

Battery-Electric Locomotives



Battery-electric locomotives (BEL) power from onboard batteries instead of burning fuel. With today's charging technology it can take several hours to charge a BEL. Refueling a diesel locomotive takes minutes. BELs use regenerative braking to recharge their batteries, especially traveling downhill. BELs operate on existing tracks, can be combined with other zero-emission strategies or diesel, and don't use fuel.

Pros

- Zero tailpipe emissions
- Regenerative braking recovers energy
- Batteries are more efficient than burning diesel
- Fuel cost savings
- Cheaper maintenance than diesel locomotives

Cons

- Limited range
- Need charging stations
- Charging is slower than refueling
- Can have problems at extreme temperatures
- Batteries have limited lifetime

Uses

BELs are ideal for short-range freight and passenger service where they are always near a charger. Battery-electric locomotives and tenders can increase grid resilience by providing electricity in extreme events.¹

Because of their limited energy storage and long charging times, BELs by themselves may not be suitable for long-distance freight or passenger service until battery technology is more advanced. BELs can be used with overhead contact systems (OCS), hydrogen fuel cells, or existing diesel locomotives. BELs used with other locomotives can reduce fuel usage with regenerative braking. BELs can be charged while moving on track with OCS wires.

¹ Amol Phadke & Elif Tasar, Lawrence Berkeley National Laboratory, "Big Batteries on Wheels". Weblink: https://eta-publications.lbl.gov/sites/default/files/working_paper_004_7-18-19_0.pdf

Safety

Batteries in transportation are safer than fossil fuels.² Battery-electric locomotives go through the same rigorous safety testing as any other locomotive. The Federal Railroad Administration requires specific crashworthiness testing, daily inspections, yearly tests, and many more safety precautions.³

Battery Tenders

Battery tenders are railcars filled with batteries. Battery tenders can be used with BELs to extend the train's range. Existing diesel locomotives can be converted to connect to a battery tender.⁴ This turns diesel trains into hybrids, able to run on either diesel or battery power. Hybrid trains also have the advantage of regenerative braking. Once a tender's batteries are empty, the tender must be recharged or swapped out of the train.

Resources

- *CARB Zero Emission Rail Project Dashboard*
- *CARB In-Use Locomotive Regulation Initial Statement of Reasons, Appendix F, September 2022*
- *CARB, Zero Emission Train from the Port of Los Angeles to Barstow*
- *Caltrans, California State Rail Plan*
- *U.S. Department of Energy (DOE), An Action Plan for Rail Energy and Emissions Innovation, December 2024*

² Department of Energy, Department of Transportation, Environmental Protection Agency, and Department of Housing and Urban Development. "An Action Plan for Rail Energy and Emissions Innovation". P. 40. Weblink: https://www.energy.gov/sites/default/files/2024-12/doe-eere-modal-reports_rail-energy-emissions-action-plan.pdf

³ Code of Federal Regulations, Title 49, Subtitle B, Chapter II, Part 229. Weblink: <https://www.ecfr.gov/current/title-49/subtitle-B/chapter-II/part-229>

⁴ CARB, In-Use Locomotive Regulation 15-Day Changes, Appendix C: Technical Support Document: Zero Emission Locomotive Conversion. Weblink: <https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2022/locomotive22/15dayappc.pdf>