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Via Email (a-and-r-docket@epa.gov)

Mr. William Charmley
Director, Assessments and Standards Division
Office of Transportation and Air Quality
U.S. Environmental Protection Agency
EPA Docket Center, OAR
Docket EPA-HQ-OAR-2023-0589
Mail Code 28221T
1200 Pennsylvania Ave. NW
Washington, DC 20460

Re: Comments for Environmental Protection Agency Action on California Air Resources Board's Request for Clean Air Act Waiver of Preemption and Authorization

Dear Mr. Charmley:

Our clients, the American Trucking Associations ("ATA") and the California Trucking Association ("CTA"), appreciate the opportunity to submit comments on the California Air Resources Board's ("CARB") request for a waiver of Clean Air Act ("CAA") preemption and authorization for the Advanced Clean Fleets ("ACF") regulation.[1]

Many members of the ATA and CTA will be directly regulated by ACF. This will require substantial capital investment by ATA and CTA members and will have far-reaching environmental and economic effects. We believe that ACF is an ill-conceived, infeasible to implement regulation which does not meet the Clean Air Act requirements for the U.S. Environmental Protection Agency ("EPA") to grant a waiver of preemption. We thus ask EPA to decline CARB's request to grant a waiver of preemption and authorization to ACF.

I. Statement of Interest.

"Truck driver" is one of the most common jobs in California and according to the U.S. Bureau of Labor Statistics there are approximately 3.55 million truck drivers in the U.S.[2] There are approximately 550,000 commercial vehicles registered in California and an additional 1.5 million commercial vehicles registered in other states that operate in California. Most of these vehicles are owned by small businesses: 50% of all trucks are owned by fleets of 3 or fewer

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[1] Environmental Protection Agency, Advanced Clean Fleets Regulation Request for Waiver of Preemption and Authorization; Opportunity for Public Hearing and Comment, 89 Fed. Reg. 57151 (July 12, 2024).
[2] American Trucking Associations, American Trucking Trends 2024, p. 17.

trucks and 80% of all trucks are owned by fleets with fewer than 50 trucks. The number of commercial trucks in the U.S. is estimated to be at 14.33 million as of 2022.[3] The trucking industry moved some 80.7% of the nation's freight value in 2022, and 72.6% of freight tonnage.[4] However, the average operating cost of trucking has risen steadily in recent years, reaching a high of $2.27 per mile for average operating cost in 2022, an increase of 38% from 2020.[5]

The ATA is the largest and most comprehensive national trade association for the trucking industry. For 90 years, the ATA has worked with its state trucking association affiliates in all 50 states to promote and protect the interests of the trucking industry, representing motor carriers in every sector—from agriculture and livestock to auto haulers, and from large motor carriers to small mom-and-pop operations. CTA is ATA's federation partner in California, and is the nation's largest statewide association representing the trucking industry. ATA and CTA members are actively participating in the development, piloting, and demonstration of alternative fuel and electric-drive capable vehicles. In fact, some member fleets have been working to bring electric-drive vehicles to market for nearly ten years. The ATA and CTA support a coordinated and measured transition to alternative fuel and electric-drive capable vehicles and believe that this is best achieved by comprehensive, federal-level standards rather than a balkanized state-by-state approach to regulation.

II. Background on the Advanced Clean Fleets Regulation.

As described in EPA's Notice of Opportunity for Public Hearing and Comment, dated July 12, 2024, CARB's Board adopted ACF on April 28, 2023, received final Office of Administrative Law approval for the regulation on September 29, 2023, and the regulation became effective on October 1, 2023. Though ACF has compliance deadlines as early as January 1, 2024, CARB left no time between the adoption of ACF and these deadlines to obtain a waiver of preemption and authorization from EPA, as required under the CAA. CARB is well experienced in the timeframes historically taken by EPA to approve a waiver request, yet CARB refused to alter the compliance deadlines in ACF. CARB was aware of the regulatory morass it would create by adopting a regulation that needed EPA approval before it could be enforced, while knowing it would not get such approval before compliance deadlines occurred.

As anticipated, the regulatory morass created by ACF has led to huge uncertainty in the market and beyond. Since ACF was adopted, it has been challenged in five separate court actions: *California Trucking Association v. California Air Resources Board* (E.D. Cal., Case No. 2:23 cv 02333 TLN CKD); *American Free Enterprise Chamber of Commerce, et al. v. Steven S. Cliff, et al.* (E.D. Cal., Case No. 2:24 cv 00988 KJM-JDP); *Nebraska, et al. v. Steven S. Cliff, et al.* (E.D. Cal., Case No. 2:24-cv-01364-JAM-CKD); *Western States Petroleum Association v. California Air Resources Board* (Fresno County Superior Court, Case No. 23CECG02976); and *Western States Trucking Association v. California Air Resources Board* (Fresno County Superior Court, Case No. 23CECG02964). Though 10 states have adopted CARB's Advanced Clean Trucks ("ACT") regulation and 9 states have adopted CARB's Low-NOx Omnibus ("Omnibus")

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[3] *Id.* at 7.

[4] American Trucking Associations, American Trucking Trends 2023.

[5] Leslie, Alex, Ph. D., and Dan Murray, *An Analysis of the Operational Costs of Trucking: 2024 Update,* American Transportation Research Institute (June 2024).

regulation under CAA section 177 (despite the fact that EPA has not yet issued a preemption waiver for Omnibus), no state has yet adopted ACF.[6]

Despite CARB's description of ACF as "the latest development in CARB's decades-long history of promulgating increasingly stringent emissions standards for mobile sources,"[7] ACF is in fact a complete departure from CARB's prior mobile source regulations, for which EPA has previously granted preemption waivers. The ACF regulation is the first "buy side" emissions standard adopted by CARB and thus represents a departure from CARB's historic regulations aimed at Original Equipment Manufacturers ("OEMs") on the "sell side". The ACF regulation not only regulates what California fleet operators can buy, it also controls what vehicles fleets can operate in California and mandates retirement of vehicles after certain criteria are met, impacting truck fleets and purchases well beyond the State's borders.

III. EPA Does Not Have Authority to Grant a Waiver of Clean Air Act Preemption for ACF.

Clean Air Act section 209(a) preempts states from adopting or attempting to enforce "any standard relating to the control of emissions from new motor vehicles…"[8] This prohibition against state-level regulation of new mobile source emissions is both "categorical" and expansive[9] and is intended to avoid a balkanization of emissions standards for sources which travel across state lines.

However, under CAA section 209(b), EPA must grant a waiver of preemption to California if EPA finds (1) that the State's determination that the rule will be at least as health protective as federal rules is not arbitrary and capricious, (2) that the State needs such standards to meet compelling and extraordinary conditions, and (3) that the State standards and accompanying enforcement procedures are consistent with section 202(a). As described below, the waiver criteria have not been met and thus EPA cannot grant a waiver of preemption for ACF.

a. ACF is unlike any prior CARB regulation for which EPA has granted a waiver of preemption.

Though EPA's review of California's waiver request is dictated by statutory criteria, no California regulation has yet been granted a waiver which (i) addresses fleet operations rather than manufacturer sales, and (ii) relies on a wholesale transformation of nationwide infrastructure and power supply in order to be feasible. For these reasons, EPA must take a hard look at the waiver requirements and consider them in light of the unique nature of ACF: a "buy-side" fleet rule which requires massive built infrastructure in order to be feasible, rather than

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[6] CARB, States that have Adopted California's Vehicle Regulations | California Air Resources Board

[7] Letter from Steve Cliff, CARB Executive Officer to Michael Regan, EPA Administrator, Re: Request for Waiver and Authorization Action Pursuant to Clean Air Act Sections 209(b) and 209(e) for California's Advanced Clean Fleets Regulation, dated Nov. 15, 2023.

[8] CAA § 7453(a) (otherwise known as section 209(a)); *see also Engine Mfrs. Ass'n v. S. Coast Air Quality Mgmt. Dist.*, 541 U.S. 246 (2004) ("*EMA*").

[9] *EMA*, 541 U.S. at 252-53.

simply another in a long line of CARB rules which require ratcheting down of emissions limits in new vehicles or balancing of vehicle sales on the part of manufacturers.

The extraterritorial effects of ACF as compared to prior emission reduction regulations adopted by CARB, and granted preemption waivers by EPA, is also unique. While California's policy decisions may be due some deference, ACF is not just a policy which dictates actions within California. Due to the broad application of ACF, it has far-reaching extraterritorial impacts that militate against EPA rubber stamping CARB's action.

b. ACF does not establish standards as protective as applicable Federal standards.

CARB has spoken clearly. ACF "is part of a comprehensive strategy that would, consistent with public health needs, accelerate the widespread adoption of zero emission vehicles ("ZEV") in the medium- and heavy-duty truck sector and in light-duty package delivery vehicles"[10] in order to effect the mandate by Governor Gavin Newsom to transition California's mobile sources away from conventional ICE vehicles.[11] Because the outcome has thus been predetermined, CARB failed to independently and objectively evaluate the assumption that the replacement of internal combustion engine ("ICE") trucks with ZEVs, and in particular battery electric vehicles, will necessarily result in lower emissions. This was in error.

ACF will result in impacts both in and outside of California that render the regulation less protective of the public than federal standards. Just as it failed to do in evaluating Advanced Clean Trucks ("ACT"), CARB did not conduct a sufficient life-cycle analysis to evaluate increased pollutants from battery electric vehicles due to, among other things, increased particulate matter emissions from tire wear due to the substantially increased weight of these vehicles. As noted in comments on the waiver for ACT, CARB's approach does not deliver results as early and as cost-effectively as an approach that incorporates low-nitrogen oxides ("NOx") emission vehicles coupled with increased introduction of renewable liquid and gaseous fuels.

The American Transportation Research Institute found that the trucking industry can decrease GHG emissions through a variety of vehicle types. Among other findings, the report concludes that based on a lifecycle analysis, Class 8 battery electric vehicle production results in more than six times the carbon dioxide emissions as compared with a Class 8 ICE vehicle due to the size and replacement cycle of lithium-ion batteries necessary to support long-haul trucking.[12] Moreover, CARB failed to consider the emissions associated with rare earth and other mining operations necessary to produce batteries, the battery production process, transmission and distribution grid updates, or battery disposal. CARB also failed to consider environmental impacts related to the use of ZEVs, including increases in battery fires at facilities and on

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[10] CARB, Public Hearing to Consider the Proposed Advanced Clean Fleets Regulation, Staff: Report Initial Statement of Reasons ("ISOR"), Aug. 30, 2023, p. 1.

[11] Executive Order N-79-20 (Sept. 23, 2020).

[12] American Transportation Research Institute, Understanding the CO2 Impacts of Zero-Emission Trucks (May 2022), p. 38.

highways, the latter of which will also increase overall traffic congestion, shut down highways and ensure an aggregate increase in emissions from ICE vehicles of the general population.

ACF also purports to prohibit the addition of non-California certified ICE vehicles to the fleets that motor carriers use in California.[13] CARB has determined that enforcing this prohibition with respect to model years 2024 and 2025 "may not be warranted based on the specific and fluctuating circumstances of engine sales."[14] This was in response to concerns raised by the Truck and Engine Manufacturers ("EMA") that section 2015(r) is "severely constraining the ability of EMA member-company OEMs to accept or fill orders from any out-of-state ACF-regulated fleets, given the low volumes of fully Omnibus-compliant medium- and heavy-duty engine families that are currently being certified for sale."[15] CARB's equivocal determination leaves motor carriers concerned about what CARB may ultimately enforce, and that uncertainty is affecting fleet purchase decisions, with some motor carriers delaying normal turnover cycles and holding onto older equipment longer than they otherwise would. For this and related reasons, motor carriers are not shifting to newer, cleaner equipment as quickly as they would have absent ACF.

In the absence of the required independent analysis of whether ACF, and California's program as a whole, are more protective than federal standards; and in light of the various incentives ACF provides for motor carriers to keep older equipment on the road longer than they otherwise would have, CARB's contention that ACF is at least as protective as federal standards is arbitrary and capricious.

c. **California does not require ACF in order to meet compelling and extraordinary circumstances**.

EPA may only grant a waiver if California needs a separate state program to meet compelling and extraordinary circumstances.[16] ACF is intended to address global climate change, the impacts of which do not constitute compelling and extraordinary circumstances within the meaning of section 209(b)(1)(B). "It was clearly the intent of the [Clean Air] Act that [the 209(b)] determination focus on *local* air quality problems—problems that may differ substantially from those in other parts of the nation." *Ford Motor Co. v. EPA*, 606 F.2d 1293, 1303 (D.C. Cir. 1979) (emphasis added). California does not uniquely contribute to global climate change—on the contrary, U.S. Energy Information data indicates that California is among the states with the least carbon dioxide emissions on a per-capita or per-GDP basis[17]—

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[13] ACF § 2015(r).

[14] Letter from Ellen M. Peter, CARB Chief Counsel to Jed R. Mandel, President, Truck & Engine Manufacturers Association, Re: Request for Enforcement Discretion Under California Code of Regulations, Title 13 Section 2015(r), dated July 6, 2023, CARB Response to EMA Request for Enforcement Discretion.

[15] Letter from Jed R. Mandel, Truck & Engine Manufacturers Association to Ellen M. Peter, Chief Counsel, CARB, Re: Request for Enforcement Discretion Under California Code of Regulations, Title 13 Section 2015(r), dated June 28, 2023, EMA Signed Request Enforcement Discretion Under Title 13 Sec 2015(r) (ca.gov).

[16] 42 U.S.C. § 7543(b)(1)(B).

[17] U.S. Energy Information Administration, Energy Related CO_2 Emission Data Tables, State Carbon Dioxide Emissions Data - U.S. Energy Information Administration (EIA).

nor does the state experience unique impacts as a result of greenhouse gas emissions. Emissions in California therefore “bear no particular relation” to any “California-specific circumstance.”[18]

CARB argues that the state continues to grapple with continued air pollution problems, specifically in the South Coast and San Joaquin Valley Air Basins, that constitute extraordinary and compelling circumstances. Challenges with criteria pollutants, however, do not give CARB carte blanche to tack on any air quality regulation, particularly one that is aimed at greenhouse gas emissions, rather than the criteria pollutants which cause the air quality issues in these air basins. CARB further contends that, even reviewed on an individual basis, California faces climate change impacts so unique as to justify a separate program. In particular, CARB notes challenges with drought, sea level rise, and wildfire; all of which have been experienced by western and coastal states and are in no way a challenge specifically faced by California. Unlike the state-specific impacts giving rise to section 209, nothing about global climate change establishes compelling and extraordinary circumstances necessitating that California take action separate and apart from the rest of the nation.

d. ACF is inconsistent with multiple provisions of CAA section 202(a).

i. The ACF regulation establishes classes or categories of vehicles based on inappropriate factors.

CAA section 202(a)(3)(A)(ii) requires that, “[i]n establishing classes or categories of vehicles or engines for purposes of regulations under this paragraph, the Administrator may base such classes or categories on gross vehicle weight, horsepower, type of fuel used, ***or other appropriate factors***” (emphasis added). The ACF regulation does not utilize appropriate factors to develop classes or categories of new motor vehicles or new motor vehicle engines as required by this section.

When applying this section, EPA generally categorizes vehicles by class into Light Duty (Class 1-2), Medium Duty (Class 3-6), and Heavy Duty (Class 7-8). EPA defines vehicle categories, also by Gross Vehicle Weight Rating (“GVWR”), for the purposes of emissions and fuel economy certification, such as Class 2 (trucks with a GVWR of 6,001-10,000 lbs.) or Class 8 (heavy-duty trucks with GVWR over 33,001 lbs.). CARB similarly classifies vehicles based on their GVWR into light- medium-, light heavy-, medium heavy-, and heavy heavy-duty.[19] EPA has also adopted classes or categories based on the vehicle’s primary function, frontal area, special features, or capacity.[20] In every case, the class or category is defined by factors intrinsic to the vehicle itself. EPA previously rejected a proposal to treat vehicles as different classes

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[18] EPA, The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule Part One: One National Program, Withdrawal of waiver; final rule, 84 Fed. Reg. 51310, 51346 (Sept. 27, 2019); EPA, California State Motor Vehicle Pollution Control Standards; Notice of Decision Denying a Waiver of Clean Air Act Preemption for California’s 2009 and Subsequent Model Year Greenhouse Gas Emission Standards for New Motor Vehicles, Notice, 73 Fed. Reg. 12156, 12160 (March 6, 2008).

[19] CARB, Clean Air Action Section 209(b) Waiver and section 209(e) Authorization Request Support Document, November 15, 2023.

[20] *See, e.g.*, 40 C.F.R. §§ 86.1803-01.

based on method of manufacture because to do so would result in a different class for a vehicle with “exactly the same function and market” as an existing category.[21]

Regulating the same vehicle in a different way based on characteristics extrinsic to the vehicle itself is exactly what ACF does. The ACF regulation creates sub-categories of normal classes which means that vehicles with “exactly the same function and market” may be subject to ACF in some instances, but not in others. This sub-categorizing by CARB to create standards which vary in their applicability to the same vehicle is not based on appropriate factors under CAA section 202(a).

The ACF regulation applies to “any entity that owns, operates, of directs one or more vehicles in California that is either:

> (1) an entity or combination of entities operating under common ownership or control that have $50 million or more in total gross revenue in the prior year;
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> (2) a fleet owner that owns, operates, or directs 50 or more vehicles in the total fleet, excluding light-duty package delivery vehicles;
>
> (3) a fleet owner or controlling party whose fleet in combination with other fleets operated under common ownership and control total 50 or more vehicles in the total fleet, excluding light-duty package delivery vehicles; or
>
> (4) a federal government agency.[22]

Under ACF, the same truck (as characterized by EPA) would have a different standard to comply with depending on whether it is (1) operated in a fleet greater than 50 trucks or a fleet less than 50 trucks, or (2) operated in a fleet with an entity with greater than $50 million revenue or less than $50 million revenue. CARB has provided no explanation as to how vehicles require different emissions classifications merely as a function of their ownership. There is nothing in the emissions or operations of the selected vehicles that necessitates sub-classifications with different emissions standards.

In addition, ACF’s definitions of “controlling party” and “common ownership or control” create unreasonable and incoherent classes or categories of vehicles regulated separately under the ACF. Under the regulation, common ownership or control means being owned or managed on a day-to-day basis by the same person or entity and includes “vehicles owned by different entities but operated using common or shared resources to manage the day-to-day operations using the same motor carrier number, ***displaying the same name or logo***, or contractors whose services are under the day-to-day control of the hiring entity are under common ownership or control” (emphasis added). This means that, for example, sprinter vans provided by a third party who services an online retailer could count as under common control by the retailer in certain instances but not others. The online retailer may have to count vans with their logo on them as part of their fleet for purposes of the ACF regulation; but if the vans do not have the retailer’s

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[21] EPA, Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles—Phase 2, Final rule, 81 Fed. Reg. 73478, 73518-19 (Oct. 25, 2016).

[22] ACF § 2015(a)(1).

completed a thorough assessment of the various options for compliance in each model year, how are fleets supposed to understand what technologies are available for compliance and plan accordingly? By failing to complete this analysis, CARB has rendered the ACF regulation ineligible for a waiver of preemption.[28]

Nowhere in its 296-page Initial Statement of Reasons ("ISOR") for ACF does CARB conduct a thorough technological assessment of vehicles available in each model year for which the ACF regulation will apply. CARB explains that "[i]t is somewhat challenging to precisely predict which ZE technologies fleets would use for complying with the proposed ACF regulation."[29] CARB frames its lack of analysis as "flexibility," forcing covered owners to make their own determination as to what technology is available at the time of compliance subject to CARB's review.[30] CARB takes itself off the hook by mandating that regulated parties themselves prove which vehicles are commercially unavailable and then petition CARB.[31] For the ZEV unavailability exemption, CARB states that it will maintain a list of vehicle configurations that are eligible for the exemption on the CARB Advanced Clean Fleets webpage, *i.e.*, vehicles that are commercially unavailable. However, no such list exists. Appendix J to the ISOR is a list of commercially available ZEVs as of 2022; however, the ISOR states that Appendix J is only "a partial list of medium- and heavy-duty ZEVs that are currently available or that can be ordered" and is not the list of commercially ***unavailable*** vehicles that the ISOR says CARB will produce. Nor has CARB since posted such a list, despite the fact that ACF was adopted over a year ago and that CARB intends to retroactively require compliance with ACF if and when a waiver is granted.[32] In fact, CARB does not plan to publish such a list until sometime in 2025.[33]

In crafting the ACF regulation in this way, CARB has turned the required technological assessment into an individual assessment of various regulated parties' statements about which vehicles are or are not commercially available, rather than the class-by-class assessment that CARB is required to undertake pursuant to section 202(a).

Moreover, CARB has defined "commercially available" to mean a vehicle which is available to order or has had at least one model delivered to a customer.[34] But a vehicle that is available to

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[28] Indeed, EPA has already acknowledged the fundamental uncertainties surrounding CARB's standards. In its analysis of zero emission technology as part of its Phase 3 Greenhouse Gas rulemaking, EPA considered comments from CARB suggesting the need for EPA to adopt the stringent emissions targets proposed under ACT. However, EPA's final rule set zero emission adoption rates well below CARB's standards, explaining that "the caps [on adoption rates] serve as proxies for uncertainties that can affect feasibility of the standards, including timing of infrastructure deployment, … availability of critical minerals and associated supply chains, and adequacy of battery manufacture." EPA, Greenhouse Gas Emissions Standards for Heavy-Duty Vehicles: Phase 3 - Response to Comments, EPA-HQ-OAR-2022-0985-3859 (April 22, 2024), p. 717.

[29] ISOR, p. 171.

[30] ISOR, pp. 100, 269.

[31] ACF § 2015.3(e).

[32] CARB, Advanced Clean Fleets Regulation Exemptions and Extensions Overview, Advanced Clean Fleets Regulation Exemptions and Extensions Overview | California Air Resources Board ("[s]tarting 2025, CARB will maintain a ZEV Purchase Exemption List with common vehicle body configurations that are not available to purchase as a ZEV or NZEV"); Letter from Steve Cliff, CARB Executive Officer to Chris Shimoda, California Trucking Association, Re: CTA v. CARB, dated Dec. 27, 2023, CARB Letter to CTA Re: CTA v. CARB.

[33] *Id.*

[34] ISOR, pp. 9-10, 70, 91, 93, 98.

order but not available for purchase and delivery in a reasonable (or even predictable) time frame, at an ordinary commercial price, and in the quantities needed, is not "commercially available" in any meaningful sense.[35] It is clear that many of the vehicles CARB has listed on Appendix J are open for order but are not being delivered in a reasonable time or in the amount ordered. Many commenters reported during the ACF rulemaking process about orders which were decreased in volume or for which they waited extreme amounts of time to receive their vehicles, and this uncertainty in the market has only increased since ACF was adopted. ATA and CTA are aware of entities who ordered trucks at a price still uncertain and without a firm delivery date before ACF was even adopted, but which still have not been delivered. This does not amount to being commercially available.

CARB has also repeatedly emphasized the nuanced requirements for specialized fleets,[36] yet has not and cannot ensure that the technology the ACF regulation will require is commercially available for all regulated entities. ISOR, pp. 171-72 (admitting that BEVs have not yet proven functional for fleets with high range or high payload needs, but not discussing what technology will be available to address those needs as ACF standards begin to apply to those uses); *see also id.* (discussing the mix of ZEVs CARB assumes for purposes of the economic analysis and stating that there are currently "limited small-scale deployments of fuel cell electric truck tractors by several small and major truck manufacturers" and "fuel cell electric technologies leading to commercialization in the latter half of the decade," yet also assuming that FCEVs will be 10% of the fleet until 2027 and 25% afterwards).

Indeed, EPA's own regulatory and market analysis as part of the Heavy-Duty Greenhouse Gas Phase 3 regulation reflects the uncertainty in the zero emission market for technology development, deployment and required infrastructure development. EPA has committed to publish periodic reports to monitor zero emission technology development, adoption, and infrastructure construction to ensure compliance, and the agency has indicated that it may "initiate a future rulemaking to consider modifications to Phase 3 rule (including giving appropriate consideration to lead time as required by section 202 (a)), or make no changes to the Phase 3 rule program."[37]

iii. The regulation does not give appropriate consideration to the cost of compliance within each period.

CAA section 202(a)(2) and (a)(3)(A)(i) require that, in adopting vehicle emission standards, EPA give appropriate consideration to the cost of compliance ***within each period***. Given that, as discussed above, CARB does not actually identify the technology with which specific classes or categories of vehicles will comply with the rule, it is not possible for CARB to have undertaken an analysis of the actual cost of compliance during each period that the ACF regulation will apply. In fact, the various compliance options (Model Year Schedule and ZEV Milestone Option) and the multiple exemptions from rule applicability (ZEV unavailability, daily mileage

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[35] Compare with federal contracting rules requiring products be "Sold in substantial quantities in the commercial marketplace." 48 C.F.R. § 2.101.

[36] ISOR, pp. 91, 98

[37] EPA, Greenhouse Gas Emissions Standards for Heavy-Duty Vehicles—Phase 3, Final rule, 89 Fed. Reg. 29440, 29481 (April 22, 2024).

logo, they may not. The online retailer is not the operator of the fleet in either instance, but the regulation considers some vans to be part of the retailer's "fleet" because the retailer is the "controlling party".[23]

In this instance, CARB is not regulating the vehicle itself, nor even the owner or operator of the van, but the client the van serves, and is treating vehicles with the same function as different for purposes of emission control standards.[24] In comparison, any vehicle emission standard promulgated by EPA under the CAA would apply to the vehicle itself, regardless of how it is used or by whom. The regulation's complicated determination of which vehicles are regulated and which are not thus conflicts with the CAA section 202 requirement that the determination of classes or categories to be regulated be based on appropriate factors.

ii. The ACF regulation does not make the required technological determinations.

CAA section 202(a)(3)(A)(i) requires EPA to adopt vehicle emission standards which represent "[t]he greatest degree of emission reduction achievable ***through the application of technology which the Administrator determines will be available for the model year to which such standards apply***, giving appropriate consideration to cost, energy, and safety factors associated with the application of such technology" (emphasis added). This analysis requires EPA to complete an exhaustive process in which it assesses the technologies that will be available in each model year in order to determine the emission reductions that are achievable each year.[25]

Instead of following this required section 202 process, CARB has inverted it. Rather than complete a full assessment of the technologies which will be available in each model year in order to determine the emissions reductions achievable in that year, CARB has picked an emission level (zero emission) and then told fleet operators that they have to comply with that level regardless of technology or commercial availability. By allowing for ZEV unavailability exemptions, daily usage exemptions, and vehicle delivery delay extensions,[26] CARB has admitted that it has not undertaken the analysis required by section 202 to determine in advance which technologies will be available for each class or category of vehicles in each model year.[27] This analysis is the cornerstone of any vehicle emission standard. If neither CARB nor EPA has

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[23] *See* ACF § 2015(b) ("Controlling party" means the motor carrier, broker, or entity that directs or otherwise manages the day-to-day operation of one or more fleets under common ownership or control to serve its customers or clients).

[24] EPA has promulgated its own definitions of "ownership" and "control" applicable to a purchase standard implemented as part of an authorized Clean Fuel Fleet Program, with which ACF is also inconsistent. 40 C.F.R. § 88.302-94.

[25] *See, e.g.*, EPA, Revised 2023 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions Standards, Final rule, 86 Fed. Reg. 74434, 74473-488 (Dec. 30, 2021) (assessing technical feasibility of final standards including projected target levels by manufacturer, projected per vehicle cost for each manufacturer, projections of EV and PHEV technology penetration rates, and explaining why the final standards are technologically feasible); *see also* EPA, Revised 2023 and Later Model Year Light-Duty Vehicle GHG Emissions Standards: Regulatory Impact Analysis, Chapter 2: Technology Feasibility, Effectiveness, Costs, and Lead-Time, https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P1013ORN.pdf.

[26] ACF § 2015.3.

[27] CARB's enforcement discretion letter, discussed above, similarly constitutes an admission by CARB of the unavailability of compliant ICE vehicles.

usage, infrastructure construction delay, and vehicle delivery delay) make it impossible to assess the cost of compliance within each period. The Department of Finance also noted the uncertainty in whether and how certain regulated parties would comply with the ACF regulation in its comments on the Standard Regulatory Impact Assessment ("SRIA"). Appendix C-2: Department of Finance Comment Letter, pp. 1-2 (stating that the SRIA assumes that the purchase requirements of the ACF regulation will complement the sales requirements in the Advanced Clean Trucks regulation, but noting that differences in timing between ACF and ACT may hinder compliance of fleets that utilize heavier vehicle classes and asking that the SRIA include a sensitivity analysis to analyze this issue).

In addition, CARB's SRIA looks not at the cost of compliance within each period based on determined methods of compliance, but at the macroeconomic costs of ACF across the state compared to baseline operations.[38] Further, major changes were made to the proposed ACF regulation after CARB completed its SRIA.[39] As explained in the ISOR, CARB's SRIA modeling assumed that high priority fleets would comply solely through meeting the ZEV milestone requirements. However, in the proposed regulation, high priority fleets by default must meet the Model Year Schedule, but may opt-in to the ZEV Milestone Option if they waive their useful life rights. For this reason, the SRIA cannot accurately predict the cost of compliance within each period as required by section 202(a).

CARB has identified numerous cost-barriers to ACF implementation, including high vehicle upfront costs and the real concern that ZEVs will not be able to replace existing combustion-powered vehicles on a one-to-one basis due to payload, mileage, or other issues. ISOR, pp. 200 (stating that "higher upfront cost of ZEVs can place a barrier in vehicle purchasing patterns" and that ZEVs can meet ***most*** daily needs on a one-to-one basis provided the ZEV is placed in applications where it is suitable). Yet CARB conveniently ignores these real challenges in its SRIA. This economic analysis is not sufficient to meet the demands of section 202(a).

iv. The ACF regulation does not meet the lead time requirement, and is not feasible.

CAA section 202(a)(3)(C) provides, "Any standard promulgated or revised under this paragraph and ***applicable to classes or categories of heavy-duty vehicles or engines*** shall apply for a period of no less than 3 model years beginning no earlier than the model year commencing 4 years after such revised standard is promulgated" (emphasis added). These Congressionally-mandated lead time and stability periods were originally created in order to allow individual truck manufacturers to make the capital investments necessary to respond to new regulations. Congress determined that these lead time and stability provisions were essential to successful implementation of the CAA's technology-forcing objectives.

As explained above, ACF was adopted in April 2023, became effective in October 2023, and has statutory deadlines for compliance which purportedly begin on January 1, 2024, despite the fact

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[38] ISOR, pp. 157-58.
[39] ISOR, pp. 159-60.

that CARB knew or should have known at the time it adopted ACF that it could not obtain a waiver of preemption or authorization from EPA by this date.

In order to comply with the lead time provisions, the regulation cannot apply before model year 2028. Under the Model Year Schedule option for the high priority/federal fleets and for drayage fleets, the regulation would take effect in 2024, requiring the purchase of only ZEVs starting on January 1, 2024.[40] This directly contravenes section 202(a). In addition, the fleet ZEV Milestone Option requires 10 percent of a fleet's vehicles to be ZEVs in 2025 for milestone group 1 and 10 percent of a fleet's vehicles to be ZEVs in 2027 for milestone group 2.[41] Thus, the Milestone Option also directly contravenes the required 4-year lead time.

This conclusion is supported by federal case law and by EPA's own prior waiver determinations. Specifically, in *American Motors Corporation v. Blum*, 603 F.2d 978 (D.C. Cir. 1979), the D.C. Circuit held that where Congress has specified a lead time period for certain types of mobile source regulations, CARB is bound to comply with that specified lead time just as much as EPA. If CARB fails to provide that Congressionally-mandated lead time, the CARB regulations are not consistent with CAA section 202(a) and so are ineligible for a waiver of preemption under section 209(b). *Id.*

EPA consistently has followed the D.C. Circuit's reasoning in *Blum*, and has explicitly addressed the applicability of section 202(a)(3)(C) to California as a requirement to obtain a waiver under section 209(b). EPA issued a memorandum on September 16, 1994, signed by then-Assistant Administrator Mary Nichols, that expressly concluded that CARB must comply with the Congressionally-mandated four-year lead time provision of section 202(a)(3)(C) in order for CARB's regulations to be consistent with CAA section 202(a) and to qualify for a waiver of preemption.[42] EPA explained:

> EPA disagrees with CARB's conclusion [that *Blum* is not applicable to its heavy-duty regulations]. EPA believes that *Blum* indicates that California would be required to provide the statutory lead time required under section 202(a)(3)(C) for its proposed gasoline and diesel standards. . . .
>
> EPA believes this case to be similar to the facts in *Blum* in that Congress specified a specific amount of lead time to be provided for heavy-duty manufacturers. The Congressional concern for adequate lead time for manufacturers under certain conditions must be incorporated by California in determining the adequacy of lead time to permit the development of new technology to meet new requirements. . . .
>
> The *Blum* court concluded that . . . a Congressional mandate of a specific amount of lead time should be grafted into section 202(a) and that the California standards may not be inconsistent with this required lead time. Given that *Blum* decision, EPA believes that the heavy-duty lead time requirement, already a part of section

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[40] ACF § 2015.1.

[41] ACF § 2015.2.

[42] *See* Decision Document, Sept. 16, 1994, pp. 30, 32, https://www.regulations.gov/document/EPA-HQ-OAR-2022-0332-0020.

> 202(a), should be provided in order for California standards to be considered consistent with section 202(a).[43]

Federal statutes must be construed to give full effect to their plain meaning, and when statutes are unambiguous the plain language of the statute controls, without the need to explore any matters beyond the clear terms of the statute.[44]

Even were EPA to interpret this prong of the waiver analysis so as not to require a set amount of lead time, EPA has previously interpreted it to require "California's standards to be feasible."[45] This feasibility analysis includes an assessment of "the program's standards as a whole, accounting for the interactions between technologies necessary to meet both new and existing standards, and any interactions between those technologies that would affect feasibility."[46] Here, the relevant interaction is between the technology available for ZEVs and charging infrastructure sufficient to enable those vehicles to actually be used for fleet operations. Thus, in the context of ACF, "technologically feasible" must mean more than just that ZEVs exist. These vehicles cannot be utilized by fleets unless the infrastructure necessary to support them, including both depot and public charging; the roads able to withstand heavier vehicles;[47] the necessary substation and transmission line upgrades; and sufficient power to meet the demands of an all-electric California fleet, also exist. While the CAA originally recognized the importance of lead time in order to give OEMs the chance to make plans for compliance and ramp up production, this time is equally, if not more, important for purchasers and end-users of vehicles, especially in light of the infrastructure challenges currently facing fleets which utilize ZEVs.

In its approval of the 2009 model standards, EPA stated that "[t]here is nothing inherently different about how GHG control technologies should be reviewed when making a determination about technological feasibility or consistency of test procedures".[48] However, there is something inherently different about ACF and its mandate for ZEVs across entire fleets; they rely on charging infrastructure that is not readily available in California, let alone across the U.S. CARB itself understands the infeasibility of utilizing zero emission trucks when infrastructure is not in place, based on its creation of the ZEV Infrastructure Delay Extension, which includes both delay from the ability of a utility to provide electricity to a site and construction delays from installation charging infrastructure.[49]

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[43] *Id.* at pp. 26, 28, 29-30 (emphasis added). *See also* EPA, Petition for Reconsideration of Waiver of Federal Preemption for California to Enforce Its NOx Emission Standards and Test Procedures, Notice of denial, 46 Fed. Reg. 22032 (April 15, 1981) (EPA held that when Congress has specified a lead-time period, California "must make provision for the extra lead time Congress itself found necessary").

[44] *See United States v. Barnes*, 295 F.3d 1354, 1359 (D.C. Cir. 2002).

[45] EPA, California State Motor Vehicle and Engine Pollution Control Standards; Heavy-Duty Vehicle and Engine Emission Warranty and Maintenance Provisions; Advanced Clean Trucks; Zero Emission Airport Shuttle; Zero-Emission Power Train Certification; Waiver of Preemption; Notice of Decision, Notice of decision, 88 Fed. Reg. 20688, 20704 (April 6, 2023).

[46] *Id.* at 20706.

[47] ISOR, p. 4 (stating that weight may be an issue for 10 percent of the largest trucks on the road).

[48] EPA, California State Motor Vehicle Pollution Control Standards; Notice of Decision Granting a Waiver of Clean Air Act Preemption for California's 2009 and Subsequent Model Year Greenhouse Gas Emission Standards for New Motor Vehicles; Notice, 74 Fed. Reg. 32744, 32767 (July 8, 2009).

[49] ACF § 2015.3(c).

CARB recognizes the need for massive infrastructure to support the move to zero emission trucks, stating that 157,000 medium- and heavy-duty electric truck chargers will be necessary by 2030 and 258,000 chargers by 2037 to meet the demand for electrification.[50] This includes approximately 5,500 high speed (350-1,599 kW) en-route chargers by 2030 and 8,500 high speed en-route chargers by 2037.[51] However, as of August 2024, there are approximately 152,000 public and shared EV charging stations (overwhelmingly for light-duty vehicles), including 14,700 direct current fast chargers (15-350 kW),[52] which are not the high speed en-route chargers needed for medium- and heavy-duty fleets. There are also only 3 heavy-duty hydrogen stations publicly available[53] compared to the 200 hydrogen refueling stations needed by 2030.[54] According to the California Energy Commission, California is behind its 2030 EV charger target for all vehicle types by 747,989 chargers.[55]

CARB must utilize a "requirement of reason" in projecting future available technology to demonstrate the technological feasibility of its regulations in order to obtain a preemption waiver.[56] In *Natural Resources Defense Council v. EPA* (''NRDC''), 655 F.2d 318 (D.C. Cir. 1981), the court noted that "the Clean Air Act requires the EPA to look to the future in setting standards, but the agency must also provide a reasoned explanation of its basis for believing that its projection is reliable." Notably here, that includes demonstrating that infrastructure sufficient to charge and fuel ZEVs will be available in order for fleets to comply with ACF. CARB has not even attempted to do this in adopting ACF and using a "requirement of reason" analysis, it is not reasonable to think that California will build almost three-quarter of a million chargers in the next 6 years, almost 350 chargers ***per day***.

In fact, California's own Public Utilities Commission ("CPUC") agrees that the State has no plan to construct this infrastructure. In a recent ruling, the CPUC notes that impact from medium- and heavy-duty vehicle charging is "not well studied," that "energization delays have emerged as a significant barrier to California's transportation electrification goals," and that "the pace and scale of transportation electrification adoption is challenging the [investor-owned utilities'] ability to provide utility-side infrastructure in a timely manner."[57]

CARB provides no explanation as to how this necessary infrastructure will be enabled in order to allow regulated entities to comply with ACF. Instead, CARB caveats its analysis with assumptions about the future with no reasoned explanation. See, e.g., ISOR, p. 53 ("Long-haul

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[50] ISOR, pp. 72, 140.

[51] California Energy Commission ("CEC"), Assembly Bill 2127 Electric Vehicle Charging Infrastructure Assessment, 2021, https://efiling.energy.ca.gov/getdocument.aspx?tn=238853.

[52] CEC EV Charger Dashboard, Electric Vehicle Chargers in California.

[53] CEC, Final Staff Report, Senate Bill 643: Clean Hydrogen Fuel Production and Refueling Infrastructure to Support Medium- and Heavy-Duty Fuel Cell Electric Vehicles and Off-Road Applications, January 2024, CEC-600-2023-053-SF, p. 28.

[54] ISOR, pp. 72, 140.

[55] CEC, AB 2127 EV Charging Infrastructure Assessment (Jan. 2024), https://www.energy.ca.gov/publications/2024/assembly-bill-2127-second-electric-vehicle-charging-infrastructure-assessment.

[56] *International Harvester v. Ruckelshaus*, 478 F.2d 615, 629 (D.C. Cir, 1973).

[57] CPUC Order Instituting Rulemaking Regarding Transportation Electrification Policy and Infrastructure (April 12, 2024) 3, 6, 7, https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M529/K525/529525879.PDF.

applications are expected to be served through a mixture of depot charging and high-speed public ZE infrastructure (charging and hydrogen fueling), both of which are expected to become commonplace over time"), p. 73 (describing extreme high-powered charging system under development "with the promise" of reducing charging time).

CARB also assumes that most vehicles will be able to charge with depot charging, but even its conservative assumptions leave out the large number of Class 7-8 trucks which will rely solely on publicly-available charging.[58] And CARB does not provide support for its belief that the thousands of publicly-accessible charging stations in California, to say nothing of the rest of the U.S., necessary to comply with ACF will come into being in time for compliance. CARB has failed to provide a reasoned explanation of how every entity can comply with ACF given the extreme infrastructure challenges facing the state and the necessity of that infrastructure for ACF's success.[59]

Courts have previously "probed deeply" into lead time when much longer lead times were provided than here. In *International Harvester v. Ruckelshaus*, 478 F.2d 615, 626 (D.C. Cir, 1973), the relatively short 2-year lead time for model year standards was given a hard look by EPA. Here the lead time was ***3 months*** from the effective date of ACF to the first compliance deadline for drayage trucks and the model year schedule requirements, and ***1 year and 3 months*** for the ZEV milestone option. Other waiver requests have been approved based on 3-5 years of lead time before the first phase of compliance.[60]

We are not aware of any previous action where CARB adopted a regulation it knew required a waiver of preemption with only 3 months to obtain that waiver before compliance deadlines began. This timeline and process is unprecedented and creates troubling precedent for CARB's ability to strong-arm compliance by regulated entities.[61] The purpose of the lead time provision, or even merely a demonstration of technical feasibility, is to avoid the Hobson's choice that now faces fleet operators; either create a long-term comprehensive compliance strategy with multi-million dollar investments in order to comply with a regulation that has not yet been granted a waiver, or fail to prepare a plan and face illegal retroactive enforcement by CARB once a waiver is granted.[62] The CAA did not contemplate the investment of millions of dollars in compliance

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[58] ISOR, p. 73 ("Staff is assuming that non-tractor trucks traveling under 200 miles per day will rely solely on depot charging until 2030, while Class 7-8 tractor trucks will rely on depot charging for 25 to 75 percent of the time, depending on vehicle range, duty cycles, and access to infrastructure both at home and away"), p. 5 ("publicly accessible options will be needed to enable a widespread charging network for long-range and interstate travels").

[59] Exhibit A vividly illustrates the implications of the ACF regulation across the country: it shows that trucks operating during a one-day period in six southern California counties traveled in nearly every state, as far as the east coast, within three days. Those trucks, and the countless others like them, would require a massive nationwide build-out of charging stations and electrical infrastructure in order to comply with ACF. A recent study by the Clean Freight Coalition, attached as Exhibit B, estimates the cost of this build-out at nearly $1 trillion.

[60] *See, e.g.*, 74 Fed. Reg. 32744, 32768 (July 8, 2009) (granting a waiver for 2009 and subsequent year Greenhouse Gas Emission Standards); 88 Fed. Reg. 20688, 20704 (April 6, 2023) (granting waiver for ACT).

[61] *See* Letter from Steve Cliff, CARB Executive Officer to Michael Regan, EPA Administrator, Re: Request for Waiver and Authorization Action Pursuant to Clean Air Act Sections 209(b) and 209(e) for California's Advanced Clean Fleets Regulation, dated Nov. 15, 2023 (stating that CARB "reserves all of its rights to enforce the ACF regulation in full for any period for which a waiver is granted…").

[62] *See Central Valley Chrysler-Jeep, Inc. et al. v. Goldstene*, 563 F.Supp.2d 1158, 1168 (E.D. Cal. 2008) (stating that standards may come into effect immediately if and when a waiver of federal preemption is granted by EPA);

with a regulation that had not yet faced federal review, and EPA should not sanction CARB's unprecedented attempt to force its hand here.

ACF is a Gordian knot, riddled with convoluted and unpredictable exceptions designed to obscure the fact that CARB cannot demonstrate that its regulation is feasible. The relevant provisions of the CAA are clear and unambiguous. In order for CARB to receive a waiver for ACF, its standards must be at least as protective as federal standards, necessary to meet compelling and extraordinary circumstances in California, and consistent with section 202(a) of the CAA. Since none of these criteria—much less all of them —have been met, ACF is ineligible for a waiver of federal preemption under CAA section 209(b)(1)(C). For this reason, EPA should deny a waiver of preemption or authorization to CARB for ACF.

Sincerely,

Marne S. Sussman

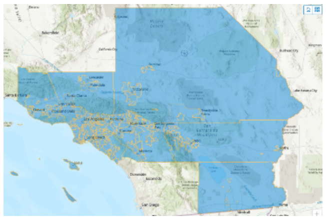
Marne Sussman
Partner, Holland & Knight

Letter from Steve Cliff, CARB Executive Officer to Chris Shimoda, California Trucking Association, Re: CTA v. CARB, dated Dec. 27, 2023, CARB Letter to CTA Re: CTA v. CARB.

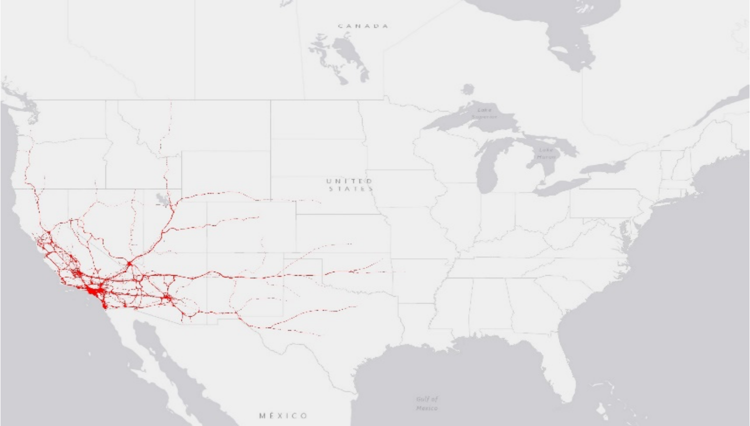
EXHIBIT A

Exhibit A: Freight Flow from the six county Southern California Association of Governments (SCAG) region (Source: ATRI Freight Performance Measures)

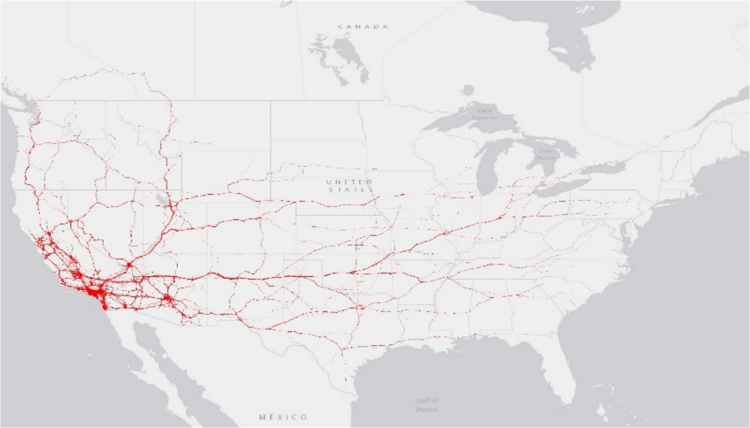
Six County SCAG Region: *Trucks were detected as operating in this region on day 1.*



1 Day Flow of Trucks: *Tracking of identified trucks at the end of day 1.*



2 Day Flow of Trucks: *Tracking of identified trucks at the end of day 2.*



3 Day Flow of Trucks: *Tracking of identified trucks at the end of day 3.*

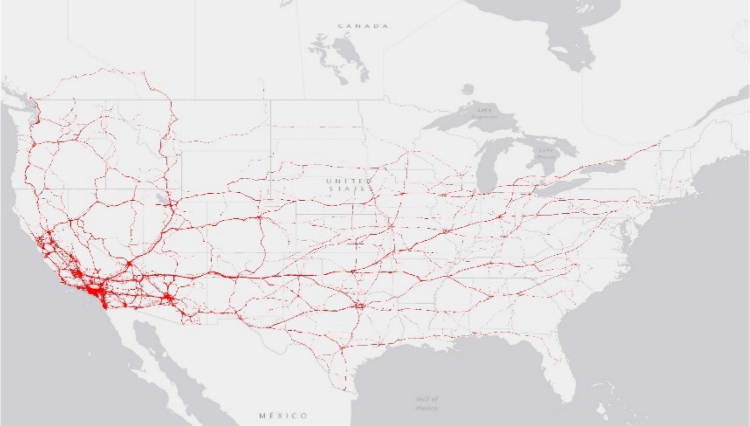
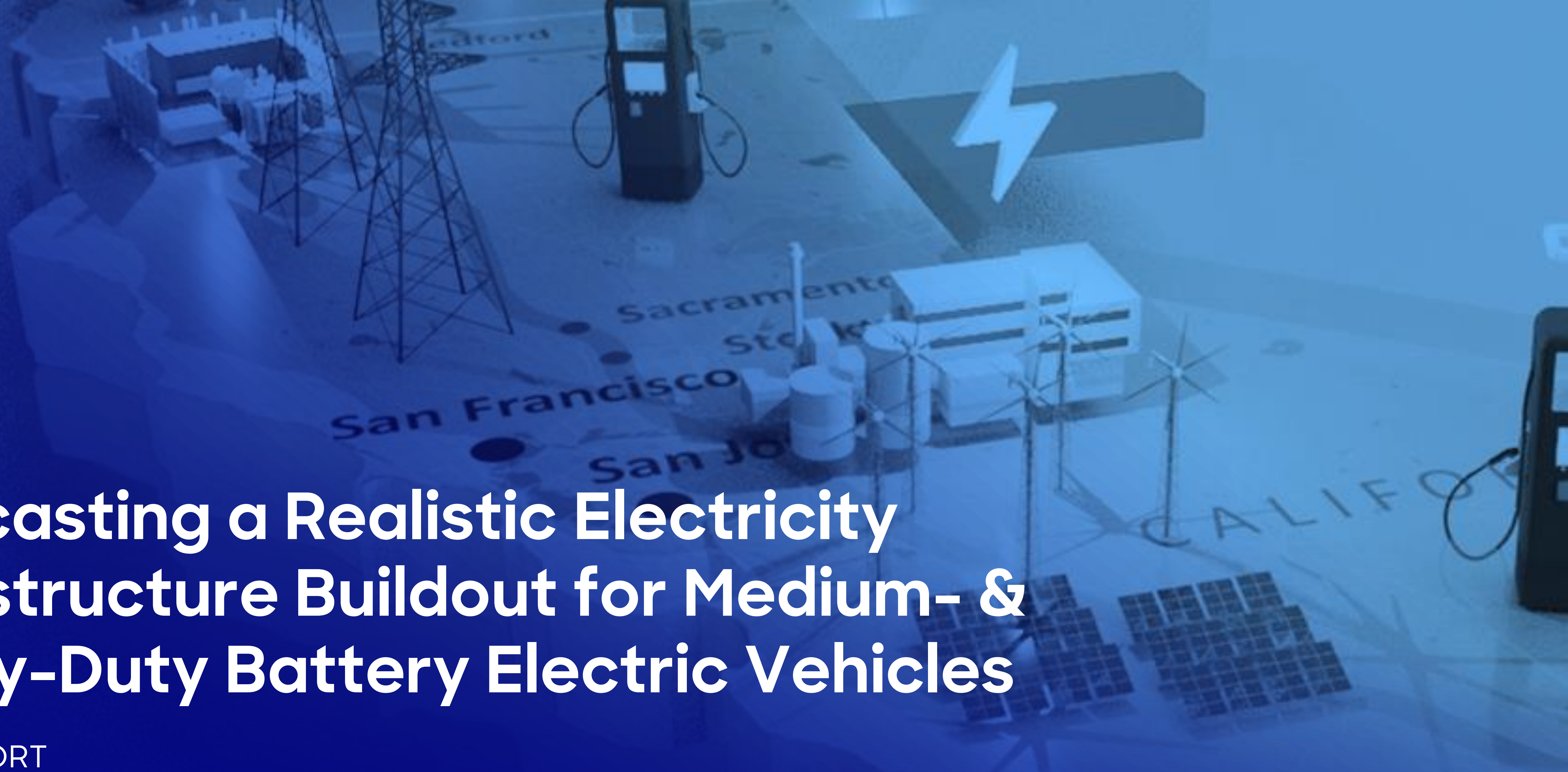


EXHIBIT B



Forecasting a Realistic Electricity Infrastructure Buildout for Medium- & Heavy-Duty Battery Electric Vehicles

FINAL REPORT

March 18, 2024

Roland
Berger

Contents

A. Overview of methodology

Objective of this study is to estimate the investment need for the buildout of the infrastructure required to support full electrification of the U.S. MDHD fleet

Objectives of this study

I

Determine the **total investment need** for the buildout of

- **electricity distribution** and **vehicle charging** infrastructure
- **electricity generation** and **transmission** infrastructure

to support **100% battery electric vehicle (BEV) penetration** in the **U.S. MD and HD CV fleet** and **compare to historic investment rates** (where available).

II

Highlight **current challenges and constraints** in terms of **funding** of the infrastructure buildout, **permitting**, **charging service provider availability** as well as **practical challenges** of fleets.

We simulated charging networks for MDHD vehicles and analyzed implications for the electricity generation, transmission and distribution infrastructure

1 Charging network simulation

LOCAL CHARGING NETWORK

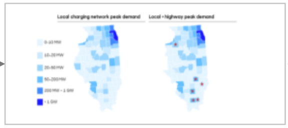
Geographic analysis

Analyze regional MDHD distribution (metro, sub-urban and rural areas)

Charging strategy

Allocate MDHD populations to on-site or on-route charging

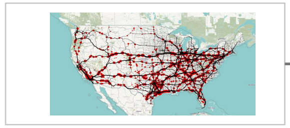
Local charging network



Determine regional distribution of chargers and peak load

HIGHWAY CHARGING NETWORK

Charging location network

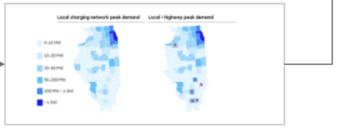


Map MDHD traffic flow and simulate highway charging network

Highway charger configuration

Determine number and power capacity of charge points for each location

Highway charging network

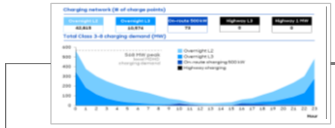


Determine regional distribution of highway chargers and peak load

2 Infrastructure needs assessment

ELECTRIC LOAD IMPACT

Charging behavior and load impact analysis



Aggregate load profiles and overlay with available capacity by geography

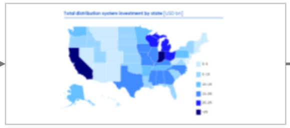
SITE INFRASTRUCTURE

Charging & "make ready" investments

Estimate on-site infra cost based on size and number of chargers

DISTRIBUTION INFRA

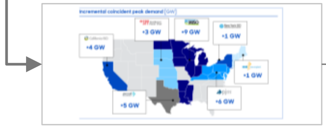
Incremental distribution grid investment



Estimate local grid capacity upgrade needs and utility investment needs

POWER SYSTEM INFRA

Incremental generation & transmission investment



Estimate investment in power system assets based on incr. capacity need

INVESTMENT NEEDS

Investment analysis

Consolidate into total overall investment need

3 General challenges and constraints

Collect operational challenges for fleet operators

Identify other challenges and constraints to the infrastructure buildout

Note: MDHD includes Over-the -Road Bus (OTRB)

Two fundamental charging location types exist: on-site and on-route local charging and on-route highway charging for long-haul vehicles

Types of charging locations and strategies

Location	**Local charging**			**Highway charging**
Strategy	**On-site charging**		**On-route charging**	
Description	**Private chargers** installed at fleet's owned depot location	**Shared charging hubs** with dedicated availability for fleet customers	**Fully public-access** chargers for on-route or destination use	**Fully public-access** chargers along the highway network
Typical fleet characteristics	Large national fleets with **sufficient depot infrastructure**	Small to medium sized fleets with **insufficient depot characteristics**	Used by **various** fleet types (esp. for high-mileage use cases)	Used by **long-haul** vehicles (trucks and OTRBs)
Charger configurations1)	**Level 2** **Level 3** **DCFC** (limited cases)	**Level 2** **Level 3** **DCFC** (limited cases)	**DCFC**	**DCFC**

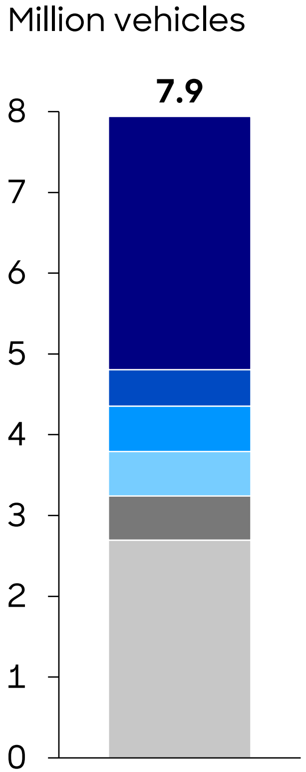
1) Level 2 charging refers to AC chargers less than 20 kW. Level 3 refers to DC chargers 50-150 kW. DCFC refers to DC fast chargers 350 kW and above.

Source: Interviews with market participants; Roland Berger Analysis

Within the MDHD population, we categorized four broader use case segments that can be mapped to the different charging location types

Use case segments

Vehicle count: →



	Medium Duty (Class 3-6)		Heavy Duty (Class 7-8)	
Use case segment	① **Local (low mileage)**	② **Local (high mileage)**	③ **Local**	④ **Long-haul**
Description	MD vehicles (e.g., P&D, utility service, school buses, walk in vans) where daily driving distance **does not exceed usable range of BEV**	MD vehicles (e.g., P&D, utility service, school buses, walk in vans) where daily driving distance **exceeds usable range of BEV**	**All other Class 7-8** vehicles (e.g., drayage, distribution)	**Over-the-road** vehicles primarily running longer inter-regional routes, incl. trucks and OTRB
Charging locations	**On-site** at depot locations	**On-site** at depot locations, in addition to **on-route** charging at public locations	**On-site** at depot locations, in addition to **on-route** charging at public locations	Both top-up and overnight charging at **highway truck stop** locations

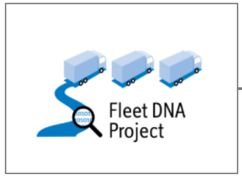
Note: Simulations are based on today's fleet size, except for long-haul trucks. The incremental weight of batteries results in a payload penalty. Trucks that weigh out today would exceed the maximum GVW limit and additional truck capacity is needed to carry the same amount of freight. For each diesel long-haul truck today, ~1.1 battery electric trucks will be needed.

Source: US Census Bureau; Roland Berger Analysis

For the local charging network, we analyzed where, when, and how much vehicles will charge, to determine the charging network and load profile

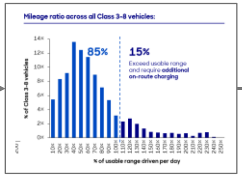
Methodology for local charging network and load profile analysis

Fleet telematics data[1)]



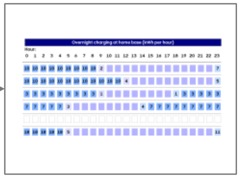
How are Class 3-8 vehicles (excl. long-haul) operated throughout the day?

Mileage distribution and duty cycle

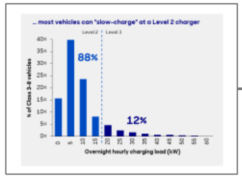


How much demand can be served by overnight vs on-route charging?

Overnight charging demand

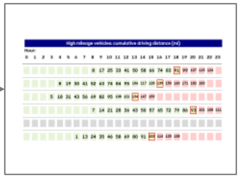


How much charging will occur at base?

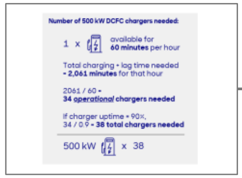


What charging infrastructure will fleets need to install?

On-route charging demand



How much charging will occur on-route?



Number of 500 kW DCFC chargers needed:

1 x available for **60 minutes** per hour

Total charging + lag time needed **= 2,061 minutes** for that hour

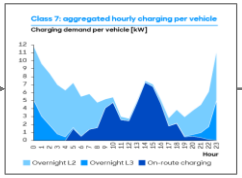
2061 / 60 =
34 operational chargers needed

If charger uptime = 90%,
34 / 0.9 = **38 total chargers needed**

500 kW x 38

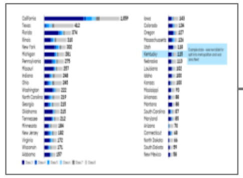
What charging infrastructure will public stations need to install?

Overall charging demand



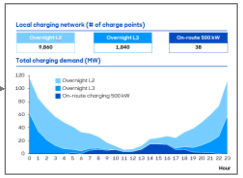
Aggregated average load curve per vehicle class

Vehicle populations



Regional vehicle distribution by weight class

Local network simulation



Charger installations and load curve **at the county level**

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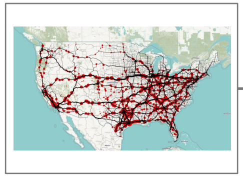
1) Data from NREL Fleet DNA Project

For long-haul vehicles we modeled a highway charging network that provides top-up charging capabilities and overnight charging

Methodology for highway charging network and load profile analysis

Highway truck stop locations



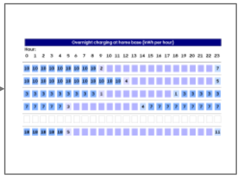
Where are long-haul vehicles refueling and parking today?

Long-haul truck traffic

How many long-haul vehicles are on the road at each location?

How many will recharge at each location?

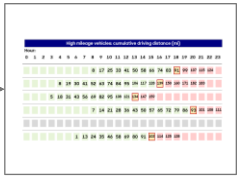
Top-up (MW) charging demand



How much top-up charging will occur on-route?

What charging infrastructure would need to be in place at each station?

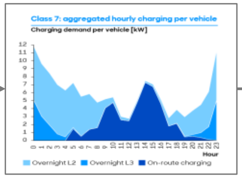
Overnight charging demand



How much overnight charging will occur on-route?

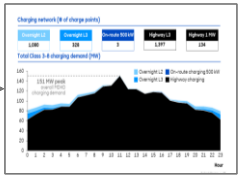
What charging infrastructure would need to be in place at each station?

Overall charging demand



Aggregated average load curve

Local network simulation



Charger installations and load curve **at the county level**

Our analysis focuses on characterizing the investment needs and challenges across both charging infrastructure and energy infrastructure

Investment landscape analyzed in this study

		Charging infrastructure			Energy infrastructure	
	Not in scope		"Make ready" infrastructure			
	Vehicle	Charger	Site	Electric service	Distribution grid	Generation/ transmission
Investment need	BEV purchase	Charger cost & installation	Civil & electrical	Utility service upgrade	Increased grid capacity	New power system assets
Capital outlay	Fleets	Fleets Developers	Fleets Developers	Fleets Developers Utilities	Utilities	Utilities, IPP's and developers
Subsidies or public funding (including utility rate base)	• Federal EV tax credit • State incentives	• Federal EVSE tax credit • State rebate programs	• N/A	• Utility-side make ready support in some states	• Federal funding available in some cases	• Federal funding available in some cases

We looked at two alternative scenarios: Electrification based on currently available technology and electrification based on improved technology

Technology scenarios

	Current technology	Improved technology
BEV adoption	**Full electrification** of Class 3-8 vehicles	**Full electrification** of Class 3-8 vehicles
Scenario definition	Assuming performance characteristics of **today's commercially available** vehicles and charger products	Assuming improved capabilities based on **reasonably expected performance improvement** in the medium-term
BEV range	Based on **today's commercially available** Class 3-8 BEV models **Max. Class 8 range: 180 mi**[1)]	**Increased range for Class 6-8** vehicles due to improved battery density **Max. Class 8 range: 250 mi**
Maximum fast-charging capacity	**350 kW**	**500 kW** (local) **1 MW** (highway)

1) Currently no electric long-haul truck in series production. Range estimate is based on the Daimler eActros 600 (European model, also expected to become available in the US). Assumes 80%-20% SOC

Backup

Based on currently available Class 3-8 models, we derived assumptions for battery size, "spec" range, and "usable" range and projected future performance

Vehicle assumptions by class

			Current technology			Improved technology		
	Example vehicles	Mileage efficiency [kWh/mi]	Battery capacity [kWh]	OEM spec range [mi]	Usable range [mi]1)	Battery capacity [kWh]	OEM spec range [mi]	Usable range [mi]1)
Class 3	Rivian, Ford eTransit, MB eSprinter	0.7	100	150	**90**	100	150	**90**
Class 4	Workhorse W4CC	0.7	100	150	**90**	100	150	**90**
Class 5	Freightliner Mt50e, Workhorse W56	1.5	100	150	**90**	100	150	**90**
Class 6	Kenworth, Navistar eMV, Freightliner eM2	1.3	218	163	**98**	305 2)	228	**137**
Class 7	Kenworth, Navistar eMV, Freightliner eM2	1.3	218	163	**98**	305 2)	228	**137**
Class 8	Freightliner eCascadia, Volvo VNR	2.0	440	220	**132**	616 2)	308	**185**
Long-haul	No electric long-haul truck in series production today. Range estimate is based on the Daimler eActros 600 3)	2.0	600	300	**180**	850 2)	420	**250**

1) "Usable range" assumes the battery never falls below 20% SOC, and is never charged above 80% SOC
2) Assumed improvement in gravimetric density: 40%; OEMs use improvement to increase range while keeping battery weight constant
3) European model, also expected to become available in the US; specs for currently available OTRBs (e.g. Van Hool CX45E) comparable to RB assumptions

Source: OEM websites, Roland Berger analysis

B. Results and key takeaways

B.1 Current Technology

We analyzed the infrastructure needs and challenges to the electrification of medium- and heavy-duty CVs in the current technology scenario

Technology scenarios – Focus of this section

	Current technology	Improved technology
BEV adoption	**Full electrification** of Class 3-8 vehicles	**Full electrification** of Class 3-8 vehicles
Scenario definition	Assuming performance characteristics of **today's commercially available** vehicles and charger products	Assuming improved capabilities based on **reasonably expected performance improvement** in the medium-term
BEV range	Based on **today's commercially available** Class 3-8 BEV models **Max. Class 8 range: 180 mi1)**	**Increased range for Class 6-8** vehicles due to improved battery density **Max. Class 8 range: 250 mi**
Maximum fast-charging capacity	**350 kW**	**500 kW** (local) **1 MW** (highway)
	Focus of this section	

---

1) Currently no electric long-haul truck in series production. Range estimate is based on the Daimler eActros 600 (European model, also expected to become available in the US). Assumes 80%-20% SOC

With the current technology landscape, only low mileage medium-duty vehicles are feasible to electrify; High mileage & heavy duty use cases face major hurdles

Charging infrastructure challenges – Current technology scenario

	Vehicle cost/TCO not in scope of analysis	Charging infrastructure			
Use case segment	**Vehicle**	**Charger**	**Site**	**Electric service**	**Key findings**
1 **Medium duty – local (low mileage)**	Vehicle cost still high, but getting more cost competitive for some use cases	On-site Level 2 chargers sufficient and available at low cost	Upgrade cost is highly site-specific and can be substantial	Minor service upgrades for smaller fleets More extensive service upgrades for larger fleets	Smaller, low mileage fleets with least challenges, but still require significant upfront investment
2 **Medium duty – local (high mileage)**	Vehicle cost still high, but getting more cost competitive for some use cases	Only feasible with sufficiently dense on-route charging network	Upgrade cost is highly site-specific and can be substantial	Minor service upgrades for smaller fleets More extensive service upgrades for larger fleets	High mileage medium duty vehicles cannot electrify before a substantial buildout of on-route charging occurs
3 **Heavy duty – local**	⚡ Prohibitively high vehicle cost (>2X of diesel) negatively impact TCO	High upfront cost for Level 3 and DCFC units	Highly site-specific costs	Expensive utility service upgrades	Heavy-duty local fleets face high upfront costs for chargers and utility service upgrades
4 **Heavy duty – long haul**	⚡ Prohibitively high vehicle cost (>2X of diesel) negatively impact TCO	⚡ Time penalty from on-route charging negatively impact TCO	Parking/space constraints at on-highway charging locations	Long lead time for inter-connection	Long-haul vehicles require increased range AND very high capacity chargers to reduce charging times

⚡ xxx = Critical challenge / major adoption hurdle

xxx = Major challenge

xxx = Minor/no challenge

Low mileage medium-duty vehicles will not need on-route charging, and can use Level 2 chargers on-site, minimizing charger and make-ready investments

Illustrative charging and utility service need for MD local fleet (low mileage)

I Illustrative duty cycle for Class 6 delivery fleet

Hour:	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
	🟦	🟦	🟦	🟦	🟦	🟦	🟦	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	🟦	🟦	🟦	🟦	🟦	🟦	🟦
	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	🟦	🟦	🟦	🟦	🟦
	🟦	🟦	🟦	🟦	🟦	🟦	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	🟦	🟦	🟦	🟦	🟦	🟦

Available charging time at home base typically >12 hours

II Illustrative on-site charging need

x 30
fleet size

131 kWh
effective full charge

13
avg. hours overnight

20 kW L2 x 30
on-site chargers needed

→

600 kW
incremental service need

III Indicative cost of utility service upgrades

Minor utility service upgrades can cost in the range of

USD 7,500 per L2 charger

for typical fleet locations

Cost of utility service upgrade (paid by fleet)

USD 225K total

USD ~7,500 per vehicle

🟦 at home base ⬜ on-duty

However, for depot locations with a larger number of vehicles, a more extensive service upgrade may be needed …

- This same example fleet, if it consisted of 150 vehicles instead of 30, would require a **3 MW service level**
- For individual sites requiring significant power capacity (~ 1 MW and above), **utilities may need to upgrade more upstream infrastructure** (e.g. feeder segments, larger transformers), which can translate into much larger investment need on a per vehicle basis
- These costs are highly variable, depending on existing infrastructure

Source: NREL; Roland Berger analysis

① **Medium-duty local (low-mileage)**

However, regardless of charger capacity, there are several sources of hidden or unforeseen costs that can greatly increase upfront investment for fleets

Hidden cost of depot electrification

Vehicle

Relatively transparent, and not site-specific

Charger

Relatively transparent, and not site-specific

Site

The specific nature of **civil engineering / construction work needed** is highly site-specific (e.g., need for conduits, clearances, etc.)

Electrical

The scale and cost of **wiring** and other electrical components **can vary by +50%** even across comparable sites

Utility

The cost of a **service upgrade** can vary greatly based on state policy, existing grid infrastructure, and scale of load increase required

Operational

Need for **backup solutions** in case vehicles cannot be (sufficiently) charged before they need to be redeployed

Source: Interviews with market participants

2 Medium-duty local (high mileage)

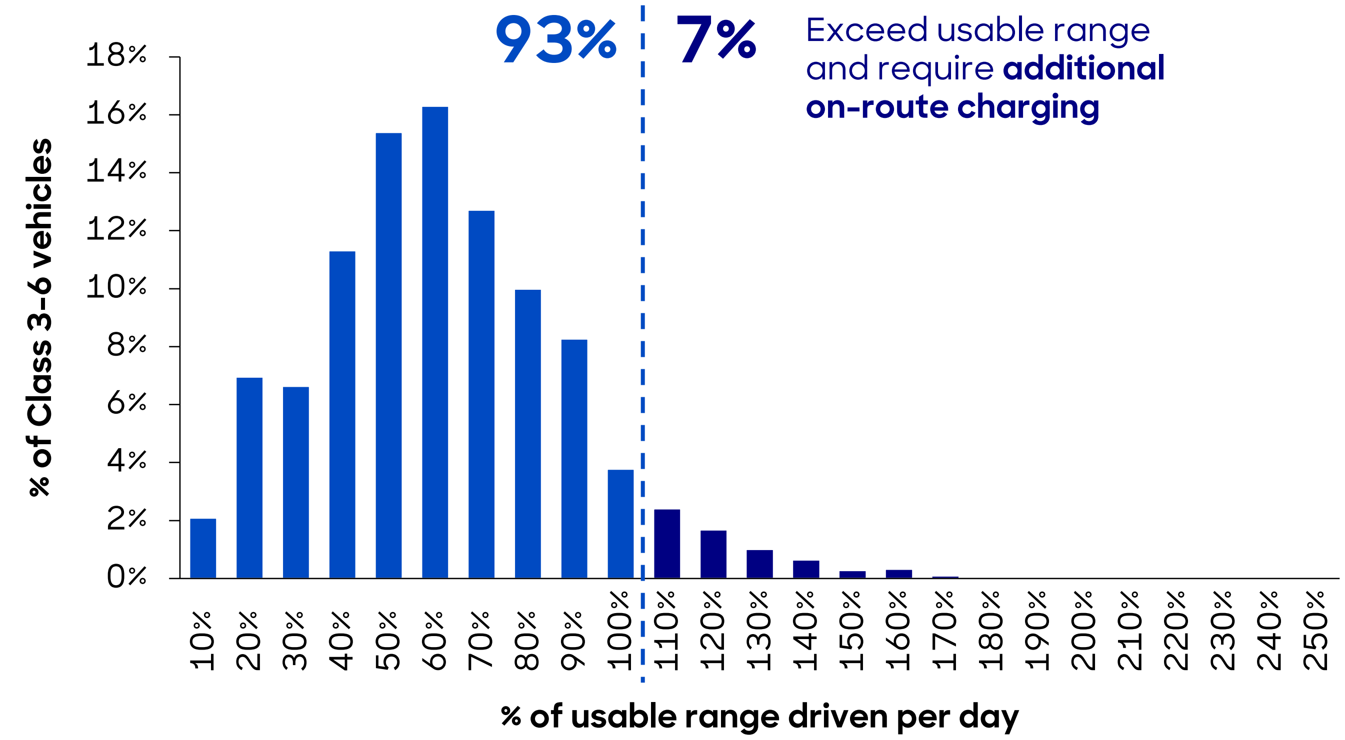
For local medium-duty fleets, a small share of vehicles are "high mileage" use cases – these vehicles cannot electrify without an on-route charging network

Daily mileage requirement vs. range for MD local fleet (high mileage)

Results across Class 3-6
[% requiring on-route charging]

Class 3	**100 kWh** battery	**90 mi** usable range	**4%** need on-route charging
Class 4	**100 kWh** battery	**90 mi** usable range	**9%** need on-route charging
Class 5	**218 kWh** battery	**90 mi** usable range	**3%** need on-route charging
Class 6	**218 kWh** battery	**98 mi** usable range	**8%** need on-route charging

Mileage ratio distribution for local Class 3-6 vehicles:



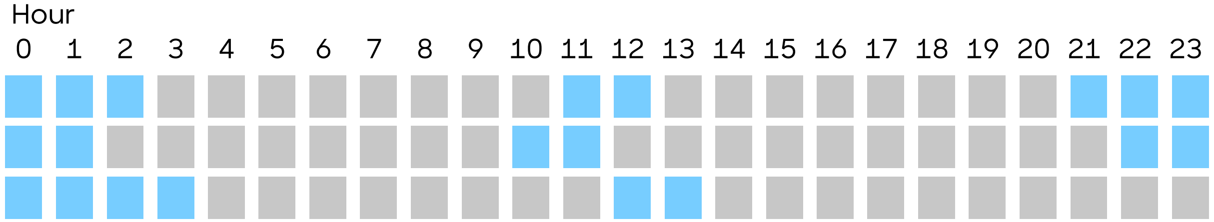
Exceed usable range and require **additional on-route charging**

Source: NREL; Roland Berger analysis

For many local HD use cases, fleets would need high capacity L3 or DCFC chargers on-site, but just the cost of utility service upgrades can be prohibitive

Illustrative charging and utility service need for HD local fleet

Ⅰ Illustrative duty cycle for Class 8 high-mileage local fleet



Hour

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
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Available charging time at home base 2-6 hours

Ⅱ Illustrative on-site charging need

x 30
fleet size

264 kWh
effective full charge

1.5
max vehicles per charger

350 kW x 20
on-site chargers needed

→

7 MW
incremental service need

Ⅲ Indicative cost of utility service upgrades

Large utility service upgrades can cost anywhere from

USD 500K – 2.5M per MW

of additional electric load

Cost of utility service upgrade (paid by fleet)

USD 4-18M total

USD ~150-600 K per vehicle

🟦 at home base ⬜ on-duty

For HD local fleets, the potential paths to electrification all involve significant cost and risk:

- If high-capacity charging is prohibitive because of utility cost, there are no good alternatives for fleets:
  - Charging vehicles at lower rates will require additional vehicles to ensure continued operation
  - Rely heavily on public charging (at higher electricity rates and additional operational risk)
- In all cases, the incremental cost needs to get passed down to customers, or negatively hits the profitability of fleets

To remove this roadblock, regulators would need to approve use of ratepayer funding for service upgrades and other "make ready" investments, removing the burden from individual fleets

Source: NREL; fleet interviews, Roland Berger analysis

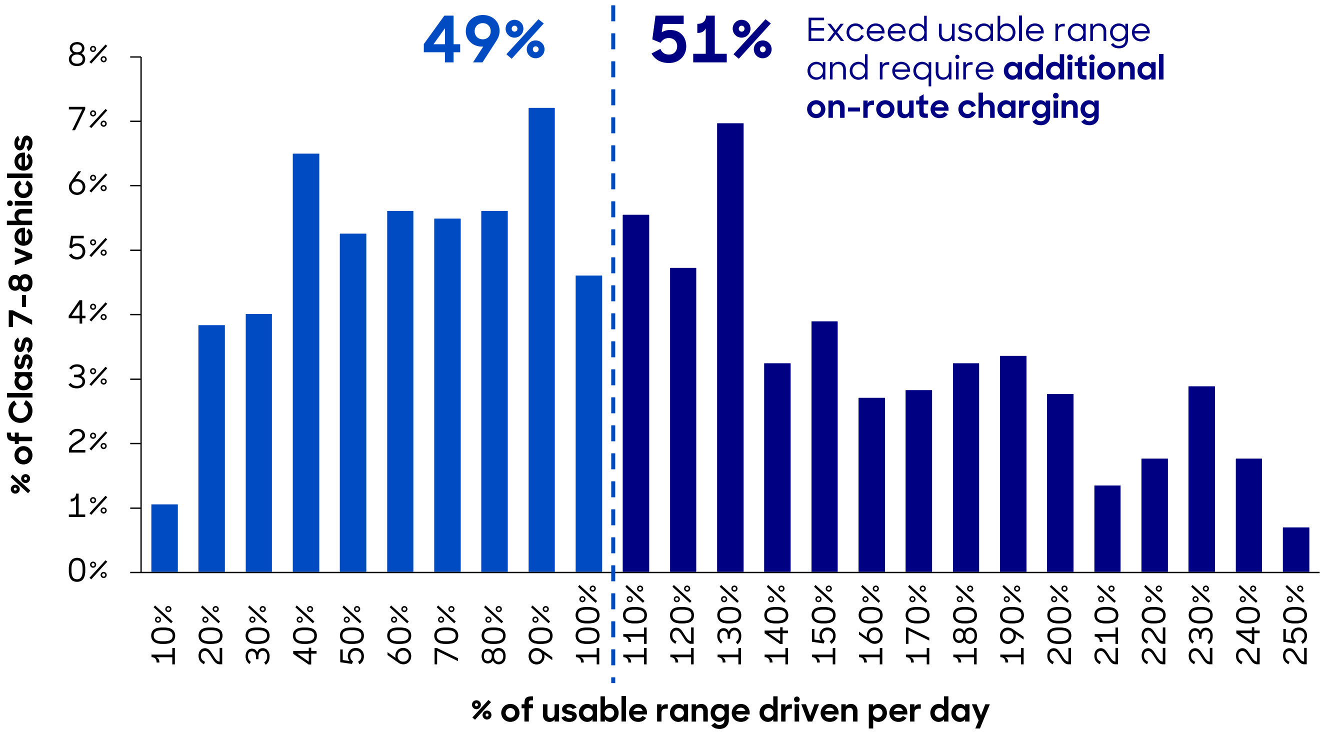
At today's vehicle range, half of the heavy-duty local fleet would exceed the usable range of BEVs, and require access to on-route fast-charging

Daily mileage requirement vs. range for HD local fleet

Results across Class 7-8
[% requiring on-route charging]

Class 7	**218 kWh** battery	**98 mi** usable range	**48%** need on-route charging
Class 8	**440 kWh** battery	**132 mi** usable range	**59%** need on-route charging

Mileage ratio distribution for local Class 7-8 vehicles:

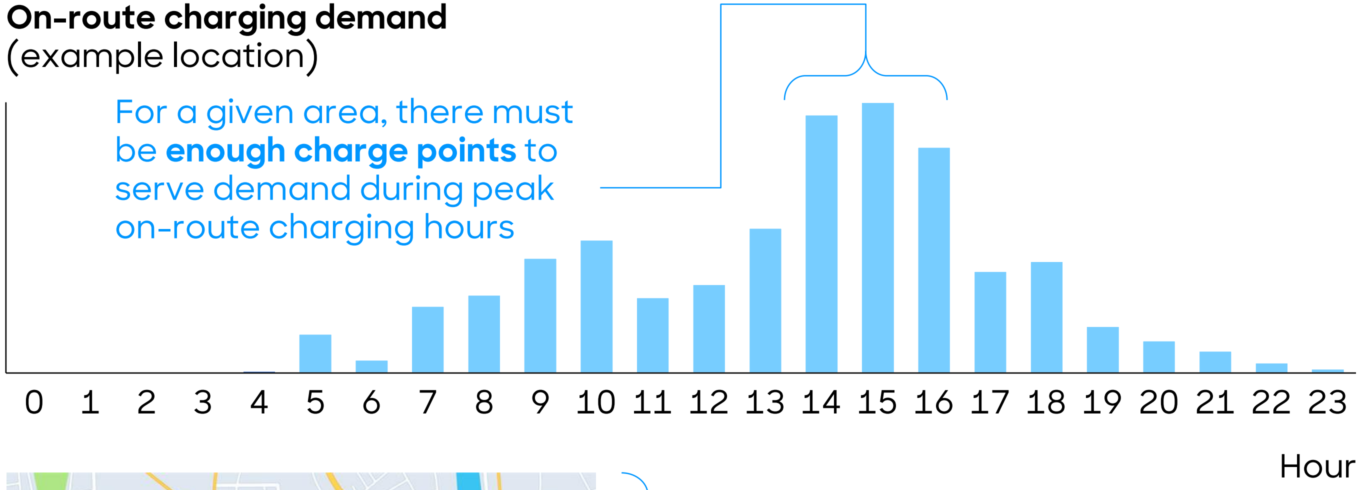


Source: NREL; US Census Bureau, Roland Berger analysis

A reliable local on-route charging network must exist before high mileage vehicles can electrify, but utilization risk poses a major challenge to investment

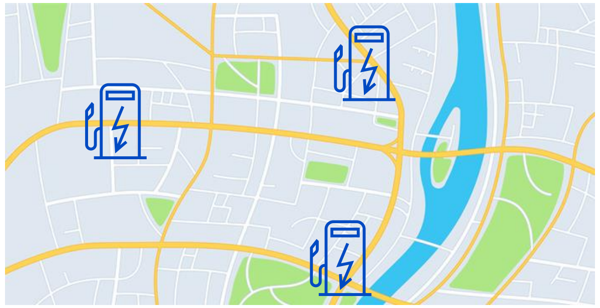
Challenges and investment hurdles for on-route charging

A sufficiently dense network needs to exist to avoid queueing …



On-route charging demand
(example location)

For a given area, there must be **enough charge points** to serve demand during peak on-route charging hours



Further, those charge points must be geographically dispersed such that they **align with fleet traffic volumes and existing routes**

… but the investment case to develop such a network is very challenging …

- **Timing & adoption:** given that significant adoption of high-mileage vehicles will not occur before a sufficient network exists, there is a **"first mover disadvantage"**
- **Utilization & economics:** at full density, individual locations may see **low utilization rates**, which would require **large price premiums** at the plug (which fleets would have to absorb)

- **Planning and coordination needed to ensure efficient sizing and placement of chargers**
- **Economic support may be required to overcome utilization risk**
- **Concern over utility ownership of public charging infrastructure remains a key regulatory uncertainty**

Source: Expert interviews, Roland Berger analysis

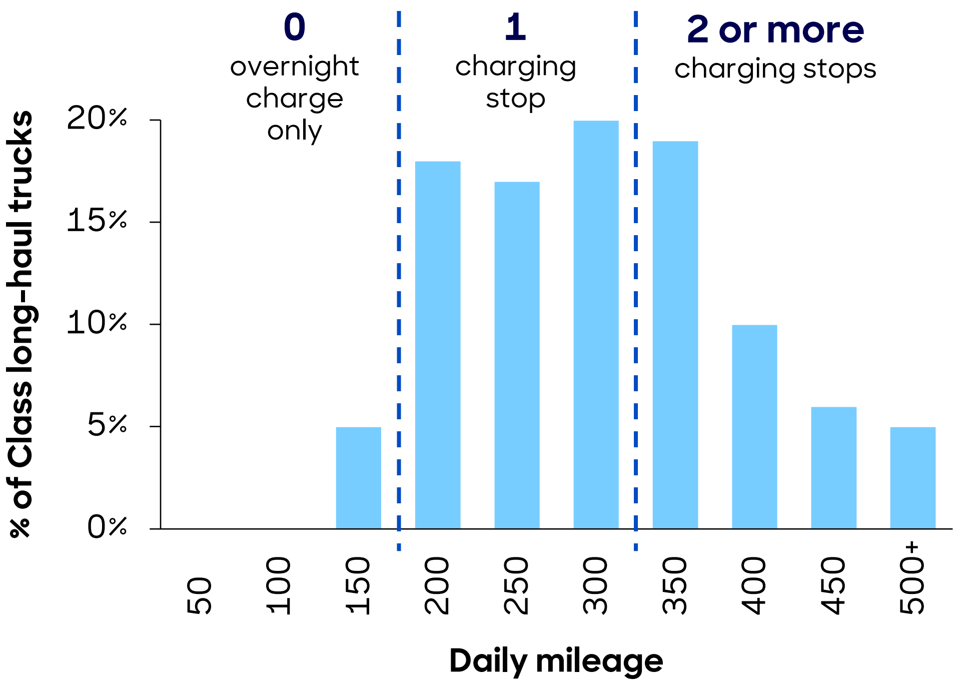
Long-haul vehicles, at current range and charging levels would incur a downtime penalty of 1-2 hours per day from top-up charging, negatively impacting TCO

Suitability of current technology[1] electric trucks for long-haul

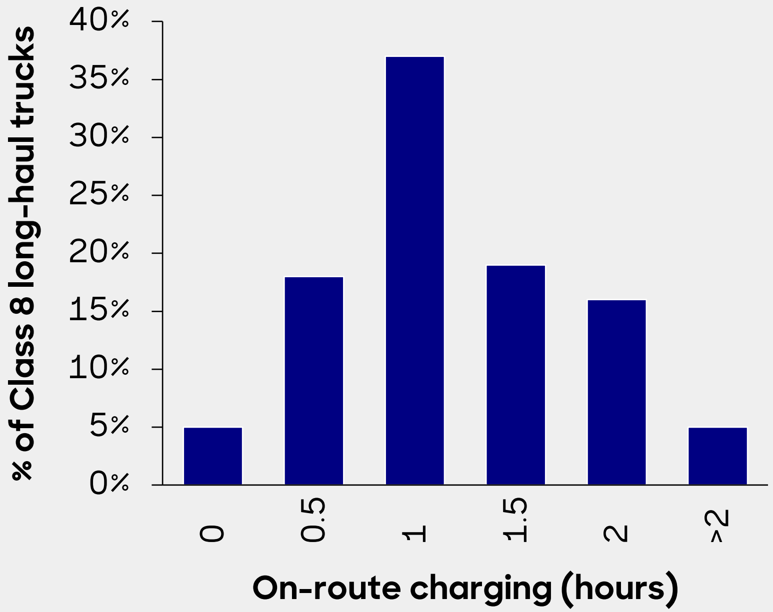
Range of long-haul electric vehicles in the near-term is still insufficient compared to typical daily mileage requirements…

180 mi

usable range[1] of Class 8 long haul BEV



…and with 350 kW chargers, drivers would need to spend long periods of time charging on-route:



Electrification of long-haul use case not feasible with current technology due to high uptime penalty from charging

---

1) Currently no electric long-haul truck in series production. Range estimate is based on the Daimler eActros 600 (European model, also expected to become available in the US). Assumes 80%-20% SOC

Source: 2021 VIUS (Vehicle In-Use Survey) - US Census; Roland Berger analysis

B.2 Improved technology

In the advanced technology scenario, vehicle range is expected to increase, esp. for long-haul vehicles and higher-capacity chargers are expected to be available

Technology scenarios – Focus of this section

	Current technology	Improved technology
BEV adoption	**Full electrification** of Class 3-8 vehicles	**Full electrification** of Class 3-8 vehicles
Scenario definition	Assuming performance characteristics of **today's commercially available** vehicles and charger products	Assuming improved capabilities based on **reasonably expected performance improvement** in the medium-term
BEV range	Based on **today's commercially available** Class 3-8 BEV models **Max. Class 8 range: 180 mi**1)	**Increased range for Class 6-8** vehicles due to improved battery density **Max. Class 8 range: 250 mi**
Maximum fast-charging capacity	**350 kW**	**500 kW** (local) **1 MW** (highway)

Focus of this section

---

1) Currently no electric long-haul truck in series production. Range estimate is based on the Daimler eActros 600 (European model, also expected to become available in the US). Assumes 80%-20% SOC

Even with improved vehicle and charger technology, fleets and charging location developers face many challenges related to charging infrastructure

Charging infrastructure challenges – Improved technology scenario

	Vehicle cost/TCO not in scope of analysis	Charging infrastructure			
Use case segment	**Vehicle**	**Charger**	**Site**	**Electric service**	**Key findings**
1 Medium duty – local (low mileage)	• Vehicles expected to meet performance requirements of all use cases in improved technology scenario • Vehicle prices are assumed to decline to enable positive TCO across use cases	On-site Level 2 chargers sufficient and available at low cost	Upgrade cost is highly site-specific and can be substantial	Minor service upgrades for smaller fleets More extensive service upgrades for larger fleets	Smaller, low mileage fleets with least challenges, but still require significant upfront investment
2 Medium duty – local (high mileage)		Only feasible with sufficiently dense on-route charging network	Upgrade cost is highly site-specific and can be substantial	Minor service upgrades for smaller fleets More extensive service upgrades for larger fleets	High mileage medium duty vehicles cannot electrify before a substantial buildout of on-route charging occurs
3 Heavy duty – local		High upfront cost for Level 3 and DCFC units	Highly site-specific costs	Expensive utility service upgrades	Heavy-duty local fleets face high upfront costs for chargers and utility service upgrades
4 Heavy duty – long haul		Only feasible with sufficiently dense highway charging network	Parking/space constraints at on-highway charging locations	Long lead time for transmission interconnection	Long-haul vehicles require increased range AND very high capacity chargers to reduce charging times

xxx = Major challenge   xxx = Minor/no challenge

About 6 m on-site charges and ~176 k on-route chargers will be needed to support full electrification of the US medium and heavy-duty vehicle fleet

Charging infrastructure needs [charger counts]

Vehicle cost/TCO not in scope of analysis

Charging infrastructure

Use case segment

1 **Medium duty – local (low mileage)**

2 **Medium duty – local (high mileage)**

3 **Heavy duty – local**

4 **Heavy duty – long haul**

Vehicle

- Vehicles expected to meet performance requirements of all use cases in improved technology scenario
- Vehicle prices are assumed to decline to enable positive TCO across use cases

Charger | Site | Electric service

Local charging networks — **6.42 M**

A
- L2 on-site — 4.84 M
- L3 on-site — 1.53 M

B
- 500 kW on-route — 46 k

Highway charging networks — **130 k**

C
- L3 on-route — 120 k
- 1 MW on-route — 12 k

Total on-site chargers

6.38 M

Total on-route chargers

~176 k

To deploy all of this infrastructure, fleets and charge point operators will need to invest USD 620 billion into chargers, site infrastructure, and utility service costs

Charging infrastructure investment needs

Use case segment

1. **Medium duty – local (low mileage)**
2. **Medium duty – local (high mileage)**
3. **Heavy duty – local**
4. **Heavy duty – long haul**

Vehicle cost/TCO not in scope of analysis

Vehicle

- Vehicles expected to meet performance requirements of all use cases in improved technology scenario
- Vehicle prices are assumed to decline to enable positive TCO across use cases

Charging infrastructure

Charger | **Site** | **Electric service**

Local charging networks **565 B**

A
- L2 on-site 163 B
- L3 on-site 333 B

B
- 500 kW on-route 69 B

Highway charging networks **57 B**

C
- L3 on-route 30 B
- 1 MW on-route 27 B

Total on-site charging investment needed

496 B

Total on-route charging investment needed

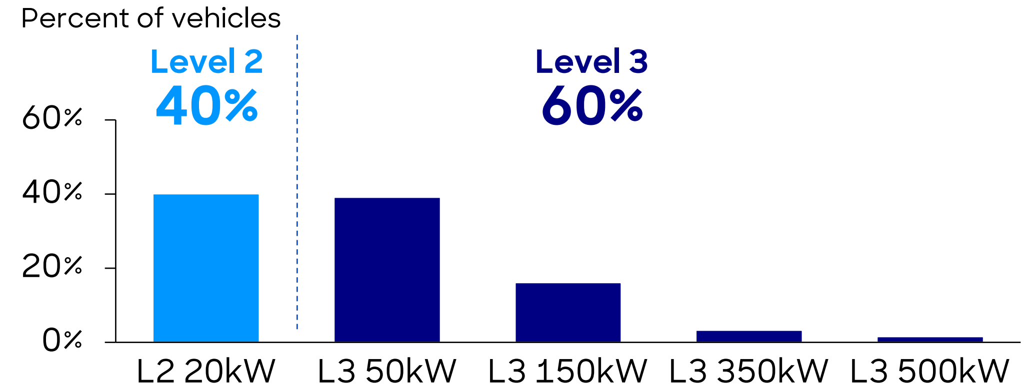
126 B

The total investment need for local on-site charging of USD 496 B is driven primarily by the heavy-duty segment requiring Level 3 charging

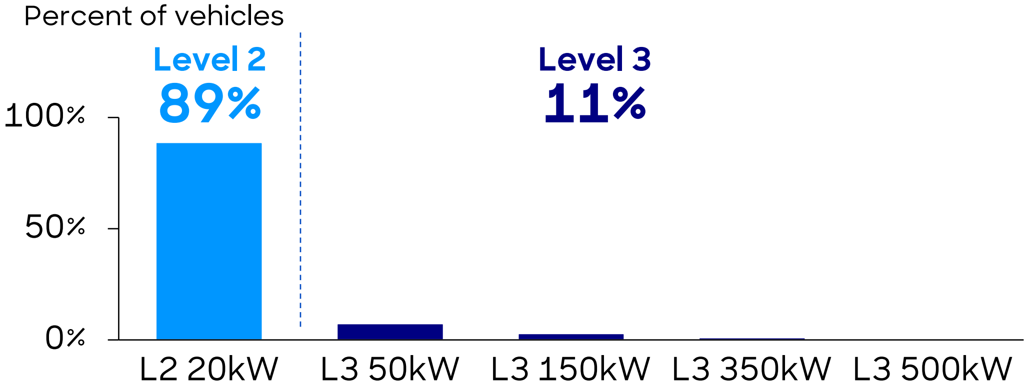
Investment need for local on-site charging network

Segment | **Required on-site charger technology**

Heavy duty - local



Medium duty - local



Total investment need local on-site charging network [USD]

	L2 on-site	L3 on-site
	163 B	333 B
HD	22 B	220 B
MD	141 B	113 B

Charging infrastructure investment per vehicle [USD]

Heavy duty - local

145 K

Medium duty - local

54 K

Heavy duty vehicles have more intensive charging requirements, and will require ~3X the infrastructure investment per vehicle compared to medium duty

Source: NREL; US Census Bureau, Roland Berger analysis

Even with improved technology, a significant share of the HD local fleet requires access to on-route fast-charging locations, driving investment need of USD 69 B

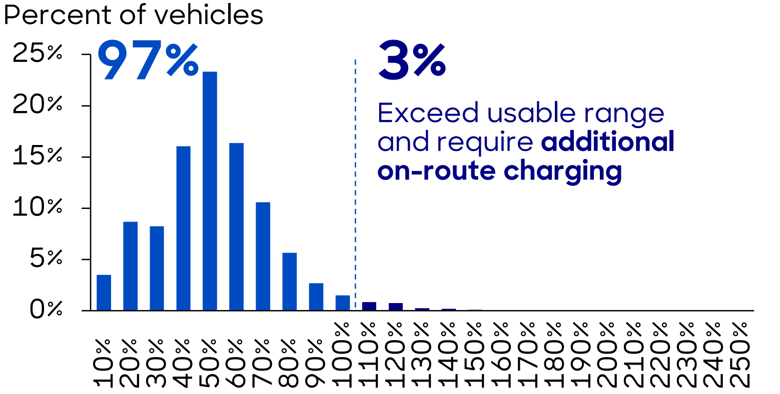
Investment need for local on-route charging network

Results across Class 3-8
[% requiring on-route charging]

Class 3	100 kWh battery	90 mi usable range	**4%**	need on-route charging
Class 4	100 kWh battery	90 mi usable range	**9%**	need on-route charging
Class 5	305 kWh battery	90 mi usable range	**3%**	need on-route charging
Class 6	305 kWh battery	137 mi usable range	**1%**	need on-route charging
Class 7	305 kWh battery	137 mi usable range	**28%**	need on-route charging
Class 8	616 kWh battery	185 mi usable range	**38%**	need on-route charging

Segment | **Mileage ratio distribution**

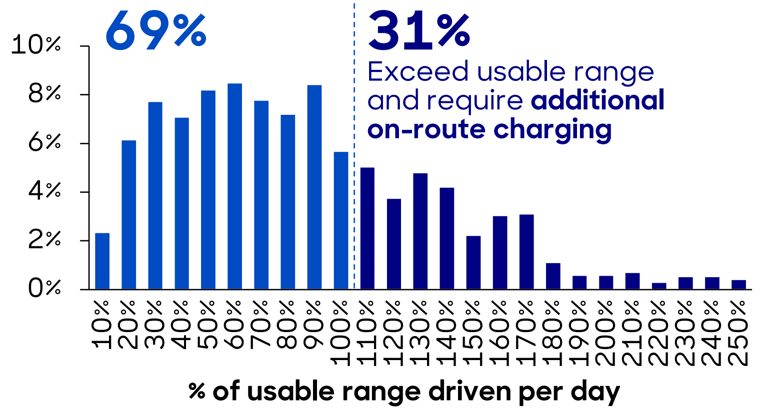
Medium duty - local



97%

3%
Exceed usable range and require **additional on-route charging**

Heavy duty - local



69%

31%
Exceed usable range and require **additional on-route charging**

Total investment need local on-route charging network [USD]

On-route 500 kW

69 B

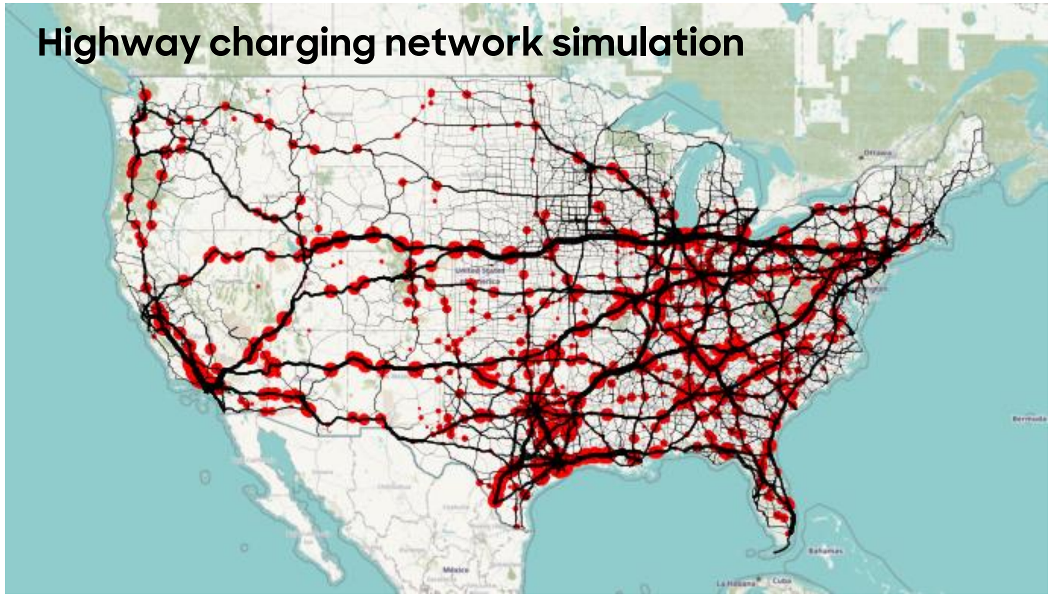
Heavy duty vehicles need larger physical footprint at the charging station - likely requiring dedicated charging locations

Source: NREL; US Census Bureau, Roland Berger analysis

To support full electrification of long-haul vehicles, USD 57 bn need to be invested in converting truck stops into a sufficiently dense charging network

Investment need for highway charging network

Highway charging locations have been simulated across rural and metro areas …



Land cost and space constraints may challenge development, esp. in metro areas

… and each one will need to deploy significant fast charging and overnight charging infrastructure in order to electrify:

Average number of charge points per location:

Rural	Fast chargers	20-25
	Overnight chargers	150-200
Metro	Fast chargers	30-45
	Overnight chargers	200-300

Total investment need highway charging network [USD]

L3 Overnight	On-route 1 MW
30 B	27 B

Total highway charging investment

57 B

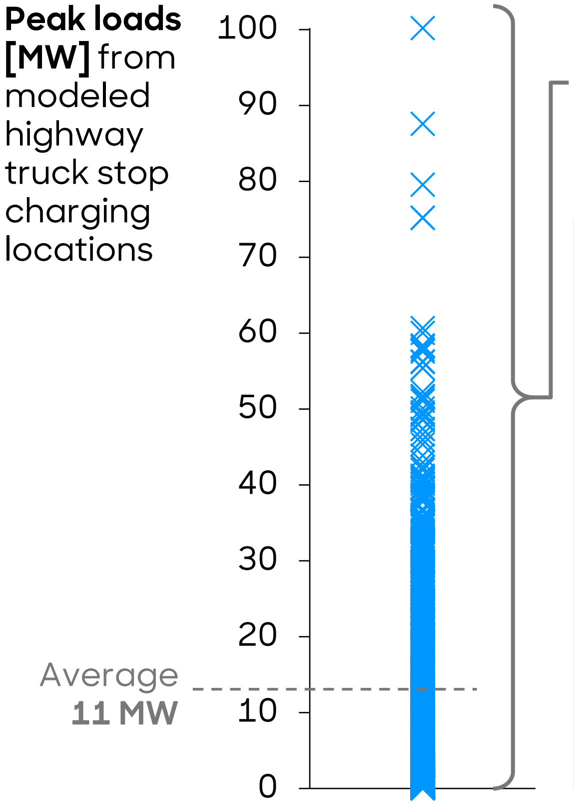
● ● ● Traffic volume of long-haul combination trucks at simulated charging locations (charging stations will also be utilized by OTRBs)

Source: NATSO; DOT Freight Analysis Framework; Roland Berger Analysis

Investment in highway charging will be challenged by very long lead times for transmission infrastructure development and regulatory/planning processes

Highway charging network deployment hurdles

Highway charging depends on transmission infrastructure:



To support full electrification of long-haul vehicles, **many truck stops** would each need as much **power supply** as a **large industrial plant**

Transmission development is a prolonged, multi-stakeholder process:

1. Local permitting & approval processes
2. System planning studies, cost allocation, and portfolio prioritization
3. Competitive solicitation and long construction lead times

While charger installation can be completed in a matter of months, **larger transmission interconnections and upgrades** can take anywhere from **3-8 years to approve and construct**

Additional challenges:

- **Land and parking space constraints:** Overall space requirements for tractor-trailers and OTRBs significantly higher compared to conventional fueling stations, given 2-3x number of ports
- **Technology obsolescence**: Earlier generation chargers (less than 1 MW) will eventually become obsolete once MW charging network is in place

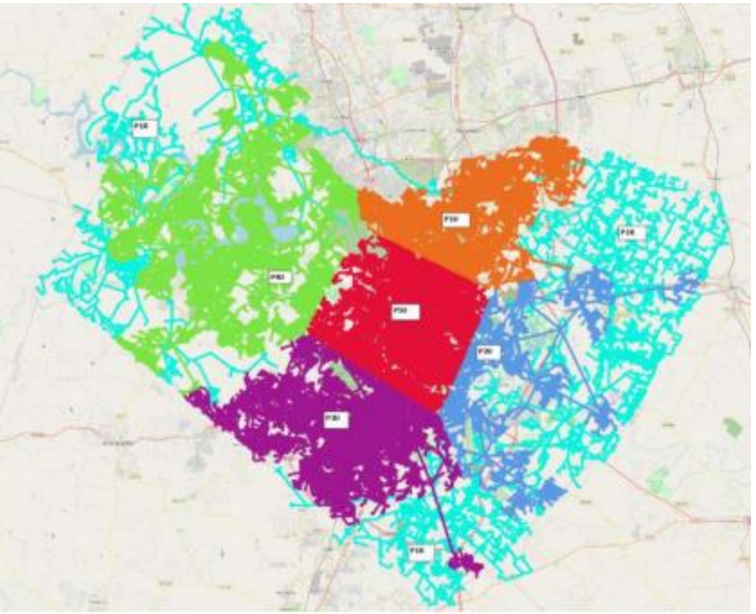
Source: NATSO; DOT Freight Analysis Framework; Roland Berger Analysis

We ran a detailed analysis of distribution grid impact and investment need for select geographies across CA, TX, and NC – covering rural and urban areas

Methodology for distribution grid impact analysis (1/2)

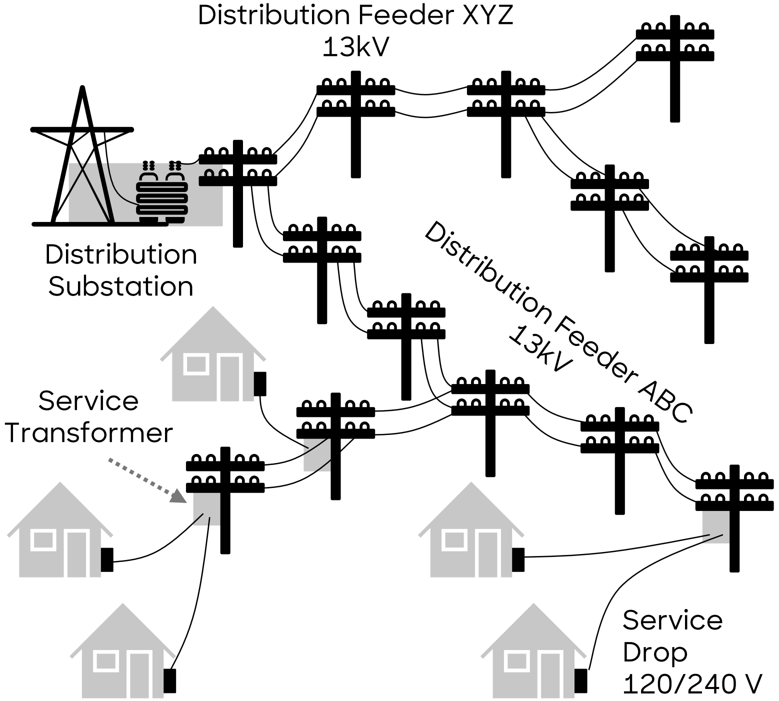
Selected geographies

Example: Austin, TX



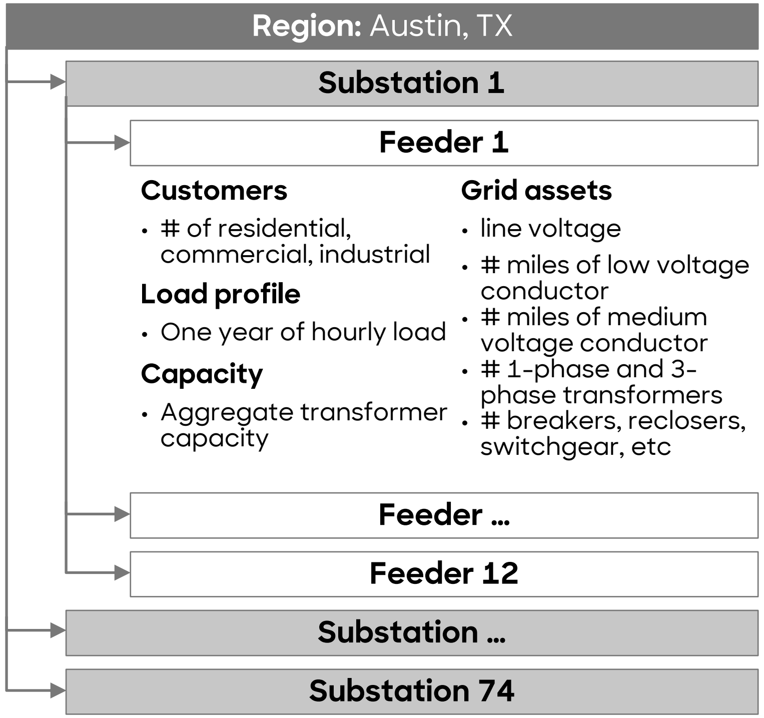
Grid infrastructure models are available for selected geographies from NREL Smart DS1)

Distribution system components



We analyzed the impact of MDHD's on every feeder and substation within each geography

Customer, load, and infrastructure data



Region: Austin, TX

Substation 1

Feeder 1

Customers
- # of residential, commercial, industrial

Load profile
- One year of hourly load

Capacity
- Aggregate transformer capacity

Grid assets
- line voltage
- # miles of low voltage conductor
- # miles of medium voltage conductor
- # 1-phase and 3-phase transformers
- # breakers, reclosers, switchgear, etc

Feeder …

Feeder 12

Substation …

Substation 74

Smart DS dataset includes customer counts, load profiles, and detailed infrastructure data

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1) Analysis was run on NREL Smart DS simulated distribution grid architecture and customer load datasets for Austin TX, Greensboro NC, and Northern California regions

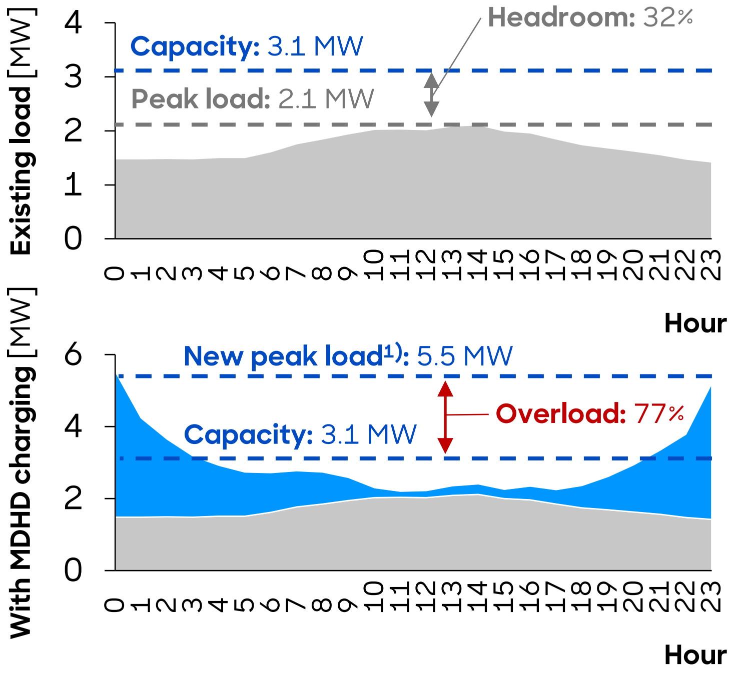
Source: NREL, Roland Berger analysis

We simulated the impact of MDHD charging on existing grid infrastructure, and estimated the "overnight cost" of increasing capacity of impacted grid assets

Methodology for distribution grid impact analysis (2/2)

Feeder-level load impact

Example of an impacted feeder:



We layered MDHD charging onto existing load for each feeder to determine impacted assets

Capacity expansion options

Feeder level:

① **Reconductoring**
Replace overloaded lines and equipment with higher voltage rating

If reconductoring is insufficient:

② **New build**
Add new circuits to distribute load

Substation level:

If reconductoring any downstream feeders:

③ **Transformer upgrade**
Add/replace to manage increased voltage

If total downstream feeder load exceeds substation capacity:

④ **Substation rebuild**

There is a limited solution set for utilities to expand capacity of impacted grid assets

Cost of upgrade or new build

Feeder architecture (non-exhaustive):

Low voltage conductor	Medium voltage conductor	3-phase trans-formers	Reclosers	...
24.4 miles	**14.1** miles	**48** units	**2** units	**...** ...

Equipment + installation costs:

Low voltage conductor	Medium voltage conductor	3-phase trans-formers	Reclosers	...
0.6 M USD/mi	**1.3 M** USD/mi	**81 K** USD/unit	**126 K** USD/unit	**...** ...

Cost of reconductoring (non-exhaustive):

0 USD	**18 M** USD	**4 M** USD	**250 K** USD	**...** ...

Based on the architecture of each feeder, we determined the cost of each upgrade

🟦 Local MDHD charging ▨ Existing load

1) County level results for MDHD charging load profile were distributed across each underlying feeder by analyzing the distribution of commercial and industrial customers

Source: NREL Smart DS, NREL Distribution Unit Cost Database, Roland Berger analysis

We analyzed the grid impacts and investment need for each of the counties within our grid dataset, to determine investment needed on a "per vehicle" basis

Distribution grid investment per vehicle

Example: distribution investment analysis [Lake County, CA]

For each region, we analyzed the impacts of MDHD charging on all of the grid assets located within each individual county…

	Loading[1) [%]	Recond-uctoring [USD]	Feeder new build [USD]	Transformer upgrade [USD]	Substation rebuild [USD]
Substation 1	78%			4 M	
Feeder 1	169%	11 M	0		
Feeder 2	426%	25 M	42 M		
Feeder 3	66%	0	0		
…	---	---	---	---	---
Substation 2	165%				13 M
…	---	---	---	---	---

…to determine the county-level distribution investment need:

Lake County, CA	**16.5 M** **Feeder investment** [USD]	**98 M** **Substation investment** [USD]	**115 M** **Total distribution investment** [USD]

For each county analyzed, we determined the total distribution investment need on a "per vehicle" basis:

	Total distribution investment [USD M]	Class 3-8 vehicles [count]	Distribution investment per vehicle [USD K]
Guilford County, NC	204	16,703	12
Travis County, TX	486	19,256	25
Solano County, CA	859	11,752	73
Lake County, CA	115	1,020	113
…	---	---	---

Investment need per vehicle varies significantly across geographies, but this variation is predictable by specific factors (see next page)

1) A grid asset is considered "overloaded" and in need of intervention if peak loading is at or above 95%

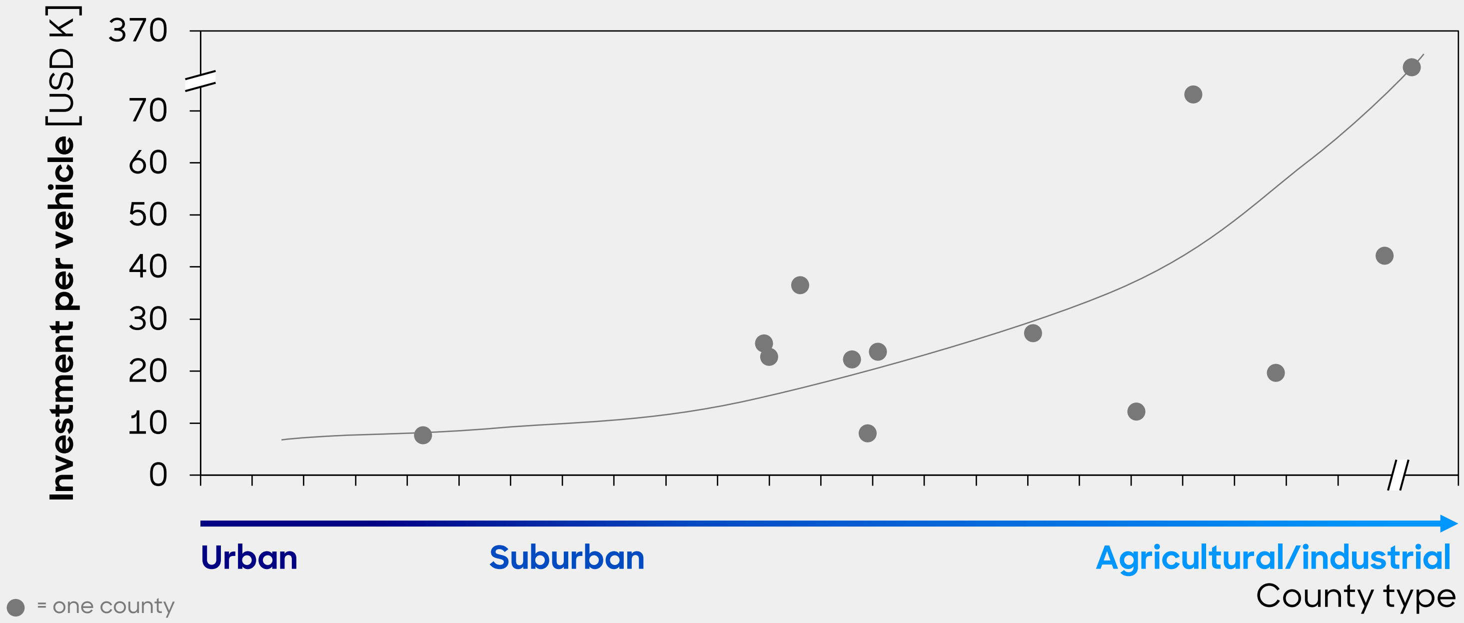
Source: NREL, US Census, Roland Berger analysis

Distribution grid investment

In more rural and industrial areas, utilities will need to spend more per vehicle – we quantified this relationship to extrapolate these results to other geographies

Key drivers of variation in distribution investment – rural vs urban

Distribution grid investment needs (per vehicle) increase farther away from denser urban areas:



Key drivers of variation:

- In more rural geographies, the average distance between customers is much greater than in dense urban areas, **requiring more miles of conductor when replacing or upgrading grid capacity** in these regions

We applied this correlation[1] to determine the "per vehicle" investment need for all other US counties

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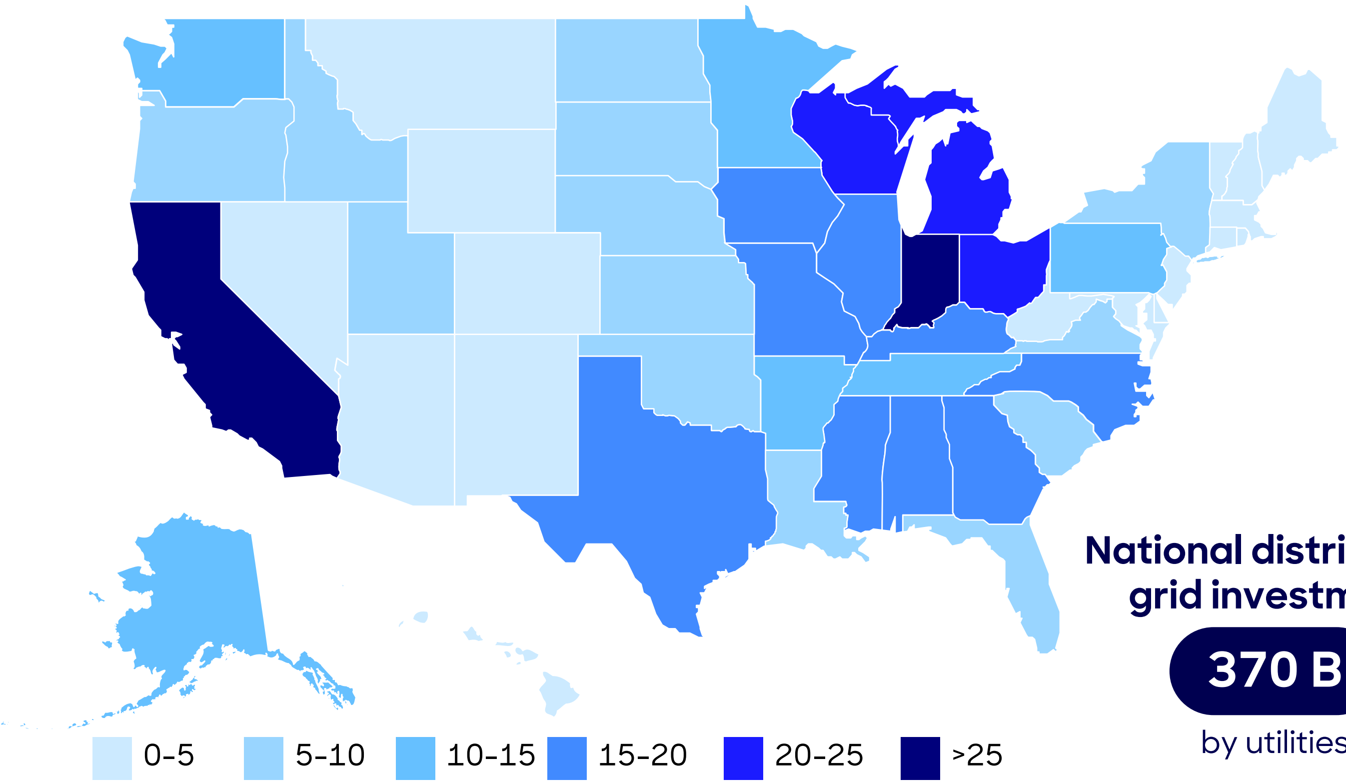
1) Predictor variable used for correlation is the % share of total county-level employment in agriculture, construction, and manufacturing sectors

Source: NREL Smart DS, US Census CBP, Roland Berger analysis

Nationally, utilities will need to invest around USD 370 billion[1] on distribution grid upgrades and new builds to serve local charging demand[2] from MDHD vehicles

Distribution system investment need - nationwide

Total distribution system investment by state [USD bn]



National distribution grid investment

370 B

by utilities

Challenges and constraints:

- **Utilities will need to build** infrastructure ahead of demand **ahead of MDHD adoption** to avoid bottlenecks and delays
- However, these investments require more **sophisticated grid planning** as well as **regulatory support** – both limited to date
- The overall **pace of utility investment** will still be **constrained** by the need to control rate increases and **maintain affordability**

Potential mitigating factors:

- **This analysis shows** the grid impacts and investment need given **"unmanaged" charging**
- If fleets were able to **shift or manage peak charging** load (e.g. with battery-integrated chargers), **utility investment could be significantly reduced**
- However, **appropriate incentives** and/or price signals would need to exist **to support fleet economics**

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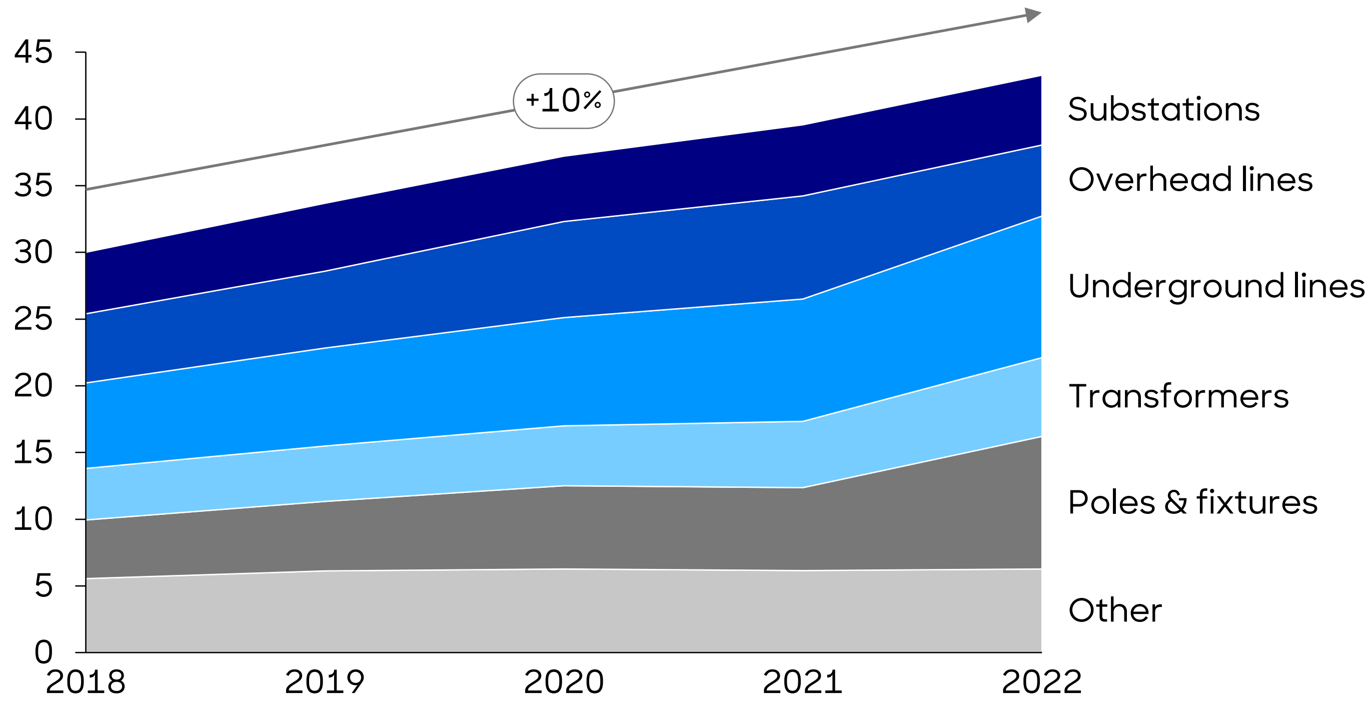
1) Based on "overnight" capital cost of grid infrastructure at current price levels – actual utility investment will be higher due to 1) price inflation of labor and equipment, and 2) Utility guaranteed rate of return
2) Distribution grids will serve on-site and on-route charging demand from local fleets – long-haul vehicles/ highway charging stations will be served by the transmission grid and bulk power system

Source: NREL, US Census, Roland Berger analysis

Just to support MDHD charging, utilities would need to spend nearly the equivalent of what was spent on the entire system during the past 15 years

Distribution investment – comparison to historical investment rates

Historical distribution system investment by US investor-owned utilities [USD bn]



Key takeaways:

- Cumulatively over the last 15 years, utilities invested roughly USD 450 B across the US **for all distribution investment needs**
- In comparison, the **estimated 370 B** just for upgrades and new construction **related to MDHD** charging represents **82% of what was spent** on all distribution grid investments **over the past 15 years**
- Moreover, distribution **spending is expected to continue increasing** across multiple priorities (e.g. DER integration, resiliency), of which **MDHD electrification is just one competing priority**
- **Proactive investments will likely be constrained by limits on rate increases**, potentially delaying charging infrastructure buildout

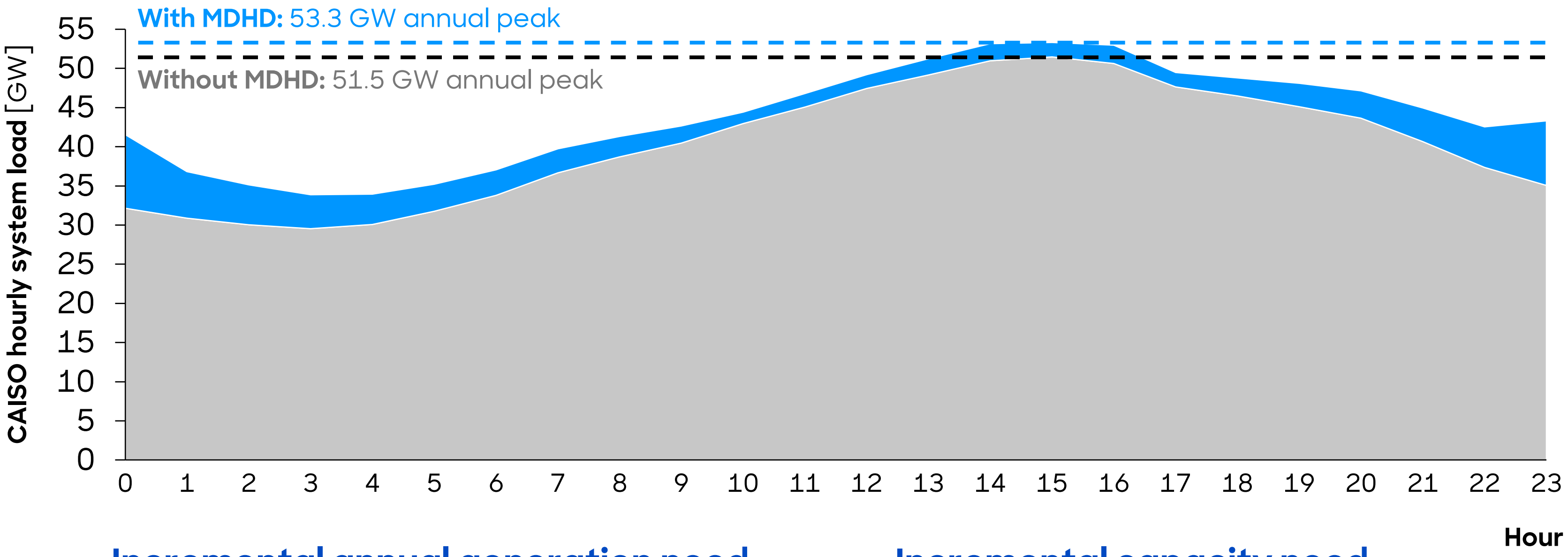
Source: FERC, S&P Capital IQ

At the power system level, the impact of MDHD charging on peak energy demand is diminished, as most charging occurs overnight – avoiding the system peak

Impact of MDHD charging on bulk power system (CAISO example)

California ISO: impact of MDHD charging on annual peak load

[hourly load during annual system peak day, GW]



Incremental annual generation need

31,000 GWh
(+14%)

Incremental capacity need

2 GW
(+4%)

Generation vs capacity needs:

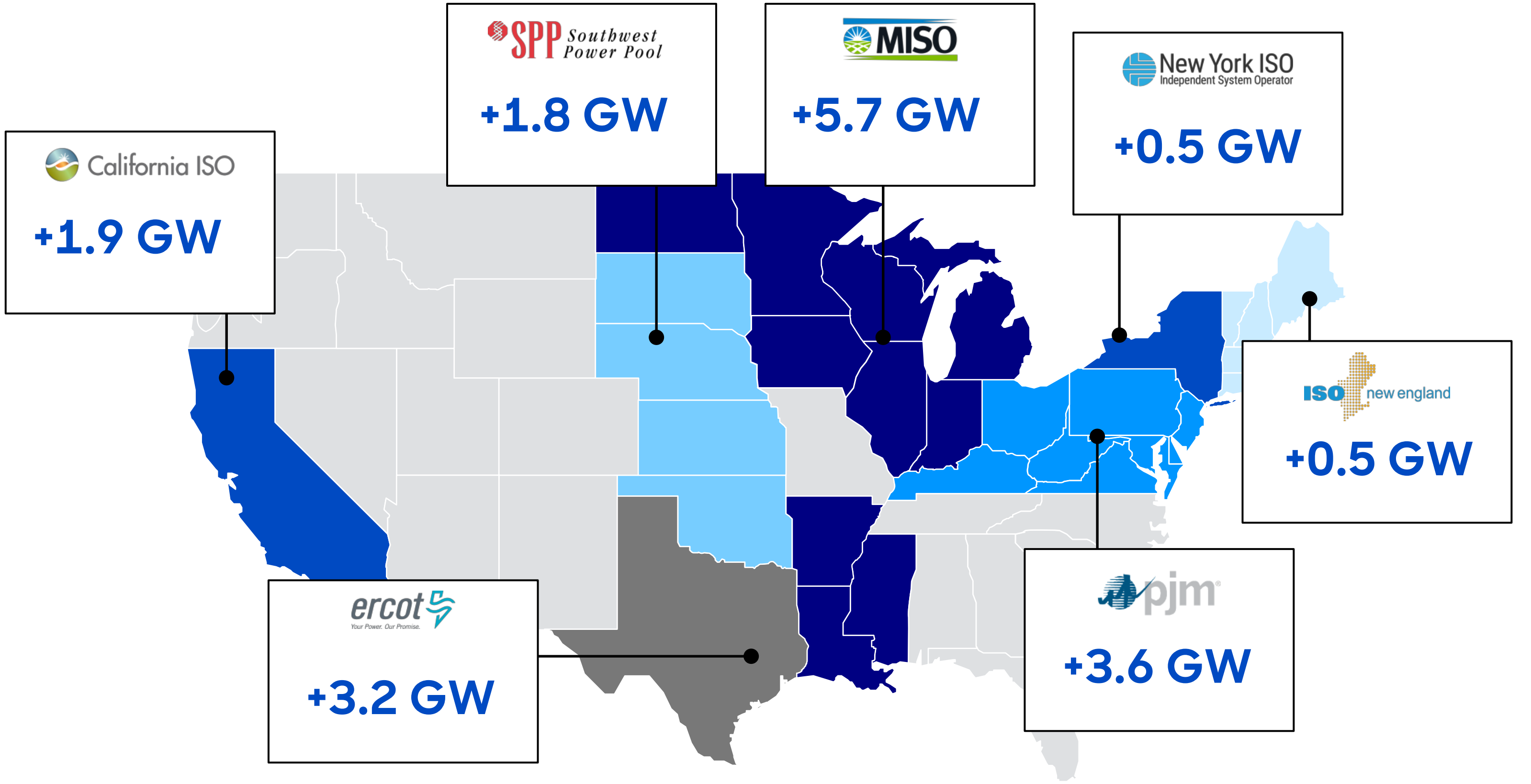
- MDHD charging will require a meaningful increase in energy generation
- However, charging will have a less significant impact on **system capacity requirements**, which are primarily **a function of peak energy demand** across a region
- The level of **investment in generation and transmission** resources for a given region is **driven by system capacity requirements**
- Whereas increased **energy generation need** typically translates into **increased utilization of existing resources**

Source: S&P Capital IQ, Roland Berger analysis

While there will be some incremental capacity need (and investment need) created by MDHD charging…

MDHD charging – impact to annual system peak load by ISO

Incremental coincident peak demand [GW]



Incremental investment in generation and transmission capacity:

Generation

22 B

Transmission

12 B

Based on EIA forecasted mix of resource additions and forecasted capital costs (by year of addition) through 2040

Source: EIA AEO 2023, S&P Capital IQ, ISONE 2050 Transmission Study, Roland Berger analysis

…power system operators are already planning for significant generation and capacity growth from transportation electrification, as well as from other trends

MDHD load impact vs ISO forecasts of overall load growth

	Generation				Capacity			
ISO region	**2022 annual generation** [GWh]	**MDHD charging** [GWh]	**Increase from MDHD** [incremental % of 2022]	**2040 ISO load forecast** [incremental % of 2022]	**2022 peak load** [GW]	**MDHD peak impact** [GW]	**Increase from MDHD** [incremental % of 2022]	**2040 ISO load forecast** [incremental % of 2022]
SPP Southwest Power Pool	283,187	19,932	**7%**	**48%**	53	1.8	**3%**	**26%**
MISO	665,254	64,493	**10%**	**17%**	120	5.7	**5%**	**18%**
pjm	795,214	45,998	**6%**	**39%**	148	3.6	**2%**	**20%**
California ISO	223,677	30,980	**14%**	**68%**	52	1.9	**4%**	**42%**
ISO new england	118,887	8,180	**7%**	**46%**	25	0.5	**2%**	**72%**
ercot Your Power. Our Promise.	429,895	31,556	**7%**	**58%**	80	3.2	**4%**	**29%**
New York ISO Independent System Operator	152,681	8,284	**5%**	**34%**	31	0.5	**2%**	**44%**
	Historical	**RB estimate**	**RB estimate**	**ISO forecast**	**Historical**	**RB estimate**	**RB estimate**	**ISO forecast**

Source: ISO long-term load forecasts, Roland Berger analysis

C. Other operational challenges

In addition to the economic hurdles, regulatory constraints, and operational challenges already discussed, further challenges still need to be addressed

Additional operational challenges raised by fleet operators

1. **Prohibitively high purchase prices**
While electric LCVs are more affordable, electric vehicles in Class 6-8 segment are still prohibitively expensive today due to limited scale

2. **No TCO benefit today in Class 6-8**
In combination with increasing electricity prices, there is currently no TCO benefit versus Diesel trucks in the Class 6-8 segment

3. **Tank truck segment especially hit by incremental battery weight**
Certain use cases, esp. in the tank truck industry weigh out before they cube out and incremental battery weight leads to a payload penalty. Without the ability to increase current thresholds (bridge formula), fleets will be forced to absorb the cost

4. **Vehicle portfolio still immature**
Limited choice of vehicles with many coming from startups without sufficient track record and unclear service support offering

5. **Drivers need to get compensated during charging times**
Drivers will need to get compensated if they have to wait for vehicles being charged during their hours-of-service window. Lower driver utilization negatively impact fleet profitability or drives up freight rates

Roland
Berger