Approaching Zero Emission Trucking: Challenges and Opportunities

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MIT Sustainable Supply Chain Lab

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MIT Center for Transportation & Logistics

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Executive Summary

On 6 – 7 November 2024, the MIT Center for Transportation & Logistics (CTL) hosted a roundtable titled "*Approaching Zero Emission Trucking: Challenges and Opportunities.*" Facilitated by the MIT FreightLab and the MIT Sustainable Supply Chain Lab, the roundtable brought together some 30 stakeholders, including motor carriers, shippers, nongovernmental organizations (NGOs), researchers, and government experts, as well as researchers from CTL for productive and wide-ranging discussions. Participants shared their thoughts on identifying, measuring, and managing Scope 3 emissions; emission-reduction strategies, including zero-emission (ZE) trucking solutions; and the risks and challenges of implementing emission-reduction initiatives. They also identified potential research topics that would provide value to their organizations and industries.

Key Takeaways

There were three major takeaways from the roundtable discussions:

1. There is no one-size-fits-all solution or "silver bullet" for reducing emissions in the trucking industry. Battery-electric trucks are seen as a promising technology for certain applications, such as last-mile delivery and short-haul trucking. However, other options, such as renewable diesel, biodiesel, renewable natural gas, and hydrogen fuel cells, may be more appropriate for other use cases. Improved operational efficiency has a role to play too. The government's dominant focus on battery-electric trucks was viewed as overly restrictive and in some cases counterproductive. Other bridging or transition technologies that would greatly reduce emissions with minimal economic impact should play a role.

2. There is a need for greater standardization in how emissions, mainly Scope 3, are measured, allocated, and reported. The lack of a reliable standardized methodology makes it challenging for companies to determine not just what to measure but also how to do it. This creates doubts about the accuracy of the reported data. This lack of clarity also makes it difficult to compare emissions data across companies and to track progress over time. An additional challenge is how to determine the true economic value of emission-reduction efforts.

3. Risks and barriers to adoption and implementation are difficult and costly to overcome. Corporate leaders often are reluctant to invest in the necessary equipment, technology, and personnel without a quantifiable ROI. And carriers that invest in expensive zero-emission (ZE) equipment and infrastructure are finding that even those customers who value—and even demand—lower-emission transportation aren't willing to pay more for those services. The biggest holdup, though, is the lack of adequate charging

infrastructure and utilities' inability to provide it when trucking fleets need it. Solving these and other barriers to adoption will require collaboration among multiple stakeholders, including governments.

Potential Next Steps

Roundtable participants agreed that few—if any—of the cost, technical, regulatory, or operational barriers to adoption and implementation of zero-emission vehicles will be overcome by a single player. Instead, collaboration among stakeholders will be essential for overcoming the challenges of transitioning to a zero-emission trucking industry. This includes cooperation among motor carriers, shippers, vehicle manufacturers, utilities, technology providers, research institutions, and government agencies. Collaborative efforts will be needed to develop standardized methodologies, optimize infrastructure deployment, and explore innovative solutions.

Participants suggested several potential research projects that they believe would "move the needle" regarding reducing or eliminating truck emissions. The following are some of their suggestions:

- Fueling infrastructure: What network of fueling stations would be required to accommodate the number of electric and other alternative fuel trucks that will be needed to meet emissions-reduction goals?
- Permitting: Can we develop a framework for regulatory bodies on how to approve EV projects, including construction and utility service?
- Human resources: It's hard to get engineers to work in this area, so how can we help and support staffing expertise in utilities and local governments?
- Empty miles: Decarbonization may be hard for individual fleets. How could shippers and carriers work together to minimize empty miles?
- Battery capacity and range: How can batteries be improved to reduce or eliminate some of the current distance and performance constraints?
- Cost projections: What assumptions should we be making about the future prices of fuel, maintenance, trucks, and tax incentives?
- Calculating ROI: How can we calculate the economic value of zero-emission vehicles, and what would be a sufficient incentive for companies to adopt them?
- Scope 3 emissions: Double counting of Scope 3 emissions by various players is unavoidable. How do multiple stakeholders identify that overlap, share those costs, and benefit from the emissions savings?

Summary of Discussions

MIT CTL Roundtables are open-ended, free-form discussions between all participants. There are no presentations or pre-prepared lectures. The conversation was moderated, and notes were taken by CTL staff. This summary organized the conversations into the three main takeaway themes.

Solutions for reducing emissions in the trucking industry

Roundtable participants largely focused on electric vehicles (EVs), the most common zero-emission equipment. But the discussion covered a range of other options and strategies for reducing emissions.

Battery-electric vehicles

To date, battery-electric power is the number one choice for zero-emission trucks; hydrogen has few adopters so far. Battery technology is well-developed, EVs are available in various capacities from several OEMs, governments offer tax incentives, and some regulatory regimes, such as in California, require or incentivize their adoption. Their lack of emissions and engine noise make them well-suited to urban applications. Class 8 EVs are expensive, though; one participant called them "a $350,000 asset," while another cited a $100,000 price tag. However, a shipper with a fleet of last-mile delivery vans said the smaller vehicles can be less expensive to buy than the gasoline-powered equivalent.

Battery-electric power has limitations that affect route planning, duty cycles, and the type of loads assigned. One is travel range per charge, which is influenced by distance, load weight, topography, driver behavior, temperature, and other factors. One carrier running Class 8 EVs is getting about 250 miles on a single charge for drayage operations, while a shipper said they get over 400 miles on their private fleet's Class 8s. The shipper limits the geographic operating area to ensure that the trucks, which take 6–8 hours to charge, can make it home before the battery runs out. (Some manufacturers' models take less time to charge.) The cost of electricity, which varies significantly with the location, time of day, and the utility providing it, is another consideration. Still, some shippers expressed optimism that Class 8 EVs will soon gain ground. "The economics are starting to look more attractive. If we can make the economics work in the US, that will incent adoption," a shipper said.

Battery-electric trucks may not be as effective in reducing carbon emissions as many assume. When a trucking industry research organization looked at the *total* emissions associated with EV batteries (such as emissions from mining and processing lithium and other minerals, battery production and transport, and electricity plants that burn fossil fuels) they found only a 30% reduction in carbon emissions compared to the use of diesel

fuel. “If we were to convert all heavy-duty long-haul fleets,” a researcher said, “per truck, that would only decrease total emissions by 30%. We were shocked, and it was also disappointing.”

Alternative fuels

Some participants advocated for renewable fuels as a means to reduce carbon emissions by 30% and potentially more. However, those fuels still require combustion and therefore produce carbon and other pollutants, albeit less than regular diesel does. Among the options participants currently use are biodiesel (made from treated vegetable oils and animal fats), renewable diesel (a hydrocarbon made from plant matter that is chemically equivalent to petroleum diesel), and renewable natural gas (made from organic matter that has been processed to produce compressed natural gas or liquefied natural gas). Users noted that biodiesel is 7–8% less energy-dense, and that renewable diesel is about the same energy density as regular diesel. Cost is a consideration: In California, renewable diesel is less expensive than regular diesel, one shipper said. But some alternative fuels are not widely available outside of the West and Gulf Coasts, and prices can be high in other regions. Several motor carriers said they blend biodiesel and regular diesel; one noted that this does not require any significant modifications to the truck, while another cited a cost of about $30,000 to modify a truck to be able to use 100% renewables. A major national carrier said, “We think renewable natural gas is the future and that we could achieve about a 70% reduction in emissions with it. But it would require a completely new engine and much more mature technology.”

Other methods

Participants felt that providers and buyers of transportation services should look beyond batteries and the gas tank to other strategies for reducing carbon emissions, even though they do not totally eliminate emissions. Examples included:

- *Vehicle design*. Emissions can be reduced through greater fuel efficiency, achieved by aerodynamics (such as with cab designs and trailer skirts that reduce drag) and more efficient engine designs. According to one carrier, new Class 8 trucks are up to 90% more fuel-efficient than similar, 12-year-old models.
- *Operational efficiency*. Minimizing empty miles and consolidating shipments on fewer trucks were mentioned by several participants. As one carrier put it, “A mile not traveled has no emissions.”
- *Carbon offsets*. A company buys carbon offsets through an established program, and the money is used to fund specified emissions-reduction efforts. In effect, the buyer is compensating for its own emissions by paying to have carbon reduced elsewhere. Shippers who are using offsets said they help them meet corporate

goals. “We will try to reduce carbon emissions by X% and go for what’s economically possible, and then use offsets to close the gap,” said one shipper.

The challenges of measuring and reporting emissions

The lack of a standardized methodology makes it challenging for companies to determine not just what to measure but also how to do it. Participants broke this issue down into three steps: goal setting, measuring, and reporting.

Setting goals

Emission-reduction goals ranged widely, with some reflecting overall corporate commitments and others specific to trucking fleets. One motor carrier committed to a 32% reduction of emissions by 2034, arriving at that figure through research and consulting with vehicle OEMs, fuel suppliers, and other stakeholders. Several participants said they adopted moderate goals after considering aggressive, moderate, and low options. Those scenarios were based on projections for fuel and equipment costs, technology, economic conditions, market demand, and implementation costs over a set time frame; 5, 10, and 20 years out were common.

One shipper cautioned that goals and any roadmap for achieving them should be reevaluated periodically. “You have to revisit and reevaluate a roadmap that may not be legitimate any longer because it is based on assumptions that may not have played out. For example, we thought we would be buying hundreds of electric vehicles by now, but because charging infrastructure is lacking it is taking much longer than expected.” For that reason, an NGO recommended adopting realistic goals, and then outlining a basic plan for reaching them, with the stated caveat that the goal may be modified as new information and technology become available.

Deciding how to measure emissions

Many participants are unsure how best to measure their emissions and allocate them to parties with some responsibility for generating them. Examples of approaches they currently use include modeling/projecting fuel consumption; extracting mileage and fuel usage from a telematics system; tallying gallons of fuel purchased; and measuring ton-miles. A CTL researcher noted, “Fuel usage is affected by distance, weight, topology, temperature, driver behavior, truck engine model, etc. If you really want to know truck emissions, you have to measure at the tailpipe.” Participants, though, cautioned against getting too fine-grained. One carrier asserted that the greater the granularity, the more difficult it is to be accurate, because of complexity and the large amounts of data and data sources. A shipper recommended measuring factors that will have a significant impact on emissions reduction, rather than devote costly resources to metrics that will make little or

no difference in progress toward sustainability goals. And while a CTL researcher agreed with that, he argued that it's important to also have a method that considers the "levers" that inform decisions. For example, many decisions will be made at the equipment level, such as whether to buy new trucks with better technology.

Reporting emissions

Motor carriers report their emissions and/or reductions for two reasons: either for regulatory compliance, or to demonstrate their achievements to customers and investors. Carriers said they increasingly see RFPs from large customers that require a specified minimum score on sustainability practices, including emissions reduction. These scores or certifications are awarded by certain organizations, such as EPA SmartWay, CDP, and Ecovadis. Depending on the organization, it can take well over 100 hours to prepare a submission. Criteria are strict: One carrier noted that it may be necessary to create required policies if an applicant doesn't already have them; his company, for example, had to create a supplier code of conduct.

Several participants from public companies noted that posting claims of sustainability achievements in annual or other reports can create liability issues if they are not documented. The wording is important to avoid any legal actions by shareholders. Posting potential targets and goals are fine, but a company should not make claims of achieving goals if not backed up. A shipper said auditing and third-party verification is critical to ensure consistency and transparency in emissions reporting.

Risks and barriers to adoption and implementation

Participants saw numerous business risks and barriers to adoption and implementation of zero-emission trucks. Some were economic or regulatory in nature, while others involved technology and infrastructure.

Return on investment

Private and for-hire fleet operators recognize that decarbonization is a public good, but unless they can demonstrate the economic value of sustainable transportation, fleets will struggle to gain financial support from company leaders for expensive equipment, technology, infrastructure, and personnel. So far, they can't rely on their customers for help: Every carrier in the room agreed that, with extremely rare exceptions, even customers who are clamoring for EVs are unwilling to share the financial burden—even if the extra charge would be as little as $60–$90 per load. EV usage will not scale up until the vehicles are cost-competitive and attractive to invest in, one shipper said. Another shipper with a private fleet said, "It's very hard to make economic sense where all equipment is zero emissions. I don't see it happening anywhere without it being required by regulations."

Regulatory compliance

Compliance with carbon-emissions regulations places costly administrative burdens on motor carriers. Carriers said they have had to hire staff and outside consultants to help them monitor and comply with federal, state, and local regulations. California, with the strictest air-quality regulations in the nation, was deemed the most difficult and confusing for regulatory compliance, due to the state's numerous required audits, documentation, registrations, and certifications. For example, one private fleet executive noted that local air-quality districts in that state have their own specific rules.

Thinking about the future of emissions regulation, participants wondered whether states might become more aggressive if the new federal administration loosens environmental regulations. That seems likely: According to an NGO participant, a consortium of 17 states has adopted a target of 30% of new heavy-duty vehicles to be zero-emission models by 2030 and 100% by 2050. The consortium is developing a model action plan for member states. However, state and local regulations will still differ so much that they will continue to be difficult and costly to manage.

Technology and infrastructure

Roundtable participants identified several technical barriers to EV adoption. Top of mind for many was the need to expand battery capacity and range for Class 8 trucks. Otherwise, trucks carrying heavy loads will continue to be limited in distance and geography, introducing inefficiencies and additional cost. They were especially concerned about the difficulty of obtaining high-capacity electrical service for vehicle charging. Local utilities may take two or more years to install upgraded electrical service, even though the property owner covers much of the cost. "If a utility can provide 3 megawatts, we can order electric trucks today and have a new DC built and delivered in 5 to 6 months, but the utility infrastructure takes 3 to 5 years," said a shipper with a private fleet. "So I can buy all the trucks I want, but the infrastructure isn't in the same time frame." Nationally, the lack of charging infrastructure on interstate and state highways severely constrains EV travel. A study for the American Trucking Associations (ATA) forecast that it would cost trillions of dollars to provide the necessary charging stations and electrical service across the country. This may largely be left to federal and state governments: Private industry will not invest in infrastructure unless there is an ROI, but federal law prohibits commercial activity—including paid charging—at 40,000 rest areas, a researcher said.

Additional Resources

For those looking for further information about the current state of zero-emission vehicles and infrastructure, relevant regulations, and the future of zero-emission vehicles in the United States, roundtable participants suggest the following research reports:

- From the MIT Sustainable Supply Chains lab:
  - The latest annual State of Supply Chain Sustainability Report
  - The Effect of Framing the Environmental Impact of Fast Shipping on Nudging Consumers to Opt for Slow Home Deliveries: Evidence from the Field. This study challenges previous studies that claimed that individuals with higher socioeconomic status, younger age, and female gender are more environmentally concerned. Results show that these factors do not affect consumers' willingness to choose green deliveries when they are provided with relatable information about environmental impact.
- From the North American Council for Freight Efficiency:
  - Confidence in Renewable Natural Gas Report
  - Summaries of past *Run on Less – Electric Efforts* - 2023 - 2021
  - The PepsiCo 1076-mile day
  - Messy Middle Decarbonization fleet decision making
- From the Joint Office of Energy and Transportation:
  - National Zero-Emission Freight Corridor Strategy
  - Multi-State Transportation Electrification Impact Study: Preparing the Grid for Light-, Medium-, and Heavy-Duty Electric Vehicles
  - Major Drivers of Long-Term Distribution Transformer Demand
- From the Environmental Defense Fund:
  - EDF report: Building The Grid To Need: There is much utilities can do to expedite the build-out of charging infrastructure that is appropriate for trucks. This report presents several best practices for utilities to proactively develop the local grid to support heavy-duty electrification.
  - EDF Green Freight Handbook: This is a guidance document for shippers seeking to drive forward on their sustainability journey. While it is a bit dated, the core framework holds for both the immediate opportunities that shippers have for reducing emissions from freight efficiency and mode choices; and the long-term impact they can have by working with carriers to support the uptake of lower emission equipment.
  - *Nature* article: This article from Gaige Hunter Kerr, et al., makes a clear connection between pollution in and around warehouses and its impact on

local communities. The authors used satellite data to uncover the impacts of air pollution from warehousing in the United States. EDF was not affiliated with this study.

- From the American Trucking Research Institute:
  - ATRI-Renewable-Diesel-A-Catalyst-for-Decarbonization-04-2024.pdf File Size 2.7 MB Click Here to Download
  - ATRI Understanding CO2 Impacts of Zero-Emission Trucks 05 2022.pdf File Size 5.8 MB Click Here to Download
  - ATRI Charging Infrastructure Challenges for the U.S. Electric Vehicle Fleet 12 2022.pdf File Size 4.3 MB Click Here to Download
- From Link Logistics:
  - 2023 Sustainability Report | Link Logistics