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.

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.

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.

### Objective | Cost of Avoided Emissions | Emissions Reduction | Cost Increase | Cost | Emissions |
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<td>Cost of Avoided Emissions</td>
<td>$170/ton CO₂</td>
<td>36%</td>
<td>59%</td>
<td>$190/ton CO₂</td>
<td>47%</td>
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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.

Visit [transportation.northwestern.edu](http://transportation.northwestern.edu) for more NUFRIEND Insights.

This work is funded under the LOwering CO2: Models to Optimize Train Infrastructure, Vehicles, and Energy Storage (LOCOMOTIVES) project by the Advanced Research Projects Agency - Energy (ARPA-E) of the U.S. Department of Energy under Award Number DE-AR0001469. The views and opinions of the authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.