

**NYSERDA Clean Transportation Research &
Development Evaluation Case Study:
Clear-Vu Lighting Subway Lights**

Final

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NYSERDA

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Acronyms and Abbreviations List

CFL	Compact fluorescent light
Clear-Vu	Clear-Vu Lighting; a company that developed advanced subway lighting technology with NYSERDA support
CO ₂	Carbon dioxide
CO ₂ e	Carbon dioxide equivalent, a metric used to measure the radiative forcing impact (i.e., climate impact) of greenhouse gases relative to carbon dioxide (e.g., a gas with a CO ₂ e of 25 is 25 times more potent than CO ₂)
EPA	U.S. Environmental Protection Agency
ft	Feet
kWh	Kilowatt hours
LED	Light Emitting Diode
MTA	New York Metropolitan Transportation Authority
MWh	Megawatt hours
NYC	New York City
NYS	New York State
NYSERDA	New York State Energy Research and Development Authority
W	Watts

1 Introduction

Using NYSERDA funding, Clear-Vu Lighting designed, developed, and tested a novel lighting fixture for subway tunnels in New York City. This document serves as an outline and written supplement for the Clear-Vu Lighting Subway Lights case study that described the benefits of the lighting technology as installed in a limited portion of the New York subway system. The case study comprises findings from in-depth interviews and previous reporting on the lighting technology.

The new lighting product is more efficient than the legacy CFL light system currently installed in most MTA subway tunnels. It includes wireless remote monitoring and has a four-hour battery backup that allows the light to continue to function during power outages. Clear-Vu also installed a wireless mesh network with over 500 network nodes in the Canarsie Tunnel for monitoring fixture health remotely, helping to save on labor and maintenance costs. The fixtures last up to ten times as long as the legacy light fixtures, require less maintenance, and are more resilient in the case of an emergency. In addition, the technology features a universal quick-connect system for quick fixture replacement, which simplifies installation.

In this case study, background research, program documentation, and program data informed the development of research areas and the associated metrics by which impacts could be estimated. Interviews with stakeholders elicited information on outcomes related to the economic, energy, environmental, non-energy, and replication benefits of the Clear-Vu lighting technology. In addition, interviewees were asked about the extent to which NYSERDA's support influenced these positive outcomes. Table 1 shows a complete list of research areas and metrics.

Table 1: Research Areas and Metrics

Research Areas and Metrics	Potential Sources/Methods
Economic Benefits	
Number of jobs created at subject companies, follow-on funding, internal/external investments, sales information, cost savings, deferred capital expenses where applicable	Interviews, previous reports
Reduced travel time	Interviews, previous reports, literature review
Reduced operations and maintenance costs	Interviews
Energy Benefits	
Fuel savings	Interviews, previous reports
Environmental Benefits	
CO ₂ e reduction	Interviews, previous reports, literature review
Reductions of other automotive pollutants	Interviews, previous reports, literature review
Non-Energy Benefits	
Traffic safety: reduced car crashes, improved bicycle / pedestrian safety	Interviews, previous reports, literature review
Improved bus transit flow, reduced transportation time / congestion	Interviews, previous reports
Replication Benefits	
Similar initiatives undertaken by others	Interviews, literature review
Patents, publications, or communication and marketing activities used to encourage additional third-party investment and market development	Interviews
External investments, internal investments, in-market pilots, commercial-scale product launches	Interviews

NYSERDA provided three potential interviewees as the initial sample frame for interviews, with the expectation that these respondents could identify additional interviewee candidates, following a snowball sampling approach. The interviewees identified only one additional interview candidate from the MTA, but this person was not responsive to repeated outreach.

Table 2 shows interviewee roles and their respective organization. Interviewees were offered anonymity to encourage them to offer candid feedback.

Table 2: Disposition of Interview Respondents

Organization	Role
NYSERDA	Project Manager
Clear-Vu Lighting	Organization executive (title withheld for anonymity)
Metropolitan Transportation Authority	Organization executive (title withheld for anonymity)

2 Findings

2.1 Economic Benefits

The case study interviews and background research included a review of the economic benefits derived from NYSERDA’s initial investment in Clear-Vu’s lighting technology.

Clear-Vu derived economic and financial benefits from NYSERDA’s investment, while other economic benefits were realized by the stakeholders associated with the development and implementation of these products. Clear-Vu was asked about their sales related to this technology, whether they received additional funding for follow-on product development or commercialization, and if they were able to defer any capital expenses. Potential economic benefits for other stakeholders might include cost savings associated with the use of the final product, such as reduced labor and maintenance costs and deferred capital expenses. Clear-Vu’s relationship with NYSERDA also included recoupment terms, to ensure that NYSERDA would attain an equitable share of the benefits derived from the risk associated with its investment in the Clear-Vu project.

Clear-Vu reported that they created two to three new full-time equivalent jobs as a result of this lighting technology. They expect that an additional two to three positions could be created in the next twelve to twenty-four months. Clear-Vu also estimated that two to three new full-time equivalent jobs were created at other organizations, and an estimated two to three new positions might be created at these organizations in the next twelve to twenty-four months. Since beginning

their work with NYSERDA in 2018, Clear-Vu reported that they had installed approximately 1,273¹ units in the Canarsie Tunnel as of the time of this study.

The MTA interviewee estimated the capital cost savings for the MTA to be approximately \$380 per fixture. When extrapolated to the 1,273 installed fixtures, this yields an estimated capital savings of \$483,740. The MTA interviewee also reported that the new fixtures would not be subject to the legacy fixtures' five-year maintenance schedule, which typically included battery and lamp replacements. By no longer needing to perform this maintenance, every five years the MTA would save \$1,130 in material costs and \$300 in labor costs per installed fixture. When extrapolated to the 1,273 installed fixtures, this yields over \$1.8 million saved every five years.

The new lighting products allow for remote monitoring, reducing the time workers spend walking through tunnels to look for malfunctioning lights. The Clear-Vu interviewee estimated that \$200,000 would be saved on labor and maintenance annually if these fixtures were installed in the entire Canarsie Tunnel, due in large part to the benefits of remote monitoring.²

The previous report³ calculated electricity savings related to the technology holding the following assumptions: 20 watts saved per fixture (as compared to legacy lights), illumination of 24 hours a day and 365 days per year, and a fixed electricity price of \$0.16/kWh. Under these assumptions, the 1,273 currently installed fixtures yield \$35,684 in electricity savings annually. When extended over their seven-year useful life, this yields \$249,793 saved. If Clear-Vu's lights were installed throughout the entire Canarsie Tunnel (1,400 fixtures), the estimated electricity savings would be \$39,244 annually, and \$274,713 over their seven-year useful life (assuming no changes in the above assumptions). If Clear-Vu's lights were installed in all 20,000 under-river tunnel fixtures, the estimated electricity savings would be \$560,640 annually, and over \$3.9 million over their seven-year useful life.

Electricity savings estimates can be seen in Table 3. The table compares savings values for the actual, as-installed project, with the potential savings that could be derived from expanding the

¹ At the time of NMR's interview with Clear-Vu, 700 fixtures were installed in the Canarsie Tunnel. Before publication of the case study, Clear-Vu provided an updated count of 1,273 installed fixtures in the Canarsie Tunnel.

² Clear-Vu and MTA provided responses separately. Accordingly, the maintenance savings estimates provided by each organization likely overlap to some extent and may not be fully additive.

³ Ibid.

installation to a) the entire Canarsie Tunnel and b) all under-river subway tunnels in the MTA system.

Table 3: Cost Savings Relative to CFL Legacy Fixtures⁴

	Current Installation	If Installed in:	
	Current Project	Canarsie Tunnel	Under-River Tunnels
Number of Fixtures	1,273	1,400	20,000
Annual Electricity Savings	\$36,000	\$39,000	\$561,000
Electricity Savings over Useful Life	\$250,000	\$275,000	\$3.9M

Assumptions: 20 watts saved per fixture, 24/7 operation, a seven-year useful life, \$0.16/kWh electricity costs

Findings Adjusted for or Excluded from the Final Case Study. One finding in the case study was transformed to present annual rather than multi-year savings. One respondent reported \$1 million in savings for labor and maintenance per track mile over a ten-year period. This is presented in the case study as \$200,000 per year if these fixtures were installed in the entire Canarsie Tunnel. The previous report⁵ estimated \$11.6 million in savings from lighting fixture inspections over seven years and 460 miles of track. This finding was excluded from the final case study because these savings already appear as a subset of the \$200,000 savings described above. One finding about a dual lighting feature, which creates additional task lighting during maintenance work, was excluded from the final case study because it was speculative and based on a future product that is not yet available.

⁴ Ibid.

⁵ Ibid.

2.2 Energy Benefits

The case study interviews and background research included a review of the energy benefits (i.e., energy savings) derived from NYSERDA's initial investment in Clear-Vu's lighting technology. Energy benefits include electricity or fuel savings associated with the use of the technology. The previous report⁶ and new data from the stakeholder interviews indicated that there were significant electricity savings associated with the product in the initial demonstration in the MTA system.

The stakeholder interviews corroborated findings from the previous report⁷ indicating that 175 kWh are saved per fixture per year. These savings are largely attributable to the switch from CFL to LED technology. The new lighting fixtures use 50% less electricity (20 watts) than the legacy lights (40 watts), and they include the added feature of a four-hour battery backup.

The previous report⁸ calculated energy savings related to the technology holding the following assumptions: 20 watts saved per fixture (as compared to legacy lights), and illumination 24 hours a day and 365 days per year. Under these assumptions, the 1,273 currently installed fixtures yield savings of 223 MWh/year. When extended over their seven-year useful life, this yields savings of 1,561 MWh. If Clear-Vu's lights were installed throughout the entire Canarsie Tunnel (1,400 fixtures), the estimated energy savings would be 245 MWh annually, and over 1,717 MWh over their seven-year useful life. If Clear-Vu's lights were installed in all 20,000 under-river tunnel fixtures, the estimated energy savings would be about 3,504 MWh annually, and 24,528 MWh over their seven-year useful life. Estimated electricity savings can be seen in Table 4. The table compares energy savings values for the actual, as-installed project, with the potential energy savings that could be derived from expanding the installation to a) the entire Canarsie Tunnel and b) all under-river subway tunnels in the MTA system.

⁶ Ibid.

⁷ Ibid.

⁸ Ibid.

Table 4: Estimated Energy Savings Relative to CFL Legacy Fixtures⁹

	Current Installation	If installed in:	
	Current Project	Canarsie Tunnel	Under-River Tunnels
Number of Fixtures	1,273	1,400	20,000
MWh Saved/Year	223	245	3,504
MWh Saved Over Useful Life	1,561	1,717	24,528

Assumptions: 20 watts saved per fixture, 24/7 operation, and a seven-year useful life

Findings Adjusted for or Excluded from the Final Case Study. In the final case study, one finding was transformed to present annual savings rather than multi-year savings. One respondent referenced the previous report¹⁰ that estimated electricity savings of 1,752 kWh per fixture over a ten-year period. This is presented in the case study as 175 kWh saved per fixture annually.

2.3 Environmental Benefits

The case study interviews and background research included a review of the environmental benefits derived from NYSERDA’s initial investment in Clear-Vu’s lighting technology, which stem directly from the energy savings created by the project. Environmental benefits include CO₂e emissions reductions associated with the LED lighting product’s reduced electrical consumption relative to the legacy CFL fixtures.¹¹

The previous report¹² calculated CO₂e emission savings related to the legacy CFL technology holding the assumptions of 20 watts saved per fixture (as compared to legacy lights), and illumination 24 hours a day and 365 days per year. Under these assumptions, the 1,273 currently installed fixtures save 158 metric tons of CO₂e annually and 1,104 metric tons of CO₂e over their seven-year useful life. If Clear-Vu’s lights were installed throughout the entire Canarsie Tunnel

⁹ Ibid.

¹⁰ Ibid.

¹¹ Estimates based on the U.S. EPA’s emissions estimate tool. <https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator>

¹² Clear-Vu Lighting. Final Report to NYSERDA under Agreement No. 123743. January 2020.

(1,400 fixtures), they are estimated to save 173 metric tons of CO₂e per year and 1,214 metric tons of CO₂e over their seven-year useful life. If Clear-Vu’s lights were installed in all 20,000 under-river tunnel fixtures, they are estimated to save 2,477 metric tons of CO₂e per year and 17,342 metric tons of CO₂e over their seven-year useful life. Reduced emissions can be seen in Table 5. The table compares CO₂e reductions for the actual, as-installed project, with the reductions that could be derived from expanding the installation to a) the entire Canarsie Tunnel and b) all under-river subway tunnels in the MTA system.

Table 5: Reduced CO₂e Emissions Relative to CFL Legacy Fixtures¹³

	Current Installation	If installed in:	
	Current Project	Canarsie Tunnel	Under-River Tunnels
Number of Fixtures	1,273	1,400	20,000
Metric Tons of CO₂e Saved/Year	158	173	2,477
Metric Tons of CO₂e Saved Over Useful Life	1,104	1,214	17,342

Assumptions: 20 watts saved per fixture, 24/7 operation, and a 7-year useful life

2.4 Non-Energy Benefits (NEBs)

In addition to energy and environmental benefits, the case study interviews and background research included a review of the potential non-energy benefits that might have been derived from NYSEDA’s initial investment in Clear-Vu’s technology. Non-energy benefits are positive impacts yielded by the use of a new technology, beyond direct energy savings. Respondents were asked about NEBs that might be associated with the Clear-Vu product, such as potential improvements to lighting quality, longer fixture lifetimes, reduced fixture downtime, improved occupational and rider safety, increased resiliency, fewer train delays and missed days of work, and improved emergency response capabilities.

Respondents corroborated findings from the previous report.¹⁴ They indicated that the Clear-Vu product had yielded improvements to lighting quality, longer fixture lifetimes, improved

¹³ Ibid.

¹⁴ Ibid.

occupational and rider safety, fewer train delays, and increased transit system resiliency. Examples of improved lighting quality included more uniform illumination, better color rendering, and higher lighting output. Clear-Vu's subway lighting fixtures last up to ten times longer than the legacy CFL system and have a higher-quality backup battery that lasts twice as long as the legacy light battery. Occupational and rider safety was reportedly improved by fixtures having a four-hour backup battery that allowed passengers and maintenance crews to move through a lighted tunnel in the event of a power outage. The fixtures' remote monitoring capability allows maintenance workers to monitor the health of fixtures without having to walk through tunnels to directly observe the lights, reducing their exposure to potential hazards. Fewer train delays were described as an outcome of this product as well, as it helped allow for a more regular (and less frequent) maintenance schedule that reduced the need for general orders (system shutdowns). Resiliency was reportedly increased as well, given that battery backup and remote monitoring functionalities can help maintain system up-time during power outages. According to respondents, cost savings related to operations and maintenance were the most valuable NEB associated with Clear-Vu's subway lights.

Of note, the Clear-Vu interviewee explained that they were developing a fixture that could accommodate the addition of modular sensors with different functions. These sensors could be added on to the new type of fixture to monitor the health of other equipment installed in subway tunnels, or could even be designed to sense temperature or hazards, such as sarin gas or carbon monoxide.

2.5 Replication Benefits

The case study interviews and background research also reviewed the replication benefits associated with the Clear-Vu project. Replication benefits include positive impacts related to similar initiatives undertaken by others as a result of the Clear-Vu project in the MTA system. This may include patents, publications, and communication and marketing activities to encourage additional third-party investment and market development.

Since launching in New York with NYSERDA support, Clear-Vu has initiated pilot programs in Washington, D.C., and Philadelphia. They reported near-term plans to expand to Chicago and Boston as well. Clear-Vu reported that they have several pending patent applications and, in 2019, engaged in three trade shows and presented at multiple conferences. One interviewee explained that the subway lighting market has not yet caught up to the NYSERDA-supported

advanced lighting technology. Another respondent explained that the legacy MTA subway lights are outdated and there is substantial market potential for advanced fixtures. One respondent recommended that future NYSERDA projects establish baseline data early on to facilitate later analysis comparing legacy systems to new technologies.

2.6 NYSERDA's Influence

Finally, the case study interviews and background research assessed the extent to which the energy, environmental, non-energy, and replication benefits could be attributed to NYSERDA's support. NYSERDA provided financial backing that may have helped with the development, production, and commercialization of the Clear-Vu product, thereby helping to achieve the aforementioned benefits.

Clear-Vu described NYSERDA's support as essential to helping them take risks and develop a new product that could be commercialized. Another respondent praised NYSERDA's efforts to help the MTA shift away from old legacy systems and toward more innovative and energy-efficient solutions.

Findings Adjusted for or Excluded from the Final Case Study. NYSERDA's internal assessment of its influence was excluded from the case study because it was deemed outside the scope of this evaluation.