

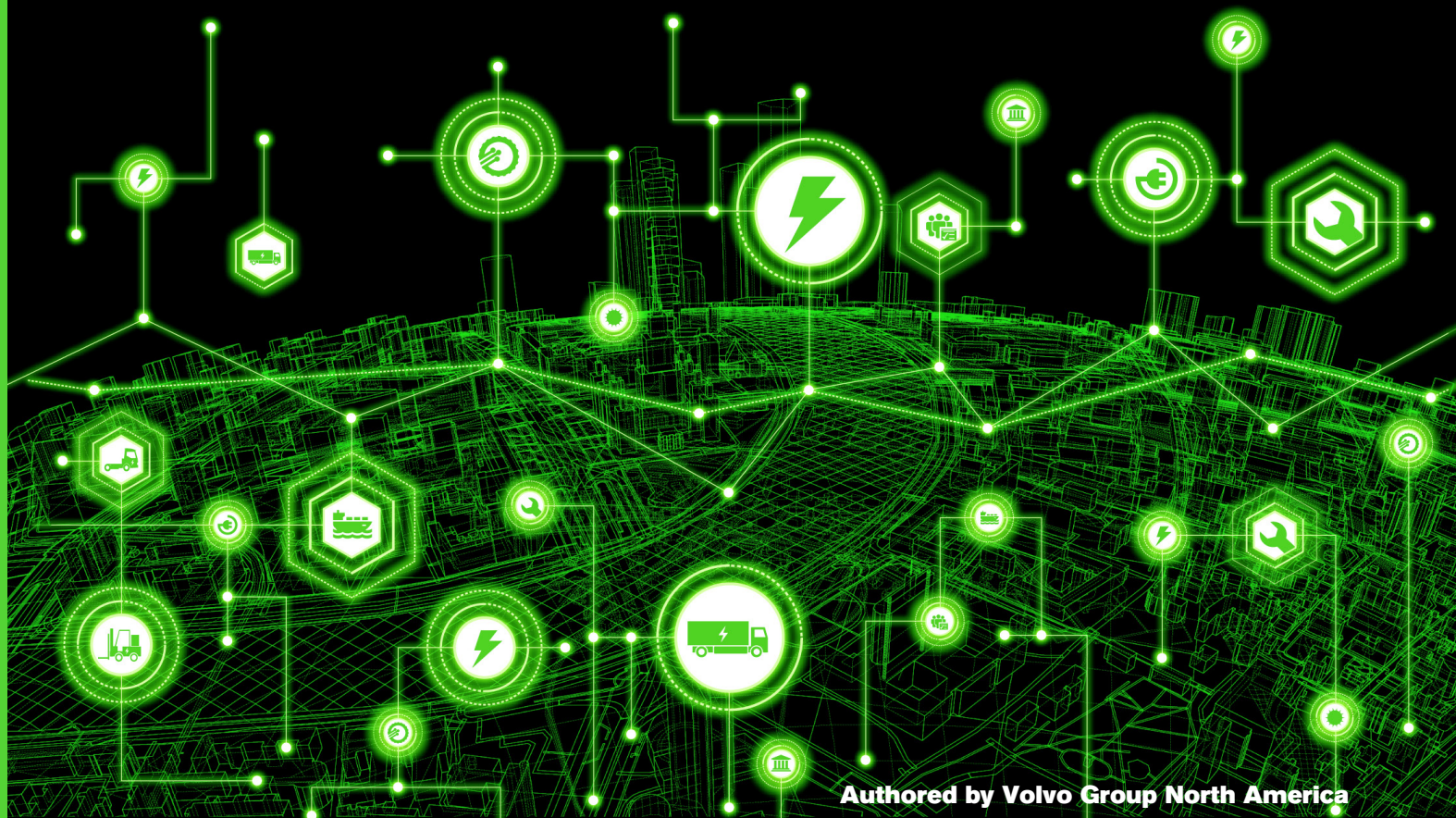


VOLVO LIGHTS

BRINGING BATTERY-ELECTRIC FREIGHT TRUCKS TO MARKET

FROM DEMONSTRATION TO COMMERCIALIZATION

Lessons Learned Guidebook



Authored by Volvo Group North America



Volvo LIGHTS (Low Impact Green Heavy Transport Solutions) is part of California Climate Investments, a statewide initiative that puts billions of Cap-and-Trade dollars to work reducing greenhouse gas emissions, strengthening the economy, and improving public health and the environment — particularly in disadvantaged communities. The total project cost was \$90 million, with a funding award of \$44.8 million.

INTRODUCTION



Across the United States, more than 70% of all goods used in our daily lives — from food to manufactured products — are transported to our stores and homes by trucks. As the nation's demand for goods continues to reach record levels, our cities are facing an increase in congestion, noise, and air pollution.

Unlike the diesel-fueled trucks we are used to seeing on the roads, battery-electric trucks rely solely on electricity to power the vehicle. As a result, battery-electric trucks are significantly quieter and emit zero tailpipe emissions, which helps cities achieve cleaner and healthier air quality while protecting the climate through greenhouse gas reductions. For fleet operators, battery-electric trucks also provide an exciting opportunity to reduce fueling and maintenance costs, while helping to meet their sustainability goals. However, switching from diesel to electric power will take far more than just the truck technology.

The organizations that partnered on the Volvo LIGHTS project (detailed in the following section) played an integral role in helping to transform goods movement, as they worked together to design a blueprint to introduce zero-tailpipe emission battery-electric trucks and equipment into the market at scale. During the project, which ran from 2019 to 2022, the partners demonstrated innovations critical for the commercial success of battery-electric freight movement.



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ESTABLISHING NEW PARTNERSHIPS



Caption: Volvo LIGHTS project partners at a press conference to announce the project at ACT Expo 2019.

Achieving successful widescale deployment of commercial battery-electric trucks will require a complete paradigm shift that goes beyond delivering a quality vehicle and includes establishing a more holistic support network to help customers make the transition. Through the Volvo LIGHTS project, the diverse set of partners uncovered the value of close cooperation and realized that no single entity could have unilaterally delivered the project.

The Volvo LIGHTS project was a unique collaboration between Volvo Trucks North America, South Coast Air Quality Management District (AQMD), and 12 other organizations that each contributed critical expertise, capital, and commitment to accomplishing the goals of the project. Many of the Volvo LIGHTS project partners had no previous experience working together (at least in the context of traditional commercial transactions).

“Partnership is the new leadership, and we believe that strong partnerships are the key to success.”

— Volvo Group CEO Martin Lundstedt

In February 2020, Volvo Trucks North America introduced its zero-tailpipe emission Class 8 VNR Electric project trucks to a pair of Southern California fleets — NFI Industries (NFI) and Dependable Highway Express (DHE). The two fleets piloted the demonstration trucks in their daily routes and provided valuable real-world feedback to Volvo Trucks ahead of its commercial product launch. TEC Equipment Fontana, Volvo Trucks’ largest West Coast dealership, was trained and equipped to provide local maintenance and repair support for NFI and DHE’s demonstration trucks and provided access to high-power chargers as needed. TEC Equipment also helped Volvo Trucks build the framework for its EV Certified Dealership program and allowed local fleet customers to pilot Volvo’s VNR Electric trucks in real-world trials.

Shell Recharge Solutions (formerly Greenlots) supported DHE, NFI, and TEC Equipment with the installation of private networked charging stations for the trucks, as well as electric vehicle chargers for employees to utilize for their personal vehicles. The combination of average and high-powered DC fast chargers featured Greenlots SKY EV Charging Network Software, which integrated with Volvo’s truck telematics, to balance the needs of the vehicle, facility, and utility grid. Additionally, some locations installed onsite renewable energy production and storage systems to demonstrate the economic benefits of generating their own power. This was key, as both fleets also deployed battery-electric yard trucks and forklifts at their freight facilities. The Ports of Los Angeles and Long Beach also provided infrastructure planning support to help facilitate the early adoption of battery-electric trucks for port drayage, while Southern California Edison analyzed the impacts of charging on the grid.

The wide-scale electrification of the transportation system will require a highly skilled and specialized work force to support, maintain, and repair advanced electric drivetrains and their increasingly sophisticated technology. To assist with the region's workforce development, Rio Hondo College and San Bernardino Valley College both launched heavy-duty electric truck technician training programs, which offered a blend of in-person and online coursework. Volvo Trucks provided the colleges with electric drivetrains and components from the Volvo VNR Electric, enabling the students to have valuable hands-on learning opportunities. In total, more than 45 students completed the programs at the two colleges in 2021 and 2022.

The Volvo LIGHTS team, Volvo Academy, and community outreach partner Reach Out worked with first responders to raise awareness about the high-voltage components on the Volvo VNR Electric and develop the first responder safety document that is now publicly available from the National Fire Protection Agency. Finally, the University of California, Riverside – Bourns College of Engineering Center for Environmental Research & Technology (UCR CE-CERT) used project data to develop algorithms to improve truck routing and reduce impacts on local communities.

Volvo Trucks is now replicating this partnership model with customers, infrastructure partners, dealerships, and communities across the country as it delivers trucks to more and more fleets. Whether you are talking about a partnership in the transportation world, or some other industry, Volvo Trucks has learned that the key to success is respecting the concerns and challenges raised by key stakeholders and working together to design mutually beneficial solutions.

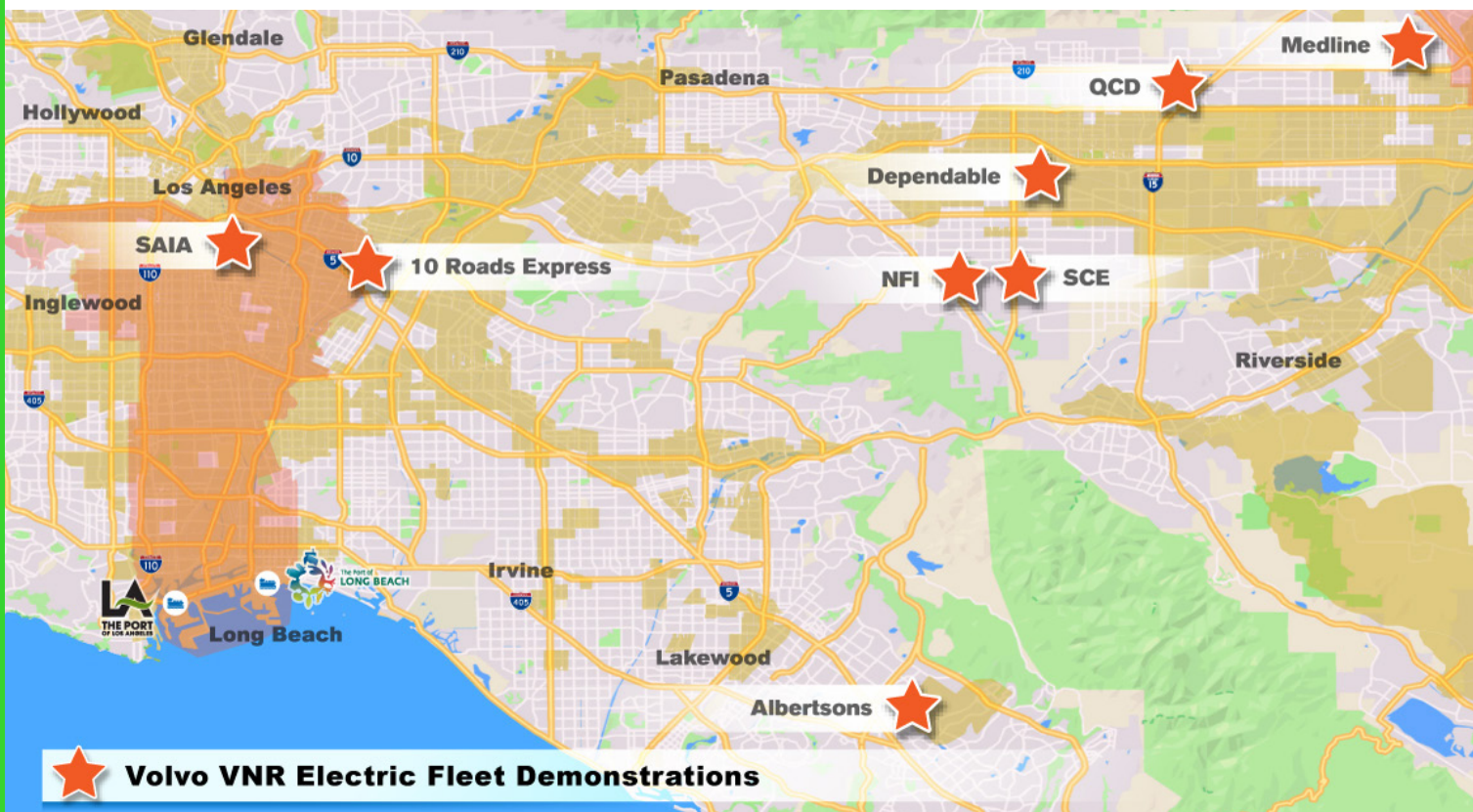
VOLVO LIGHTS PROJECT PARTNERS:



DEMONSTRATING CLASS 8 BATTERY -ELECTRIC TRUCK INNOVATIONS

Volvo Trucks has played a lead role in the introduction of Class 8 zero-tailpipe emission vehicles for the North American trucking industry. In 2020, Volvo Trucks deployed its first pilot VNR Electric trucks to several fleet operators in Southern California as part of the Volvo LIGHTS project with the goal of collecting real-world operating data and customer feedback ahead of commercialization. The first demonstration units were delivered to TEC Equipment in Fontana, California, for local parts distribution, as well as NFI and DHE for freight transport throughout the region.

Starting in 2021, TEC Equipment also provided the opportunity for local fleet customers representing diverse business sectors — including Albertsons, Penske Truck Leasing, Medline, SAIA, Quality Custom Distribution (QCD), 10 Roads Express, Southern California Edison (SCE), and others — to lease Volvo VNR Electric trucks to gain hands-on operating experience and determine where battery-electric trucks might best fit into their routes. With supplemental funding through an EPA Clean Air Technology Initiative Grant, a total of 30 battery-electric trucks were deployed through the Volvo LIGHTS project.



30 Battery-Electric
Heavy-Duty Trucks



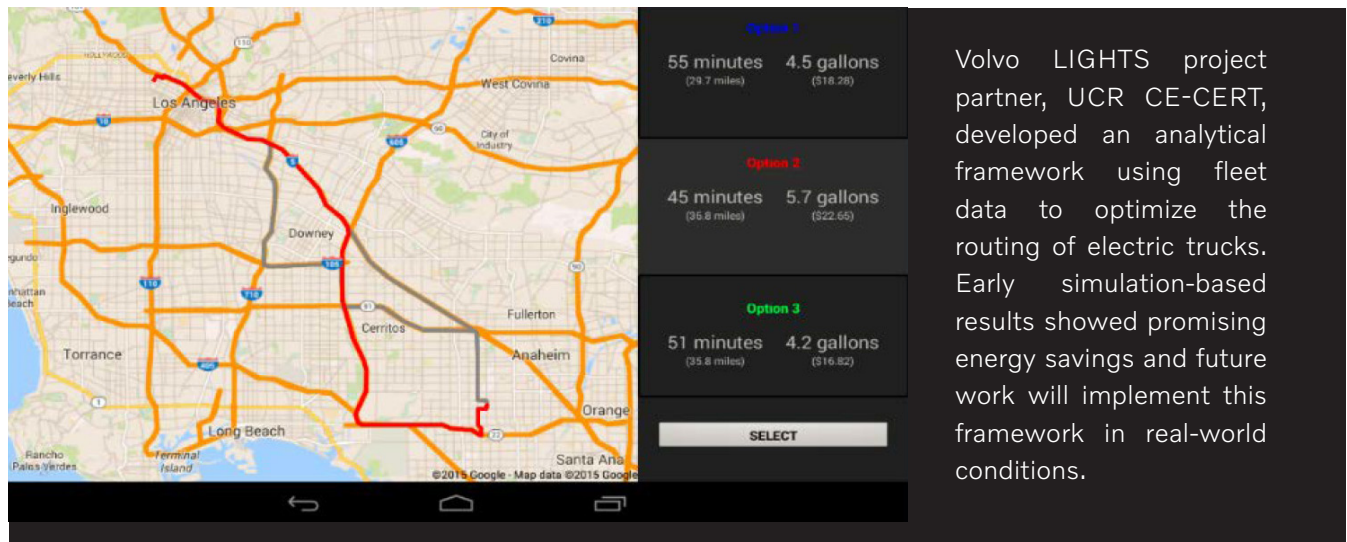
SB 535
Disadvantaged
Communities (2018)



AB 617
Communities (2022)

Insight Gained: Identifying Ideal Routes is Key to Electrification Success

A variety of businesses utilized Volvo VNR Electric trucks in commercial operation as part of the Volvo LIGHTS project, hauling freight 80-150 miles per day. Assessing the viability of using electric trucks in fleet operations requires looking beyond a battery range figure, especially in these early days, given the state of onboard energy storage systems and lack of charging networks. The truck's range can be impacted by several factors, such as the length of the route between stops, topography (particularly in hilly and mountainous terrains), and weather conditions (particularly, extreme heat or cold). Driving style can also impact the range, making it critical to train drivers on ways to maximize the regenerative braking benefits, which can potentially add between 5-15% of the power back to the battery. The fleet, OEM, and dealer should work together to understand a fleet's operational details and identify customer routes and applications that are best suited for electric trucks.



Volvo LIGHTS project partner, UCR CE-CERT, developed an analytical framework using fleet data to optimize the routing of electric trucks. Early simulation-based results showed promising energy savings and future work will implement this framework in real-world conditions.

Insight Gained: Assigning a Dedicated Project Manager Improves Efficiency

Fleet facility or warehouse projects involving the deployment of battery-electric vehicles (BEVs) and charging infrastructure are complex. While the OEM or technology providers will have experts who can assist in the vehicle requirements and optimization of operations, it is recommended that fleets identify a dedicated staff person to coordinate all aspects of the project. Identifying primary project contacts for organizations to work with at the utility and government agencies would also help improve project efficiency.

Insight Gained: Fleets Should Think Holistically About Needs When Determining Vehicle Specs

The Volvo VNR Electric has been designed as a sustainable transportation solution for fleet operators supporting local and regional distribution, pickup and delivery, and food and beverage distribution. Vehicle manufacturing specs such as gross vehicle weight rating, gross axle weight rating, transmission, engine ratings, tires, electrical and air systems, and cab configuration can vary greatly to meet business needs based on geography, duty cycles, and payloads. With the advent of battery-electric trucks, fleet operators should engage their OEM and dealer partners to determine the vehicle configurations that will best meet their needs, as limited onboard energy and availability of charging affect the range, charging frequency, and operational duty cycle. While additional batteries can be added to increase the range, the additional vehicle weight due to the battery pack may impact how much cargo the fleet can transport to stay within the limit of 82,000 GVWR.



Caption: NFI Industries deployed three Volvo VNR Electric trucks at its Chino, California facility to service regional distribution routes.

Insight Gained: Heavy-Duty BEVs Offer Considerable Lifecycle Emission Reduction Benefits

UCR CE-CERT evaluated the performance of the Volvo VNR Electric using a heavy-duty chassis dynamometer and performed an environmental life cycle assessment (LCA) of its well-to-wheel impact. The results showed that the Volvo VNR Electric saves 65% in total energy, 81% in fossil energy, and provides an emissions benefit of more than 80% reduction in GHG emissions and criteria pollutants/toxics compared to the baseline vehicles evaluated in this study.



Commercial Market Update:

In December 2020, Volvo officially launched its VNR Electric Class 8 truck model for sale in the U.S. and Canada. In January 2022, Volvo announced production of an enhanced VNR Electric model, including new vehicle configurations, an operating range of up to 275 miles, and the ability to achieve an 80% charge in 90 minutes for the six-battery package and 60 minutes for the four-battery version. In order to make the transition to electric truck ownership smooth and seamless for its customers, Volvo Trucks introduced the Volvo Gold Contract for the VNR Electric — a turn-key solution that allows customers to have operational peace of mind with electric vehicles. The Volvo Gold Contract includes scheduled and preventive maintenance, towing and vehicle repair including the vehicle's lithium-ion batteries and the complete electromobility system, to ensure peak vehicle uptime, performance and productivity.

INNOVATIONS IN WAREHOUSE EQUIPMENT



Caption: Dependable Highway Express replaced 100% of the forklifts at its Ontario facility with battery-electric forklifts from Papé Material Handling.

Insight Gained: BEV Technology Brings Improved Safety and Comfort to Warehouse Equipment

The battery-electric forklifts and yard tractors at DHE and NFI were widely accepted by the equipment operators. Among the many benefits they noted, operators appreciated the quieter, smoother operations. The forklift operators described a better turn radius, less vibration, and smoother braking with automatic stopping, which prevents unsafe sliding. The operators felt that the electric forklifts and yard tractors improved onsite safety, as drivers could more easily hear their surroundings, there were built-in safety features such as a beep while reversing, and they did not require storing combustible fuels onsite.

Insight Gained: Higher Upfront Costs Can Be Offset by Lower Operating Costs

Electric forklifts and yard tractors demonstrated lower operating costs and maintenance costs relative to diesel and propane equipment (76-100% less fueling costs and 50-64% less maintenance costs). This can be attributed to a combination of many factors such as lower electricity costs, improved efficiency of electric propulsion, and, most importantly, the availability of California's Low Carbon Fuel Standard (LCFS) credits; additional savings may be possible by scheduling charging sessions when electricity rates are lower.

Insight Gained: Battery-Electric Forklifts and Yard Trucks Offer Significant Local Emission Reduction Benefits

Yard tractors and forklifts typically only operate within the proximity of a warehouse facility, thereby impacting the local air quality in the vicinity of the warehouses. During their lifetime, it is estimated that each battery-electric forklift and yard tractor deployed is equivalent to removing 30 and 100 gasoline-powered cars from roads for a year, respectively.

RELIABLE & COST-EFFECTIVE CHARGING INFRASTRUCTURE



Caption: Three Volvo VNR Electric trucks charging at Dependable Highway Express' facility in Ontario, California.

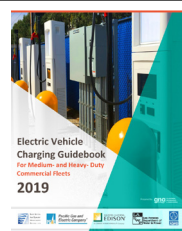
As part of Volvo LIGHTS, project partners demonstrated a range of strategies to provide reliable and cost-effective power to commercial fleet operators, while maintaining a safe and stable electric grid.

Insight Gained: Clearly Define Project Requirements Upfront

When fleets transition from conventionally fueled vehicles — like gasoline and diesel — to BEVs, there are several infrastructure-related factors to consider. Engaging with an experienced infrastructure partner (which could be an electric vehicle service provider, vehicle manufacturer, or even dealership) and turnkey installer is a great first step to help fleets identify:

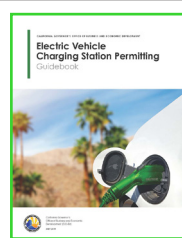
- Key internal and external stakeholders who need to be involved in the project
- The amount of energy required, planning for future charger installations and power demands
- An optimal charging schedule that allows fleets to meet their operational needs while reducing charging during peak pricing and minimizes demand charges
- Necessary electrical, charging, and energy storage equipment
- Ideal locations to install charging infrastructure
- Available incentives to offset costs
- Anticipated infrastructure installation timelines

CHARGING INFRASTRUCTURE RESOURCE SPOTLIGHT



Electric Vehicle Charging Guidebook for Medium- and Heavy-Duty Commercial Fleets

Gain a comprehensive overview of the BEV charging station procurement process for medium- and heavy-duty commercial fleets. The guidebook was prepared by Gladstein, Neandross and Associates (GNA) and sponsored by two Volvo LIGHTS project partners — Southern California Edison and South Coast Air Quality Management District — along with other partners.



Electric Vehicle Charging Station Permitting

Learn about California's permitting process for electric vehicle charging stations, including a focus on heavy-duty vehicle charging projects. The guidebook was prepared by California Governor's Office of Business and Economic Development with support from Volvo LIGHTS project partners — Shell Recharge Solution (formerly Greenlots), Southern California Edison and South Coast Air Quality Management District — along with other partners.

Insight Gained: Charging Infrastructure Projects Can Significantly Vary in Cost & Time Required

Charging infrastructure upgrade costs can range from a few thousand dollars for lower-power chargers to millions of dollars for higher-power chargers. This is influenced by several factors, including the current condition of a fleet's site, charging equipment costs (which vary by vendor, order size, and level of sophistication), and a fleet's load profile (i.e., how much electricity must be delivered to the selected BEVs and when it needs to be delivered).

Understanding how to manage the tradeoffs between a powerful charger that can achieve 80% state of charge within 1.5 hours (e.g., a 250-kW charger) and a less powerful one that will take about 2.5 hours to achieve the same state of charge (e.g., 150-kW charger) can be difficult. A more powerful charger may entail longer installation timelines and higher capital investment costs in the form of civil and electrical upgrades that are difficult to justify during an early demonstration stage but can provide a faster charging experience. Faster charging is typically more expensive because it requires an electrical system to operate at peak power, for which utilities levy higher demand charges, since it puts more stress on the electric grid; however, these higher energy costs can often be managed through a sophisticated electric vehicle service platform for smart charging. On the other hand, while the less powerful chargers can be installed more quickly and are more affordable to purchase and operate, the longer charging times may hinder the overall viability of the trucks.

In the end, fleets might want to consider a good mix of high- and low-power DC fast-charging stations with future-proofing charging solutions. Ultimately, upgrading infrastructure can be very expensive, especially if one does not plan for it, so it is important that any chosen solution allows for the easiest and least expensive means for adding charging power or chargers at a future date.

Insight Gained: Early Stakeholder Engagement is Essential

Charging infrastructure development is complicated by the fact that it necessitates unprecedented cooperation with stakeholders who are often unfamiliar with the trucking industry, such as utility companies, charging station providers, and local permitting authorities. Early engagement with all these stakeholders can help clarify costs and timeline ramifications for the overall project. Here are a few tips to keep in mind:

- It is important to engage with the local utility early, as obtaining a utility interconnection can be a complex process that often takes more than a year to complete.
- Careful coordination with city planning will help identify and resolve issues around site selection, especially in the case of public charging stations. State priorities and existing utility tariff laws may unwittingly hinder the deployment of charging stations, especially in the case of semi-public and public sites. Potential misalignment between stakeholder priorities may take several months to overcome and necessitate cooperation with additional stakeholders such as the Public Utilities Commission or the state legislature and lead to potential modification of utility rules or the use of electricity in vehicles.
- Requisite permits must be acquired from city and county officials, which have unique codes, requirements, and interpretations. Whether a project is a renovation, addition, or new construction, all facility designs are subject to some form of compliance from local permitting agencies. Building relationships with local officials and community leaders may also help alleviate unnecessary bottlenecks in the permitting process.
- Coordinated interaction between utility and local permitting staff in designing a site build-out can minimize delays and misjudgments. This will help mitigate redundancies and ensure a code-compliant design, so any civil and electric site work that follows can be streamlined and made more efficient.
- If a fleet's warehouse is leased rather than owned, they will need to consult with their landlord on how to handle costs, easement rights, and commitments related to infrastructure installation. It is important to start these conversations as early as possible.

- Electric vehicle supply equipment (EVSE) uptime is critical for commercial fleet operators, so fleets should have a support plan in place to resolve charger hardware and software issues in a timely manner before vehicles are put into service.

Insight Gained: Anticipate Unexpected Project Delays

One of the most important lessons learned about infrastructure development is the need to anticipate delays in charging infrastructure installation and to build in extra time ahead of the planned BEV delivery. Fleets should start site and equipment planning early to understand their power needs and develop project plans for infrastructure installation. Proactively engaging key stakeholders early — including the utility company and city agencies — will further mitigate delays and help calibrate a fleet's own expectations.



Infrastructure development projects with battery storage, photovoltaic solar systems, and other distributed energy resources (DER) are even more complicated and prone to delays. Procurement timelines for each piece of equipment must line up with the availability of the construction crew for site upgrades and installations. Utilities and contractors are more involved due to the additional equipment and have their own timeline considerations that need to align with project goals. Scheduling for multiple capacity checks and commissioning must be done well in advance of the equipment delivery date and are difficult to reschedule if the equipment installation is not ready for review.

Outside funding to offset project costs for the installer comes with hard deadlines for deployment dates and must be planned for at least half a year before the official project start date. The multifaceted nature of the project creates numerous opportunities for disruption that are outside the control of the project team.

Insight Gained: Utilities Should Streamline Internal Process Flows

Installing EV chargers requires a considerable amount of coordination from multiple entities, including the EVSE provider, the software provider, the construction/project management team, the funding agency (when relevant), the landlord (when relevant), city permitting offices, the local utility, and others. To further complicate the level of coordination required, the EV charging site owner must work with several different internal groups just within the utility when obtaining a utility interconnection, including the initial site inspection team, customer account, design, site energization crew, and final inspection team. Additionally, if the site has multiple devices (e.g., yard trucks, forklifts, chargers, solar panels, energy storage), the site owner may need to coordinate with additional groups within a utility company. Providing a single point of contact from the utility to facilitate the project and coordinate all internal team members would greatly streamline the process and improve the customer experience.

Insight Gained: Contract a Service Provider to Maintain and Repair EV Chargers

Maximizing vehicle uptime is critical for commercial fleets as their vehicles play a central role in their day-to-day operations. With that in mind, it's imperative that any issues that might prevent EV chargers from reliably

charging vehicles to the level needed at the time needed be resolved quickly. While several best practices have been introduced to maintain EVSE equipment — including installing collision protection measures, using shorter cords and cord controls, adding screen protectors, and more — site owners may still encounter issues. Many EVSE suppliers offer three-year warranties on equipment, but the warranty for added networking or cloud-based communication services may be handled separately. Additional challenges that can impact charger performance include electrical issues, damage caused by wear and tear or nature, connectivity, and more.

It's vital for site owners to establish a plan for quickly resolving EVSE performance issues. One recommendation is to establish a service-level agreement with a vendor that specializes in charger maintenance that can serve as a single point of contact for the site owner. Work with the chosen vendor to document agreed upon response times for EVSE troubleshooting and repair (hardware and software), as well as to ensure pricing transparency.

Insight Gained: Building Public Charging Infrastructure Comes with Unique Challenges

Public charging for heavy-duty trucks will help accelerate market adoption of battery-electric technology, however there are many independent factors that must be coordinated, making these sites especially challenging to plan. Existing state laws must first allow entities other than existing utilities to re-sell electricity to zero-emission truck owners. Once allowed, considerations ranging from site design, needed power expansion, and coordination with municipalities and planning authorities can make this an extremely long and cumbersome endeavor. Much depends upon the details behind a specific site and the potentially competing priorities and restrictions that must be aligned. While the Volvo LIGHTS project had originally included plans for a heavy-duty public charging station, the inability to overcome challenges with the site or to identify and develop a new site within the project timeline necessitated the elimination of this deliverable from the original project plan.







STRATEGIES TO REDUCE TOTAL COST OF OWNERSHIP

While transitioning to a BEV fleet can enable companies to significantly reduce vehicle operating costs over the long term, the upfront costs to procure BEVs and install charging infrastructure can be prohibitively high for many organizations. This presents a challenge as most business decisions are profit driven, and the shift to BEVs will not change this requirement. The overall cost of owning and operating electric trucks must be equal (at the very least) or cheaper (preferable) than today's diesel equivalent to motivate fleets to purchase them. Several strategies can be utilized to obtain cost parity with diesel trucks, including maximizing available funding and incentive programs, as well as incorporating onsite renewable energy generation and storage to reduce peak charging costs.

Insight Gained: Funding & Incentive Programs are Critical in Early Stages

While California legislation is being considered to provide some sales tax relief for zero-emission trucks, battery-electric truck purchase prices are still more than double their diesel counterparts. The higher purchase costs also translate to higher insurance costs, all of which must be offset with lower operating or maintenance costs for total cost of ownership calculations to be compelling. With BEVs being an early stage technology, it is difficult to rely on current estimates for long-term operational savings. As a result, fleets will require government funding incentives or tax breaks to offset upfront purchase prices and improve the business case for their investment. The federal government and some states offer dedicated grant programs for BEVs and related infrastructure, but the funding currently available isn't sufficient to support widescale market deployment. In California, several utilities offer incentive programs to buy down the capital equipment cost for their customers, which is a model that other states should consider emulating. Finally, fleets are encouraged to learn how LCFS credits can provide fuel cost savings and can even offset the entire cost of charging depending on the credit price.

Here are a few key lessons learned about the highly competitive funding landscape during the Volvo LIGHTS project:

	Align Goals — The funding agency may have different objectives than the fleet. To improve chances of receiving project support, it's vital to carefully review and understand a program's goals and scoring criteria.
	Plan Ahead — Developing a new clean vehicle project plan can take longer than the timeframe that funding agencies provide to apply. In addition, some programs are structured as "first come, first served," meaning that funding can be depleted before the application window even ends. Start monitoring funding programs opening in the future so that you can design your project strategy in advance and be prepared to respond to a solicitation as soon as it opens.
	Stack Opportunities — To further lower project costs, some funding agencies allow applicants to combine awards from more than one funding program. This is especially critical for infrastructure.
	Consult an Expert — Tracking the 500-plus funding programs across North America, understanding how to submit a winning application, and managing reporting requirements that come with grant awards can be a major challenge for organizations. Consider hiring a team of experts to provide additional grant funding support.

Insight Gained: Mitigate Peak Energy Demand Costs with On-Site Solar & Storage

Fleets should review their utility's EV rate plan and see if time of use rates and/or demand charges apply. If time of use rates apply, fleets should avoid charging during on-peak hours (4-9 p.m. in Southern California Edison's territory where the Volvo LIGHTS project took place). If demand charges apply, fleets should work to reduce their maximum power draw from the grid. This can be done by staggering charging times so not all equipment is charging at once, decreasing their max charge rate (kW), and/or installing on-site solar and energy storage systems. When electricity costs are low (usually in the morning), the energy storage device is charged. Then, when electricity costs peak, a fleet can charge its vehicles using the stored energy and minimize the impact of demand charges. This practice of avoiding the use of grid power during peak periods is known as "peak shaving," benefitting both utilities and fleets by reducing the total demand on the grid.

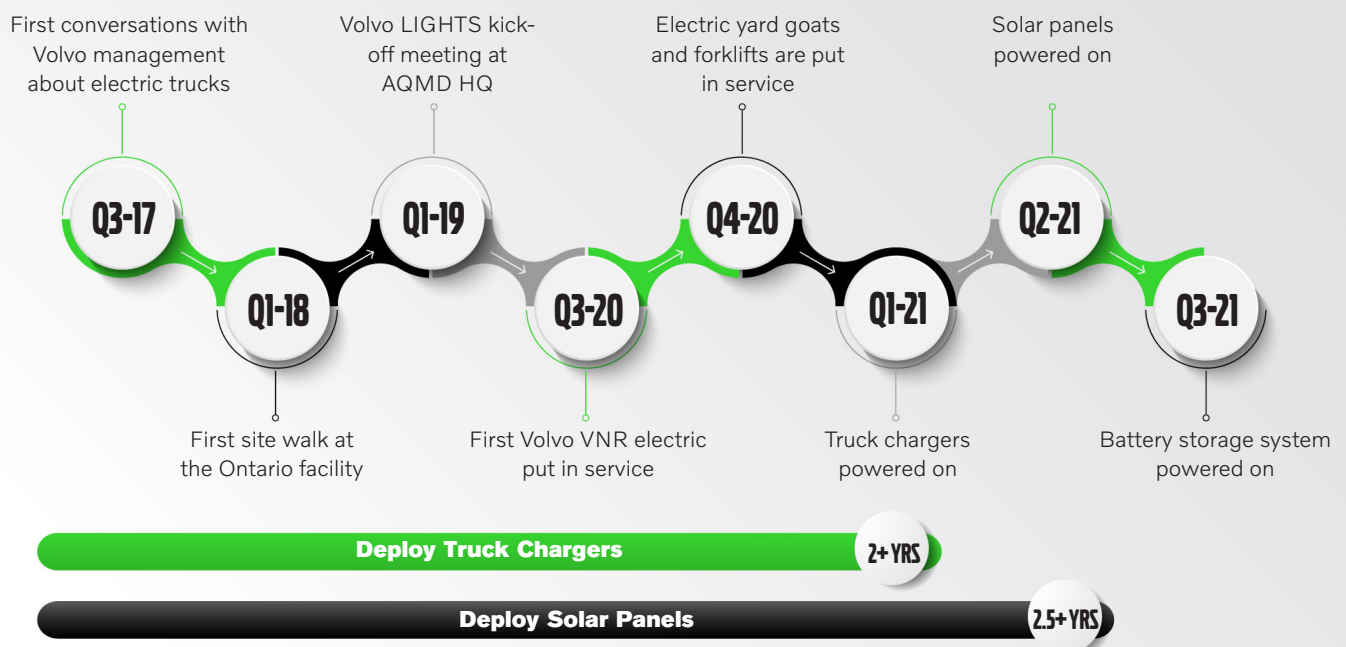


Caption: Dependable Highway Express installed solar panels and onsite energy storage at its shipping and receiving facility in Ontario, California.

Spotlight on the Dependable Highway Express (DHE) Ontario Facility:

As part of the Volvo LIGHTS project, DHE installed more than 2,300 solar panels on the roof of its Ontario facility and employee parking canopies. Annually, the solar panels will generate 1.11 GWh of renewable electricity — more than enough to power its building, the Volvo VNR Electric fleet, employee electric vehicle chargers, and battery-electric freight equipment without minimized peak utility pricing. DHE's investment in onsite solar panels, energy storage, and electric vehicles and equipment have enabled the company to save more than \$100,000 annually on fuel and energy costs.

While the solar panels have enabled DHE to garner positive economic and environmental benefits, the completion of the project took several years as shown in the graphic below. Fleet operators considering onsite solar installations should keep this in mind when establishing project timelines.



CUTTING-EDGE JOB TRAINING



Caption: Through the Volvo LIGHTS project, Rio Hondo College and San Bernardino Valley College designed a technician program specific to Volvo heavy-duty electric truck maintenance, helping to support workforce development in the region. Pictured: In May 2021, Rio Hondo's first students graduated from the program. From Left to Right: Adolfo Munoz, Duminda Edirisinghe, Thanh Nguyen, Cecilia Ledesma, Anthony Hong, Salvador Nieves, Januario Escutia, Richard Hadley, and Pedro Garcia.

Insight Gained: Workforce Development is Vital

Achieving widescale deployment of commercial BEVs and charging equipment will require a broad range of stakeholders to learn new and specialized skills, including truck technicians, drivers, first responders, charging solution providers, utility companies, and more. Through the Volvo LIGHTS project, each of these stakeholder groups had the opportunity to gain new skillsets for their individual roles, and also had the unique opportunity to understand each other's training needs and priorities. This insight is valuable so that each group can effectively collaborate as BEV deployments quickly expand.



Truck Technicians

Trained technicians are critical for boosting the uptime of electric trucks. Electric powertrains are vastly different than diesel trucks in terms of their parts. A common perception is that electric trucks will have fewer moving parts and are therefore less technically complex than diesel- and gasoline-powered trucks. Although true on one level, electric trucks also have highly specialized components, such as battery systems, advanced power management software and computing systems, regenerative braking systems, and high-voltage electrical systems, requiring the development and implementation of appropriate training modules for the safety of service technicians.

Commercial Market Update

Volvo Trucks Academy opened a state-of-the-art facility in Hayward, California, to support training efforts for the Volvo VNR Electric. The new training center will provide resources and support for technicians, dealer sales staff, and aftermarket personnel, as well as owner-operators and fleet customers.





Fleet Managers & Truck Drivers

Not unlike their diesel predecessors, driving style can have a significant impact on a truck's fuel economy, or charging range. This becomes even more important in these early days given the lack of public charging networks and limited opportunity chargers. Driver training is critical to maximizing the regenerative braking benefits, even for experienced drivers, potentially adding between 5-15% of the power back to the battery to extend range. Driver performance can help extend power in the battery; however, the battery state of charge can also be a function of the routes being driven. Even the best driver can only gain as much power from the regenerative braking as the chosen route allows. Length of the route between stops, topography, and weather conditions all impact the use of brakes and the draw of power on the battery, thereby further underscoring the importance of route optimization from a charging and duty cycle perspective.

Resources are available for fleet managers to analyze routes with Volvo's Electric Performance Generator Route Simulation Tool, allowing them to better understand which routes match the capability of the Volvo VNR Electric.



First Responders

First responders need the best training possible to effectively do their jobs in challenging and often hazardous environments and situations. When introducing an entirely new vehicle technology to a market — such as battery-electric trucks — it is vital to train first responders before the technology takes to the road. The vehicle manufacturer is an ideal place to start when assembling a team. The engineers who designed the vehicle can provide detailed technology diagrams and share training materials that have been developed for its dealership network and vehicle technicians, as well as important information about high-voltage charging safety.

It's also helpful to partner with local education and training organizations that may have already conducted similar types of training with first responders. For the Volvo LIGHTS project, Rio Hondo and San Bernardino Valley College were a perfect fit given their experience training students to maintain and repair vehicles equipped with advanced vehicle technologies. In addition to helping design training resources, both schools can help provide on-the-ground, long-term training support moving forward.



Charging Station Technicians

Uptime for fleets is a critical metric, so performance issues with chargers need to be diagnosed and addressed immediately, particularly if they hamper the ability to charge the trucks. Most early adopter fleets will not have the technical background, nor prior experience, using or troubleshooting this new equipment. Charging solution providers need to have staff available to support fleets during the initial handoff and early days to aid a smooth transition and positive experience. In addition, it is critical to have access to a local network of trained service technicians that can help troubleshoot issues and get EV chargers back online quickly.



Utility Companies

To increase adoption of electric trucks, utilities can first begin with dedicated programs that offer infrastructure incentives, business-friendly electricity rates, and resources to fleet operators transitioning to electric vehicles. By recruiting and training dedicated program staff, utilities can more effectively reach their existing commercial customers and engage with them through a long process of fleet education. It is critical that utilities clearly translate the benefits of deploying electric vehicles with an emphasis on the cost savings available for fleet operators.

Some of the nation's largest utility companies are now creating entirely separate business units to support transportation electrification initiatives and staffing up to guide their customers along this transition. At a national level, most utilities are simply not ready today to support a large-scale transition to commercial BEVs.

ROBUST SALES & SERVICE SUPPORT



Caption: TEC Equipment Fontana was named Volvo's first EV Certified Dealership.

Truck dealerships play an important role in the introduction of new vehicle technology, serving as a vital resource for the point of sale — including advising on the right configuration to meet a fleet's operational needs, offering test drive opportunities, arranging vehicle financing and registration, and more. After vehicles are delivered, dealerships serve as a local resource to perform routine maintenance and repairs, keeping parts in their local inventory to minimize downtime.

More than 122,000¹ people are employed at truck dealerships across the nation to support medium- and heavy-duty trucks, the majority of which are equipped with diesel engines. This robust support model needs to be replicated to support the widescale introduction of battery-electric trucks. There are numerous factors to take into consideration: comprehensive training requirements, unique safety concerns, infrastructure upgrades, sourcing and ordering new parts, configuring maintenance bays to accommodate additional equipment, and more.

To support the fleet customers operating battery-electric trucks through the Volvo LIGHTS project, Volvo Trucks collaborated with its largest West Coast dealership, TEC Equipment, to design and implement the training, as well as the necessary facility and equipment upgrades.

Commercial Market Update:

Volvo utilized the experience gained working with TEC Equipment on the Volvo LIGHTS project to launch its Volvo Trucks Certified EV Dealer program. The certification program will enable Volvo Trucks to build the robust sales and service ecosystem required to help fleets across the country achieve their zero-emission transportation goals. TEC Equipment in Fontana, California, was the first to achieve the certification, with additional dealers in California, Texas, Virginia, New York, and Quebec following soon after. By the end of 2022, Volvo Trucks anticipates having 20 Certified EV Dealers.

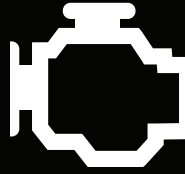


Insight Gained: Dealer Preparation is Key



Sales Support

At the point of sale, it's critical for sales staff to be able to help customers evaluate which of their routes might be the most ideal for electrification and how to select the right vehicle configuration.



Parts & Components

To minimize service times and quickly get customers back on the road, dealerships should maintain a stock of key parts and components for battery-electric models.



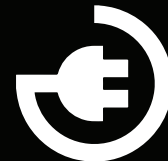
Safety Protocols

Dealerships must ensure technicians understand the proper safety procedures when servicing high-voltage electric drivetrains and components, as well as provide personal protective equipment.



Repairs & Maintenance

Technicians will need specialty training to work on battery systems, advanced power management software and computing systems, regenerative braking systems, and high-voltage electrical systems.



Charging Infrastructure

Dealerships will need to install chargers inside truck maintenance bays to avoid issues with battery depletion, as well as outside to enable fleet customers to fast charge at the dealership.



Caption: TEC Equipment Fontana's technicians have been fully trained and equipped to safely perform battery-electric truck maintenance and repairs for trucks in operations.

PROJECT SUMMARY

Over the three-year project, the Volvo LIGHTS partners designed and implemented a blueprint for the complete ecosystem needed to successfully deploy commercial battery-electric freight trucks. While the Volvo LIGHTS project took place entirely in Southern California, the lessons learned from the project can be replicated in any region to support fleets with the transition to electromobility solutions.

The project underscored the interdependence among diverse stakeholders and the need for cooperation and engagement from all of them to be successful.

FLEET OPERATORS

Freight transport companies will need to identify routes that are best suited for electric trucks and train their drivers and technicians to maximize efficiency and uptime.

PUBLIC AGENCIES

Local, state, and federal agencies will need to offer public funding and incentives during early stages of market adoption to make the transition more cost-effective for fleets of all sizes.

DEALERSHIPS

Dealership staff must be fully trained and equipped to provide the robust sales and service support required for customers to achieve zero-emission transportation goals while maximizing uptime.

VEHICLE MANUFACTURER

BEV manufacturers will need to adapt product offerings based on customers' unique operating requirements (i.e., range, charging frequency, operational duty cycle, dwell time) and financing needs.

FIRST RESPONDERS

First responders should receive proper training on how to safely respond in case of an incident or accident involving a battery-electric truck.

TECHNICIAN TRAINING CENTERS

Partnerships with workforce development organizations (e.g., technical colleges) are needed to ensure technicians have the proper technical training and understand all safety procedures when servicing electric drivetrains and components.

EV CHARGING PROVIDERS

Robust public and private infrastructure will need to be developed to minimize range anxiety and extend the length of transport routes. Charging will need to be reliable and cost effective. Involving permitting authorities early will improve project success.

ELECTRIC UTILITIES

Local utilities should support commercial customers with electric truck adoption by offering financial incentives and rebates for charging infrastructure, as well as hiring and training experts who can help fleets design and implement necessary facility electrical upgrades.

VOLVO LIGHTS BY THE NUMBERS

TRUCKS & EQUIPMENT

30

battery-electric heavy-duty trucks deployed

58

public and private electric vehicle chargers installed

29

battery-electric vehicles to support warehouse operations

250,000+

miles driven

2

electric truck aftermarket service centers

ENVIRONMENTAL BENEFITS

1.86

million kWh of renewable energy generated

3,020

metric tons of GHG emissions reduced per year

3.57

tons of NOx, ROG, and PM emissions reduced annually

207,000

diesel gallons equivalent displaced annually

FUNDING & PARTNERSHIPS

14

public and private partners

\$90

million in costs

\$44.8

million in funding

WORKFORCE DEVELOPMENT

2

colleges designing electric truck maintenance programs

45+

graduates from the Rio Hondo and San Bernardino Valley College HDBEV technician training programs during the project

2

Southern California dealerships completed the Volvo Certified EV Dealer training for their sales and service teams

VOLVO LIGHTS PROJECT AWARDS

BREATHE SOUTHERN CALIFORNIA 2020 INNOVATION AWARD



The Volvo LIGHTS project was named the 2020 Innovation Award Honoree at the Breath of Life Awards Gala. The event celebrated influential leaders in the Southern California community for accomplishments that align with BREATHE Southern California's mission of promoting clean air and human health through research, education, advocacy and technology.

[LEARN MORE](#)

CALSTART 2020 BLUE SKY AWARD



The Volvo LIGHTS project was honored with CALSTART's 2020 Blue Sky Award at the organization's Annual Meeting. The annual Blue Sky Award is presented to organizations and individuals who have made outstanding marketplace contributions to clean air, climate change mitigation, and the development of clean transportation technologies.

[LEARN MORE](#)

2021 CLIMATE LEADERSHIP AWARD - INNOVATIVE PARTNERSHIP



The Volvo LIGHTS project accepted a 2021 Climate Leadership Award for Innovative Partnership. The award was presented by the Center for Climate and Energy Solutions (C2ES) and The Climate Registry (TCR) during a virtual event to showcase and recognize exemplary corporate, organizational, and individual leadership in reducing carbon pollution and addressing climate change in their operations and strategies.

[LEARN MORE](#)

SOUTH COAST AQMD'S 32ND ANNUAL CLEAN AIR AWARD



Volvo Group North America was selected as South Coast AQMD's 32nd Annual Clean Air Awardee for Innovative Clean Air Technology. This award is presented for the Volvo LIGHTS project for an extraordinary contribution to the development and application of a new and innovative technology designed to reduce emissions.

[LEARN MORE](#)

SCAG 2022 SUSTAINABILITY AWARD



The Volvo LIGHTS project won the 2022 Southern California Association of Governments (SCAG) Sustainability Award for Outstanding Achievement in Sustainability. This is the highest honor category in the program and recognizes projects that best exemplify the core principles of sustainability.

[LEARN MORE](#)



Caption: Volvo LIGHTS project partners at an educational launch event hosted in February 2020.

To view additional details on the Volvo LIGHTS project, including photos and videos, visit:

www.LIGHTSproject.com

Reference Materials:

1. American Truck Dealers, a division of NADA. "ATD Data." Retrieved March 28, 2022, from <https://www.nada.org/atddata/>
2. Fenton, Dawn and Aravind Kailas. "Redefining Goods Movement: Building an Ecosystem for the Introduction of Heavy-Duty Battery-Electric Vehicles" World Electric Vehicle Journal. September 7, 2021.

