

PROGRESS RAIL

Emissions Reduction Solutions

October 2022

Progress Rail
A Caterpillar Company

WE KEEP YOU ROLLING

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Sustainable Solutions for Rail

Progress Rail is committed to delivering a suite of options to drive sustainable rail operations

Be the recognized leader in rail decarbonization by providing comprehensive solutions that help our customers meet their goals.

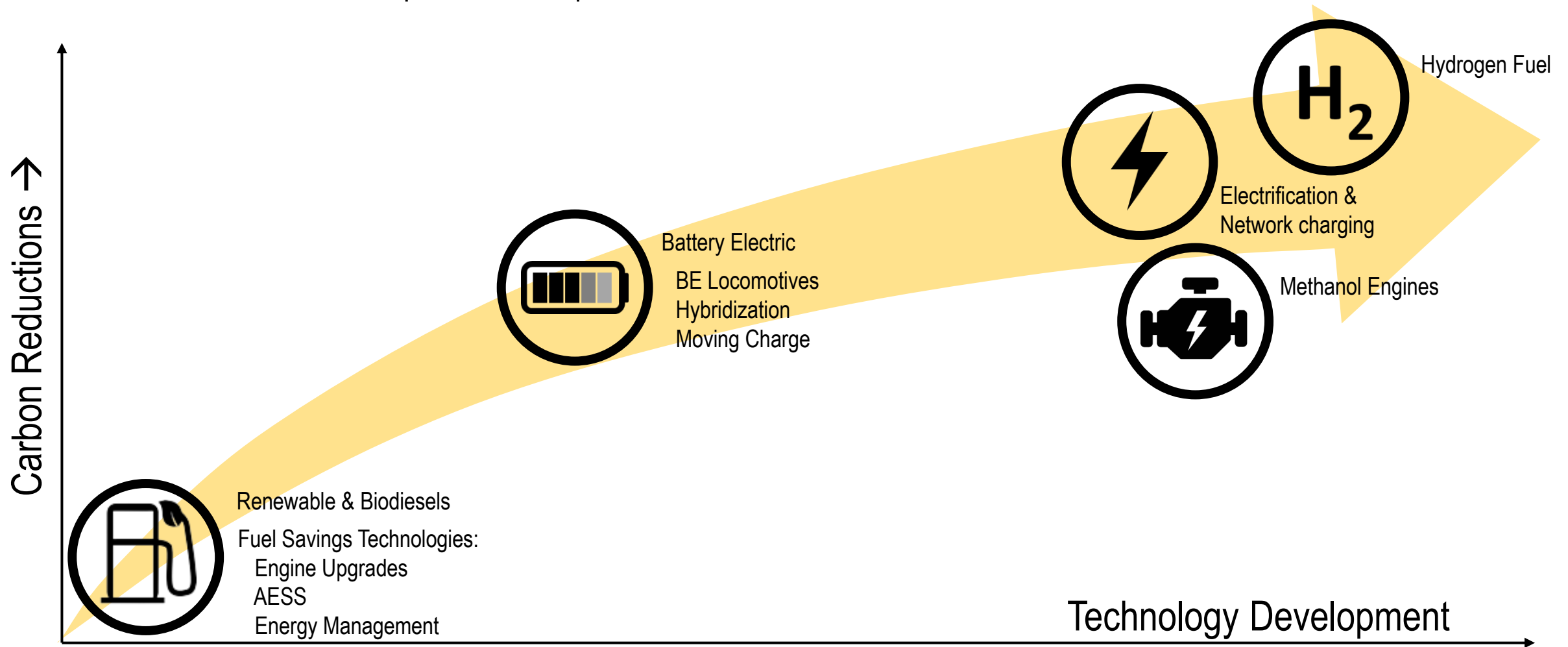
Prioritize:

- Safety
- Sustainability
- Transition Path



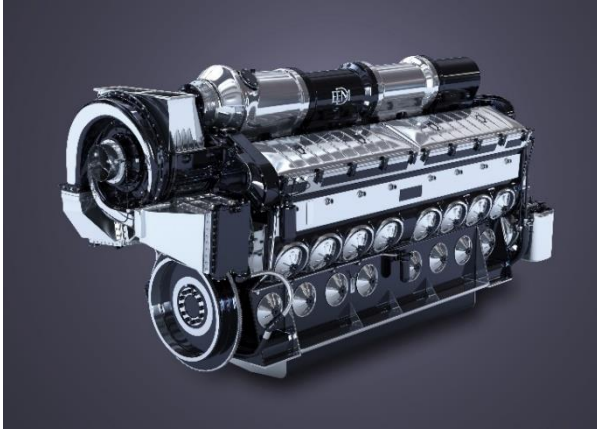
Emissions Reduction Solutions

Available now and in development for full path to zero emissions



Exhaust Emissions Reductions

Progress Rail Key Focus Areas



Renewable Fuel Development

- Approval of B20 for use in all EMD® 710 engines
- Testing of up to B100 and R100



EMD® Joule Battery Electric Locomotives

- Zero exhaust emissions operations of Vale EMD® Joule
- Partnerships with PHL, FMG, BHP, BNSF and UP



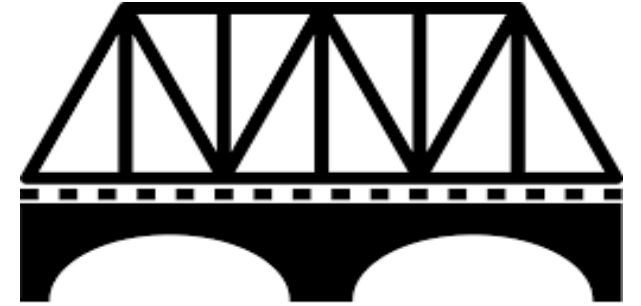
Hydrogen Fuel Cell Development BNSF and Chevron

- Demonstration of a locomotive powered by hydrogen fuel
- Partnership for technology demonstration & development

Biodiesel & Renewable Diesel

Biodiesel & Renewable Diesel are medium-term “bridge fuels”

- Substantial GHG reduction in “short time” with minimal impact to fuel infrastructure
- Less capital and operating cost impact; lower risk level to achieve GHG reduction targets
- Minimal impact to locomotive engines and fuel systems:
 - Future kit expected to ensure emissions compliance, performance & reliability



Extensive testing & observation programs in process:

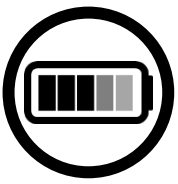
- Comprehensive stationary testing of 710 & 645 engine at SwRI with multiple blends of bio and renewable fuel.
 - Test for performance & emissions
 - Field testing plans with up to 100% alternate diesel with captive fleet– 18+ month duration
 - Observation plans with multiple engine fleets (globally) with wide range of B and R fuels
- Discussions on B100 tests
 - Target: small fleet, captive service, collaborative review of inspections and results from B50 up to B100 operation

**Developing solution for performance, reliability, durability and efficiency,
while ensuring compliance with emissions regulations.**



EMD® Joule Locomotive Capabilities & Features

Joule locomotives will meet or exceed diesel performance, excluding range

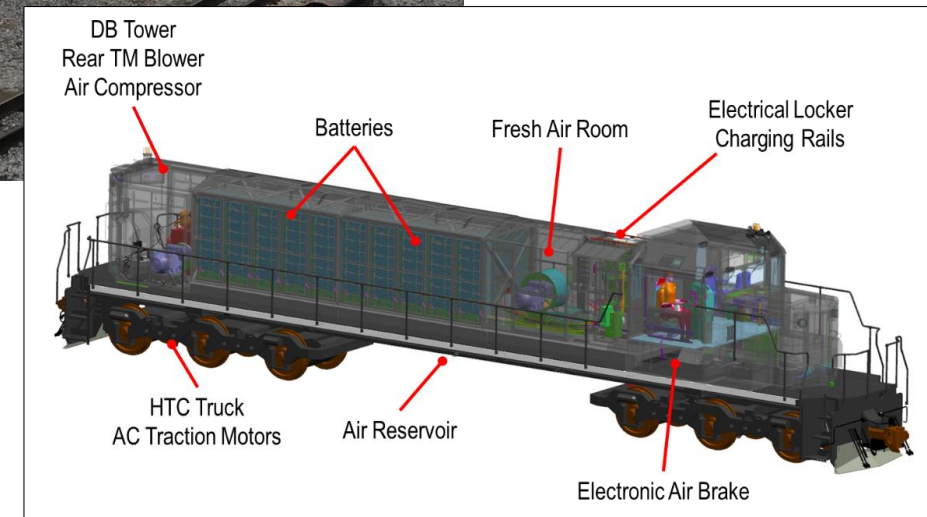
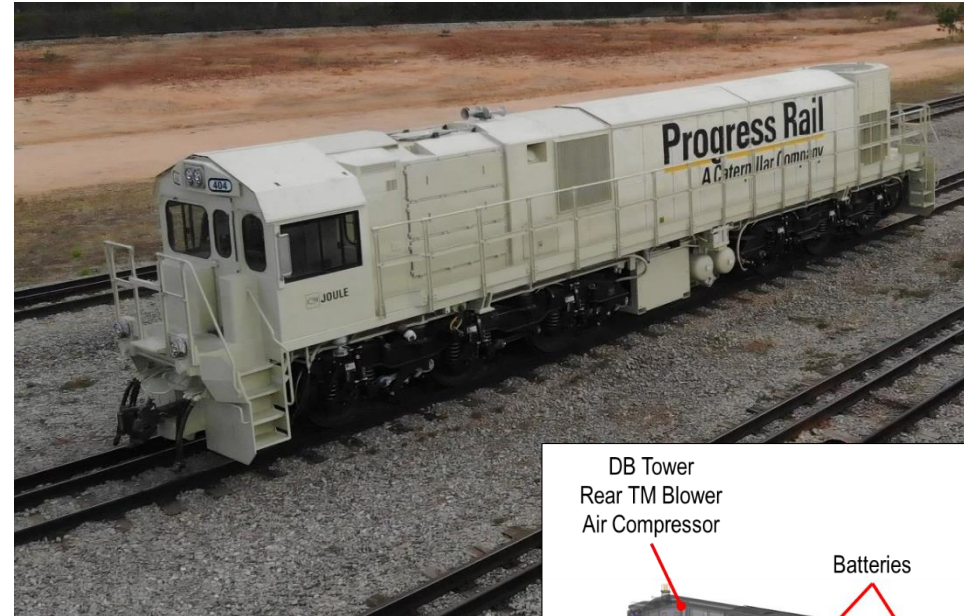


Capabilities

- Produces the same *or more* HP & TE as a diesel
- Endurance limitations (“smaller fuel tank”)
- Well suited for selected (captive) corridors and yards
- Zero exhaust emissions operation

Features

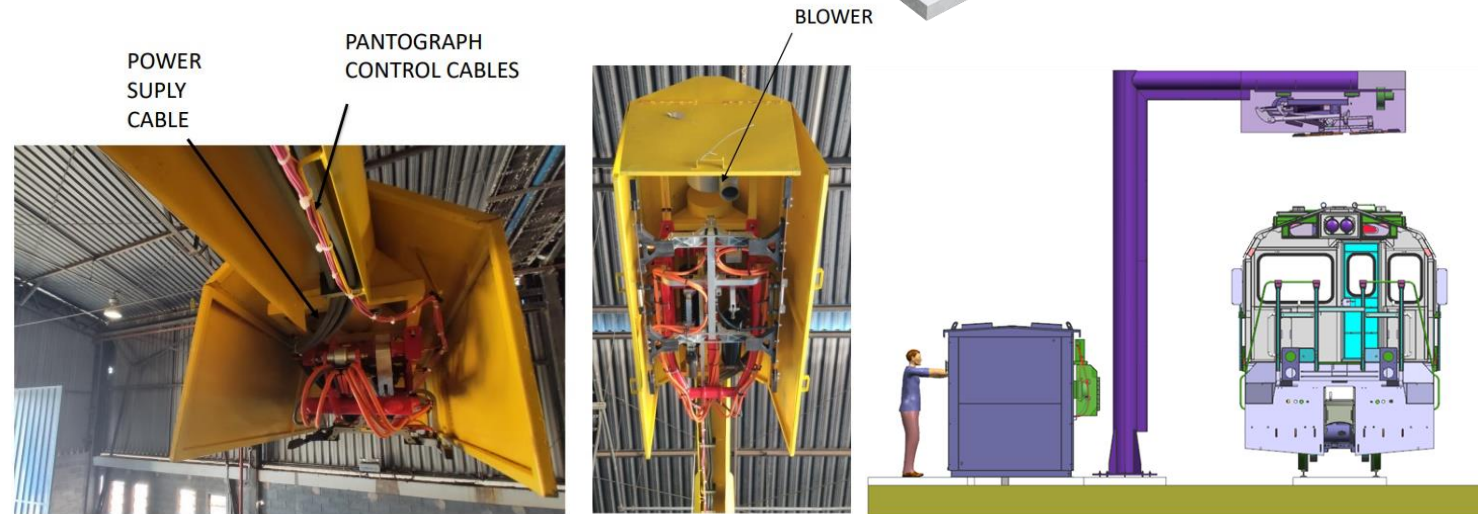
- AC traction with individual axle control
- Regenerative braking using blended braking
- Inverter-driven auxiliary equipment
 - Motor-driven rotary screw air compressor
- Very low noise (<70dB) and vibration



Battery Electric Locomotive Charging

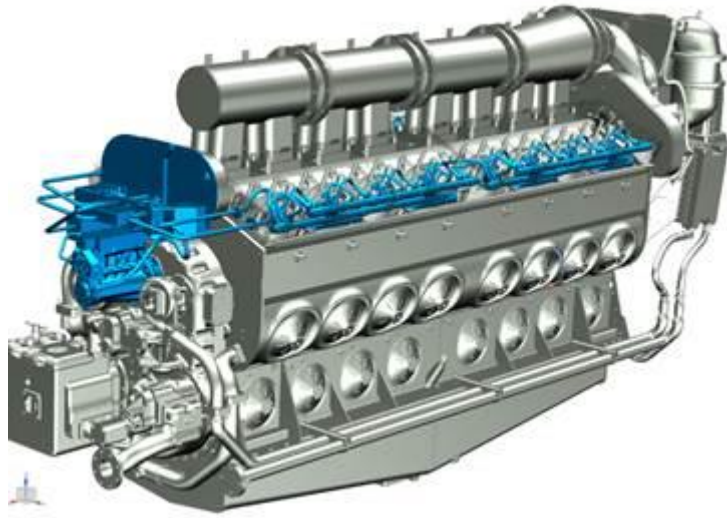
Critical factor for adoption success

- Current System
 - Reverse pantograph with Wifi Communication
 - 700 & 1400 kW charging powers
 - Multiple chargers can increase power
- AAR Standardization
- MCS integration



Hydrogen in Rail

Direct Injected Gas - Retrofit Existing Diesel



- Target conversion of existing fleets

Fuel Cell Locomotive



**Caterpillar, BNSF and Chevron
Agree to Pursue Hydrogen**

Closing & More Discussion

