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[redacted]

Introduction

On behalf of the members of the Association of American Railroads (AAR), thank you for the opportunity to testify about the California Air Resources Board's (CARB) regulation on emissions from in-use locomotives. AAR's freight railroad members account for the overwhelming majority of U.S. freight rail mileage, employees, and traffic, including in California.

At the outset, let me be clear that the rail industry shares the goal of CARB, the Environmental Protection Agency (EPA), and members of Congress to improve air quality and reduce greenhouse gas (GHG) emissions related to rail transportation. Railroads know that, as cumulative global emissions continue to rise, emissions reductions and policies aimed at transitioning toward a net-zero economy are desirable.

Those policies, though, must be realistic, lawful, and reasonable from a cost-benefit standpoint. The policies cannot assume that technology that does not exist can simply be willed into existence. And the policies must not unduly impair the efficient functioning of the national freight rail network. Unfortunately, as explained below, CARB's regulation fails on all these fronts, which is why the EPA should deny the authorization necessary for it to take effect.

Railroads Are Crucial for Economic and Environmental Progress

Freight railroads play an outsized role in keeping our economy moving. They serve our industrial and agricultural economies by moving enormous quantities of raw materials and finished goods to and from production areas. Without railroads, international trade as we know if could not exist: railroads connect our farmers, mining operations, and manufacturers with both domestic markets and markets in Canada, Mexico, and overseas. Millions of Americans work in industries that are more competitive in the tough global economy thanks to the affordability and

productivity of America's freight railroads. Railroads also make it possible for retailers to fill their shelves with the products we want to buy. In short, it is virtually impossible to overstate freight railroads' contribution to our economic well-being, standard of living, and quality of life.

Railroads also play an outsized role in meeting our climate goals and are already an environmentally preferred way to move freight. On average, railroads move a ton of freight nearly 500 miles on one gallon of fuel. Railroads are three to four times more fuel efficient than trucks, and a single train can replace several hundred trucks on our already congested highways. Railroads account for approximately 40 percent of U.S. long-distance freight volume (measured by ton-miles) but account for just 1.8 percent of total U.S. transportation-related GHG emissions and just 0.6 percent of total U.S. GHG emissions.

Railroads, though, are not satisfied with the status quo: they are continually seeking out further emissions reductions, both voluntarily and as the result of cooperative partnerships with local and state regulators. In recent years railroads have:

- Initiated extensive research and development efforts aimed at developing more environmentally friendly locomotives, including those powered by both batteries and hydrogen.
- Introduced pioneering technologies, such as highly advanced fuel management systems.
- Modernized thousands of locomotives in their existing fleets to improve fuel efficiency.
- Installed idling-reduction technologies, such as stop-start systems, and expanded the use of distributed power (positioning locomotives in the middle of trains) to reduce the total fuel consumption.
- Explored the feasibility and commercial viability of using higher biofuel blends and renewable fuels in the existing locomotive fleet.
- Introduced hybrid and zero-emission cranes and other equipment in rail intermodal terminals and rail yards and deployed technologies to reduce idling time for trucks as they move in and out of these facilities.
- Adopted approved targets with the Science Based Target Initiative, an organization driving ambitious climate action in the private sector.

As noted above, AAR's members have been working with locomotive manufacturers to

develop and test low- and zero-emission battery-powered locomotives, and several railroads are also investigating the potential of hydrogen fuel-cell locomotives. However, as discussed in more detail below, these locomotives at present are still firmly at the development and testing stage and are nowhere near commercial viability.

What CARB's Regulation Entails

CARB's regulation, if authorized, would prohibit railroads, beginning in 2030, from operating locomotives in California that are more than 23 years beyond their original manufacture date. This means locomotives originally built in 2007 or earlier would effectively be banned in California. The regulation also states that, beginning in 2030 for industrial, switch, and passenger locomotives and 2035 for line-haul locomotives, newly purchased locomotives operated in California must be zero-emission.[1]

Of the approximately 23,000 locomotives in the U.S. Class I railroad locomotive fleet today, more than 15,000 — nearly two-thirds — were built before 2007. Non-Class I railroads operate several thousand additional locomotives. According to CARB, as of 2020, the average age of non-Class I locomotives in California was 43 years old.[2]

CARB's regulation also requires railroads to deposit funds into an escrow account overseen by the state to be used exclusively to purchase and test zero-emission technology. Initial estimates from BNSF and Union Pacific, the two Class I freight railroads operating in

[1] Generally speaking, switch locomotives are lower horsepower units used primarily to move railcars in rail yards and short distances outside rail yards. Line-haul locomotives are generally higher horsepower units used predominantly on mainline tracks for long-distance movements.

[2] Class I railroads — there are six today — are those with 2022 revenue of at least $1.03 billion. They account for roughly 95 percent of U.S. rail industry revenue. The more than 600 non-Class I railroads, also called short line and regional railroads, range in size from tiny operations handling a few carloads a month to much larger entities operating across several states. Non-Class I railroads rarely purchase new locomotives, but instead typically purchase used units from Class I carriers, leasing companies, rail equipment dealers, or other non-Class I railroads.

California, indicate the required deposit would amount to $700 – $800 million per year per railroad. Non-Class I railroads too would be required to pay up to several million dollars into this fund each year — in some cases, far exceeding what the railroads could absorb without facing insolvency.

Commercially Viable Zero-Emission Freight Locomotives Do Not Exist

In recent years, the rail industry and their suppliers have made significant investments in developing and testing prototype battery electric and hydrogen fuel cell locomotives. Significant progress has been made and much promising work continues.

That said, given the current stage of development of zero-emission locomotive technologies, compliance with the time frames found in this regulation is not feasible. Today, zero-emission locomotives are still in the early testing phase of development and are not close to widespread commercial viability. The premature retirement of older locomotives, without availability of zero-emission replacements, simply makes no sense.

CARB's regulation goes also goes beyond what the U.S. Department of Energy (DOE) believes to be technologically feasible. In its Fiscal Year 2025 Budget Request, DOE requested $35 million to, among other items, *demonstrate* a 50% reduction in GHG emissions in a locomotive engine by 2030.[3] This stands in stark contrast to the portion of CARB's regulation which would require all new locomotives purchased for use in California to be fully zero-emissions beginning in 2030.

CARB itself does not suggest that zero-emission locomotives are available now or will be by 2030. Rather, CARB says only that zero-emission technology *might* be *possible* at some

[3] U.S. Department of Energy, *FY 2025 Congressional Justification, Vehicle Technologies, Decarbonization of Off-Road, Rail, Marine, and Aviation Technologies* (March 2024) https://www.energy.gov/sites/default/files/2024-03/doe-fy-2025-budget-vol-4-v2.pdf

point. CARB fails to consider if the technology will be safe, reliable, maintainable, or operable on the North American rail network. CARB's regulation relied on flawed literature and interviews with non-rail personnel who lack the requisite knowledge needed on this topic.

Battery-Electric Locomotives

In terms of battery-electric locomotives, CARB entirely ignores the physical energy storage limitations of current battery technology. The largest battery-electric locomotives available to order and being operated to date in North America contain 2.4 megawatt hours (MWh) of energy. To replace a single diesel locomotive with a 5,000-gallon fuel tank, a battery would need to store approximately 80-100 MWh of energy. Thus, to operate just one line-haul locomotive with today's battery technology would require the use of battery tenders, technology that is also not commercially available today. Because a large percentage of rail long-haul movements require the power of multiple locomotives, in practice the battery power gap would be much more acute. The sheer weight that those batteries would place on existing infrastructure and the time required to charge them are hard facts the regulation ignores.

Of course, research to increase battery capacity and develop new battery technologies, such as solid-state batteries, is ongoing. However, there is no prospect in the foreseeable future of a battery that can reasonably replace a locomotive diesel engine. Even leaving that critical issue aside, once developed, all major new rail technologies must undergo rigorous field testing (including under various environmental and operational extremes including weather, altitude, elevation, while pulling tens of thousands of tons) and obtain regulatory approvals related to safety, efficiency, and operability. The testing and approval process alone takes years to complete, further making CARB's timelines completely unrealistic.

Hydrogen Fuel Cell Locomotives

Several major railroads are currently evaluating the feasibility of hydrogen as a viable alternative fuel for line-haul rail at scale. This technology too is still in a nascent stage.

As the Federal Railroad Administration has recognized, hydrogen fuel cell locomotives "would require an entirely new design of locomotive" and "if hydrogen is to be used and stored onboard a locomotive, new standards or requirements will need to be written" to safely incorporate hydrogen tanks into rail operations.[4] The pathway will require extensive testing before full scale incorporation into rail operations. It is not a feasible zero-emission technology in the timeframes contemplated by CARB's regulation.

Conversion of the Existing Locomotive Fleet to Zero-Emission

CARB has claimed that railroads will be able to convert existing locomotives to zero-emission models. However, as the primary manufacturer of freight locomotives has stated on many occasions, it is not currently feasible to convert the existing fleet of locomotives from diesel to zero-emission fuel sources on any significant scale.

A retrofit from a diesel locomotive to a zero-emission locomotive would require the complete removal of the existing diesel engine and replacement with a new engine that runs on a different fuel source. Only the original locomotive chassis would remain as part of the newly constructed locomotive, making the effort the equivalent of a new engine, not a retrofit or reconfiguration. Such an effort is neither straight-forward nor scalable on a fleet-wide basis.

Catenary Electrification

Some claim that catenary electrification of the rail network is a viable way to achieve

[4] Federal Railroad Administration, *Study of Hydrogen Fuel Cell Technology for Rail Propulsion and Review of Relevant Industry Standards*, June 2021 (DOT/FRA/ORD-21/20) at 2.

zero-emission freight rail operations. It is not.

In California alone, electrification would require building and maintaining a high-voltage transmission and catenary system with poles and wires across some 5,000 route-miles in every kind of geographic location, including congested cities and suburbs, rugged mountains, and across rivers. Bridges would have to be rebuilt to provide clearance and support for catenary wires. Electricity would need to be delivered through scores of rail tunnels (many lacking space for overhead wiring) or an alternative power source would need to be supplied. Transmission substations would have to be built to deliver uninterrupted electricity. Complex and time-consuming permitting and historic preservation processes would have to be followed.

While it's not possible to precisely calculate the costs of freight rail electrification, they would clearly be immense and the time frame likely measured in decades, not years.[5] In addition, of course, much of the existing U.S. locomotive fleet would have to be replaced. An electric locomotive that can satisfy the demanding requirements of long-distance, heavy-haul freight railroading would likely cost far more than the $3-$4 million a typical new diesel locomotive costs today. Disruptions to rail operations during the many years construction of an electrified system would take would also be immense and would cause substantial harm to the economy. Finally, power outages, blackouts, and brownouts would cause significant disruption in catenary electric rail operations and could upset the national supply chain.

Production and Delivery Issues

Locomotives are expensive and long-lived assets, typically with long lead times between order placement and delivery. Over the past decade, Class I railroads have purchased

[5] In 1992, the Southern California Regional Rail Authority concluded that electrifying only 806 miles of track in Southern California would have cost $3.26 billion, the equivalent of $6.97 billion in today's dollars.

approximately 2,000 new locomotives. Even if zero-emission locomotives were available — and as discussed above, they are not — the two major North American heavy-haul freight locomotive manufacturers would almost certainly be unable to produce the number of locomotives implementation of the regulation would require within the required time frame.

As it is, supply issues are leading to long lead-times for prototype battery electric locomotives. For example, in early 2022, one Class I railroad ordered several prototype battery electric locomotives to test in railyards. Due to ensuing procurement difficulties, that railroad does not expect those units to be delivered until 2026. This delay demonstrates the considerable complexities associated with locomotive technology that is not yet fully developed.

A Zero-Emission Transition Requires Significant Infrastructure Build-Out

In a future where battery electric technology dominates transportation, the electrical grid and related infrastructure would require substantial upgrades to provide sufficient and reliable charging locations — not just in California, but throughout North America. As the Biden Administration has observed, "The current electric grid was not developed with today's electrification needs in mind."[6] Local utilities will need to upgrade their production and electric distribution capabilities, which includes replacing dated infrastructure, to vastly improve reliability. Blackouts and brown-outs due to insufficient energy supplies would have devastating impacts on transportation providers and the domestic and global supply chains.

A recent analysis from the Brattle Group found that between 2035 and 2050, costs for grid investment associated with battery electric locomotives in California alone would total more than $2 billion, not including the considerable costs associated with charging infrastructure and

[6] U.S. Department of Energy, *Biden Administration Launches $2.5 Billion Fund to Modernize and Expand Capacity America's Power*, (May 10, 2022) https://www.energy.gov/articles/biden-administration-launches-25-billion-fund-modernize-and-expand-capacity-americas-power.

the battery electric locomotives themselves.[7] This same analysis suggests that, depending on the eventual uptake of battery-electric locomotives, some 8,500 GWh of electrical energy and 965 MWh of charging capacity will be needed in California alone by 2050 — far exceeding the total electricity consumed by all of the residents of San Diego County in 2022.

Significant infrastructure would likewise be required to support a transition to hydrogen technology, including production of low-carbon hydrogen, distribution, liquefaction, transportation, storage, and fueling facilities. The supply chain for hydrogen fuel is energy intensive and raises complicated issues regarding the location of the needed infrastructure.

No matter the power source, new infrastructure will require permits and environmental reviews, which would take years even in a best-case scenario. It would be impossible to meet either the 2030 or 2035 timelines established in the regulation, even if an adequate number of theoretical zero-emission line-haul locomotives actually existed.

The CARB Regulation Would Cripple Interstate Rail Traffic

A key feature of the North American rail network is its interoperability, which underlies its efficiency and cost effectiveness. Locomotives cross state lines and national borders thousands of times a day, seamlessly pulling trains from one end of the country to the other and everywhere in between. Railroads do not, and could not, have dedicated fleets for each state.

Yet CARB's regulation would force railroads to adopt such a model. This means that if CARB's regulation were authorized, more than two-thirds of the U.S. Class I locomotive fleet could not enter California (and any state that replicated the CARB rule). According to data from the Surface Transportation Board, California is sixth in the nation in the volume of rail carloads

[7] Brattle Group, Memorandum to AAR, Review of CARB's Proposed Regulation, April 22, 2024.

that originate, terminate, or move through a state — 6.8 million carloads for California in 2022.[8] Moreover, California is home to the two largest intermodal ports in the United States (Los Angeles and Long Beach). A huge variety of imported goods arrive at these ports and move inland by rail, while exports from throughout the country make their way by rail to those ports for shipment overseas.

CARB's regulation would therefore hamstring interstate commerce. Under the best-case scenario, locomotives would need to be switched at the California border — assuming a compliant locomotive were available and railyards were subsequently constructed at every intersection point along the state borders. If no compliant locomotive were available, freight coming into California would need to be transferred from train to trucks. The result would be severe supply chain disruptions and widespread diversions of freight from rail to trucks that are less fuel efficient and less cost effective than railroads. Truck-caused highway damage would also increase. Supply chains would become hopelessly snarled and logistics costs would skyrocket.

It is not just rail track and carloads that are interconnected. At any given moment, 5% to 10% of the line-haul locomotives operated by Class I railroads are owned or leased by another railroad, a practice known as "locomotive run-through interoperability." As a result, it is a regular occurrence, for example, for trains to leave Chicago for a destination in California without a change to the locomotive(s) pulling that train. This practice allows railroads to maximize operational efficiency and reduces transportation time by eliminating the need to exchange locomotives when moving from one railroad's line to another's. Therefore, CARB's regulation of emissions from locomotives "that operate in California" is tantamount to the

[8] See https://www.stb.gov/wp-content/uploads/CARSSTATE-2022.xlsx.

nationwide regulation of locomotive emissions.

The regulation would force railroads to set aside massive funds each year to support a premature transition to zero-emission technology. Forcing railroads to set aside this level of funding will almost certainly increase the cost of rail service in California and elsewhere, ultimately driving up prices for consumers and pushing more rail traffic to trucks. For many small railroads, the required set aside will lead to their insolvency. A policy that leads to such an outcome cannot possibly be considered sound.

Finally, if EPA were to authorize CARB's regulation, California would be the first state to adopt these standards, but not the only one. Other states are given the authority to adopt an identical regulation to California's if EPA does grant that authorization. Comparing this regulation to equivalent ones on passenger vehicles and the trucking sector, it is probable that anywhere from a dozen to eighteen other states could chose to adopt California's regulation into their own state laws. This would further degrade the interoperability of the network and compound the financial obligations of the spending account provision as the regulation spreads across the country.

The CARB Regulation Violates Federal Law

Congress has provided neither CARB nor EPA the authority to mandate the rapid and technologically infeasible decarbonization of the rail industry. Moreover, Congress has long recognized that if the rail network is going to function safely and efficiently while meeting the economic needs of the nation, railroads cannot be subject to a patchwork of different state and local regulations across the country.

CARB's regulation violates the Clean Air Act's (CAA) prohibition on states regulating emissions from new locomotives. Section 209(e) of the CAA, which EPA cannot waive, bars

states from regulating emissions from new locomotives or engines, including remanufactured locomotives. It also prohibits regulations governing emissions from on all non-new locomotives unless CARB secures authorization from EPA. CARB's rule unequivocally violates the CAA by attempting to change the locomotive fleet nationwide to new, zero-emission models.

CARB's regulation also violates the ICC Termination Act (ICCTA) of 1995. When Congress passed ICCTA, it recognized that the federal government should retain exclusive control over the regulation of railroad operations due to the inherent interstate nature of freight railroading. ICCTA therefore prohibits states and localities from regulating rail operations, including locomotives. By specifically targeting the rail industry, CARB's rule runs afoul of ICCTA's preemption sections.

Conclusion

In the past, railroads and CARB have worked collaboratively to drive significant reductions in emissions. These initiatives have helped pave the way for more sustainable rail operations across the nation. It is deeply unfortunate that CARB has decided to forego the proven path of collaboration in favor of flawed assumptions, regulations that lack legal authority, and a casual and willful disregard for technological realities. While the spirit behind CARB's regulation is consistent with the rail industry's environmental commitment, the regulation itself is unworkable and infeasible. EPA should therefore deny the authorization needed for CARB's regulation to be enforced.