NYSERDA Case Study:

Shared Mobility Network

FINAL REPORT

Prepared for:

NYSERDA

Albany, NY

Jeremy Simpson
Project Manager

Prepared by:

Industrial Economics, Inc

Cambridge, MA

Daniel Kaufman
Principal

Emma Fox, Ph.D.
Associate

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NYSERDA Case Study: Shared Mobility Network

Key Results

- **Leveraged funds:** Under the Shared Mobility Network, **every $1 spent by NYSERDA leveraged $14.** This value includes cost share and follow-on investment from other sources (primarily the NYS Transportation Alternatives Program and Congestion Mitigation and Air Quality Improvement Program (TAP-CMAQ) and Independent Health).
- **Bikeshare ridership:** Across all bikeshare programs, annual ridership increased 16-fold from 2016 to 2021, or from **~9,000 ~148,300** rides taken.
- **Carshare cost savings:** Estimated annual transportation cost savings range from **~$5,400 to ~$6,600** per participant across carshare programs.
- **Vehicles shed:** An estimated cumulative total of **552 gas vehicles** were shed across all years of the program from carsharing, bikesharing and vanpooling. Vehicles shed is an estimated metric that assumes partial substitution of carshare vehicles for personal vehicles. It is an estimation of reduced car use across an entire fleet of shared vehicles based on published and peer-reviewed studies.
- **Emission reductions:** An estimated 21,784 MT CO2e emissions were avoided between 2015-2021. CO2e gas emissions avoided were highest from carsharing (17,637 MT CO2e) when compared to bikesharing (4,068 MT CO2e) or vanpooling (79 MT CO2e) between the years of 2015-2021.
- **Societal benefits from reduced emissions:** Estimated benefits from CO_2e reductions were $2.4 million during the same period. Estimated benefits from CO_2e reductions were highest from carsharing (~$2.0 million) compared to bikesharing (~$450,000) and vanpooling (~$8,800).
- **Health and wellness:** Bikeshare riders across Reddy Bikeshare, HOPR, and CDPHP Cycle! burned over **15.5 million calories** in 2021 alone.
- **Equity**: A majority of carshare and bikeshare cars, bike racks, and bike stations were located within walkable distance (0.25 miles) of disadvantaged communities, providing increased mobility access.

1 Introduction

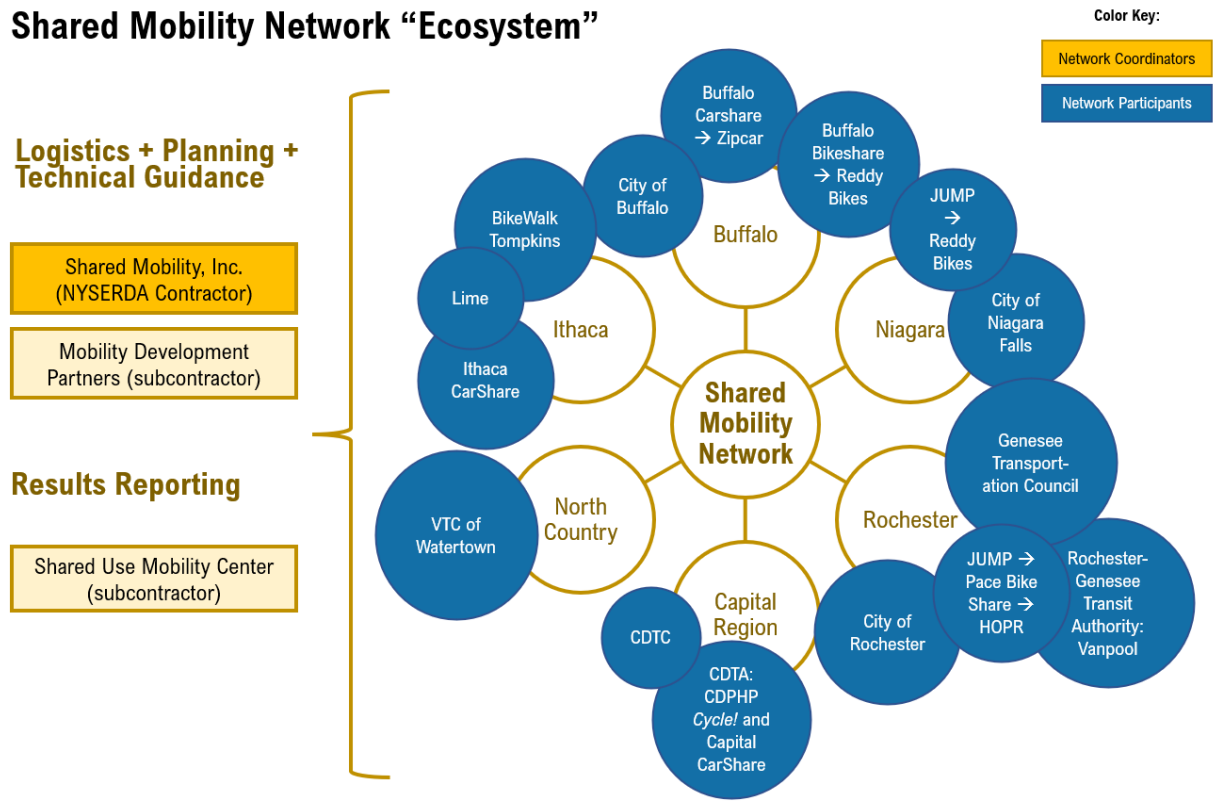
The Shared Mobility Network (Network), a project funded by NYSERDA and the New York State Department of Transportation (NYSDOT) and implemented by Shared Mobility, Inc. (SMI), is a network of 15 non-profits, transit agencies, municipal offices, service providers, and volunteer transit organizations that initiated and expanded a series of shared mobility programs across Upstate New York: Buffalo, Ithaca, Niagara Falls, Rochester, the Capital Region, and the North Country between 2015 and 2019.[1] The project supported the launch and expansion of mobility services in these areas such as carshare, bikeshare, vanpool, and the Volunteer Transportation Center (VTC) of Watertown, NY.[2] In service of these launch and expansion efforts across the Network, SMI worked with local governments and other non-government organizations to scope shared mobility feasibility studies and provide other types of assistance, including the development of business plans and grant applications.

[1] Shared Mobility, Inc. 2019. Shared Mobility Network for New York State. *Prepared for New York State Energy Research and Development Authority and New York State Department of Transportation.* NYSERDA Contract 46831, NYSDOT Task Assignment C-14-08.

[2] The VTC works with Medicaid/Medicare to provide rides to medical appointments for qualifying individuals.

Throughout the project, SMI worked with stakeholders to scope feasibility studies and provide other types of assistance, including the development of business plans and grant applications. The "ecosystem" of shared mobility services and network of partners was large (**Exhibit 1**), leveraging the strengths of its partners. Over the course of the project, NYSERDA invested a total of $255,073 for the Network and NYSDOT provided a cost share of $93,314.

EXHIBIT 1. SHARED MOBILITY NETWORK PARTNERS AND SERVICES



The Shared Mobility Network project was split into two phases: Phase I (2015-2016) was focused on the planning and development of shared mobility opportunities and laid the foundation for work in Phase II (2017-2018), which focused on initiating and expanding mobility demonstrations and systems (see extended background description in **Appendix A**). In Phase I, SMI provided technical support during several ownership and business model transitions across both carshare and bikeshare programs, in logistics preparation for bikeshare demonstration launches, and in the preparation of applications to the Transportation Alternatives Program and Congestion Mitigation and Air Quality Improvement Program (TAP-CMAQ). TAP-CMAQ provides funding to state transportation and transit agencies for projects to reduce traffic congestion and improve air quality. At the end of Phase I, SMI hosted the first of three Shared Mobility Network conferences – the 2016 Mobility Solutions Summit in Ithaca, NY – which was the impetus for many of SMI's endeavors during Phase II.

In Phase II, several organizations in the Network received TAP-CMAQ funding, a major influx of public investment for shared mobility programs in New York State. While existing carshare

services continued into Phase II, SMI shifted emphasis toward bikeshare and micromobility with the launch of new bikeshares. In addition to consulting with municipalities and transit operators on their respective carshare and bikeshare programs, SMI supported the Volunteer Transportation Center (VTC), a non-profit organization that provides transportation to medical appointments by volunteer drivers (subsidized through Medicare/Medicaid), during their expansion from Watertown to other Upstate New York municipalities. SMI also hosted two more conferences: one in Buffalo, NY, and one in Rochester, NY that focused on sharing information on micromobility trends and bringing together transit operators, service providers, and users to learn and network.

This case study highlights the range of benefits of mobility services, programs, and partnerships developed through the Shared Mobility Network during the Phase I and Phase II project years (2015 – 2018) and beyond (2019 – 2021). Including funding for the Shared Mobility Network, total NYSERDA funding for related shared mobility service demonstration, research, projects was approximately $1.5 million between 2015 - 2019.[3]

2 Business + Sustainment + Scaling Up Benefits

The Shared Mobility Network contributed significantly to the adoption of shared mobility programs in New York by way of providing local governments and other organizations with support to enable them to apply to grants to scale up and sustain these programs. The Shared Mobility Network supported four bikeshare demonstrations, which overall saw ridership increase 16-fold, and annual mileage increase 17-fold, from 2016 to 2021 (**Exhibit 2**). The increase was driven by the popularity of the programs. An interview with a service provider pointed to a "bike boom" at the beginning of the COVID-19 pandemic, when people were spending more time at home and looking for ways to be active outside. Bikeshare programs were growing in popularity before the pandemic and were further boosted by this "bike boom." By contrast, vanpooling was challenged by a drop off in customer trips due to the pandemic. Passenger miles and revenue miles (miles for vanpool transportation where passengers pay fares, as the Rochester-Genesee vanpool is partially subsidized)[4] dropped off considerably as well, leading to an increase in the per-customer operator cost of running the program. VTC was likewise challenged by COVID-19 impacts but managed to stay open and is still operating. There were two carshare demonstrations within the Shared Mobility Network time frame (Buffalo CarShare and Capital CarShare) and lessons from which have since informed new EV carshare demonstrations in Rochester and the Capital Region. The results for each type of program (bikeshare, vanpool, volunteer transportation, and carshare) are described below.

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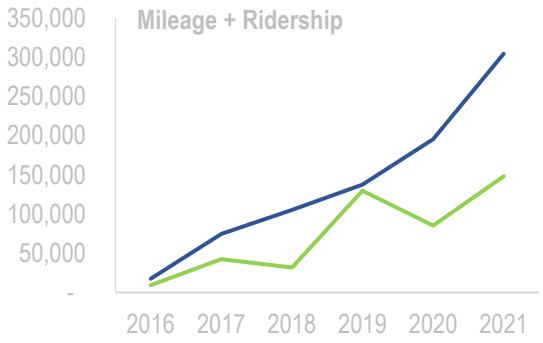
[3] Importantly, leveraged funds are associated with the Shared Mobility Network as a whole, beyond the NYSERDA funding received by SMI for this project ($255,073). For this reason, all related NYSERDA funds (including those with NYSDOT cost share) are included in the denominator of the leveraged benefits calculation.

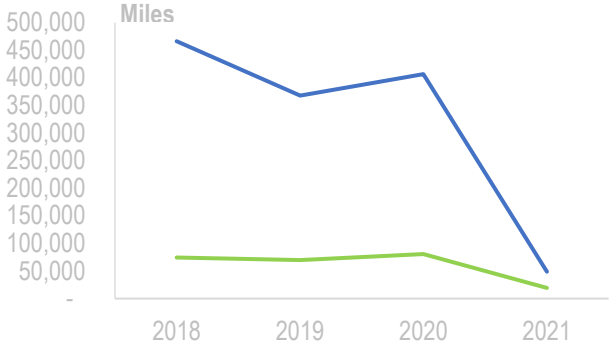
[4] U.S. Department of Transportation Federal Transit Administration. 2022. National Transit Database (NTD) Glossary: Revenue Vehicle Miles. Accessed online Feb. 2023: https://www.transit.dot.gov/ntd/national-transit-database-ntd-glossary#S

EXHIBIT 2. CUMULATIVE BIKESHARE, VANPOOL, AND VTC PERFORMANCE (INCLUDING EXPANSION)

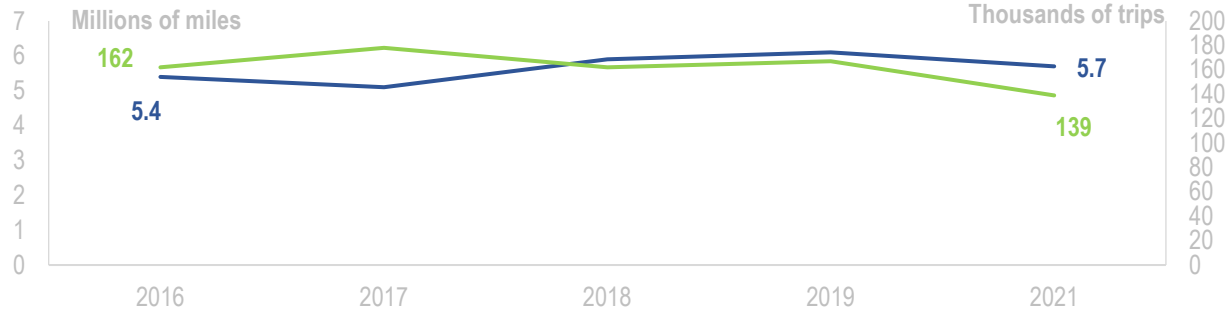
Between 2016 and 2021, **total bikeshare mileage** increased from less than 18,000 to nearly 305,000. **Cumulative bikeshare ridership** increased from ~9,000 to more than 148,000.



Between 2018 and 2020, **total vanpool passenger miles traveled** decreased dramatically, from 466,236 to 48,765. **Vanpool revenue miles** also decreased, from 74,444 to 19,309. Vanpool was notably impacted by COVID.



VTC miles traveled decreased over time, from 6.1 million in 2019 to 5.7 million in 2021 (primary Y-axis). **Total VTC passenger trips** decreased abruptly during COVID, from 167,000 in 2019 to 139,000 in 2021 (secondary Y-axis).



Note: Carshare performance data were not available in the same way as bikeshare, vanpool, and VTC data.

Bikeshare

Reddy Bikeshare in Buffalo/Niagara is the longest consistently running bikeshare in the Shared Mobility Network (program-specific exhibits for this section are in **Appendix C**). Buffalo BikeShare was replaced by Reddy Bikeshare in 2016 under the leadership of SMI and has since expanded to include the City of Niagara Falls. Ridership increased from approximately 9,400 in 2016 to over 47,000 in 2021. The CDPHP *Cycle!* Program, a bikeshare program offered through the Capital District Transit Authority (CDTA) in partnership with Capital District Physicians Health Plan (CDPHP), launched with technical and planning support from SMI in 2017 and increased its ridership from 11,000 in the first year of the program (2017) to nearly 80,000 in 2021. The CDPHP *Cycle!* bikeshare was first launched in four municipalities in the Capital Region and has since expanded to include three more.

Vanpool

Participation in the Rochester-Genesee vanpool program, a partnership between the Regional Transit Service and Commute with Enterprise, decreased between 2018 and 2021 (**Exhibit 2**). During 2020, the first year of the COVID-19 pandemic, the program went from using an average fleet of four to two vans, likely due to a drop off in participation. While decreasing passenger

miles (average passengers in a van multiplied by the miles traveled in one trip)[5] tells a story about reduced participation, revenue miles (miles for which customers pay a subsidized fare) gives an indication of program financial health and sustainment. Time will tell if vanpool participation increases after concerns about COVID-19 diminish.

Volunteer Transportation

The VTC of Watertown is a non-profit organization that coordinates a network of volunteer drivers who provide rides for registered clients (over 26,000 in 2022).[6] **Exhibit 2** includes miles traveled and passenger trips in Watertown and areas to which VTC expanded during the Shared Mobility Network project (described below). Clients connect directly with the VTC by phone or online, or indirectly through a Medicaid/Medicare transportation broker. VTC provides service exclusively for seniors, disabled customers, and other vulnerable populations. The VTC grew their program reach and updated their non-profit model with the help of SMI. The VTC started in New York's North Country region and expanded into Southern Erie County, Genesee County in Western New York, and even California. Part of this growth can be attributed to the VTC's investment in the development of an app, called "Simple Neighborhood Accessibility Platform" (SNAP), which tracks volunteers, pickups, and drop-offs. VTC schedules the rides and drivers using the app, a process that manages 250 volunteers post-COVID.[7]

With support from SMI, the VTC also created "VTC in a box," which gives other volunteer transportation programs VTC's model to benefit other NYS counties and even other states (e.g., California).[8] VTC holds the "VTC in a box" as a training event where they educate attendees on how to find operational efficiencies in their own volunteer transportation programs. The VTC's growth waxed and waned during the years of the Shared Mobility Network project, maintaining an average of 162,000 trips annually until COVID. However, the VTC managed to stay open through 2020, and trip numbers have reportedly started to rebound.

Carshares

The *2019 SMI Final Report* indicates that Buffalo CarShare membership stagnated and began to decline after ZipCar assumed ownership.[9, 10] The Capital CarShare program was phased out of the Capital District Transportation Authority (CDTA) portfolio of transit operations and mobility services in 2019. CDTA determined that the cost of insuring, operating, and maintaining the

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[5] For example, two people traveling 10 miles on a bus results in 20 passenger miles. This definition is roughly consistent with the Federal Highway Administration (FHWA) definition, which multiplies vehicle miles by average occupancy rates. Assumptions on occupancy rates change slightly from year to year. **Source:** U.S. Bureau of Transportation Statistics. N.d. U.S. Passenger-Miles. Accessed online: https://www.bts.gov/content/us-passenger-miles

[6] Volunteer drivers are reimbursed for their mileage at the IRS per-mile reimbursement rate, not paid to drive.

[7] This is about 200 less than the pre-COVID volunteer pool. The average age of VTC volunteer drivers is 60 years. Health/exposure concern amongst volunteers contributed to a decline in the volunteer pool during COVID.

[8] "VTC in a box" training offers the logistic technical support and employee-handbook style information for other non-profits seeking to replicate the VTC's transportation model.

[9] IEc was unable to reach ZipCar for data, so Buffalo area carshare data are limited to the Shared Mobility Network project lifetime. Zipcar does also have locations in Albany, Rochester, and Syracuse; however, these are out of the scope of the present analysis. Interviews with SMI and their project partners suggest that carshares in general have been challenged by competition from ride hailing services. Membership dropoff under the transition to Zipcar ownership may be a result of changed access (e.g., membership through Zipcar rather than Buffalo CarShare) and a different pricing structure, in addition to competition from ride-hailing services.

[10] SMI staff confirmed ZipCar did not provide data for the *SMI 2019 Final Report* after acquiring Buffalo CarShare.

eight-vehicle fleet was greater than the benefit, especially as more customers began to take advantage of ride-hailing services. During its tenure, Capital CarShare saw a modest fleet increase, from seven to eight vehicles (compact model gasoline-powered vehicles and one EV).

More recently, the CDTA has tried to reinvigorate Capital Region carshares with a new, rebranded carshare called "*DRIVE* CDTA," with EV-only options (which ride-hailing services, (e.g., Uber, Lyft and taxis) have yet to offer in a systematic way). This EV carshare is currently in the beta-testing phase with six EVs in the Albany area. The *DRIVE* CDTA carshare benefits from the lessons learned during the Capital CarShare (e.g., being proactive with navigating changes in technology and mobility preferences) and can be tied to the Shared Mobility Network in terms of knowledge-sharing by SMI and their partners.

Ithaca CarShare launched in 2008, prior to the project performance period (2016 – 2018), with the support of an initial $150,000 grant from NYSERDA and the New York State Department of Transportation (NYSDOT). During the Shared Mobility Network project, the program increased their fleet from 26 to 30 vehicles, including 2 battery EVs and 3 plug-in hybrid EVs. Ithaca CarShare is still operating with a fleet of 33 vehicles (a combination of compact model internal combustion engine vehicles, EVs, and hybrids).[11] Rochester's new FloShare EV vehicle network is still being established (currently operating six vehicles); the early stages of planning were supported by SMI. FloShare received $350,000 from TAP-CMAQ, which leveraged another $500,000 from NYSERDA/NYSDOT to launch the carshare pilot. The pandemic delayed Rochester's carshare plans, so FloShare is still in its performance demonstration phase.

3 Environmental Benefits

Estimated Vehicles Shed

IEc reviewed the methodology used by the Shared Use Mobility Center (SUMC) to estimate car ownership reductions linked to the Shared Mobility Network.[12] IEc also independently conducted a review of published literature on emissions reductions attributed to shared mobility programs (i.e., carshare and bikeshare programs). Estimating vehicles shed, or the total number of cars considered off the road as a result of a shared mobility program, requires the use of a shed rate (i.e., the rate at which carshare vehicle or bikeshare use replaces the use of a gasoline-powered passenger car).[13, 14, 15] Importantly, the shed rate reflects avoided personal vehicle

[11] IEc was able to access the 2019 SMI Final Report, the Ithaca CarShare website, and data from the Center for Community Transportation (operator of Ithaca CarShare).
[12] SUMC was founded in 2014 and is a public-interest organization whose goal is to foster solutions for shared mobility. SUMC was a partner to SMI in much of their mobility assistance work and performed the calculations for GHG emissions reductions, vehicles shed, reduced cost of vehicle ownership, and other benefits of interest reported to NYSERDA in the *SMI 2019 Final Report.*
[13] IEc estimates vehicles shed using the following equation: Vehicles shed = (bikes, vehicles, or estimated vanpool passengers)* (shed rate). Shed rate is based on behavioral survey research suggesting that carshare and bikeshare participants report shedding a vehicle in favor of using the carshare or bikeshare as a mobility solution. Different methodologies are used for different modes: for bikeshares IEc used a value of 1 car shed per 11.6 bicycles added to the system, and for carshares IEc used a value of 6 personal vehicles shed per 1 carshare fleet vehicle.
[14] IEc used shared mobility service program fleet information (where it was available) to estimate the total count of equipment across all programs.
[15] Bikeshare equipment also includes scooters.

ownership based on the shared mobility fleet as a whole, in an attempt to control for differences in use patterns between personal and carshare fleet vehicles. To account for these differences, the shed rates assume partial substitution of carshare vehicles for personal vehicles. IEc determined that the vehicle shed rates provided by SUMC were the most appropriate for this analysis, as SUMC's shed rates are anchored toward the lower end of the range of published shed rates for both bikeshare and carshare programs. IEc's estimates of total vehicles shed are dampened from SUMC's original estimates for the Shared Mobility Network using their updated and more conservative shed rates for both bikeshare and carshare.[16, 17] Vanpool-related shed rates depend on participants *and* equipment. More detail on this methodology is included in **Appendix F.**[18]

An estimated 552 vehicles were shed across all programs. While bikeshares had the highest equipment counts (**Exhibit 3**), carshares resulted in the highest count of vehicles shed in all years (**Exhibit 4**). Vanpool had modest participation in all data years (2017 – 2021), reflected in both the average number of vans used (a decrease from 4.1 to 2.1 vans) and total vehicles shed. Importantly, vehicles shed is an estimate, the equation for which relies on a rate identified in the urban planning literature and which depends on geography. Different shed rate assumptions would result in significant changes to the estimates in **Exhibit 4**. These impacts are explored in a sensitivity analysis in **Appendix C.**

EXHIBIT 3. CUMULATIVE TOTAL EQUIPMENT/PASSENGER COUNTS BY SHARED MOBILITY MODE [19]

Mode	2015	2016	2017	2018	2019	2020	2021
Carshare vehicles	24	50	51	52	62	62	68
Bikeshare equipment	490	1,180	1,180	1,180	1,630	1,630	1,630
Vanpool (total estimated passengers)	*No Data*	28.7	28.7	28.7	14.7	14.7	14.7

EXHIBIT 4. ESTIMATED CUMULATIVE TOTAL VEHICLES SHED BY SHARED MOBILITY MODE [20, 21]

Mode	2015	2016	2017	2018	2019	2020	2021
Carshare	270	563	574	585	372	372	408

[16] SUMC estimated benefits from carshare, bikeshare, and vanpool for the *2019 SMI Final Report.*
[17] IEc uses the original SUMC car shed rate from 2015 – 2018 (11.25 personal vehicles shed per carshare fleet vehicle on the road) and the updated shed rate from 2019 onward (6 personal vehicles shed per carshare fleet vehicle on the road).
[18] IEc does not estimate vehicles shed, vehicle miles reduced, or emissions and pollutants reduced through the use of volunteer transportation through the VTC. VTC users can only secure rides for medical-related appointments, so the VTC is not a substitute for other essential or recreational travel like a carshare vehicle or bikeshare equipment.
[19] Shed rates are calculated differently for different shared mobility modes. For vanpool, shed rate is estimated as cars shed by passenger, as the passengers are splitting the trip. Carshare/bikeshare participants do not actually share the vehicle at the same time; rather, they subscribe to access to the fleet. Carshare/bikeshare is estimated as personal vehicles shed per fleet vehicle.
[20] Vehicles shed 2019 and onward were calculating using SUMC's updated methodology. Source: SUMC. 2020. Shared Mobility Benefits Calculator Method. Accessed online April 2022: https://learn.sharedusemobilitycenter.org/casestudy/shared-mobility-benefits-calculator-method/
[21] Shed rate has come down since the end of the project as new options for mobility have increased in their popularity (e.g., ride hailing services).

Mode	2015	2016	2017	2018	2019	2020	2021
Bikeshare	42	102	102	102	141	141	141
Vanpool	*No Data*	7.5	7.5	7.5	3.8	3.8	3.8

Estimated Reduced Vehicle Miles

Using the value for vehicles shed, IEc calculated the reduced vehicle miles traveled (VMT) for the different transportation modes (vanpool, carshare, bikeshare) using an assumed average annual VMT of 11,599 miles traveled per year.[22, 23] IEc used the U.S. Federal Highway Administration value for average VMT because VMT reduction study results are highly variable, often survey-based, or reliant upon assumptions unjustifiable for this analysis.

Since reduced VMT estimation depends on vehicles shed, the decrease in carshare vehicle miles reduced between 2019 and 2021 are noteworthy (**Exhibit 5**). The COVID-19 pandemic also impacted carshares and vanpools more negatively than bikeshares; in fact, according to their *2020 Seasonal Impact Report*, Reddy Bikeshare in Buffalo and Niagara experienced a bike boom during the pandemic.[24]

EXHIBIT 5. ESTIMATED TOTAL REDUCED VEHICLE MILES BY YEAR AND SHARED MOBILITY MODE

Mode	2015	2016 – 2018	2019 – 2021
Vanpool	*No Data*	466,236	406,431
Carshare	3.1 million	19.9 million	13.4 million
Bikeshare	489,000	3.5 million	4.9 million

Estimated GHG Emissions and Air Pollutant Reductions

IEc estimated GHG emissions reductions for the entire carshare, bikeshare, and vanpool fleet using the NYS emissions factors for motor gasoline developed by NYSERDA.[25] For volatile organic compounds (VOCs) nitrogen oxide (NO_x), and particulate matter ($PM_{2.5}$), IEc used the Argonne National Laboratory-developed Alternative Fuel Life-Cycle Environmental and Economic Transportation (AFLEET) tool to estimate pollutant emission reductions.[26, 27] The

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[22] U.S. Federal Highway Administration. 2019. Highway Statistics 2019. Table VM-1. Accessed online May 2022: https://www.fhwa.dot.gov/policyinformation/statistics/2019/vm1.cfm. IEc used 2019 values because 2020 was an anomaly due to the COVID-19 pandemic. 2021 was similar and values are not yet available for that year.
[23] IEc estimated reduced vehicle miles traveled using the following equation: Reduced VMT= (average VMT)*(vehicles shed).
[24] Reddy Bikeshare. 2020. Reddy Bikeshare Season 5 Impact Report. *Prepared in partnership with Independent Health.* Accessed online June 2022: https://reddybikeshare.socialbicycles.com/static/REDDY_impact_report.pdf
[25] Specific documentation can be found in: (1) Emissions values from "Fossil and Biogenic Fuel Greenhouse Gas Emission Factors" (NYSERDA, 2022a), and New York State Energy Research and Development Authority (NYSERDA). 2022b. "Projected Emission Factors for New York State Grid Electricity," NYSERDA Report Number 22-18. Albany, NY. nyserda.ny.gov/publications. (2) Upstate and downstate electricity emissions factors are consistent with "Projected Emission Factors for New York State Grid Electricity" (NYSERDA 2022b). Upstate includes Erie, Genesee, and Tompkins counties, while downstate includes Albany County.
[26] Argonne National Laboratory. 2020. Accessed online May 2022: https://afleet.es.anl.gov/home/
[27] AFLEET allows the user to estimate air pollutant emissions, greenhouse gas emissions, and reduced petroleum use for passenger vehicle replacements using the vehicle footprint calculator (a module of the larger AFLEET tool).

advantage of using AFLEET for VOCs, NO_x, and $PM_{2.5}$ is that AFLEET provides damage cost values for each county of carshare and bikeshare operation, which is consistent with the spatially explicit focus of the analysis (local air pollutants). The NYSERDA lifecycle values do not include VOCs, NO_x, or $PM_{2.5}$.

Greenhouse gas emissions avoided were highest from carsharing (17,637 MT CO_2e) when compared to bikesharing (4,068 MT CO_2e) or vanpooling (79 MT CO_2e) between the years of 2015-2020. During the same time period, VOCs, NO_x, and $PM_{2.5}$ emissions avoided through carsharing also outweighed the emissions avoided through bikesharing. Vanpooling avoided the fewest emissions overall.

IEc estimated net air pollutants and GHG emissions avoided through the use of the carshare fleets, which were each a combination of gasoline-powered and EVs. Buffalo CarShare/ZipCar had a single EV, Capital CarShare had one EV, Ithaca CarShare had two EVs, and FloShare had six (a fully electric fleet). **Exhibit 6** reports net savings due to the use of the carshare fleet (EVs and gasoline-powered vehicles combined) in place of the shed vehicles (all assumed to be gasoline-powered).[28] **Exhibit 7** shows the associated estimated net externality costs avoided by shared mobility mode. **Appendix D** includes additional information on emissions avoided, and **Appendix F** includes additional methodological information.

EXHIBIT 6. ESTIMATED NET AIR POLLUTANTS + GHGS (MT CO_2E) AVOIDED BY SHARED MOBILITY MODE

Mode	2015	2016-2018	2019-2021	TOTAL
Carshare	1,610	10,006	6,037	17,653
Bikeshare	123	1,434	2,514	4,071
Vanpool	No Data	63	19	82
TOTAL	**1,733**	**11,503**	**8,570**	**21,806**

Note: "No Data" indicates a lack of program data.

EXHIBIT 7. ESTIMATED TOTAL NET EXTERNALITY COSTS ($) AVOIDED BY SHARED MOBILITY MODE

Type	2015	2016-2018	2019-2021	TOTAL
Carshare	$178,505	$1,110,377	$672,719	$1,961,602
Bikeshare	$13,679	$159,013	$278,697	$451,389
Vanpool	No Data	$6,770	$2,039	$8,808
TOTAL	**$192,184**	**$1,276,160**	**$953,455**	**$2,421,799**

Note: "No Data" indicates a lack of program data.

Vehicle emissions are linked with a dollar value representing the cost of those emissions to society more broadly (i.e., the externality cost, or monetized indirect damages of fuel

[28] Shed vehicles are assumed to be gasoline powered because owning an EV or hybrid is already considered to be an environmentally-minded choice.

consumption and use to human health and the environment).[29] Externality benefits such as avoided GHGs and air pollutants are reported in terms of net costs avoided due to the use of the carshare fleet (EVs and gasoline-powered vehicles combined) in place of the shed vehicles (all assumed to be gasoline-powered).[30] Externality benefits from greenhouse gas emissions avoided were highest from carsharing (~$2.0 million) when compared to bikesharing (~$450,000) or vanpooling (~$8,800). VOCs, NO_x, and $PM_{2.5}$ externality benefits from carsharing far outweighed the benefit from bikesharing. Vanpooling externality benefits were limited for all pollutants. **Appendix D** includes additional information on externality costs.

4 Economic Benefits

Estimated Transportation Savings

IEc conducted a limited assessment of estimated annual savings for a single household participating in either the Buffalo and Niagara ZipCar program or the Ithaca CarShare program.[31, 32] Transportation savings are higher for ZipCar ($3,668, compared to $2,405 per participating household with Ithaca Carshare), predominantly because Ithaca CarShare's $330 regular membership fee and daily use rate of $5.00/hour plus $0.32/mile adds to more per year than ZipCar's $90 membership fee and $12.50/hour daily use rate, resulting in greater overall savings. It is important to note that savings would increase by $240 per participating household with an additional bump of $0.50/gallon in the price of gas. Transportation savings would decrease minimally with daily mileage over 180 miles, above which ZipCar charges a premium of $0.58/mile.[33, 34]

Public and Private Investment

IEc gathered public and private investment data through interviews and validated them using publicly available data (e.g., CDTA, Department of Transportation's Transportation Alternatives Program Congestion Mitigation and Air Quality Improvement Program (TAP-CMAQ)).[35, 36, 37]

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[29] For example, replacing a gasoline-powered vehicle with an electric vehicle, or EV, is considered a positive externality (i.e., a benefit linked with reduced health or environmental damages).

[30] In 2021, EVs represented 20 percent of the carshare fleet vehicles for this study. The *total market share* of EVs in New York State was estimated to be 2 percent in 2021. **Source:** IEc. 2022. Clean Transportation Market and Evaluation: EV Rebate Program Market Evaluation. Prepared on behalf of NYSERDA. https://www.nyserda.ny.gov/-/media/Project/Nyserda/Files/Publications/PPSER/Program-Evaluation/Transportation/2022-12-Matter-No-16-02180-NYSERDA-CleanTransportation-EV-RebateMarketReport.pdf

[31] These are the only two carshare programs for which IEc was able to collect annual and hourly/mileage use rate information. Capital CarShare is defunct and FloShare is still in its beta-testing phase.

[32] Household is treated synonymously with individuals, here.

[33] IEc uses the AFLEET default assumption of $2.33/gallon, the average rate from the AFDC price report for October 2019 – July 2020.

[34] IEc assumes the average annual travel is distributed evenly throughout the year, and therefore the additional ZipCar mileage range does not factor into the present calculation.

[35] Interview discussion with CDTA.

[36] NY Department of Transportation. TAP-CMAQ 2018. Accessed online May, 2022: https://www.dot.ny.gov/divisions/operating/opdm/local-programs-bureau/tap-cmaq/TAP-CMAQ-2018

[37] NY Department of Transportation. TAP-CMAQ. 2016. Accessed online May, 2022: https://www.dot.ny.gov/divisions/operating/opdm/local-programs-bureau/tap-cmaq/tap-cmaq-2016

All public and private funds reported here were successfully garnered with the support of SMI, significantly leveraging NYSERDA's funding for the Shared Mobility Network.[38]

According to a project partner interviewee, Buffalo CarShare and Ithaca CarShare programs relied primarily on NYSERDA funding between 2008 – 2013. The interviewee identified funding diversification as a major success of the Shared Mobility Network, citing a move to include federal block grant resources (e.g., TAP-CMAQ funds) and general funds from transit operators in various programs. Diversified funding could support projects after NYSERDA funding ended (typically on a three-year cycle) and was seen as a selling point for potential private investors, according to the interviewee.

TAP-CMAQ provided the most public-sourced funding overall, approximately $12.5 million, the majority of which was awarded beginning in 2018 (**Appendix B**). NYSERDA contributed $1.3 million across all shared mobility recipients during the Shared Mobility Network project (exclusive of SMI and the Shared Mobility Network).[39] Private sponsorship to SMI totaled approximately $3 million during the 2016 – 2021 period. Ultimately, each NYSERDA dollar invested leveraged $14 dollars from other sources under the Shared Mobility Network.

5 Health and Wellness

Increased Health/Wellness from Increased Biking

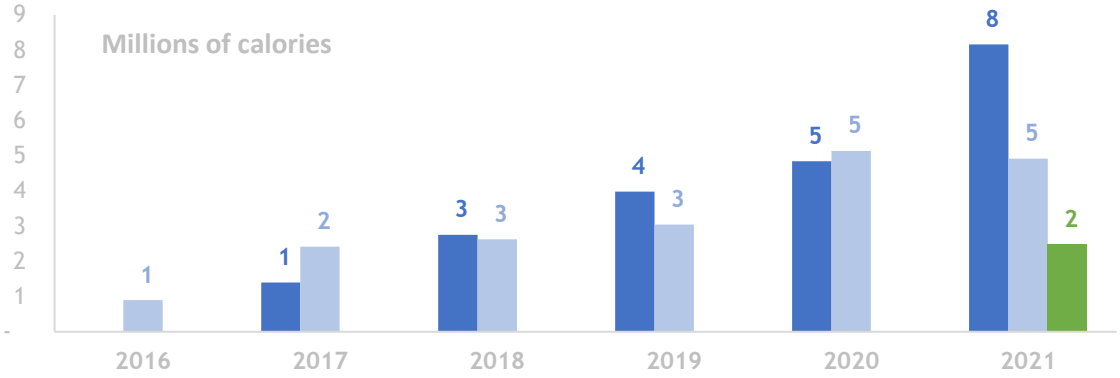
Calories burned during exercise can approximate health benefits and is calculated using total miles ridden and an estimate of calories burned per mile. IEc calculated calories burned during exercise for currently operating bikeshare programs: CDPHP *Cycle!*, Reddy Bikeshare, and HOPR.[40, 41, 42] CDHP *Cycle!* users burned the most calories (8.16 million in 2021, **Exhibit 8**), more than three million calories more than Reddy Bikeshare users during the same year (4.91 million). This difference is due to the breadth of the CDPHP *Cycle!* program, which covers Albany, Troy, Cohoes, and Schenectady. As bikeshare programs continue to expand their reach with new station locations and new participants, calories burned during cycling are expected to increase. The methodology used to calculate calories burned is described in **Appendix F.**

[38] Importantly, funds from TAP-CMAQ and Independent Health are considered "leveraged" funds, whereas other public/private (non-NYSERDA/NYSDOT) funds contributed by SMI or their partners are considered "cost share."
[39] NYSERDA provided SMI with funding equal to $255,073 toward the Shared Mobility Network. $255,073+$1.3 million = $1.5 million total NYSERDA funding.

[40] HOPR is the name of a proprietary micromobility service provider offering bikeshare and scooter options. It is not an acronym.
[41] IEc only received HOPR miles traveled information for 2021.
[42] It is important to note that calories burned per mile is an approximate value and varies considerably based on individual weight, speed, and weight of the bicycle. Age, fitness level, diet, sleep, and oxygen intake are also explanatory factors. This calculation is a rough approximation.

EXHIBIT 8. ESTIMATED ANNUAL CALORIES BURNED DURING EXERCISE FROM BIKING [43]

In 2021, CDPHP Cycle! users burned a total of 8.16 million calories, while Reddy Bikeshare users burned 4.91 million and HOPR users burned 2.27 million calories.



6 Access to Bikeshare and Carshare

To assess general access to transportation services, IEc examined the location of shared mobility services in relation to DACs using NYSERDA's final DAC criteria and mapping data.[44, 45] As of 2022, there are a total of 269 bikeshare stations/mobility hubs and carshare vehicles in Upstate New York in programs that are or were linked with the Shared Mobility Network. **Exhibit 9** links these individual stations with their service region and mobility service provider. Capital CarShare is not included because the program was shut down by CDTA during the funding period (2015 – 2018). Ithaca's Lime bikeshare is not included because it shut down in 2019.

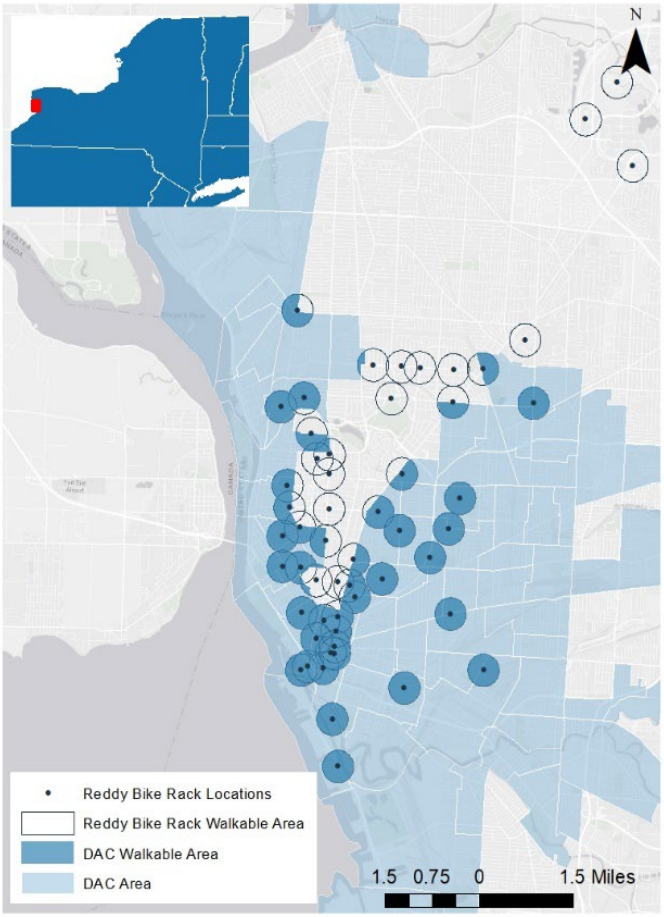
EXHIBIT 9. CURRENT CARSHARE AND BIKESHARE STATIONS IN UPSTATE NEW YORK

Service Region	Mobility Service Provider	Station/ Rack/ Vehicle Count	Total area with walkable access (sq. miles)	Walkable access range within DACs
City of Buffalo	Reddy Bikeshare (includes Niagara Falls, Buffalo, Buffalo University)	97 racks	15.14	86%
	ZipCar	*No data*	*No data*	*No data*
City of Rochester	HOPR Bikeshare	67 stations	13.16	81%
	FloShare	6 vehicles	*No data*	*No data*
Capital Region	CDPHP Cycle! (Includes Albany, Troy, Schenectady, and Cohoes)	105 stations	18.84	57%
Ithaca	Ithaca Carshare	29 vehicles	5.69	20%

[43] Note: Calories burned increases over time are likely due to more users, rather than increased biking distances.
[44] NYS Climate Action Working Group. 2023. Disadvantaged Communities Criteria. Accessed online April 2023: https://climate.ny.gov/resources/disadvantaged-communities-criteria/
[45] The NYS Climate Action Working Group definition for DACs is based on a set of criteria, including employment; income level; home ownership/rental status; particulate matter exposure; asthma rate; proximity to highways, industrial land use, landfills, remediation sites, and/or wastewater discharge; and more.

In general, most stations/car locations are clustered near central areas or population centers (like a downtown area). This arrangement allows the stations to serve the most users, and it also appears to benefit DACs, where residents may not have access to a personal motor vehicle or primarily rely on public transportation. There were 201 bike racks/stations/vehicle parking spots within walking distance of DACs, and 74 bike racks/stations/vehicle parking spots outside of DAC walking distance.

EXHIBIT 10. REDDY BIKESHARE LOCATIONS: BUFFALO



- *Buffalo and Niagara:* In Buffalo, Reddy Bikeshare racks are centrally located in the downtown area, near the Buffalo Zoo, on the Buffalo River waterfront, and near the Buffalo Niagara Medical Campus. In Niagara Falls, many bike racks are located adjacent to the Niagara Falls State Park. The Buffalo and Niagara area has 66 bike racks within walkable distance of DACs, creating a total walkable access area of more than 15 sq. miles. For this analysis, IEc overlayed the map of DACs with bikeshare stations/docks and carshare designated parking to assess where the stations are in relation to New York's overburdened and underserved communities. While Buffalo is shown below (**Exhibit 10**), other maps for relevant shared mobility programs are in **Appendix E**.
- *Rochester:* HOPR stations are clustered in the Midtown District, Convention District, Manhattan Square, Washington Square, and East End neighborhoods. Rochester has 54 bike stations in walking distance of DACs, with an access area of over 13 sq. miles.
- *Capital Region:* CDPHP *Cycle!* stations are located in population centers or downtown areas, near areas of interest (e.g., University at Albany, the Albany International Airport, and the Mohawk River waterfront in Schenectady). The region has 65 stations within DACs, with an access area of more than 18.5 sq. miles.
- *Ithaca:* Ithaca CarShare vehicles were located predominantly near the downtown area, Collegetown, Cornell University, and Hotel Ithaca. The City of Ithaca had 16 vehicles

within walking distance of DACs, creating a total walkable access area of more than five sq. miles.[46]

7 Equity

Access to reliable transportation and access to various modes of transportation are important components of equity, and the availability of zero and low-emissions transportation options is an ever-growing concern under climate change. In **Section 6**, IEc analyzed the proximity of bike racks and carshare vehicles to DACs and found that many shared mobility equipment stations do provide walkable access. However, there are other barriers that may prevent an individual's use of shared mobility services. The NYSERDA *DAC Barriers and Opportunities Report* identifies a series of barriers for disadvantaged communities to owning or accessing zero and low emissions transportation options, including:

- Limited access to transportation services based on disability, gender, or safety
- Limited technology or internet access.
- Limited or no access to transportation services outside of public transit for unbanked or underbanked individuals (i.e., individuals who rely primarily on financial services other than bank accounts, such as check-cashing, money orders, or prepaid cash cards)[47]

Serving Disadvantaged Communities

The 2019 Climate Leadership and Community Protection Act (CLCPA) committed New York State to an 85 percent reduction of greenhouse gas (GHG) emissions from 1990 levels by 2050. New York State's Climate Action Council 2022 Scoping Plan recognizes that GHG reductions in the transportation sector require both electrification for fleets and personal vehicles and reduction in vehicle miles traveled (VMT), and envisions diversified mobility options as complementary to public transit in reducing VMT.

The Climate Action Council's Scoping Plan also emphasizes investment in projects that serve disadvantaged communities (DACs). There are approximately 6.9 million individuals living in DACs within New York State.

NYSERDA's New York Disadvantaged Communities Opportunities and Barriers report identifies that there is currently a distinct lack of programs providing access to clean (zero or low emission) and safe transportation for DACs. Individuals living in DACs may encounter barriers relating to transportation services (e.g., the cost of vehicle rental and ride-hailing services, digital-only payment processing) that are not addressed by programs funding EV rebates or EV infrastructure expansion efforts. SMI's work in shared mobility services addresses this barrier.

More information on DACs can be found at https://climate.ny.gov/resources/disadvantaged-communities-criteria/.

These hurdles challenge individuals without access to a vehicle or a reliable means of public transportation by restricting their mobility. It appears that shared mobility services address this gap in important ways. Interviews suggest that shared mobility services customers are using these services for essential appointments and errands: visits to their doctor, shopping for groceries, picking up prescriptions

[46] At the time of the data snapshot (June 2022).
[47] Modes of transportation such as taxis and ride-hailing services typically require the use of an app linked to a bank account or credit card, both of which may be inaccessible for unbanked or underbanked individuals.

at the pharmacy, and more.[48] Other possible uses for shared mobility services are recreational (e.g., a day trip for a hike or visit to family).[49] SMI's efforts to roll out shared mobility networks across the state may give some municipalities access to lower-cost transportation options like vanpool and bike share where only car share had been available before (e.g., Rochester). Bike share especially offers a lower-cost mode of transportation but may not be a viable mode of transportation for some riders and some destinations.

Despite reduced costs and increased availability, accessing shared mobility services may still be challenging for low-tech or unbanked customers. Though smartphone penetration is high amongst all populations, equitable access calls for a variety of payment options. HOPR (Rochester) is working on integrating cash payment options with a third party that facilitates payments through retail locations such as Walgreens, CVS, Seven Eleven, Walmart, and RiteAid. Reddy Bikeshare (Buffalo and Niagara) accepts pre-paid cash cards. Cash payments support the use of shared mobility services by unbanked or underbanked individuals. Ithaca CarShare allows people to pay with cash into a carshare account at the local bank or the Ithaca CarShare office to serve individuals without a credit or debit card.[50] The account is set up as a cash payment option (similar to a pre-paid cash card) for people who do not have a bank account at a local banking institution. Ithaca Carshare also offers a low-tech option for individuals without broadband or smartphone access: users may call in to the program to access the vehicles.

Ithaca CarShare also has an "Easy Access" program, which waives the application fee and offers a reduced rate to income-qualifying individuals. The program was originally funded by the Federal Transit Authority, but the Center for Community Transportation (CCT), which runs Ithaca CarShare, determined that the rate was important to maintain for customers after the federal funding ended. Ithaca CarShare now supports the 65 customers using the "Easy Access" program through general carshare revenues and support from other investors, such as the Ithaca Downtown Alliance. Customers are required to recertify every year, and the program is only available to residents of Tompkins County.

8 Information Dissemination

Information dissemination through conferences was a critical piece of the Shared Mobility Network relationship-building process for SMI and their partners. SMI hosted three conferences with 50 to 100 participants each (**Exhibit 11**). Interviews with SMI's partners suggest that the conferences were the initial point of connection with the SMI team, who later supported their business planning, program scale-up, or grant writing. Some partners indicated that they still

[48] The Buffalo Car Share two-year report from 2011 likewise identifies grocery trips and doctor visits among the list of customers' carshare trip types. Source: Randall, C. 2011. Buffalo Carshare: Two years in review, a look at the organization's growth, membership, and impacts. *Final Report C-08-24 prepared for NYSERDA and the New York State Department of Transportation.* Accessed online March 2022: https://rosap.ntl.bts.gov/view/dot/23850

[49] The Volunteer Transportation Center of Watertown, NY only provides transportation for medical appointments.

[50] The Ithaca CarShare account at their program office or the local bank does not require individuals to have their own checking or savings account at the bank, which sometimes require a minimum deposit. The payment goes directly to the Ithaca CarShare program and does not accrue interest at the bank.

connect with SMI to share ideas about shared mobility in New York. As one interviewee stated, "*Our conversations [with SMI] always inform the bigger questions*."

The CCT has collaborated on and off with SMI over the years. CCT interviewees described variable activity with carsharing in Upstate New York since Ithaca CarShare first launched in 2008, as well as larger challenges (e.g., rising insurance cost for carshare fleets and increased tax rates for carshare providers). The CCT interviewees noted that addressing these issues "*would be significantly more difficult without the network."*

The conferences led to facilitated/supported conversations between Ithaca CarShare, Buffalo CarShare, and Capital CarShare about sharing back-office expenses and workloads through a joint software program, but this never manifested due to lack of interest. Despite this, the network continues to be an important technical support resource for Ithaca CarShare. The interviewees identified the shift to EVs as another area where SMI and the broader network of partners (e.g., Mobility Development Partners or CDTA) could be of assistance in the future.

EXHIBIT 11. CONFERENCES DURING THE SHARED MOBILITY NETWORK PROJECT

Conference Name	Date	Location	Description	Attendees
Mobility Solutions Summit	June 2016	Ithaca, NY	Trends in shared mobility and "better practices" for transportation service	90
Urban Land Institute Workshop	May 2017	Buffalo, NY	Transportation Demand Management (TDM)	50
Mobility Innovation Summit	June 2018	Rochester, NY	Smaller cities and rural transportation solutions	100

9 Conclusion

The Shared Mobility Network is one of NYSERDA's early investments in advancing shared mobility services. This project predated – but aligns with – Climate Act goals. The Shared Mobility Network has achieved more than $2.4 million in environmental benefits from reductions to CO_2e and air pollutants such as VOCs, NO_x and $PM_{2.5}$. While other benefits are difficult to assess, the project also yielded household-level savings, health benefits, and improved transportation access in disadvantaged communities. Every $1 spent under the Shared Mobility Network by NYSERDA/NYSDOT leveraged $14 in investment from other sources.

The Shared Mobility Network also resulted in the dissemination of technical assistance, strategic planning, and programmatic operations information to key partners, such as the SUMC, Mobility Development Partners, and the CCT. The project also provided important lessons learned for mobility service providers, such as the CDTA, VTC of Watertown, City of Rochester, and SMI. Interviews with SMI, VTC of Watertown, and Mobility Development Partners indicate that the organizations have gone on to support demonstrations in other NYS municipalities and even California based in part on lessons learned in Upstate New York, extending the reach and influence of the NYSERDA-backed Shared Mobility Network. Moreover, the relationships established during the project are sustained informally today in service of brainstorming solutions to barriers to maintaining and further expanding shared mobility services in New York.

Today, many shared mobility services are still evolving in scope. More than five cities in Upstate New York have bike shares that are transitioning to electric micro-mobility. Electric car shares are currently operating in the Capital Region and Rochester and will launch in the City of Buffalo in 2024. The still-expanding reach of shared mobility services continues to play an important role in reducing GHG emissions and providing diversified transportation options as New York State works to meet its Climate Act goals for the transportation sector.

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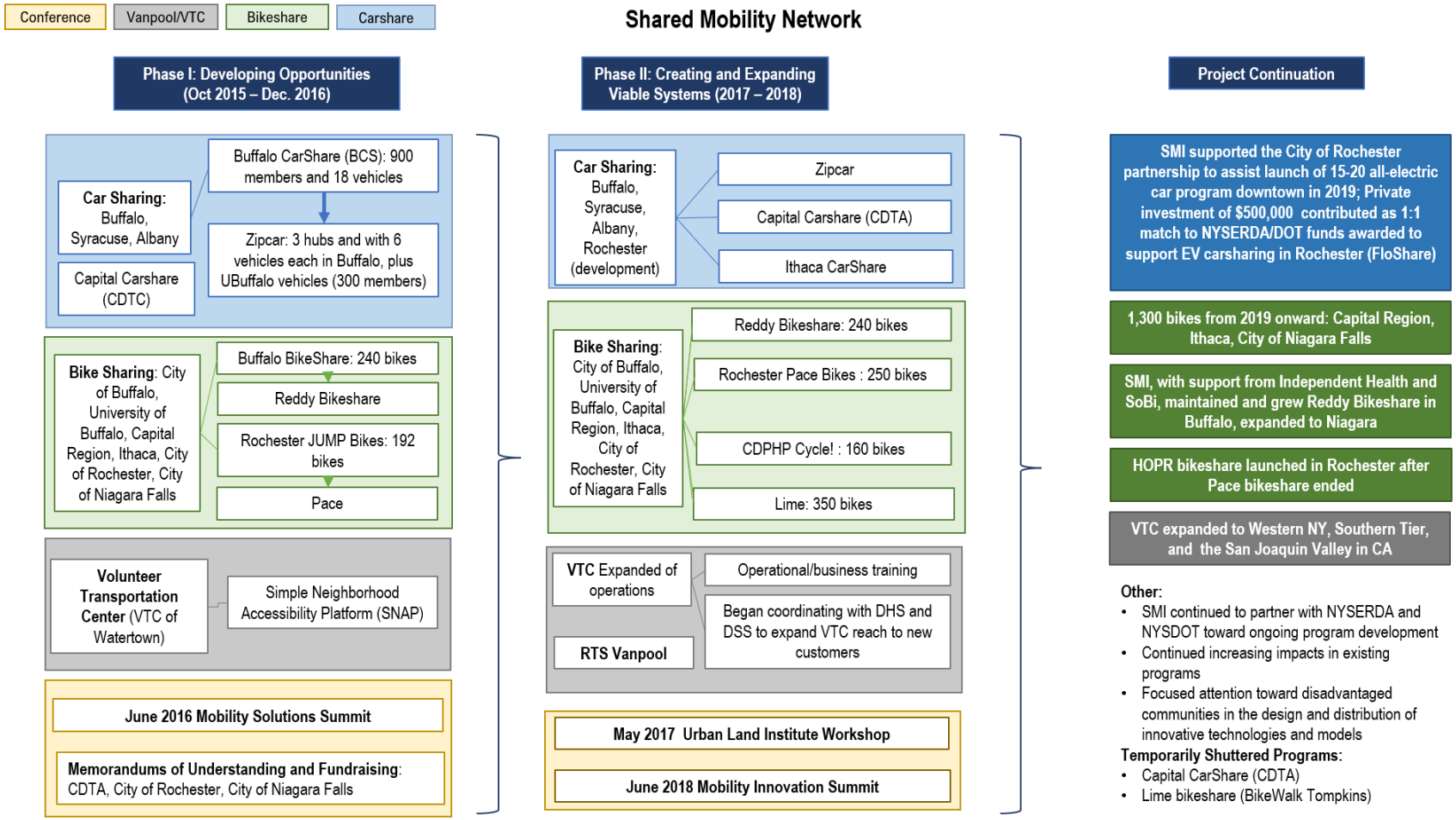
Appendix A: Extended Background

EXHIBIT 12. PHASES OF THE SHARED MOBILITY NETWORK PROJECT



Note: The Shared Mobility Network project took place in two phases. Phase I laid the groundwork for Phase II expansions. "Project Continuation" encompasses all activities after the end of the Shared Mobility Network project in 2018. A timeline of NYSERDA-funded projects is included below.

The Shared Mobility Network project was split into two phases: Phase I (2015-2016) was focused on the planning and development of opportunities for shared mobility systems and laid the foundation for Phase II work (2017-2018), which focused on initiating and expanding those systems (**Exhibit 12**).

Phase I involved several ownership and business model transitions: Buffalo CarShare was purchased by ZipCar and the founding members moved on to pursue SMI (incubated during the Buffalo CarShare years); Capital CarShare transitioned from the Capital District Transportation Committee (CDTC) to the Capital District Transportation Authority (CDTA); and the City of Rochester analyzed opportunities for shared mobility (building on the earlier Rochester Area Bike Sharing Program Study). Buffalo BikeShare transitioned to Reddy Bikeshare (managed by SMI) during the first phase of the project, incorporating more private funding. Phase I also included bikeshare demonstrations in the Capital Region, in addition to work with the City of Rochester and the City of Niagara Falls to prepare applications to the TAP-CMAQ, which provides funding to state transportation and transit agencies for projects to reduce traffic congestion and improve air quality. Both the City of Rochester and City of Niagara Falls grants were successfully funded by TAP-CMAQ during Phase II of the project. SMI also worked with SUMC to analyze Volunteer Transportation potential in Upstate New York during the first phase of the Shared Mobility Network.[51]

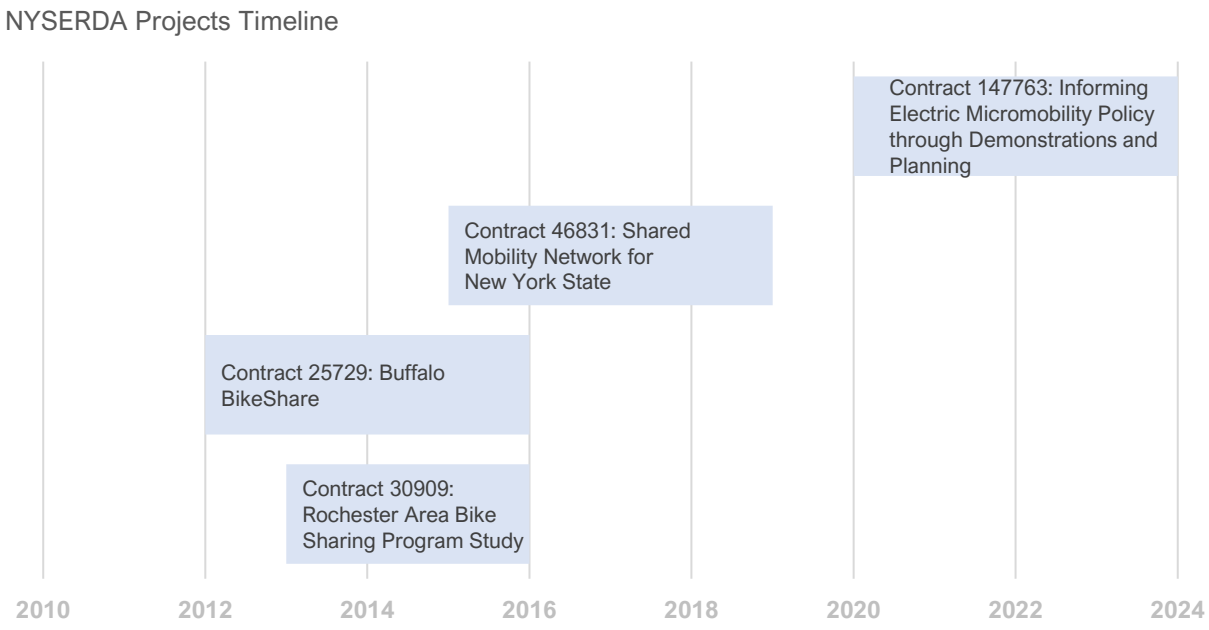
SMI advised project partners in these transitions, supported the development of memoranda of understanding for joint fundraising with several key partners (CDTA, City of Rochester, and City of Niagara Falls), and provided planning insights as partners shifted business models or sought to diversify their funding beyond NYSERDA PONs. At the end of Phase I, SMI hosted the first of three Shared Mobility Network conferences – the 2016 Mobility Solutions Summit in Ithaca, NY – which was the impetus for many of SMI's endeavors during Phase II.

The Shared Mobility Network project ran from late 2015 – 2018. **Exhibit 13** shows the timeline and overlap of related and in-scope NYSERDA-funded projects: Buffalo Bikeshare, Rochester Area Bike Sharing Program study, and Informing Electric Micromobility Policy through Demonstrations and Planning.[52]

[51] At the time, the founding Executive Director of Buffalo CarShare worked at SUMC and continued supporting SMI efforts during the Shared Mobility Network project years.

[52] The Rochester Area Bike Sharing Program Study laid the groundwork for the Rochester bike share grant proposals in coordination with SMI. The Buffalo BikeShare project overlapped with the Shared Mobility Network timeline and may have been expanded later under the Shared Mobility Network. The Informing Electric Micromobility Policy through Demonstrations and Planning project represents ongoing NYSERDA-funded work from SMI. The Electric Micromobility Policy work is informed by lessons learned from the Shared Mobility Network and SMI's earlier work with Buffalo CarShare and Buffalo BikeShare.

EXHIBIT 13. TIMELINE OF NYSERDA-FUNDED PROJECTS



Appendix B: Public and Private Funding for Shared Mobility Programs

EXHIBIT 14. PUBLIC AND PRIVATE FUNDING FOR SHARED MOBILITY PROGRAMS

Funding Recipient	Description	Funding Source	Public or Private?	Date	Amount ($)
GTCS, Inc.	Rochester Area Bike Sharing Program Study.	NYSERDA	Public	2016	$75,000
Shared Mobility, Inc.	Funding to support a Buffalo bike share.	NYSERDA	Public	2016	$128,807
Shared Mobility, Inc.	Sponsorship of bike sharing in Buffalo. Expanded system from 75 to 250 bikes.	Private Sponsor	Private	2016	Confidential
Capital District Transportation Authority (CDTA)	For the implementation of a bikeshare program.	TAP-CMAQ	Public	2016	$2,000,000
City of Rochester	For the development of a Shared Mobility Program, including EV carshare network.	TAP-CMAQ	Public	2016	$1,004,000
City of Buffalo	For the implementation of Phase I of the City's Bicycle Plan.	TAP-CMAQ	Public	2016	$1,424,000
City of Niagara Falls	For a regional bike sharing program. Shared Mobility, Inc. received funding through this project to expand the bikeshare from Buffalo to Niagara Falls.	TAP-CMAQ	Public	2016	$511,245
Shared Mobility, Inc.	Contract for purchase of 200 bike share bikes and operational support for city-wide bikeshare system in Buffalo.	Private Sponsor	Private	2017	Confidential
City of Rochester	For the deployment of a larger-scale all-electric network (15-20 vehicles).	NYSERDA/NYSDOT	Public	2017	$500,000
Capital District Transportation Authority (CDTA)	Private sponsorship for a bike share in the Capital Region in New York. This project assisted the development and implementation of bike sharing in this region. Shared Mobility, Inc. supported CDTA in securing this funding.	Private Sponsor	Private	2018	Confidential
Shared Mobility, Inc.	Private sponsorship of Buffalo bikeshare.	Private Sponsor	Private	2018	Confidential
Rochester Genesee Regional Transportation Authority	For the expansion of existing bike share and vanpool programs outside Rochester city limits.	TAP-CMAQ	Public	2018	$1,792,000
Rochester Genesee Regional Transportation Authority	For the expansion of bike share and vanpool programs.	TAP-CMAQ	Public	2018	$5,000,000
Niagara Frontier Transportation Authority (NFTA)	For the expansion of bike share, van pool, and carpool programs.	TAP-CMAQ	Public	2018	$759,226

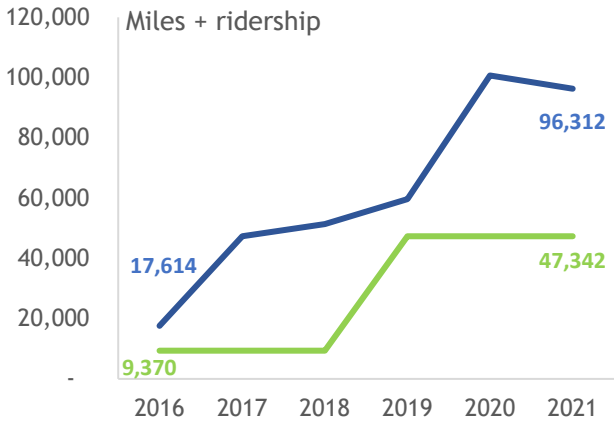
Funding Recipient	Description	Funding Source	Public or Private?	Date	Amount ($)
Shared Mobility, Inc.	Shared Mobility Network.	NYSERDA	Public	2019	$255,073
Shared Mobility, Inc.	Uber donated bikes valued at $2,100,000 to Shared Mobility, Inc. for bikeshare and library bike use.	Uber	Private	2020	$2,100,000
Shared Mobility, Inc.	Informing Electric Micromobility Policy Demonstration and Planning.	NYSERDA	Public	Ongoing	$199,465
Ithaca CarShare	For the launch of an Ithaca-based carshare program.	NYSERDA/NYSDOT	Public	Unknown	$150,000
Capital CarShare	Self-funded operation of Capital CarShare.	CDTA Funding	Public	Unknown	Unknown
VTC of Watertown	Self-funded software development for organizing and dispatching volunteers.	VTC	Public	Unknown	Unknown
NYSERDA/NYSDOT Total					**$1,308,345**
TAP-CMAQ Total					**$12,490,471**
Private Sponsorship					**~$3 million**
Private Donation - Equipment					**~$2.1 million**
***ALL Sources**					**$18,898,816**

Note: The total funding amounts reported here are reflective of amounts both publicly available and reported confidentially to NYSERDA, including both individual project funding amounts and/or cost share amounts. Therefore, the total costs may be higher than the sum of the individual project amount column. A donation of bikes from a private sponsor valued at $2-3 million dollars is not included here. Totals listed here do not include the individual project funding amounts listed as "unknown" – while interviewees indicated that they were funded by particular sources, IEc was not able to locate dollar amount information for those sources.

Appendix C: Performance of Shared Mobility Demonstrations

EXHIBIT 15. ANNUAL REDDY BIKESHARE MILEAGE, RIDERSHIP, AND EQUIPMENT INCREASES

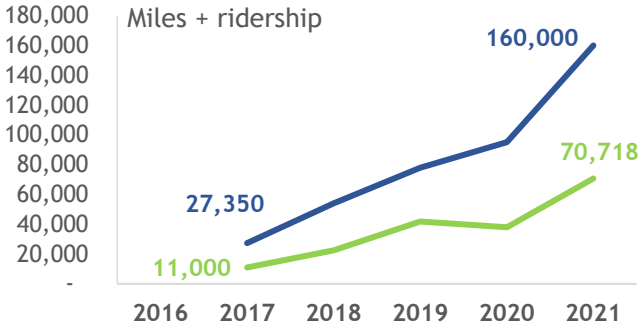
Between 2016 and 2021, **total mileage** traveled increased nearly six-fold, and **ridership** increased more than six-fold for Reddy Bikeshare.



Between 2016 and 2021, Reddy Bikeshare **equipment** nearly doubled.

EXHIBIT 16. ANNUAL CDPHP *CYCLE!* MILEAGE, RIDERSHIP, AND EQUIPMENT INCREASES

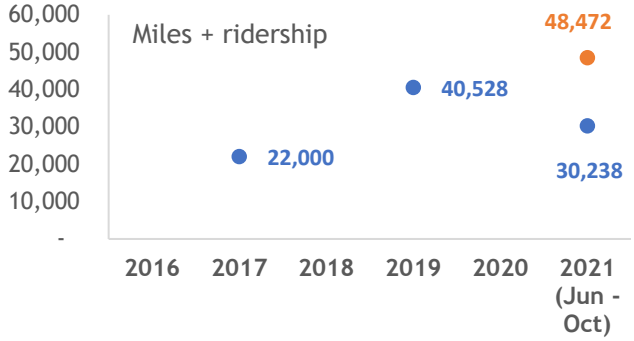
Between 2017 and 2021, **total mileage** traveled increased nearly six-fold, and **ridership** increased more than six-fold for CDPHP *Cycle!*.



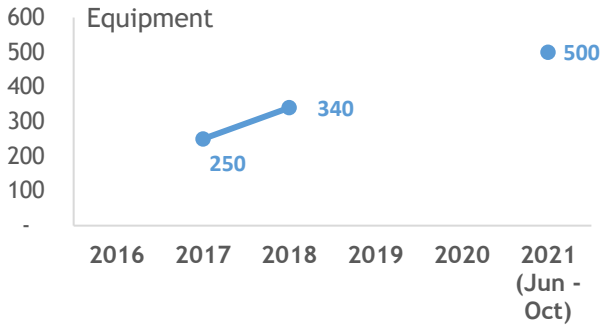
Between 2017 and 2021, CDPHP *Cycle!* **equipment** increased nearly three-fold.

EXHIBIT 17. CITY OF ROCHESTER BIKESHARE RIDERSHIP, MILEAGE, AND EQUIPMENT OVER TIME

Between 2016 and 2021, the City of Rochester saw several different service providers, so annual ridership and mileage were reported inconsistently. HOPR, the most recent, is seasonal (June - October).



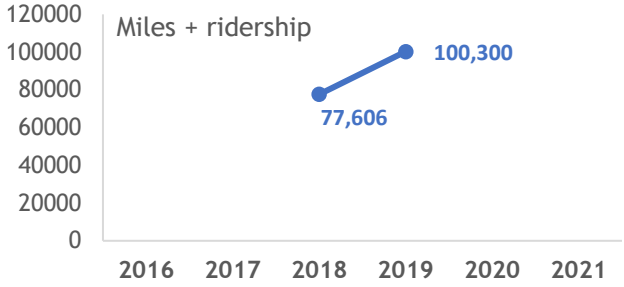
Between 2016 and 2021, the City of Rochester saw several different bikeshare service providers, but HOPR, a seasonal program (June - October), appears to be providing the most equipment to bikeshare users across the city.



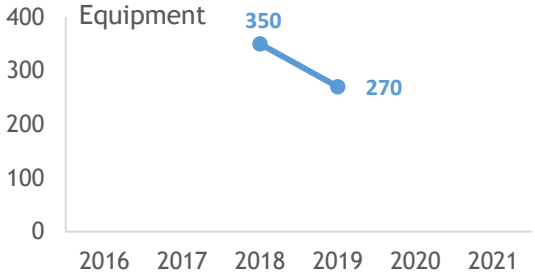
Note: Data for the City of Rochester's various bikeshares were limited, and thus are reported as disconnected scatterplots.

EXHIBIT 18. LIME BIKESHARE RIDERSHIP AND EQUIPMENT: 2018-2019 DEMONSTRATION

Lime bikeshare was a demonstration initiated in 2018 and extended for one additional year in 2019, so annual ridership is reported only for that time period. Lime did not report total mileage.



Lime bikeshare was a demonstration initiated in 2018 and extended for one additional year in 2019, so equipment was reported only for that time period.



Appendix D: Estimated GHG and Pollutant Emissions and Externality Costs

This appendix includes tables from all shared mobility programs discussed in **Section 3.** Specific methods for GHG and pollutant emissions estimation (and costs) are described in detail in **Appendix F**.

EXHIBIT19. ESTIMATED NET AIR POLLUTANTS/GHGS AVOIDED BY CARSHARING

Carshare Program	Net Emissions Avoided (MT)	2015	2016-2018	2019-2020
Buffalo Car Share/ZipCar (Buffalo)	CO2e	1,206	3,563	1,900
	PM 2.5	0.0	0.1	0.1
	NOx	0.4	1.2	0.6
	VOCs	0.6	1.8	1.0
FloShare (Rochester)	CO2e	N/A	N/A	583
	PM 2.5	N/A	N/A	0.0
	NOx	N/A	N/A	0.2
	VOCs	N/A	N/A	0.3
Capital CarShare (Capital Region)	CO2e	402	1,408	714
	PM 2.5	0.0	0.0	0.0
	NOx	0.1	0.5	0.2
	VOCs	0.2	0.7	0.4
Ithaca CarShare (Ithaca)	CO2e	No Data	5,027	2,835
	PM 2.5	No Data	0.2	0.1
	NOx	No Data	1.7	1.0
	VOCs	No Data	2.6	1.5
Total (MT)		**1,610**	**10,006**	**6,037**

Note: "No Data" indicates a lack of program data, while "N/A" values indicate that the program did not yet exist. Blank values are zero.

EXHIBIT 20. ESTIMATED NET EXTERNALITY COSTS AVOIDED BY CARSHARING

Carshare Program	Externality Cost Avoided ($)	2015	2016-2018	2019-2020
Buffalo Car Share/ZipCar (Buffalo)	CO2e	$133,875	$396,350	$211,381
	PM 2.5	$0.8	$2.4	$1.3
	NOx	$1.2	$3.6	$1.9
	VOCs	$2.0	$6.1	$3.1
FloShare (Rochester)	CO2e	N/A	N/A	$65,763
	PM 2.5	N/A	N/A	$0.4
	NOx	N/A	N/A	$0.5
	VOCs	N/A	N/A	$0.7
Capital CarShare (Capital Region)	CO2e	$44,625	$156,187	$79,896
	PM 2.5	$0.2	$0.9	$0.4
	NOx	$0.3	$1.1	$0.5
	VOCs	$0.6	$2.0	$1.0
Ithaca CarShare (Ithaca)	CO2e	No Data	$557,812	$315,663
	PM 2.5	No Data	$2.7	$1.5
	NOx	No Data	$4.2	$2.4
	VOCs	No Data	$5.0	$2.9
Total ($)		**$178,505**	**$1,110,377**	**$672,719**

Note: "No Data" indicates a lack of program data, while "N/A" indicates that the program did not yet exist. Blank values are zero.

EXHIBIT 21. ESTIMATED NET AIR POLLUTANTS AVOIDED BY BIKESHARING

Bikeshare Program	Net Emissions Avoided (MT)	2015	2016-2018	2019-2020
Reddy Bikes (Buffalo + Niagara)	CO2e	123	370	670
	PM 2.5	0.0	0.0	0.0
	NOx	0.0	0.1	0.2
	VOCs	0.1	0.2	0.3
HOPR (Rochester)	CO2e	*N/A*	*N/A*	770
	PM 2.5	*N/A*	*N/A*	0.0
	NOx	*N/A*	*N/A*	0.3
	VOCs	*N/A*	*N/A*	0.4
Capital CarShare (Capital Region)	CO2e	*N/A*	524	655
	PM 2.5	*N/A*	0.0	0.0
	NOx	*N/A*	0.2	0.2
	VOCs	*N/A*	0.3	0.3
Lime Bikeshare (Ithaca)	CO2e	*N/A*	539	416
	PM 2.5	*N/A*	0.0	0.0
	NOx	*N/A*	0.2	0.1
	VOCs	*N/A*	0.3	0.2
Total (MT)		**123**	**1,434**	**2,514**

Note: "No Data" indicates a lack of program data, while "N/A" indicates that the program did not yet exist. Blank values are zero.

EXHIBIT 19. ESTIMATED NET EXTERNALITY COSTS AVOIDED BY BIKESHARING

Bikeshare Program	Externality Cost Avoided ($)	2015	2016-2018	2019-2020
Reddy Bikeshare (Buffalo + Niagara)	CO2e	$13,678	$41,034	$74,375
	PM 2.5	$0.1	$0.3	$0.5
	NOx	$0.1	$0.4	$0.7
	VOCs	$0.2	$1.1	$-
HOPR (Rochester)	CO2e	No Data	No Data	$85,488
	PM 2.5	No Data	No Data	$0.5
	NOx	No Data	No Data	$0.6
	VOCs	No Data	No Data	$-
CDPHP *Cycle!* (Capital Region)	CO2e	N/A	$58,132	$72,665
	PM 2.5	N/A	$0.3	$0.4
	NOx	N/A	$0.4	$0.5
	VOCs	N/A	$0.8	$0.9
Lime Bikeshare (Ithaca)	CO2e	No Data	$59,842	$46,164
	PM 2.5	No Data	$0.3	$0.2
	NOx	No Data	$0.5	$0.3
	VOCs	No Data	$0.5	$0.4
Total ($)		**$13,679**	**$159,013**	**$278,697**

Note: "No Data" indicates a lack of program data, while "N/A" values indicate that the program did not yet exist. Blank values are zero.

EXHIBIT 20. ESTIMATED NET AIR POLLUTANTS AVOIDED BY VANPOOLING

Vanpool Program	Net Emissions Avoided (MT)	2016-2018	2019-2020
RTS Vanpool	CO2e	61	18
	PM 2.5	0.00	0.00
	NOx	1.70	0.98
	VOCs	0.03	0.01
Total (MT)		**63**	**19**

EXHIBIT 21. ESTIMATED NET EXTERNALITY COSTS AVOIDED BY VANPOOLING

Vanpool	Externality Cost Avoided ($)	2016-2018	2019-2020
RTS Vanpool	CO2e	$6,769	$2,039
	PM 2.5	0.04	0.02
	NOx	0.05	0.02
	VOCs	0.03	-
Total ($)		**$6,770**	**$2,039**

Exhibits 25 and 26 summarize the sensitivity analysis IEc conducted of estimated net air pollutants and externality costs avoided. This analysis used different vehicle shed rate values for

carshare and bikeshare programs to capture the high and low values in the published literature in addition to the ranges reported in **Section 3.** Shed rates for carshare in the published literature ranged from 3.9 to 28 personal vehicles per carshare fleet vehicle (both values reported by Namazu and Dowlatabadi, 2018). Shed rates for bikeshare ranged from one vehicle shed for every 10 to 20 bikes (respective values reported by LDA Consulting, 2012; and Shaheen and Martin, 2015).

EXHIBIT 25. SENSITIVITY ANALYSIS: RANGE OF ESTIMATED NET AIR POLLUTANTS/GHGS AVOIDED

Type	Net Emissions Avoided (lbs)	Low	Reported (Average)	High
Carshare	CO2e	7,944	17,637	57,848
	PM 2.5	0	1	2
	NOx	3	6	20
	VOCs	4	9	30
Bikeshare	CO2e	2,359	4,068	4,719
	PM 2.5	0	0	0
	NOx	1	1	2
	VOCs	1	2	2
Total		**10,312**	**21,724**	**62,622**

EXHIBIT 26. SENSITIVITY ANALYSIS: RANGE OF ESTIMATED NET EXTERNALITY COSTS AVOIDED

Type	Externality Cost Avoided ($)	Low	Reported (Average)	High
Carshare	CO2e	$884,058	$1,961,552	$6,437,756
	PM 2.5	$5	$11	$34
	NOx	$6	$16	$46
	VOCs	$10	$23	$76
Bikeshare	CO2e	$261,800	$451,379	$523,599
	PM 2.5	$1	$3	$3
	NOx	$2	$4	$4
	VOCs	$2	$4	$4
Total		**$1,145,885**	**$2,412,991**	**$6,961,523**

Appendix E: Program-Specific Accessibility Data and Maps

This appendix includes summary data and maps from all shared mobility programs discussed in **Section 6 (Access)**. For this analysis IEc overlayed the map of DACs with bikeshare stations/docks and carshare designated parking to assess where the stations are in relation to New York's overburdened and underserved communities.

EXHIBIT 22. MAPPED BIKE STATION AND CARSHARE ACCESSIBILITY SUMMARY BY PROGRAM

Program	Data point	Count
Reddy Bikeshare	Total number of bike racks	97
	Unmappable bike racks	14
	Bike racks within of walkable distance of DACs	66
	Bike racks outside of walkable distance of DACs	17
CDPHP *Cycle!*	Total number of bike racks	105
	Unmappable bike racks	9
	Bike racks within of walkable distance of DACs	65
	Bike racks outside of walkable distance of DACs	31
Ithaca Carshare	Total Cars	29
	Cars within walkable distance of DACs	16
	Cars outside of walkable distance to DACs	13
HOPR	Total number of stations	67
	Stations within of walkable distance of DACs	54
	Stations outside of walkable distance of DACs	13

EXHIBIT 23. REDDY BIKESHARE: NIAGARA

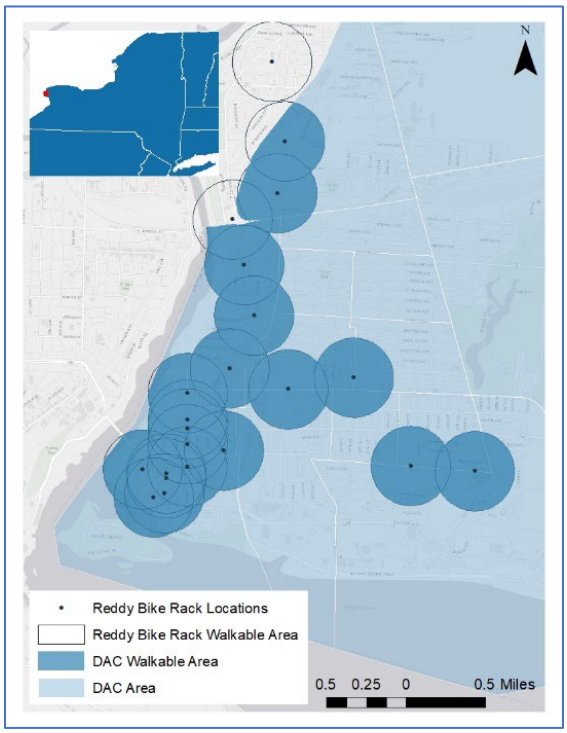


EXHIBIT 24. ITHACA CARSHARE CAR LOCATIONS [53]

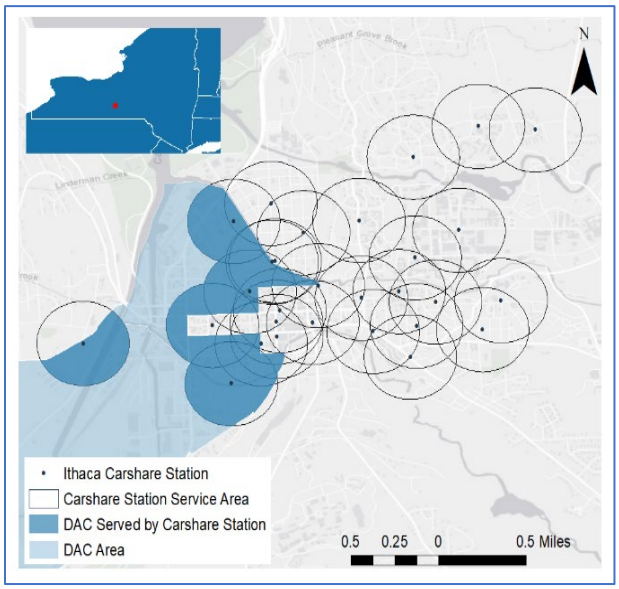
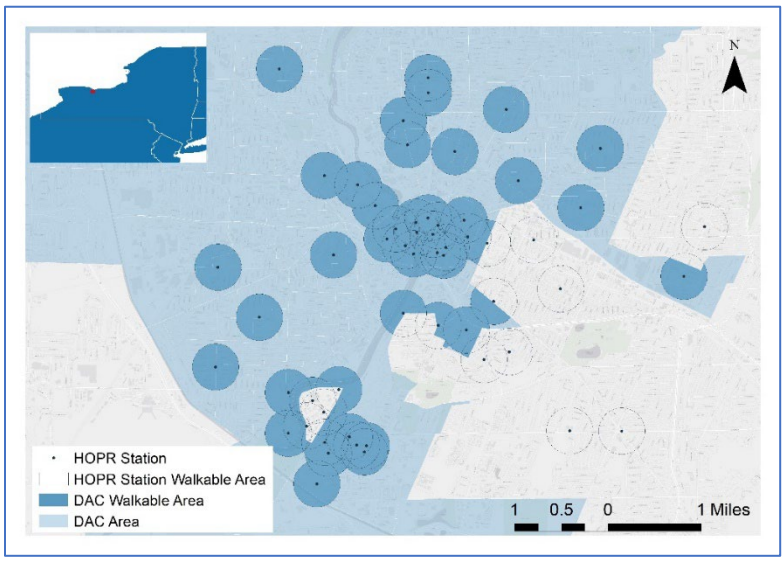


EXHIBIT 25. HOPR BIKESHARE LOCATIONS - ROCHESTER



[53] The map is a snapshot in time of car locations. IEc was unable to reach Ithaca CarShare to request data.

EXHIBIT 26. CDPHP *CYCLE!* BIKESHARE: TROY AND COHOES

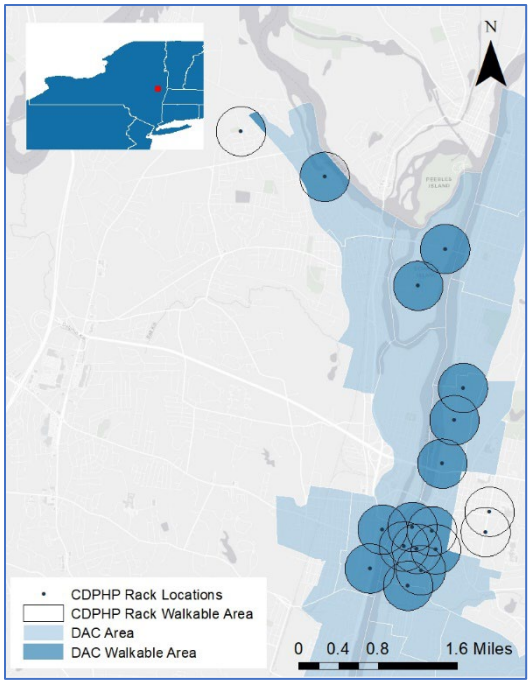


EXHIBIT 27. CDPHP CYCLE! BIKESHARE: ALBANY

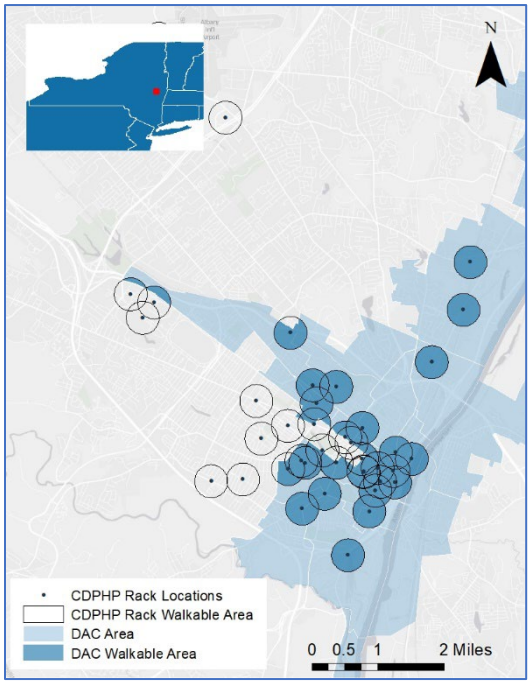


EXHIBIT 28. CDPHP *CYCLE!* BIKESHARE: SARATOGA

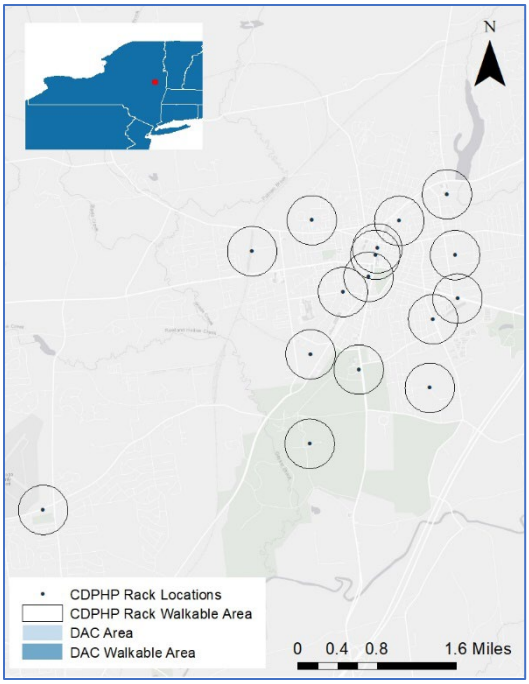
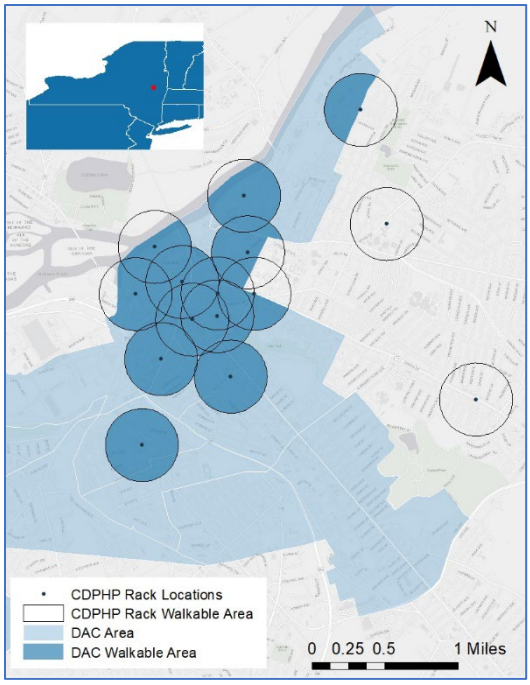


EXHIBIT 29. CDPHP *CYCLE!* BIKESHARE: SCHENECTADY



Appendix F: Additional Methodological Information

Estimated Vehicles Shed

IEc multiplied the total number of cars or bicycles for an individual shared mobility fleet by the shed rate (number of personal cars shed per carshare fleet vehicle or bicycle).[54] IEc relied on different shed rates for bicycles versus carshare vehicles according to differences across the shared mobility modes: for bikeshares, IEc used a value of 1 car shed per every 11.6 bicycles added to the system, and for carshares, IEc used a value of 6 personal vehicles shed per every 1 carshare fleet vehicle. Vehicles shed by year for carshare decreases from 2018 to 2019 because car shed rates in the literature declined (linked with a change in carshare use, which saw competition from ride hailing services). Accordingly, SUMC updated their calculator from a rate of 11.25 personal vehicles shed per carshare vehicle to just six personal vehicles shed per carshare vehicle in 2019, following a meta-analysis of the published literature. IEc agreed with this justification and similarly used updated values for 2019. IEc's estimates of total vehicles shed are dampened from the original SUMC estimates because of this more conservative shed rate. Bikeshare shed rates were assumed to be the same over the assessment period, which similarly produces more conservative vehicles shed estimates from the original SUMC estimates. Unlike carshare and bikeshare, vanpool vehicle shed rates are not calculated using equipment; rather, personal vehicles shed are calculated using the number of vans multiplied by individuals per van (seven) and the vehicle shed rate (0.26 personal vehicles shed per vanpool passenger). Due to the high level of uncertainty with this estimation approach, IEc conducted a sensitivity analysis (reported in **Appendix D**).

Estimated GHG Emissions Reductions

IEc used NYS emissions factors to estimate GHG emissions for GHG reductions scenarios using a variety of inputs (**Exhibit 35**). While the NYS emissions factors were the primary input for this analysis, we used the AFLEET Tool's Footprint Calculator for values for VOCs, NOx, and $PM_{2.5}$ since these emissions factors are not included in the list of NYS emissions factors.[55]

Step 1: IEc calculated the GHG emissions for a single shed passenger vehicle powered by gasoline for one year, and then multiplied the GHG or pollutant outputs of interest for *every car shed* linked to each program (e.g., ZipCar, formerly Buffalo CarShare).[56] The difference in emissions between carshare vehicles and shed vehicles was considered representative of net emissions. IEc used the GHG emissions calculation approach outlined in "Fossil and Biogenic

[54] IEc used shared mobility service program fleet information (where it was available) to estimate the total count of equipment across all programs.

[55] New York State Energy Research and Development Authority (NYSERDA). 2022a. "Fossil and Biogenic Fuel Greenhouse Gas Emission Factors," NYSERDA Report Number 22-23. Prepared by Energy and Environmental Economics, Inc. San Francisco, CA. nyserda.ny.gov/publications.

[56] The program link matters here because county is an AFLEET input which impacts externality cost outputs. Counties modeled include Genesee, Albany, Erie, and Tompkins. Though realistically benefits extend outside of these counties, they are the main locations of the carshare/bikeshare/vanpool vehicles.

Fuel Greenhouse Gas Emission Factors" (NYSERDA, 2022),[57] which estimated emissions as a product of fuel consumed and the emissions factor (specific to fuel type and sector):

$$Emissions\ (metric\ tons) = \ gallons\ consumed * fuel\ cycle\ emissions\ factor * cf$$

*where gallons consumed are reported by year and vehicle type in **Exhibit 35**, NYS emissions factors are reported in **Exhibit 36** (MT/MMBtu), and cf (conversion factor) is the calculated gasoline higher heating value, or 0.123 MMBtu/gal (this value is borrowed from the 2022 NYS Statewide GHG Emissions Report and used to convert from gallons to metric tons).*[58]

EXHIBIT 30. INPUTS FOR DIFFERENT VEHICLE TYPES

INPUT	Year	Bike[59]	Light Truck/Van	Passenger Car (Gasoline)	Passenger Car (EV)[60]
Cars Shed Rate *(results are sensitive to this input)*	2018	0.086	0.26	11.25	11.25
	2019	0.086	0.26	6	6
VMT[61] (miles)	2018	198	11,486	11,576	11,576
	2019	198	11,263	11,599	11,599
Fuel Use (gallons or MWh)	2018	0	475	481	3.96
	2019	0	640	481	3.96
Vehicle Age (years)	2018	N/A	5	5	5
	2019	N/A	5	5	5

Note: To simplify the analysis, 2015-2018 outputs all use 2018 input values, while outputs for 2019 – 2021 use 2019 input values. Like year, county is an input that varied for each carshare/bikeshare program (not included here for simplicity, but worth mentioning as another source of variation in the modeling analysis). Some air pollutant externality cost outputs from AFLEET are sensitive to county as an input (e.g., $PM_{2.5}$, NO_x and VOCs).

[57] New York State Energy Research and Development Authority (NYSERDA). 2022a. "Fossil and Biogenic Fuel Greenhouse Gas Emission Factors," NYSERDA Report Number 22-23. Prepared by Energy and Environmental Economics, Inc. San Francisco, CA. Table 2. nyserda.ny.gov/publications

[58] Note that the "Fossil and Biogenic Fuel Greenhouse Gas Emission Factors" (NYSERDA, 2022a) does not include a higher heating value for all fuels. The higher heating value is the gross calorific value, or the total heat of combustion of a unit quantity of fuel (includes water vapor). NY DEC identified a value consistent with other reporting in NYS: https://www.dec.ny.gov/docs/administration_pdf/ghgappxclcpaemissfctrs22.pdf.

[59] Importantly, bikeshare car shed rates are calculated slightly differently than the shed rates related to carsharing—for every 11.6 bicycles added to the system, one car is shed. The assumed annual vehicle mileage removed (i.e., car that is no longer on the road) is still assumed to be the average U.S. passenger vehicle VMT.

[60] IEc estimated the EV fuel use value using the AFLEET value of 106.2 MPGe for passenger EVs, divided by 33.705 (an EPA conversion factor for kilowatt-hours/gallon of gasoline equivalent). IEc then multiplied the product by the total VMT for the specific year (11,576 VMT in 2018 and 11,599 VMT in 2019). **Conversion factor source:** U.S. EPA. 2016. Green Vehicle Guide: Technology. Accessed online Jun. 2023: https://www3.epa.gov/otaq/gvg/learn-more-technology.htm

[61] Note: VMT for carshare would almost certainly be less than the average VMT for passenger vehicles due to differences in carshare use patterns. Ultimately, it was important to use widely accepted and published values for VMT for this analysis for internal consistency in comparing across counties, programs, and years.

EXHIBIT 31. EMISSIONS FACTORS [62, 63, 64]

INPUT	CO_2	CH_4	N_2O
Motor Gasoline (metric ton/MMBtu)	8.46E-02	1.45E-04	8.75E-06
2022 EV Electricity Use UPSTATE: Annual Average of Long-run Marginal Emission Factors, Full Fuel Cycle (metric ton/MWh)	2.90E-01	1.60E-03	2.04E-06
2022 EV Electricity Use DOWNSTATE: Annual Average of Long-run Marginal Emission Factors, Full Fuel Cycle (metric ton/MWh)	3.50E-01	1.94E-03	2.47E-06

Step 2: IEc calculated the GHG emissions for a single replacement vehicle (assumed to be either another gasoline-powered passenger vehicle, an EV, a bicycle, or a light truck/van) for one year.[65] The replacement vehicle outputs were then multiplied by the *number of vehicles in the carshare/bikeshare/vanpool fleet* in each specific program. For passenger EV GHG emissions, we used the equation from Step 1, replacing gallons of fuel consumed with megawatt hours (MWh) consumed.

$$Emissions\ (metric\ tons) = MWh\ consumed * grid\ emissions\ factor$$

*where MWh consumed were reported by year in **Exhibit 35** and NYS electricity grid emissions factors were reported in **Exhibit 36** (in metric tons/MWh).*

IEc accounted for grid transmission and distribution loss by multiplying the end-use MWh consumption value by 1.077 to estimate generation.[66] This operation accounted for the later application of emissions factors, which are generation-based.

Step 3: IEc subtracted the carshare/bikeshare/vanpool fleet vehicle emissions from the vehicles shed emissions to estimate the *net benefit* in terms of emissions avoided and externality benefits (monetized value of GHG emissions avoided) for each carshare/bikeshare/vanpool program. Bringing each of these pieces together, IEc assigned the NYS DEC dollar value to the net GHG emissions by type (CO_2, CH_4, N_2O).

$$Emissions\ avoided\ value\ (2020\$) = emissions\ avoided\ (metric\ tons) * emissions\ value\ (\$/ton)$$

where emissions avoided values were calculated using the relevant equation from Step 1 (gasoline vehicles) or Step 2 (EVs), and the emissions value was the central estimate (in 2020$, calculated using a 2% discount rate) reported in "Establishing a Value of Carbon: Guidelines for Use by State Agencies"

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[62] Emissions values from "Fossil and Biogenic Fuel Greenhouse Gas Emission Factors" (NYSERDA, 2022a), and New York State Energy Research and Development Authority (NYSERDA). 2022b. "Projected Emission Factors for New York State Grid Electricity," NYSERDA Report Number 22-18. Albany, NY. nyserda.ny.gov/publications

[63] Upstate and downstate electricity emissions factors are consistent with "Projected Emission Factors for New York State Grid Electricity" (NYSERDA 2022b). Upstate includes Erie, Genesee, and Tompkins counties, while downstate includes Albany County.

[64] CO_2, CH_4, and N_2O values are converted to CO_2e with NY DEC GWP conversion factors (CO2:1, CH4:84, N2O:264).

[65] Essentially, where vanpool use replaces personal vehicle use, the total vanpool fleet size is used to estimate benefits. The same is true for cars and bikes.

[66] NYSERDA. 2022b. "Projected Emission Factors for New York State Grid Electricity," NYSERDA Report Number 22-18. Albany, NY. nyserda.ny.gov/publications.

(NYS Department of Environmental Conservation, updated 2022, or $121 per $MTCO_2e$, $2,700 per $MTCH_4$, and $42,000 per MTN_2O.[67]

IEc applied the same three-step approach for air pollutants ($PM_{2.5}$, NO_x, and VOCs), but instead of the equation described above, we use AFLEET's vehicle lifecycle emissions footprint calculator because the NYS emissions factors do not include factors for $PM_{2.5}$, NO_x, or VOCs.[68] In AFLEET's footprint calculator, IEc calculated vehicle lifecycle emissions avoided as well-to-wheels emissions during vehicle operation on an annual basis.[69, 70] In AFLEET, IEc estimated the value of emissions avoided using marginal damage cost values specific to $PM_{2.5}$, NO_x, or VOCs. Marginal damage costs were county-specific for Albany, Genesee, Tompkins, and Erie (used as AFLEET inputs for the shared mobility programs relevant to those counties).[71]

For fleet composition, IEc assumed a combination of electric and gasoline-powered vehicles only where there is a known proportion of electric vehicles; otherwise, the fleet is assumed to be all gasoline-powered. An interview we conducted with the CCT confirmed that even plug-in hybrid vehicles are run predominantly on gasoline due to the lack of sufficient built-out EV charging infrastructure in upstate New York (for carsharing purposes). Where bicycles replace personal vehicle use, we assumed no replacement vehicle (this is associated with a larger impact to GHG emissions reductions). For passenger vehicle fuel use and VMT assumptions for replaced vehicles, IEc used values from the U.S. Federal Highway Administration's Annual Highway Statistics Report from 2018 and 2019.[72, 73, 74] Consistent with past work for NYSERDA, IEc assumed a replaced vehicle age of 5 years (i.e., if the estimation year is 2019, the vehicle model year is assumed to be 2014).[75, 76] This assumption was intended to keep the AFLEET estimation conservative: the older the vehicle, the greater the emissions savings.[77]

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[67] NYS Department of Conservation. Updated 2022. "Establishing a Value of Carbon: Guidelines for Use by State Agencies." Accessed online Apr. 2023: https://www.dec.ny.gov/docs/administration_pdf/vocguid22.pdf

[68] NYSERDA. 2022a. "Fossil and Biogenic Fuel Greenhouse Gas Emission Factors."

[69] Burnham, Andrew. 2021. User Guide for AFLEET Tool 2020. *Prepared for Argonne National Laboratory.* Accessed online May 2022: https://greet.es.anl.gov/files/afleet-tool-2020-user-guide

[70] This AFLEET calculation captures greater benefits than SUMC's original calculation in the *SMI 2019 Final Report* because it includes fuel extraction and fuel production stage emissions in addition to vehicle operation. Also differing from SUMC's calculation for GHG emissions, AFLEET calculates local air pollutants and applies an externality cost in dollars. The latter two benefits were not included in the *SMI 2019 Final Report* but are included in this case study.

[71] Though realistically benefits extend outside of these counties, they are the main locations of the carshare/bikeshare/vanpool vehicles.

[72] Federal Highway Administration. Highway Statistics 2018, Table VM-1. Accessed online May 2022: https://www.fhwa.dot.gov/policyinformation/statistics/2018/vm1.cfm

[73] Federal Highway Administration. Highway Statistics 2019, Table VM-1. Accessed online May 2022: https://www.fhwa.dot.gov/policyinformation/statistics/2019/vm1.cfm

[74] 2020 is considered an anomalous year for travel due to the COVID-19 pandemic, and 2021 data are not yet published by the FHWA.

[75] This low vehicle age provides a conservative estimate for GHG emissions, fuel use, and local air pollutant savings. A relatively new vehicle would see lower value for GHG emissions avoided than an older vehicle.

[76] See for example, IEc. 2022. Clean Transportation Market and Impact Evaluation: Impact Report. *Prepared for NYSERDA.*

[77] Cars shed is a "black box" estimate and the average age of the (presumably) shed vehicles is unknown, so it is prudent to use a conservative parameter for vehicle age as an input for AFLEET.

Importantly, where years are grouped for reporting, air pollution and GHG emissions reductions assumed current year reductions and multiplied by the average vehicles shed for the year-group (e.g., 2016 - 2018). The average air pollution and GHG emissions reductions values are then multiplied by three (i.e., to account for 2016, 2017, and 2018).

For the bikeshare, IEc estimated net air pollutants and GHG emissions avoided through the use of the bikeshare fleets, which were assumed to have zero emissions. IEc reported net savings, a representation of total savings due to the use of the bikeshare fleet in place of shed household vehicles (all assumed to be gasoline-powered). For the vanpool, IEc estimated net air pollutants and GHG emissions avoided through the use of the RTS commuter vanpool, operated through "Commute with Enterprise." Emissions for each vehicle were assumed to have the emissions equivalent of a light duty truck, a default setting in AFLEET called "passenger truck." This analysis reports net air pollutants avoided by vanpooling, a representation of total savings due to the use of the vanpool in place of shed household vehicles (all assumed to be gasoline-powered). IEc was conservative with vanpool use estimates based on an interview with a City of Rochester representative that suggested that the vanpool program receives minimal use.[78]

A key limitation in this analysis is that the vehicles shed calculation is a "black box" methodology based on total vehicle mileage (and the reason IEc conducted a sensitivity analysis with values reported in **Appendix D**). Another important caveat is that while Ithaca CarShare was a member of the Shared Mobility Network, its operations were not materially impacted by support from SMI from 2015 – 2018. Ithaca CarShare received technical assistance, but interviewees from the CCT were careful to say that the assistance from SMI did not directly translate into an expanded Ithaca fleet or increased operations in Tompkins County. IEc approached this analysis from the perspective of benefits accrued in relation to the Shared Mobility Network, rather than SMI as a specific entity, so IEc determined that the emissions and pollutants avoided, as well as the externality benefits, were linked with the carsharing network in Upstate New York due to efforts from SMI and their partners.[79] This interpretation of benefits appears to be consistent with the approach that SMI took in their *2019 Final Report*.

Transportation Savings

A key assumption in this analysis was that shared mobility service users benefitted from a decrease in transportation costs due to reduced travel in their personal passenger vehicles or downsizing to one car for a household. IEc estimated transportation savings using average annual VMT avoided.[80] This measure used average passenger vehicle mileage (assuming carshare mileage replaces completely the average American's vehicle use),[81] the federal wear and tear

[78] IEc assumed a full van of passengers (7 seats) taking a single commuter round trip per day, multiplied by the average fleet size.
[79] In 2016, all of the carshares in Upstate New York had to switch service providers, and interviewees from the Center for Community Transportation indicated that the Shared Mobility Network was useful to them during that period. The group provided technical support during the transition.
[80] Federal Highway Administration. Highway Statistics 2019, Table VM-1. Accessed online May 2022: https://www.fhwa.dot.gov/policyinformation/statistics/2019/vm1.cfm
[81] This calculation assumes that individuals sharing bikes or cars would otherwise be driving their household vehicle.

compensation rate of $0.585,[82] vehicle fuel savings (481 gallons/year, or approximately $1,361), and the annual cost of a carshare program assuming the user drives the complete 11,576 annual average VMT.[83] This measure also assumed approximately 331 hours traveled/year (an estimate backed out of average annual VMT, using a travel rate of 35 miles per hour for urban off-peak and rural travel).[84]

Spatial Analysis of DAC Accessibility with ArcGIS

Using ArcGIS (a geographic information system software), IEc created a 0.25-mile buffer around bike stations/car locations to more precisely capture access to bike and car share in DACs located in Upstate New York.[85, 86] Though 0.25 miles is a distance defined by Mashhoodi, van Timmeren, and van der Blij (2019) in an analysis of EV charging stations' walkability, a buffer or radius of 0.25 miles is consistent with the reasonable bikeshare station catchment range of 200m – 800m, identified by Zhang et al. (2019).[87] The idea is the same potential customers are most likely to use stations that are located within a shorter walking distance.

Increased Health/Wellness from Increased Biking

Calories burned during exercise was used as a rough approximation of health benefits. IEc estimated calories burned using the total mileage of bike trips reported and a value for calories burned per mile of outdoor cycling (approximately 51 kCal, assuming an average American body weight of 184.2 pounds or 83.55 kilograms, a speed of approximately 13 miles per hour, and a duration of 5 minutes, or the approximate time it takes to travel one mile on a bike at 13 mph).[88] A metabolic equivalent for the task (MET) equal to seven (indicating vigorous activity, aligned

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[82] U.S. General Services Administration. 2022. Privately Owned Vehicle Mileage Reimbursement Rates. Accessed online May, 2022: https://www.gsa.gov/travel/plan-book/transportation-airfare-pov-etc/privately-owned-vehicle-pov-mileage-reimbursement-rates

[83] While a 1:1 mileage replacement of carshare for personal vehicle use is likely an overestimate in terms of carshare usage by an individual, this assumption lends itself to a conservative estimate of transportation savings

[84] Urban off-peak and rural travel rate of 35 miles per hour is based on U.S. travel cost assumptions from the Victoria Transportation Policy Institute's (VPTI) 2022 Travel Time and Speed guidelines. **Source:** VPTI. 2022. *Transportation Cost and Benefit Analysis II – Travel Time Costs.* Section 5.2 Travel Time and Speed. Accessed online Dec. 2022: https://www.vtpi.org/tca/tca0502.pdf

[85] Transportation and mobility accessibility for DACs can be facilitated by stations within a reasonable walking distance. In the EV charging literature, this is defined as a five-minute walk, or 0.25 mile, according to. Mashhoodi, van Timmeren, and van der Blij (2019). A 0.25 mile "buffer" zone around bike stations (a shared resource not unlike EV charging stations) will shed light on public accessibility for mobility and transportation services in DACs. Source: Mashhoodi, B., van Timmeren, A., van der Blij, N. (2019). The two and a half minute walk: Fast charging of electric vehicles and the economic value of walkability. *Environment and Planning B: Urban Analytics and City Science*, 48(4): 638-654. https://doi.org/10.1177/2399808319885383

[86] IEc used a time-limited snapshot of carshare location data for the analysis.

[87] G. Zhang, H. Yang, S. Li, Y. Wen, Y. Li and F. Liu. 2019. What is the best catchment area of bike share station? A study based on Divvy system in Chicago, USA. 2019 5th International Conference on Transportation Information and Safety (ICTIS), pp. 1226-1232, doi: 10.1109/ICTIS.2019.8883774.

[88] Ultimately, there are a range of different possible assumptions for calorie burn rate, body weight, and average speed, all of which have a direct impact on the final "calories burned" benefit value. IEc used information from Ketchum, Dan. 2019. Calories Burned Biking One Mile. *Published on Livestrong.com.* Accessed online May 2022: https://www.livestrong.com/article/135430-calories-burned-biking-one-mile/

with an average commuting biking speed) was used as a conversion factor when calculating calories per mile.[89, 90, 91]

$$Total\ calories\ burned = (mileage\ of\ bike\ trips) * (calories\ per\ mile)$$

Calories burned per mile was an approximate measurement and varied considerably based on individual weight, speed, and weight of the bicycle.[92] Again, it is noteworthy that this was an *approximation* of health benefits used by bikeshare service providers and organizations like Shared Mobility, Inc. in their grant applications. Due to the coarse nature of the metric, any additional exercise-related benefit association would be spurious or not justifiable based on the available data (fewer heart attacks or lower incidence of diabetes, for example, would require additional health data to which bikeshare service providers or administrators do not have access).

[89] The MET for bicycling two and from work at a self-selected pace is 6.8, according to the 2011 Compendium of Physical Activities. MET values are typically reported as a whole number, so IEc rounded up to 7. Source: Ainsworth BE, Haskell WL, Herrmann SD, Meckes N, Bassett Jr DR, Tudor-Locke C, Greer JL, Vezina J, Whitt-Glover MC, Leon AS. 2011 Compendium of Physical Activities: a second update of codes and MET values. Medicine and Science in Sports and Exercise, 2011;43(8):1575-1581. Accessed online May 2022: https://sites.google.com/site/compendiumofphysicalactivities/Activity-Categories/bicycling

[90] The MET is a rate of energy spent that corresponds with the intensity of physical activity for the task. A MET rate of 1 suggests a person is at rest. Source: U.S. Department of Health and Human Services. 2019. *Physical Activity Guidelines for Americans (2nd Edition).* Accessed online May 2022: https://health.gov/sites/default/files/2019-09/Physical_Activity_Guidelines_2nd_edition.pdf

[91] Calories per mile=[(duration)*(MET)*3.5*(weight in kg)]/200 The 3.5 and 200 values are constants in the equation.

[92] Age, fitness level, diet, sleep, and oxygen intake are also explanatory factors. Again, this calculation is a rough approximation.