NUFRIEND Insights

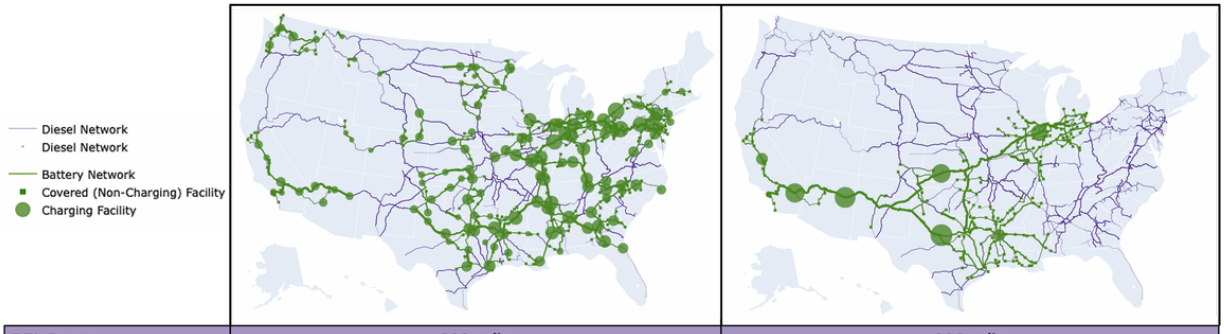
RANGES OF BATTERY-ELECTRIC LOCOMOTIVES (BELS)

Northwestern University Freight Rail Infrastructure & Energy Network Decarbonization (NUFRIEND) is a comprehensive industry-oriented tool to simulate the deployment of new energy technologies across U.S. freight rail networks. Scenario-specific simulation and optimization modules provide estimates for carbon reductions, capital investments, costs of carbon reductions, and operational impacts for any given deployment profile.

WHY DO BEL RANGES MATTER?

- The ranges of BELs are much more limited compared to existing diesel-electric locomotives.
- They require charging stations between terminals for linehaul shipments, incurring significant capital costs.

This NUFRIEND Insights models future BEL deployment in an aggregated U.S. Class I railroad network under 200-mile vs 800-mile ranges, to analyze their costs and emissions.



BEL Range	200-mile	800-mile
Cost of Avoided Emissions[1]	0.9 [$/kgCO2]	0.1 [$/kgCO2]
# of Charging Facilities	143 out of 544	7 out of 544
Emissions Reduction	7.18%	29.06%

Optimization results of an aggregated transcontinental U.S. rail network where 20% shipments are served by BELs.

HOW DO BEL RANGES AFFECT RAIL DECARBONIZATION?

Range is critical, as deploying charging stations in locations with no proximal railyards may be economically infeasible.

200-mile Range:

- Mass deployment of charging stations limited to regions with existing railyards.
- Limited linehaul corridor options to deploy BELs.
- High cost of avoided emissions from capital investment to build a lot of charging facilities.

800-mile Range:

- Few charging stations needed to decarbonize the high-volume linehaul routes.
- Flexibility to deploy BELs on easy-to-decarbonize routes.
- Cost of avoided emissions in line with potential U.S. carbon credit pricing.

SUMMARY

- Longer-range BELs require a smaller capital investment while attaining a higher carbon reduction.
- Longer ranges mean more flexibility for railroads to deploy BELs and leverage economies of scale in heavily trafficked corridors.
- For individual railroads and different BEL ranges, the NUFRIEND tool can optimize the deployment of charging infrastructure and offer more pointed insights.

[1] The cost of avoided emissions measures the average cost required to reduce emissions by one kg of CO2 and serves as a strong evaluation and policy metric.

NUFRIEND Insights for:

RAILROADS

- BEL charging time causing high delay costs
- Significant benefits attainable from advanced roll-out planning
- Potential gains from easy-to-decarbonize routes
- Value of accurate range estimates and forecasts

OEMS

- Value of range improvements
- Innovations in charging speeds
- Need for cost-competitive manufacturing relative to other fuel technologies

ENERGY PROVIDERS

- Coordination to ensure adequate electricity supply for connected charging infrastructure

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