INTERMITTENT ELECTRIFICATION WITH BATTERY LOCOMOTIVES AND THE POST-DIESEL FUTURE OF NORTH AMERICAN FREIGHT RAILROADS

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Train 121 with FEC 807 and 302 (LNG Fuel Tender)
Flickr User BBT609 photo (CC BY 2.0)
**BATTERY-ELECTRIC VS. DIESEL**

- 5,000 gals
  - 190 MWh
- 3,750 gals
  - 142.5 MWh
- 2,500 gals
  - 95 MWh
- 1,250 gals
  - 47.5 MWh
- Refuel

1,000 miles

- 14.5 MWh
- 200-mile Electrified Segment
- 200-mile Electrified Segment

- 4 hours
  - hauling @ 3.3 MW
  - (4,400 hp)
- 4 hours
  - charging @ 3.7 MW +
  - hauling @ 3.3 MW
- 4 hours @ 7.0 MW

Lineart by RailToonBronyFan3751 at DeviantArt (CC-BY NC 3.0)
Figure 3(a)

Cumberland Subdivision

Charge Remaining (MWh) vs Mile

- Theoretical Maximum (95%)
- Charge Rate Limited (C/4)
- No Regen (Worst Case)
CASE STUDY – INTERMITTENT
CASE STUDY – CONTINUOUS

Figure 5(c)
Figure 6(a,b)
Figure 6(c,d)
Lifecycle Cost Analysis (Sample Class I)

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Base Case</th>
<th>B1-B4</th>
<th>C1-C3</th>
<th>Full</th>
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Scenarios:
- Base Case = Diesel Service Only
- B1-B4 = Intermittent + Battery Electric, Phases 1 thru 4
- C1-C3 = Continuous Electrification, Phases 1 thru 3
- Full = Total Mainline Electrification

Discount Rate = 5%

All Maintenance Costs are NPV.
PRACTICAL ISSUES

• Proving high-capacity battery-electric locomotives
• Clearances for double-stack trains
• Non-electrified routes for high/wide loads
• Effects of extreme climate in North America
• Impacts on signal systems and maintenance practices
Indian Western Railways operates a electric double-stack container train from Palanpur to Botad in Gujarat, June 10, 2020; Piyush Goyal photo (India Government Open Data License via indianrailways.gov.in)
Trees in the Comm and Signal Power Lines
Anthony Anderson photo
NEXT STEPS

• Federal assistance: demonstration programs
• Commodity flow analysis: where to build?
• Business case analysis: what’s in it for me?
• Joint network, capacity, and infrastructure planning by railroads with electric utilities
FIGURE 5
TRAFFIC DENSITY ON
SIGNED MAINLINES IN REGION

Rail Service in the Northeast and Midwest Region
U.S. Department of Transportation (1973)
INSTITUTIONAL MECHANISMS

• Tax credits
• Joint ventures
• Infrastructure improvement grants
• Cap-and-trade
• “Cash for clunkers” for diesel locomotives
CONCLUSIONS

• Discontinuous electrification is workable with battery-electric locomotives
• Technology is rapidly developing and should be ready for service within a few years
• Alternating about every 200 miles between electrified and non-electrified