

NUFRIEND Insights

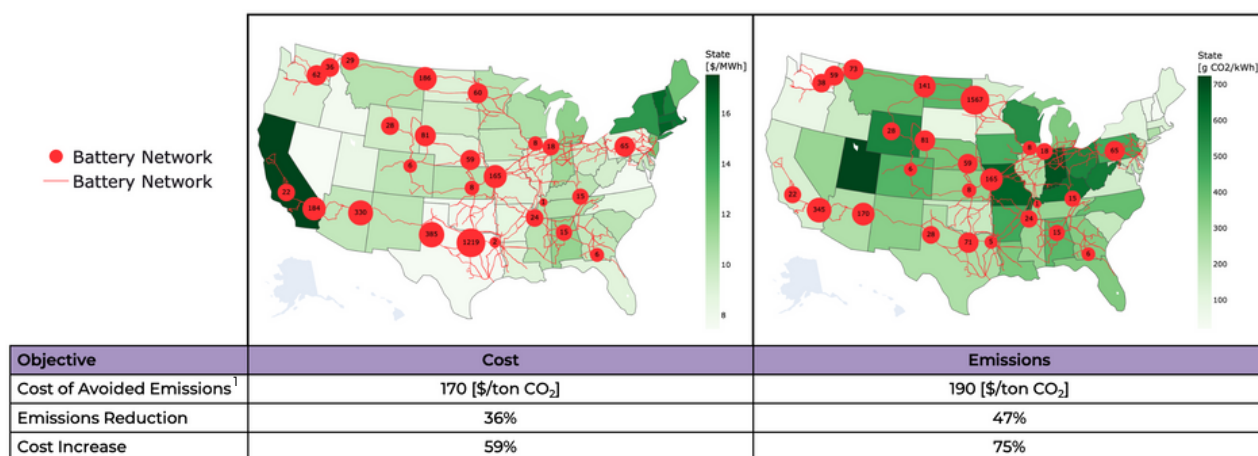
OPTIMIZATION OBJECTIVES - COST VS EMISSIONS

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.

WHAT IS BEING OPTIMIZED?

- The NUFRIEND framework determines the optimal refueling/charging facility capacities for serving freight demand.
- The optimization objective can be based on state-specific **electricity costs** or **electric grid carbon emissions**.

This NUFRIEND Insights models the difference between cost and emissions objectives for sizing charging facilities for 600-mile range battery-electric locomotive deployment in an aggregated U.S. Class I railroad network.



Optimization for cost and emissions objectives where 80% shipments are served by BELs. Bubble sizes are proportional to the power (in MW) assigned to each charging facility location.

HOW DO THESE OBJECTIVES AFFECT RAIL DECARBONIZATION?

States differ in their electricity prices and generation mixes, which affect the amount of energy sourced from each facility.

Cost Objective:

- Sizing facilities to minimize costs means the largest facilities are in lower-cost states like Texas and Arizona.
- Lower cost of avoided emissions as baseline electric grid is cleaner than diesel.

Emissions Objective:

- Sizing facilities to minimize emissions means larger facilities in cleaner states like California and Minnesota.
- Higher cost of avoided emissions may require incentives to realize further emissions reductions.

SUMMARY

- Altering the optimization objective between minimizing energy costs vs. minimizing energy emissions provides stakeholders with a tool to analyze a challenging trade-off.
- Renewable electricity may be purchased from states at different cost premiums, which can be factored into the optimization.
- Carbon credits or trading schemes may help to make more costly emissions reductions efforts economically sensible.

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

- Economic value of green initiatives.
- Forecasts for future cost of diesel and other locomotive fuel technologies.

ENERGY PROVIDERS

- Importance of knowing the capacity of the electric grid within and across states.
- Forecasts for future electricity prices and generation mixes.

GOVERNMENT

- Consideration of climate policy impacts on emissions reductions.

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