SUMMARY

The RAIL ELECTRIFICATION COALITION'S
April 30, 2024
ELECTRIFICATION WORKSHOP

During its second major Workshop, the REC continues its search for feasible pathways to railroad electrification in North America. We believe the interest in rail electrification is climbing the list of national priorities as other modes of transportation electrify, as the supply chains become more competitive, as the electric power business is transforming technologically and operationally, and as public and private infrastructure investment amps up. The coming changes in the energy and transportation economies stir new questions about the role of government in driving, guiding, or funding new developments, whether industries as critical as electric power and railroads can change, communicate, and collaborate to advance their respective economic interests and historical advantages, and how the timing and depth of electrification measures will impact regulation and system planning, manufacturing priorities and technological advances, investment patterns, and state and federal public policy, and consumer and community developments around the country.

The REC April 2024 WORKSHOP is focused on diverse case studies and new innovations principally in the railroad industry. The record of innovation and deployment of proven electric technologies is surprisingly robust. It presents new opportunities for both electric utilities and developers and the rail companies themselves, many times involving proven technologies and motive power approaches that were both proven and deployed more than a half century ago. That does not make today's business decisions facing Class I and other railroads any less complicated, but we believe that investing in these deliberations will help point companies, their suppliers, and customers in new directions. Recognizing that public policy is changing rapidly at FERC, DOE, DOT, on Capitol Hill and at the State level, our Coalition encourages exploration of new proposals, techniques, and projects which point the way toward electrification, digitalization, clean energy, and transportation efficiency.

Note: "This summary is not a transcript. It is based on notes taken in good faith, without identifying names or companies, to encourage open comment. We regret any errors."

THE WORKSHOP began at 9:00 a.m.

CASE STUDY 1: BRIEFING FROM INDIA ON ITS PATH TO NET ZERO

Representatives from USAID, New Delhi, and Indian Railways

India has committed to reaching net zero emissions by 2070 and has set targets to achieve 50% of its energy requirements from non-fossil fuel sources by 2030. The International Energy Agency stated in its Net Zero 2050 report that "more efforts are needed" by the world's rail systems. India has emerged as an unlikely hero. Consistent with its big commitment made at COP28 in Dubai, India's rail network is now 94% electrified – an achievement largely made in the past decade. Indian Railways had signed a Memorandum of Understanding with US AID to collaborate on investing in energy efficient buildings in close proximity to the railways, procurement of round the clock renewable energy power for traction loads, and the adoption of EV's across Indian Railways. Energy storage has been a key asset for peak load management as India's rail electrification progressed.

India Railways has electrified 40,000 km of track since 2014 at a cost of about $5.5 Billion, jumping in the ranks of the Climate Change Performance Index (CCPI) from 31st to 7th despite its massive population and being 139th in per capital GDP. Behind electrification is an effort to move up the development trajectory from dependence on its abundant coal supply for fuel (for steam), to petroleum, to investments in solar and other renewables, and digitalization. Indian Railways plans to be a net-zero emitter by 2030. The Modi Government drove electrification, despite India's significant coal and oil resources, because of its climate commitments and the central importance of railroads to the country's economy and supply chains. It's fair to say that the speed of the conversion to rail electrification in India is unprecedented.

Discussion included:

1. What lessons can be fairly drawn from India's drive for rail electrification? Is North America in a better or worse position to perform as well on the range of climate change metrics?
2. Is Indian Railways as strong a service provider to the Indian economy as North American Class1s? Are there technological differences that make changes to the rail system more possible (e.g., passenger service as a bigger share, lighter rail equipment, less difficult terrain, etc)?
3. The major shift in Indian railway electrification is in part the product of a government industrial policy. However, the investments are strongly supported by the private sector.
   For instance, the government has allocated $2.2B to develop 5 million metric tons of green hydrogen and 125 GW of renewable resources; another $200B is pledged by private capital in support of India's energy roadmap. Is the US infrastructure legislation in 2022 sufficient to match this performance?

INTRODUCTION OF RAIL ELECTRIFICATION STUDY [*IN PROGRESS*]: COST AND BENEFIT RISK FRAMEWORK FOR MODERN RAILWAY ELECTRIFICATION OPTIONS

Presenter: Rydell Walthall, Doctoral Student, University of Texas.

With funding by the Federal Railroad Administration, the University of Texas commenced research on a cost and benefit risk framework for assessing modern railway electrification options. The project will examine past electrification efforts to identify the organizational, technical, and economic reasons they were or were not implemented, and what conditions might make rail electrification feasible going forward. The project, which is planned for completion during the Fall of 2024, contains (3) tasks: a review of past/current railway electrification studies, a review of alternative technologies and strategic implementation approaches, and the development and demonstration of an updated risk-based electrification benefit-cost framework. The study will also look at electrification case studies from other countries Walthall pointed to a similar study in Scotland showing a 60% cost reduction from discontinuous electrification (i.e., a concept that reduces infrastructure clearance costs by leaving gaps in overhead line equipment where non-compliant structures exist and using on-board energy storage systems to power trains across those gaps). While there is no opportunity for public comment on the framework, an industry advisory panel is being created to provide input as it is developed.

CASE STUDY 2: WHAT ROLE WILL ENERGY STORAGE PLAY IN RAIL MODERNIZATION? This session explored new ideas about rail-based deployment of energy storage and dispatch. Rail transportation is emerging as a testbed for energy storage technologies (e.g., batteries) as an alternative to investment in electric transmission and another way to deliver clean electrical generation. The Workshop explores how near these exciting new undertakings are to actual deployment and the potential that battery technology has for transforming the electric power and transportation systems. Batteries could provide an economical means to capture regenerative power and a motive power resource that is mobile, unlike catenary.

Senior Executive, Global Strategy & Marketing, Locomotive Manufacturer
This manufacturer produces a 100% battery-electric, heavy-haul locomotive capable of a maximum battery capacity of 8MWh. It had worked with a Class I railroad on a heavy-haul battery locomotive project in California. Over a three-month pilot program, the battery-driven locomotive has delivered more than an 11 % average reduction in fuel consumption and greenhouse gas emissions for an entire train saving over 6,200 gallons of diesel fuel and approximately 69 tons of CO2 emissions reduced. Regenerative braking was able to capture up to 30% of the energy from the battery, allowing it to charge twice, thereby saving fuel in the process.

Researchers, Lawrence Berkley National Labs (LBNL)
The researchers discussed the LBNL study which finds that rail-based mobile energy storage is a feasible way to ensure reliability inn response to extreme weather events and other exigencies. Batteries aboard trains are a cost-effective option for backup power. The published analysis found that mobile energy storage could travel between major power markets along existing rail lines within a week without disrupting freight schedules. A good example of this would be the State of New York, its rail network could utilize rail-based mobile energy storage to overcome the current transmission constraint between upstate clean energy generation and downstate load centers.

CEO, entrepreneurial developer proposes to move energy via utility-scale battery facilities scaled up as part of unit trains.
The concept for this organization is based on using the rail network to supply massive amounts of mobile energy, even as baseload when the freight rail system is not utilized at capacity. Coal railway substations that have been decommissioned are/can be used as charging stations for these utility scale batteries. They are currently working with two Class I railroads and have determined that the pricing model for transporting these batteries is similar to deploying transmission technology; however, such rail-based storage can be deployed for similar purposes in 24 months, compared to 10-15 years to develop transmission solution to reliability challenges. Another use case for this

model would be temporary power for first responders in the aftermath of a natural disasters. It is argued that rail-based energy delivery has reliability advantages even over the use of rail for conventional supply chain deliveries. This model of rail-based energy delivery could create novel questions about whether FERC or the STB would have sole regulatory oversight of this model and which grid entity would manage the dispatch of this storage. The developer is already advancing a prototype and an interconnection application in the West.

Discussion questions included:

1. What is the feasible future role of battery technology in supporting expansion of the electric grid, either as a mobile resource, a resilience or reliability asset, a network real estate support, major load, or a combination?
2. How might the use of battery-powered locomotive propulsion impact the need for catenary, and vice versa? Is there a strategic case for deploying catenary and battery technology jointly as a major or intermediate step toward rail electrification?
3. As part of locomotive propulsion systems, does the use of batteries as either propulsion or as grid support necessarily require development of a network of external charging facilities?
4. Does current development of prototype battery-electric locomotives indicate there is a nascent movement in the industry to a move away from established (diesel) traction?
5. What are battery capabilities now and potentially in the future, especially for heavy freight transport? What are their best uses and major disadvantages?
6. What battery technologies are best suited to railroad use, both on-board and trackside, at the present time? What technological developments will enhance that suitability?
7. Does the potential for delivering electric power from mobile sources like a unit train represent potential alternative or complement to development of macrogrid facilities? Can such development become an alternative base load resource in some regions? What is the potential impact on grid resilience and reliability? What appetite do investors have for such long-term investment?
8. What differences, if any, from the international state-of-the-art catenary installation will North America require?
9. What companies can build the machines that build the catenary? Can the electrification process be "industrialized" to support rapid implementation?
10. How is the Benefit-Cost Analysis of the catenary and battery/hybrid balance determined?

CASE STUDY 3: TRANSMISSION CO-LOCATION WITH RAIL. The Workshop continued previous discussion of the opportunity to install HVDC, HVAC, or lower voltage electric facilities alongside existing rights-of-way (e.g., railroads or highways). At a moment when transmission expansion and upgrades are needed to address coming challenges from extreme weather, massive demand growth, snarled supply chains, and a need to access more non-fossil energy, transmission development has proven incredibly difficult, in part due to regulatory delay at the state level and outmoded methods of planning the grid regionally or inter-regionally. Using existing rights of way – including railroads, highways, existing transmission corridors, even pipeline routes – offers the prospect of reducing the need for massive environmental reviews of "greenfield" properties, eminent domain, and long delays. That opportunity has not been clearly recognized by DOE, FERC, or DOT except in passing, while some state governments have helped to encourage use of "brownfield" (i.e., industrial, or established rights-of-way) to minimize community impacts and help regulated utilities preserve local reliability. What's the experience so far and are railroads paying attention?

Director of Corridor Services, Class I Railroad

This Class I Railroad is working with a transmission developer and regulators in the Northeast as part of their project to bring wind and hydropower from Quebec to New York City. Railroad websites often have online tutorials and a portal through which property assets can be identified. The permitting process for a utility to use an existing railroad rights-of-way starts with an application on the electric power side, which then goes through quality control and engineering review before the agreement between the railroad and the developer is created and executed. There are several things to consider on 3rd party installations along rights-of-way, especially railroad operations, design, and construction. Inductive interference from parallel overhead lines (AC) can pose safety risks and the potential for disrupting railroad communications and signaling. Railroad rights-of -way are not universal in width so when burying HVDC it needs to be at the edge of the property line. Train operations need to be able to continue during construction so future interactions between the utility and the railroad are reduced. Access is critical both in construction as well as maintenance. That said, the rail network and its associated real property network may actually be a natural site for interregional electric transmission that may need to cross utility boundaries, market boundaries, and regional grid or state boundaries with differing environmental regulations and community interests. It can be a totally different conversation if an abandoned right-of-way is being considered. Class I railroads generally know what they own and whether their rights-of-way will support installation of lateral facilities for non-railroad purposes.

VP Development, Transmission Developer
Large renewable energy developers recognize the major need for more transmission investment. Several barriers can impede the timeliness and cost-effectiveness of transmission planning, design, and construction – not the least of which is permitting and siting which is typically managed by the states and increasingly subject to multiple stakeholder and community engagement requirements. Access to established rights-of way is an important option for overcoming those barriers. The transmission companies, especially those that seek to develop projects that would be built in more than one market or jurisdiction, need to plan for worst case scenarios with respect to transmission planning. Geospatial tools are used to identify potential areas of opportunity for best routes. Any transmission modeling needs to fully quantify all benefits. There are layers of factors to consider with respect to the location of a project and the impact on communities and landowners. Using railroad or other rights-of-way will be preceded by extensive commercial negotiations, just as might be the case for private "greenfield" property. The Class I railroad representative agreed with that observation.

Advisor, Department of Energy, Grid Deployment Office, and former RTO planner
Transmission is currently a hot topic, both at the DOE and at FERC. The DOE will soon be releasing updated guidance on National Interest Electric Transmission Corridors (NIETC). Acting through two of its national labs (National Renewable Energy Lab and Pacific Northwest National Lab) as well as GDO, DOE will issue this summer the National Transmission Planning Study, a multi-model framework for better understanding the role, value, and opportunities for US transmission development mapped out in over 100 future scenarios and solutions. There is a need for a shared vision of the "electric future" and greater collaboration between state and federal government and between government and industry. After DOE issues for comment its proposed designations of NIETC corridors (very soon), FERC will establish procedures for reviewing and authorizing projects proposed for location within such designated corridors. More importantly is FERC's forthcoming major Final Rule on transmission planning and cost allocation. [See below] Ten years after FERC's last major rulemaking on transmission planning, the agency and its constituents generally recognize that sufficient transmission, especially interregional transmission

projects that can bring renewables to market and enhance the system's reliability and resilience, are not being considered and built in time to meet the national need for such capacity arising from a surge in electric demand, increases in extreme weather that threaten reliability, and looming decarbonization goals.

Discussion questions:

Electric Grid Synergy

1. What are the needs of the electric industry for new transmission corridors?
2. Do railroad ROWs have particular advantages/disadvantages for transmission co-location?
   Do railroads view this as a legitimate long-term business opportunity? What practical questions must be answered to evaluate the co-location of new transmission lines along rail rights-of-way? Are priorities compatible between rail and utilities or developers?
3. What considerations impact the sharing of risks and economic benefits between railroad ROW owners and high voltage transmission developers? Can an electrified railroad serve both the needs of the larger grid and local needs for power and transportation?
4. Will rail electrification expand the market for the construction of new remote renewable power generation?
5. What is the value of grid-connected idle switching (and road) locomotives offering peak shaving, line conditioning, and backup electric power?
6. What potential benefits to trackside communities could be available as a result of installation of high voltage?
7. What other elements could use grid electric power, such as reefer units and crossing signals, charging stations?

Power Delivery

8. What are the cost and construction implications of each power delivery method (i.e., overhead wire, third rail, induction from buried cable, etc.?) Can a forensic and credible analysis demonstrate the variations, strengths, and weaknesses?
9. Installation of underground cable will entail disturbing a ROW; what issues does this raise for potential waste disposal, impacts on adjacent landowners, and reduction in permitting time and complexity compared to "greenfield" development.
10. What is the experience with overhead catenary suffering pole and wire damage from shifted loads and/or damaged railcars? How can this risk be minimized?
11. What are the lifecycle economics of using composite catenary poles versus steel poles?
12. What is the experience with catenary clearing double-stacked containers and other taller railcars?
13. Can power suitable for locomotives be drawn from very high-voltage transmission lines? How could this affect transmission development decision.

*[**NOTE**: Side conversations during lunch involved the planning and cost allocation reforms that the FERC will consider during its May 13 open meeting. The Coalition has commented multiple times on the need to explore the use of existing rights-of-way for the co-location of major transmission facilities. FERC Order No. 1920 (Docket Nos. RM21-17-000) and Order No. 1977 (Docket No. RM22-7-000); also, DOE has designated National Interest Electric Transmission Corridors under FPA §216, which is the predicate for transfer of some state siting authority to FERC. Docket DOE-HQ-2023-0039-0001.]*

CASE STUDY 4: A REPORT FROM THE PASSENGER SIDE. Because of North America's vast expanse and competition from highway transportation (in part supported by taxpayers), passenger rail is widely available only in metropolitan areas and in the Northeast US. Asian and European countries have invested more heavily in passenger service as a principal mode of moving people. The US has fewer miles of electrified rail than Uzbekistan, according to a recent Sierra Club report. Amtrak has received a recent infusion of funds, but much of it will be required for the improvement of existing railbed. Amtrak may consider electrifying more of its routes outside of the Northeast, but outcomes are not clear. The many individuals and organizations that are working to expand passenger rail services across the country also support greater investment in commuter services and in high-speed rail in North America between now and 2050.

Representatives, California High Speed Rail Authority
The California HSR Authority is a 494-mile electrified rail corridor that will connect San Francisco to Los Angeles/Anaheim in Phase 1 of the project. The subsequent Phase 2 will extend 300 miles to provide connections to Sacramento and San Diego. Trains will travel at approximately 220 mph. Currently 119 miles are under construction, approximately 422 miles have been environmentally cleared, and (4) Central Valley Stations are being designed. Since the start of the project, over 13,000 construction jobs have been created and 840 small businesses have been employed. There has been an overall push for interoperability throughout the project. Among the efficiency benefits of the electrified high-speed trains is its ability to supply regenerative power for up to 18% of the system's needs. Under the Infrastructure Investment and Jobs Act (IIJA), over $3.3Billion grant funds have been received to help fund this project. Coordination with the local utility suppliers will be achieved via traction power substations placed approximately every 30 miles along the corridor to provide load balancing and reliability services.

Director, Virginia Rail Policy Institute (VRPI)
VRPI's mission is to strengthen and improve public policy with respect to both freight and passenger rail in the Commonwealth of Virginia. VRPI's studies include truck diversion to rail; shared use, high performance infrastructure; optimal station design, autonomous rail vehicles; and public incentives for common carrier best practices. One potential concept for further exploration is the North American Steel Interstate System (SIS) which is a concept of a core national network of high-capacity, grade-separated, electrified railroad mainlines. SIS freight trains will operate on one track at truck-competitive speeds, while passenger trains will travel on the other track at auto-competitive speeds. This could be demonstrated in the Interstate-81 corridor. Virginia is well-suited to extend the Northeast Corridors (NEC) electrification to cover the reach of the NEC regionals into VA. VRPI promotes electrification of the Richmond-Washington corridor, with 20 stations and multiple round trips daily.

Chair, US Rail Passenger Association
The Rail Passenger Association is the largest advocacy organization for rail passengers in the United States. It is a transformational period for passenger rail transportation in America, case in point the State of Virginia which has made significant progress in improving transforming its rail network via a 10-year, $4 Billion program. Rail is the optimal solution to alleviate traffic congestion along the interstate 95 corridor between Richmond and Washington, DC. There are gaps in our current US passenger rail systems that can result in people not having easy access to essentials such as healthcare, particularly in rural locations. An enhanced electrified national passenger rail network can provide more trains for people in these areas allowing them to improve their economic and social well-being.

Discussion Questions

1. Is improvement of passenger rail service to communities, especially those in rural America and rural Canada or Mexico, a sufficiently high priority among state and federal transportation legislators and other policy makers?

2. Can electric power and transportation policy makers work collaboratively to make deployment of their network industry resources more efficient and environmentally positive using strategic electrification and decarbonization?
3. What are the expected levels of investment in (non-local transit) passenger rail in the US? In Canada? What have been the most helpful/strategic investments of public monies the last two years and going forward? Does Congress need to do more?
4. How would electrification strategies for (non-electric) passenger rail compare to those for Class I, II, or III freight rail in terms of tactical steps, timing, or the available technological alternatives?
5. What is the per gallon price of diesel that would make electrification an obvious economic choice? Is this the key metric or only part of a more complex analysis?
6. How can locomotives be designed to take advantage of regenerative braking, vibration harvesting, and other waste energy capture methods?
7. What portion of the North American rail network should be electrified?
8. How are target sections determined?
9. How should electrification be staged to secure maximum benefits?
10. How will electrification coexist with residual diesel-powered segments?
11. What models of locomotives are candidates for conversion in the relatively near-term? Is this the most cost-effective option or an incremental approach?
12. What companies can perform the conversions?
13. How many fewer all-electric locomotives can be employed for the same service(s), compared to the same train using diesel-electric power?
14. What concerns do railroad management have about a move away from established (diesel) traction? To what extent do investors, consumers, and policy makers share those How can their fears be addressed or balanced by anticipation of new economic opportunities or social gains?
15. What entities and resources can (or should) be mobilized to advance such an industry transformation carefully but deliberately and economically?

The Workshop concluded at 3:30, after brief announcement regarding the following planned events later this year: a Public and Private Investment conference in the Fall 2024, most likely combined with the REC Annual meeting, and a possible third workshop.

(All the slides from this workshop are available on the Coalitions Website)

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During all Coalition meetings, the central question we seek to answer is ----

Can we identify ways to ensure that technology developers, railroads, investors, and policymakers make the wisest energy and operational efficiency decisions so that North American railroads can (1) contribute o lowering the emissions and resource requirements of freight and passenger movement, (2) capitalize on their current and potential efficiencies to sustain and grow rail's market share, strengthen supply chains, enhance customer services, and participate in expansion and strengthening the electric system, and (3) attract private and public capital sufficient to support the transition to a cleaner energy economy?

If your company or organization desire to become an official member in the Coalition, you may apply via the following URL:
[Rail Electrification Coalition Membership Application]