New York Truck Voucher Incentive Program (NYT-VIP)

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NEW YORK STATE OF OPPORTUNITY.

Truck Voucher Incentive Program

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New York Truck Voucher Incentive Program (NYT-VIP)

Final Report

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Abstract

The New York Truck Voucher Incentive Program (NYT-VIP) reduces barriers to clean vehicle uptake by lowering the upfront purchase cost of eligible clean truck and bus technologies. By bringing advanced vehicle technology prices nearer to the cost of conventional-fuel vehicles, voucher incentives drive regional fleet acceptance of advanced vehicles and accelerate the market for hybrid, alternative fuel, and all-electric trucks and buses in New York State with the goal of creating a self-sustaining market. NYT-VIP provides a transparent and easy-to-use process to encourage clean vehicle innovation and uptake in polluted areas by offering a streamlined approach that verifies eligibility of clean vehicle technologies to release pre-approved voucher amounts, which vendors connect and distribute along with advanced vehicles to end-fleet users. The vouchers result in point-of-sale cost reductions, providing immediate cost relief to fleets that cannot access additional capital but want to adopt new, clean vehicle technologies. Between 2013 and 2018, NYT-VIP disbursed 594 vehicle vouchers worth more than a combined $14.5 million to 60 fleets. These voucher-facilitated vehicle adoptions not only save fuel and maintenance costs, but they avoid between 1,460 and 3,690 short tons of carbon dioxide each year, which corresponds to avoided social cost of between $54,000 and $137,000 per year. These estimates indicate that the cost to New York State per short ton of greenhouse gas (GHG) abatement is between $34,000 and $285,700 per ton. The deployment of clean, advanced vehicle technologies also mitigates the negative health impacts of poor air quality resulting from bus and truck operations in communities suffering from high air pollution.

Keywords

Alternative fuel vehicles, electric vehicles, truck incentives, criteria air pollution, greenhouse gas emissions

Acknowledgments

CALSTART appreciates the support and partnership of NYSERDA, the New York State Department of Transportation, and the New York City Department of Transportation in capitalizing and administering NYT-VIP. CALSTART wishes to recognize the important contributions of Tetra Tech for its work in voucher processing and vendor communications. Finally, CALSTART thanks Empire Clean Cities, New York Metropolitan Transportation Council, and the members of the Northeast Diesel Collaborative for their assistance in disseminating information about NYT-VIP to potential fleet and vendor participants.

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Acronyms and Abbreviations

AFLEET	Alternative Fuel Life-Cycle Environmental and Economic Transportation (tool developed by Argonne National Laboratory)
AFV	alternative fuel vehicle
CMAQ	FHWA Congestion Mitigation and Air Quality Improvement Program
CNG	compressed natural gas
CO_2	carbon dioxide
DECD	diesel emission control device
DGE	diesel gallon equivalent
DOE	United States Department of Energy
EPA	United States Environmental Protection Agency
EREV	extended-range electric vehicle
EV	electric vehicle
FHWA	United States Federal Highway Administration
GHG	greenhouse gas
GVWR	gross vehicle weight rating
MOVES	Motor Vehicle Emissions Simulator (from United States EPA)
NAAQS	National Ambient Air Quality Standards
NO_x	nitrogen oxides
NYCAFV-VIF	New York City Alternative Fuel Vehicle Voucher Incentive Fund
NYCDER-VIF	New York City Diesel Emission Reduction Voucher Incentive Fund
NYSERDA	New York State Energy Research and Development Authority
NYSEV-VIF	New York State Electric Vehicle Voucher Incentive Fund

NYT-VIP	New York Truck Voucher Incentive Program
$PM_{2.5}$	particulate matter less than 2.5 microns in diameter (also known as fine particulates)
SO_x	sulfur oxides
VOCs	volatile organic compounds
VPC	Voucher Processing Center

1 Background

The market for advanced technologies that reduce emissions of greenhouse gases (GHG) and harmful tailpipe toxins in trucks and buses is still in the early stages of development. The production of these models has not yet achieved the economies of scale at which the market can be self-sustaining and no longer require government support. As a result, fleets interested in acquiring clean trucks and/or buses are still likely to encounter the barrier of higher upfront costs that may overwhelm the benefits of reduced operating costs.

The New York Truck Voucher Incentive Program (NYT-VIP) addresses this barrier to clean vehicle uptake in the short term by bridging the gap between today's elevated vehicle prices and the lower prices expected in the future. The incentives reduce the up-front incremental costs enough to spur vehicle purchases, drive fleet acceptance and understanding of advanced vehicles, and speed the maturation of markets for hybrid, alternative fuel, and all-electric trucks and buses that can be ultimately self-sustaining.

NYT-VIP has distributed funding for clean vehicle technologies since the program's creation in 2013. The goal of the program has remained consistent throughout: to expand the use of clean vehicle technologies in New York City and other New York State counties in nonattainment with National Ambient Air Quality Standards (NAAQS), thereby reducing harmful tailpipe emissions as well as the State's dependence on foreign petroleum, while developing a clean vehicle economy. The specified technologies to reduce gasoline and diesel use included diesel emission control devices (DECD), compressed natural gas (CNG) equipment, hybrid-electric technologies, and battery electric vehicle (EV) technologies. The primary contractor, CALSTART, has administered these vehicle vouchers through a purpose-built, integrated program that connects fleets with dealers and vehicle manufacturers to facilitate deployment of clean vehicle technologies. By the end of September 2018, NYT-VIP has disbursed 594 vehicle vouchers worth more than a combined $14.5 million to 60 fleets. Fleet managers' interest in the program continues to expand, and vehicle availability through NYT-VIP has blossomed since the program's inception.

1.1 Project Summary

NYT-VIP is a tool designed to help New York State advance its climate mitigation objectives while addressing air quality priorities tied to the Federal Highway Administration's Congestion Mitigation and Air Quality Improvement (CMAQ) program—a program that distributes federal funding for the express purpose of improving air quality through surface transportation projects. New York State

sought ancillary benefits through its investment in a sustainable system of clean vehicle vouchers, such as accelerating technology advancement within the State and developing a clean vehicle economy. The overall NYT-VIP goals included the following:

- **Air Quality and the Environment.** Reduce transportation-derived GHG emissions and harmful tailpipe emissions that negatively impact the health and well-being of New York State residents.
- **Technology Advancement.** Accelerate the adoption and development of alternative fuel vehicles, diesel emission control devices, and all-electric vehicles.
- **Job Creation.** Create new jobs in the production and manufacturing of new advanced vehicle technologies.
- **Technology Transfer.** Serve as a platform for information exchange, business best practices, and partnership development for vehicle manufacturers, vendors, and fleets throughout New York State.
- **Global Leadership.** Demonstrate New York's global leadership in advancing the integration of technologies that are smarter for the economy, environment, and energy future.
- **Energy Independence.** Promote fuel independence for New York.

NYT-VIP helps New York State meet these goals through a transparent and easy-to-use program that encourages clean vehicle innovation and uptake in polluted areas. The voucher incentive program offers a streamlined approach that verifies eligibility of clean vehicle technologies to trigger pre-approved voucher amounts and vendors to distribute these vehicles to end users. The pre-approved voucher amounts are as much as 80 percent of the incremental cost of the clean vehicle technology over a conventional-fuel comparable vehicle, subject to a cap determined by the vehicle weight (see Table 1). The vouchers result in point-of-sale cost reductions, providing immediate cost relief to fleets that cannot access additional capital but want to adopt new, clean vehicle technologies.

Table 1. Voucher Funding Caps by Vehicle Class and Technology

Vehicle Class	GVWR (lbs)	All-Electric	EREV/Plug-in Hybrid	Hybrid	CNG
2	6,001-10,000	$55,000	$45,000	$20,000	$50,000 cap across GVWR
3	10,001-14,000	$60,000	$50,000	$30,000	
4	14,001-19,500	$90,000	$55,000	$40,000	
5	19,501-26,000	$100,000	$60,000	$50,000	
6	26,001-33,000	$110,000	$70,000	$60,000	
7	33,001-38,000	$120,000	$100,000	$80,000	
8	> 38,000	$150,000	$120,000	$100,000	

Three separate funding streams were established to allocate the funds made available through the CMAQ program:

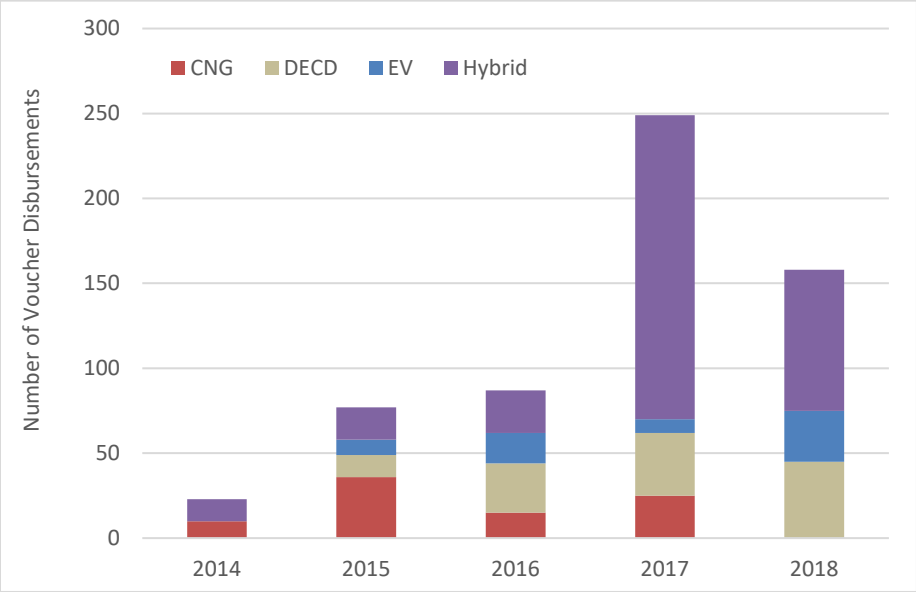
- The New York City Diesel Emission Reduction Voucher Incentive Program (NYCDER-VIF) provided $4 million for verified diesel emission control technologies for vehicles operating predominantly in New York City's five boroughs.
- The New York City Alternative Fuel Vehicle Voucher Incentive Fund (NYCAFV-VIF) provided $5 million for the following vehicle technologies for vehicles operating predominantly in New York City's five boroughs:
    - Class 2—8 All-Electric Vehicles (EVs) and All-Electric Conversions
    - Class 2b—8 Hybrid Vehicles and Conversions
    - Class 2—8 Compressed Natural Gas (CNG) Vehicles and Conversions
    - Diesel Emission Reduction (DER) Technologies (Passive and Active Diesel Particulate Filters)
- The New York State Electric Vehicle Voucher Incentive Fund (NYSEV-VIF) provided $9 million for class 3–8 vehicles that operate predominantly in one of New York State's 30 counties currently or recently in nonattainment.

These programs are collectively aimed at accelerating uptake of vehicle technologies that reduce petroleum use in locations with a demonstrated need for improved air quality. The expected benefits of reducing petroleum use in affected counties include reduced GHG emissions and the emissions of diesel particulate matter, hydrocarbons, oxides of nitrogen, carbon monoxide, and other toxic air pollutants. By promoting these technologies, NYT-VIP has helped reduce the impact of harmful emissions, improved air quality, and protected public health in New York State.

2 Program Results

NYT-VIP disbursed most available funds—more than $14.5 million out of a total $18 million was claimed for nearly 600 clean truck deployments. All funding for the NYCAFV-VIF and NYCDER-VIF had been committed by the end of 2017. Nearly two-thirds of available NYSEV-VIF was disbursed, with medium-duty vehicles accounting for the greatest voucher values through 2016 and heavy-duty vehicles growing in voucher values by 2018 (see Figure 1 for vehicle sales by voucher amount and Accounting of Program Funds for a further breakdown of vehicle sales). The differences in timing reflects the maturity of technologies—the battery electric vehicle market is quite new relative to other available technologies. The rapid uptake in vouchers toward the end of NYSEV-VIF funding availability reflects the maturation of EV technologies and the growth of the regional EV market. The drop-off in vouchers for other alternative fuel vehicle (AFV) technologies does not indicate a lack of consumer interest, but rather reflects the exhaustion of AFV funding.

Figure 1. Voucher Disbursements by Technology Type



Fleet managers have an increasingly robust choice of vehicles that can meet a variety of occupational functions. Over the course of the NYT-VIP, dozens of vehicle manufacturers registered vehicles that can meet delivery needs, haul cargo in port settings, or safely transport passengers. The variety of vehicle choices is captured in Table 2.

Table 2. Vehicle Manufacturers and Models Eligible for NYT-VIP by Technology Type

	DECR	CNG	CNG Conv	Hybrid	Hybrid Conv	EV	Totals
Manufacturers	5	9	3	4	3	13	**37**
Models	15	28	29	8	11	50	**141**
Fleets	9	4	4	22	3	18	**60**

Interest in participation exceeds the figures shown above—CALSTART has engaged with several large automakers that expect to have new vehicle models in production in time for the next round of NYT-VIP, with greater than a dozen new models anticipated. At least one large EV manufacturer plans to open an expansive assembly and repair facilities in New York State, in part because of the benefits conferred by the continued existence of NYT-VIP. Similarly, current NYT-VIP fleet recipients and new participants alike have inquired about new funding streams for the NYCAFV-VIF and NYSEV-VIF and eagerly anticipate opportunities to purchase new vehicles through the program. NYT-VIP has successfully laid a sustainable and popular foundation for a clean vehicle economy in New York State.

2.1 NYT-VIP Outreach and Promotion

CALSTART made regular, ongoing outreach efforts to promote the program to prospective participants. These outreach activities included, but were not limited to the following:

- Webinars: CALSTART has presented on several webinars that focused solely on NYT-VIP, either as the webinar host or when speaking through associations and collaborations for clean vehicle technologies, such as the Northeast Diesel Collaborative.
- Speaking engagements have presented opportunities to promote NYT-VIP with audiences of interested parties, as well as to engage with audience members individually after a presentation. CALSTART has presented on multiple occasions at the annual Advanced Energy Conference in New York City, for instance.
- CALSTART has also been able to lead discussions about voucher incentives at workshops over the past several years. NYT-VIP has been presented and discussed at workshops hosted by Empire Clean Cities and the New York Metropolitan Transportation Council.
- Outreach efforts have been tailored wherever possible to meet audiences that are most likely to understand, appreciate, and participate in the program. At several technology panels hosted by the Northeast Diesel Collaborative, CALSTART shared new vehicle technology updates and funding opportunities.

2.1.1 NYT-VIP Website

The NYT-VIP website provides a simple platform for vehicle manufacturers to connect with interested fleets and vendors. The website lays out the program's goals and processes, provides resources and news updates, and lists eligible vehicles and vendors that allow fleet managers to learn more about eligible vehicle options and how to take the next steps in connecting with eligible vendors to begin down the path of adopting clean vehicle technologies.

Program Information: The website hosts several valuable pieces of information about NYT-VIP—what it is and how it works—most notably implementation manuals for each of the Voucher Incentive Funds. Visitors can download this information at their convenience to learn more about NYT-VIP's goals, processes, and eligibility requirements.

Listed Participants: Each of the Voucher Incentive Funds has a separate section where eligible vehicles and vendors are listed. Interested fleet managers can refer to these pages to assess which vehicles can fit their needs as well as how much voucher funding they can qualify for to facilitate their purchase. Interested fleet managers can then reach out to qualified vendors (typically manufacturers or dealers) to begin the process of procuring clean vehicles through the use of voucher funding.

Voucher Ticker and News Updates: The website is updated regularly to provide stakeholders with a clear sense of available opportunities. A ticker lists the available funding for each Voucher Incentive Fund so that fleet managers, vendors, and vehicle manufacturers can proceed with certainty about available levels of funding. Regular news updates about noteworthy fleet deployments or presentations on NYT-VIP create opportunities to continue to share best practices and a better understanding of how to adopt clean vehicle technologies.

Voucher Processing Center (VPC): The website provides simple instructions for how to contact CALSTART and its voucher processing partner, Tetra Tech, with any questions or to submit voucher applications, voucher redemption requests, and supporting documentation. Outreach through the VPC creates valuable opportunities to interact with potential participants, to thoughtfully explain the program, and to help guide vendors through the steps in applying for vouchers and submitting for reimbursement.

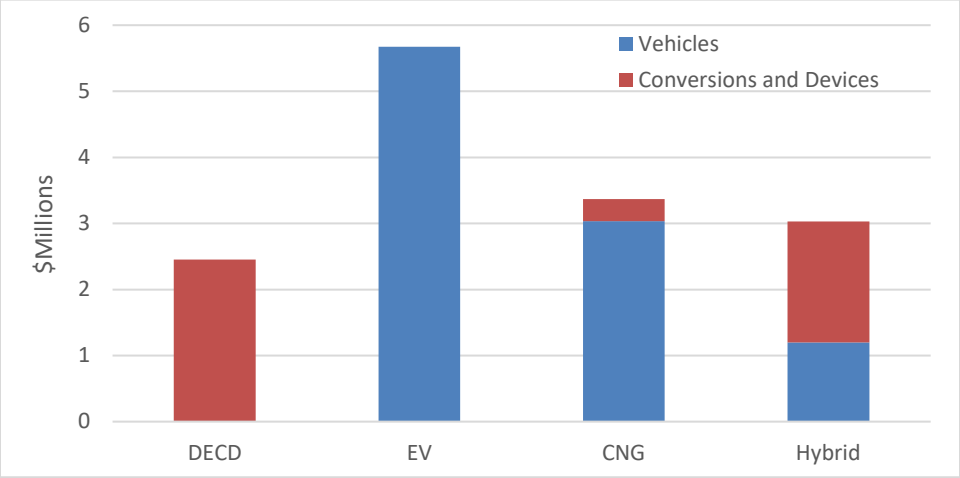
2.2 Accounting of Program Funds

All-electric vehicles received the greatest amount of voucher funding of any eligible technology at greater than $5.5 million. In addition to the higher vehicle costs and voucher amounts for this technology, the reason all-electric vehicles received the most voucher funding may also have been attributable to the technology's exclusive eligibility for the largest single voucher fund ($9 million through NYSEV-VIF) and additional eligibility for the NYSAFV-VIF. CNG and CNG conversions accounted for approximately $3.4 million, slightly greater than hybrid and hybrid conversions, which totaled approximately $2.1 million. Total distribution figures are listed in Table 3 and represented graphically in Figure 2.

Table 3. Total Voucher Counts and Amounts by Technology

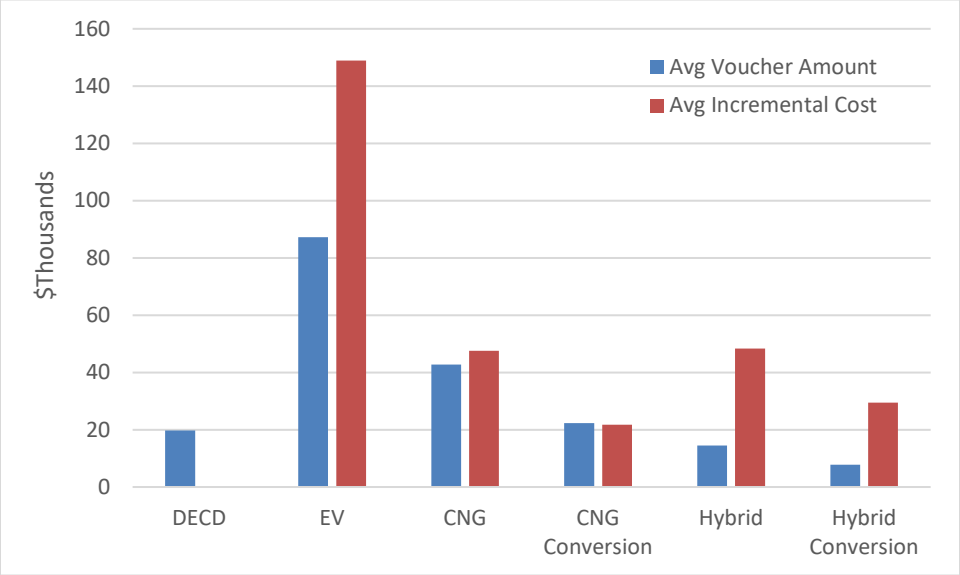
Technology	Number of Vouchers	Voucher Funds
DECD	124	$2,452,304.80
EV	65	$5,673,093.00
CNG	71	$3,033,524.00
CNG Conversion	15	$334,272.00
Hybrid	83	$1,198,179.20
Hybrid Conversion	236	$1,830,776.00
Total	**594**	**$14,522,149.00**

Figure 2. Aggregate Voucher Funding Amounts by Fuel Source



The average voucher disbursement was also the highest for EVs at more than $87,000 per vehicle. The high voucher amount reflects not only the higher incremental cost of eligible electric vehicle models but also a distribution of vehicle weight that skews higher for EVs owing to the redemption of 22 out of 65 EV vouchers for Class 8 technologies (e.g., transit buses and terminal tractors). Figure 3 shows the average incremental cost for vehicles by technology type as listed on the NYT-VIP website and the average voucher amount issued for each technology type.[1]

Figure 3. Average Vouchers and Incremental Costs by Technology Type



While the vouchers for EVs were of the highest value on average and overall, the figure above demonstrates that fleets are still left with the largest cost burden for this technology. The percentage of incremental costs covered by the average hybrid and hybrid conversion voucher is also lower, at least when contrasted with the average CNG voucher. In fact, the average CNG conversion voucher exceeded the average incremental cost of CNG conversion kits, though this incongruity can be attributed to the fact that many CNG conversion vouchers went toward more expensive CNG conversion technologies than the reference Landi Renzo conversions used to characterize incremental cost. The discrepancy in "voucher coverage" between electric technologies and CNG technologies is simply a product of the persistently high up-front costs of all-electric technologies, likely owing to the high costs of battery production.

[1] Note that DECDs do not have an incremental cost listed because they do not have a diesel comparison baseline as is expected of alternative fuel or all-electric powertrains .

Table 4 captures the final voucher request activity, approvals, redemptions, denials, and balances for each of the three incentive funds under NYT-VIP.

Table 4. Final Voucher Spending and Balances by Incentive Fund

Project Fund	NYSEV-VIF	NYCAFV-VIF	NYCDER-VIF
Voucher Requests			
Number of Vouchers Submitted	73	532	69
Number of Vouchers Approved	65	469	58
Number of Vouchers Denied	0	1	0
Number of Vouchers Cancelled	8	60	11
Voucher Redemptions			
Number of Redemptions Initiated	65	471	58
Number of Redemptions Completed	65	469	58
Number of Redemptions Denied	0	0	0
Number of Redemptions Outstanding	0	0	0
Voucher Cost Overview (Vendor Submittal)			
Total Voucher Amt. Requested	$5,673,093.00	$7,874,232.00	$974,824.00
Total Voucher Amt. Approved	$5,673,093.00	$7,874,232.00	$974,824.00
Total Voucher Amt. Spent	$5,673,093.00	$7,843,384.00	$974,824.00
Total Voucher Amt. Remaining	$3,326,907.00	$156,616.00	$0.00

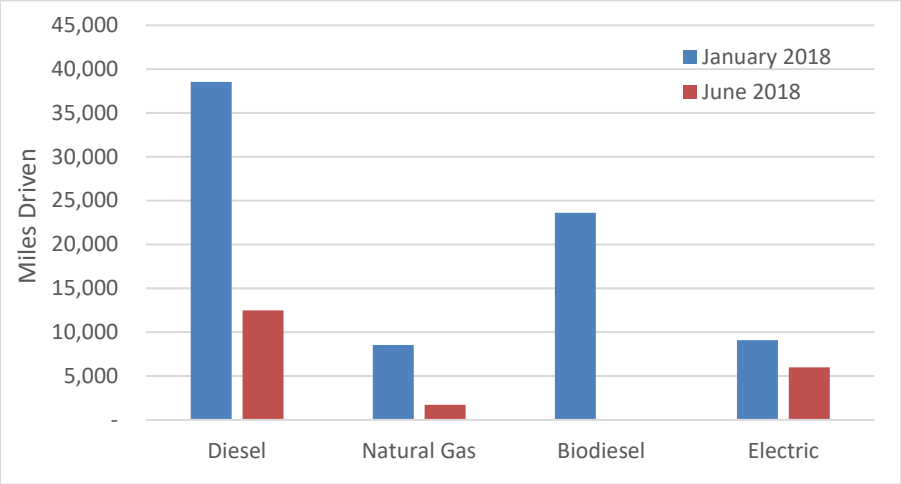
2.3 Fleet Results

The value of the NYT-VIP to voucher recipients' past and future can be estimated on the basis of how current participants view the reliability and cost savings of vehicles purchased with the help of vouchers. New alternative fuel vehicles that operate at least as reliably as their diesel counterparts garner confidence in the new technologies and reduced fueling, and maintenance costs help companies justify their financial investments—particularly when vouchers are available to erode the up-front cost premium.

Estimates for reliability, cost-savings, and overall satisfaction were requested in semi-annual usage reports that CALSTART collected from fleet operators following voucher redemptions. The semi-annual usage reports were conducted in the form of an online survey to collect data that ultimately served as the basis for constructing the metrics used to measure the program's success. Each participant is required to submit detailed information about their vehicle fleets, including the mileage for each vehicle that received a voucher. Figure 4 shows the median miles driven for the vehicles (including those not acquired with vouchers) reported by participating fleet respondents. Using this information, CALSTART worked

with subcontractor Tetra Tech to derive estimates for fuel cost and maintenance savings using industry averages and vehicle performance metrics. It should be noted, however, that these estimates come from a limited and potentially self-selecting group of survey respondents,[2] and as such results and findings are intended to be illustrative of potential cost savings and are not representative of all fleets.[3]

Figure 4. Median Miles Driven for Vehicles Reported by Participating Fleets



2.3.1 Fuel Cost Savings

The available data (note the data disparities between reporting periods) limit the ability to accurately calculate total miles driven and fuel consumption for participating fleets. Estimated fuel savings were calculated based on 2015 U.S. Department of Energy (DOE) fuel pricing and the limited data that was gathered from the semi-annual usage reports (Josephs, 2015). The estimated cost of diesel fuel is $0.50 per mile, based on a diesel fuel economy of 6.1 miles per gallon (U.S. DOE, 2018). Based on average annual mileage per vehicle, a diesel cost baseline was established by applying diesel fuel cost to all vehicle categories for the purpose of estimating fuel savings by comparing this cost baseline to the vehicle's observed fuel cost.

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2 Despite extensive outreach efforts by CALSTART, response rates to the required survey were typically quite low. The number of fleets responding between 2016 and 2018 ranged between 10 and 18 respondents per survey, despite 60 total fleets having received vouchers to date. The data used to estimate impacts was collected in January 2018 and June 2018 to reflect reporting for the most recent voucher recipients and the newest technologies deployed.

3 Some data was inconsistent or featured extreme outliers. To correct for these extremes, median values were employed wherever necessary.

Based on the average annual mileage, estimated fuel savings were calculated for each fuel type that was eligible through the program using the following assumptions:

- Industry standard CNG cost of fuel is estimated at $0.47 per mile (U.S. DOE, 2018), based on CNG fuel economy of 5.28 miles per diesel gallon equivalent (DGE) (Josephs, 2015).
- Since there is no industry standard on hybrid electric-to-diesel ratios, various ranges were presented to capture different scenarios (10/90, 80/20, 70/30).
- Seventy percent fuel savings were assumed for electric vehicles based solely on diesel fuel usage and real-world estimates of transit bus charging (not accounting for potential impacts of demand charges) (Gallo et al, 2014; King County Metro, 2017).
- There is zero fuel savings for retrofitted vehicles since the fuel type (diesel) remains unchanged.
- Biodiesel was excluded from the average mileage since it was reported by only one participant.

Fuel cost savings estimates are illustrated in Table 5. Comparing diesel fuel cost to alternative fuel cost demonstrates that the operation of electric, natural gas, and hybrid-electric vehicles achieves annual fuel cost savings for fleets participating in NYT-VIP.

Table 5. Annualized Fuel Cost Savings by Fuel Type

	Annual Average per Vehicle			
	January 2018		June 2018	
Fuel Type	Annual Fuel Cost	Annual Fuel Savings*	Annual Fuel Cost	Annual Fuel Savings*
Natural Gas Vehicles	$4,013.00	$256.15	$805.20	$51.40
Electric Vehicles	$1,365.90	$3,187.44	$900.00	$2,100.14
Retrofits	$19,280.81	$0.00	$6,237.89	$0.00
Hybrid Vehicles (10% Electric/90% Diesel)	$17,931.54	$1,349.66	$5,801.24	$436.65
Hybrid Vehicles (20% Electric/80% Diesel)	$16,581.49	$2,699.32	$5,364.55	$873.34
Hybrid Vehicles (30% Electric/70% Diesel)	$15,231.83	$4,048.98	$4,927.89	$1,310.00

* Annual fuel savings was calculated by subtracting the annual actual vehicle fuel cost from the annual baseline diesel fuel cost.

2.3.2 Maintenance Cost Savings

The semi-annual usage reports collected qualitative participant ratings for maintenance and reliability of their new vehicles; however, the report did not collect maintenance cost information. This precludes the calculation of actual maintenance savings relative to conventional-fuel vehicles.

Research shows that diesel-powered vehicle maintenance cost per mile has continued to increase since 2010 due to the high cost of emission control equipment maintenance in diesel-powered vehicles, such as diesel particulate filters, diesel oxidation catalyst, selective catalytic reduction, etc. (American Transport Research Institute, 2017). The average maintenance cost in 2015 was $0.16 per mile for a diesel-powered vehicle (American Transport Research Institute, 2017). The average maintenance cost of a diesel-powered vehicle was applied to all vehicle categories to estimate maintenance savings by comparing the maintenance cost of a diesel-powered vehicle to the cost of maintenance for the vehicle's actual fuel type.

Applying the same concept used to estimate fuel cost savings, the following assumptions were made to estimate maintenance cost savings:

- Industry reported CNG maintenance cost in 2015 was $0.082 per mile (Josephs, 2015).
- Since there is no industry standard on hybrid maintenance cost, electric-to-diesel ratios were used with various ranges presented to capture different hybridization scenarios (10/90, 80/20, 70/30).
- Using real-world transit bus measurements, the analysis assumes a 25 percent reduction below the costs to maintain diesel-powered vehicles (King County Transit 2017; California Air Resources Board 2016).
- There is zero fuel savings for retrofitted vehicles since the fuel type (diesel) remains unchanged.

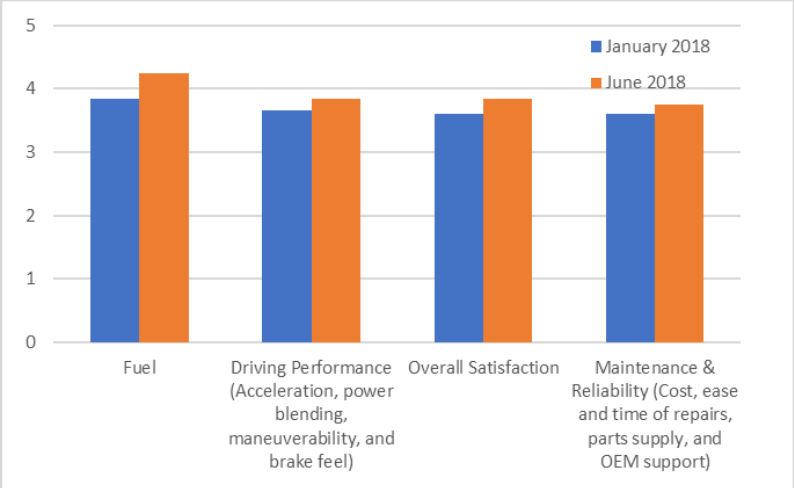
Maintenance savings estimates are illustrated in Table 6. Comparing the maintenance cost of a diesel-powered vehicle to the maintenance cost of the alternative fuel vehicle, demonstrates that the operation of electric, natural gas, and hybrid-electric vehicles does achieve maintenance cost savings for fleets participating in NYT-VIP.

Table 6. Annual Maintenance Cost Savings by Fuel Type

	Annual Average per Vehicle			
	January 2018		June 2018	
Fuel Type	**Annual Maintenance Cost**	**Annual Maintenance Savings**	**Annual Maintenance Cost**	**Annual Maintenance Savings**
Natural Gas Vehicles	$700.14	$665.99	$140.48	$133.63
Electric Vehicles	$4,624.40	$1,547.50	$1,497.10	$499.03
Retrofits	$6,169.86	$0.00	$1,996.13	$0.00
Hybrid Vehicles (10% Electric/90% Diesel)	$6,035.11	$154.75	$1,946.23	$49.90
Hybrid Vehicles (20% Electric/80% Diesel)	$5,880.37	$309.50	$1,896.32	$99.81
Hybrid Vehicles (30% Electric/70% Diesel)	$5,725.62	$464.24	$1,846.42	$149.71

The semi-annual usage reports also requested that fleets characterize their experience with the vehicles purchased through the voucher program using a 1–5 rating scale, with 1 being least satisfied and 5 being most satisfied. From the January to June report, there was a slight overall improvement in satisfaction for each category as demonstrated in Figure 5. A review of the responses revealed a composite average across all categories of 3.68 in the January 2018 report and 3.92 in the June 2018 report. However, specific fleet responses reveal more about the potential range of experiences; one participant went from highly satisfied (average rating of 3.25) in the January report to extremely dissatisfied (average rating of 1) in June, while another participant went from extremely dissatisfied (average rating of 1) in January to relatively satisfied (average rating of 4.25) in June. The remaining respondents in this section in both months remained similarly satisfied across reporting periods.

Figure 5. Average Satisfaction Scores for Fleets that Received Voucher Incentives



3 Impact Assessment

To estimate the environmental benefits and cost effectiveness of voucher investments, CALSTART employed the Alternative Fuel Life-Cycle Environmental and Economic Transportation (AFLEET) tool developed by Argonne National Laboratory for the U.S. Department of Energy's Clean Cities program. AFLEET estimates petroleum use, greenhouse gas emissions, air pollutant emissions, and cost of ownership of light-duty and heavy-duty vehicles using simple spreadsheet inputs. The information is customizable and makes use of local information, such as population density and grid energy mix, to refine cost values and pollution estimates. The tool uses data from Argonne's Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) fuel-cycle model to generate necessary well-to-wheels petroleum use and GHG emission coefficients. The U.S. Environmental Protection Agency's Motor Vehicle Emission Simulator (MOVES) and certification data are used to estimate tailpipe air pollutant emissions.

The outputs that the AFLEET tool provides, in conjunction with the information gathered from NYT-VIP semi-annual reports, allows for an approximation of total emissions and social costs associated with those emissions. The estimates vary based on the number of miles driven. CALSTART's analysis uses three values to complete range estimates: a default industry value (16,500 miles) provided by AFLEET, a high range based on semi-annual mileage reports for each technology type, and a low range based on semi-annual mileage reports for each technology type (see Table 7). These values were used to establish the range of potential impacts associated with the vouchers disbursed to date.

Table 7. Annual Vehicle Mileage and Fuel Economy Assumptions

	DECD / Hybrid	EV	CNG
Industry Default*	16,500	16,500	16,500
High Value Reported	38,500	9,100	8,500
Low Value Reported	12,500	6,000	1,700
Miles per Gallon (or Equivalent) for Heavy-Duty Single Short Haul Truck	7.4 for diesel	18.9	6.3
	9.7 for hybrid (operating as 20% EV)		

* Default value suggested by AFLEET for medium- and heavy-duty applications

Notably, EVs are unique in long-term emissions forecasting because their emissions are connected to the electric grid. The fuel mix can change over time, and the GHG outputs of the regional electric sector are likely to improve due to state climate change commitments. Because EVs effectively shift emissions from

on-road sources to the State's power grid, with no certainty regarding the location of induced emissions, this analysis does not attempt to characterize upstream criteria air pollutants for EVs.

Using the assumptions presented above, CALSTART established ranges for annual avoided emissions of greenhouse gas and criteria air pollutants, based on the number of vouchers disbursed by technology type to date. These estimates assume that voucher-enabled vehicles displace a counterfactual conventional diesel vehicle that would have driven an equivalent number of miles. CALSTART then assigned external cost indicators to each avoided emissions calculation to estimate avoided social costs. Finally, CALSTART divided the aggregate voucher awards in each category by the potential emissions avoided to determine the range of cost-effectiveness in terms of dollars per unit emissions abatement. The results of each dimension of this impact assessment are catalogued in Table 8.

3.1 Greenhouse Gas (GHG) Emissions

As displayed in Table 8, NYT-VIP has facilitated vehicle adoptions that avoid between 1460 and 3690 short tons of carbon dioxide each year, which corresponds to avoided social cost of between $54,000 and $137,000 per year (using the AFLEET social cost of carbon of $37 per ton CO_2e). These estimates indicate that the cost to New York State per short ton of GHG abatement is between $34,000 and $285,700 per ton, kept elevated by CNG vouchers, which are costly relative to their GHG avoidance potential.

Table 8. CO_2 Impacts

	EV	CNG	Hybrid	DECD	Total
	Total Annual Avoided Emissions (short tons)				
Default	1,345.5	120.4	1,320.7	0.0	2,786.6
High	740.0	62.0	2,889.5	0.0	3,691.5
Low	489.8	12.4	959.5	0.0	1,461.7
	Total Annual Avoided Social Cost (dollars)				
Default	$49,783.50	$4,454.80	$48,864.42	$ -	$103,102.72
High	$27,380.93	$2,294.22	$106,910.95	$ -	$136,586.10
Low	$18,121.19	$458.84	$35,502.38	$ -	$54,082.42
	NYS Investment Per Short Ton Avoided				
Default	$4,216.35	$27,971.73	$1,856.88	$ -	$34,044.95
High	$7,666.08	$54,314.03	$848.70	$ -	$62,828.82
Low	$11,583.37	$271,570.17	$2,555.75	$ -	$285,709.29

3.2 Nitrogen Oxide (NO_x) Emissions

As displayed in Table 9, NYT-VIP has facilitated vehicle adoptions that avoid between 2690 and 7590 pounds of NO_x emissions each year, which corresponds to avoided social cost of between $1,000 and $3,000 per year (using the AFLEET external cost of $0.40 per pound NO_x). These estimates indicate that the cost to New York State per pound of NO_x abatement is between $5,000 and $20,700 per pound. This range is influenced by the low end of reported mileage estimates, which result in poorer cost-effectiveness even for CNG engines that are practically as effective at reducing NO_x emissions as all-electric technology.

Table 9. NO_x Impacts

	EV	CNG	Hybrid	DECD	Total
	Total Annual Avoided Emissions (pounds)				
Default	2,177.5	2,734.8	2,137.3	0.0	7,049.6
High	1,199.2	1,408.4	4,979.9	0.0	7,587.5
Low	792.3	281.7	1,620.1	0.0	2,694.0
	Total Annual Avoided Social Cost (dollars)				
Default	$872.15	$1,095.37	$856.05	$ -	$2,823.58
High	$480.32	$564.12	$1,994.60	$ -	$3,039.04
Low	$317.32	$112.82	$648.89	$ -	$1,079.04
	NYS Investment Per Pound Avoided				
Default	$2,605.32	$1,231.46	$1,147.38	$ -	$4,984.17
High	$4,730.70	$ 2,391.18	$492.44	$ -	$7,614.32
Low	$7,160.63	$11,955.92	$1,513.70	$ -	$20,630.25

3.3 Sulfur Oxide (SO_x) Emissions

As displayed in Table 10, NYT-VIP has facilitated vehicle adoptions that avoid between 22 and 60 pounds of SO_x each year, which corresponds to avoided social cost of between $1,300 and $3,500 per year (using the AFLEET external cost of $58.67 per pound SO_x). These estimates indicate that the cost to New York State per pound of SO_x abatement is between $810,000 and $4.7 million per pound, owing largely to the relatively modest quantities of SO_x avoided across technologies relative to voucher amounts.

Table 10. SO_x Impacts

	EV	CNG	Hybrid	DECD	Total
	Total Annual Avoided Emissions (pounds)				
Default	19.5	8.6	19.1	0.0	47.2
High	10.7	4.4	44.6	0.0	59.8
Low	7.1	0.9	14.5	0.0	22.5
	Total Annual Avoided Social Cost (dollars)				
Default	$1,144.16	$504.60	$1,123.04	$ -	$2,771.80
High	$630.12	$259.87	$2,616.68	$ -	$3,506.67
Low	$416.29	$51.97	$851.26	$ -	$1,319.53
	NYS Investment Per Pound Avoided				
Default	$290,927.85	$391,604.19	$128,124.60	$ -	$810,656.63
High	$528,261.19	$760,396.48	$54,989.10	$ -	$ 1,343,646.77
Low	$799,603.80	$3,801,982.39	$169,029.81	$ -	$4,770,616.00

3.4 Fine Particulate Matter ($PM_{2.5}$) Emissions

As displayed in Table 11, NYT-VIP has facilitated vehicle adoptions that avoid between 114 and 332 pounds of $PM_{2.5}$ each year, which corresponds to avoided social cost of between $6,000 and $17,500 per year (using the AFLEET external cost of $52.72 per pound $PM_{2.5}$). These estimates indicate that the cost to New York State per pound of $PM_{2.5}$ abatement is between $544,000 and $1 million per pound. Note that this is the only emissions category for which there are impacts attributable to the DECD category, while CNG vouchers had no discernible impact relative to diesel vehicles.

Table 11. $PM_{2.5}$ Impacts

	EV	CNG	Hybrid	DECD	Total
	Total Annual Avoided Emissions (pounds)				
Default	32.5	0.0	31.9	105.4	169.8
High	17.9	0.0	68.0	245.6	331.5
Low	11.8	0.0	22.8	79.9	114.5
	Total Annual Avoided Social Cost (dollars)				
Default	$1,713.43	$ -	$1,681.80	$5,556.78	$8,952.01
High	$942.39	$ -	$3,585.96	$12,947.30	$17,475.65
Low	$623.69	$ -	$1,201.18	$4,212.04	$6,036.90
	NYS Investment Per Pound Avoided				
Default	$174,556.71	$ -	$76,874.76	$292,958.35	$544,389.82
High	$317,375.83	$ -	$36,053.82	$682,592.96	$1,036,022.62
Low	$479,551.39	$ -	$107,634.23	$222,062.43	$809,248.06

3.5 Volatile Organic Compound (VOC) Emissions

Finally, as displayed in Table 12, NYT-VIP has facilitated vehicle adoptions that avoid between 260 and 670 pounds of VOCs each year, which corresponds to avoided social cost of between $875 and $2,240 per year (using the AFLEET external cost of $3.38 per pound VOC). These estimates indicate that the cost to New York State per pound of VOC abatement is between $34,000 and $81,000 per pound. As previously indicated, there is no discernible impact of CNG vehicles on VOC emissions relative to diesel engines.

Table 12. VOC Impacts

	EV	CNG	Hybrid	DECD	Total
	Total Annual Avoided Emissions (pounds)				
Default	234.0	0.0	229.7	0.0	463.7
High	128.9	0.0	535.2	0.0	664.0
Low	85.1	0.0	174.1	0.0	259.2
	Total Annual Avoided Social Cost (dollars)				
Default	$789.95	$ -	$775.36	$ -	$1,565.31
High	$435.05	$ -	$1,806.60	$ -	$2,241.65
Low	$287.41	$ -	$587.73	$ -	$875.14
	NYS Investment Per Pound Avoided				
Default	$24,243.99	$ -	$10,677.05	$ -	$34,921.04
High	$44,021.77	$ -	$4,582.42	$ -	$48,604.19
Low	$66,633.65	$ -	$14,085.82	$ -	$80,719.47

4 Program Lessons Learned and Challenges

NYT-VIP launched a new and innovative program, introducing ecologically minded new processes and vehicles into a marketplace that had relied consistently on conventional-fuel vehicles. Early adopters among fleets and vendors became crucial allies to helping make inroads with additional users and expand the program's reach. CALSTART learned early on to value the champions at companies that explored clean vehicle technologies and purchased new vehicles through NYT-VIP, both as clients and as messengers as well as to promote their efforts in a mutually beneficial manner. For example, several early adopters, including vehicle dealer Milea Truck Sales and Leasing and delivery fleets Manhattan Beer and Fresh Direct, were recognized with the Northeast Diesel Collaborative's Breathe Easy awards for their clean vehicle deployments. The relationships developed with the managers of these fleets created opportunities for CALSTART to call upon them to deliver positive testimonials and recommend NYT-VIP to colleagues.

Relationships and partnerships are critical to expanding outreach opportunities beyond the initial set of early adopters. New and interested parties must be made aware of truck vouchers through direct methods: speaking directly with individual fleet managers or to larger groups on webinars or at conferences, seeking out new participants through word-of-mouth or by providing collateral at trade shows, or with exciting new developments sent out through e-mail blasts or on the program website. Expanding the program, particularly in its earliest iteration, required inventive and tireless outreach efforts conducted in conjunction with close partners such as the New York State Energy Research and Development Authority (NYSERDA), New York State Department of Transportation, New York City Department of Transportation, Northeast Diesel Collaborative, Clean Cities coalitions, and the Port Authority of New York and New Jersey's Truck Replacement Program.

Once successfully engaged, interacting with fleets presented new challenges.

- Alternative fuel vehicle applications and incentive programs are still relatively new for medium- and heavy-duty vehicles, and fleet managers and fuel suppliers might not be aware of potential business opportunities. CALSTART has facilitated meetings to overcome such barriers by working with stakeholders to negotiate deals and highlight how clean vehicle technology investments can be profitable to all parties, such as establishing purchase agreements between a CNG supplier and a fleet adopting CNG trucks.
- NYT-VIP was designed as a simple and straightforward program, but fleet managers not accustomed to navigating incentive programs may at first have difficulty conforming to eligibility requirements or assessing the suitability of new technologies for their operations. Multiple vouchers were requested for vehicles that were not compatible with chosen

technologies, such as DECDs. In other instances, vouchers were requested for vehicles that would be domiciled in ineligible counties—in one instance, for a vehicle that was already registered out of the State. These anecdotes underscore the importance of an active program administrator and processing function that can engage in a constructive relationship with potential vendors and vehicle end users, leveraging this relationship to walk them through the initial voucher eligibility criteria and application steps.

- NYT-VIP provides established guidelines for application processes, but truck operators and vendors may need extensive assistance in applying for vehicle and vendor eligibility as well as for voucher reimbursement. The Voucher Processing Center, including CALSTART and Tetra Tech, interact extensively to resolve questions, identify misunderstandings, and prevent any foreseeable problems from inhibiting clean vehicle deployments.
- Once vouchers have been disbursed, continued engagement with most fleet operators has been challenging despite regular and direct electronic and telephone requests. Many operators may not be fully aware of semi-annual reporting requirements or may not otherwise be prepared or willing to fulfill the reporting requirements. If the primary contact at a fleet leaves the company or is unavailable, colleagues have been unable or unwilling to complete reports. Over the last few years of the program, when reporting should have been at its height as the total number of fleets approached 60, the number of responses ranged from 10 to18 during reporting periods. With the extreme outlying data and partially completed surveys, the information received through these surveys is often unrepresentative of the larger group of program participants.

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