

Zero Emission Road Freight Strategy

2020-2025

PUBLIC, April 1, 2020

Thanks to those who contributed to the strategy development:

Consultant: Hovland Consulting LLC

Funders: Aspen Global Change Institute, Children's Investment Fund Foundation, ClimateWorks Foundation, Energy Foundation, Energy Foundation China, Energy Innovation, European Climate Foundation, Heising Simons Foundation, IKEA Foundation, Mcknight Foundation, Mercator, Oak Foundation, Pisces Foundation, Shakti Sustainable Energy Foundation, Tempest Advisors, Zero Now Fund

NGOs and Experts: Better World Group, C40 Cities Climate Leadership Group, CALSTART, Center for Community Action and Environmental Justice, Chicane labs, Coalition for Clean Air, Clean Energy Works, Climate Nexus, Communities for a Better Environment, Earthjustice, East Yard Communities for Environmental Justice, Electrification Coalition, Energy Media, Environmental Defense Fund, EV100/The Climate Group, Forth, Greenlining, International Council on Clean Transportation, Labor Network for Sustainability, Lawrence Berkeley National Laboratory, Los Angeles Cleantech Incubator, Moving Forward Network, Natural Resources Defense Council, North American Council for Freight Efficiency, Rocky Mountain Institute, Sierra Club California, Smart Freight Centre, Transport & Environment, UC Davis, Union of Concerned Scientists

Others: California Air Resources Board (CARB), Deutsche Post DHL Group, Former CARB policymaker, Former Senior Environmental Protection Agency policymaker, South Coast Air Quality Management District, Tesla, shippers, and others

Table of Contents

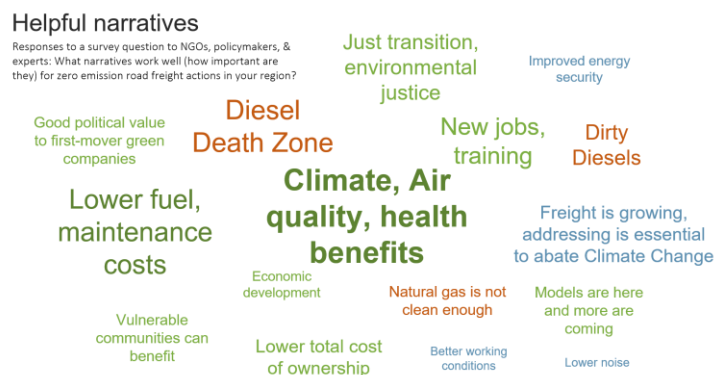
Executive Summary	1
1. Why we must address road freight now	5
The problem and opportunity	5
What do we need to overcome?	7
Why now? Dropping battery prices, market taking off, good news in all market segments, growing numbers of allies, and attractive total cost of ownership	10
2. Theory of change, outcomes, and interventions	19
Overall theory of change and goals	19
A. Accelerate zero emission trucks (ZE Trucks)	22
B. Deploy large-scale charging/infrastructure & zero emission fuels	24
C. Broaden and deepen support: Allies, coalitions, knowledge sharing, comms, funding	26
3. Regional landscapes & strategy overviews	31
China	33
Europe	34
United States	35
India	36
Cross-regional	37
4. Funding	38
\$75+ million per year needed	38
5. Monitoring	39
Implementation markers	39
Risks	40
Appendix A: Process and interviewees	42
Lessons from passenger vehicle electrification evaluation	43
Appendix B: Detailed logic model and additional research	45

Executive Summary¹

Climate context: In 2017, the Hewlett Foundation's Board renewed its third five-year commitment to our Climate Initiative. The new [climate strategy](#)² aims to achieve deep decarbonization by mid-century, focusing on the biggest emitting regions (the United States, China, India and Europe), six thematic areas (Transportation; Electricity; Industry; Finance; Strategic Communications and Carbon dioxide removal). This strategy is a sub-set of our transportation strategy and zeroes in on road freight – covering why it's important, what has changed recently, what needs to be overcome, what we plan to fund and where, how much it will cost, and how we plan to track progress. Note that we will continue to support passenger transport decarbonization, although we will rebalance our funding as our overall transportation program budget is largely unchanged. We will soon be releasing an update of our overall transportation strategy.

Why freight? In today's global economy, trucks work around the clock to deliver goods from ports, warehouses and manufacturing hubs. Freight movement, particularly by road, is increasingly a major contributor to climate change: Road freight emissions make up 30% (today) to 35% (in 2050) of transportation CO₂ emissions, and ton-kilometer activity is predicted to triple globally by 2050 (in contrast, passenger kilometer traveled is expected to increase by 15% by 2050). Trucks have dire health consequences: Each year, 180,000 people die from the effects of pollution from on-road diesel vehicles, representing 3.7 million years of life lost annually. To reduce emissions in line with a below 2°C scenario and dramatically improve health and air quality, road freight must transition to zero emissions. Our goals are to realize 30+% zero emission share of truck sales by 2030, 80% by 2040, and 100% by 2050 in our regions, with uptake in the rest of the world lagging only slightly – and absent philanthropic investment and partner actions we are not on the trajectory to get there.

What's changed? Fortunately, in the last couple of years, opportunities have emerged that give us a viable pathway to decarbonize road freight, and momentum is building. Increasingly, governments at all levels (city, sub-national, national) are demanding reduced emissions and oil use from the transportation sector to improve public health, improve energy and economic security, and mitigate climate change (see figure for other positive narratives related to zero emission freight). Several governments have implemented or begun deliberating policies for trucks and refueling (charging) infrastructure that will lead to zero emission truck deployment at scale, including California's Advanced Clean Truck Rule.³



¹ This document was prepared as part of the Hewlett Foundation's internal planning process and does not represent actions to be taken by Hewlett Foundation staff or by grantee staff at the Foundation's direction. Although some of the activities described and implementation markers may reflect the passage of legislation (based on inputs from grantees and experts in the field), the Hewlett Foundation does not lobby or earmark its funds for prohibited lobbying activities, as defined in the federal tax laws. The Foundation's funding for policy work is limited to permissible forms of support only, such as general operating support grants that grantees can allocate at their discretion, and project support grants for non-lobbying activities (e.g., public education and nonpartisan research).

² "Climate Initiative Strategy 2018-2023," Hewlett Foundation (2017). <https://hewlett.org/wp-content/uploads/2018/01/Hewlett-Foundation-Climate-Initiative-Strategy-2018-2023.pdf>

³ <https://ww2.arb.ca.gov/our-work/programs/advanced-clean-trucks>

The COVID-19 pandemic and recession

This strategy document was almost ready for release when the COVID-19 pandemic ballooned into a global crisis that has dramatically changed everyday life and is all but certain to lead to a severe global recession. The shelter-in-place and curfew orders in China, Europe and the United States have, if anything, dramatically accelerated an ongoing trend toward online shopping for food and other goods. In India and the rest of the Global South we may not see such dramatic changes in the same trend due to lower incomes and therefore, lower adoption rates of home delivery. The dramatic drops in transportation emissions⁵ we are seeing due to imposed lockdowns are mostly expected to be temporary, but the shift to online shopping may endure. From this perspective, the focus of this strategy on increasing the share of zero emission freight vehicles of all types becomes even more critical and can potentially mitigate greenhouse gases even further than we expect.

Further, governments around the world are already passing legislation for massive public spending to combat the recession precipitated by the pandemic. While the bulk of these stimulus packages should provide immediate relief for those most impacted by the crisis, the parts dedicated to longer-term recovery may result in new political opportunities to advance zero emissions transportation. For example, large scale public spending on charging infrastructure for electric trucks, which would have been difficult to realize previously may now be possible in all regions. The majority of the outcomes, pathways and tactics presented in this strategy continue to hold true in this new scenario although priorities may be reordered. We actively invite ideas from our grantees on new opportunities and barriers to help us update our strategy as the crisis evolves rapidly. Further, as we make grants, we will remain flexible with respect to the goals and theory of change of our grantees.

As battery costs continue to drop faster than expected, zero emission truck models are emerging, with 200 models announced, including many in the heaviest, long-haul segments. Electric trucks have substantially lower fuel and maintenance costs than diesel trucks, leading to increasing interest among shippers and truck operators for zero emission road freight. Hydrogen and fuel cell technology also shows potential to be a viable solution for long-range trucks; however, the costs and infrastructure needs still present a steep challenge. Over the past few years, ~1,000 Zero Emission Trucks (ZE Trucks) have been tested in more than 60 pilots in medium and heavy-duty applications.

Additionally, first-mover fleets and governments across the world are serious about achieving zero emissions. Shenzhen's (China) urban logistics fleet went from 0% to 35% electric in just three years with over 60,000 e-vehicles. Deutsche Post DHL (Europe) has over 9,000 zero emission (mostly electric) trucks delivering parcels, and thirty cities in the Netherlands committed to zero emission urban logistic zones in city centers by 2025. Amazon (US) ordered 100,000 electric urban delivery vans for delivery by 2030. Delhi (India) plans for up to 1,000 electric delivery vehicles by early 2020. IKEA (global) has fully-electrified deliveries in Shanghai and will have full zero emission delivery by 2025. The ports of Los Angeles and Long Beach (CA, US) committed to 100% zero emission port (drayage) trucks by 2035. Refuse trucks are going electric in China, Europe, and the US. And Tesla has 2,000 pre-orders for its long-haul battery electric tractor trailer. Nikola unveiled two long-range fuel cell tractor-trailer models in 2019 that are capable of refueling in 10 to 15 minutes and travel 750 miles on a full tank of hydrogen.⁴

What needs to be overcome? For the first time, viable technological solutions exist to put road freight (and virtually all road transport) on a path toward zero emissions by mid-century with significant benefits for human health and the climate. But to succeed, we must overcome steep barriers to uptake. The three dominant concerns of truck buyers today are higher vehicle prices, low model availability, and a lack of fueling infrastructure. Purchase price parity for some truck types will be here within 5 years and total cost of ownership is already attractive for many use cases. As electric truck sales

Barriers

Based on responses to a survey question to NGOs, policymakers, & experts; expert interviews; funder group input; and expert convening input. The survey question was: How strong are the following opposition arguments?

Not enough heavy duty models
Trucks are too expensive
Fuel (H₂) too expensive
Not enough medium-duty models
Low range
Charging infrastructure isn't developed enough
Burdens on low-income or small owner-operators

Oppositional pushback

We will lose good-paying oil and gas jobs
Inequitable charging infrastructure
Natural gas is clean enough
Still see lifecycle emissions from electric-drive trucks
Battery supply chain concerns
Where will we get money for road taxes?
Market-based systems should solve on their own
Truck OEMs can't focus on more than 2-3 technologies or regulations (including diesel) at a time
Regulations are over-reaching
Fuel source concerns
Incentives don't have funding sources

⁴ Nikola hydrogen fuel cell overview, fast fueling in 15 minutes, <https://nikolamotor.com/hydrogen>

⁵ <https://www.carbonbrief.org/analysis-coronavirus-has-temporarily-reduced-chinas-co2-emissions-by-a-quarter>

increase, we can expect opposition from the oil and gas industry and laggard truck manufacturers to increase, potentially aiming to exploit these barriers and spread misinformation (see word cloud). Positively, things are changing quickly (as described above with dropping prices and increasing models), addressing many of these barriers. This strategy addresses these barriers through regulations (increasing models); financial incentives, financing, and knowledge sharing (addressing price); investment and policy for fueling infrastructure; and building allies and strategic communications to win industry and public support and better respond to opposition.

How do we get to our goals? To achieve long-term outcomes to get to ZE road freight and significantly improve air quality and health, we will support key grantee interventions that fall into three main categories (see Figure ES1):

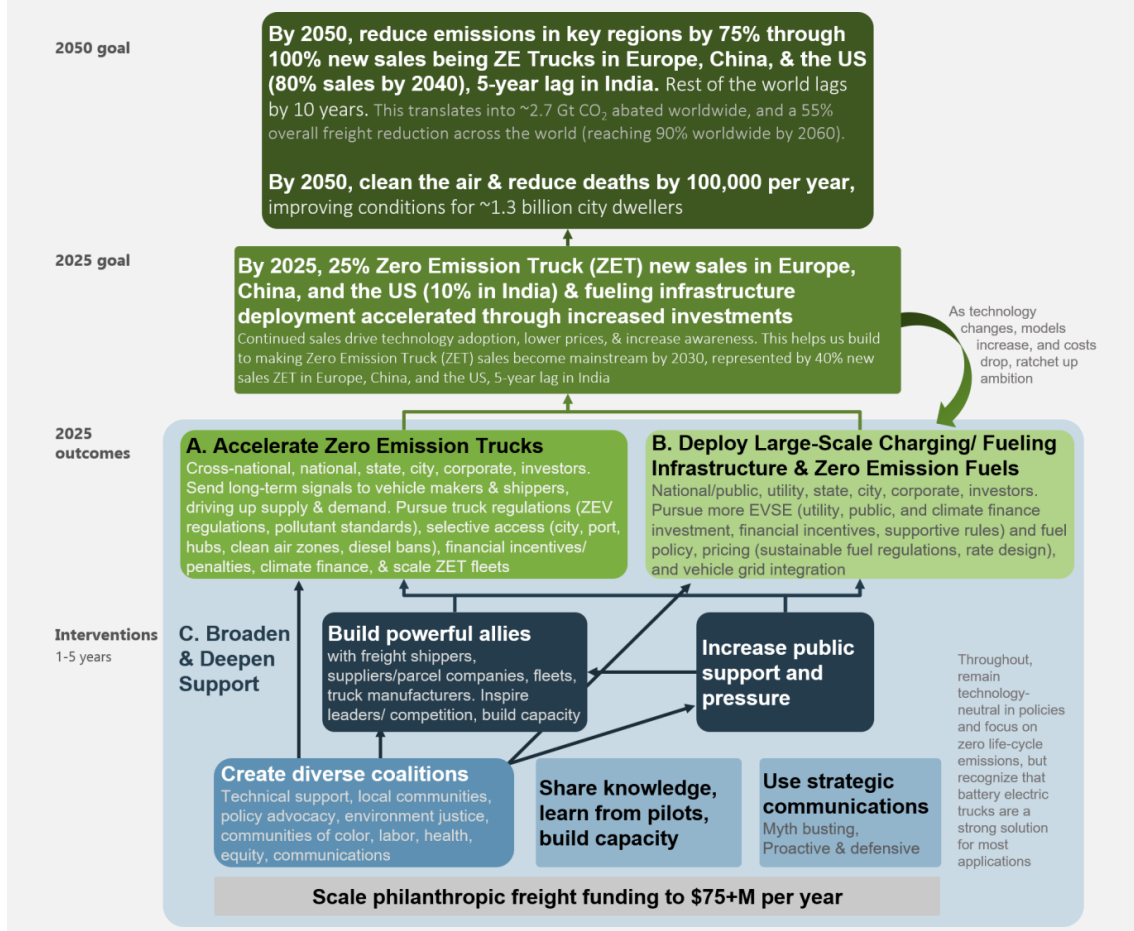
- **Grantee work to Accelerate Zero Emission Trucks:** Truck regulations that cover all classes of vehicles from urban delivery to long-haul tractor-trailers (such as zero emission truck requirements) are foundational policies. Complementing these are key interventions to scale zero emission fleets, create clean air zones in cities, establish financial incentives/penalties, and find innovative financing solutions. Within these, our grantees will pursue a balance between regulations and incentives as well as short-term successes with long-term policy signals, especially for longer distance trucks.
- **Grantee work to Deploy Large-Scale Charging/Fueling Infrastructure & Zero Emission Fuels:** The most important interventions will create large-scale public and utility investments in infrastructure, ensure fuels are zero emission through sustainable source fuel regulations, and optimize charging, vehicle-grid integration, and electricity rate design (e.g., link cheap daytime solar or off-peak nighttime power with truck charging). Complementing and supporting these are interventions to define incentives and to pass and implement supportive rules.
- **Grantee work to Broaden and Deepen Support:** Key interventions to support work to cultivate and elevate powerful allies in freight shippers, parcel companies, fleets, and truck manufacturers; engage frontline communities and environmental justice groups to build diverse, local coalitions to build resilient long-term success; foster public support or pressure to lower freight emissions; share knowledge and build capacity; and employ strategic communications.

Where? Considering abatement potential, promising air quality and health improvements (avoided deaths from on-road diesel), and likelihood of achieving reductions, we prioritize grantmaking in China, Europe, the United States, India, and cross-regional efforts. Chapter 3 provides specific strategies by region. However, while Hewlett’s funding will be focused in these regions, efforts to move toward zero emission freight are also critical in all other parts of the world. We welcome the opportunity to coordinate with philanthropic funders who are interested in other regions.

What doesn’t the strategy cover? This strategy focuses on road freight only (moving goods from ports and manufacturing hubs to their end delivery location). We do not look at logistics, other modes like rail, marine, or air, nor does this strategy include shifting freight away from road to less carbon intensive modes of transport. We recognize these as complementary strategies, but separate philanthropic strategies cover other modes, their emissions mitigation, and greening freight logistics. For example, the Alliance for Logistics Innovation through Collaboration in Europe notes that the forecasted 300% increase in freight transport demand could be achieved with only a 50% increase in

Figure ES1: Overview of zero emission road freight theory of change

Based on numerous interviews, surveys, and meetings with advocates, experts, and leaders, the following reflects a shared theory of change held by our partners and grantees.



trucks.⁶ But to achieve our climate goals, these trucks must still be zero emission. We will help the field connect zero emissions to these other complementary paths.

How much funding is needed? From 2015-2018, funding to decarbonize freight and diesel vehicles has only been \$4-8 million per year from a group of large philanthropic foundations as tracked by the ClimateWorks Foundation, and almost none of it was for zero emissions. Hewlett believes that this is the right time to significantly increase our investment in zero emission freight within our transportation portfolio and did so in 2019 (funding at \$7-8 million per year, 2.5 times the levels in the prior three years) with plans to continue over the next five years. However, the total funding need is much higher – roughly \$75 million per year – leaving an annual funding gap of ~\$65 million per year. If we broadened the scope to include activities in all regions of the world, the total funding need is closer to \$100 million per year. To achieve the goals outlined in the strategy, Hewlett will partner with the Climate Leadership Initiative and other climate funders to close this funding gap.

⁶ Alliance for Logistics Innovation through Collaboration in Europe (ALICE) Roadmap Towards Zero Emissions Logistics 2050 (December 2019), <https://www.etp-logistics.eu/?p=3152>

1. Why we must address road freight now

The problem and opportunity

Transportation accounts for nearly a quarter⁸ of global energy-related greenhouse gas emissions, is the highest emitting sector in the US and Europe (representing one-third of emissions), and is one of the fastest growing sectors in emerging economies, especially in India and China.

Within transportation, freight represents 40% (now) to almost 50% (in 2050) of CO₂ emissions. Road freight contributes the most, representing 80% of the ton-km traveled (Figure 1) and 95% of the energy consumed as trucks are less efficient than rail travel.⁹ Road-freight alone accounts for 30-35% (now and in 2050) of global transport-related carbon dioxide (CO₂) emissions, over half of the transport-related PM_{2.5} emissions, and 75% of premature deaths from excess NOx emissions. These emissions exacerbate climate change and contribute significantly to negative health impacts, especially in urban environments.

Addressing freight, or goods movement, is crucial for a two main reasons:

Freight greenhouse gas emissions are significant and growing quickly, and the abatement potential is 2.7 GT per year by 2050 (and up to 4.9 Gt by 2060).¹⁰ Road freight emissions are ~2.8 GT CO₂ annually (2014) and are projected to increase by 77% by 2050 (5 Gt/year, Figure 2). Ton-kilometer activity is set to triple across the world by 2050 (Figure 1, representing almost 8 percent growth per year) – in contrast to passenger km traveled which is expected to increase by 15% by 2050. Crucial regions (and those that are projected to see dramatic growth) are China, the US, India, and Europe. In cities, commercial freight has been identified as one of the top 12 opportunities for delivering on the objectives of the Paris Agreement.¹¹

Figure 1: Freight growth through 2050

Trillions of ton-kilometers (Source: IEA Energy Technology Pathways 2017, Reference Technology Scenario)⁷

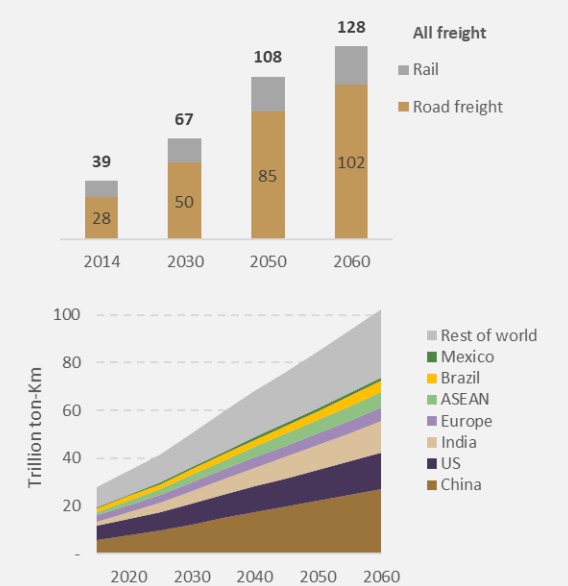
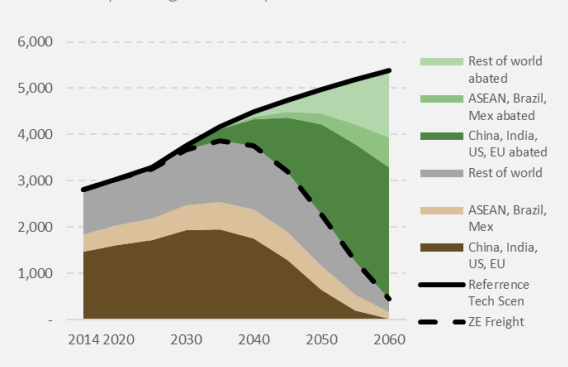


Figure 2: Emissions and abatement

Mt CO₂, modeled using data from IEA Energy Technology Pathways (2017). See Figures B3 and B4 for new sales ZE trucks and power grid makeup.



⁷ IEA Energy Technology Perspectives 2017 <https://www.iea.org/etp/>

⁸ IEA Energy Technology Pathways, 22-23% in 2014, rising to 25% in 2050. <https://www.iea.org/etp/>

⁹ Excluding shipping and air

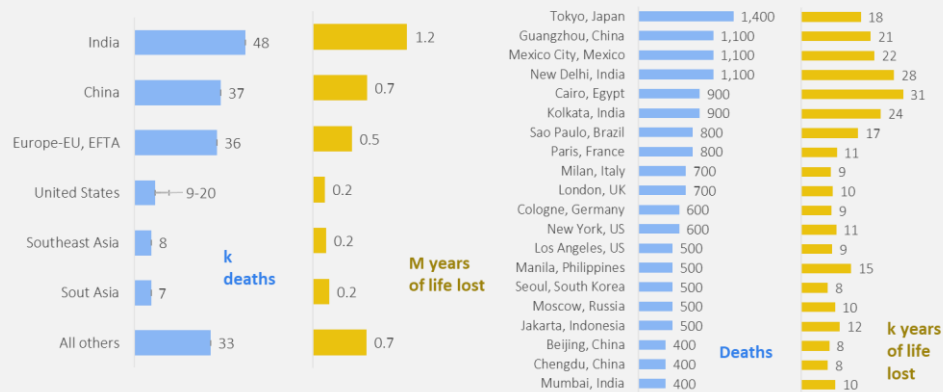
¹⁰ We estimated a 'high-ambition' scenario for zero emission freight assuming at least 30% new truck sales are zero emissions (ZE) by 2030 in Europe, China, and the US (by 2035 in India) and 100% ZE sales by 2050 (see Appendix B Figures B3-B4 for more details). The mitigation potential for this scenario leads to ~4.9 Gt CO₂ annual abatement in 2060 (~2.7 Gt in 2050). These estimates assume significant uptake across all regions and globally, do not discount for likelihood of success, and do not include additional abatement potential that could be realized from medium and heavy-duty efficiency standards. Figure 2 shows that the big abatement occurs in 2040 and beyond, but is dependent on aggressive action within the next few years.

¹¹ McKinsey (2017) Focused Acceleration

Figure 3: 180,000 deaths, 3.7 million years of life lost per year from on-road diesel*

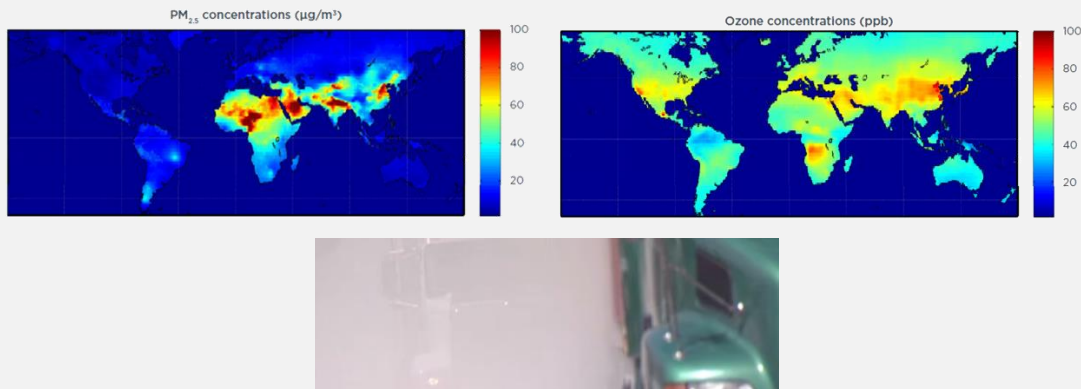
Includes freight and passenger diesel (e.g., buses)

Left charts by region: Thousands of deaths (blue) and millions of years of life lost (yellow). Right charts by city: Deaths (blue) and thousands of years of life lost (yellow). Source: ICCT and CCAC (2019) and Clean Air Task Force (2005)¹⁶ Right charts: Top 20 urban area health impacts: Deaths (#, left) and years of life lost (thousands, right)



PM_{2.5} and ozone emissions

Total PM_{2.5} (annual average) and ozone concentrations (6-month average of the 8-hour daily maximum) in 2015. Max globally: PM_{2.5} 329 µg/m³ and ozone 94 ppb. Source: ICCT and CCAC (2019)¹⁷. Photo from <http://www.zeroemissionsnow.net/>



Air pollution from diesel trucks causes up to 180,000 deaths per year. Freight movement represents half of total transport-related PM_{2.5}¹² contributing significantly to negative health impacts, especially in urban environments and with disproportionate effects on people of color and those with lower-income.¹³ 92% of outdoor air pollution-related deaths occur in low-income and middle-income countries.¹⁴ PM is a leading cause of respiratory disease (including lung cancer), ischemic heart disease, stroke, diabetes, and black carbon; in Europe alone, 65-90 percent of the urban population is exposed to levels above World Health Organization guidelines.¹⁵

¹² PM emissions come from combustion of petroleum-based fuels and abrasion, wearing, and corrosion of vehicle components. PM_{2.5} from trucks are particularly detrimental to human health due to people's direct proximity and exposure to road traffic.

¹⁶ ICCT and Climate and Clean Air Coalition, Nature (2019-09) The global burden of transportation tailpipe emissions on air pollution-related mortality in 2010 and 2015 <https://iopscience.iop.org/article/10.1088/1748-9326/ab35fc> (data https://iopscience.iop.org/1748-9326/14/9/094012/media/erl_14_9_094012_sd_2.xlsx and https://iopscience.iop.org/1748-9326/14/9/094012/media/erl_14_9_094012_sd_3.xlsx) and Clean Air Task Force (2005) Diesel and Health in America: The Lingering Threat, https://www.catf.us/wp-content/uploads/2019/02/CATF_Pub_Diesel_Health_America.pdf. Also see (2019-02) A global snapshot of the air pollution-related health impacts of transportation sector emissions in 2010 and 2015, <https://theicct.org/publications/health-impacts-transport-emissions-2010-2015>

¹⁷ ICCT and Climate and Clean Air Coalition (2019-02) A global snapshot of the air pollution-related health impacts of transportation sector emissions in 2010 and 2015 (Figure 1) <https://theicct.org/publications/health-impacts-transport-emissions-2010-2015>

Every year, on-road diesel vehicles cause 180,000 premature deaths and 3.7 million years of life lost (PM_{2.5} and ozone-attributable), with 74% of the fatalities occurring in the four largest markets: China, India, Europe, and the United States (Figure 3). The urban areas with the highest number of diesel vehicle-induced deaths include Tokyo, Guangzhou, Mexico City, New Delhi, Kolkata, Paris, Milan, London, Cologne, New York, Los Angeles, Jakarta, Beijing, Chengdu, and Mumbai. Without action, outdoor air pollution deaths are expected to increase by more than 50% by 2050.

What do we need to overcome?

Achieving a successful transition to zero emission road freight at a pace and scale consistent with climate goals will require overcoming real and perceived barriers to uptake as well as refuting and countering the opposition. Figure 4 shows a summary of these barriers and perceptions. Initial costs, vehicle model availability, and infrastructure dominate, but other aspects such as equity, jobs, lifecycle emissions and supply chain, and regulation over-reach also appear. Table 1 provides more details on the top perceived barriers or critiques and the good news or response.

Figure 4: Real and perceived barriers (left) and opposition pushback (right)

Informed by surveys, interviews, research, and NGO partners. Size relative to strength of barrier. Opposition pushback narratives are shown at the right of the line, plus highlighting barriers (left)

Barriers

Based on responses to a survey question to NGOs, policymakers, & experts; expert interviews; funder group input; and expert convening input. The survey question was: How strong are the following opposition arguments?

Not enough heavy duty models

Trucks are too expensive

Charging infrastructure isn't developed enough

Low range

Burdens on low-income or small owner-operators

Fuel (H₂) too expensive

Not enough medium-duty models

Oppositional pushback

We will lose good-paying oil and gas jobs

Inequitable charging infrastructure

Natural gas is clean enough

Still see lifecycle emissions from electric-drive trucks

Battery supply chain concerns

Market-based systems should solve on their own

Truck OEMs can't focus on more than 2-3 technologies or regulations (including diesel) at a time

Regulations are over-reaching

Fuel source concerns

Incentives don't have funding sources

Where will we get money for road taxes?

¹⁵ Transport & Environment, 2015, Don't Breathe Here, www.transportenvironment.org/publications/dont-breathe-here-tackling-air-pollution-vehicles

¹⁶ ICCT and Climate and Clean Air Coalition, Nature (2019-09) The global burden of transportation tailpipe emissions on air pollution-related mortality in 2010 and 2015 <https://iopscience.iop.org/article/10.1088/1748-9326/ab35fc> (data https://iopscience.iop.org/1748-9326/14/9/094012/media/erl_14_9_094012_sd_2.xlsx and https://iopscience.iop.org/1748-9326/14/9/094012/media/erl_14_9_094012_sd_3.xlsx) and Clean Air Task Force (2005) Diesel and Health in America: The Lingering Threat, https://www.catf.us/wp-content/uploads/2019/02/CATF_Pub_Diesel_Health_America.pdf. Also see (2019-02) A global snapshot of the air pollution-related health impacts of transportation sector emissions in 2010 and 2015, <https://theicct.org/publications/health-impacts-transport-emissions-2010-2015>

¹⁷ ICCT and Climate and Clean Air Coalition (2019-02) A global snapshot of the air pollution-related health impacts of transportation sector emissions in 2010 and 2015 (Figure 1) <https://theicct.org/publications/health-impacts-transport-emissions-2010-2015>

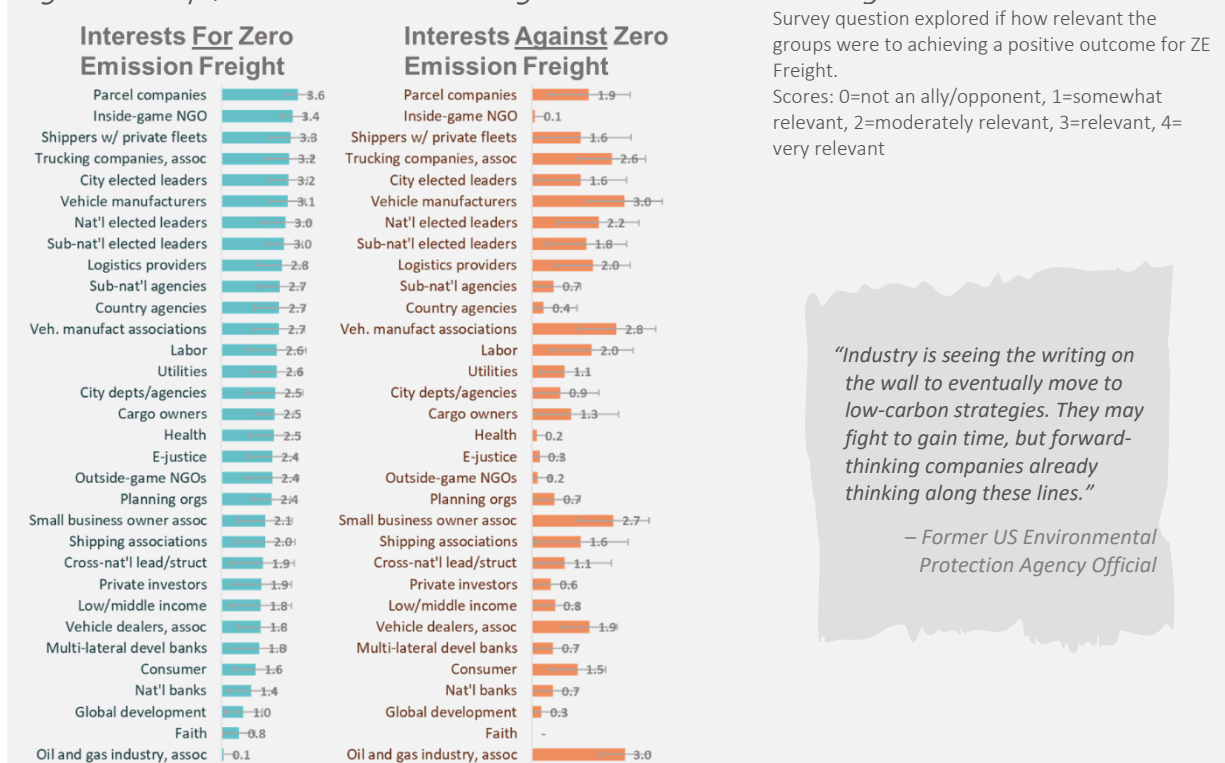
Table 1: Top perceived barriers and response/realities

Topic	Critique or perceived barrier	The good news or response
High purchase price	<p>Individual businesses face increased upfront costs for purchasing ZE trucks. Today, battery electric trucks cost 15-125%¹⁸ more than a diesel truck.</p> <p><i>“Financing of vehicle up-front costs and charging equipment is an impediment to all but the largest of shipping groups.”</i> – Environmental Defense Fund</p>	<p>Things are changing rapidly: In 2017, the price premium was 60 -100% (medium-duty) and 200-300% (heavy-duty trucks). Purchase price parity is expected for light and medium (Class 3-6) trucks between 2025-2030, and around 2030 for heavy duty trucks. Additionally, the total cost of ownership (including significant fuel and maintenance savings) for many ZE truck applications is already at parity with diesel trucks, and this will improve as battery costs decline. See next section for more details on total cost of ownership.</p>
Limited vehicle models	<p>Models need to exist across widely varying use cases. Different businesses have different shipping truck needs, ranging from short-distance drayage trucks, in-city delivery trucks, and heavy long-haul trucks. ZE freight vehicles need to be either highly adaptable, or solutions must be tailored to specific business needs, which vary within and across countries.</p>	<p>Globally, over 115 truck manufacturers are already making almost 200 truck models across all categories – light, medium, and heavy-duty trucks. See chart below and next section for more details on model availability.</p> <p>Models Sources: EDF, RMI, other</p>
Lack of charging/refueling infrastructure	<p>Refueling/charging infrastructure (especially high-power charging) and power delivery at charging stations is currently insufficient. Because of the high power needs and uncertain utilization, the private business case is not compelling. There is no common standard for refueling/charging infrastructure. Additional obstacles include: Uncertain impacts on the grid; uncertainty regarding ideal location for new infrastructure and availability of land/ space to match charging demand with grid capacity; high costs of charging infrastructure; unfamiliarity with infrastructure. Low utilization rates and uncertainty on how costs are split among parties disincentivize infrastructure construction. There are long lead times for infrastructure, especially in urban areas. Additionally, soft costs of permitting, standardization, utility approvals are highly variable.</p>	<p>Pilot projects include creating infrastructure (see below for examples) and incentives exist to promote high-power charging (DOE Megawatt charger project). Strategic efforts prioritize engaging utilities, large-scale public investment (addressing the issue that the private business case for charging infrastructure is limited), education, sharing information with fleets, and applied research.</p> <p><i>“The electric charging infrastructure isn’t developed enough to support heavy transport”</i> – Global shipper</p>
Opposition from the oil and truck manufacturing industry, and others	<p>Resistance from the powerful oil and gas industry threatens quick ZE truck progress through many means, including investment in ways to delay cost parity, such as Electric Vehicle (EV) fees and messaging that spreads disinformation about unsubstantiated threats to the small business owner. Laggard vehicle</p>	<p>As part of the theory of change (see Chapter 2), responding to opposition is critical. This includes developing a strategic communications strategy, cultivating powerful allies such as electric utilities and corporations, and empowering ZE truck manufacturers to counter opposition. There is also the opportunity to applaud and highlight leaders (truck makers, owners, and</p>

¹⁸ ICCT (2019): Long-haul battery electric trucks purchase prices are 15% more than diesel trucks, and hydrogen fuel cell trucks cost 25% more (today vs. ~\$220k diesel truck). However, by 2025 we see rough purchase parity for both types. Today, battery electric drayage trucks (Class 8) cost 20% more, and hydrogen fuel cell drayage trucks cost 35% more. Those differences are expected to drop to 6-12% by 2025, and purchase parity for battery electric is anticipated to occur in 2027. LBNL (2019): Today, the 500-mile range heavy duty truck purchase price premium is 125% (vs. ~\$125k diesel truck) and expected to drop to 75% in 2025. CARB (2019): Short-haul day cab tractor purchase cost is expected to be 60% higher in 2024 (\$290k BET vs \$180k diesel).

	manufacturers opposed to EV and ZE freight innovation can discourage policymakers. Potential other opponents may include smaller owner/operators, and workers in vehicle maintenance/service.	shippers), getting the leaders to be vocal in support (see Figure 5). Messaging should promote lower maintenance and fuel costs (and lower total cost of ownership); benefits to climate, air quality, and health; the good news about model availability; benefits for vulnerable communities; the negative side of dirty diesels (Diesel Death Zone), and busting myths (see Chapter 2 for more details).
Lack of competitively-priced, sustainable zero emission fuels	While electricity fueling is generally much cheaper per mile than diesel, demand charges can severely impact charging costs. Higher demand charges for electricity in some places/times reduce the business case for ZE trucks.	Focus strategic efforts on optimized charging and rate design (e.g., link cheap daytime solar or off-peak nighttime with truck charging) and sustainable source fuel regulations. Optimized vehicle grid integration can lower kWh costs for all utility customers due to the lower need for capacity increases and greater use of existing infrastructure across which to spread fixed costs.
Truck Original Equipment Manufacturers (OEMs) slow to supply vehicles	Big truck manufacturers are slow to respond, even in the face of significant orders (Amazon, DHL).	Some shippers have invested directly in electric vehicles. DHL invested in StreetScooter and Amazon invested in e-truck startup Rivian (100k electric delivery van purchases) because neither could convince current OEMs to produce e-trucks at the scale needed. Hence, it is crucial to impose supply regulations on manufacturers and not rely only on private sector demand. <i>"Manufacturers need regulatory certainty to commit to scale the production of zero emissions trucks."</i> — EDF

Figure 5: Groups/interests that are for or against zero emission road freight



Secondary barriers, perceptions, and responses include:

- **Low awareness of zero emission trucks, limited service and support networks, and technology confusion.** There is limited fleet owner, philanthropic funder, and policymaker awareness of the technological status and potential of zero emission trucks. Fleet owners are concerned with maintenance and availability. This leads to confusion about preferred technology: battery electric, fuel cell, or other powertrains. We can address this through grants that support education, convenings, analysis on technology availability and cost of ownership, sharing examples of training programs (e.g., Volvo LIGHTS), prioritizing a just transition, and engaging labor groups (see below for more details).
- **Risk-averse and diverse operating environment.** Risk-averse businesses (often small operators) with low operating margins (1-3%) avoid new technologies to guard against failures or reduced performance. Some businesses own their own fleets (in China and India, 90 and 75 percent of owners are driver-owners), while others lease. There are variable duty cycles, many types of trucks, slow fleet turnover in some markets, and applications that can slow the pace of uptake. Priority should focus on supporting work engaging fleets, showcasing successes (first with fleets, eventually with smaller business owners), finding innovative financial solutions, sharing challenges, and building knowledge (including new business models such as leasing) and capacity.
- **Equity concerns**, especially for small business owners. To address this, we initially support work that concentrates on big fleets that can invest in trucks and their own charging infrastructure (working directly with the fleets to scale their ZE trucks and indirectly through fleet regulations) that can help lower truck prices via economies of scale, prioritize building coalitions with frontline communities and environmental justice groups to help make the case for ZE truck policies (as diesel pollution disproportionately affects low income groups in cities and near ports) that explicitly include benefits for poor communities and people of color, and prioritize training and just transition (maintenance, etc.).
- **Selective allies** might support incentives but not mandates and may act contrary to their stated commitment to ZE truck development. Grantees are building support with easier wins (e.g., incentives), applauding and highlighting leaders while shedding light on the types of backward-looking approaches that need to change, and over time asking for support from allies in challenging areas (e.g., mandates).
- **Budget concerns with incentives.** Policymakers are concerned about the budgetary impacts of Zero Emission Trucks /infrastructure incentives. We support work that considers existing or new funding sources and prioritize feebates (that create funds) and regulations that don't need funding sources.

Why now? Dropping battery prices, market taking off, good news in all market segments, growing numbers of allies, and attractive total cost of ownership

Zero emission truck sales are already growing exponentially – from less than 10,000 in 2015 to over 70,000 in 2017 – and the city of Shenzhen in China currently has over 60,000 ZE trucks in daily operation. The full transition to zero emission trucks is possible and can happen very soon. We are on the cusp of market takeoff: 55-85% of truck uses are suitable for currently commercial zero emission technology, and the technology will soon be available for all segments to go zero emission. There is good news with allies pushing ZE trucks in all market segments – urban and parcel delivery, ports and

regional haul, and heavy duty and long-haul. Total cost of ownership is attractive, and there are strong technical and economic cases for many modes, including long-haul trucks.

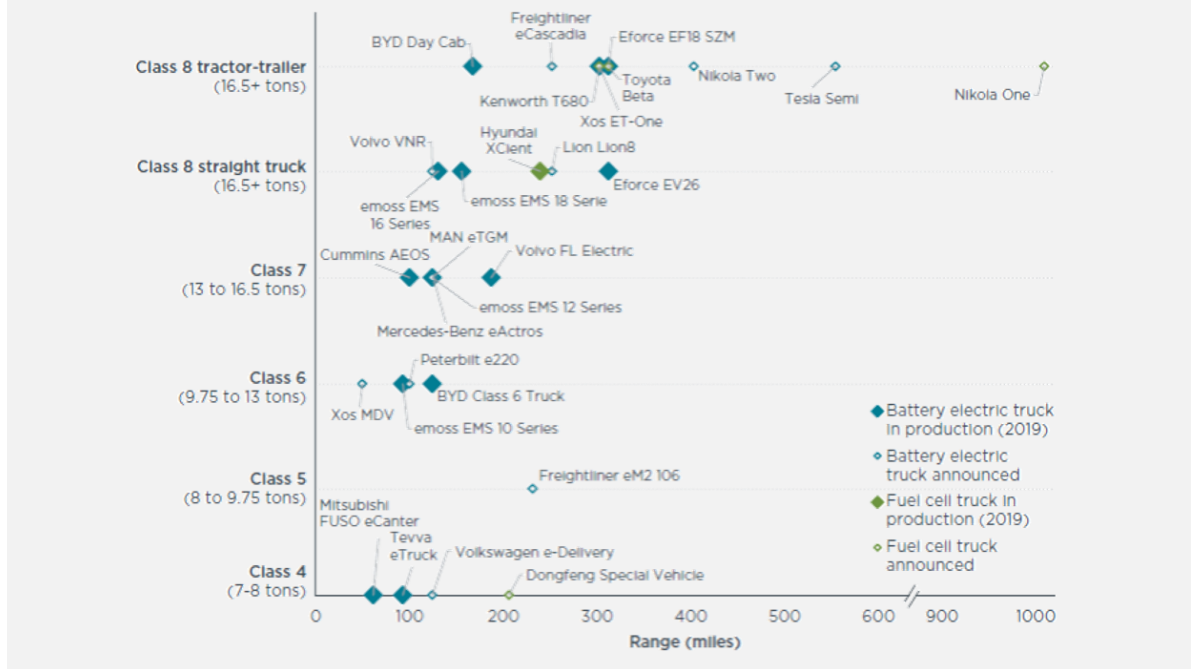
The vehicle market is taking off – numerous models are coming

As noted earlier, over 115 truck manufacturers are making almost 200 truck models across all categories. Smaller and upstart companies investing in truck electrification along with financial incentives, the emergence of regulations, climate goals (at national, state, city, and company levels), and falling battery prices have helped to spur major Original Equipment Manufacturers (OEMs) to move more quickly to bring options to market. Tesla, Nikola, and others have now been joined by Volvo, Daimler, Cummins, and others demonstrating and producing electric trucks or drivetrains. Daimler aims for a CO₂-neutral fleet in its main markets by 2039.¹⁹ See Figure 6 for images and truck models across vehicle types, and Table 2 for leading ZE truck manufacturer allies. Sharing this knowledge with the shipping industry, philanthropic partners, and policymakers is part of the strategy. As an example, CALSTART has a Zero Emission Technology Inventory Tool providing details for current and announced electric trucks by platform, manufacturer, model, and region (North America now, Europe/Asia soon).



Figure 6: Models are coming

Sources: ICCT²⁰, CALSTART



¹⁹ Daimler e-trucks www.bloomberg.com/news/articles/2019-10-25/clean-trucks-race-heats-up-as-daimler-hones-in-on-electric-rigs

²⁰ ICCT, CALSTART, and C40 Cities. Zero-Emission Freight - Vehicle Market & Policy Development Briefing for C40 Cities, September 2019.

Table 2: ZE Truck manufacturer leaders and potential allies (data from EDF, RMI, Alibaba²¹)

Region	Leaders in ZE trucks	Followers or small players, but putting out ZE trucks	Number of models																																																																																																												
US or Europe	Also Diesel: Volvo (Renault), Daimler (Mercedes), Cummins (Westport), Traton (MAN, Scania (owned by VW), Ryder	Renault, Toyota, Hyundai, Ford, Mack, Navistar	<div><div><div>Light duty truck (class 2-3, <7 tons)</div><div>Medium duty truck (class 4 to 6, 7-13 tons)</div><div>Heavy duty truck (class 7-8, >13 tons)</div></div><table><tr><td>BYD</td><td>9</td><td>Artisan</td><td>1</td></tr><tr><td>Volvo Group</td><td>8</td><td>Blue Bird</td><td>1</td></tr><tr><td>Daimler</td><td>7</td><td>Chanje</td><td>1</td></tr><tr><td>Motiv</td><td>6</td><td>Cummins</td><td>1</td></tr><tr><td>EMOSS</td><td>4</td><td>Dennis Eagle, PVI, Phoenix</td><td>1</td></tr><tr><td>Lion Electric</td><td>4</td><td>E-force</td><td>1</td></tr><tr><td>US Hybrid</td><td>4</td><td>ESORO</td><td>1</td></tr><tr><td>Nikola</td><td>4</td><td>Hyundai</td><td>1</td></tr><tr><td>Ginaf</td><td>3</td><td>Kalmar</td><td>1</td></tr><tr><td>Workhorse Trucks</td><td>3</td><td>Meritor</td><td>1</td></tr><tr><td>StreetScooter</td><td>3</td><td>Navistar</td><td>1</td></tr><tr><td>XOS (formerly Thor Trucks)</td><td>2</td><td>Orange EV</td><td>1</td></tr><tr><td>New Flyer</td><td>2</td><td>PACCAR</td><td>1</td></tr><tr><td>Spartan Motors</td><td>2</td><td>Symbio F Call</td><td>1</td></tr><tr><td>Gillig/ Cummins</td><td>2</td><td>Tesla</td><td>1</td></tr><tr><td>Phoenix Motorcars</td><td>2</td><td>Toyota</td><td>1</td></tr><tr><td>SEA Electric</td><td>2</td><td>Transpower</td><td>1</td></tr><tr><td>Lightning Systems</td><td>2</td><td>Wrightspeed</td><td>1</td></tr><tr><td>Rivian</td><td>2</td><td>EFA-S</td><td>1</td></tr><tr><td>Smith</td><td>2</td><td>EVI</td><td>1</td></tr><tr><td></td><td></td><td>Iveco</td><td>1</td></tr><tr><td></td><td></td><td>Oten & EFA-S</td><td>1</td></tr><tr><td></td><td></td><td>Panel Itex</td><td>1</td></tr><tr><td></td><td></td><td>Proterra</td><td>1</td></tr><tr><td></td><td></td><td>Roush Clean Tech</td><td>1</td></tr><tr><td></td><td></td><td>Spijkstaal</td><td>1</td></tr><tr><td></td><td></td><td>XL</td><td>1</td></tr></table></div>	BYD	9	Artisan	1	Volvo Group	8	Blue Bird	1	Daimler	7	Chanje	1	Motiv	6	Cummins	1	EMOSS	4	Dennis Eagle, PVI, Phoenix	1	Lion Electric	4	E-force	1	US Hybrid	4	ESORO	1	Nikola	4	Hyundai	1	Ginaf	3	Kalmar	1	Workhorse Trucks	3	Meritor	1	StreetScooter	3	Navistar	1	XOS (formerly Thor Trucks)	2	Orange EV	1	New Flyer	2	PACCAR	1	Spartan Motors	2	Symbio F Call	1	Gillig/ Cummins	2	Tesla	1	Phoenix Motorcars	2	Toyota	1	SEA Electric	2	Transpower	1	Lightning Systems	2	Wrightspeed	1	Rivian	2	EFA-S	1	Smith	2	EVI	1			Iveco	1			Oten & EFA-S	1			Panel Itex	1			Proterra	1			Roush Clean Tech	1			Spijkstaal	1			XL	1
	BYD	9	Artisan	1																																																																																																											
Volvo Group	8	Blue Bird	1																																																																																																												
Daimler	7	Chanje	1																																																																																																												
Motiv	6	Cummins	1																																																																																																												
EMOSS	4	Dennis Eagle, PVI, Phoenix	1																																																																																																												
Lion Electric	4	E-force	1																																																																																																												
US Hybrid	4	ESORO	1																																																																																																												
Nikola	4	Hyundai	1																																																																																																												
Ginaf	3	Kalmar	1																																																																																																												
Workhorse Trucks	3	Meritor	1																																																																																																												
StreetScooter	3	Navistar	1																																																																																																												
XOS (formerly Thor Trucks)	2	Orange EV	1																																																																																																												
New Flyer	2	PACCAR	1																																																																																																												
Spartan Motors	2	Symbio F Call	1																																																																																																												
Gillig/ Cummins	2	Tesla	1																																																																																																												
Phoenix Motorcars	2	Toyota	1																																																																																																												
SEA Electric	2	Transpower	1																																																																																																												
Lightning Systems	2	Wrightspeed	1																																																																																																												
Rivian	2	EFA-S	1																																																																																																												
Smith	2	EVI	1																																																																																																												
		Iveco	1																																																																																																												
		Oten & EFA-S	1																																																																																																												
		Panel Itex	1																																																																																																												
		Proterra	1																																																																																																												
		Roush Clean Tech	1																																																																																																												
		Spijkstaal	1																																																																																																												
		XL	1																																																																																																												
	ZE truck-only: BYD, Tesla, StreetScooter (DHL), Motiv, EMOSS, Lion Electric, Nikola, Workhorse, XOS/Thor, Rivian, Chanje, Meritor	New Flyer, Spartan Motors, Phoenix Motorcars, SEA Electric, Lightning Systems, Kalmar, Orange EV, PACCAR, Wrightspeed, Proterra, Roush Clean Tech, XL, Greenpower, Urb-E cargo bikes, Orange EV, many others (see right)																																																																																																													
China	Also Diesel: Dongfeng (Nissan), Sinotruck	Geely Yuan Cheng Auto, Kaiyun Motors Co Ltd, CE, Chengdu Dayun, Chongqing Ruichi, Chrey, FDG Electric Vehicles, FOTON, Greenwheel, Hubei Xinchuf, JAC, Nanjing Jinlong, New Longma, Senyuan, Tianjin Zhongyi Electric Vehicle Co, soon StreetScooter (DHL), others	<div><div><div>Light duty truck (class 2-3, <7 tons)</div><div>Medium duty truck (class 4 to 6, 7-13 tons)</div><div>Heavy duty truck (class 7-8, >13 tons)</div></div><table><tr><td>BAIC BAW</td><td>11</td><td></td><td></td></tr><tr><td>BYD</td><td>7</td><td></td><td></td></tr><tr><td>Dongfeng (& Nissan)</td><td>5</td><td></td><td></td></tr><tr><td>Sinotruck</td><td>2</td><td></td><td></td></tr><tr><td>ZEV Auto</td><td>2</td><td></td><td></td></tr><tr><td>Geely Yuan Cheng Auto</td><td>1</td><td></td><td></td></tr><tr><td>Kaiyun Motors Co Ltd</td><td>1</td><td></td><td></td></tr><tr><td>CE</td><td>1</td><td></td><td></td></tr><tr><td>Chengdu Dayun</td><td>1</td><td></td><td></td></tr><tr><td>Chongqing Ruichi</td><td>1</td><td></td><td></td></tr><tr><td>Chrey</td><td>1</td><td></td><td></td></tr><tr><td>FDG Electric Vehicles</td><td>1</td><td></td><td></td></tr><tr><td>FOTON</td><td>1</td><td></td><td></td></tr><tr><td>Greenwheel</td><td>1</td><td></td><td></td></tr><tr><td>Hubei Xinchuf</td><td>1</td><td></td><td></td></tr><tr><td>JAC</td><td>1</td><td></td><td></td></tr><tr><td>Nanjing Jinlong</td><td>1</td><td></td><td></td></tr><tr><td>New Longma</td><td>1</td><td></td><td></td></tr><tr><td>Senyuan</td><td>1</td><td></td><td></td></tr><tr><td>Tianjin Zhongyi Electric Vehicle Co</td><td>1</td><td></td><td></td></tr><tr><td>48+ others (Shenzhen)</td><td></td><td></td><td></td></tr></table></div>	BAIC BAW	11			BYD	7			Dongfeng (& Nissan)	5			Sinotruck	2			ZEV Auto	2			Geely Yuan Cheng Auto	1			Kaiyun Motors Co Ltd	1			CE	1			Chengdu Dayun	1			Chongqing Ruichi	1			Chrey	1			FDG Electric Vehicles	1			FOTON	1			Greenwheel	1			Hubei Xinchuf	1			JAC	1			Nanjing Jinlong	1			New Longma	1			Senyuan	1			Tianjin Zhongyi Electric Vehicle Co	1			48+ others (Shenzhen)																											
	BAIC BAW	11																																																																																																													
BYD	7																																																																																																														
Dongfeng (& Nissan)	5																																																																																																														
Sinotruck	2																																																																																																														
ZEV Auto	2																																																																																																														
Geely Yuan Cheng Auto	1																																																																																																														
Kaiyun Motors Co Ltd	1																																																																																																														
CE	1																																																																																																														
Chengdu Dayun	1																																																																																																														
Chongqing Ruichi	1																																																																																																														
Chrey	1																																																																																																														
FDG Electric Vehicles	1																																																																																																														
FOTON	1																																																																																																														
Greenwheel	1																																																																																																														
Hubei Xinchuf	1																																																																																																														
JAC	1																																																																																																														
Nanjing Jinlong	1																																																																																																														
New Longma	1																																																																																																														
Senyuan	1																																																																																																														
Tianjin Zhongyi Electric Vehicle Co	1																																																																																																														
48+ others (Shenzhen)																																																																																																															
	ZE truck-only: BAIC BAW, BYD, ZEV Auto																																																																																																														
India	Also Diesel: Mahindra Electric, Tata Motors	BYD India, Altigreen PL, Euler Motors, Evy Mobility, Hero Electric, Jitendra EV, Li-ions Elektrik, Onnbikes, Shigan Voltz, Tork Motors, and Va-yu																																																																																																													

²¹ Model availability sources include Environmental Defense Fund Announced and Available Electric Truck database (via personal communication) downloaded August 2019, Rocky Mountain Institute Shenzhen: A City Miles Ahead (June 2019) <https://rmi.org/shenzhen-a-city-miles-ahead/>, Rocky Mountain Institute (India) <https://rmi.org/wp-content/uploads/2019/11/Expression-of-Interest.docx>, and Alibaba searches for electric trucks (November 2019)

Actions are happening across the market segments

To fully address freight emissions, it is important to address heavy, medium, and light duty trucks (Figure 7).

Pilot projects have already proven uses for medium- and heavy-duty trucks. This includes ~60 pilots, ~1,000 vehicles, ~70 km e-highways, mostly in Europe and the US (Figure 8). Many of these are battery electric or e-highways, but some are fuel cells. More, momentum is building across all of the market segments, detailed below.

Figure 7: Heaviest trucks dominate (50-90%) oil consumption

M barrels oil per day by truck category (ICCT)²²

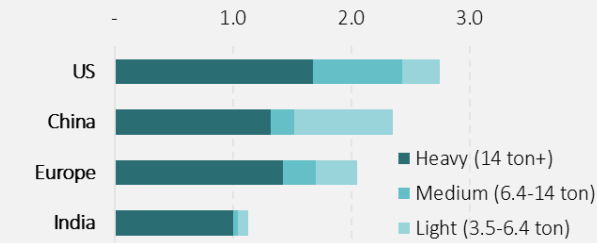
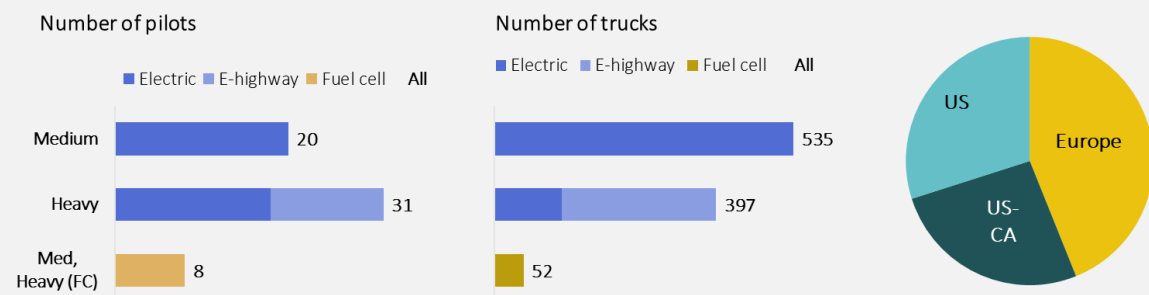


Figure 8: ~60 pilots, ~1,000 vehicles, ~70 km e-highways, mostly Europe and the US

Left: Number of pilots. Middle: Number of trucks. Right: % of trucks. Sources include ICCT 2017²³, CALSTART 2019



Urban and parcel delivery

Urban and parcel delivery is going electric (Figure 9). Earlier pilots included hydrogen, but today almost all deployments are battery electric.

Figure 9: FedEx, UPS, and Volvo urban electric trucks

Sources: <https://about.van.fedex.com/newsroom/fedex-acquires-1000-chanje-electric-vehicles/>, <https://www.engadget.com/2018/05/09/ups-electric-trucks-arrival/>, <https://www.lightsproject.com/volvo-trucks-launches-sales-of-electric-trucks-for-urban-transport/>



²² ICCT 2015. Literature Review: Real-World Fuel Consumption of Heavy-Duty Vehicles in the United States, China, and the European Union, https://theicct.org/sites/default/files/publications/ICCT_HDV_FC_lit-review_20150209.pdf

²³ ICCT (September 2017): Transitioning to Zero-Emission Heavy-Duty Freight Vehicles, <https://theicct.org/publications/transitioning-zero-emission-heavy-duty-freight-vehicles>

Shenzhen reached 35% electric urban logistics vehicles in three years (2015-2018) – representing over 60,000 vehicles by mid-2019 (see Chapter 3 China section for more details). **Deutsche Post DHL** has over 9,000 zero emission (mostly electric) trucks delivering parcels (see Chapter 3 Europe section for more details). **IKEA** has completely electrified deliveries in Shanghai and will have full zero emission delivery globally by 2025 (see Figure 21). **Amazon** ordered 100,000 electric urban delivery vans in 2019 (see Figure 16).

In late 2018, **FedEx** acquired 1,000 Chanje V81000 electric delivery vehicles by purchasing 100 and leasing 900 from Ryder Systems. The trucks are manufactured by FDG in Hangzhou, China, have 150-mile range, and operate in California.²⁴ FedEx has piloted all-electric vehicles in its fleet since 2009, using both battery electric and hydrogen fuel cell examples (20 trucks in Memphis, Tennessee & California in 2017).

UPS has 300 electric trucks as of 2018 in Europe (including Paris and London) and the US (including Atlanta, Dallas, and LA) using Workhorse Group and Arrival trucks and has ordered 125 Tesla semis. UPS deployed 100 electric medium-duty delivery trucks to its California fleet in 2013 and in 2014 explored hydrogen fuel cell demonstrations.

Delhi is electrifying its final mile delivery and currently has 340 electric vehicles with plans for up to 1,000 in 2020 (see Chapter 3 India section for more details). **Frito Lay** is evaluating 250 Smith Newton electric delivery trucks as well as the Tesla Semi, Peterbilt E220, and BYD yard trucks to better understand the effectiveness of electric trucks in real-world applications. In 2017, **Gnewt Cargo** in the UK leased 33 electric vehicles for last-mile logistics.

Ports and regional haul (drayage, corridors)

Regional haul routes (< 300-mile routes that return to home daily) are prime candidates for battery electric trucks. See Figure 10 for an example of Walmart hub and spoke network.

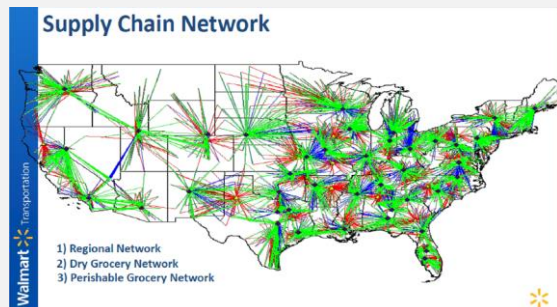
In 2019, the ports of Los Angeles and Long Beach began a **Volvo Low Impact Green Heavy Transport Solutions (LIGHTS)** pilot to demonstrate success of heavy-duty trucks and port/drayage equipment, including 23 electric heavy-duty trucks, 75 truck chargers, and 29 pieces of electric freight-moving warehouse equipment (see Chapter 3 US section for more details).

In 2015, **TransPower** demonstrated four **Class 8 drayage trucks** traveling 110 miles from San Diego to the LA-Long Beach port region. **Houston** piloted three hydrogen fuel cell heavy-duty Class 8 drayage trucks at its port. From 2016-2018, in **California** **BYD** partnered with San Bernardino city government for a demonstration project of 23 battery-electric **Class 8 yard trucks**.

Figure 10: Regional haul - Walmart hub and spoke network

Source: NACFE Growth of Regional Haul (2019)
<https://nacfe.org/regional-haul/>

In 2005 Walmart set a goal to reduce fuel use per pallet delivered by 50 percent by 2015 and achieved nearly 90 percent of that goal by the end of 2014.



²⁴ Fedex e-trucks <https://about.van.fedex.com/newsroom/fedex-acquires-1000-chanje-electric-vehicles/>

Heavy duty and long-haul

Heavy duty Class 8 trucks are seeing significant pilots, product announcements, and robust early sales.

Refuse/trash trucks: In New Zealand, Auckland and Christchurch committed to electrifying 26-ton trash trucks and tested trucks in 2016-17. Additional pilots are taking place in Fredericksburg, Denmark; Sparsborg, Norway; Bremerhaven, Germany; and in the United States in Chicago, Sacramento, and New York.

Heavy-duty trucks: In 2017, Germany implemented the Green Electric Last Mile (eGLM) project with nine 40- to 50-ton electric heavy-duty trucks in the cross-border logistics region of North Limburg-Duisburg. From 2013-14, EMOSS tested two fully electric 19-ton trucks, the largest electric trucks of their kind in Europe. Heineken tested one 19-ton electric freight truck in its delivery fleet in the Netherlands in 2017. BYD, Volvo, and EMOSS have Class 8 trucks (straight or tractor). A current ZANZEFF project (California) funds ten Class 8 ZE trucks, two large hydrogen fueling stations, and two ZE yard tractors

Long-haul trucks are expected to be available in 2020. Eforce has a 300-mile range EV26 Class 8 straight truck in production. Kenworth (Toyota) will develop ten zero emission hydrogen fuel cell trucks (T680s) for the ports of Los Angeles. Tesla has over 2,000 orders for its long-haul semi (~550-mile range, see right), with production scheduled to begin in 2020. And Nikola, Freightliner, Toyota, Eforce, and Xos have announced ZE tractor trailers (see Figure 11).

Fueling and Charging Infrastructure

The pilots above incorporate infrastructure (often charging), and others focus specifically on charging corridors for freight and electrified highways (such as high-power charging, catenary, or in-highway charging).

Daimler Trucks launched a **Global Electric Truck Charging Initiative** in early 2020 to establish charging stations at truck terminals and shops in the US and Europe.²⁵ The Department of Energy has a \$4M **Megawatt charging pilot** with Kenworth. In 2019, California began electrifying a **freight corridor on Interstate 710** (Figure 12) with initial deployment of 50-100 zero emissions drayage trucks with 1-2 fleet operators, coordinated infrastructure, and third-party logistics yards, truck stops & zero emissions mobile charging options.

Figure 11: Tesla Long-Haul Class 8 truck

With 2,000 pre-orders for its long-haul Class 8 truck, Tesla aims to begin production in late 2020. Companies that have ordered the Tesla semi include: UPS (125), PepsiCo (100), Los Angeles-based TCI Transportation (50), Bee'ah (a United Arab Emirates-based refuse-hauling company) (50), Sysco (50), Walmart (45), Anheuser-Busch (40), Canadian grocery chain operator Loblaw Cos. (25), DHL (10), Florida-based City Furniture (5), Michigan-based grocery chain Meijer (4), Ryder Systems, J.B. Hunt, Minnesota Trucking Association, and Tesla itself.



Announced specifications:

Short-range day-cab: \$150,000 (300-mile range, ~500 kWh battery) and Mid-range truck: \$180,000 (500- to 600-mile range). Potential Megawatt charger – 400 miles in 30 minutes.

Compared to diesel day-cab of \$120,000 – expected to pay off price premium in two years - \$1.26/mile operating EV vs 1.51/mi diesel, assuming \$0.07/kWh to charge).

Sources: <https://www.trucks.com/2019/09/05/everything-we-know-about-the-tesla-semi-truck/>, <https://insideevs.com/tesla-semi/>

Figure 12: I-710 corridor in California

Source: Moving Forward Network



²⁵ Daimler e-truck <https://www.truckinginfo.com/351286/daimler-trucks-launches-global-electric-truck-charging-initiative>

California’s Port Advanced Vehicle Electrification (PAVE) project will develop and install a \$17M electrification project for the Port of Long Beach. It includes installation of 40 charging outlets, purchase of four direct current electric yard tractors, and two AC fast-charging yard tractors. The project will deploy battery storage and energy management strategies to analyze grid impacts, and will develop an energy forecasting tool to predict how much infrastructure will be needed to support zero emission terminal equipment.

In Europe, roughly **70 km of catenary lines** have been built. Almost all of the demonstrations are in Germany (Hamburg, Frankfurt, Berlin), with some in Sweden. **Sweden**, in partnership with Volvo, proposes a **large-scale expansion of both e-roads and charging infrastructure** for heavy goods transport.²⁶ However, there are potential concerns with catenary regarding locations, costs, and providers.²⁷ Scania and Asko in Norway piloted **hydrogen fuel cell** distribution for trucks ranging 500 km with locally produced hydrogen from solar.

Allies & leaders exist

To succeed, certain private-sector allies are key: Parcel companies, shippers with private fleets, other big shippers, zero emission truck manufacturers (Table 2), and utilities. Significant allies exist among many of the first movers noted above. In addition to promoting ZE trucks, the Smart Freight Centre identifies Smart Freight Leaders²⁸ by considering emission reduction goals and actions. Complementing these key allies are the elected city, sub-national, and national leaders and diverse coalitions members that can provide technical support, organize communities, create public support or pressure, advocate for policies, and represent labor, health, and environmental justice concerns. Table 3 shows allies and leaders, with more regional details in Chapter 3.

Table 3: Allies and leaders (see Table 2 for vehicle manufacturers. See more regional details in Chapter 3)

Type	Big players/ leaders	Newer entrants or showing interest	Ally relevance Survey results, 0=not an ally, 1=somewhat relevant, 4= very relevant
Parcel companies / freight suppliers/ / postal/ logistics	DB Schenker (high), DP DHL (high), FedEx (high), UPS (medium). Shunfeng (parcel delivery), Tencent (delivery)	Sinotrends, Dutch Transport Association, Long Beach Container Terminal, Austrian Post, Swiss Post, TNT, Kuehne+Nagel	
Shippers (retail)	IKEA, Amazon, Frito Lay, Alibaba (online sales), Aramark, Walmart, Lowe's	H&M, AT&T, HP, Nike, Metro AG, Askuk (Japan), Alcoa, Best Buy, Campbell's, DELL, Dow Chemical Company, Epson, Intel, Kohl's NIKE, Philips, Procter and Gamble, Unilever	
Private fleet day cabs, service vehicles, others	Telecom (BT, NTT), PepsiCo, Coca Cola, Staples	Sysco, Heineken, Ball Corporation, Grocery chains, Heinz, Morning Fresh Dairy, New Belgium Brewery	

²⁶ Sweden e-highways <https://www.linkedin.com/pulse/more-hesitation-take-decisions-build-electric-roads-now-henriksson/>

²⁷ Catenary concerns are: **Locations:** Limited to key corridors, and not readily movable. **Requires dedicated lanes:** Need cross border (e.g., Europe) compatibility and regional coordinated decision making. **Costs and business model:** Huge investment cost in roads that are already poorly maintained (in some regions). Viable business models.

²⁸ Freight leaders are identified using five criteria: 1) Logistics emission reduction targets; 2) Measurement, reporting and verification of emissions; 3) Achieved emissions reductions through actions; 4) Collaboration strategies to mobilize action across the logistics supply chain, including a) green knowledge transfer and communication; b) investment and resource transfer; and c) management and organizational practices; and 5) Pro-active policy input, in particular in relation to climate change

Total cost of ownership is attractive and continues to improve

Battery prices are the most significant factor affecting the cost of a battery electric truck (BET). For example, the batteries in a heavy-duty long-haul truck with 500-mile range constitute 50-65% of the current purchase cost. Positively, through innovation in battery technology supported by policy and research and development funding, battery prices continue to fall dramatically (Figure 13).

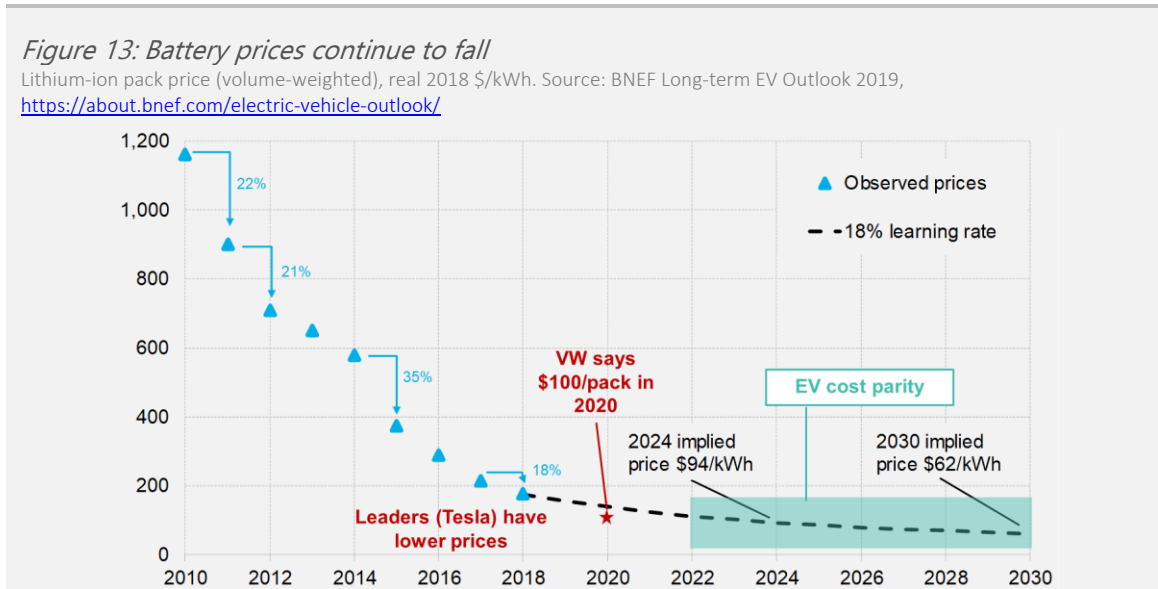


Figure 14 summarizes total cost of ownership of battery electric and hydrogen fuel cell trucks over time, and time parity estimates from seven data sources. While it varies a little in each study, the total cost of ownership generally considers initial purchase cost, operating costs (fuel and maintenance), infrastructure cost, residual market value, and sometimes other factors (time penalty, weight penalty).

For battery electric trucks, some usage segments have total cost of ownership parity **now** (urban uses, walk-in step vans, deliveries) and many more will see parity **by 2025** (drayage, regional cabs, heavy goods). Long-haul tractor-trailers can achieve parity **by 2030** (some models show total cost of ownership parity **now**). Other uses with high immediate suitability include box truck (pickup) <200 mi/day, parcel delivery step van, municipal fleet step van, leased box trucks, heavy duty parcel delivery, short haul regional tractor, refrigerated box truck, straight truck pickup/delivery, heavy load >100 miles/day, trash/recycling truck, utility service, yard tractor, and dump truck. Elements that most impact a truck's usage and cost environment and can drive down payback periods include low charging costs (most sensitive parameter), low battery prices, higher annual mileage, and high diesel prices. Note that for all use cases, battery electric trucks have much lower Total Cost of Ownership (TCO) than hydrogen fuel cells (see Appendix B, Figure B5).

This attractive total cost of ownership means that, assuming success, ZE freight can also offer significant economic benefits in addition to greenhouse gas (GHG) savings, important arguments for the truck owners and policymakers. Since electricity prices are often regulated, and in some countries, oil is not, electric trucks also avoid price volatility in the TCO. In places like India and China, the rapid growth in freight activity (see Figure 1) offers opportunities to 'leapfrog' combustion vehicles, avoiding the lock-in of a supply chain based on oil.

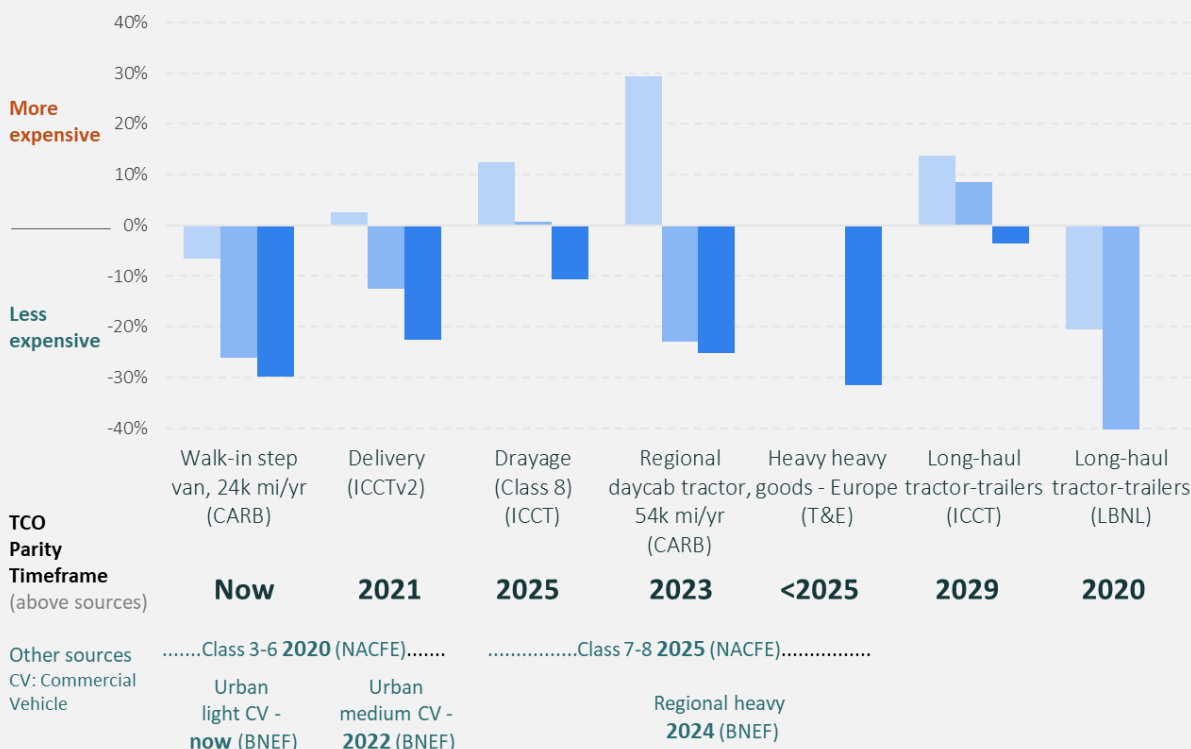
Figure 14: Total Cost of Ownership of Battery Electric Trucks vs. Diesel Trucks over time and parity by use case

Percent of diesel TCO in the given year. BET: Battery Electric Truck. TCO: Total Cost of Ownership. See Figure B5 for TCO of hydrogen fuel cell trucks.
Sources: ICCT 2019 (2 sources), BNEF Long-term EV Outlook 2019, North American Council on Freight Efficiency (May 2018), Transport & Environment (2019), LBNL (2019), CA Air Resources Board (Feb 2019, not that this analysis includes benefit of Low Carbon Fuel Standard fuel credits),²⁹

Battery Electric Truck Total Cost of Ownership

% vs. Diesel truck

■ 2020 ■ 2025 ■ 2030



Though helpful, achieving parity in terms of total cost of ownership or price is insufficient to achieve the necessary fleet transformation rate to meet any meaningful climate goals. As described earlier, to be on track for a below 2-degree change world, we need to see 30+% of new truck sales in key markets to be zero emission trucks by 2030, 80% by 2040, and 100% by 2050, with uptake in India lagging 5 years and the rest of the world lagging only slightly (see Figure B3 for details). While declining costs will help accelerate adoption, incentives and regulatory actions over the next ten years are critical for transforming the market. As a result, philanthropy needs to play a big role in supporting efforts that will accelerate adoption.

"Just because e-trucks exist (and even with cost parity) doesn't mean there will be accelerated takeoff of the products absent ZEV mandates or strong regulatory pushes." – ICCT

²⁹ CA Air Resources Board (February 2019), Advanced Clean Trucks Total Cost of Ownership Discussion Document, https://ww2.arb.ca.gov/sites/default/files/2019-02/190225tco_0.pdf. ICCT 2019v1: Estimating the Infrastructure Needs and Costs for the Launch of Zero-Emission Trucks, <https://theicct.org/publications/zero-emission-truck-infrastructure/>. ICCT 2019v2: ICCT, CALSTART, and C40 Cities. Zero-Emission Freight - Vehicle Market & Policy Development Briefing for C40 Cities, September 2019. BNEF Long-term EV Outlook 2019, <https://about.bnef.com/electric-vehicle-outlook/>. North American Council on Freight Efficiency (May 2018), Electric Trucks: Where They Make Sense, <https://nacfe.org/future-technology/electric-trucks/>. Transport & Environment (2019 via European Climate Foundation). Lawrence Berkeley National Laboratory (2019). Long-haul battery electric trucks are technically feasible and economically compelling, <https://eta.lbl.gov/publications/working-paper-005-long-haul-battery>.

2. Theory of change, outcomes, and interventions

Overall theory of change and goals

Goal statement: Our goals are to support grantee work that eliminates greenhouse gas and other emissions from freight (making zero emission trucks mainstream within ten years) and significantly improves air quality and health, all in line with a well below 2-degree scenario. See Table 4 for the quantitative targets over time.

Table 4: Goals

Category	Metric / region	2025	2030	2040	2050
ZE truck sales	% of new sales that are ZE trucks in Europe, China, and the US	15%	30%	83%	100%
	% of new sales that are ZE trucks in India	8%	15%	57%	98%
	% of new sales that are ZE trucks in the rest of the world	4%	8%	32%	83%
Tons abated	Mt CO ₂ abated worldwide	45 Mt	95 Mt	730 Mt	2,700 Mt
Health/air quality	Deaths avoided per year				100,000 deaths avoided per year (affecting ~1.3 billion city dwellers)
Finance	Mobilize public and private finance to accelerate the zero emission freight transition	Specific dollar targets would be identified during strategy implementation.			

Theory of change: The global nature of the truck manufacturing industry and supply-chain encourages a global strategy. Philanthropy can support research, advocacy, technical assistance, and coalition building to overcome key barriers at a pace and scale consistent with the climate challenge. The overall theory of change is depicted in Figure 15 and described below.

We achieve emission, air quality, and health outcomes by increasing zero emission (ZE) truck share of sales and fueling infrastructure deployment. Over time, continued sales drive technology adoption, lower prices, and increase awareness. Throughout, we remain technology-neutral in policies, but focus on zero emissions, recognizing that battery electric trucks are the best solution for most applications. Achieving scale is a priority. As such, grantee work to encourage national policies are important goals, and international companies are critical stakeholders.

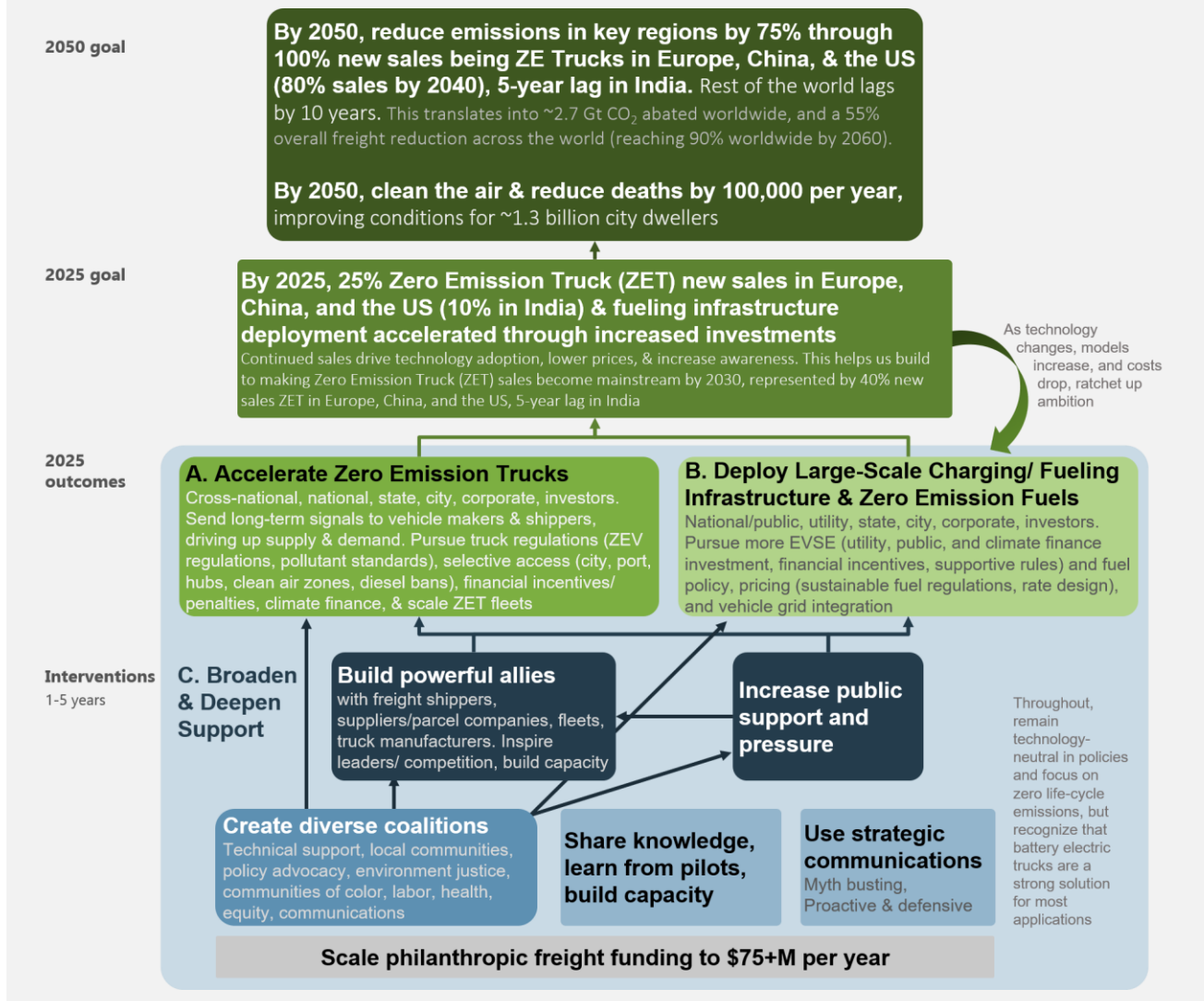
“Success in overcoming barriers will create regulatory, social, and financial drivers that provide impetus for fleet conversion and give manufacturers the certainty they need for production investments”
– Environmental Defense Fund

To achieve our long-term outcomes, key policies, incentives, and interventions fall into three main categories described below. Throughout all, we aim to support strategic communications work that can effectively tell the success stories, uplift voices of allies, and refute false narratives.

- A. **Accelerate Zero Emission Trucks.** Support grantee work to set aggressive truck regulations and generate investments at cross-national (e.g., EU), national, state, and city levels, sending long-term signals to vehicle manufacturers and shippers alike, driving up demand and ZE truck sales. Strong policies and increased investments help expand models and infrastructure, with policy especially important for long-haul that requires up-front investments as well as infrastructure corridor development. Successful adoption of policies in cities and states—and subsequent positive experiences—can lead to national adoption. Over time, as technology and the market mature, and as demonstrations and fleets prove uses, increase ambition. Additionally, scale zero

Figure 15: Theory of change

Based on numerous interviews, surveys, and meetings with advocates, experts, and leaders, the following reflects a shared theory of change held by our partners and grantees.



emission truck fleets: Large progressive fleets will champion the cause and influence peers when they incorporate and use ZE trucks. By focusing initially on large private fleets (building allies, sharing knowledge, addressing barriers, and through fleet regulations), we will build impressive use cases that will help drive the market, build momentum, and increase policymaker confidence.

- B. **Deploy Electric Vehicle Supply Equipment (EVSE) & Zero Emission Fuels.** Support grantees to lead to dramatically increased investment in infrastructure by engaging national, utility, state, city, and corporate stakeholders.
- C. **Broaden and Deepen Support.** To achieve these results, grantees can broaden and deepen support in a variety of ways:

- **Build powerful allies** in freight shippers, suppliers/parcel companies, fleets, truck manufacturers, and other influential parties. By inspiring leaders and fostering healthy competition, we can build capacity, overcome barriers, and increase pressure/accountability to lower emissions.
- **Increase public support or pressure**, which can influence key stakeholders, policies, and investments (see Figure 16 for the Amazon example).
- **Generate support and coordinate through diverse coalitions.** An aggressive coalition building effort that focuses on technical support, local communities, and public pressure will be critical to success. These coalitions should include environmental justice, communities of color, labor, health, and communication groups. Coalitions can engage stakeholders, encourage public funding for priority pilots, directly influence policies and investments, build public support, and use strategic communications to neutralize opposition. Many of the coalitions will be local, but in some cases might be national or cross-national (at the EU).
- **Share knowledge and build capacity.** Closing the information gap on ZE trucks will make them more accessible to decision makers, truck purchasers, shareholders, and the public. Sharing details about ZE truck potential, technological readiness, cost of ownership, results of pilots, and need/benefits to climate/air quality/communities can help build interest and commitment. Leveraging the success of publicly funded pilot projects can offer important lessons, inspiring others through success stories, and increasing public visibility. Sharing successes and lessons can give public and private decisionmakers confidence in actions.
- **Throughout, use strategic communications** like myth busting, and proactive & responsive (defensive) communications.
- **Scale philanthropic funding.** To close the significant funding gap, work closely with the Climate Leadership Initiative to raise awareness among philanthropic partners, create common resources for fundraising, fundraise among interested and potential new foundations and high net worth individuals, and collaborate with freight funders over time.

Figure 16: Amazon – Shipment Zero and Climate Pledge

Sources: [Amazon Shipment Zero](#), [Shareholder resolution](#), [Climate Pledge](#), [Truck image source](#)

In a pressure campaign in late 2018, shareholders adopted a resolution asking Amazon to “adopt a policy with quantitative, company-wide goals for managing greenhouse gas (GHG) emissions, considering the objectives and timelines of the Paris Climate Agreement.” The resolution provided examples of other companies with GHG reduction goals (Apple, Johnson & Johnson, General Motors, AT&T, Procter & Gamble, JP Morgan Chase, McDonald’s, and Microsoft) and peers with GHG management goals (Walmart, Target, Google, Best Buy, Otto, and Oracle).

Responding to shareholder pressure, in spring 2019 Amazon committed to reducing delivery emissions 50% by 2030 and making all shipments net zero in the longer term in an initiative called “Shipment Zero.”

In September 2019, Amazon committed to Net Zero emissions by 2040 and 100% renewable energy by 2030. Consequently, Amazon ordered 100,000 electric delivery vehicles from ZE vehicle startup Rivian to be on the road from 2021, 10,000 by 2022, and 100,000 by 2030. Amazon is also exploring electric bikes or electric rickshaws in India.



Details on how to Accelerate Zero Emission Trucks, Deploy Electric Vehicle Supply Equipment (EVSE) & Zero Emission Fuels, and Broaden and Deepen Support are below.

A. Accelerate zero emission trucks (ZE Trucks)

"Strong requirements in China paired with significant incentives have been a powerful combination driving huge commercial vehicle adoption in key cities."
— CALSTART

To accelerate zero emission trucks, increase model availability, and address cost barriers, focus on supporting grantee work in three main areas: truck regulations, selective access rules, and financial incentives/solutions/ penalties.

Truck regulations and fleets

Regulations are the most attractive and effective ways to advance the market.

- **Zero Emission Truck regulations for OEMs** (national, sub-national regulations). Regulation is needed to foster sales targets for OEMs and drive ZE Truck uptake. See Figure 17 for the leading regulation under development in California.
- **Fleet regulations or rules.** Rules overseeing publicly-owned fleets, refuse trucks, others that specify ZE truck uptake (% of fleets) are efficacious tools and encourage adoption.
- **Strict GHG truck standards or air pollutant standards.** Establishing strict national or cross-national (European Commission) standards can protect the health and welfare of populations, clean up air quality, and drive adoption of ZE vehicles. As costs of fossil-fuel based engines increase, ZE trucks gain price parity sooner.
- Also consider **supportive policies** such as weight exemptions (to avoid loss of payload) for ZE trucks including within EU countries

Selective Access

- **Cities: Secure commitment for, designate, and implement clean air zones or areas (also known as zero emission zones).** Creating these designations or imposing diesel bans in cities that focus on medium- and heavy-duty

"Setting up a zero emission zone in a US city would be a game changer, sending a strong signal to the industry."
— Union of Concerned Scientists

Figure 17: CA Advanced Clean Trucks Rule

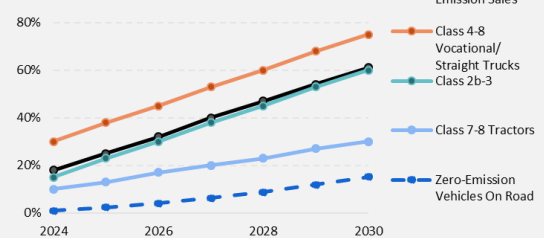
Leading the world, California's Air Resources Board (CARB) is proposing an Advanced Clean Trucks (ACT) Rule that would apply to Model Year 2024-2030 trucks, including Class 2b-3, Class 4-8 straight trucks, and Class 7-8 tractors.

NGO goals (see charts below) are to see 15% of the total fleet of on-road zero emission vehicles by 2030. However, the current CARB proposal is not as ambitious, calling only for 4% of the nearly two million trucks to be electric by 2030 (based on 2024, 7% ZE Trucks of Class 4 to Class 8 straight trucks sales and 3% of all other truck sales; by 2030, 50% ZE Trucks Class 4-8 straight trucks sales and 15% of all other truck sales).

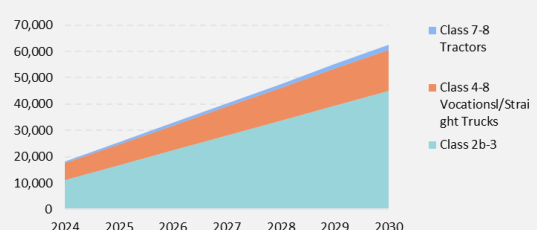
The broad campaign coalition includes 70+ people and 25+ groups. Industry representatives include BYD, Tesla, So Cal Edison, and Motiv. The coalition includes **NGOs** (UCS, Earthjustice, Sierra Club, NRDC, Greenlining, others). Community Groups: Including East Yard Communities for Environmental Justice, Center for Community Action and Environmental Justice, Communities for a Better Environment, Moving Forward Network, others) and **labor** (International Brotherhood of Electrical Workers, BlueGreen Alliance, National Electrical Contractors Association).

The rule has been under discussions for the last 3 years, a draft rule³⁰ came out in late October 2019, the board hearing is in December 2019, and the final vote will be in spring 2020.

Zero Emission Sales Percent



Zero Emission Trucks



³⁰ California Advanced Clean Truck draft rule, October 2019, <https://ww3.arb.ca.gov/regact/2019/act2019/isor.pdf>

vehicles (allowing zero emission vehicle access) have proven effective. For example, Shenzhen (China), the first city (July 2018 start) to create “green logistics zones,” a pilot project, has effectively focused on electric logistics vehicles. Rotterdam (Netherlands) has a new (2019) zero emission street for trucks ('s-Gravendijkwal). And 35 cities so far have committed to creating zero emission areas including zero emission freight deliveries through C40’s Green and Healthy Streets Declaration. Given the growing interest, it is important to facilitate information sharing and support implementation among cities to increase adoption.

“Mayors hearing from other mayors is powerful.” – C40

- **Advance zero emission hubs (sea ports, multimodal facilities, railyards, and warehouses):** Including ZE freight mandates into permit requirements for large-scale infrastructure projects including road and port expansion can have significant, widespread impact. Building on national policies such as the US’s Clean Air Act or China’s Domestic Environmental Control Areas and sub-national/city commitments, this initiative addresses freight emissions, potentially during the permitting process, such as when a new building applies for a building permit or when a facility wants to expand square footage the local county.
- **Other access constraints/ZE truck benefits.** Favoring ZE trucks by allowing access during preferred times of the day—for instance, night delivery to avoid direction—can incentivize adoption, as can creating preferential parking or loading/unloading zones for ZE trucks.

Financial incentives/penalties and financing

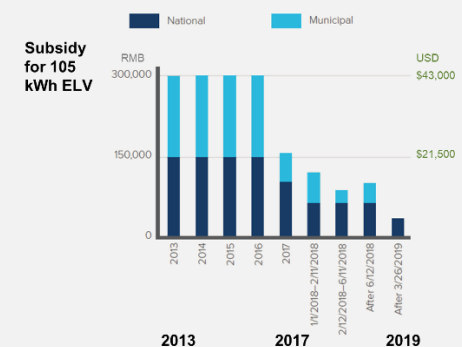
Financial incentives, penalties, and financing can address the barrier of high initial cost and also send a strong signal to manufacturers. These incentives are only necessary in the first few years (e.g., 5 years) since battery prices are falling and technology is changing rapidly. Options include supporting grantee work to increase public incentives like rebates, feebates (where high CO₂ vehicles or fuels are charged premiums that feed into benefits such as rebates for low CO₂ vehicles or fuels), or scrappage incentives for older diesel trucks (to be used for ZE truck purchase). We recommend grantmaking that prioritizes heavy duty and some light/medium duty ZE trucks. There is also potential to match incentives with penalties to foster transitioning to ZE trucks. The following describes a range of solutions that grantees are promoting:

- **Purchase incentives and tax rebates:** The most direct and effective way to reduce the purchase cost is to establish purchase incentives through mechanisms like rebates or exemption of electric trucks from sales or value-added taxes, though governments phase these down as price parity is achieved, and to encourage competition. Figure 18 describes purchase incentives in Shenzhen (also detailed in Chapter 3) and in the US in California, New York, and Chicago.

Figure 18: Shenzhen and US purchase incentives

Sources: RMI, UCS, CALSTART

Shenzhen has purchase subsidies at the national, state, and municipal level targeting near-price parity with internal combustion vehicles. \$20-45k/truck. Capital recovery occurs in 1-1.5 years. The subsidies are being phased out in 2020 as purchase prices have fallen (see chart).



Source: <https://rmi.org/insight/a-new-ev-horizon>

California has significant incentives through HVIP (Hybrid and Zero Emission Truck and Bus Voucher Incentive Project) financial incentives: \$40k-150k per zero emission truck.

New York has a \$15 million voucher program for electric trucks (Truck Voucher Incentive Program)

Chicago has a \$11.3M e-truck voucher (Drive Clean Chicago, another \$20M coming)

- **Feebates, tolls, and penalties:** Financial disincentives are effective tools. The most common methods include road tolls, registration fees based on CO₂ coupled with discounts for ZE trucks, and “feebate” systems that charge dirtier trucks more and whose funds subsidize ZE trucks. Additionally, CO₂-based registration fees and road tolls, taxation, mileage fees, or carbon taxes are effective mechanisms.
- **Institutional financing and new business models on total cost of ownership.** Upfront costs of ZE trucks can be significant deterrents, which means there are opportunities to provide low-cost financing, or support new business models such as leasing. By working with investors, manufacturers, utilities, and governments to develop programs that finance the upfront cost of ZE trucks, we will see measurable increases in trucks on the road. Grantees could pressure financial institutions and advise bond rating organizations to incorporate climate risk into debt and equity of major truck manufacturers and oil and gas companies. Grantees could also provide evidence of positive TCO to lower risk profile of financing, encourage approving faster depreciation on EVs to support corporations to go electric, etc. Leasing companies in particular have scale, expertise, and analytics capabilities that most operators do not; this creates four classes of advantages: cost (right-sizing vehicles, aggregating demand, increasing utilization of vehicles), maintenance (ZE truck repair expertise, repair crews), operation (trained drivers at low costs, monitoring vehicle behavior and usage, collect data and optimize routing), and charging (install own charging networks, chargers near warehouses).

B. Deploy large-scale charging/infrastructure & zero emission fuels

Infrastructure and fast charging will be critical for accelerated adoption of ZE trucks. To address the challenge of infrastructure, we focus on grantmaking in the following areas: grantee work to advance policies for and investment in charging/ZE fueling infrastructure, and fuel regulations and pricing/rate structure. Without both, cost parity will be significantly delayed. Among these, the most important interventions are to create large-scale public and utility investments in infrastructure, ensure fuels are zero emission through sustainable source fuel regulations, and optimize charging and electricity rate design.

Policies for and investment in charging/ZE fueling infrastructure

Infrastructure costs add more than \$70,000 per battery electric long-haul tractor-trailer and more than \$25,000 per drayage truck or delivery truck, amounting to 7% to 9% of the lifetime operating cost in each application (ICCT 2019). Without public funding for infrastructure, cost parity on a total cost of ownership basis would be pushed from the early 2020s to 5-10 years later. Investments, incentives, and supportive rules address this barrier.

Figure 19: California fuels and infrastructure investments

Sources: UCS

Utility investments: Southern California Edison, Pacific Gas & Electric, and San Diego Gas & Electric are utility champions. In 2018, the California Public Utilities Commission approved \$738 million in charging and EV investments: a 5-year project with chargers for 18,000+ trucks and equipment.

Low Carbon Fuel Standard credits (goal: 20% reduction in CO₂ by 2030 vs. gas/diesel). Revised in 2017 to go through 2030. Potential \$10-20k+ per truck (\$0.16/kWh)

California Electric Vehicle Infrastructure Project (CALeVIP) has charging infrastructure rebates, with up to \$80,000 for DC fast charging stations.

- **Large-scale public, institutional, and utility investment in EVSE infrastructure in each region:** Because of the challenging private business case for infrastructure, it is critical to get public investment in infrastructure to accelerate the transition to zero emission trucks. Important to this effort will be to support for work to develop public and institutional funding sources for and commitment to direct investment in infrastructure/charging investments. This includes work that focuses on: A) Big sources of **public funding**, such as national transportation infrastructure spending. B) Financing through **climate (or green) bonds**, while ensuring they have more attractive financing terms than traditional bonds (e.g., interest). C) Engaging with **utilities** (both leading and in unexpected places, see Figure 19 for California examples) to accelerate investment and educate them about the loads of electric trucks. Additionally, supporting grantee work that contributes to utility rulemaking (e.g., Public Utility Commission hearings in the US) and promotes ‘pay-as-you-save’ models for utility investment in charging for customers will be worthwhile objective.
- **Financial EVSE incentives:** Support grantee work on EVSE infrastructure subsidies (national, state, city) that focus on fast chargers will foster growth and uptake of ZE trucks. Especially for early large fleets installing their own private EVSE, financial incentives will help improve their business case (for economically attractive business cases, charging infrastructure utilization generally needs to be >33%).
- **Supportive infrastructure rules and siting:** Fund grantees to accelerate implementation, improve public space access (curb space, other) for charging, expand siting options (logistics yards, truck stops, roving charging at ports, hubs or depots), and designate ZE freight hubs with charging/refueling infrastructure, especially around cities. Grantee work should consider siting and management of multiple loads, such as base-charging trucks (fast or slow charging) and on the road charging or hydrogen refueling (e.g., designating corridors, hubs). Over time, as ZE trucks expand, grantees can promote the use of data on charger uses to inform planning, siting, and potential vehicle to grid (V1G or V2G) (e.g., learning from lessons in Shenzhen).

“Charging infrastructure for long-haul is easier than other sectors – they are on highways and close to transmission lines.”

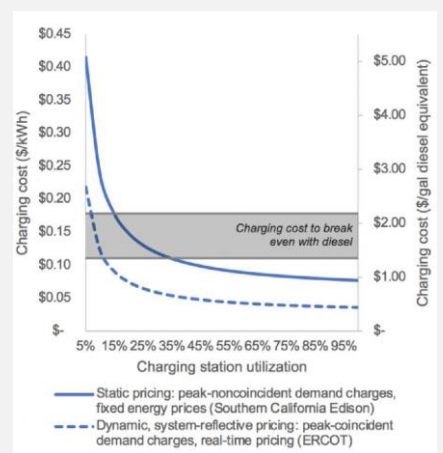
– Lawrence Berkeley National Laboratory

Fuel regulations and pricing/rate structure

- **Sustainable source fuel regulations** (e.g., Low Carbon Fuel Standards). Supporting grantees that pursue requirements on sustainable fuels are vital to avoid the risks of using CO₂-based fuels such as natural gas for electric-drive trucks. Other important grantee work should include looking at Low Carbon Fuel Standards that, while requiring sophisticated regulatory environments, can encourage fuels with lower CO₂ and offer significant offsetting costs to the operation of zero emission (electric and renewable hydrogen) trucks (see California’s incentives, Figure 19). Grantee work on carbon taxes, while politically challenging, are also effective ways to move the market to more sustainable fuels.

Figure 20: Electricity rate design – charging rates under \$0.10-0.18/kWh to break even with diesel

Sources: LBNL 2019³¹



³¹ Lawrence Berkeley National Laboratory, June 2019, Reforming electricity rates to enable economically competitive electric trucking, <https://ies.lbl.gov/publications/working-paper-003-reforming>

- **Optimized vehicle grid integration and electricity rate design:** We need key reforms on rate design and demand charges because the price of electricity has a major impact on the total cost of ownership. Without reforming electricity pricing rates and low utilization of charging infrastructure, charging costs nearly quadruple. Grantmaking will support favorable charging rates for trucks and methods to manage the electrical load – as this occurs, the cost of ZE trucks becomes more attractive than diesel trucks. Accomplishing this will require changes in the utility system, such as utilities and users linking cheap daytime solar or off-peak nighttime power with truck charging times. To enable economically competitive electric trucking, grantmaking can support reform demand charges to reflect the true system costs (in the US, charging at \$0.06/kWh will make electric trucking substantially cheaper than diesel, see Figure 20) and share knowledge with fleets to avoid charging during high-price periods (e.g., <40 hours in a year in CA). Optimized vehicle grid integration can reduce new utility capacity requirements and enable cheaper expansion of renewable power supply. As data on charging behavior becomes available, opportunities exist to reform rate design that incorporates this information on charging times (e.g., learning from lessons in Shenzhen, influence when people charge to limit peak demand).

C. Broaden and deepen support: Allies, coalitions, knowledge sharing, comms, funding

As described in the theory of change, to deepen and broaden support for strong policies/incentives and create demand, we must support organizations trying to build alliances with freight shippers, parcel companies, fleets, truck manufacturers; create diverse local coalitions; increase public support or pressure; learn from publicly-funded demonstrations; share knowledge and build capacity; and use strategic communications.

Build powerful allies

Industry champions are particularly important. The following are some examples of grantee objectives that we should look to support:

- **Powerful multinational company allies, including parcel companies, shippers, and fleets,** set aggressive ZE freight goals, transparently report on emissions, commit to and roll out ZE trucks, and support aggressive ZE truck policies. Large fleets seeking to reduce their CO₂ footprint from freight activities and to advertise those efforts can optimize ZE truck benefits, routes, and fleet charging. These partnerships will benefit all involved. Not only will they foster trust and encourage innovation, public-private partnerships can encourage corporate commitments (including zero

“Parcel companies and cargo owners will together determine whether this campaign is a success. It’s essential that they’re engaged in face to face meetings so that the [partners] fully understand the factors going into their decision on whether to use ZE freight or not”

– Global Strategic Communications Council

Figure 21: IKEA zero emission delivery & EV100

IKEA has company-wide goals to reduce the carbon footprint of its products 70% by 2030. In 2018, IKEA, a founding member of the corporate EV100 leadership program, committed to deliver every item worldwide by electric vehicle by 2025. The initial target was to transition entirely to EVs in five cities by 2020 – New York, Los Angeles, Paris, Amsterdam, and Shanghai. IKEA achieved this goal early in Shanghai by the end of January 2019 by working with leasing companies (DST).

We learned “that in order to succeed, we need the right partners and the courage to challenge our current ways of working”

– Angela Hultberg, who oversees sustainable mobility at Ingka Group (owner of IKEA)

The EV100 platform builds on IKEA’s commitment and leverages lessons to engage and inspire other EV100 members including DHL, Leaseplan, HP, Wipro, NJ/NY Port Authority and more.



Source: <https://www.fastcompany.com/90297201/in-shanghai-every-ikea-delivery-is-now-made-with-an-electric-vehicle>

emission guidelines in corporate procurement guidelines); address questions/barriers to demonstrate the economic and operational viability of fleet conversion; spark accountability/public/stakeholder pressure campaigns (e.g., Zero Now, Amazon pledge, Figure 16); and build capacity to educate freight business owners about the values, attractive total cost of ownership, and more. Integrating GHG data into transport management systems/telematics of carriers, logistical service providers, and shippers can be particularly influential by exposing logistical and operational decision makers to the myriad benefits of transitioning to ZE trucks.

- **ZE truck fleets scale.** To grow the number of ZE trucks on the road, fleet deployments can act as large-scale proof of ZE truck freight. Scaling these successes can also advance policymaker ambition, and create an environment to share lessons with freight and fleet owners. We should support advocates who are leveraging lessons from fleets to share with other regions and public and private fleets.
- **Establishing at least 5 allied ZE truck manufacturers (per region) will provide essential public support and demonstrate viability and OEM commitment.** It will encourage support in the public and with important decision makers about aggressive ZE Truck policies and influence peer OEMs to act. By including major players and newer (only ZE) entrants through engaging the truck makers in knowledge-sharing networks that share pilot success and coordinate with coalitions on policies, our grantmaking can help foster an ambitious, optimistic mindset regarding ZE trucks. See Table 2 for specific ZE truck maker allies including key allies of Daimler, Volvo, and Tesla.

“Trucking OEMs are even more critical than in the car sector”

– European Climate Foundation

Increase public support/pressure

Increase public support or pressure and accountability. Governments, investors/financiers, and activist organizations are increasing the pressure on companies to be transparent about the CO₂ impacts of their supply chains, including logistics. In turn, shippers can pressure suppliers (e.g., through procurement policies). Companies should increasingly be compelled to share their emissions footprint and/or measures taken (e.g., ZE trucks purchased) or will take to reduce impacts. For example, the Climate Action 100+³², launched in late 2017, is an investor initiative to ensure the world’s largest corporate GHG emitters take necessary action on climate change. Philanthropy can support grantee work to amplify the public, shareholder, and shipper calls for action, including working with front line communities to build strong public support for policies and investments that increase zero emission truck deployments.

“Local frontline communities advocating for environmental justice are the cornerstone of progress – and not just for pressure to act, but to help shake up the status quo and help create solutions”

– Moving Forward Network

Create diverse coalitions

Environmental justice and movement building are important for action on zero emission road freight. Impacted communities cover many types of geographies: seaports, inland ports (logistics hubs/centers), congested urban delivery areas, and truck corridors. Labor (represented by unions) can be a powerful player and must be aligned with the zero emission (electrification) transition and involved in coalitions, since air quality and climate change affect individual health, workers’ livelihoods, and the economy.

“The history of environmental justice in California and a growing number of legislators of color combine to create strong support for ZE truck deployment.”

– Greenlining Institute

³² Climate Action 100+, <http://www.climateaction100.org/>

We will make grants to organizations who are **building and empowering coalitions to support zero emission road freight in every region** – in Europe, the US (including environmental justice and communities of color), China, India, and select cross-national coalitions. Local coalitions should be broad and include community groups, technical support, low income areas, communities of color, labor, health, equity, communications, and other stakeholders. Local frontline communities in particular should be engaged from the beginning of campaigns, listened to regarding priorities (met where they are), and supported to increase their growth, power, and influence. With labor, we will focus our grantmaking on a just transition (including training) with strong implementation that connects training programs with jobs on the other end.

“Make a living on a living planet.”

– Labor Network for Sustainability

By supporting regular interactions, coordinated asks, and policy development, we can increase the coalitions’ effectiveness to advocate for change, policies, and progress on zero emission trucks and fueling infrastructure (strategic priorities identified throughout this strategy). Coalitions can organize public and stakeholder pressure and also provide support (technical, public support, op-eds, etc.) for decision-makers.

Share knowledge, learn from pilots, and build capacity

- **Global knowledge sharing platforms & networks** can build capacity of decision makers, truck purchasers, shareholders, and the public and ensure that these efforts do not occur in a vacuum. Making available the results of applied research and sharing lessons from pilots will close the knowledge gap and provide unbiased information to policymakers and other stakeholders. Global knowledge sharing platforms & networks regularly convene (webinars, meetings, networks) and share results, challenges, successes, best practices, and technical support from research (including TCO, infrastructure), data (including model availability such as through model availability guides), and pilots. Audiences include the NGO community, public policymakers and private decision makers (corporate allies, fleet owners). Knowledge sharing should also connect and share knowledge about coalitions and strategic communications.
- **Share results from demonstrations broadly and with important audiences**, public and corporate. As described above, pilots have already proven uses for medium- and heavy-duty trucks – including ~60 pilots, ~1,000 vehicles, ~70 km e-highways, mostly in Europe, the US, and China, with companies and governments dramatically ramping up deployments to the tune of thousands and hundreds of thousands of vehicles per year. Ongoing demonstrations can provide further lessons. The aim is not to let OEMs use demonstrations as a delay tactic, but to test specific unknowns and scale what works (e.g., IKEA tried seven approaches simultaneously and scaled what worked best). Ideally, show a few successful examples in each region. Share results from: A) **Urban and parcel delivery**, including Shenzhen, IKEA, DP DHL, and Deliver Electric Delhi. B) **Regional haul, drayage, ports**, such as Long Beach/LA port. C) **Inland freight hubs (as focal points for rapid scaling)**. For example, Columbus, Ohio, is a logistics hub, and 40% of the US’s GDP is within a one-day truck drive of Columbus.
- **Leverage the experience and knowledge from electrification pilots into credible guidelines** that benefit all businesses
- **Direct public funding for demonstrations** to medium/heavy duty applications.

“Convenings and case studies are critical to get the next tranche ‘fast followers’”

– North American Council on Freight Efficiency

- **Encourage long haul and charging corridor demonstrations/deployments**, with 1-3 heavy duty long haul/e-highway pilots completed (1+ in Europe such as in Sweden, China, US, India).
- **Research key topics**, including charging infrastructure locations/corridors for road freight at convenient locations (e.g. ports, hubs, truck stops, etc.) and recommendations for addressing road funding. Put simply, we will focus research on key barriers and share the results.

Use strategic communications

Communication has historically been under-resourced, and this initiative requires a positive, proactive communications strategy to counter the myriad attacks on ZE trucks by those who have vested interests in slowing or stopping change. The ZE truck transition will be considered radical to some actors, and they may propagate myths and misinformation in hopes of delaying action on ZE trucks. We anticipate they will aggressively engage with communities, businesses, and labor to persuade them against electrification. Electrification can also be conflated with automation, and these actors promote that conflation/confusion. Our messaging must be clear, engaging, fact-based, and accessible to broad audiences. Given the limited attention spans of audiences and short lifetime of stories, we will need a thorough communication strategy to keep the benefits of ZE trucks in the spotlight and garner positive attention.

Strategic communications is “communicating the best message, through the right channels, measured against well-considered organizational and communications-specific goals. It’s the difference between doing communications stuff, and doing the right communications stuff.”

– Climate Nexus

Specifically, this strategy supports **impactful, strategic communications** that provide regular proactive, positive, and fact-based assessments of ZE trucks and unbiased information, highlight benefits (including air quality, health, justice, and jobs), myth bust/release defensive communications, and support specific coalitions or decisionmakers as needed. Additional details are below.

- **Communications should be integrated early and throughout advocacy efforts.** A good communications process includes setting a goal, developing a strategy, defining target audiences, testing (polling, various messages), developing core messages (accessible, value-based, and succinct), determining tactics, measuring progress, and evaluating. This might include partnering with communication firms.

Helpful narratives

Responses to a survey question to NGOs, policymakers, & experts: What narratives work well (how important are they) for zero emission road freight actions in your region?



- **Establish the narrative.** Don't let the detractors define the issue. Improved communications should define and concentrate communications on the expansive possibilities of ZE freight. Improved air quality and health benefits are meaningful to the public, particularly since they provide a clean alternative to diesels and Diesel Death Zones. The economic benefits of transitioning for truck owners via reduced fuel and maintenance costs and through job creation are great, and ZE trucks address climate concerns. See Word Cloud for other helpful narratives.
- **For positive communications**, support organizations who are providing values-based messages, identifying key messengers who can drive the narrative, making messages personal, using compelling images and video (with people), and increasing coverage around events. Also support grantees who are: Regularly publishing a positive analysis report of zero emission freight;

providing analysis of the social and economic benefits of the use of ZE trucks to increase public awareness and help remove obstacles to their adoption; targeting fleet purchasers with analysis on total cost of ownership of EVs benefits; producing positive case studies of their rivals moving ahead; and proactively telling the real stories about small businesses saving money and improving working conditions and communities.

- **Rebut myths.** Support grantees who use data and real-world examples to prove the viability of electrification and shift away from investment in fossil fuel-based infrastructure, and who bust myths.
- **Audiences and venues.** Support work whose audiences include decision makers (national, state, city), companies (e.g., shippers of goods and parcel companies), ZE truck manufacturers (leaders like Volvo, Daimler, BYD, Tesla), utilities, the public, and allied groups and organizations; and whose venues include earned media (op-eds), paid media, social media, branding, marketing, testing.

Scale philanthropic funding

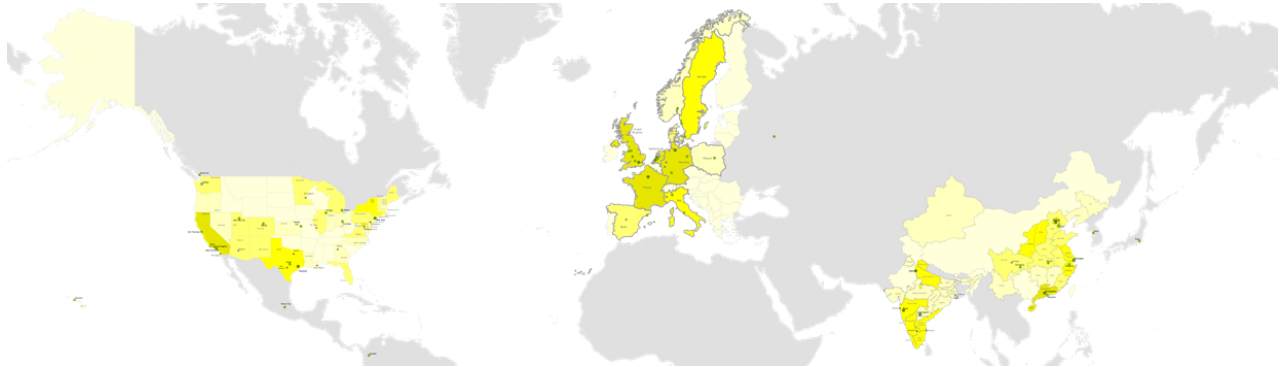
As introduced in the executive summary (and detailed more in Chapter 4), even with increased Hewlett funding for zero emission road freight, we are still left with a large funding gap to achieve the medium and long-term goals in this strategy. Hence, working with partner funders to scale philanthropic investment in zero emission freight is an integral part of this strategy. Our goal is to catalyze at least \$75 million per year to freight.

In 2019, three endowed funders (Hewlett Foundation, Tempest Advisors, Heising Simons Foundation) and five re-granting funders (ClimateWorks Foundation, Energy Foundation, Energy Foundation China, European Climate Foundation, and the Zero Now Fund) funded zero emission freight activities. Positively, many other funders are interested in zero emission freight, including the IKEA Foundation, Children's Investment Fund Foundation, Oak Foundation, Pisces Foundation, Mercator, McKnight Foundation (US Midwest), Aspen Global Change Institute, and others.

Activities to scale philanthropic funding include:

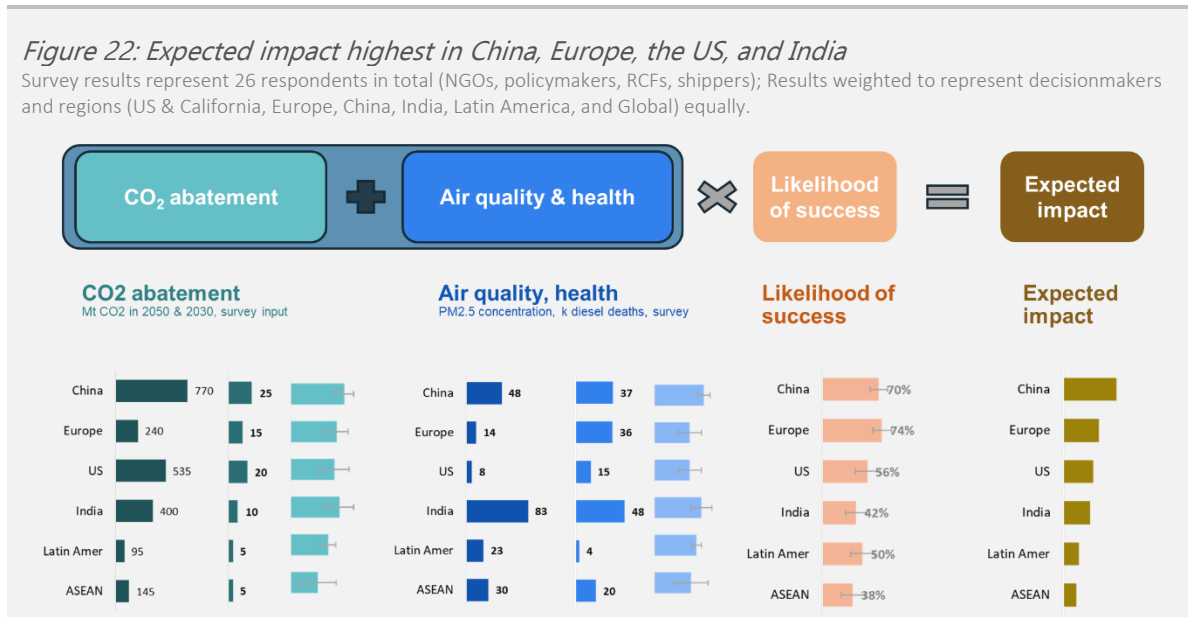
- **Among philanthropic partners, increase awareness** of the technological readiness (e.g., model availability, attractive total cost of ownership, etc.), and political opportunities (detailed in this document) to pursue zero emission trucks, funding needs, and funding gaps.
- **Create common resources for fundraising, including summary presentations** that introduce the overall strategic themes, offer regional specifics, and present high priority potential investments (by region and globally).
- **Fundraise by working with the Climate Leadership Initiative (CLI)** to present the opportunities and turn excitement into committed funds for zero emission road freight. This will involve reaching out to foundations (see above for initial potential funders) and high net worth individuals through multiple channels.
- **In the longer term, collaborate with freight funders to** 1) Track the funding landscape and gaps by topic, region, and grantee, 2) Support multi-regional platforms and regional climate foundations, 3) Share information on grantees, and 4) Consider funding through existing intermediaries or pooled funds.

3. Regional landscapes & strategy overviews



With near-term (2030) and long-term (2050) emissions abatement potential, promising air quality and health improvements (avoided deaths from on-road diesel), and a moderate to high likelihood of achieving reductions (e.g., representing the political will to do so and viable ZE truck solutions), significant potential exists across China, Europe, the US, and India, with an outsized benefit in China. These four regions are Hewlett's focus geographies across its climate funding, meaning that we will look to support grantees and institutions doing this work in these geographies. As noted earlier, while Hewlett's funding will be focused in these regions, efforts to move toward zero emission freight are also critical in all other parts of the world. We welcome the opportunity to coordinate with philanthropic funders who are interested in other regions.

A summary of the potential is below and detailed in Figure 22.



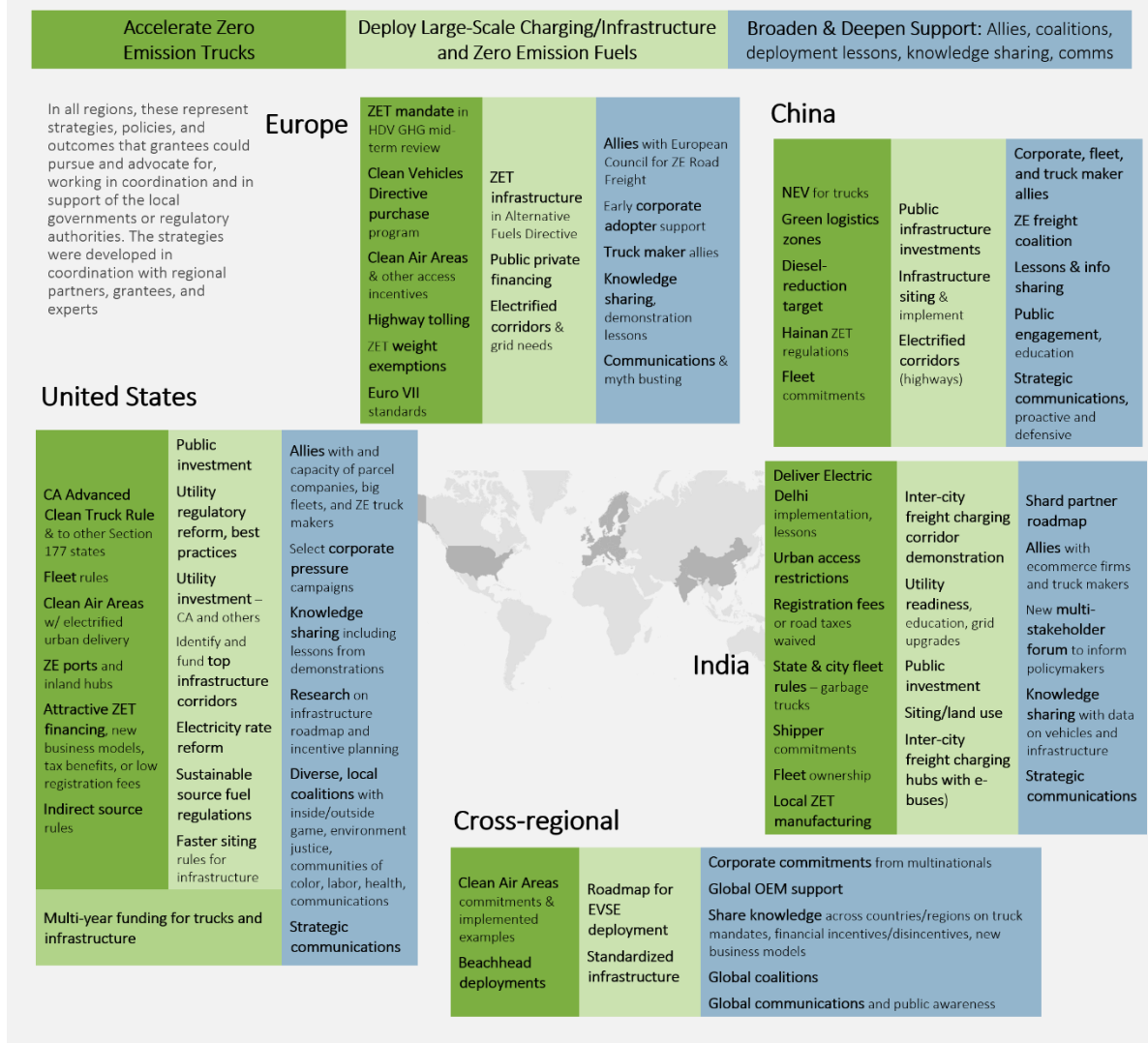
- **China** has the highest abatement potential, high air quality/health improvement potential, and a high likelihood of success.
- **Europe**, while having a moderate abatement potential, has a very high likelihood of success and significant potential to avoid deaths from diesel vehicles.

- **The US** has a high abatement potential, lower air quality/health potential when compared to other regions (though still significant), and moderate likelihood of success due to current politics.
- **India** has the highest air quality/health improvement potential and high CO2 abatement, though slightly lower likelihood of success (but this could increase over time).

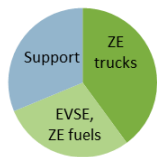
Figure 23 provides an overview of the regional strategies. For each region and cross-regional efforts, an overview of the region, priority geographies, and a summary of important strategies follow. *Note that the strategies reflect comprehensive ideas and Hewlett alone cannot fund all of them.*

Figure 23: Overview of zero emission road freight regional strategies

Opportunities below represent potential priorities that grantmaking can support in each region



China



China has the highest emissions abatement potential of 40 Mt CO₂/year in 2030 and 715 Mt/year in 2050 (960 Mt by 2060). Additionally, it has very poor air quality—on average four times the World Health Organization (WHO) guidelines—affecting at least 700 million urban

dwellers. Approximately 37,000 people die per year due to on-road diesel vehicles. Positively, China is committed to aggressive action as evidenced by its Blue-Sky National Action Plan and National Clean Diesel Campaign to accelerate electrification and reduce diesel vehicle emissions, and its world-leading New Energy Vehicle (NEV) policy (focused on light duty electrification).

The likelihood of success in China is very high. **China's strong requirements** (such as the New Energy Vehicle mandate) paired with significant incentives (including financial and selective access) have induced rapid and significant uptake for electric drive vehicles, with an initial focus on light duty, then on buses, and, soon, trucks. Some local governments, such as Hainan Province, have adopted or plan to adopt even more ambitious electrification targets. **Economic competitiveness** is a key driver in China. Its zero emission truck manufacturers are leading the world with models. BYD (Build Your Dreams), based near Shenzhen, supports rapid electrification of light duty and urban logistics vehicles (see right) and has over 20 models of battery electric trucks. There are other big players in the ZE truck market as well – including BAIC BAW, Dongfeng, Sinotruk, and many others (see Table 2). **Cities are key in Chinese truck electrification efforts** as they have a combination of policies including selective access (restricting heavy duty truck operation in cities due to air quality concerns), ambitious goals, subsidies, and planning. See right for Shenzhen's suite of policies and dramatic uptake of urban logistics vehicles and IKEA's success in Shanghai (Figure 21). **Barriers** to address include flexible technology solutions (battery electric and fuel cell), infrastructure funding, battery recycling, power capacity needed for fast charging, and potential equity considerations of access limitations.

Strategic opportunities

In partnership with our key grantee the Energy Foundation China, below are examples of zero emission road freight strategic opportunities that grantees are interested in pursuing in China.

- Support the government to create a New Energy Vehicle (NEV) policy for zero emission trucks (e.g., 5-40% new sales BEV by 2030 by segment)
- Support cities to expand green logistics zones (or zero emission zones)
- Expand infrastructure planning, funding, siting, and implementation and pilot electrified highway corridors
- Support the government to create a diesel reduction target
- Support the Hainan Province government to create truck regulations
- Build allies: Cultivate corporate allies and ZE truck fleets, encourage ambitious truck manufacturers to influence policies, create a zero-emission freight coalition
- Share information with and build capacity of key stakeholders, engage and educate the public, and increase strategic communications

Shenzhen deliveries – 35% ZE Trucks in 3 years

Shenzhen in China offers a dramatic ZE freight success story. In three years (2015-2018), the city electrified 35% (61,800 of 350,000) of its commercial trucks (focusing on logistic vans), building on its experience electrifying buses. Electrified logistics vehicles (ELV) represent 24% of all EVs in the city.

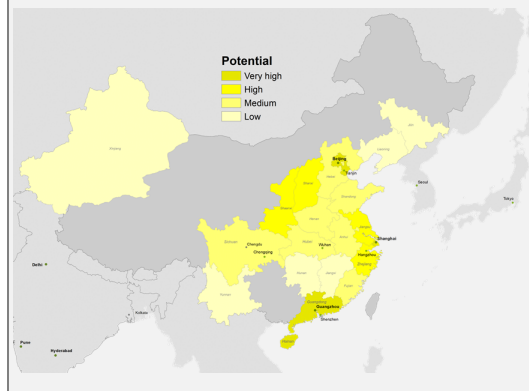


Prime interventions to support the ELV growth were:

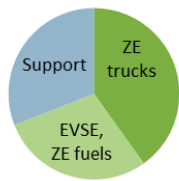
- * **45+ electric urban vehicles models available.**
- * **Purchase subsidies** at the national, state, and municipal level targeting near-price parity with internal combustion vehicles. Note that the subsidies are being phased out in 2020 (see Figure 18).
- * **Preferential city access**, such as daytime entry, entry every day, and access to green logistics zones, ramping up in 2017 as it moved away from relying as heavily on subsidies.
- * **Innovative business models** including leasing companies which could lower costs through aggregating demand, increasing utilization, optimizing routing, and establishing charging networks near warehouses.
- * **Preferential electricity rates, operational subsidies, and fee exemptions for charging operators**
- * **EV charger incentives and district-specific charger targets** to encourage private investment. Early (2013-2015) subsidies for chargers were 30% of the installed cost; in 2017 they adjusted to be higher for faster charging. Installation targets encourage private sector investment. District targets had minimums to ensure a balanced network, with an overall target of 13,400 chargers in 2018. Source: <https://rmi.org/insight/a-new-ev-horizon>

Geographies

Rapid electrification efforts have occurred in a number of cities: Beijing, Guangzhou, Shenzhen, and Shanghai. Hainan island intends to ban fossil fuel vehicles by 2035. Other priority areas includes those of focus in the Blue-Sky plan, which prioritizes e-bus, e-municipal vehicles, and charging infrastructure (see map). The top 15 urban areas with the most deaths from on-road diesel are: Guangzhou-Shenzhen, Beijing, Chengdu, Shanghai, Chaozhou-Shantou, Wuhan, Chongqing, Hangzhou, Tianjin, and Changzhou.



Europe



Europe has a moderate emissions abatement potential of 20 Mt CO₂/year in 2030 and 240 Mt/year in 2050 (280 Mt by 2060). Europe has a growing mandate to address air quality and prioritize health in cities as illustrated by low emission zones in many cities, and commitments to establish zero emission areas. 36,000 people die per year due to on-road diesel vehicles.

Europe has a very high likelihood of success to achieve zero emission road freight. **Significant policy changes** in Europe have occurred in the last few years that, coupled with existing conditions, mean that Europe can electrify the trucking industry rapidly as regulations economically favor ZE trucks. Key reasons include: 1) The Volkswagen Dieselgate emissions cheating scandal influenced manufacturers to shift to electrification and away from diesel. 2) The public and policymakers are supportive of change, as evidenced through zero emission zones, diesel bans, and strict passenger vehicle CO₂ standards. 3) Recent first European heavy-duty CO₂ standards (February 2019) require a 30% CO₂ reduction by 2030 and have a 2% benchmark for Zero and Low Emissions trucks. 4) The update to European cabin geometry rules, moving from brick-shaped cabins to rounder cabins will improve aerodynamics and BET ranges. 5) A freight weight exemption for battery electric trucks allows similar payloads as fossil-fuel based trucks. 6) European vehicle legislation limits speeds to 90 kph (3.5+ tons), increasing the range of ZE Trucks by 15-20%. 7) Mandatory driver rest times and a maximum shift distance provide charging opportunities. 8) Higher diesel prices increase the fuel cost savings of BETs. 9) Countrywide road tolls based on emissions offer up to 100% discounts for ZE Trucks. 9) Slightly shorter shipping distances than the US. 10) Finally, there are emerging coalitions pushing for zero emission freight, including the European Clean Trucking Alliance (European Climate Foundation) and the Transport Decarbonisation Alliance's Coalition for Zero-Emission Freight Vehicles. **Allies exist.** New entrants to the goods movement industry and established European-based companies are using ZE freight to gain market share (e.g., DP World and DHL). These companies have announced commercial and prototype ZE trucks that have resonated with the public and created interest. Some OEMs (MAN, Daimler) favor battery electric trucks, declared that the current diesel engines will be their last³³. **Barriers** to address include worry about job losses in the transition to zero emission vehicles (public and unions), industries that could be affected, and concerns about costs.

DP DHL Urban Delivery goes electric

Deutsche Post DHL has set ambitious climate goals: reduce GHG by 50% by 2025, see zero emission logistics by 2050, and reduce local air pollution emissions by operating 70% of their own first/last mile services by 2025.

A few years ago, DP DHL saw a lack in the vehicle supply market for battery electric trucks. DP DHL partnered with StreetScooter, and now have over 9,000 battery electric mail/parcel delivery trucks on the road (as of 2018), representing ~12% of its vehicles. They have logged over 56 million km driven and see cost savings of 10-20,000 Euros per vehicle over the vehicle's lifetime. Current battery electric truck models cover 80-200 km range (Work, Work L, Work XL). They aim to ramp up production in China to 100,000/year (1st year), eventually 900,000/year.



Strategic opportunities

In partnership with our key grantee the European Climate Foundation, below are examples of zero emission road freight strategic opportunities that grantees are interested in pursuing in Europe.

- Support the European Commission (EC) to incorporate a ZE truck mandate or credit in the mid-term review for trucks CO₂ standards in 2022
- Build the European Clean Trucking Alliance, including ~20 leading companies focused on creating demand and advancing ZE freight
- Support the EC to incorporate ZE truck infrastructure in the Alternative Fuels Infrastructure Directive and explore public-private EVSE financing
- Support the EC to incorporate ZE trucks into the Clean Vehicles Directive, a public purchasing program.
- Support cities to implement Clean Air (Zero Emission) zones
- Expand cross-national and domestic highway tolling based on CO₂
- Foster early corporate adopters and build relationships with truck makers
- Expand communications and myth-busting

Geographies

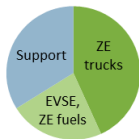
Working at the European Union level is key. Important countries include Germany, Britain, France, Sweden, and the Netherlands (especially on city logistics zero emission). Key ports are Rotterdam, Amsterdam, and Utrecht, Gothenburg, and Hamburg. Green and Healthy Street Declaration cities and cities with the most urban deaths are highlighted in the map.

Potential
 Very high
 High
 Medium
 Low



³³ Daimler e-trucks www.bloomberg.com/news/articles/2019-10-25/clean-trucks-race-heats-up-as-daimler-hones-in-on-electric-rigs,

United States



The US has a high emissions abatement potential of 30 Mt CO₂/year in 2030 and 470 Mt/year in 2050 (680 Mt by 2060). Between 9,000 and 21,000 people die per year due to on-road diesel vehicles. Many places do not meet air quality standards (see map). Currently, the US has a moderate likelihood of success to achieve zero emission road freight – higher in states (especially in California), but lower nationally (dependent on 2020 election).

California is leading the way on zero emission freight. Around the Los Angeles (LA) and Long Beach ports, addressing air quality and engaging the local communities is paramount (see right); the cities and two ports are aggressive movers with many pilots, commitment to zero emission delivery zones, and corridor electrification (I-710 highway). Mayor Garcetti is the new chair of C40. The California Advanced Clean Truck (ACT) Rule is essential. Utilities are investing significantly, and lessons from this can help replicate and inspire other utilities. Incentives through the Low Carbon Fuel Standard (LCFS) and Hybrid and Zero Emission Truck and Bus Voucher Incentive Project (HVIP) offer significant dollars for purchase and operations. **Improving health and air quality (and decreasing disease and deaths) and emphasizing environmental justice**, equity, and economic opportunities are essential benefits and engage diverse constituents. An example coalition, the Moving Forward Network, connects local communities to national campaigns, working with the Environmental Protection Agency (EPA) clean truck initiative, national Transportation Investment Act for ZE truck funding, California ACT, the northeast Transportation Climate Initiative, EPA indirect source rules, and the clean trucks program in New Jersey. **Allies** exist in companies, fleets, and electric utilities. **Barriers** include infrastructure – there are long lead times for charging installation; high power charging that may require grid upgrades; and pushback from industry groups against zero emission road freight.

Strategic opportunities

In partnership with our key grantee the Energy Foundation and other US grantees (and through a working convening), below are examples of zero emission road freight strategic opportunities that grantees are interested in pursuing in the US.

- Support ARB to adopt a strict California Advanced Clean Truck Rule (see Figure 17) and expand it to the northeast/other states and include or address fleet rules
- Work with cities, ports, and hubs to establish Clean Air Zones and electrified delivery
- Increase large-scale public investment in infrastructure and for ZE fuel corridors. Support utilities to invest in infrastructure, especially outside of California
- Encourage attractive ZET financing, new business models, tax benefits, feebates
- Build allies with shippers/parcel companies and ZE truck manufacturers. Build capacity & commitments. Pursue select corporate pressure campaigns.
- Develop strong, diverse, local coalitions with frontline communities, technical support, environmental justice, labor, health, and communications groups.
- Significantly expand strategic communications
- Share knowledge, lessons, and build capacity of fleets, policymakers, utilities
- Reform retail electricity rates to enable economically competitive ZE trucks
- Consider sustainable source fuel regulations like LCFS in states beyond CA
- Work with the EPA to refine indirect source rules to include freight

Los Angeles/Long Beach ports, the Inland Empire, and the Volvo LIGHTS project

Los Angeles, Long Beach, and California have set ambitious goals. The mayors of these port cities committed to 100% ZE port trucks by 2035 (Mayors' declaration). By 2028 (via the Zero Emission Roadmap), they aim for 25-50% Medium duty EV delivery, 10-40% heavy duty ZE drayage, 5-25% heavy-duty ZE Long haul, and 10-100k ZE chargers for goods movement. By 2030, CA aims for 100k ZE freight vehicles and 25% reduction in freight CO₂ (Sustainable Freight Action Plan³⁴).

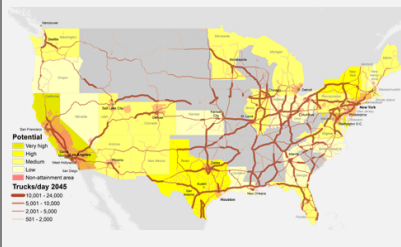


The ports of Los Angeles and Long Beach, which transport over half of America's goods, are partnering with Volvo, trucking companies, charging providers, fleet leasers, and two colleges on a \$90 million Low Impact Green Heavy Transport Solutions (LIGHTS)³⁵ pilot to demonstrate success of heavy duty trucks and port/drayage equipment such as fork lifts and yard tractors to the broader LA region (see map). The project will see 23 electric heavy-duty trucks, 75 truck chargers (11 fast chargers, others level 2), and 29 pieces of electric freight-moving warehouse equipment (forklifts, yard tractors) operating between 2019 and 2021.

Geographies

Work in the US can focus on states and consider state or city regulation potential, freight hubs, and environmental justice (the map shows non-attainment areas for ozone, PM_{2.5}, SO₂, and lead).

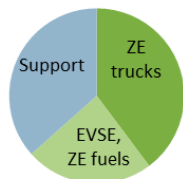
Important regions include California, other states that follow CA's stricter vehicle rules (Section 177 states), the 13 northeast states part of the Transportation Climate Initiative, Texas, and others highlighted in the map below, including hub cities. The map shows air quality, projected trucking corridors in 2045 (US Bureau of Transportation Statistics, Freight Analysis Framework), and potential priorities.



³⁴ California Sustainable Freight Action Plan http://www.dot.ca.gov/casustainablefreight/documents/Main Document_FINAL_07272016.pdf

³⁵ Volvo LIGHTS, <https://www.lightproject.com/>

India



India has a medium near-term emissions abatement potential of 10 Mt CO₂/year in 2030, that grows to 410 Mt/year in 2050 (645 Mt by 2060). Additionally, it has extremely bad air quality (over eight times the WHO guidelines) affecting at least 350 million urban dwellers. With 48,000 deaths per year, India has the highest

deaths due to on-road diesel vehicles. The government of India is motivated by energy security, air quality improvement, and industrial competitiveness and the associated job/economic benefits (such as through the “Make in India” initiative in 2014 encouraging manufacturing of products in India).

India is in its early stages of ZE truck deployment. Because most electric drive vehicles efforts now focus on passenger vehicles and buses, India has a lower near-term and moderate mid-term likelihood of success (LOS) to achieve ZE road freight. This LOS may be higher in specific states that are pushing EV policies and have supportive private allies. **Recent policies** and actions support electrification include: 1) India’s Faster Adoption and Manufacturing of Electric Vehicles (FAME II) was approved, providing incentives for two- and three- wheelers, buses, and some infrastructure. 2) Select strict rules are being explored, such as a potential ICE ban for 2- and 3-wheelers in Telangana. 3) The Central Government is exploring higher ICE registration fees. 4) Ministries and departments have introduced complementary fiscal and non-fiscal incentives such as green license plates, registration fee exemptions, road taxes waived on EVs, EV charging as a service, rationalized customs duty, income tax deductions, tax reduction on chargers, tax-exempt buses, building bylaws to support EV charging. 5) Some OEMs, such as BYD India, have announced electric logistics vehicles. 6) India has emerging indigenous battery manufacturing. **Considerations** of ZE freight work include a) Solutions should include 2-, 3-, and 4-wheel vehicles; b) Congestion and reduced costs of freight (and GDP effects) are important co-benefits. **Barriers** to address include potential auto industry pushback, potential inconsistent policy signals, lack of roadmaps to vehicle electrification, implementation delays, limited charging, a lack of standardization, and limited models.

Deliver Electric Delhi

Delhi is conducting a freight demonstration on electrifying final mile delivery. Companies have deployed over 450 electric vehicles through the program with plans for up to 1,000 by early 2020. Phases to date included stakeholder outreach, pilot design (May 2019), pilot details at a multi-day solutions workshop (June 2019), pilot execution and data collection (in process), and later pilot documentation.



Rocky Mountain Institute (RMI) is supporting this effort with India’s Dialogue and Development Commission (DDC), including engaging with over 35 companies participating in the program. Companies include ecommerce firms (Amazon, Bigbasket, Flipkart, Grofers, Uber Eats and Zomato) vehicle aggregators and logistics firms (Amplus Solar, Areon, Blue Dart Express, DOT, Efleet Logix and GATI), and charging station companies (Delta Group, Magenta Power, Charge-Zone, Sun Mobility while in DISCOMs, BSES Rajdhani Power, BSES Yamuna Power, Tata Power Limited).

The project aims to make the case for the electrification of all final mile delivery vehicles in India. Deliver Electric Delhi is part of the Urban Mobility Lab, an initiative that RMI hosts in Delhi, Pune, and Bangalore to support electric passenger and freight mobility solutions.



Sources: https://rmi.org/wp-content/uploads/2019/08/rmi_report_uml_delhi.pdf, <https://rmi.org/wp-content/uploads/2019/11/Expression-of-Interest.docx>, <https://www.cnbctv18.com/startup/delhi-government-rocky-mountain-institute-launch-ev-pilot-for-freight-transport-3814871.htm>, <https://rmi.org/insight/urban-mobility-lab-pune/>

Strategic opportunities

In partnership with our key grantee Shakti Sustainable Energy Foundation and other grantees, below are examples of zero emission road freight strategic opportunities that grantees are interested in pursuing in India.

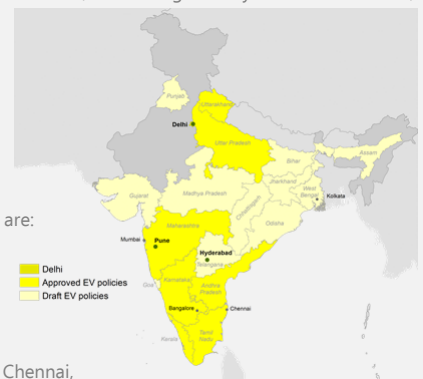
- Implement and learn from Deliver Electric Delhi and share lessons
- Support cities to create urban access restrictions
- Improve utility readiness for infrastructure, establish public investment in infrastructure, and support siting of infrastructure
- Demonstrate an inter-city freight corridor between two major cities
- Support governments to waive registration fees and road taxes for zero emission trucks
- In the longer term, support the government to create a ZE truck regulation
- Cultivate corporate allies (ecommerce, shippers, logistics) and ZE Truck fleets, encourage local truck manufacturers to make ZE trucks
- Convene key NGOs and partners to clarify roadmaps and milestones
- Deploy strategic communications

Geographies

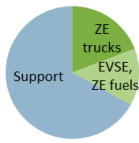
States are playing a leading role in developing EV sales targets, manufacturing incentives, and exploring access restrictions. Key states include Delhi, Gujarat, Kerala, Tamil Nadu, Andhra Pradesh, Karnataka, Uttar Pradesh, and Telangana. Key cities include Delhi, Pune, Hyderabad, and Bangalore.

The top 15 urban areas with the most deaths from on-road diesel are:

New Delhi, Kolkata, Mumbai, Hyderabad, Bangalore, Asansol, Pune, Chennai, Surat, and Dhanbad.



Cross-regional



Truck manufacturers most often look at and respond to the global market. Lessons from passenger electrification (see Appendix A for details) underscore the importance of working in several regions to send global signals and to support learning across

boundaries. This includes creating strict regulations (e.g., ZEV regulations among a cohort), ambitious commitments (e.g., zero emission areas with peer networks), global pressure (e.g., public outcry to address air quality), multi-national corporate engagement and commitments, and fostering the capacity of partners and advocates to work and share lessons across countries. To advance zero emission road freight, cross-regional efforts are predominantly focused on fostering support, including sharing knowledge across regions. Policy efforts can build on recent international momentum and collaboration on medium/heavy-duty efficiency standards and light duty ZEV regulations.

Strategic opportunities

In partnership with our key grantees and global experts, including the ClimateWorks Foundation, below are examples of zero emission road freight strategic opportunities that grantees are interested in pursuing on a cross-national basis.

- Support global coalitions and knowledge sharing platforms. Example platforms to accelerate the transition to ZE trucks globally are highlighted at right: CALSTART's 'Drive to Zero' Program, C40's Green and Healthy Streets, TDA's Zero-Emission Freight Vehicles ACTION Group, EV100 corporate commitments. Other grantees working across regions include ICCT, Smart Freight Centre, RMI, EDF, NRDC, Global Strategic Communications Council, and others.³⁷ Knowledge shared can include results of demonstrations, challenges, successes, models, applied research, financial incentives/disincentives and timing, new business models on total cost of ownership.
- Work with cities to secure commitments for and implement access constraints globally, such as zero emission zones/areas or diesel bans
- Create a global roadmap for infrastructure deployment
- Cultivate multinational companies (including parcel companies, shippers) to set aggressive ZE freight goals, transparently report on emissions, deploy ZE Trucks in their operations, and support aggressive ZE truck policies.
- Encourage global vehicle manufacturers to dramatically ramp up ZE Truck production & support aggressive ZE truck policies.
- Create global resources for strategic communications with positive frames, myth busting from a global perspective

CALSTART – Commercial Drive to Zero Program

CALSTART's Commercial Drive to Zero program, launched in 2018, aims to drive adoption of ZE commercial vehicles with full market penetration by 2040. CALSTART's initial focus is on enabling ZE urban freight and leveraging that capability to build the capacity for long distance freight. As of February 2020, there were 75 pledge supporters, including 30 manufacturers, 13 governments, 8 cities, 5 fleets, and 4 utilities/infrastructure providers. Building on its 200+ members, including parcel companies such as FedEx and UPS, shippers such as Frito Lay and PepsiCo, and truck makers such as GM, Ford, and Lightening Systems, CALSTART engages with fleets and corporations; pursues delivery, medium, and heavy regional applications in key first-mover regions; builds aligned policies; and shares lessons across regions, such as through its Policy Toolkit, vehicle availability guide, and total cost of ownership calculator.



C40 Cities – Zero Emission Area Commitments

As part of the C40 Cities' Green and Healthy Streets Declaration, 35 cities so far have committed to designating a portion of their cities zero emission areas, including zero emission freight deliveries. To support ZE freight, C40 Cities has convened an in-person Freight Academy (fall 2019, in partnership with CALSTART and ICCT), hosts webinars, has a regular newsletter, a freight working group, and publishes case studies on its Knowledge Hub.



ZE Freight Vehicle (ZEFV) ACTION (Action towards Climate-friendly Transport) Group

The Transportation Decarbonization Alliance has a ZEFV ACTION Group aiming for cost parity of urban and regional trips by 2025, 80% of such trips ZE by 2040, and full ZE freight by 2050. Stakeholder members include CALSTART, EV100, C40, ICCT, Smart Freight Centre, ICLEI, WEF, and others. Their fall 2019 vision paper provides further details.³⁶



The Climate Group – EV100 Corporate Leadership Initiative

The Climate Group's EV100 platform is where major businesses pledge to go electric in their own operations by 2030. To date, 59 companies have signed up (see right). The EV100 commitment currently focuses on vehicle categories up to 3.5 tons (100% fleet transition commitment by 2030) and 3.5-7.5 tons (50% fleet transition commitment by 2030). EV100 companies currently focused on freight include: postal/logistics companies (DB Schenker, Deutsche Post DHL, Austrian Post, and Swiss Post), retail (IKEA, Metro AG, Askul), and telecom (BT, NTT)



³⁶ Zero Emission Freight Vehicles ACTION Group – Creating a Mass Market for Zero-Emission Freight Vehicles Vision Paper (December 2019), https://www.smartfreightcentre.org/pdf/Vision-Paper-ZEFV-ACTION-Group_Final.pdf

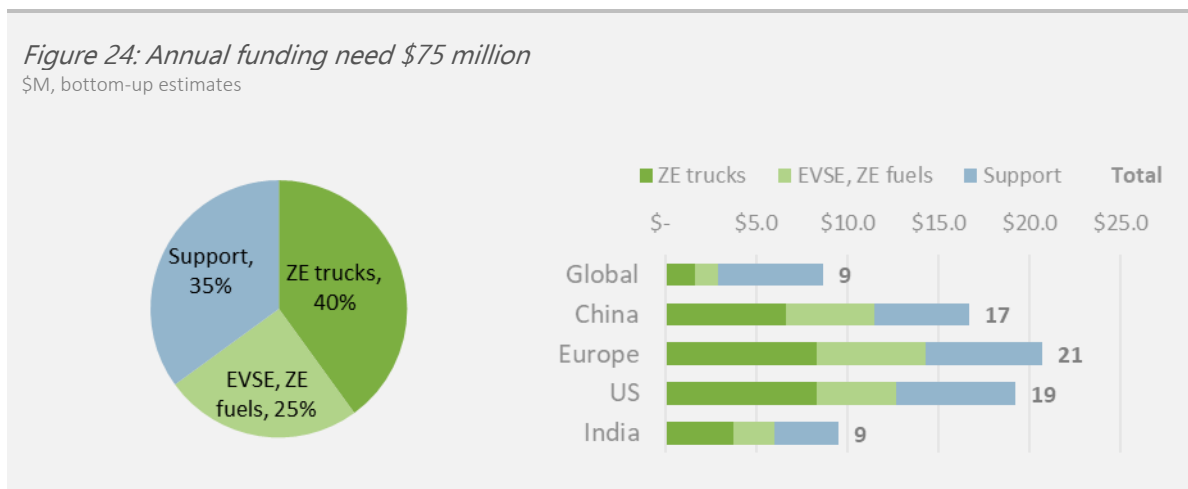
³⁷ Other cross-national initiatives that represent venues where zero emission freight could be advanced and elevated include the International ZEV Alliance, Global Green Freight Action Plan (SmartWay-based public-private partnerships and standardized emissions reporting via GLEC), UNEP's Climate and Clean Air Coalition (CCAC), and programs currently focused more on passenger mobility. These include Clean Energy Ministerial Electric Vehicles Initiative (EVI) and Pilot City Program (PCP), Decarbonizing Transport Initiative, Under2 Coalition, and Global e-mobility Program (UNEP, IEA, ADB, others).

4. Funding

\$75+ million per year needed

Total funding needs to advance zero emission freight in the US, Europe, China and India range from \$40 to \$75 million per year. This is based on two estimates: a top-down assessment that would fund freight at a level relative to its emissions compared to total current transport funding (55% of transport emissions in 2060) yielding ~\$40 million per year, and a bottom up estimate by geography for all logic model activities (assuming the activities would be pursued for roughly 10 years) yielding ~\$75 million per year. If we broadened the scope to include activities in all regions of the world, the total funding need is closer to \$100 million per year.

By region, Figure 24 shows that there are significant funding needs in Europe, the US, China, and moderate needs in India and globally.



Total annual foundation funding to lower emissions related to freight (and diesel vehicles) from 2015-2018 has only been \$4-8 million per year (average of \$6.6 million) from known philanthropic funders. Therefore, there is a significant gap in funding.

The Hewlett Foundation is committed to significantly funding zero emission road freight at ~\$7-8 million per year (direct funding to including funding through general operating support that is estimated to be applied to zero emission freight), totaling \$30-40 million over five years. This funding level is 2.5 times what was spent in the prior three years, and earlier funding was not focused on zero emission trucks.

However, even this level of funding leaves an annual ~\$65 million gap. To achieve the goals outlined in the strategy, Hewlett will partner with the Climate Leadership Initiative and other climate funders to close this funding gap, as described under the support strategy to scale philanthropic funding.

5. Monitoring

Implementation markers

Table 5 shows 5-year goals for measuring progress.

Table 6 covers strategy-specific 3-year implementation markers and 5-year outcomes. Note that because Hewlett only represents part of the funding needed to achieve the longer-term goals, achieving them also assumes funding from others in addition to Hewlett. As noted in the executive summary, it is crucial that Hewlett work together with the Climate Leadership Initiative and other philanthropic funders to close this funding gap and with partners on the ground to put road freight on a quick path to zero emissions.

We will track progress against these indicators and outcomes annually. Within the first two years, we will formulate an evaluation plan to answer key questions such as those related to overcoming barriers, addressing opposition, coalition lessons, strategies to cultivate allies, communications, and others; and inform potential strategy refinements.

Table 5: 5-year goals

Outcome	5-year goals (By 2025)
ZE trucks	<ul style="list-style-type: none"> 15% new sales ZE trucks in Europe, China, and the US by 2025 (8% in India)
EVSE/ fuels	<ul style="list-style-type: none"> Significant investments in ZE trucks and infrastructure

Table 6: Strategy implementation markers and outcomes (key regions mean China, Europe, US, and India. See Figure B1 for detailed 5-year outcomes)

What	3-year Hewlett implementation markers (By 2023)	5-year outcomes (Global, by 2025)
Zero Emission Road Freight Focus – representing strategy uptake	<ul style="list-style-type: none"> Within 18 months, convening/conference held in Europe to launch funding commitments and activities in accordance with this strategy document At least 5 new funders fund zero emission road freight at \$1M+ per year Tripwire: The US federal government revokes California’s waiver to set independent regulations or any of the key regions’ federal governments dramatically change course to abandon Paris agreements (e.g., re-evaluate opportunities and consider defense). 	<ul style="list-style-type: none"> Zero emission freight philanthropic funding grows to at least \$75M per year
Zero Emission Trucks	<ul style="list-style-type: none"> Government champions for strict truck regulations established in the US, Europe, and China Cohorts of cities exploring selective access regularly share approaches and lessons At least 3 examples of state, national, or fleet policies mandating zero or very low emission trucks passed or adopted 50+ commitments (35 as of 2019) and 5+ implemented examples of zero emission zones/areas, diesel bans, or other access constraints 5+ private fleets deploy ZE trucks at scale (>1,000 vehicles) Tripwire: Battery price drops slow and hydrogen technology improves slower than expected 	<ul style="list-style-type: none"> 20-25 national and sub-national ZEV regulations, fleet regulations, and air pollutant standards or national strict GHG truck standards 70+ commitments (35 as of 2019) and 25+ implemented examples of access constraints globally, with at least 8 commitments per region 5-10 rebates, feebates, scrappage, road tolls or registration fees based on CO2

What	3-year Hewlett implementation markers (By 2023)	5-year outcomes (Global, by 2025)
EVSE / Charging/ Fuels	<ul style="list-style-type: none"> 2+ utilities in at least 2 key regions understand and champion benefits of electrifying trucks Sustainable source fuel regulations and electricity rate reform conversations advance in California and 2 other key regions 	<ul style="list-style-type: none"> Public funding and utilities in all key regions increase investment in charging EVSE financial incentives under discussion in key markets Sustainable source fuel regulations exist in markets pursuing fuels that are not electricity Electricity rates reformed or low in all key markets
Support	<ul style="list-style-type: none"> Fleet owners understand total cost of ownership benefits, applicable incentives, and possible financing options At least 3 truck manufacturers (per region) support aggressive ZE truck policies, including major players and newer (only ZE) entrants Coalitions expanded to include environmental justice (especially in the US), labor, community, and communications groups or capacity and coalitions set ZE road freight policy targets Lighthouse projects in each region show proven low-emission operations in ports, railyards, warehousing facilities, inland ports, and urban delivery. Results shared with partners, fleets, and policymakers. Information about ZE road freight (policy options, technical status/model availability, total cost of ownership, best practices, challenges, successes, infrastructure corridor recommendations) shared with and across coalitions, and with NGOs, decision makers, fleet owners, and private companies making shipping decisions Capacity about zero emission road freight at regional and global communications firms increased with common messaging and narratives about zero emission road freight established 	<ul style="list-style-type: none"> 20+ new multinational companies deploy ZE trucks in their operations (or set procurement policies to do such) and support aggressive ZE truck policies 5+ global vehicle manufacturers dramatically ramp up ZE truck production (>10k trucks annually) Diverse and local coalitions in all key regions successfully support policies, rebut myths and false narratives, and stay in-tact to move from campaign to campaign Coalitions and public or shareholders pressure fleets and demand accountability to demonstrate and reduce impacts from supply chains that include logistics. Long haul demonstrations in each region are complete and results shared with fleets and policymakers Strategic communications provide regular pro-active positive assessments of ZE trucks, unbiased information, highlight benefits (including air quality, health, justice), myth bust/put out defensive communications, and support specific coalitions or decisionmakers as needed

Risks

Beyond addressing the barriers (cost, model availability, infrastructure, and others) and opposition (oil and gas) discussed in Chapter 1, potential risks, mainly with fuel and technology platforms, include:

- **Pursuing partial solutions that don't get freight to zero emission or don't eliminate local air pollution**, such as improved diesel efficiency, natural gas trucks, producing hydrogen from natural gas, pursuing plug-in hybrids, or using other fuels that are burned (even if their net life cycle emissions are zero)
- **Seeing battery and fuel cell price drops stagnate**. As described throughout the document, significant battery price drops have been key to making electric vehicles and trucks more attractive and approach purchase cost parity; Figure 13 showed that EV purchase cost parity is generally around the \$100/kWh pack price. Additionally, fuel cell total cost of ownership and purchase parity is quite sensitive to underlying costs (see Figure B5). While leaders are showing prices near price parity thresholds and some are pursuing alternative chemistry batteries that could be even cheaper, stagnation of battery packs or fuel cell prices represents a risk to dramatic uptake.

- **Using biofuels for trucks**, when their limited supply should go to applications such as airplanes. Other biofuel concerns are difficulty ensuring low indirect land use change (cutting down forests to grow biofuel stocks), displacing food crops (if not second-generation biofuels), and the fact that burning biofuels creates local emission (the above point).
- **Using less efficient solutions**, such as using renewable power to create liquids (i.e. in cars, direct charging with a battery electric vehicle is 73-76% efficient converting the ‘well’ to wheel energy, whereas a hydrogen fuel cell is only 22-30% efficient, and power to liquids are only 10-15% efficient)³⁸
- **Implementing more costly solutions**, such as fixed catenary lines, hydrogen fuel cells (currently more expensive on a total cost of ownership basis because of high cost of fuel, technology, and re-fueling facilities), or battery swaps that require significant investments in facilities and twice the investment in batteries (the most expensive EV component).
- **Conflating electrification with “job-killing” automation**, increasing the potential opposition by labor groups and other climate denier populists. Additionally, automation may impede uptake of battery electric trucks because of the elimination of route stops, therefore making charging downtimes for long-haul trucks less desirable. This last concern can be mostly addressed through thoughtful location of charging locations for battery electric trucks (e.g., at manufacturing or delivery locations/hubs) and consideration of fuel cell ZE trucks.
- **Failing to raise the philanthropic funds** needed to support partners to achieve the fast transition to zero emission trucks.

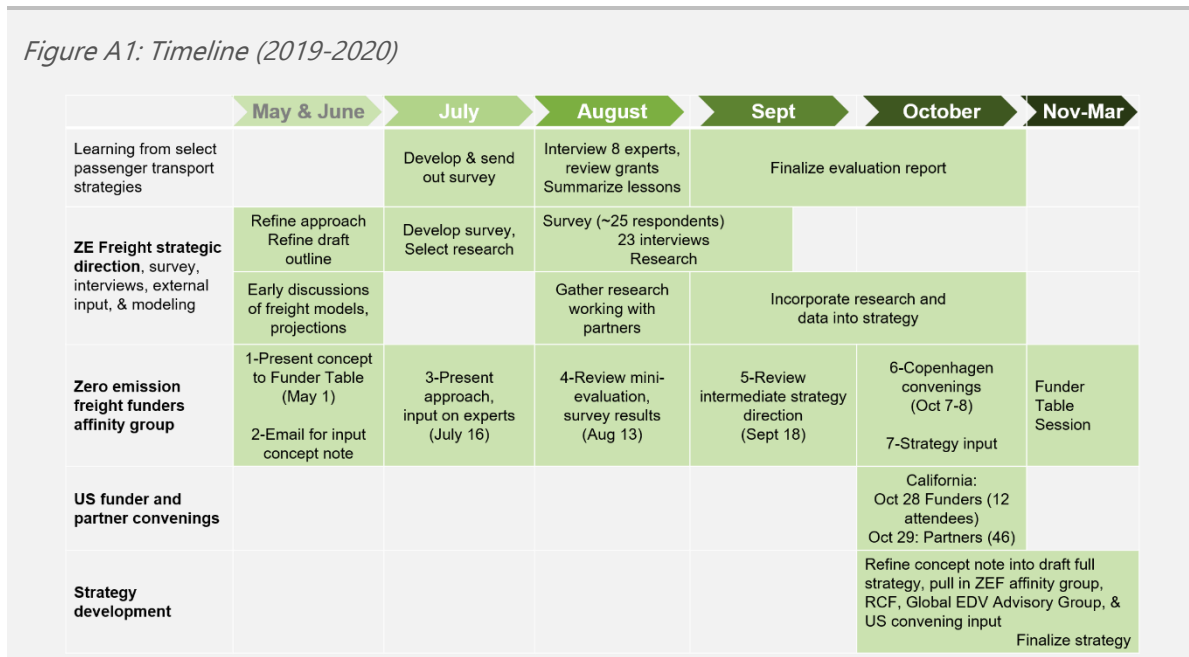
* * * *

As detailed throughout the strategy, the time is right for an intense focus on zero emission road freight – across all use cases and key geographies. Hewlett looks forward to collaborating with funders and partners around the world to make zero emission road freight a reality.

³⁸ Transport & Environment, also <https://www.volkswagenag.com/en/news/stories/2019/08/hydrogen-or-battery--that-is-the-question.html>

Appendix A: Process and interviewees

Hovland Consulting LLC (<http://www.hovlandconsulting.com/>) was the consultant to support the strategy development. Major phases in the strategy process were to learn from select passenger transport electrification strategies; gather external input (surveys, interviews) and develop strategic direction, coordinate external modeling and research, and create select ZE freight estimates; work with a zero emission (ZE) freight funders affinity group throughout the process; hold US funder and grantee convenings, and develop the strategy. Figure A1 provides an overview of the timeline and steps to create the strategy. In total, over 85 people provided input to the strategy.



Thanks to all who provided input through the funder affinity group, surveys, interviews, or participating in convenings. The organizations are detailed below:

- ZE freight funder affinity group members or convening attendee:** Hewlett Foundation, Tempest Advisors, Oak Foundation, Pisces Foundation, IKEA Foundation, Children's Investment Fund Foundation, Heising Simons Foundation, Mercator, European Climate Foundation, Energy Foundation China, Shakti Sustainable Energy Foundation, Energy Foundation, ClimateWorks Foundation, Energy Innovation, Crux Alliance, Zero Now Fund, and the Mcknight Foundation.
- NGOs and Experts:** Better World Group, C40 Cities Climate Leadership Group, CALSTART, Center for Community Action and Environmental Justice, Chicane labs, Coalition for Clean Air, Clean Energy Works, Climate Nexus, Communities for a Better Environment, Earthjustice, East Yard Communities for Environmental Justice, Electrification Coalition, Energy Media, Environmental Defense Fund, EV100/The Climate Group, Forth, Greenlining, International Council on Clean Transportation, Labor Network for Sustainability, Lawrence Berkeley National Laboratory, Los Angeles Cleantech Incubator, Moving Forward Network, Natural Resources Defense Council, North American Council for Freight Efficiency, Rocky Mountain Institute, Sierra Club California, Smart Freight Centre, Transport & Environment, UC Davis, Union of Concerned Scientists.

- **Policymakers, logistics, shippers, and vehicle manufacturers:** Current and former California Air Resources Board (CARB) policymakers, City policymaker in Los Angeles, City policymaker in Shenzhen, Former Senior Environmental Protection Agency policymaker, South Coast Air Quality Management District, Deutsche Post DHL Group, Tesla, shippers, and others.

Lessons from passenger vehicle electrification evaluation

Below, Table A1 shows general lessons and best practices for passenger electrification and Table A2 shows region-specific lessons.

Table A1. General lessons and best practices for passenger electrification as summarized by stakeholders in interview process

LESSONS AND BEST PRACTICES FOR PASSENGER ELECTRIFICATION		
Global lessons	WHAT	<p>Pursue ZEV mandates, strict CO₂/km standards, or a combination of them, as they are extremely effective. ZEV mandates in at least some geographies are seen as essential, though not sufficient on their own.</p> <p>Use (sometimes start with) financial incentives with the intention to transition to ZEV standards and phase out incentives over time.</p> <p>Invest in the infrastructure ecosystem early and create more charging infrastructure, as it is seen as an important barrier for uptake.</p> <p>Direct money from regulations (e.g., surcharge on fossil-fuel kilometers) to fund low-carbon activities.</p> <p>Price fossil fuel externalities.</p> <p>Complement regulations with non-fiscal incentives (for consumers and for industry).</p> <p>Improve customer awareness of solutions and benefits.</p>
	WHERE	<p>It is critical to create strict policies (e.g., ZEV mandates) in several regions simultaneously.</p> <p>Move in big markets such as California, Germany, France to create economies of scale, give momentum, gather other followers, and support national (US) or cross-national (Europe) ambition and action.</p> <p>Target regions/places with bad air quality to deploy electrification (and improve air quality) and garner support more easily.</p>
	HOW	<p>Find and support political champions (especially at the highest levels), but perform rigorous power maps of the most important players (covering elected politicians and appointed/career politicians) and revisit them throughout campaigns.</p> <p>Find at least two industry champions within target markets to influence peers and give policymakers confidence to set strict regulations, such as VW (post-Dieselgate and now as a leader in electrification) and Tesla.</p> <p>Highlight air quality/health, costs, climate, and industrial competitiveness benefits.</p> <p>Increase both ambition and action to reach a below 2-degree world and avoid dead-end pathways (e.g., natural gas).</p> <p>Balance near-term wins (pilots set up for success) with long-term direction to shape policies that can set up a country, region, state, city, or market segment for long-term success. Early on, don't push more challenging use cases first to avoid potential negative examples.</p> <p>Have coordinated asks from a campaign, but retain flexibility. Have a local, on the ground presence and leadership. Prioritize environmental justice and equity in solutions, coalitions, and messengers.</p>

Table A2. Region-specific lessons as summarized by stakeholders in interview process

REGION-SPECIFIC LESSONS FOR PASSENGER ELECTRIFICATION	
Across regions	<p>Share lessons across countries or states (especially on ZEV mandates, collaborations such as the International ZEV Alliance are one example of this sharing), but pay attention to local circumstances.</p>
US	<p>Focus at the state and city level in the near-term. Sub-national electrification efforts may determine national policy; for example, auto manufacturers seek one standard to be able to sell to all markets.</p> <p>Pursue state ZEV mandates as they continue to be strong forcers and send market signals that EVs are the course of the future.</p> <p>Build support for longer-term national efforts as the political environment continues to shift.</p> <p>Encourage automaker champions in electrification, such as Ford, Volkswagen, Honda, BMW, and Tesla. The first four aligned with California's emission standards in opposition to federal efforts to weaken fuel economy standards; this may signify a major shifter toward future electrification efforts, in part thanks to VW's post Dieselgate attention to EVs.</p>
Europe	<p>Focus on big markets such as Germany, France, and the United Kingdom to ensure strong implementation of European vehicle standards.</p> <p>Continue to pursue strong regulatory action at the European Parliament/ Commission/ Council level for longer term and more ambitious policies. Be aware of the influence of the three different potential levels.</p>
China	<p>Continue to pursue strong actions through the central government, working with appropriate ministers.</p> <p>Build off momentum of the government's 2020 Air Pollution Action Plan (Blue-Sky Plan) with its goals for electrification and continue to highlight the benefits of EVs to air quality.</p> <p>Continue to highlight the importance of EV development and production to the country's economic and industrial competitiveness.</p>
India	<p>Support EV implementation, deployment, and infrastructure at the state and city level.</p> <p>Continue to pursue goals, actions, and support via the central government, often through technical assistance.</p> <p>Reflecting the concerns of Make in India, partner with multiple Indian EV and battery manufacturers to influence national policy. Economic and industrial competitiveness are important selling points in India. Bring a diversity of Indian automakers to make the case for and advocate for EVs.</p>

Appendix B: Detailed logic model and additional research

Detailed logic model

Figure B1 provides a detailed logic model, as developed by Hewlett partners and stakeholders in the strategy process.

Figure B1: Detailed logic model

Based on numerous interviews, surveys, and meetings with advocates, experts, and leaders, the following reflects a shared theory of change held by our partners and grantees. See also Table 5 and 6 for goals, 3-year implementation markers, and 5-year outcomes

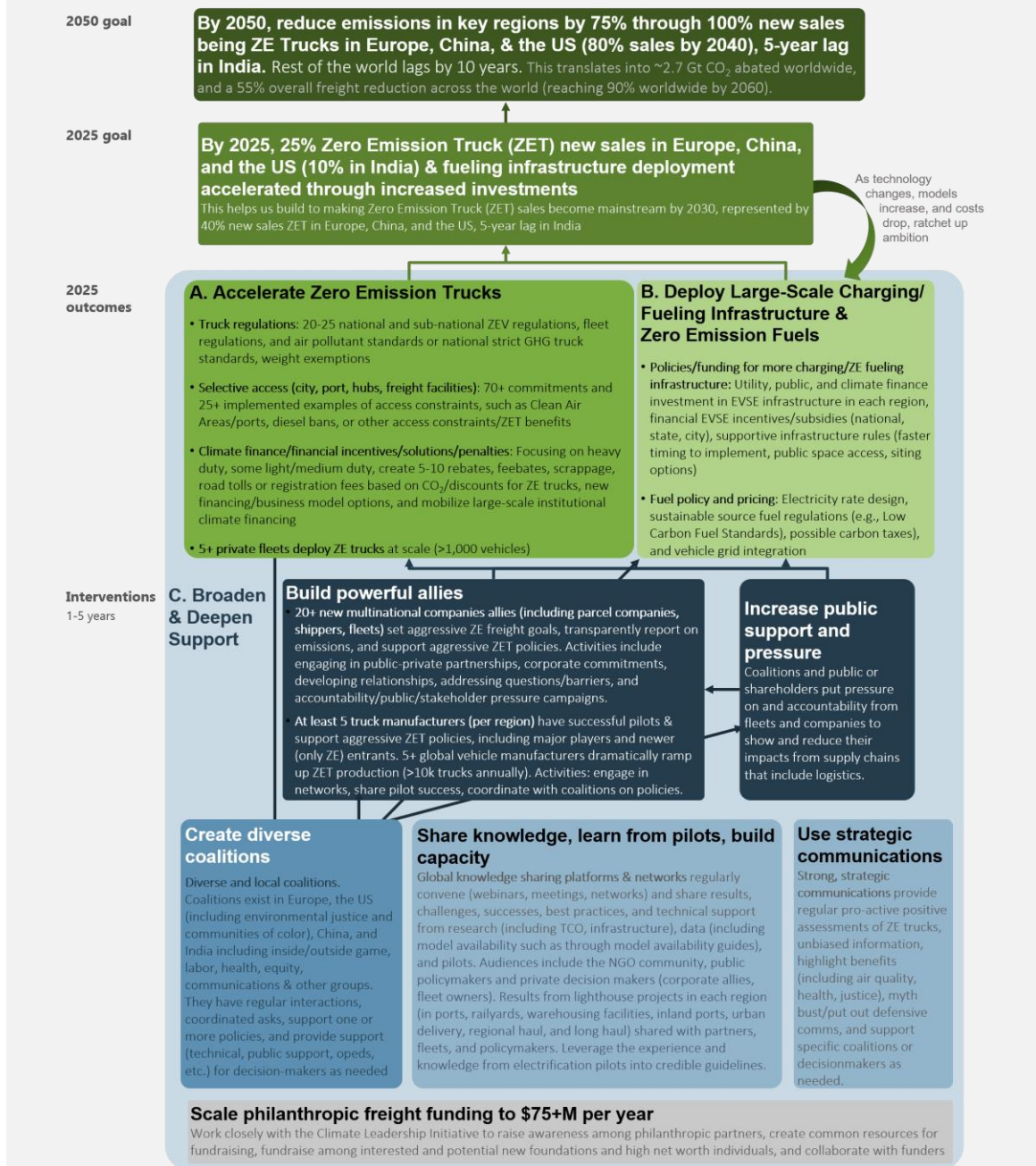
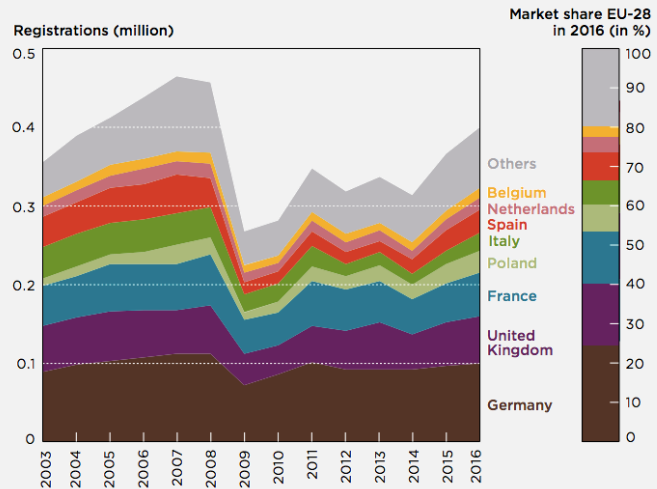


Figure B2: Europe market share for trucks & buses over 3.5 tons

Source: Transport & Environment



Abatement potential assumptions

Figures B3 and B4 show assumptions on the new sales of zero emission trucks over time and zero emission power grid makeup, both drivers of the zero-emission freight CO₂ abatement potential.

Figure B3: New sales of zero emission trucks over time

Percent of new sales. CH: China. EU: Europe.

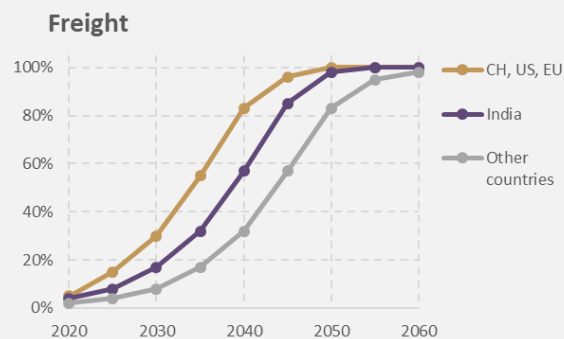
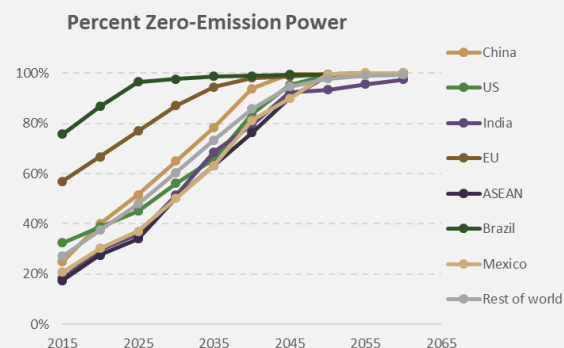


Figure B4: Power grid – clean power over time

Percent of kWh zero emission (renewables + hydro + nuclear + biomass + carbon capture and storage of any natural gas or coal). Source: IEA Energy Technology Perspectives (2017), Below 2 DS scenario. <https://www.iea.org/etp/>



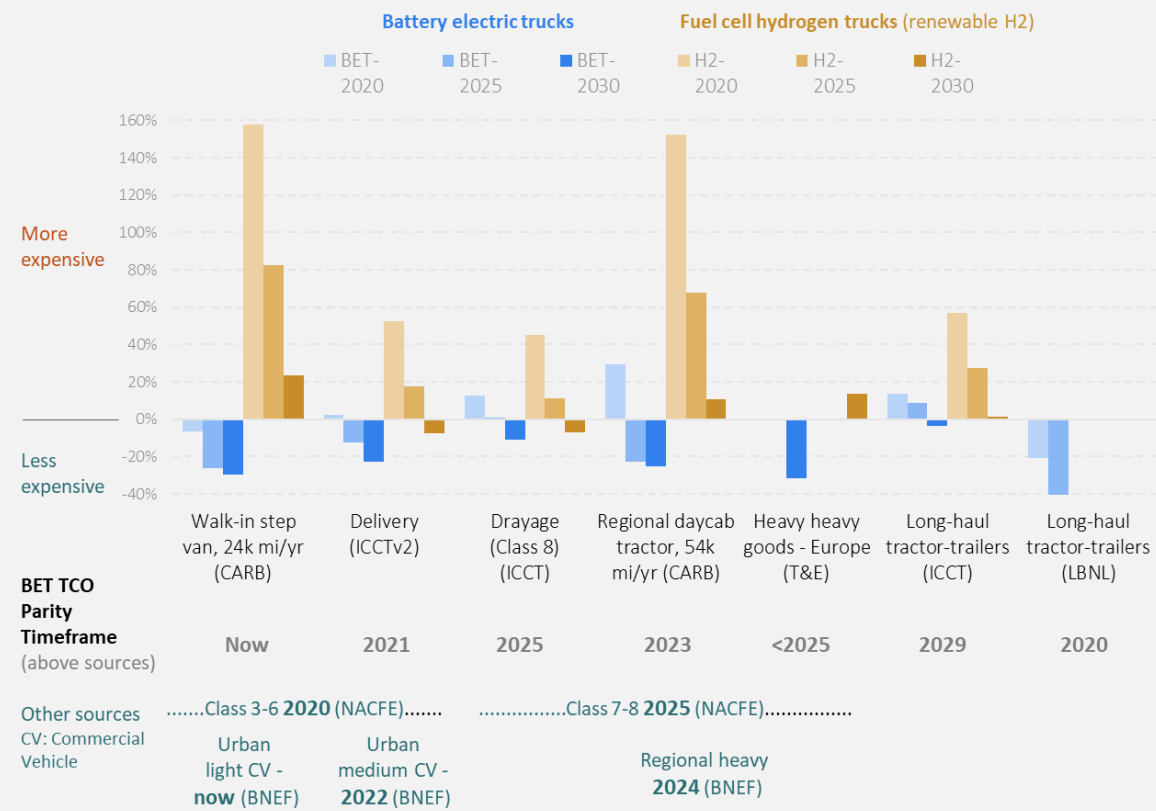
Total Cost of Ownership

Figures B5 through B10 provide more references on total cost of ownership studies.

Figure B5: Total Cost of Ownership of Zero Emission Trucks vs. Diesel Trucks over time and parity by use case

Percent of diesel TCO in the given year. BET: Battery Electric Truck. TCO: Total Cost of Ownership.

Sources: ICCT 2019 (2 sources), BNEF Long-term EV Outlook 2019, North American Council on Freight Efficiency (May 2018), Transport & Environment (2019), LBNL (2019), CA Air Resources Board (Feb 2019, not that this analysis includes benefit of Low Carbon Fuel Standard fuel credits),³⁹



³⁹ CA Air Resources Board (February 2019), Advanced Clean Trucks Total Cost of Ownership Discussion Document, https://ww2.arb.ca.gov/sites/default/files/2019-02/190225tco_0.pdf. ICCT 2019v1: Estimating the Infrastructure Needs and Costs for the Launch of Zero-Emission Trucks, <https://theicct.org/publications/zero-emission-truck-infrastructure/>. ICCT 2019v2: ICCT, CALSTART, and C40 Cities. Zero-Emission Freight - Vehicle Market & Policy Development Briefing for C40 Cities, September 2019. BNEF Long-term EV Outlook 2019, <https://about.bnef.com/electric-vehicle-outlook/>. North American Council on Freight Efficiency (May 2018), Electric Trucks: Where They Make Sense, <https://nacfe.org/future-technology/electric-trucks/>. Transport & Environment (2019 via European Climate Foundation). Lawrence Berkeley National Laboratory (2019). Long-haul battery electric trucks are technically feasible and economically compelling, <https://eta.lbl.gov/publications/working-paper-005-long-haul-battery>.

Figure B6: Attractive long-haul total cost of ownership. ~3.4 years payback period, but most sensitive to electricity prices (LBNL)

Source: Lawrence Berkeley National Laboratory (2019). Long-haul battery electric trucks are technically feasible and economically compelling. <https://eta.lbl.gov/publications/working-paper-005-long-haul-battery>.

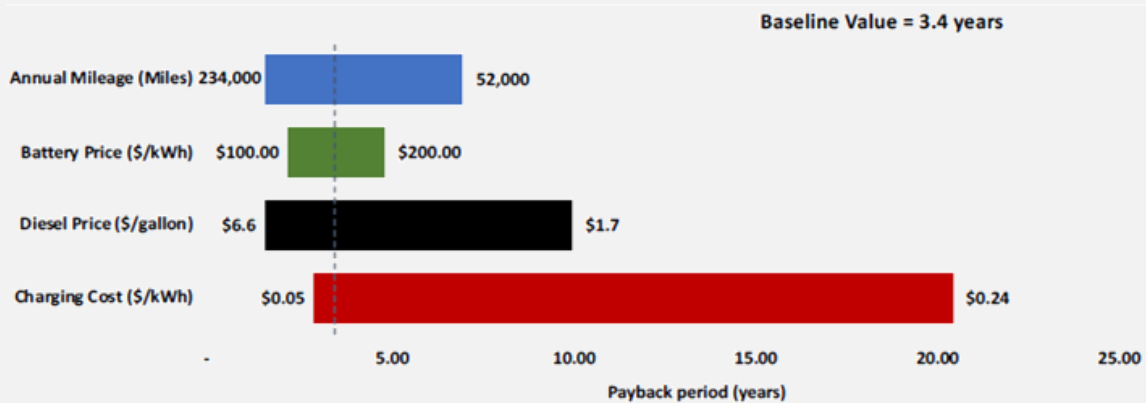
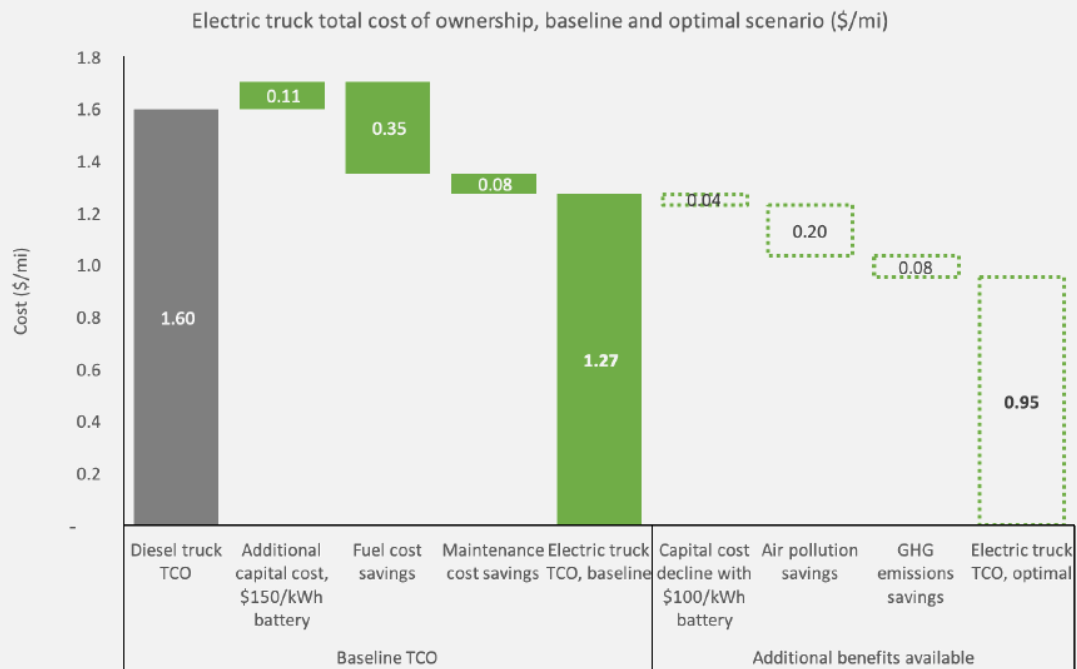


Figure B7: Long-haul tractor-trailer (top) and Class 8 drayage (bottom) total cost of ownership (ICCT)

Source: ICCT 2019: Estimating the Infrastructure Needs and Costs for the Launch of Zero Emission Trucks, <https://theicct.org/publications/zero-emission-truck-infrastructure/>. Figures 8 and 9

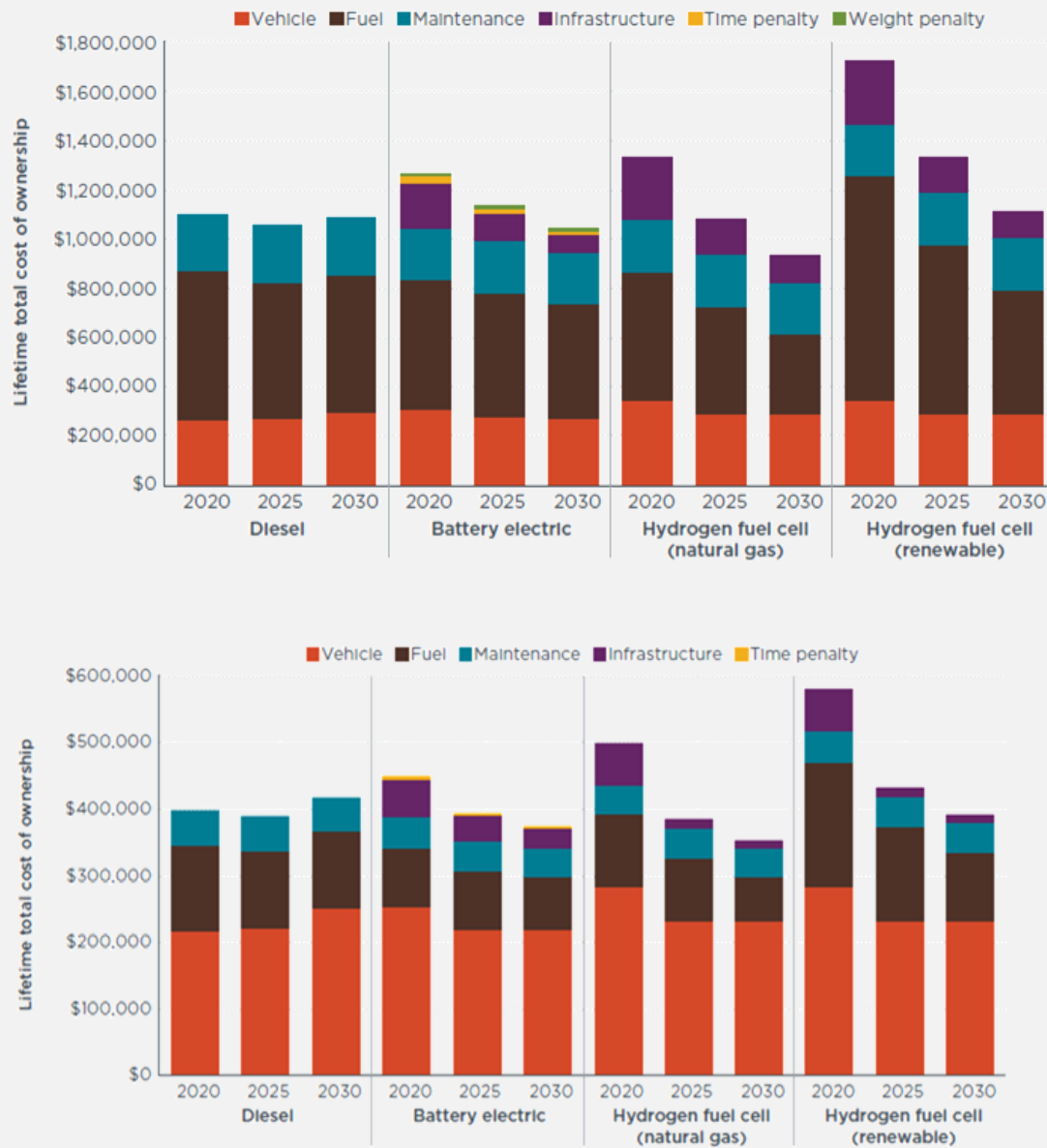
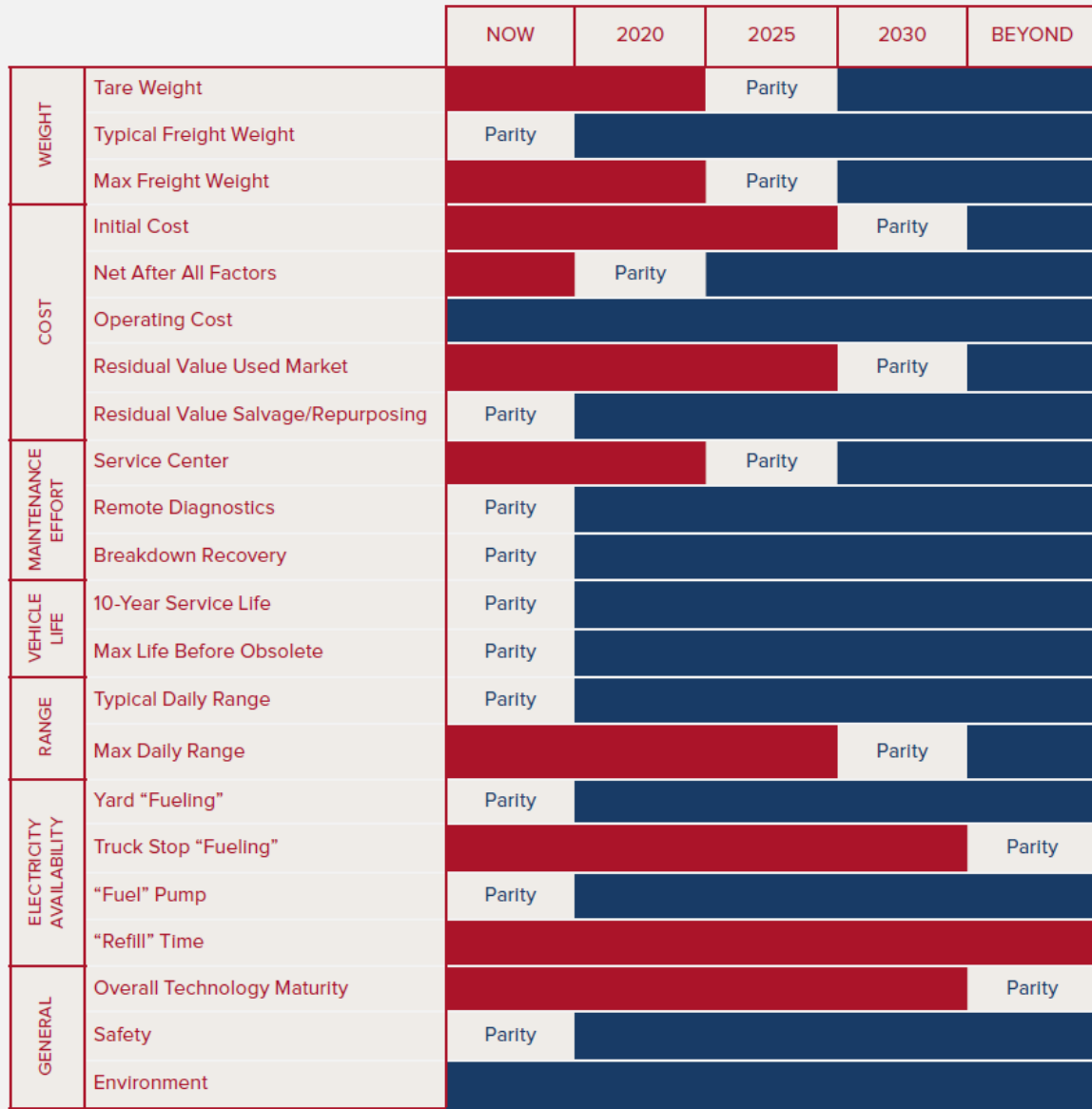


Figure B8: North American Parity vs. Time: Class 3-6 (NACFE)

Source: Electric Trucks – Where They Make Sense (May 2018), North American Council for Freight Efficiency and Rocky Mountain Institute, <https://nacfe.org/future-technology/electric-trucks/>

CLASS 3 THROUGH 6 CBEV PARITY VS. DIESEL SYSTEM (NACFE)



Key: Comparison to 'Equivalent' Diesel Baseline: ■ Worse ■ Parity ■ Better

Figure B9: North American Parity vs. Time: Class 7-8 (NACFE)

Source: Electric Trucks – Where They Make Sense (May 2018), North American Council for Freight Efficiency and Rocky Mountain Institute, <https://nacfe.org/future-technology/electric-trucks/>

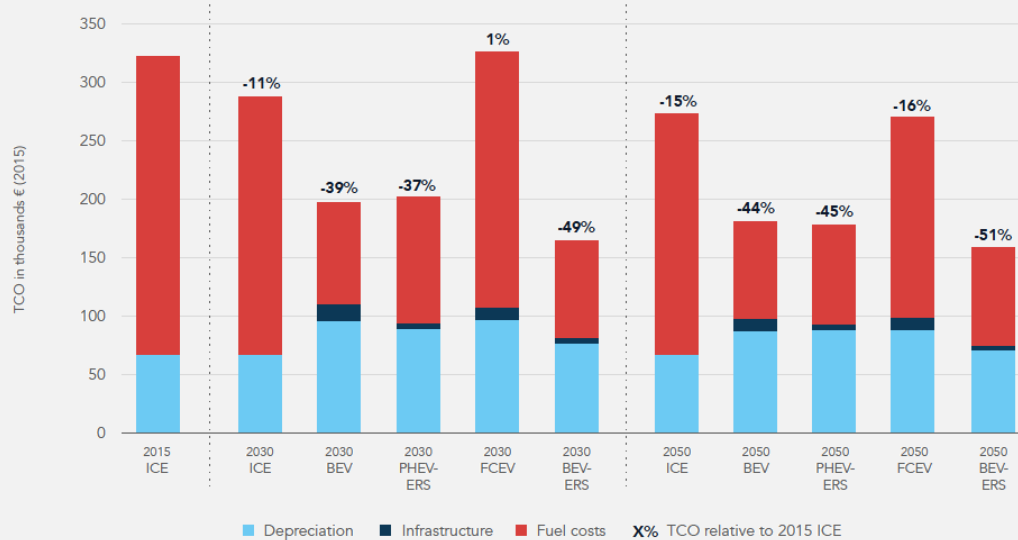
CLASS 7 AND 8 CBEV PARITY VS. DIESEL SYSTEM (NACFE)

		NOW	2020	2025	2030	BEYOND
WEIGHT	Tare Weight				Parity	
	Typical Freight Weight		Parity			
	Max Freight Weight				Parity	
COST	Initial Cost					Parity
	Net After All Factors			Parity		
	Operating Cost			Parity		
	Residual Value Used Market				Parity	
	Residual Value Salvage/Repurposing				Parity	
MAINTENANCE EFFORT	Service Center				Parity	
	Remote Diagnostics		Parity			
	Breakdown Recovery				Parity	
VEHICLE LIFE	10-Year Service Life			Parity		
	Max Life Before Obsolete					Parity
RANGE	Typical Daily Range			Parity		
	Max Daily Range				Parity	
ELECTRICITY AVAILABILITY	Yard "Fueling"			Parity		
	Truck Stop "Fueling"					Parity
	"Fuel" Pump			Parity		
	"Refill" Time					
GENERAL	Overall Technology Maturity					Parity
	Safety		Parity			
	Environment		Parity			

Key: Comparison to 'Equivalent' Diesel Baseline: ■ Worse ■ Parity ■ Better

Figure B10: Europe TCO (5-year) for heavy goods vehicles (T&E)

Sources: T&E 2019, Comparative 5-year TCO of operating Heavy Goods Vehicles with a range of drivetrains in 2030 and 2050



Models

Figure B10 shows the variety of heavy-duty electric models available on the market in India.

Figure B10: Truck models in India (current or announced)

Sources: ICCT, SIAM

