BEFORE THE
UNITED STATES DEPARTMENT OF ENERGY,
Office of Energy Efficiency and Renewable Energy

Request for Information: Progression to Net-Zero Emission Propulsion Technologies for the Rail Sector
(Docket EERE T 540.111-02)

COMMENTS OF THE RAIL ELECTRIFICATION COALITION

Introduction

The following comments of the Rail Electrification Coalition ("REC" or "Coalition")[1] are submitted in response to the November 17, 2023, Request for Information (RFI) concerning the *Progression to Net-Zero Emission Propulsion Technologies for the Rail Sector*. The Coalition's' mission is to promote the adoption of electricity as the principal motive power of domestic railroad (freight and/or passenger) transportation and the use of rail rights-of-way as an enabler of electric grid integration and innovation through transmission co-location. We are grateful for the opportunity to help kick-off a serious evaluation of the pathways to electrification and net-zero carbon for this critical network industry. However, a national strategy on transportation decarbonization has yet to focus sufficiently on railroads.[2] The Coalition is happy to help explore those pathways in collaboration with railroads, government, and those NGOs for which economic strength and sustainability are priorities.

General Questions:

1. What is your view of zero-emission, or net-zero emission, rail propulsion technologies in the next 5 years? 10 years? 30 years? In your response, please include which rail propulsion technologies for line-haul and railyard operations do you see developing most promisingly. Please provide as many details as possible e.g., battery

[1] The Rail Electric Coalition is a diverse non-profit coalition of electrical manufacturers, technology companies, transportation companies, renewable energy providers, and other stakeholders that seek to enhance the strength and efficiency of two of our most critical infrastructure networks – the North American high voltage electric transmission grid and the international, national, and regional networks of North American railroads. For more information, please visit [Rail Electrification Coalition.]

[2] We note a growing body of DOE work in this area including research and presentations from the National Renewable Energy Laboratory (on pathways to change passenger and freight mobility) and Lawrence Berkeley National Laboratory (on mobile energy storage for grid reliability).

chemistry for batteries, charger type for electrification, fuel cell vs combustion, feedstock source, etc.

Answer: Rail electrification is no longer a question of "if" but rather "when" and (most importantly) "how" this critical part of the transportation industry electrifies. Both railroads (as electric loads and even potential suppliers of power and grid support) and the electric power business will be profoundly challenged by the opportunity to use of electricity as a motive power for locomotives and for other related operations. With some exceptions, the basic technology for this transformation already exists but new applications and deployment will be both transformative and disruptive. Overhead catenary facilities (not mentioned in your question), hybrid usage of these delivery systems and hydrogen, regenerative braking, heavy batteries and related charging systems, and new management software will be developed and tested for different applications. The pace of change will be determined by the strategic judgment of investors and industry management, consideration of potential stranded costs in the form of fleets of long-lived traction engines, the reliability of the electric power system and its evolving generation resource mix, and the operational differences between passenger and freight lines and their ability to share trackage.

While REC envisions significant benefits from the swift adoption of industrial digitalization, productive energy efficiency strategies, public policy arising from climate change and health concerns, the new mix of electric generation resources and downward pressure on energy prices especially from low-cost natural gas and renewable resources, less congested and better managed supply chains for goods and services, and the evolution of interregional power markets, these evolutionary trends will not occur at a uniform pace or with equal impact in all regions. We are nevertheless persuaded that rail electrification will move apace in this dynamic context over the next two to three decades.

In that spirit, the REC has begun convening a series of workshops with railroads, their suppliers, stakeholders, and workers, and utilities, independent power and transmission developers, manufacturers, investors, and public policy makers in search of the most efficient pathways to electrification. Ironically, the consensus in favor of rail electrification and more extensive track-sharing that existed around the time of the industry's dieselization and the Staggers Act (1960- 1980) no longer seems to exist. It will only be reconstituted if the diverse interests affected can reasonably expect to share in the benefits. That said, railroads have strived to return to a growth scenario by being more fuel efficient, utilizing each other's facilities, promoting intermodal coordination with trucking to restrain the cost of trans-shipment, and consolidation. Yet it's undeniable that the physical reach of the rail system – 139,000 miles of track – is far less robust than it was a century ago, when it extended 240,000 miles. Freight railroads have lost market share to trucks consistently over the last twenty years, due only in part to the decline in coal usage by the power sector. STB officials argue that the lack of growth or the loss of markets have led to more highway freight transportation and hence more, not less, pollution than if rail capacity had been more available and robust.

The merits of rail electrification are widely recognized, especially in other modern countries. Electric rail is highly energy efficient: overhead catenary achieves 90% overall 'wire-to-wheel' efficiency, battery-catenary hybrid achieves ~85% and battery-only ~75%, based on today's technology. An electric locomotive also can have much greater power per unit than diesel, so that fewer locomotives would arguably be needed on a multi-locomotive train to do the same job; the fuel costs are likely to be much less; and, since electric locomotives have fewer moving parts, they are far less costly to maintain.

Several factors may hasten electrification. The Federal Railroad Administration ("FRA") announced in 2022 a climate challenge for the rail industry to meet net-zero greenhouse gas emissions by 2050.[3] Our Coalition recognizes that the transition towards net-zero emissions from rail propulsion technologies will occur incrementally and within different aspects of the rail industry. For example, we believe that rail yard electrification and replacement of aging switch engines will be both economically efficient and environmentally beneficial at an earlier date. Short lines and feeder lines offer another set of opportunities for electrifying freight transport, often without having to contend with the difficulties of high-density traffic on long-distance mainlines.

There are several promising technologies for rail electrification such as battery-diesel, battery-electric, third rail, and overhead catenary. At present, there is no universally applicable motive power solution, although overhead catenary (and a hybrid of overhead and battery) systems have proven workable and economic in delivering electric power directly from grid resources for transit passenger and light rail systems, witness Amtrak's Northeastern Corridor, the Keystone Corridor, Caltrain, New Jersey Transit, Maryland Area Rail Commuter, Southeastern Pennsylvania Transportation Authority, Long Island Railroad, Metro North, and Chicago Metra Electric. Electrification of domestic heavy (freight) rail and inter-city passenger rail has not advanced. Overall, overhead catenary electrification of motive power may be the long-term best option due to its superior 'tractive effort per unit' and the advantages for freight locomotives of not carrying on-board fuel in addition to moving heavy loads.

Changes in the next ten years should be more rapid, however. A lot will depend on the attractiveness of a reliable grid, the cost and impacts of power versus the cost and impacts of fossil fuels, the potential maturation of technologies like energy storage, the entrepreneurial bent of railroad management, and the drive, guidance, and possible funding coming from government.

2. What efforts are you aware of to decarbonize rail transportation, including ways to reduce diesel fuel use? Are you aware of intermediate decarbonization milestones for rail transportation? Are you aware of longer term decarbonization goals for rail transportation? If so, describe how those goals might be met, including whether low-carbon biofuels will play a role.

Answer: Class I, Class II and III freight railroads and passenger railroads are already investigating modes of electrification in limited but noticeable ways. Achieving zero-emissions is an important focus of many ESG reports and electrification is not

[3] https://railroads.dot.gov/newsroom/press-releases/federal-railroad-administration-announces-climate-challenge-meet-net-zero-0f

uncommon.[4] Many Class I railroads have long planned on intermediate decarbonization solutions such a biofuels. Overhead catenary systems may not be economically viable for Class II and III (regional and short lines) systems because of the capital costs, topography, the absence of traffic density, and the older and less-easily convertible locomotives they often operate.

These initiatives reflect a growing interest in electrification and its potential for increased high speed transportation, more reliable transit service, and decarbonization. These efforts are often limited and, in some cases, experimental. Moreover, electrification is more widely planned and implemented for passenger rail than for freight transportation, especially in metropolitan areas. In that regard, Amtrak's ongoing reassessment of the need to electrify passenger services outside the Northeast is significant but as yet unclear. There are no plans or commitments of which we are aware that will result in total electrification of mainline freight or passenger rail facilities in the coming decade in the areas of the densest services. The prospect of replacing long-lived capital equipment, including freight rail and intermodal yards with cranes and loaders may contribute to extravagant estimates of the cost of electrification of the entire rail network, up to $7 million per track mile, or about $980 Billion. In addition to being excessive, such estimates ignore the fact that converting modern locomotives from diesel to electricity would be far less difficult than the historical conversion of steam engines to diesel. Electrification will unquestionably be a phased and carefully planned process.

3. What are the benefits and challenges of the various rail propulsion technologies as compared to the other alternatives? If possible, please provide a ranking of the alternative technologies starting with the most viable/promising option.

Answer: Overhead catenary systems and "third rail" offer the highest level of benefits from an operating perspective, although interchanges and interoperability are

---

[4] Some of the more notable developments at this time include the following:

- Upgrades of Amtrak's Northeast Corridor, a 457-mile railway line connecting highly urbanized areas in the US. https://www.railway-technology.com/projects/amtraks-northeast-corridor/?cf-view
- Keystone Corridor operations, a 349-mile railroad corridor between Philadelphia and Pittsburgh, PA https://en.wikipedia.org/wiki/Keystone_Corridor
- Expansion of the Metra Electric District connecting Chicago's Millenium Stations with the city's southern suburbs https://en.wikipedia.org/wiki/Metra_Electric_District
- New funding and work on the California High Speed Rail electrification project in the Central Valley https://hsr.ca.gov/high-speed-rail-in-california/central-valley/
- Collaboration between BNSF and Wabtec on a battery-electric locomotive pilot test in California https://www.bnsf.com/news-media/news-releases/newsrelease.page?relId=bnsf-and-wabtec-commence-battery-electric-locomotive-pilot-test-in-california
- Canadian National's work with Wabtec on a 100 percent battery-electric heavy-haul locomotive https://www.cn.ca/en/news/2021/11/cn-advances-sustainability-efforts-with-wabtecs-battery-electric
- Progress Rail has an agreement with Pacific Harbor Line to supply its EMD Joule battery electric locomotive for a project operating in the Ports of Los Angeles and Long Beach, California https://www.progressrail.com/en/Company/News/PressReleases/ProgressRailAndPacificHarborLineSignAgreementForBatteryLocomotive.html

challenges that would persist as an operating issue during the transition from partial to full electrification. The case for electrification is based in part on the potential economic efficiency of electric drives as the motive force of freight rail, as well as on powerful environmental and public policy considerations. Electric engines, if animated by grid power or perhaps augmented by battery storage, is likely to reduce fuel costs overall, even when accounting for the cost and impact of generation of grid power that is delivered to a locomotive from a plant some distance away. The advantages of electric drives also relate to lower maintenance and operation costs, reductions in fueling time, increased acceleration to allow more trains ("sprinter" service) the on same tracks, and having railroads serve as the foundational pathways for remote renewable power sources and as critical support for rural communities.

Electric passenger trains, powered by overhead wires or third rail, are the most energy efficient way of rapidly moving large numbers of people over land. Any electric train so powered does not have to store its fuel supply onboard or carry its weight. Instead, it takes its energy from an external source, on an as-needed basis where the energy goes straight to the traction motors. The electric energy can be supplied from a variety of sources including renewables. In addition, trains can regenerate electric power during braking and feed electricity otherwise dissipated back into the grid.

Electrifying selected line segments, incremental direct electrification, combined with application of battery electric propulsion can potentially address many of the shortcomings of today's technologies in the near-term. The first step would be to target initial electrification at terminal station tracks, stations with high-acceleration requirements and the key grades of the route. This significantly reduces the cost of catenary electrification and allows electrified operation to begin with battery electric trainsets. With the availability of catenary power in high power demand line segments and battery recharging as trains travel along key route segments, the number of on-train batteries would be decreased, reducing weight, thus improving efficiency, and reducing vehicle cost. It should be noted that lighter weight is an advantage for passenger trains, while the opposite is true for freight locomotives, which require immense traction to move heavy loads. All things being equal, however, the electric traction motors that drive even today's trains are up to the job.

As train frequency increases and acceleration reduces travel times and improves operations, additional miles of catenary can be added. Segmented electrification with battery electric trainsets also facilitates lower cost for service to lower volume branch lines and secondary lines which do not have the train frequency to warrant investment in overhead wire. We note a major safety concern surrounding overhead and third rail facilities at grade crossings and over-bridges. Investment in safer infrastructure and designs will be an important concern for regulators as railroads electrify.

4. What obstacles to rail decarbonization is the industry facing? What plans can be put in place to overcome these challenges?

Answer: The last great conversion of freight rail from steam to diesel-fueled on-board power generation concluded 60-70 years ago. The passenger and freight rail industries have been attached to and supported by the fossil fuel since that time. The prospect of substantial capital investment and economic and operational inertia that tends to inhibit a further transition, regardless of how justifiable electrification may be on environmental grounds. At the time of the Staggers Act in 1980, railroads had abysmal returns and unsupportable regulatory burdens. The benefits of that "deregulatory" measure may have been exhausted by 2005, according to the STB, leaving railroads in a relatively no-growth position. That may render fundamental change doubly difficult. It must therefore be acknowledged that electrifying freight railroads would be a costly undertaking, whether done with battery electric locomotives, overheard catenary systems, third rail technology, or another approach not shown to be feasible at this time. Also, railroad locomotives can sometimes serve for 40+ years and the lack of consensus about motive power options for the future tend to make companies hesitant to adopt new regimes. Railroads and public policy makers nevertheless must consider the risks and costs of failing to anticipate the needs the future will impose on railroads and the supply lines they must be prepared to support.

In the past, when American mainline rail was electrified in many instances, the mode of electrification was overhead wire, or catenary. The often-repeated assertion that overhead catenary wire is today too expensive to install and maintain needs to be further examined. Evidence to the contrary exists regarding rail operations elsewhere in the world. Most of the countries that have electrified their rail networks did so primarily because it proved to be more economical than diesel power on heavily used lines while improving performance and lowering operating costs. Swifter acceleration, flexible use of tracks for multiple purposes, are arguments for grid-electric propulsion, especially over mountain grades or during frequent station stops. The determinative factor in choosing rail electrification elsewhere has often been the use of government ownership and public funding. But, the US domestic rail system, other than transit, is privately owned and companies therefore have the financial responsibility for maintaining and upgrading trackage and other facilities and investing in new plant. Despite their importance, US railroads are therefore not regarded as national assets.

Electrification of US railroads would create a new relationship with the power industry, which is itself undergoing major changes. The expansion of electric transmission facilities that move large amounts of power dates from the turn of the 20th century, but truly integrated regional grids have developed in only the past 40 years or so. Much of today's electric transmission system remains a patchwork within states or service territories. At least 25% of transmission facilities are operating far in excess of their useful lives. Legacy electro-mechanical controls are not unusual. Fast-growing renewable energy is price-competitive with other fuels, but the grid may not reach these low-cost resources. States and consumers want access to low-cost renewable resources, despite its reputation for "intermittency." Finally, expansion and integration of the nation's transmission grid --up to an estimated 500% increase in transmission capacity by 2050 – is needed to meet the demand for clean energy, concerns about vulnerability to extreme weather, and lack of capacity to meet electrification demand across multiple sectors.

Should all this activity be a cause for concern for a newly electrified business-like rail and yet another impediment to electrification? It's a fair question. It is sometimes argued that such uncertainty and the growth of distributed and different baseload electric resources may not support long-line railroading reliably one jurisdiction or service territory to the next. Our response: If sufficiently coordinated, rail electrification opportunities and more collaborative planning and operations can yield additional benefits to both industries and, most of all, to consumers of their services. The two industries need to communicate more effectively.

5. For direct electrification of rail, how do you foresee the infrastructure (such as overhead catenary) being built? Who should own and operate the infrastructure?

Answer: Electrification of trains directly supplied from the grid through overhead wires, or third rail was proven successful in the mid-20th century for passenger rail and long-distance freight operations traversing challenging physical terrain, for example the Milwaukee Road. Since the dieselization of America's freight lines (all classes), that experience has been largely discounted or forgotten. In our opinion, a return to the deployment of catenary tends to be the most strongly opposed by Class 1 railroads, compared to other newer options like energy storage (batteries), because of the expense of conversion and the difficulties associated with maintaining interoperability in other words, all mainline railroads would arguably need to develop the same system more or less at the same time in order to share tracks and other infrastructure. On the other hand, overhead catenary can be installed where feasible to serve facilities or markets with special characteristics, until such time as an industry consensus forms around the future of motive power, with the support of government and/or the investment community. Experts recognize that installing overhead catenary in areas such as tunnels or neighborhoods can be challenging. However, there are use cases such as the Amtrak Northeast Corridor and numerous examples in advanced countries in Europe and Asia where overhead catenary works well in all kinds of topography. Ownership and operation is a separate consideration, and an American solution may diverge from other examples around the world.

6. What collaboration with any other entities do you think will be necessary to support the decarbonization of rail transportation?

Answer: The railroad "ecosystem" has a diverse and numerous collection of stakeholders, many of whom (especially consumers) will benefit from a change from diesel to electric power and many of whom will remain skeptical or opposed.[5]

---

[5] Participation by these stakeholders will be key to decarbonizing rail transportation: railroads (Class I, II,, and III in the US and Canada) and rail associations, utility companies, environmental groups, community groups near yards, terminals, and rail lines, organized labor, academia and research institutes, shippers and shipper associations, investors, state, federal, and Canadian (potentially Mexican) policymakers, regulators (energy and sustainability), state DOTs and energy offices, and regional grid planners.

Decarbonization or electrification (our favorite mode of modernization) may emerge or be developed on the periphery of the rail network (e.g., short lines, rail yards, ancillary services like charging facilities) but even these measures will require the financial health, support, and cooperation of Class I railroads, AAR, and research institutions like MxV in order to begin to begin establishing and moving toward realistic goals that will ultimately affect the operations of mainlines. Congressional committees can look more deeply into the future of the rail network and this RFI is important and visible evidence that DOE is purposefully looking for answers about the future of that network, including consideration of needed rail technology investments. We are pleased to add to the list of essential change agents that have taken a favorable stance on rail decarbonization DOT's Federal Railroad Administration, and NGOs like Solutionary Rail, the Virginia Rail Policy Institute, the Sierra Club, and others.

That said, FRA's regulatory mission is principally about safety and strong infrastructure. Moreover, the Joint Office on transportation that DOE and DOT both support has focused exclusively on EVs and, to our knowledge, has no strategy for employing rail electrification or intermodal service as a way to reduce congestion and pollution on the nation's highways. There are numerous regional rail associations and various electric power groups (most prominently, the Edison Electric Institute) that could help advance rail electrification or decarbonization. Currently, we acknowledge that enthusiasm for that agenda cannot match the degree of focus on electrifying highway vehicles. The Rail Electrification Coalition has been working for four years to raise awareness, build collaborative workshops, and keep rail electrification on the nation's policy scoreboard, with mixed results. Other professional groups, like the Transportation Research Board, the national labs (Lawrence Livermore is increasingly active), port authorities, and cooperatives and groups interested in the welfare of rural America, need to galvanize their efforts in support of this aspect of our industrial policy.

The Pueblo, Co. Transportation Technology Center ("TTC"), owned by the Department of Transportation and now operated by ENSCO, should be performing testing on rail electrification. TTC has heavy freight test tracks used as proving grounds for Amtrak's Acela, Caltrain, and other transit facilities. TTC and DOT can offer freight railroads an opportunity for less expensive testing, including for electrification measures.

7. What are the most critical gaps (e.g., with respect to standards, regulations, supply chain, labor) that need to be filled to support acceptance of and markets for alternative rail propulsion technologies?

Answer: Given that the transition to net-zero rail propulsion is most likely to occur incrementally and in phases, it's important that the existing track and other infrastructure can feasibly accommodate a mix of different technologies. There is also a collective need to assess the demands that alternative propulsion technologies will place on manufacturers, shippers and customers in some cases, crews and operators, and the public agencies charged with overseeing the costs and reliability of rail operations.

For battery electric locomotives that use regenerative breaking to recover and store energy, there are concerns that, in areas of major topographic decline, all the energy from regenerative braking cannot be captured for later use. In order to address this challenge, new charging infrastructure will be necessary to ensure the sustainability of battery driven motive power. When electrification is taken seriously, railroads and technologists will have to explore the different charging methods that the kinds of electric batteries installed in locomotives will require. In the near future, we anticipate a unique opportunity to develop standardized charging methods for locomotive fleets whether employing a slow- or fast- release methods.

A significant market for alternative propulsion technologies and for associated research and development as well as manufacture is likely to grow in the next 5 – 10 years. Electrical manufacturers serve the railroads with a variety of digital and mechanical innovations but only two manufacturers are currently working on battery-electric locomotives and that work is primarily at the research and development stage. The FRA is encouraging new ventures under the CRISI program but, to date, that funding has not unleashed significant new applications nationally. A high level of acceptance of propulsion alternatives, acting as a harbinger of the future, has not yet arrived.

8. What infrastructure is required to support promising alternative rail propulsion technology? Are there specific routes, railyards, or network segments that would be a good candidate for alternative propulsion technologies (e.g., catenary, hydrogen fuel cells, or batteries)?

Answer: As stated in our response #1, the Coalition recognizes that the transition towards net-zero or zero-emission rail propulsion technologies will occur incrementally and in phases. Places where this will most likely occur first include rail yards, feeder lines, shorter segments, or by using existing networks. Many of these innovations are test beds, not full-blown strategic investments in entire systems. TTC is probably able to contribute to exploring these options now.

Collaboration between the power and rail industries will have significant collateral benefits, especially access to reliable power in the event of electrification and use of existing right-of-way within which to locate new HVDC links to bolster system reliability. An example of using an existing network to co-locate electric infrastructure is the Brightline High Speed Rail Corridor in Florida that links Orlando and Miami.[6] The Orlando segment utilized a highway ROW. On the electric transmission side, the SOO Green HVDC Link in Iowa and Illinois plans to utilize over 300 miles of rights-of-way on 3 separate rail lines to develop a 525kV HVDC line to bring renewables east to Chicago and PJM. Likewise, the Champlain Hudson Power Express, which is under construction in New York, is using railroad ROW for over 100 miles of HVDC transmission and other siting solutions to bring Canadian hydropower to New York City. Access to reliable power generated from low-carbon resources and available in large quantities is a prerequisite to switching railroads away from reliance on fossil fuels. The synergy between need for interregional transmission development, new sources of electrical generation, and the prospect for decarbonization railroads has become more obvious with time.

[6] https://www.hsrail.org/brightline-florida/

Although electrification and decarbonization may well develop in phases, the development of both electric and rail infrastructure and the pathway to success needs to be mapped out with a lengthy planning horizon in mind. Transmission is subject to extensive state, regional, and interregional or national planning requirements, whereas the future of railroad infrastructure is focused principally on maintenance of historical routes and trackage. Railroads can become a growth industry once again, in part by diversifying their sources of income.

9. What type of service testing, or derisking, of these propulsion technologies do you think are necessary for each alternative rail propulsion technology?

Answer: As stated in our response #6, MxV and TTC are uniquely positioned as the rail industry's research partners and independent advisors. MxV is supported by 6 Class 1 railroads plus APTA, AAR, and Amtrak. It provides a R&D test bed for various technologies, equivalent to services provided by EPRI to the utility industry. MxV is a major rail industry consultant that conducts railroad equipment testing and research on innovative and emerging technologies for the rail sector. Research into electrification does not appear to be its priority. MxV may nevertheless be capable of testing and de-risking propulsion technologies. TTC (as a government-owned entity, also in Pueblo, CO.) can also respond to the pro-transmission, decarbonization trends in American public policies.

Service testing or de-risking of these propulsion technologies can also occur in rail yards. For example, battery-diesel technologies, where the diesel engine can charge the locomotive allowing it to run on battery power, or a battery electric SLUG unit (a version of a diesel-electric locomotive that lacks a prime mover and gets its power to operate its traction motor from a fully powered mother locomotive).

10. What government actions do you think are necessary to help move the rail sector towards net-zero emissions?

Answer: The Infrastructure Investment and Jobs Act provides funding for the Consolidated Rail Infrastructure and Safety Improvements (CRISI) program, raising available funds for new infrastructure to about $1.47 billion per year (for five years). In addition, Congress added Provision 16, which allows FRA to fund the "Rehabilitating, remanufacturing, procuring, or overhauling locomotives, provided that such activities result in a significant reduction of emissions." This is the main funding driver for FRA's Locomotive Replacement Initiative, which seeks to remove the dirtiest locomotives from the rail network. This a significant initiative but just the beginning of a solution. CRISI is available to both Class II and III railroads. Under the 2022 awards, FRA is funding the replacement of dozens of dirtiest locomotives with cleaner ones, including the funding of fifteen zero-emission battery switcher locomotives. Short line railroads that may be looking to improve their fleet can take advantage of this initiative. In addition, the 2022 awards included the installation of photovoltaic solar panels (along with other rail-specific improvements) for a short line.

Additionally, the DOE and FRA need to collaborate on developing a national rail electrification program, continuing studies on this topic that DOT, DOE, OMB and private industry performed back in the 1970s and 1980s. The new U.S.-Canada joint task force on rail electrification (that was announced in December 2023 at the COP28 U.N. climate change conference in Dubai) should first focus on dusting off old rail electrification studies deep in the archives of both governments. This initiative makes clear that rail electrification is, and must be, a cross-sector undertaking. Government can facilitate, systematize, and support that collaboration. However, without a strategy or more support from railroads to pursue this course, the industry may continue to lose market share and address its operational issues incrementally at a slower-pace characteristic of the 20th century rather than meeting the needs of the 21st century.

11. Other than tax credits, what opportunities are there to incentivize transition to clean fuels, recognizing that costs are likely to be higher in the near to mid-term? (For example, vehicle consumer incentives in the on-road sector include the use of high-occupancy vehicle (HOV) lanes, free workplace charging, etc.).

Answer: As mentioned in response #2, the electric transmission industry has new and probably growing interest in utilizing existing rights-of-way to site its high-voltage lines. Existing railroads are uniquely positioned geographically and legally to provide strategic access to railroad rights-of-way to the extent they are determined to be sufficient in size and location to be employed in siting high voltage transmission. This would be a complex business decision that affects both the grid of the future and railroad operations. Monetizing these ROWs can create new revenue streams to help railroads finance their operations, including rail electrification, for a significant period. Electrification can also take forms other than transmission co-location, including battery motive power and related charging facilities and practices that may not require the dedication of much if any real estate for siting or construction purposes. Another opportunity that railroads may capitalize on, once electrified, is participation in the power market as Virtual Power Plants (VPPs) capable of meeting external power demand as well as their own needs. There is also a variety of financing options for rail electrification capital costs that could be supported by government, including loans and bonds.

12. What type of workforce challenges are present? Are you aware of any workforce development programs that are relevant to the clean energy transition in the rail sector?

Answer: Workforce challenges related to electrification and the clean energy transition, such as shortages of skilled labor, are not unique to the rail sector. While the clean energy transition is already generating thousands if not millions of high-quality jobs,[7] it will be a challenge for the power industry to find and retain clean energy talent. Those challenges will be even greater for rail crews which may need extensive training

[7] https://www.bluegreenalliance.org/wp-content/uploads/2022/08/BGA-IRA-Jobs-Factsheet-8422_Final.pdf

in aspects of electricity services. It will be important to up-skill the current workforce with appropriate energy skill sets relevant to the rail sector. At a time when freight railroads have already pared back their crews, electrification could result in much greater human resource needs. Moreover, the existing electric power workforce knows how the industry operates and this knowledge base can be effectively transferred to support rail operations. There is a also a wide variety of operational and installation experience here and overseas. Fortunately, there is a well-spring of expertise here and elsewhere that can be accessed during any motive power transformation. The US can tap expertise globally regarding the best practices in electric rail.

13. Are you aware of any goals for Total Cost of Ownership (TCO) willingness to pay for advanced technologies? Recognizing that DOE and industry are driving to cost parity with diesel in the long term, what do you think the goals should be regarding reasonable extra costs over the diesel baseline in the near term?

Answer: This business metric describes and measures how much an asset or range of new investments like those necessitated by electrification (in this case, locomotives and supporting infrastructure owned and maintained by domestic US railroad companies) will cost over a specific period. The life cycle cost of railroad assets, including how to stretch the useful lives of those assets, would be a critical factor in how railroads plan their business futures. One might assume that, when choosing among alternatives, for example modes of motive power, the useful lives of types or sizes of locomotives, or any of several important long-term investments and expenses, the lower the TCO the better, even if the "purchase price" up-front is high. In a capital-intensive industry like rail, the long-term durability of assets like locomotives and trackage make TCO determinations quite difficult. The Coalition is not aware that any cost/benefit evaluation of electrifying the US rail network has been conducted in several decades, including consideration of factors like the stability in diesel prices, feasible motive power alternatives, the benefits of or need for government assistance, quantified risks involved, or likely operational and traffic assumptions today or in the future.

Education (including updated modelling and cross-sector discussions of the kinds that occurred in the 19070s), collaboration, and clearer public policy will assist railroad management and industry economists in making the tough decisions this question is apparently designed to elicit. For the moment, the Coalition cannot offer a prescription on the TCO for electrification in the absence to such an undertaking.

14. In your opinion, how do certain technologies (e.g., battery) compare for different use cases (e.g., line haul, switching)?

Answer: Direct access to power through catenary or, where available, underground transmission, does not raise the same concerns about the distance a locomotive can travel (i.e., range) as batteries currently do. As that technology improves, the answer to this question (both in terms of range, weight, strength, and charging) is likely to require revision. The range and strength of batteries needed for, say, freight transportation by rail, is a challenge. The locomotives employed by Class I railroads on their mainlines are expected to travel long distances. Without advanced charging technology in relatively remote or demanding environments over varying terrains, batteries are not a preferred option. However, advancements in battery technology are improving the range of batteries. Some locomotive manufacturers have developed and are now introducing 100% electric heavy-haul locomotives designed to eventually provide mainline service.[8]

Experience shows that battery electric and overhead catenary[9] can effectively be deployed together. An international example case study is Deutsche Bahn which is the national railway of Germany. Germany has been an early adopter of battery powered trains. Deutsche Bahn has announced plans to build overhead contact line islands for their battery powered regional trains. Instead of the end-to-end electrification of a track this new technology only requires the electrification of short sections of a track.[10] Rail application of hydrogen fuel cells remains problematic, in our view. They may be most suitable for short passenger routes and local freight or switching services but require proximity to refueling stations because on-board liquid hydrogen storage would detract from payload capacity.

In sum, it is likely that a combination of technologies will prove the most workable motive power solution when traversing various geographic and market conditions demands adaptability. This approach arguably provides railroads that are hesitant to select from among the available methods of electrification because of the potential for stranded costs or an expectation that better technologies will emerge in the future, with a way to minimize risks through a flexible approach. In countries as large as the US and Canada, long-line rail transport may need to adapt to differing conditions. At bottom, this is a strategic challenge for individual companies.

15. In your opinion, what percentage of locomotives overall could reasonably be expected to be zero-emission locomotives between now and 2050? How do you think production might scale up over time?

Answer: Today in the US, there exist 25,000 locomotives, many of which technically have useful lives that will extend into the future. Freight locomotives are often recycled and retrofitted more than once, which reduces capital costs but also reduces the opportunities for complete replacement. The manufacturing capacity to make new engines or convert the fleet clearly exists in the US. There are several large locomotive shops around North America that have or could develop in-house capacity for battery electric conversions.[11] At this juncture, it is not clear what form conversions from fossil fuels will take but it appears that the industry is technically capable of converting a

---

[8] https://www.batterytechonline.com/automotive-mobility/first-flxdrive-battery-electric-locomotive-is-on-track

[9] Conventional overhead catenary is well-suited to mountain grades - dating back to the Cascade tunnel in the Washington Cascades in 1909, and the Milwaukee Road through the Cascades and Rockies not long after. In fact, mountain grade mainlines have been a priority for rail electrification worldwide.

[10] https://www.electricandhybridrail.com/content/news/deutsche-bahn-to-build-overhead-contact-line-islands-for-battery-powered-regional-trains/

[11] https://www.wabteccorp.com/celebrating-10-years-in-fort-worth; https://www.wabteccorp.com/ErieForward

relatively high percentage of the locomotive fleet to zero-emission by 2050. Although refitting or replacing the 25,000 total Class I fleet could happen well before 2050, the extent to which they will result in zero emissions individually or collectively will become apparent later. Production should ramp quickly once design choices (for new and retrofit locomotives) are made and supply chains for the new elements (catenary, batteries, and associated hardware) are created. Railroads veer toward standardization for several reasons including inter-operability and maintenance simplicity, so it's important that the change-over from diesel to forms of electrification, biofuels, or even hydrogen occurs in a timely and coordinated fashion. This may be an argument for guidance from or collaboration with public policy makers.

16. How do you think power needs should be estimated for the rail industry over time? E.g., number of locomotives or switchers?

Answer: There are grid dependencies between transition of the rolling stock and corresponding infrastructure that will need further attention and economic analyses as this transition to net-zero propulsion occurs. Grid-to-rail traction energy efficiencies are generally higher with battery electric locomotives and overhead catenary systems. Battery electric locomotives will need to be tethered to a large recharging network as they have a shorter operating range requiring more recharging enroute. Hydrogen fuel cells do tend to have a longer operating range but have a low grid-to-rails energy efficiency, plus any hydrogen system will necessitate a major infrastructure investment. Overhead catenary systems have the greatest ability to regenerate dynamic braking energy, which enhances the economic efficiency of any transit. This question highlights the importance of planning and building electric infrastructure needed to power electrified rail in its evolving iterations. EV demand and electrification of buildings, HVAC and other industries will supply guidance. There's no single answer at the moment other than hypotheticals.

There are also lessons to be learned from rail electrification projects overseas and how on-site renewable energy could meet power needs for electrified rail. As an example, the Government of India has heavily invested in the electrification of its railways. The government's goal is to have India's railways fully electrified and become the world's largest Green Railways by 2030. To provide the rail with renewable energy, India is conducting a small pilot project to generate 1.5 MW solar energy on vacant railway land.[12] India's mainlines are slated to be totally electrified by the end of this year.[13]

17. What do you think should be the estimated global market size for net-zero emission locomotives or retrofitting technologies?

Answer: A full answer to his question would focus first on passenger locomotives which tend to be more or less standard compared to freight locomotives, which are ordinarily

---

[12] https://www.mercomindia.com/indian-railways-solar-projects-vacant-lands

[13] https://www.livemint.com/news/india/railways-on-track-to-meet-target-of-100-electrification-by-dec-11690543908598.html

developed and configured for specific markets and topographies. There may be use cases for diesel or a diesel substitute for decades to come but it's hard to see why diesel won't eventually meet the same fate as coal and wood applications for steam generation. Marginal-cost electric power (especially renewables, with no fuel cost) will doom other fuel choices once the delivery infrastructure is developed. The fixed cost of petroleum refining infrastructure will then be supported by fewer and fewer customers. The rail fleet in many if not most countries may therefore be candidates for conversion from diesel to electric in the next half century, just as India is doing with its entire network.

Concluding Remarks:

America is transitioning to a transportation future that is increasingly electrified. While highway vehicle electrification is at the forefront of this trend, an electrified rail infrastructure also has the potential to transport freight efficiently and reliably and/or passengers while avoiding the adverse impacts on the environment that transportation development so often creates and serving the communities historically situated along rail lines. Freight rail transport, especially when converted to lower emissions, is significantly more efficient than highway transport and represents an opportunity for a "modal shift" that will reduce highway congestion and pollution and transportation costs overall. That trend has not begun, however; railroads have lost 2% market share since 2006, not including the loss of coal deliveries to electric utilities.

We look forward to working with your offices as this endeavor moves forward. Should you have any questions or need additional information on our responses to this RFI, please contact us directly.

Respectfully submitted,

James Hoecker
REC Counsel
Husch Blackwell LLP
(202) 378-2316
james.hoecker@huschblackwell.com

Steve Griffith, PMP
Executive Director, Regulatory & Industry Affairs, Mobility
NEMA
(703) 307-7847
steve.griffith@nema.org