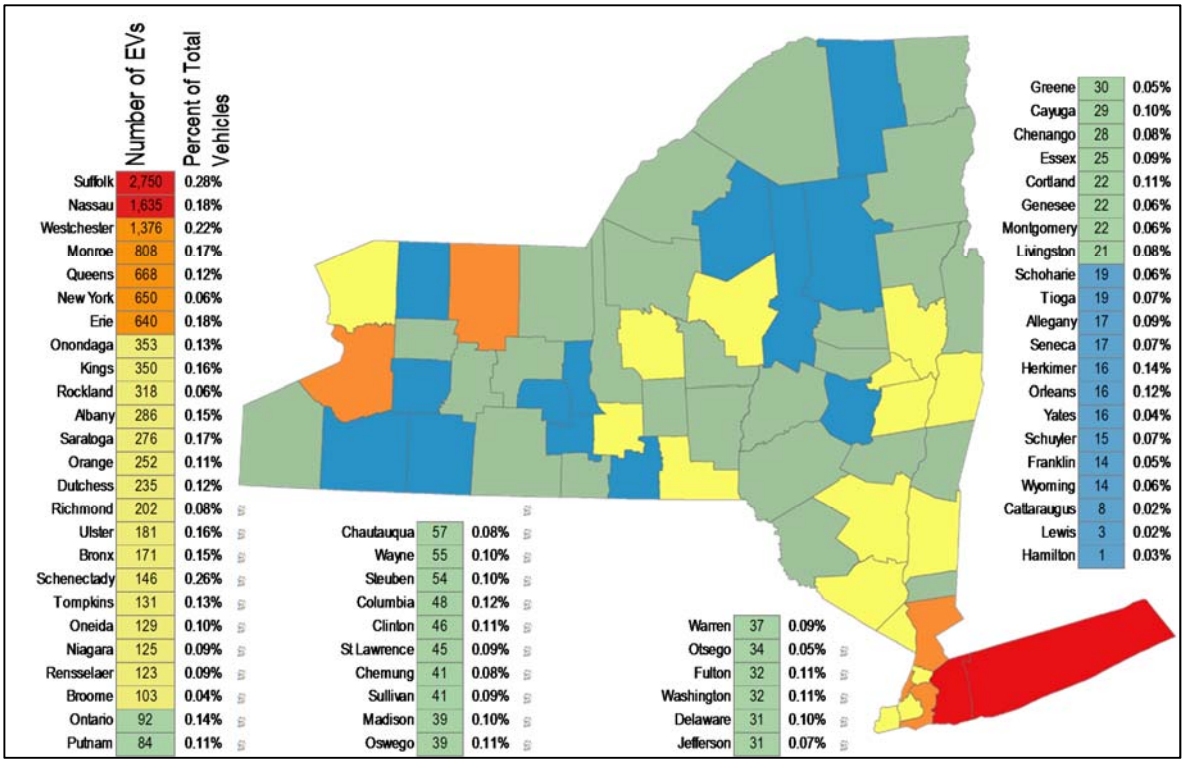

Figure 12. Electric Vehicle Registrations by County based on NYS DMV Data as of December 31, 2015

3 Key Observations

The most frequently used EV charging stations are with organizations that do a lot more than just install the station and wait for EV drivers to come charge. When sustainability is a core value within the host organization, the installation of EV charging stations is accompanied by press releases, EV information for tenants/employees, onsite personnel that are properly educated about the stations, and an embrace of the environmental benefits inherent to this technology. Many of the commonly used stations are with organizations that have multiple installations on their property, or across multiple properties throughout the state (demonstrates a commitment and genuine interest in supporting EVs).

EV drivers tend to plug-in to charge at their workplace. The usage profile for these charging stations (Figure 4) shows a significant peak in use on weekdays at 9:00 am when the majority of EV drivers arrive at their workplace. The only venues where charging stations are more heavily used than those classified as workplaces are university or medical campuses and parking lots or garages outside of New York City, which is due to EV drivers that work at or near those locations. Charging stations at multi-family dwellings have a similar occupancy rate as workplaces, but that is due to EVs being plugged into these stations for an extended period of time (average 10.7 hours per charge event). The amount of actual charging time is less than workplaces. Workplace chargers may also be the most successful at increasing EV sales because non-EV drivers see charging stations and EVs plugged in on a regular basis, have colleagues that drive and likely talk about their EVs, and have a known location away from home to charge every day which extends the functionality of EVs. NYSERDA recently published a Workplace Charging Guide [1] with an overview of the potential benefits of installing charging stations at workplaces and information to help employers through the process of planning, installing, and managing EV charging infrastructure.

On average, EVs are only actively charging for half of the time they are plugged into charging stations. Relatively low demand for charging minimizes the negative impact of longer-than-necessary EV dwell times at existing stations. However, as the number of EVs grow, demand for charging will increase. Some locations place a time limit on charging in order to optimize charging station use. Networked stations can charge a fee or increase the rate after a certain period of time to encourage EVs not to linger. However, this likely means

that EV drivers who are staying longer at that location would need to come back out and move their car. A better solution might be to reserve or plan for additional parking spaces where an EV can access the charging station after the other EV is finished charging (Figure 13). The EV community is trying to establish protocols on when it is acceptable to disconnect another vehicle from a charger and placards have been created that can convey an owners preference.

Figure 13. EV Charging Station Installations with Extra Access Spaces, such as this one at Rochester Institute of Technology where each Dual-Port Station Serves Four Parking Spaces, Optimizes Station Use without Requiring EV Drivers to Move their Vehicle to Another Space After Charging

The installation costs for these Level 2 charging stations (mostly dual-port, but some were single-port stations) ranged from $1,554 to $25,785 per station, with an average cost of $7,435 per station. The factor most influencing costs was the number of stations installed per location. Most sites only installed a single station, but locations with two or more stations had a much lower cost per station by leveraging a single common conduit run, electrical upgrades, and the electrician's time. The distance from the facility's electrical panel to the charging station location also had a significant impact on the installation costs. Another strong influence on the overall installation costs was the type of surface material the installer had to excavate and repair to lay the electrical conduit from the building to the station such as dirt, pavement, or concrete walkways as shown in the examples on Figure 14.

Figure 14. EV Charging Station Installation Examples Routing Power Through Pavement (left), Concrete (center), or Dirt (right) can Impact Costs

Outside of New York City, NYSERDA-funded EV charging stations with a fee dispense less electricity (average 3.6 kWh per week) than those that are free (average 10.5 kWh per week). The average revenue generated by stations with fee was $10 per month. While this offset the cost of electricity (about $5 per month per port), it was not enough to pay for the network fees (about $20-30 per month) that enabled the charging station to set a fee for use. Therefore, in most cases it is not currently economically viable to have a networked station where the only source of revenue or value is fees for use. Many charging station hosts view the additional electricity cost as a small price to pay for the positive exposure and added value to employees/customers. Figure 15 shows the average energy dispensed per charging station in the NYSERDA EVSE Deployment Program and the associated energy costs which are minimal based on current use. Networked stations do enable valuable options such as monitoring the station, tracking utilization, managing

turn-over (through the use of time limits or adjustable fees), and posting the current status (occupied, available, out of service, etc.). These features may justify the expense of paying the monthly network fees.

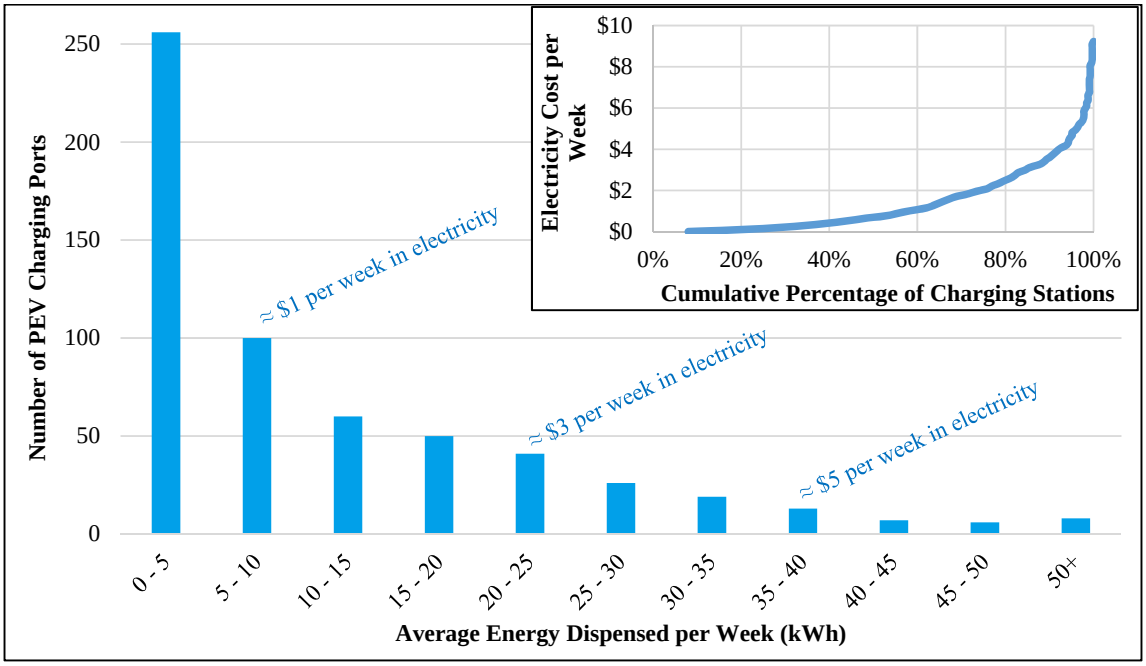

Figure 15. Average Energy Dispensed and Associated Energy Costs per Charging Station in the NYSERDA EVSE Deployment Program

Winter may be hard on EV driving range, but snow and cold also impact EV charging stations. Cords become stiffer and more challenging to properly coil, while stations or signage between parking spaces may make it more difficult to properly plow (Figure 16). Without adequate consideration of winter conditions during the planning phase, the infrastructure could potentially obstruct plowing of the parking space. Retractable cord systems can significantly reduce plow damage, and all stations should be cleared of snow regularly so they are visible and convenient to use.

Figure 16. Consideration of Adverse Weather Conditions During EVSE Installations can Prevent Station Damage or Inadequate Station Access

A little advanced planning can go a long way toward reducing installation costs and successfully locating the station in a convenient spot to both EV drivers and parking lot maintenance personnel (who clean or plow snow as needed). As more stations are installed, electricians are increasing their knowledge on this technology and have insight on the best installation locations. Many of those lessons learned are captured by NYSERDA's Best Practices Guide for Site Owners of Electric Vehicle Charging Stations on Commercial Properties [2].

References

[1] Workplace Charging Guide. NYSERDA. August 2015. www.nyserda.ny.gov/-/media/Files/Publications/Research/Transportation/ChargeNY-Workplace-Charging-Policy-Brochure.pdf

[2] Best Practices Guide for Site Owners of Electric Vehicle Charging Stations on Commercial Properties. NYSERDA. August 2015. www.nyserda.ny.gov/-/media/Files/Publications/Research/Transportation/ChargeNY-Site-Owners-EV-Charge-Stations-Commercial-Best-Practices.pdf

Authors

Mr. Bryan Roy is a Transportation Commercial Team Lead for Energetics with 10 years of research and engineering experience managing technical and feasibility assessments, technology demonstrations, and outreach projects for advanced transportation technology solutions. He leads the effort to collect information and summarize findings on the NYSERDA-funded EVSE demonstration installations throughout NYS.

Mr. Ziga Ivanic, Energetics' Transportation Program Director, is a registered Professional Engineer with more than 11 years of experience providing technical and analytical services to various federal, state, and private clients. Currently, he provides technical support to the U.S. Department of Energy (DOE) Vehicle Technologies Office and manages this NYSERDA-sponsored EVSE demonstration project.

Mr. Paul Windover has six years of experience with advanced transportation projects including fleet studies, data acquisition and analysis, technology deployments, and technology evaluation studies. For these efforts, his responsibilities include data analysis, system modelling, concept development, and market analysis.

Mr. Adam Ruder is NYSERDA's Clean Transportation Program Manager with seven years' experience overseeing a variety of transportation energy projects and nine years' experience crafting transportation policy analysis. He leads NYSERDA's transportation R&D and market development activities for: public transportation, electric and alternative fuel vehicles, smart mobility, transportation demand management, and freight. He serves on the Zero Emission Vehicle Task Force, a collaboration of eight states to advance ZEVs.

Mr. Matthew Shirk is an Advanced Research Engineer at Idaho National Laboratory. He collects and analyzes advanced vehicle, subsystem, and infrastructure test data to create fact sheets and reports. This includes the DOE EV Project and ChargePoint America Project, in addition to this NYSERDA-sponsored EVSE demonstration project.