



# Demonstrating Electric Vehicles in Buffalo CarShare

Final Report



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Prepared for:

**New York State Energy Research and Development Authority**

Albany, NY

Joseph D. Tario, PE  
Senior Project Manager

and

**New York State Department of Transportation**

Robert Ancar  
Senior Transportation Analyst

Prepared by:

**Buffalo CarShare / Wellness Institute of Greater Buffalo & Western New York**

Michael Galligano  
Executive Director

and

**Energetics Incorporated**

Bryan Roy  
Commercial Sector Team Lead – Transportation Technologies

Paul Windover  
Associate Engineer

## Notice

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## Abstract

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Buffalo CarShare (BCS) deployed four Ford Focus electric vehicles (EVs) in their fleet to evaluate the potential performance and suitability of this technology in a carsharing operation. Sponsored by the New York State Energy Research and Development Authority (NYSERDA), this project tested EVs in a carsharing environment, gathered a broad range of information on the operational characteristics of EVs in real-world conditions as used by a multitude of drivers, and increased awareness of EVs throughout Buffalo. The EVs met the carsharing member needs for many of their trips, especially during warm weather operations. BCS members were very satisfied with the EVs' performance and many chose the EVs afterward because of the superior driving experience. Unfortunately, the EVs did not have a positive return on investment for the carsharing organization because they were not driven nearly as much (only used 53% as much as the ICE cars). The EVs' limited range in cold conditions and need to charge back at base to be ready for use the next day hurt the economic viability of this concept. However, carsharing operations are a good opportunity to understand the functionality and durability of vehicle technologies in real-world conditions for a broad audience of drivers. This project also provided some useful insight on EV operations in a New York State-based fleet and gave many drivers a chance to drive an EV for the first time, significantly increasing its awareness and acceptance.

## Keywords

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Electric vehicles, carshare

## Acknowledgements

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# Executive Summary

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To evaluate the potential performance and suitability of electric vehicles (EVs) in a carsharing operation, the New York State Energy Research and Development Authority (NYSERDA) provided funding to deploy four Ford Focus EVs in the Buffalo CarShare (BCS) fleet. BCS, which began in 2009, had over 500 members and 12 internal combustion engine (ICE) vehicles at the launch of the project. This setting provided an excellent opportunity to test EVs in a carsharing environment, evaluate and enhance public education of EVs throughout Buffalo, and gather a broad range of information on the operational characteristics of EVs in real-world conditions as used by a multitude of drivers. EVs were monitored using Ford telematics software as well as hardware installed for carsharing vehicle security. The project team used this data acquisition to evaluate the use and performance of the EVs while in the BCS fleet.

The majority of the BCS fleet is comprised of small, economic sedans and hybrid electric vehicles. Additional vehicle types provide users with more options when needed, including minivans and a pickup truck. The four project EVs made up approximately 17% of the total fleet. Due to public perception, availability, and range limitations, EVs were only used 53% as much as the ICE cars. It was estimated that a utilization rate approximately 82% of the ICE vehicles would be needed for the lower operational costs of the EVs to offset their higher acquisition costs. Although heavier use is necessary for economic justification, the environmental savings are notable even at lower utilization rates. Due to the clean and renewable sources of electrical power generation in New York State, EVs have the potential to reduce on-road emissions by up to 37%.

This project illuminated some existing issues and opportunities for EV use in carsharing operations, as well as other applications. Public education and driver support were vital to program success because the majority of drivers were not familiar with EV technology at first. However, through projects such as this and the expanding EV market, this issue may not be as prominent as when the project started. Throughout the project, the majority of the issues with the vehicles pertained to driver unfamiliarity with EV technology or the activation sequence required for the carsharing hardware. Other issues included confusion with the EV charging activation process and prior users not charging the EVs. Winter-time driving range significantly decreased compared to summer-time range (due to battery performance and cabin heating) and traction on ice and snow covered roads was initially sub-par. Snow tires on two of the EVs (to replace the low rolling resistance tires) solved most traction issues, but the EVs were still removed from service during snowstorms.



Carshare members that had driven EVs responded to surveys at two different times during the project. One survey was administered near the beginning to capture operator's initial perspective and a second near the end to gauge any change in perspective and overall satisfaction. The majority of people taking the surveys reported never driving an EV before this project. Throughout both surveys, the overall reaction of the users was extremely positive. They were very satisfied with the EVs' performance and many returned to drive the EVs repeatedly because of the superior driving experience.

The project showed that EVs could meet the functionalities required by carsharing members for many of their trips. During warm weather operations, the EVs' range was sufficient for most of the trips made by the carsharing members (including trips taken with a gasoline vehicle). User satisfaction was extremely high and continuously improved throughout the demonstration due to driver education and increased awareness. As members better understood the capabilities of the EVs, the vehicles experienced steady use during the later period of the project. Other benefits noted throughout this pilot project, which are not as clearly quantifiable, included public awareness, outreach, and increased knowledge of EV operations in various conditions. The California Air Resources Board became very interested in the concept of a low-income EV carsharing program and called the project team to learn about this demonstration. In July 2015, a \$1.6 million state grant was awarded for a carsharing program in low-income Los Angeles neighborhoods that will operate about 100 electric and hybrid vehicles.

The economic analysis for this project showed strong economic potential for EVs, but ultimately the vehicles lacked sufficient use to realize this potential. Cold conditions and some extremely hot weather limited the range the EVs, due to heating or cooling requirements, and resulted in insufficient range for many users' trips. The EVs were also not available for long, overnight reservations because charging was required each night back at the base location (having BCS members charge at other locations or using the portable level 1 unit was not advised due to the challenge of providing support for that activity and potential safety risks associated with plugging the level 1 unit into an outlet that was not designed to handle it). Long reservations significantly help the business case for any carsharing vehicle, so eliminating these for the EVs caused them to not be economically viable for BCS. However, with the proper support from a vehicle manufacturer or an interested sponsor, carsharing operations are a good opportunity to understand the functionality and durability of vehicle technologies in real-world conditions for a broad audience of drivers. This project provided some useful insight on EV operations in a New York State based fleet. It is also very successful at increasing public awareness and acceptance of new technologies because many drivers get a chance to drive it for the first time and many others see or hear about their experience.

# 1 Introduction

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## 1.1 Project Overview

Buffalo CarShare (BCS) began operations in June 2009 with four vehicles and 30 pioneering members. New York State Energy Research and Development Authority (NYSERDA) and New York State Department of Transportation (NYSDOT) provided some initial funding, but the organization quickly grew and became self-sufficient. By September 2012, BCS had grown to over 500 members and 12 vehicles. Carsharing allows members to reduce their transportation costs while enjoying increased mobility and many rely on the service to access healthy food, medical care, and employment opportunities. BCS members reserve vehicles by the hour, which are located throughout Buffalo. The program offers the peace-of-mind of the automobile without the up-front costs, hassles, or larger environmental impacts of private vehicle ownership.

Electric vehicles (EVs) are ideal for short trips in city locations, which match well with the characteristics of many BCS trips. EVs have lower operating costs, so this technology presents an opportunity to increase the cost effectiveness of the carshare program. With additional funding from NYSERDA, BCS conducted a demonstration of four EVs at various sites in the City of Buffalo to determine if the technology is able to serve the needs of the members and be cost effective for their car share program. A subcontractor, Energetics Incorporated, assisted BCS with the evaluation of the demonstration activities. Three other key members of the project team are the Buffalo Niagara Medical Campus (BNMC), Buffalo State University, and Baptist Manor (a senior citizen apartment building on Linwood Avenue), which agreed to host the EVs for the duration of the project.

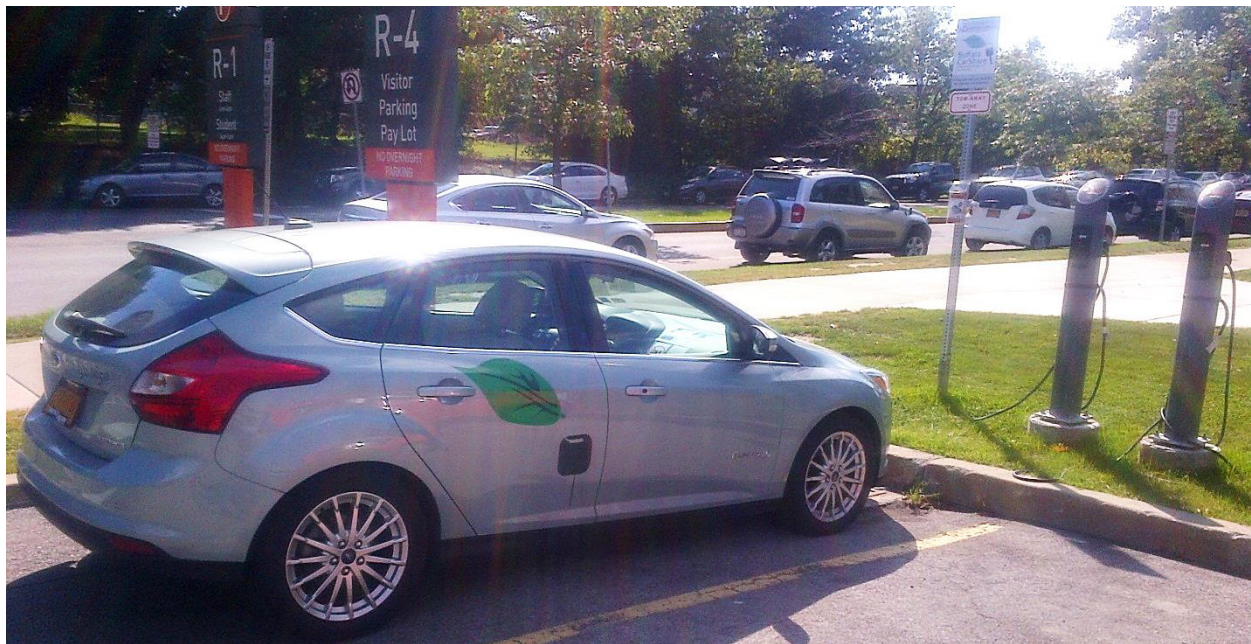
BCS selected Ford Focus EVs (Figure 1) because of their available features that were comparable to existing vehicles in the BCS fleet. BCS leased two Ford Focus EVs for a 24-month term starting in June 2013. The EVs were initially placed on the BNMC in the parking lot across from the Innovation Center and the visitor garage across from the Gates Vascular Institute where BNMC had already installed charging stations for their staff and visitors. BCS eventually moved both of these EVs to the parking lot by the BNMC SmartHome Buffalo House on Washington Street where all BCS members could better access them. When BCS was ready to lease additional EVs, they chose to continue using

Ford Focus EVs because they were performing well and it simplified the car share management and operations to use the same models so staff and members had familiarity with the vehicles. BCS added the third Ford Focus EV in January 2014 and based it at the BNMC SmartHome Buffalo House for four months until Buffalo State University installed a charging station through this project (vehicle shown in Figure 2).

**Figure 1. Example BCS Ford Focus EV**



**Figure 2. Third BCS EV (2014 Ford Focus EV)**



The fourth Ford Focus EV (Figure 3) was leased for a 24-month term by BCS starting in May 2014 and placed at Baptist Manor.

**Figure 3. Fourth BCS EV (2014 Ford Focus EV)**



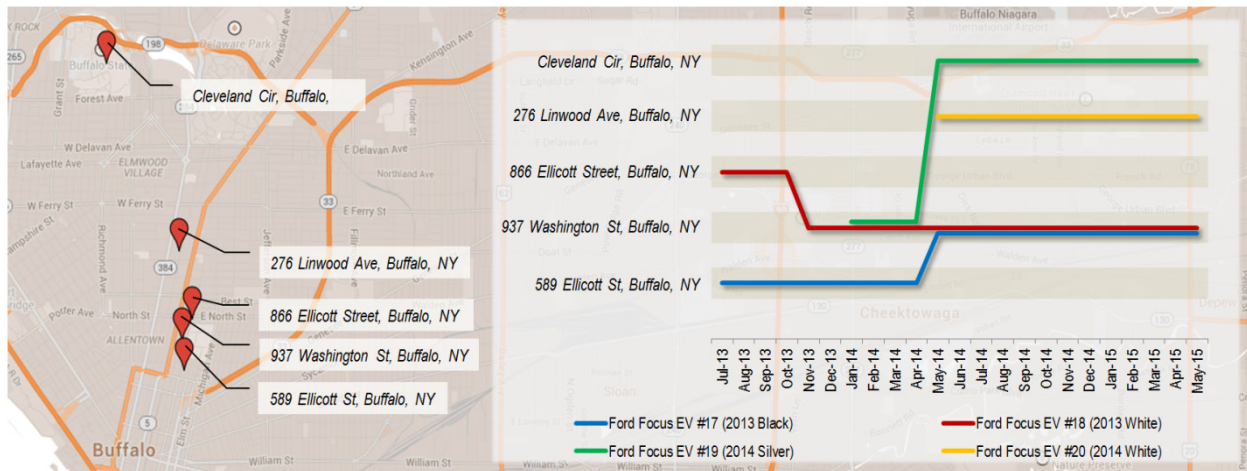
Charging stations were installed using project funding because the existing EV charging station network around Buffalo was limited. BCS EVs needed a dedicated charging outlet because it would serve as their primary (and likely only) charging location. Simple non-networked Level 2 charging stations (Figure 4) were selected to minimize costs. These stations do not have the capability to monitor charging activity, but the EVs themselves can document the amount of energy obtained during each charging event.

**Figure 4. Non-networked Level 2 Charging Stations Installed for BCS EVs**



The locations of the EVs for the project and timeline during which each was stationed there are shown in Figure 5.

**Figure 5. Map and Schedule for Electric Vehicle Base Locations**



## 1.2 Electric Vehicle Data Collection Protocol and Evaluation Procedure

The Project Team used two different systems to collect data from the EVs for each trip or event. BCS has Metavera Carsharing Solution for managing vehicle reservations, member accounts, vehicle status, and billings. This data set has all vehicle activity from both conventional models with internal combustion engines (ICEs) and EVs, which was used to compare use once the confidential member information was excluded. MyFordMobile is the EV manufacturer’s system for tracking vehicle activity. In addition to monitoring each driving event (time, distance, and duration), MyFordMobile also monitors charge events, battery state of charge, and driving efficiency. Unfortunately, there is no option on the MyFordMobile website to download all this data, so it must be manually transferred into a spreadsheet on a weekly basis (the website limits the number of events displayed, so historical data will only be available for a limited time). Figure 6 shows a sample of the MyFordMobile data displayed on the website and Figure 7 shows a sample of the Metavera Carsharing Solution data.

Figure 6. Screenshot from MyFordMobile showing Trip and Charge Log

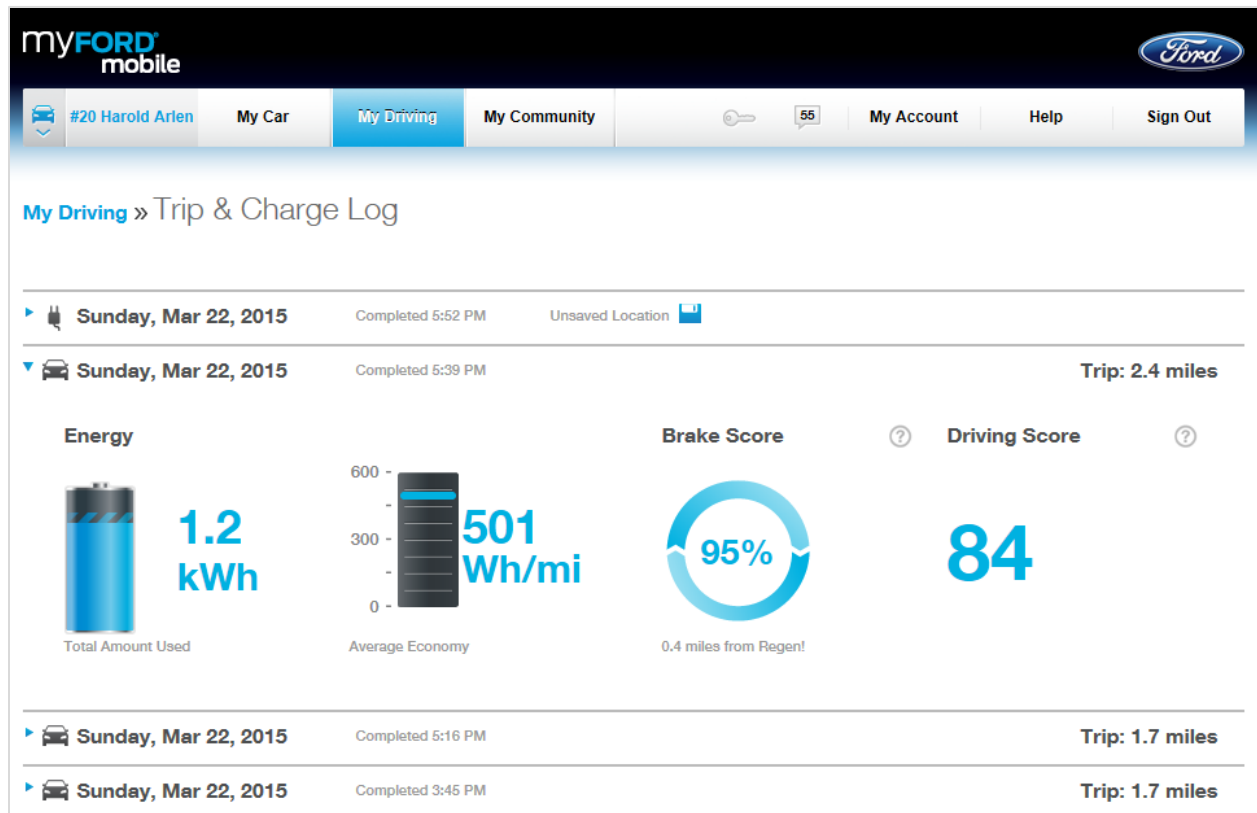


Figure 7. Sample Datafile from Metavera

Trip ID	Member ID	Reserved Vehicle ID	Reserved Vehicle Plate	Reserved Vehicle Type	Reserved Lot ID	Reserved Lot	Reservation Status	Trip Start	Trip End	Trip Time	Trip Distance Used
88511	1	2	FLD9433	Toyota Yaris (5-door Hatchback)	10	Quaker Bonnet at 175 Allen/Elmwood	Maintenance	1/9/2015 10:00	1/9/2015 12:00	2	12
83959	1	6	19015MB	Nissan Frontier	11	Allen/Medical Station (Enter and Exit on Carlton)	Maintenance	1/1/2015 0:15	1/1/2015 5:45	5.5	36
89194	1	9	FCS4038	Toyota Yaris (5-door Hatchback)	23	Canisius College Parking Ramp at Delavan/Jefferson	Maintenance	1/21/2015 11:00	1/21/2015 11:30	0.5	6
87967	1	10	FYG8048	Toyota Corolla	25	1272 Delaware/Auburn (South of Gates Circle)	Maintenance	1/5/2015 13:00	1/5/2015 13:45	0.75	6
89885	2152	19	GLP2749	100% Electric Ford Focus EV	29	Electric Vehicle (Lot R-4) No Gas 30 mi. max	Normal	1/31/2015 14:00	1/31/2015 18:00	4	20
88022	1068	16	GGP9250	Toyota Prius C	30	The Mansion at 414 Delaware/Edward	Normal	1/1/2015 10:15	1/1/2015 12:30	2.25	15
88057	2447	16	GGP9250	Toyota Prius C	30	The Mansion at 414 Delaware/Edward	Normal	1/1/2015 23:00	1/2/2015 0:00	1	30

In addition to these data, additional information from other sources was used to enable a comprehensive evaluation of the performance and economic viability of the EVs. This information included EV costs, conventional vehicle costs, maintenance costs, fuel costs, electricity costs, and the average hourly rental fee. The Project Team integrated all this data to evaluate the overall utilization of the EVs as compared to conventional vehicles in the carshare program and determine the economic viability of this advanced technology in this application.

## 2 Performance Evaluation

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BCS offers a variety of vehicle types to provide members with a range of options to best fit their needs. The adoption of EVs provides users with a more environmentally friendly option that can fulfill many of the member's transportation needs while reducing fuel consumption, emissions, and potentially operational costs for the BCS. Although there is no financial incentive for BCS members to select the EVs, these vehicles are the newest in the fleet and deliver near silent operation. Where feasible, BCS attempted to provide both an EV and conventional vehicle option to members at the same location. When these options were not possible at all the project sites and if one vehicle was already reserved, the second member might not have the choice of vehicle. The overall utilization and operational benefits, including fuel, emissions, and costs savings, are presented in the next section to quantify the potential benefits of using EVs in a carshare.

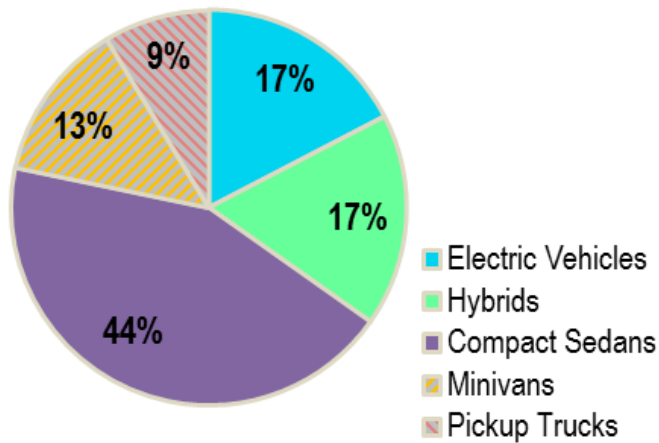
### 2.1 The Fleet

During the EV demonstration project, BCS operated a fleet of conventional vehicles that included compacts, hybrid electrics, minivans, and pickup trucks. The distribution of each vehicle type is shown in Figure 8. A complete list of BCS vehicles operated during the EV demonstration period are shown in Table 1 with the manufacturer suggested retail prices (MSRP) for that 2015 vehicle model and U.S. Environmental Protection Agency (EPA) listed city mpg rating. The vehicles shown in Table 1 represent all of the vehicles that were operated by the BCS during the evaluation period. However, some vehicles were replaced, cycled out, or added to the fleet during this period. The period during which the vehicle was used in the BCS program is listed under its "Data Period." The annual depreciation costs for all vehicles were estimated using data from Edmunds.com "True Cost to Own" calculator.<sup>1</sup> This evaluation only considered the depreciation, maintenance, and repair data (values specific to the BCS were available for the other categories including insurance, carshare hardware and software, and mileage). The Edmunds.com "cost to own" values are dependent on the vehicle age, so an annual average during its first five years was used. The evaluation excluded the pickup truck and minivans because they are not directly comparable with the EVs and likely experience specialized use.

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<sup>1</sup> Edmunds.com, "True Cost to Own" Calculator, [www.edmunds.com/tco.html](http://www.edmunds.com/tco.html)

**Figure 8. BCS Fleet Vehicle Make-up**



**Table 1. Buffalo Car Share Vehicle Inventory**

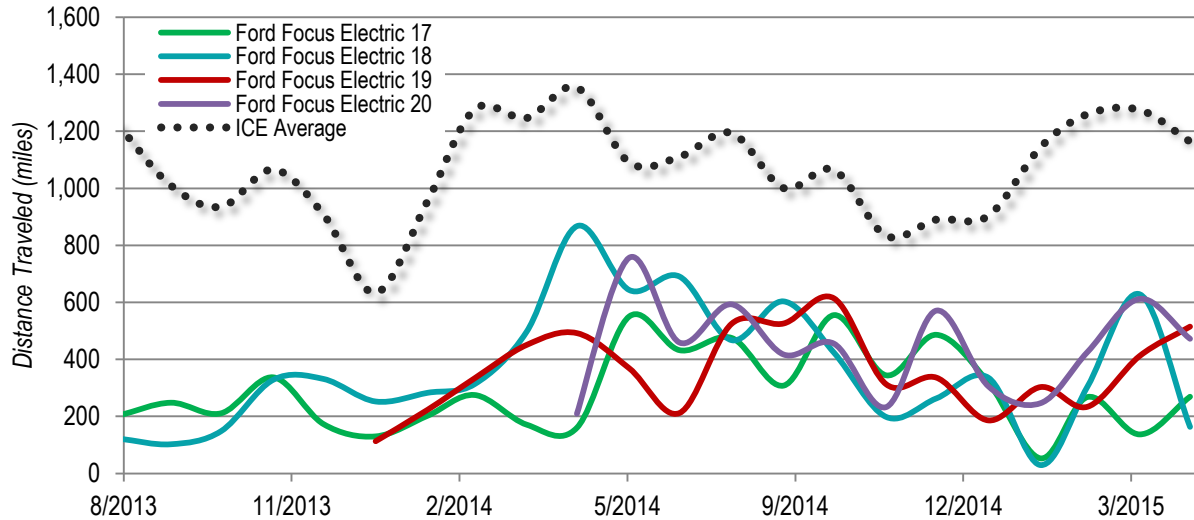
Vehicle Model	Vehicle Year	MSRP (new)	mpg	Data Period	5 Year Cost to Own <sup>a</sup>	
					Depreciation	Maintenance & Repair
Toyota Yaris	2009	\$14,430	30	8/1/2013 - 7/25/2014	\$3,457	\$5,437
Toyota Prius C Hybrid	2012	\$19,080	53	8/1/2013 - 12/31/2014	\$12,210	\$4,303
Toyota Yaris	2009	\$14,430	30	8/1/2013 - 12/31/2014	\$3,457	\$5,437
Toyota Corolla	2009	\$16,800	28	8/1/2013 - 7/7/2014	\$3,694	\$5,454
Toyota Yaris	2009	\$14,430	30	8/1/2013 - 12/31/2014	\$3,457	\$5,437
Toyota Yaris	2009	\$14,430	30	8/1/2013 - 12/31/2014	\$3,457	\$5,437
Ford F-150 Pickup	2006	\$24,445	17	8/1/2013 - 10/29/2014	\$6,159	\$8,902
Nissan Frontier	2010	\$18,741	21	10/29/2014 - 12/31/2014	\$8,029	\$4,810
Toyota Prius C Hybrid	2013	\$19,080	53	8/1/2013 - 12/31/2014	\$12,210	\$4,303
Toyota Sienna	2010	\$26,920	18	8/1/2013 - 12/31/2014	\$7,241	\$5,246
Dodge Grand Caravan	2007	\$30,783	20	12/29/2013 - 12/31/2014	\$19,704	\$3,745
Dodge Grand Caravan	2013	\$30,783	20	4/7/2013 - 12/31/2014	\$19,704	\$3,745
Toyota Yaris	2010	\$14,430	30	8/1/2013 - 12/31/2014	\$3,457	\$5,437
Toyota Corolla	2009	\$16,800	28	8/1/2013 - 12/31/2014	\$3,694	\$5,454
Toyota Yaris	2012	\$14,430	30	8/1/2013 - 12/29/2014	\$3,457	\$5,437
Kia Soul	2013	\$14,900	24	8/1/2013 - 12/31/2014	\$11,735	\$5,050
Toyota Prius C Hybrid	2012	\$19,080	53	8/1/2013 - 12/31/2014	\$12,210	\$4,303
Kia Soul	2011	\$14,900	24	8/1/2013 - 12/31/2014	\$11,735	\$5,050
Toyota Prius C Hybrid	2013	\$19,080	53	8/1/2013 - 12/31/2014	\$12,210	\$4,303
Ford Focus Electric	2013	\$35,170	N/A	8/1/2013 - 12/31/2014	\$8,051	\$5,605
Ford Focus Electric	2013	\$35,170	N/A	8/1/2013 - 12/31/2014	\$8,051	\$5,605
Ford Focus Electric	2014	\$35,170	N/A	1/1/2014 - 12/31/2014	\$8,051	\$5,605
Ford Focus Electric	2014	\$35,170	N/A	5/1/2013 - 12/31/2014	\$8,051	\$5,605

<sup>a</sup> Data developed for each specific vehicle, sourced from [www.edmunds.com/tco.html](http://www.edmunds.com/tco.html)



The average monthly use for each EV varies slightly, dependent on seasonal variations in member demand and vehicle performance. However, compared to the ICE cars, the EVs had consistently lower utilization rates, as shown for August 2013 through May 2015 in Figure 9. This difference may be partially attributed to the vehicle’s limited range, but may also be due to a lack of knowledge and possible range anxiety on the part of the BCS members.

**Figure 9. Buffalo CarShare Vehicle Utilization Rates**



## 2.2 Vehicle Use Analysis

The individual utilization of each vehicle heavily affects the overall operating cost because many of the operating costs are fixed per month and additional reservation time results in increased revenue with only slightly increased cost. This is especially true for the EVs because energy costs, which are related to overall mileage, are insignificant compared to the overall costs to just have the vehicle in the fleet. Figure 10 plots the actual operating data (reserved time and average miles per reserved hour) per month for the EVs, along with ICE vehicle data for trips under 50 miles (EVs are restricted to trips less than 50 miles because their batteries can be depleted). EV utilization rate per hour is typically similar to conventional vehicles but the reservation rate is noticeably lower for trips under 50 miles.

**Figure 10. EV vs. ICE Reservation and Utilization Levels**

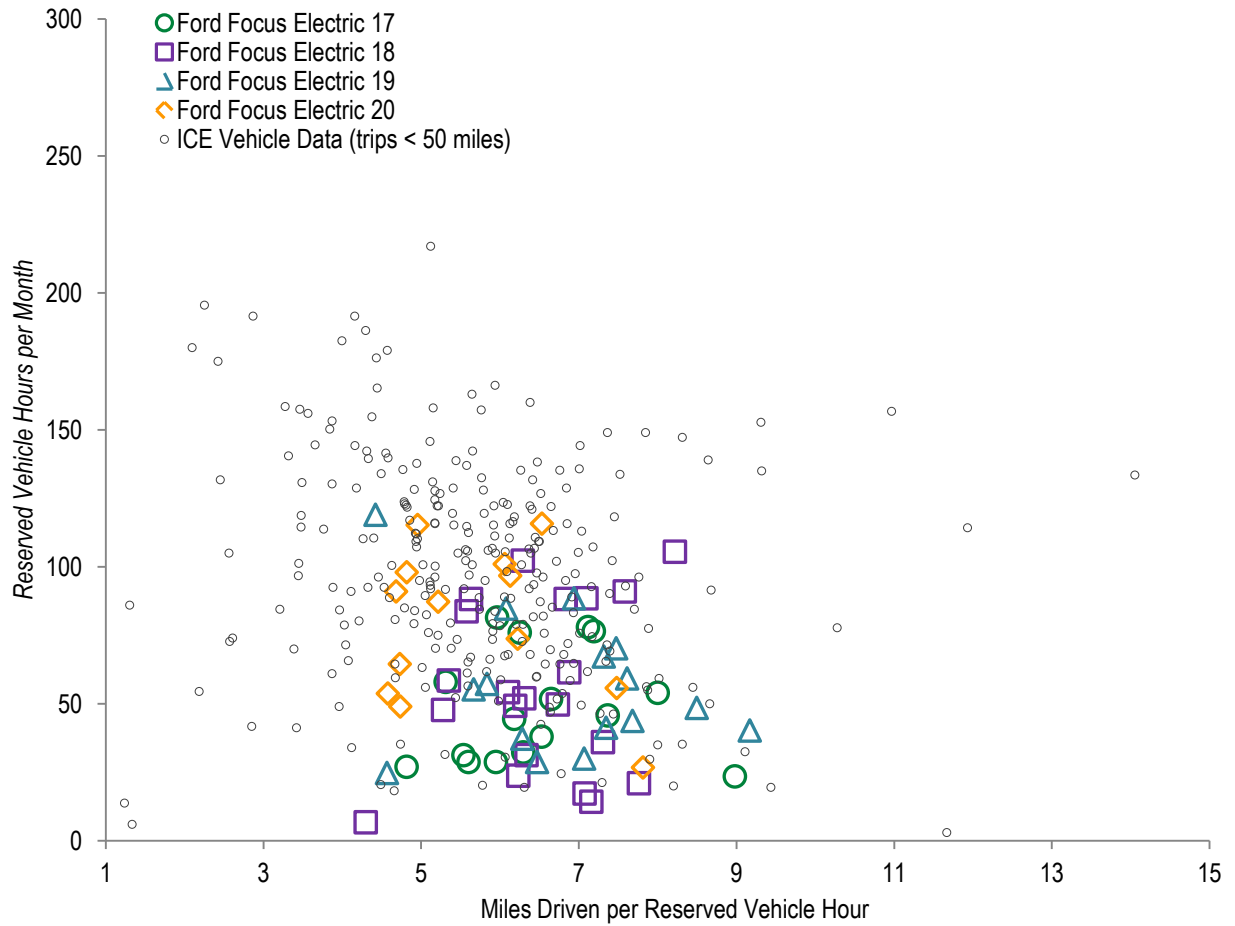
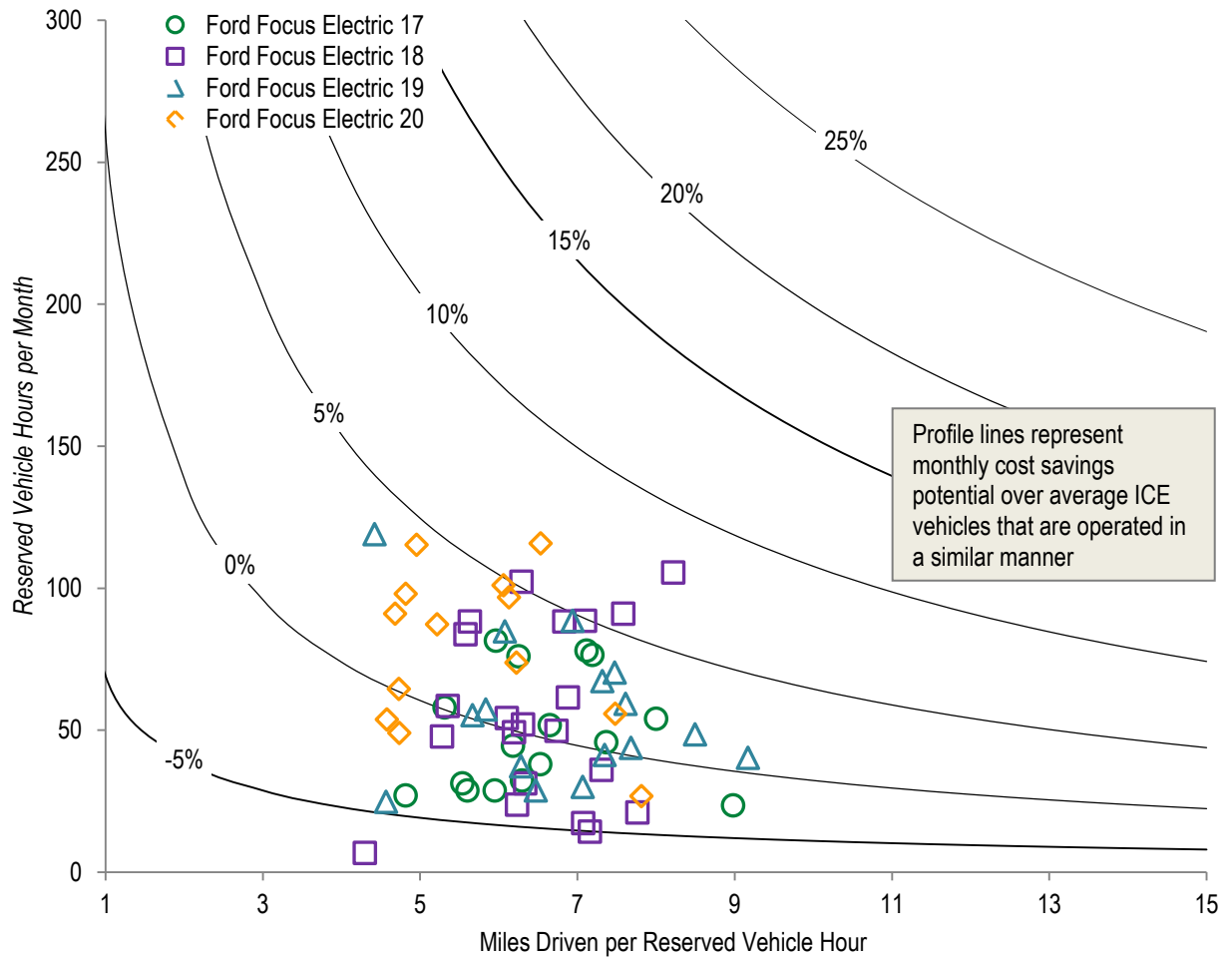


Figure 11 shows the same EV data points as Figure 10, but adds curves that represent the monthly cost savings potential compared to an ICE vehicle if it was used for the same number of reserved hours and miles. This shows that many of the EVs could have economic benefits over an ICE vehicle if they had the same utilization levels.

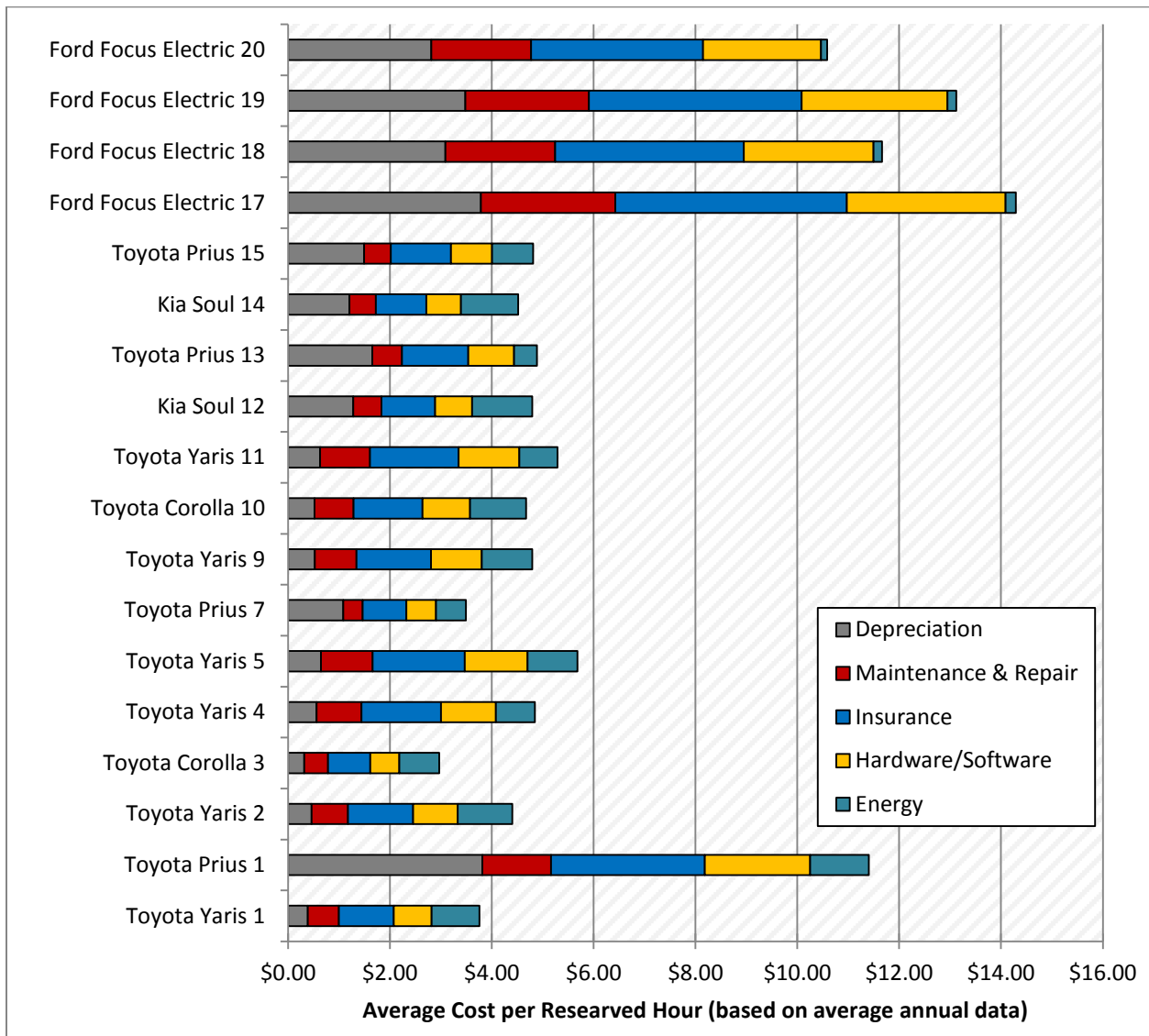
**Figure 11. EV Economics for Similar Utilization Levels**



However, as previously shown in Figure 10, the majority of the ICE vehicles are used significantly more than the EVs. Therefore, the lower utilization rates of EVs result in a much higher operational cost on a per-mile basis, as well as on a per-reserved hour basis. With less use, the fixed cost items (depreciation, insurance, hardware, etc...) end up costing significantly more per hour reserved and the potential energy cost savings by using electricity cannot offset this. Overall, the fixed monthly ownership costs of the EVs are only \$284 more than the estimated fleet average for the ICE cars. At similar utilization levels (at or ideally above the current use of the EVs) the EV's higher monthly fixed costs can quickly be offset through energy cost savings over the ICE cars. Figure 12 shows the estimated annual cost per reserved

hour for all of the BCS cars (excluding the truck and vans). Notice that the annual insurance (in blue) and hardware/software costs (in yellow) are identical in actual dollars for all BCS vehicles and the variation in the cost per mile of those items is due to difference in vehicle usage. A gas price of \$3.61 per gallon and an electricity cost of \$0.13 per kilowatt-hour (kWh) was used in the calculation.<sup>2,3</sup>

**Figure 12. Buffalo CarShare Vehicle Operating Cost**

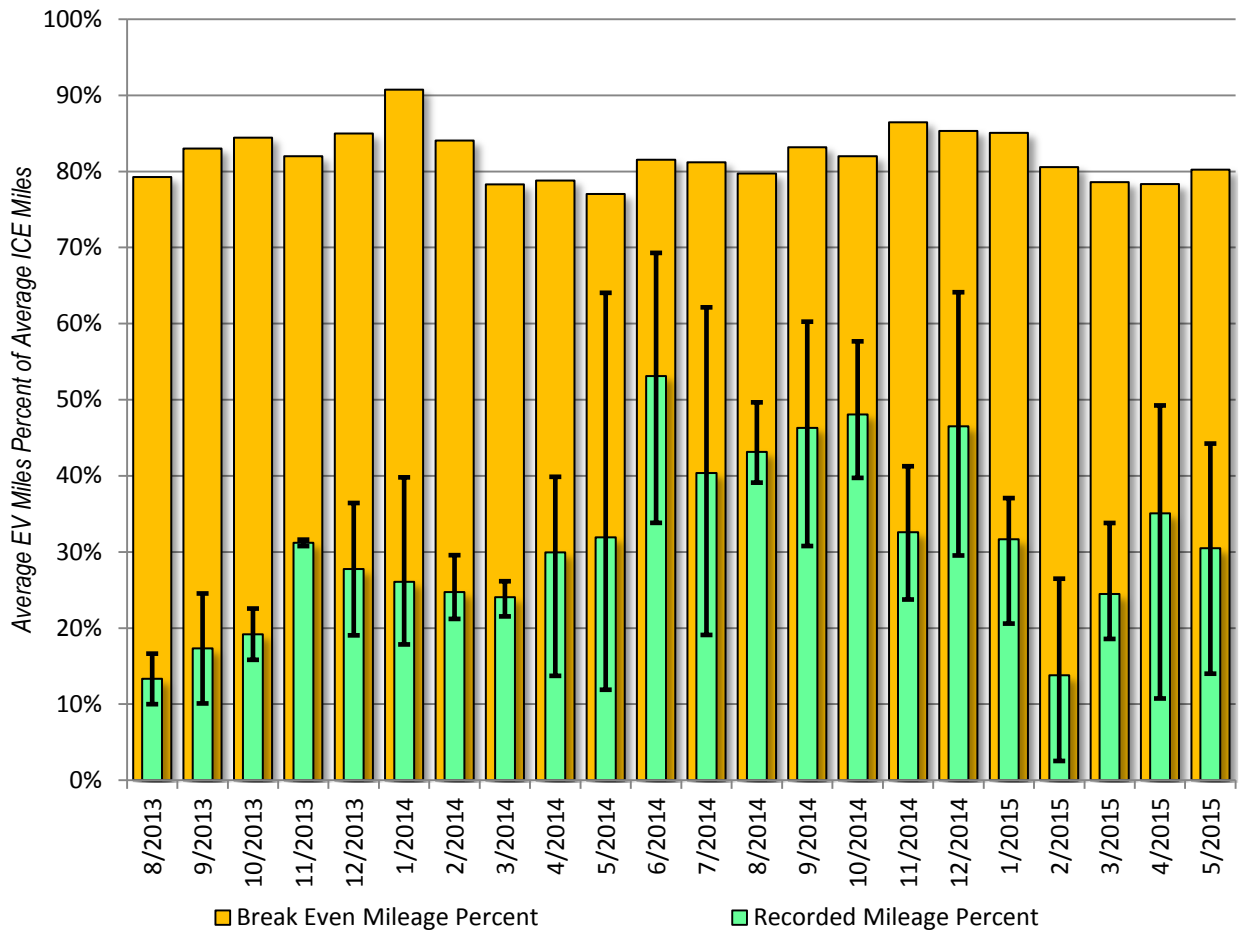


<sup>2</sup> Gas price retrieved on February 7, 2014 from [www.buffalogasprices.com/MetroGasTemperatureMap.aspx](http://www.buffalogasprices.com/MetroGasTemperatureMap.aspx)

<sup>3</sup> Electricity price retrieved on February 7, 2014 from [www.eia.gov/electricity/monthly/epm\\_table\\_grapher.cfm?t=epmt\\_5\\_6\\_a](http://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_6_a)

The operational cost difference between ICEs and EVs is almost entirely due to the lower utilization. EVs must be used more to be cost beneficial in the BCS program. Based on the average ICE car use over the past year, an EV must travel, on average 82% of the total miles an ICE car is used per month to provide equal economic results. However, as shown in Figure 13, the highest utilization per month by an EV as compared to the ICE car average was only 53% and often much lower.

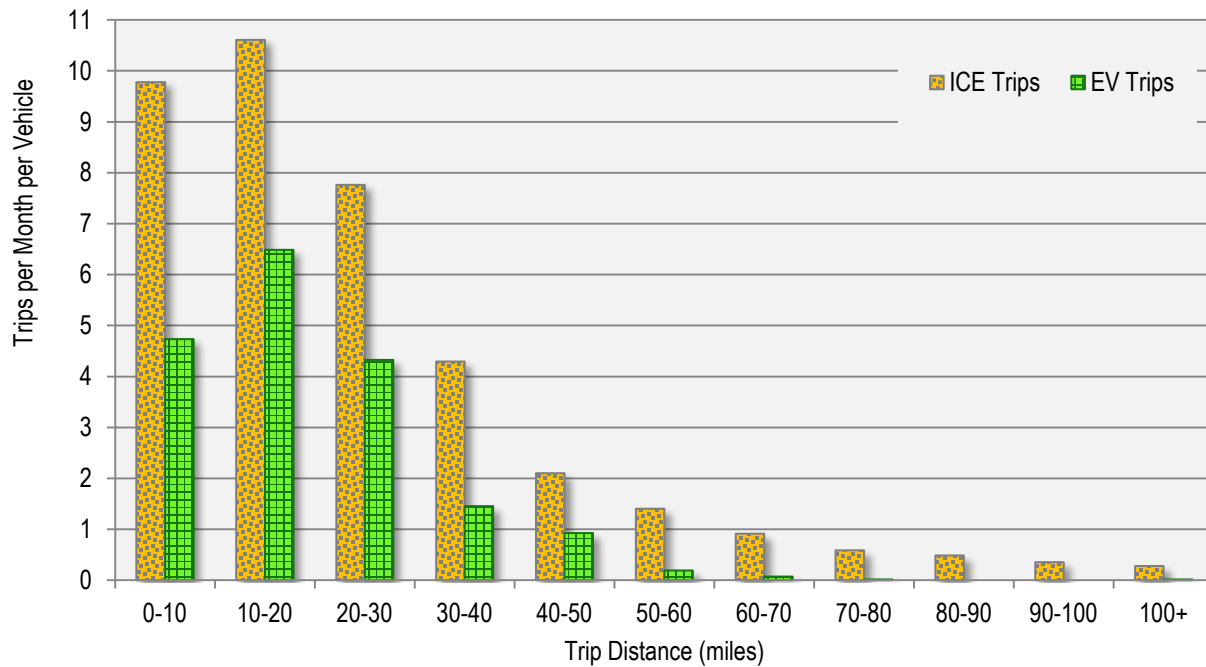
**Figure 13. EV Percent of ICE Mileage for Economic Feasibility**



In addition to the fuel and cost savings, the use of EVs in the BCS fleet also provides emission savings when compared to the ICE cars. Based on emission factors for gasoline and electricity, the EVs are capable of offsetting approximately 40.5 pounds of carbon dioxide every 100 miles they are driven instead of an ICE car.<sup>4,5</sup> From August 2013 to May 2015, the four EVs have been driven 26,200 cumulative miles, offsetting over 10,600 pounds of carbon dioxide.

The majority of BCS member trips are relatively short, as they travel primarily in and around the city of Buffalo. However, some longer trips taken by ICE cars account for a relatively large portion of the total mileage. EVs cannot support long trips due to their limited range. To date, there have only been seven trips over 60 miles (these included trips of 61, 63, 64, 65, 68, and 70 miles), and the majority of EV trips are below 20 miles. Figure 14 shows the distribution of average number of trips per month based on overall trip distance for ICE cars and EVs.

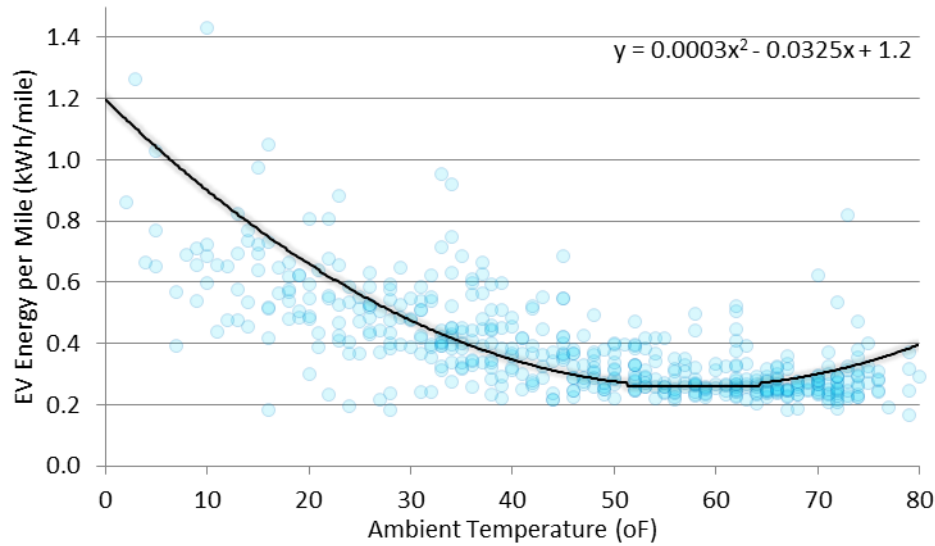
**Figure 14. Buffalo CarShare Vehicle Trip Distance Distribution**



<sup>4</sup> Emission factor for gasoline retrieved February 7, 2014 from [www.bnl.gov/earthday/docs/ORN-Idle-Reduction-Guide.pdf](http://www.bnl.gov/earthday/docs/ORN-Idle-Reduction-Guide.pdf)

<sup>5</sup> Emission factor for electricity retrieved February 7, 2014 from [www.eia.gov/electricity/data/state/](http://www.eia.gov/electricity/data/state/)

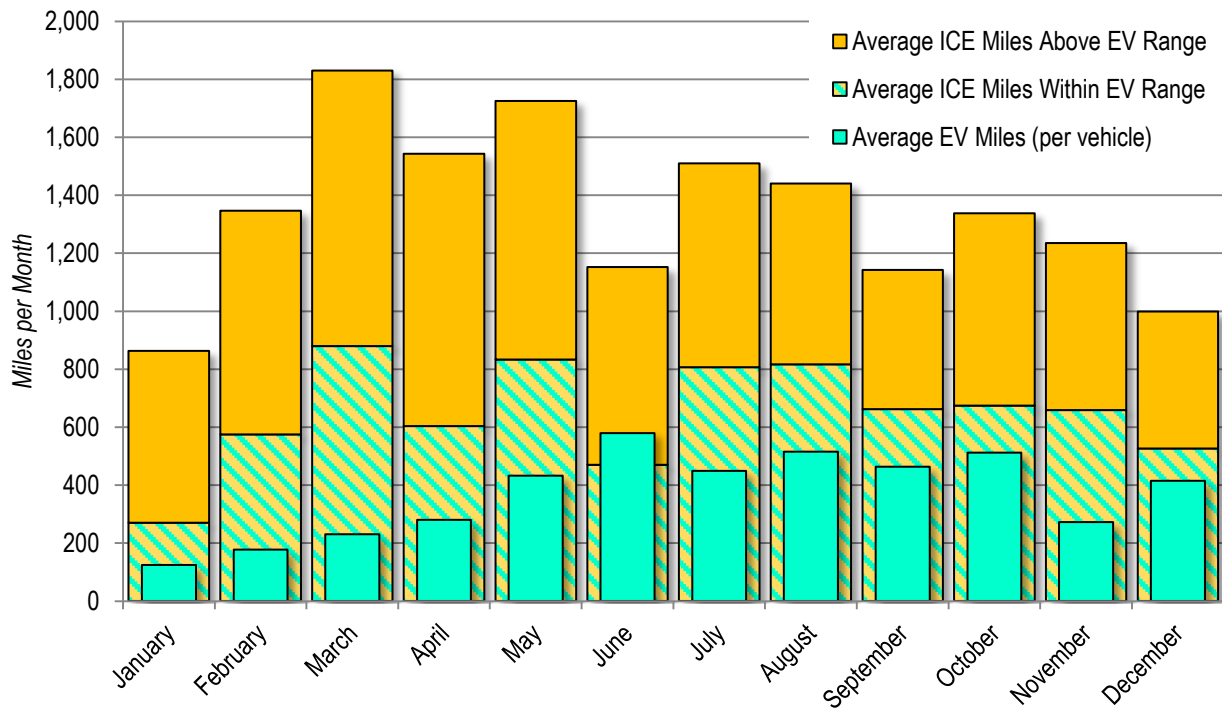
**Figure 15. EV Energy Efficiency vs. Ambient Temperature**



One limiting factor for EV use by BCS members during winter months is the shorter range available with colder weather. Due to preheating, defrosting, and lower battery performance, less energy is available to drive the EVs. Figure 15 plots the energy required to drive the vehicle per mile throughout the year under varying temperatures. A slight decrease in efficiency occurs with high temperatures as well due to increased air conditioning load and efficiency losses within the electrical system.

Although longer trips require ICE cars, BCS members predominantly use ICE cars instead of EVs for shorter distance trips. Figure 16 shows that EVs are capable of being used for many more trips than they are currently reserved for. This data is based on the approximate EV range that was estimated per month based on average monthly EV efficiency (kWh/mile) and a maximum battery discharge of 80%. The ICE usage data shown here is averaged per vehicle for ICE cars located near the EVs to ensure comparable data.

**Figure 16. Potential and Actual EV Use per Vehicle**

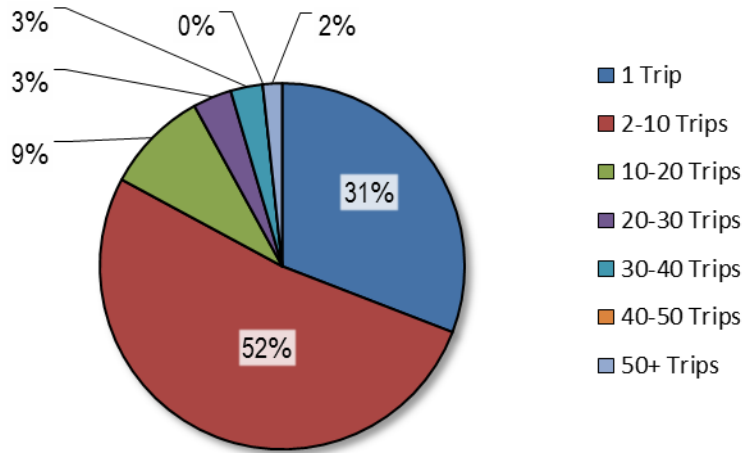


### 2.3 EV User Evaluation

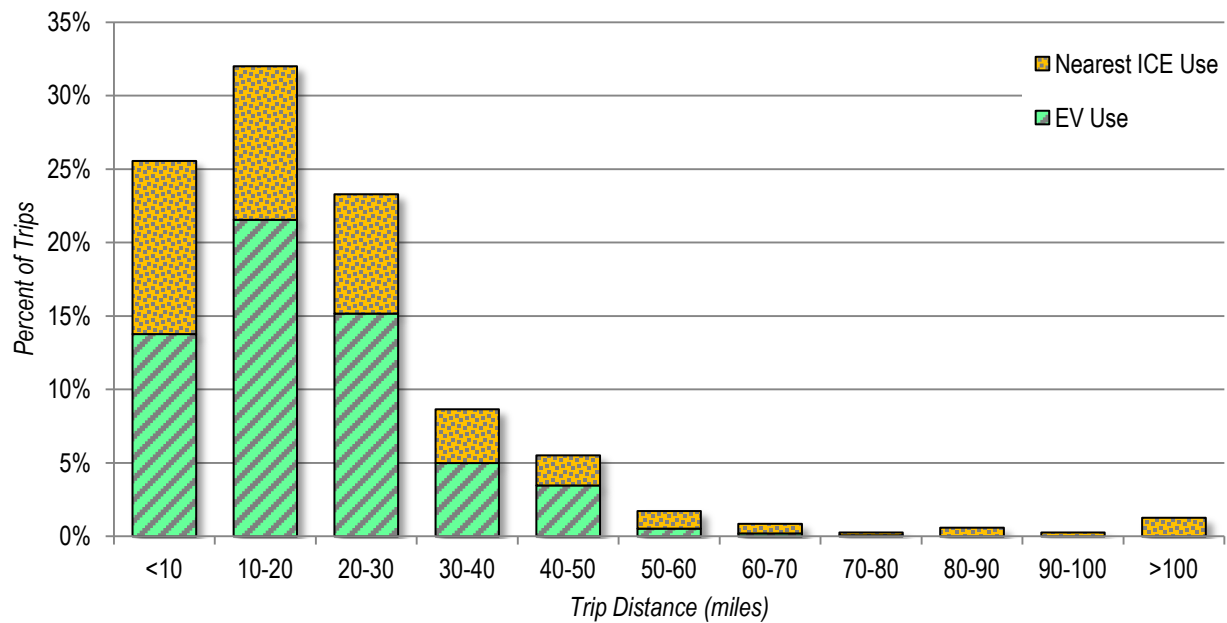
During the 17 months of the EV Demonstration Project at BCS, approximately 30% of their members tried an EV at least once (175 unique drivers have tried an EV in total). Thirty-eight percent of these users have not used the EV after that initial trip. Some of these members may have used the EV for the first time in the last two months of the period for which this analysis was performed and did not have a need to use any BCS vehicle since, while others may not regularly use a BCS vehicle where the EVs are located. Figure 17 shows the distribution of BCS members based on the number of trips taken with an EV. Some BCS members consistently return to the EV as their vehicle of choice. To reveal the BCS member’s choice of vehicle technology, EV use was compared to the closest ICE car for BCS member trips after they had tried the EV for the first time. Data analysis results in Figure 18 show that BCS members more often choose the EV for shorter distance trips after driving the EV for the first time.



**Figure 17. EV Users Total EV Trips**



**Figure 18. Experienced EV User Localized Preferences**

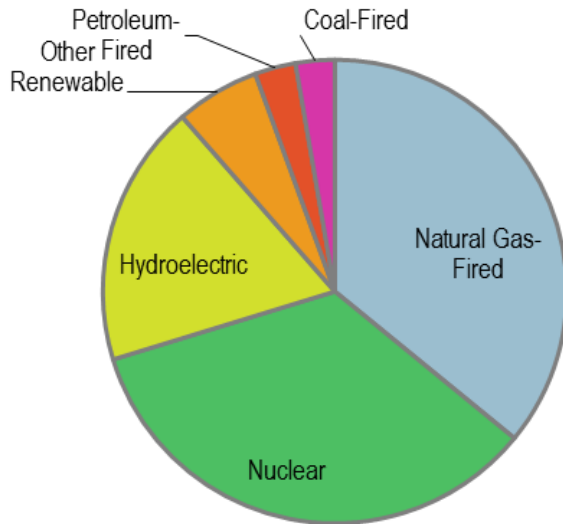


## 2.4 Environmental Savings

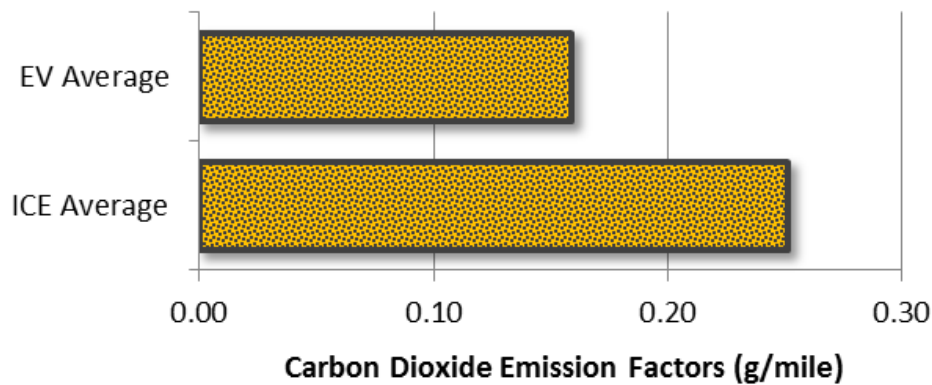
Environmental savings can be experienced from the use of EVs compared to conventional vehicles throughout the U.S. However, because of significant clean sources of electrical generation in New York State, offsetting gasoline combustion with electricity for EVs is even more beneficial. As shown in Figure 19, most of New York’s electrical energy comes from nuclear; hydroelectric; or other clean,

renewable sources.<sup>6</sup> Because of the extremely clean electrical energy available in New York State, EVs are able to reduce GHG emission by over 37% on a per mile basis on the BCS operation. This data, shown in Figure 20, was based on average data gathered from BCS operations and emission factor data from the U.S. EPA.<sup>7</sup>

**Figure 19. New York State Electricity Sources**



**Figure 20. Calculated BCS Vehicle Emission Factors**



<sup>6</sup> U.S. Energy Information Administration. New York. Retrieved April 27, 2015 from [www.eia.gov/state/?sid=NY#tabs-4](http://www.eia.gov/state/?sid=NY#tabs-4)

<sup>7</sup> U.S. Environmental Protection Agency. Calculations and References, retrieved April 27, 2015 from [www.epa.gov/cleanenergy/energy-resources/refs.html](http://www.epa.gov/cleanenergy/energy-resources/refs.html)

## **3 Lessons Learned from BCS EV Deployment**

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### **3.1 Issues and Resolutions**

BCS deployed four Ford Focus EVs in the carshare program. Each EV was leased for a 24-month period and was used by members from July 2013 through May 2015. The vehicles were outfitted with the typical carshare access hardware as well as colorful vinyl wraps to increase exposure and awareness of the EV deployment project. (These wraps often led to individuals asking BCS staff about the cars and technology).

Throughout the project, BCS staff closely monitored the EVs to ensure that members properly used the and to address any issues or concerns that arise. The section is a summary of issues and resolutions that occurred during the demonstration project.

#### **3.1.1 Member Anxiety or Confusion**

Most BCS members were a little anxious about using the EV for the first time. BCS staff even received a call from a member that was perplexed as to why the car was plugged in when they got to it and had no idea what to do. Based on lessons from other carshare organizations that already had EVs, BCS knew they would need to educate members and have clear instructions for their members on how to use the EV. From the beginning, notices popped up on the reservation system whenever a member reserved an EV, and instructions were placed in each car (Figure 21).

**Figure 21. Notices Placed Inside Each EV**



However, it seems impossible to provide enough educational materials or signage on the car to help every member. For almost every first-time EV driver, BCS staff had to talk with that member over the phone or meet them at the EV in person to provide instructions. Introducing EVs to the BCS fleet places additional burden on the staff to assist with these situations. BCS tried to find a way to be notified when a member will be driving an EV for the first time so they could proactively provide them with information, but this method was not possible with the systems that currently existed. BCS accepted and understood that helping their members use the EVs was part of their role in this demonstration, but it was a larger burden on staff than they had anticipated.

### **3.1.2 EV Car Problems**

In general, the EVs did not have many maintenance issues, but there were a few recalls that had to be addressed by BCS staff during the demonstration project. The EVs had to be taken off-line while they were brought to the dealership and repaired. Using all of the same EV models helped BCS staff and members become familiar with any EV in the fleet at the same time, but it also meant that all four vehicles would have the same recalls that needed to be fixed. The Ford Focus EVs selected for this project were some of the first models released by Ford, which led to a higher than expected level of problems that needed fixing. One of these was a wiring harness that caused the vehicle to be in the shop for multiple weeks while waiting for the back ordered part to come in.

Early on in the demonstration while one BCS staff member was using an EV, it unexpectedly would not run. They went through the start-up procedure multiple times and could not get it to start until they held the key fob very close to the dashboard. BCS staff attempted to replicate the issue, but could not. The issue did not reoccur, so it was likely just a rare glitch.

One other issue is that when the EVs did require a tow due to running out of energy or other technical issue, a flatbed tow truck was required as a typical tow truck could damage the vehicles low chassis. Towing did require some attention from the BCS staff, but was not a serious issue.

### **3.1.3 EV Charging**

It is important for EVs in the BCS program to get a full battery charge each day when they are plugged at their base location so they are ready for the next member to use. BCS elected to place a maintenance reservation on the EVs each night from 2am to 6am so they must be parked in their space and charging during this time. This scheduling limited the length of reservations for the EVs, which may have had a slight impact on their reserved time, but it was mostly successful at preventing a fully drained battery.

The charger at the Baptist Manor appeared to develop a glitch at some point during the demonstration period that caused it to stop providing a charge. BCS members reported this issue when they prepared to take the EV and it did not have enough charge for them to complete their trip. BCS staff ended up pressing the charging unit's reset button to have it start working again. After a few weeks, the same issue occurred again. Unable to diagnose the cause of the problem, the best solution was determined to be that the BCS members would need to press the charging unit's reset button every time they plugged in. Instructions were posted to press the reset button and the problem has not happened again. However, BCS staff try to regularly monitor the EV's state of charge to proactively address when a charger is not working properly.

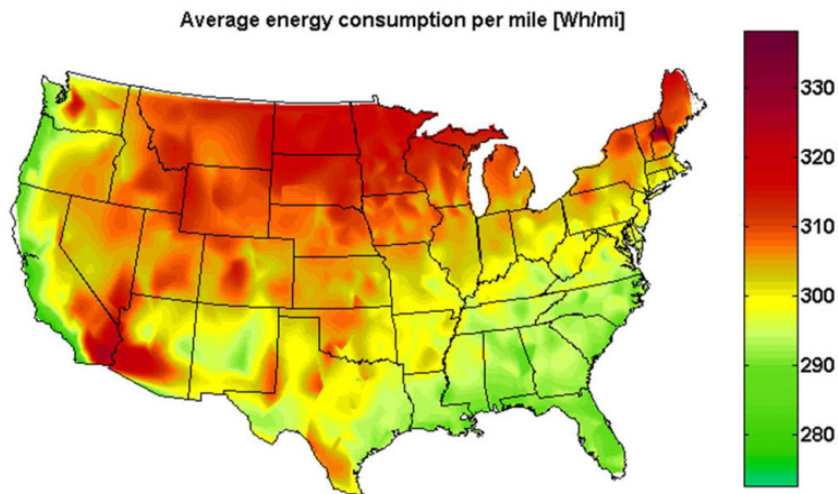
The charging station at SmartHomeBuffalo on Washington Street had an issue and was not working for two weeks in March 2015. National Grid maintains that station and they responded as promptly as possible to fix it, but it still kept the EVs offline for that period.

### 3.1.4 Quick Depletion of Battery

Extreme warm or cold weather impacts the available driving range of the EVs. Studies have shown that Upstate New York does create some issues for EVs due to cold weather operation (shown in Figure 22).<sup>8</sup> First-hand experience from this demonstration confirmed this observation. In spring and fall, the available EV range could be as high as 80 miles. On hot days, this range could drop down to 50-60 miles. During the extreme cold such as in February 2015, the available EV range dropped as low as only 20 miles and BCS had to remove the EVs from their program to prevent members from stranding the vehicles part way through their trip with no battery energy remaining.

Available driving range is based on prior driving history, so drivers with different driving habits could experience a quicker than expected drop in range if their energy use is more intensive. On a hot day, one BCS member took out an EV and drained 40% of the battery after only 40 minutes and driving 7 miles. That member was very worried about being able to get back, so BCS staff brought a replacement car to that member and exchanged the EV. This case was likely extreme excessive energy use by the driver, but BCS staff learned to keep an eye on the temperature so they could prepare drivers for lower than expected range on very hot or cold days.

**Figure 22. Average EV Energy Efficiency in the U.S.**



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<sup>8</sup> “Where It’s Best And Worst To Drive An Electric Vehicle.” [www.fastcoexist.com/3042872/where-its-best-and-worst-to-drive-an-electric-vehicle?](http://www.fastcoexist.com/3042872/where-its-best-and-worst-to-drive-an-electric-vehicle?)

Although loss of performance is expected during colder periods due to defrosting, heating, and suboptimal battery temperatures, preheating the vehicles while plugged in could significantly increase their potential range during colder periods. From the factory, the Ford Focus EV has the ability to preheat the cabin, battery pack, and defrost the windows before being unplugged to avoid draining the battery. However, because of the access technology used by the carshare program to monitor and control vehicle operation for various users, this preheating option is not functional. This access technology requires all heating and defrosting to be done once unplugged, which can account for a relatively high percent of the overall total energy and reduced the overall range of the vehicle. Currently there is no commercially available method for activating this system in conjunction with the access system.

### **3.1.5 Stranded EVs with Dead Batteries**

Despite all the warnings provided by the EV to the driver regarding available range, there were a handful of times that a BCS member drove the EV until its battery was completely dead. Therefore, the stranded EV had to be towed. When this scenario occurred on a major highway, the EV was impounded by the police and required some effort to retrieve. Ford's protocol for EVs with dead batteries (if they are notified) requires the vehicle to be towed back to the dealership. This situation is not convenient for BCS because they must find a way to go retrieve the vehicle when they have availability. When possible and properly notified by the BCS member, BCS staff attempted to find a way to trickle charge the EV using the portable Level 1 charger and a 110-V outlet. Once it had enough charge to return it to the Level 2 charger, they would do so. Otherwise, they tried to coordinate with the towing service to bring the EV directly back to the charger so they would not have to retrieve it from another location later.

### **3.1.6 Poor Traction in Snowy Conditions**

It became apparent after the first significant snowfall that the low rolling-resistance tires supplied with the EVs in this demonstration project would not be good on snowy roads during the winter in Buffalo. Initially, the EVs were removed from service whenever the roads in Buffalo were snow covered. To remedy the limited traction available with the low rolling-resistance tires, a snow tire lease was procured for one of the EVs in February 2014 and the fourth EV lease included snow tires as well (installed in November 2014). Snow tires drastically improved inclement weather performance for the two EVs that were outfitted. The other two EVs continued to be removed from service during inclement

weather. In extremely bad weather, all vehicles, including the EVs outfitted with snow tires, are removed from service for safety purposes. Based on data received, it is estimated that the addition of snow tires allowed the EVs to be removed from service 24% less than EVs with original equipment manufacturer tires (due to weather issues). However, this number is difficult to fully quantify and was up to the discretion of the BCS staff. Overall, snow tires have shown to provide 72% better acceleration, 56% better deceleration, and 100% better cornering grip in the snow than summer tires (similar to low rolling-resistance tires) in a study by Edmunds.com.<sup>9</sup>

### **3.1.7 Lower than Expected Usage**

Throughout the project, the EVs did not experience as much usage as the other conventional vehicles. Initially, the BNMC parking spaces with available charging were not in locations where BCS members were used to getting vehicles. Once the charging station at SmartHomeBuffalo was completed, the EVs were moved there, which is the main hub for BCS vehicles. Usage increased, but was still much less than the conventional vehicles.

Where possible, BCS tried to place a conventional vehicle at the exact location of the EV so vehicle preference would not be influenced by the location. They were placed at the BNMC SmartHomeBuffalo location and Buffalo State University. However, the Baptist Manor location for the fourth EV was a new location for BCS and there was not enough member demand to place two cars at this location. Regardless of whether there was a corresponding conventional vehicle at the same location or not, the EVs continued to have lower use.

### **3.1.8 EV Charger Issues**

Overall, the charging stations used to charge the Focus EVs were quite reliable and straightforward to use. However, the ChargePoint station would not work if snow was around the base because it needed to be kept clear for venting. This issue was not well known prior to this event and was likely due to the frequency of use.

Some issues did arise with cord management and users regularly had problems freeing the cord on the ChargePoint unit. On other chargers, the cord was easier to wrap up, however it did not hold the end of the plug so ice could form inside it and make it harder to insert and pull out of the car.

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<sup>9</sup> “Tire Test: All-Season vs. Snow vs. Summer,” [www.edmunds.com/car-reviews/features/tire-test-all-season-vs-snow-vs-summer.html](http://www.edmunds.com/car-reviews/features/tire-test-all-season-vs-snow-vs-summer.html)

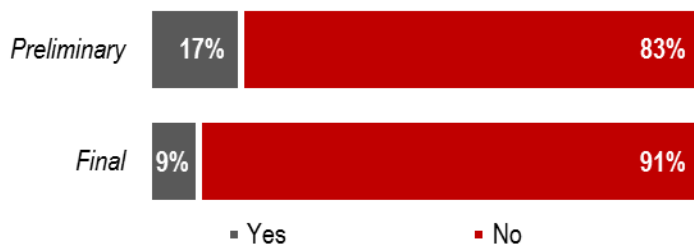


### 3.2 Survey

Two surveys were developed and sent out to BCS users that had previously used the EVs to evaluate their experience and obtain feedback on the performance and convenience of the EVs in the fleet. One of these surveys was administered nearly eight months after the deployment of the EVs in the BCS while the other survey was administered 15 months later (at the end of the project) to capture the final opinion of the BCS users that participated.

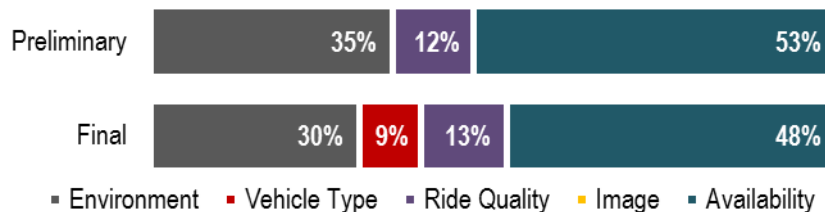
Most of the respondents reported never driving an EV before using the BCS vehicles and were very curious to drive an EV. The preliminary results showed a higher percentage of people that drove EVs prior to the car share than the later data. However, this result is likely due to a limited number of responders and not reflective of the public awareness of EVs. Prior EV use data is shown in Figure 23.

**Figure 23. Had you driven an EV prior to driving Buffalo CarShare's EV?**



The primary motivation for using the EVs was availability, but environmental concerns and ride quality were also reported as motivations. Initially, many people were not entirely clear on the environmental benefit provided by the EVs and were interested in additional information on the source of electricity in Buffalo and how the EVs compared to the gasoline and hybrid vehicles. However, the final survey revealed increased public awareness of EVs as well as their environmental savings potential. Vehicle choice motivations for EV drivers are shown in Figure 24.

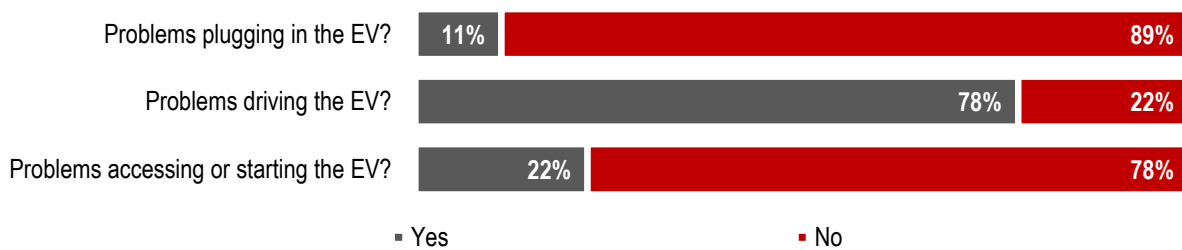
**Figure 24. What Was Your Primary Motivation for Choosing the EV?**



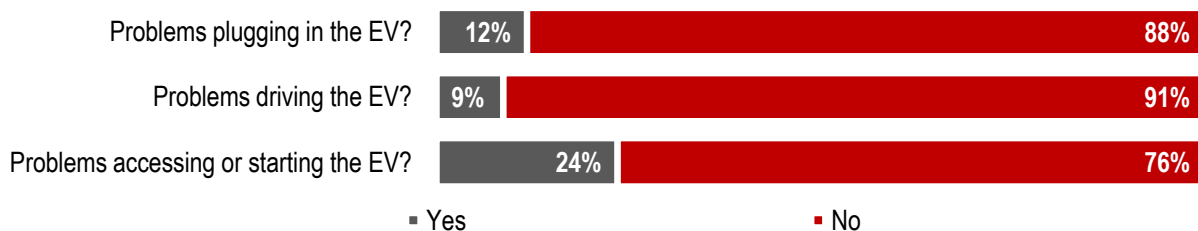
The issues reported with the use of the EVs were typically user confusion due to never using an EV before and were focused on starting, charging, and driving an EV. Users also noted the lack of range on cold days due to the heating requirements but did appreciate how quickly the cars warmed up. There was also some minor issues with the 2014 Ford Focus in general, but were not focused on it being an EV.

Overall, the majority of users reported very few issues other than during the initial survey when most users reported having a least a minor issue with the vehicles. However, this may be due to hardware and operational issues as the carshare integrated the new technology into their fleet. Minor increases in problems were reported in the final survey (Figure 26) compared to the preliminary survey (Figure 25), but this may have been due to a limited number of respondents during the preliminary survey.

**Figure 25. Preliminary Survey Problem Reports**



**Figure 26. Final Survey Problem Reports**



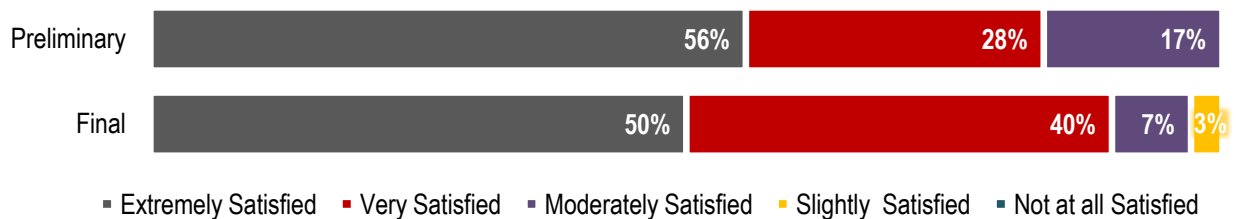
All of the respondents in the preliminary survey stated that they would choose an EV again, should their range requirements fall within the capabilities of the vehicles. However, the later survey found that some drivers would not prefer an EV. Results for both surveys are shown in Figure 27. More interest was noted for warm weather operation when the vehicles range would be greater.

**Figure 27. Would You Choose the EV for Your Next Trip?**



The overall biggest issue for each of the operators was the range capabilities and the potentially limited operation, particularly during cold weather when it is more unpredictable. Overall, respondents liked the use of the EVs and mentioned that as they use them more and become for familiar with how they operate, they would be more likely to choose this option in the future. In the final survey, over 90% of respondents were at least very satisfied with the use of the EVs as shown in Figure 28.

**Figure 28. Level of Satisfaction from EV Use**



An additional question was added in the final survey to identify the public’s view of the ideal vehicle for the carshare operation. The highest ranked vehicle type was the PHEV to allow electric operation but longer range if needed. The rankings are shown in Figure 29.

**Figure 29. Which Technology Do You Feel Is the Best for the Buffalo CarShare Fleet?**



## 4 Conclusions

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Overall, the EVs proved their functionality within the carshare setting and provided reliable service with limited issues. The Project Team successfully completed the project objective to evaluate EVs in the carshare environment. Although the economic viability for BCS to operate EVs was not good, user satisfaction and performance, along with additional factors (e.g., public awareness, information gathering, and outreach) were highly positive outcomes of the demonstration.

The economic analysis showed strong economic potential for EVs, but these vehicles lacked sufficient use to see this potential realized. Throughout this demonstration, the average utilization level of the EVs was only 53% of the gasoline-powered cars. For the EVs to be economically viable for Buffalo Car Share, they needed to achieve a utilization rate of 82% (unlikely due to the current EVs' range which limits its use on longer trips). Because of the higher acquisition costs associated with the EVs, the limited use (compared to gasoline cars) did not provide enough operational savings over the existing vehicle fleet.

EV user satisfaction was high and improved throughout the demonstration with increased driver education and awareness. A survey administered near the end of the demonstration revealed that 90% of the EV users were very or extremely satisfied with the EV performance and their overall driving experience. Few issues were reported with the operation of the EV (e.g., starting, driving, and plugging in), but most were quickly overcome after the member's first experience with the EV. One general issue addressed by BCS during the demonstration was outfitting two of the EVs with snow tires to improve winter performance since the factory-issued low-rolling resistant tires provided poor grip in snow and ice. From this group of EV drivers, there was strong interest in keeping the EVs in the fleet and over 95% of responders would choose an EV in the future if it could meet their required driving range.

During warm weather operations, the vehicle's range and performance met or exceeded BCS member's needs for many of the trips made by the car share users (even if the users chose a gasoline vehicle the EVs could have completed the trip if chosen). However, a lot of the revenue generation for the organization (reserved hours) and operational costs saving potential for the EVs (driven miles) comes from longer trips that are not feasible with EVs. Also during some months, cold weather, and to some extent extremely hot weather, lowered the EV range below what was needed for even some of the shorter in-town trips.

Additional benefits of this project were public outreach and an increased knowledge of EV operations in various conditions. Public awareness significantly increased through this project because most of the 175 EV users never previously drove an EV. The California Air Resources Board became very interested in the concept of a low-income EV carsharing program and called the Project Team to learn about this demonstration. In July 2015, a \$1.6 million state grant was awarded for a carsharing program in low-income Los Angeles neighborhoods that will operate about 100 electric and hybrid vehicles.



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**New York State  
Department of Transportation**

50 Wolf Road  
Albany, NY 12232

**telephone:** 518-457-6195

[dot.ny.us](http://dot.ny.us)

**New York State  
Energy Research and  
Development Authority**

17 Columbia Circle  
Albany, NY 12203-6399

**toll free:** 866-NYSERDA  
**local:** 518-862-1090  
**fax:** 518-862-1091

[info@nyserdera.ny.gov](mailto:info@nyserdera.ny.gov)  
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