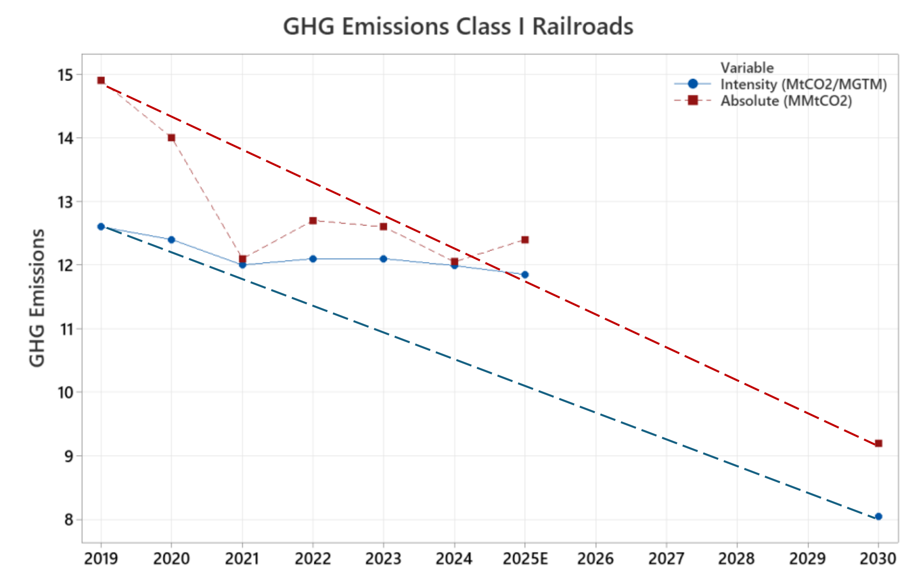
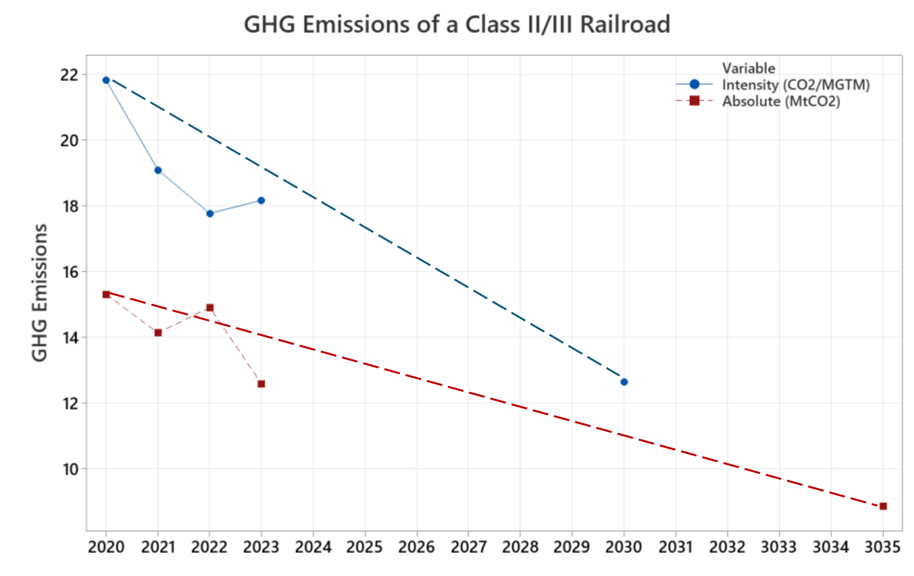
Fuel Conservation

Wayne A. Kennedy
Principal Consultant
Kennedy Consulting

Fuel Conservation – How's It Going?



Source: Sustainability Reports



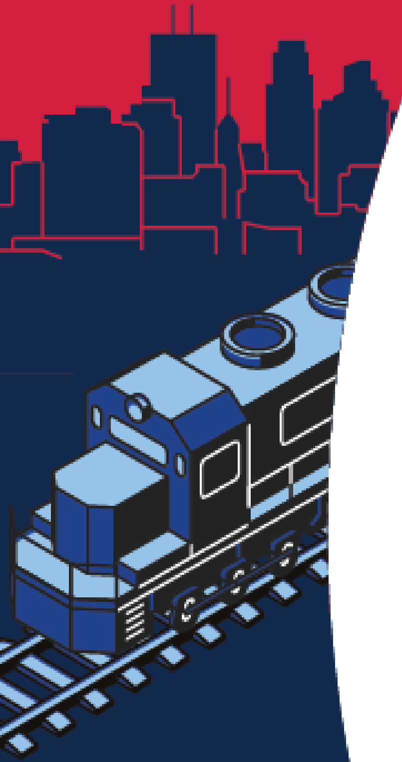
Source: Sustainability Reports

- All six Class I railroads have SBTi goals
- Fuel efficiency improvement saw good progress with 1% yearly gains historically
- Since 2020, overall performance has been generally flat through the current year, with one exception
- To-date they are about 50% towards their SBTi glideslope goals

- Only one Class II and one Class III railroad have SBTi goals thus far
- Reporting thru 2023 they are both performing better than glideslope
- No visibility for the other 600+ railroads
- Canadian required reporting shows poor performance, failed to meet 3% target

Year	Emissions Intensity (kg CO_2e/1,000 RTK)	Change from 2017 Baseline
2017	14.08 railcan	Baseline
2020	15.02 railcan	+6.7%
2021	14.42 railcan	+2.4%
2022	14.29 railcan	+1.5%

Ideas from ASLRRA webpage



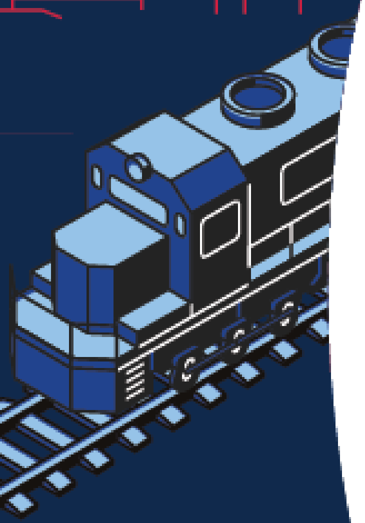
Steps Taken to Further Reduce the Environmental Footprint of Rail Transportation

- **Fuel-Efficient Locomotives:** Retrofitting older locomotives and acquiring new locomotives that emit fewer criteria pollutants and greenhouse gas (GHG) emissions.
- **Aerodynamics & Lubrication:** Adopting operational fixes to reduce fuel use. For example, advances in lubrication techniques reduce friction, ultimately decreasing drag and saving fuel.
- **Anti-idling Technology:** Using idling-reduction technologies, such as stop-start systems that shut down a locomotive when it is not in use and restart it as needed and auxiliary power units to heat locomotive water and oil and charge batteries without idling the engine.
- **Distributed Power:** Expanding use of distributed power (positioning locomotives throughout the train) to reduce the total horsepower required for train movements.
- **General Operations:** Making environmentally friendly changes throughout the workplace, including installing solar panels on office buildings and replacing company work vehicles with hybrid or electric versions.
- **Employee Training:** Training employees and contractors to help locomotive engineers and other personnel develop and implement best practices and improve awareness of fuel-efficient operations.
- **Research:** Spearheading and participating in testing and research of zero-emission locomotives and other technologies, alternative fuel use and more.

https://www.aslrra.org/environmental-impact/

All Good Steps – We'll Cover These & Some Additional Technology Applications

Approaches by General Category

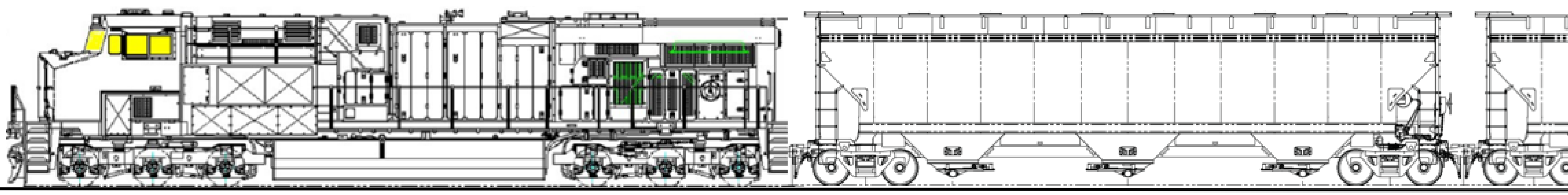


Train Drag
A. Bearing – Low friction/torque wheel bearing seal (freight cars)
B. Flange – Locomotive Wheel Flange Solid Stick Lubrication
C. Curves – Wayside TOR Friction Modifier

Removed Aerodynamics due to relatively low speeds comp Class I's

Locomotive Engine Efficiency
A. Friction modifier oil treatment (Rewitec)
B. OEM Injector Brand
C. Fuel & oil additive (Omstar)
D. Locomotive / Train Air Leaks
E. Locomotive LED Headlight (Railhead)
F. Lithium-Ion Starter Battery (MLB)
G. Water Control Valve (AMOT)
H. Reduce Air Leaks
I. Auto Engine Stop Start (AESS)

Other
A. Unneeded stop reduction
B. Fuel Management System (Veridapt)
C. Optimize Fueling Location for Lower Cost
D. Reduce Load Testing
E. High Speed Fueling - zero spill (SpillX)
F. Biofuels

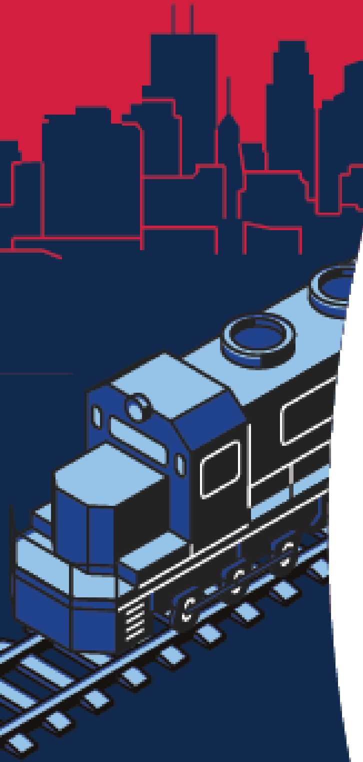


Train Power Utilization
A. EMS – Tablet driven (RailVision Analytics)
B. Yard Shutdown – Increase compliance
C. AESS Optimization thru air leak reduction/Li+ batteries
D. Locomotive Engineer training / competition
E. Reduce Horsepower Per Trailing Ton (HPTT)

Wheel/Track Rolling Resistance
A. Tangent Rail - Reduce Coefficient of Friction – Mobile TOR Friction Modifier

Two Dozen Approaches / Technologies Listed – Lets Dive Into Many in Some Detail

Auto Engine Start Stop (AESS)



1. Technology Overview for Short Lines

AESS systems monitor critical locomotive parameters (coolant temperature, main reservoir pressure, battery voltage, and reverser handle status). When parameters are safe and the locomotive is idle for a set period (typically 10-30 minutes), the system shuts down the prime mover. It automatically restarts the engine if any parameter falls below a critical threshold (e.g., low battery, low air pressure, or freezing coolant temps).

- **Relevance to Short Lines:** Short line duty cycles often involve 12-hour shifts with significant "wait time" at industries or interchanges. Without AESS, a locomotive idles at 3-5 gallons per hour (GPH). AESS can reduce this to near zero for 30-50% of the shift.
- **AESS vs. APU:** While AESS relies on the locomotive's batteries to restart the prime mover, **Auxiliary Power Units (APUs)** (like those from Hotstart or PowerRail) use a small diesel "pony engine" to keep fluids warm and batteries charged. APUs are often preferred in extreme cold (Canada/Upper Midwest) but are significantly more expensive to install ($25k-$40k) than AESS ($10k-$15k).

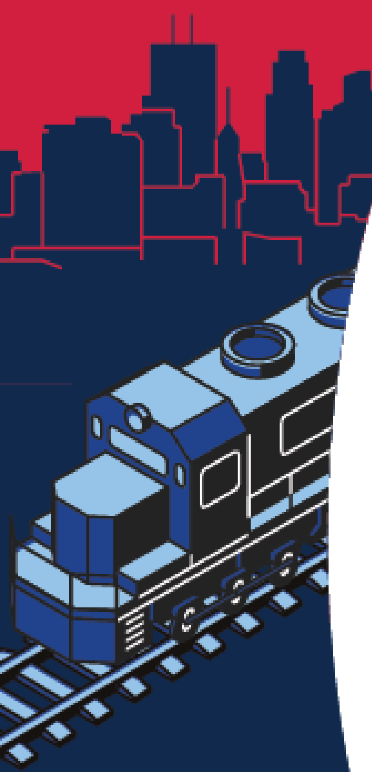
2. The Business Case: Fuel & Emissions

Fuel Savings Analysis

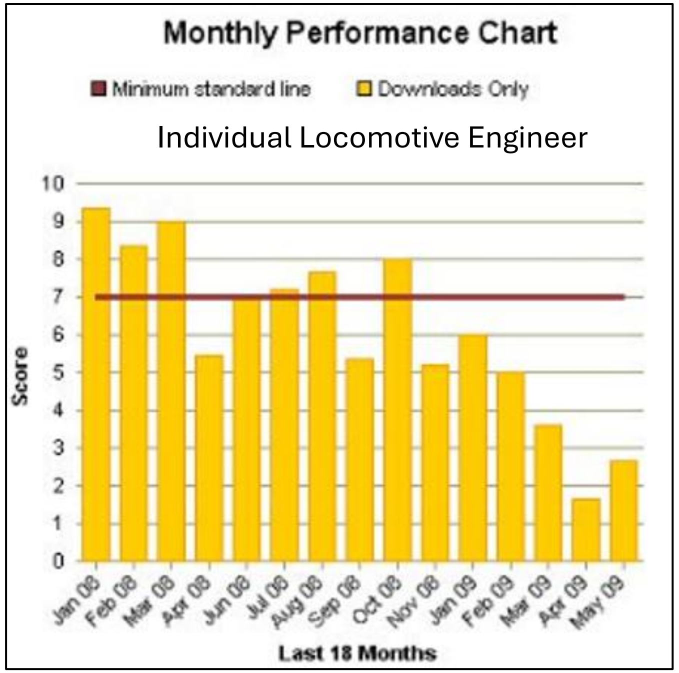
- **Idle Consumption:** An SW1500 or GP38-2 idles at approximately **3.5 to 5.5 gallons per hour**.
- **Utilization:** A typical short line switcher might run 3,000 hours/year. Without AESS, it may idle for 1,500 of those hours.
- **AESS Impact:** AESS typically cuts idle time by **40-60%**.
  - *Conservative Estimate:* 1,500 idle hours x 50% reduction = 750 hours saved.
  - *Fuel Saved:* 750 hours x 4 gal/hr = **3,000 gallons/year**.
  - *Financial Value:* 3,000 gallons x ~$3.50/gal (delivered diesel cost) = **$10,500 savings per year per locomotive**.

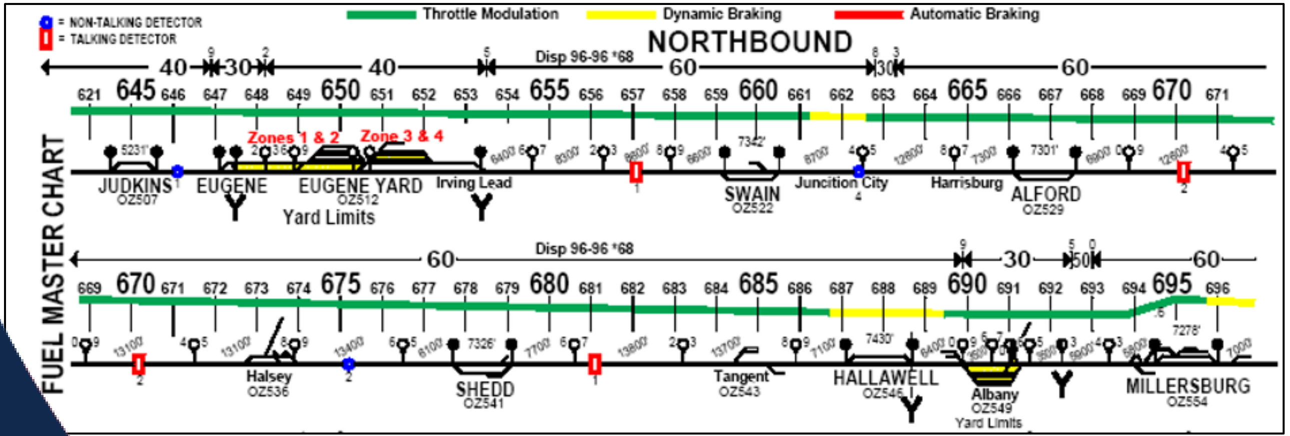
- Typical payback period of anywhere from 6-18 months, on the shorter end if grant funding is accessed
- Proven technology with multiple vendors to choose from
- Upgrade older systems with newer features such as super capacitors or Li+ batteries to handle hotel loads and air leaks
- Depending on your idling profile, AESS can be one of your largest fuel saving technologies if properly maintained and supported
- Relatively inexpensive given the degree of fuel savings potential

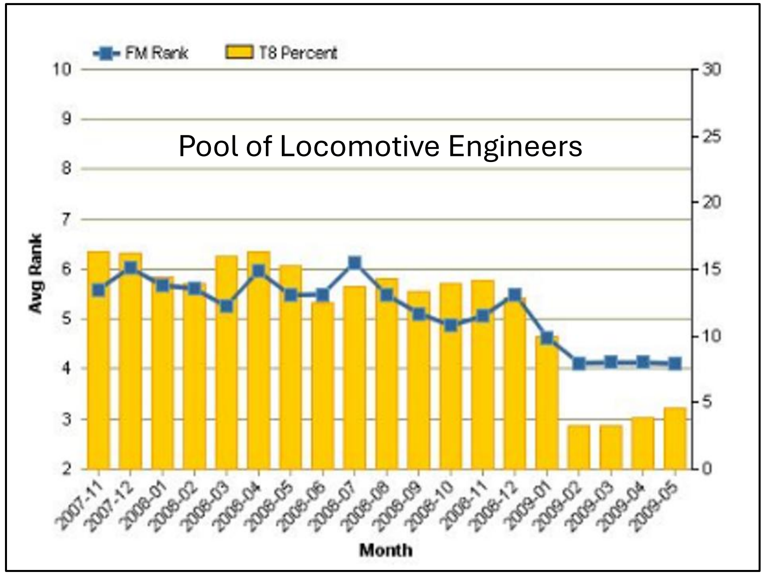
Engineer Training / Competition



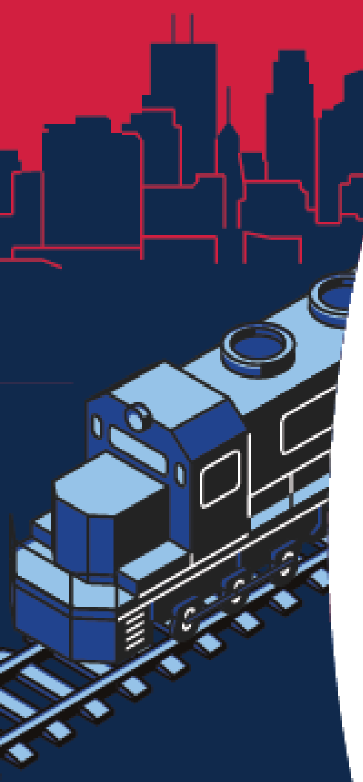
- Locomotive engineer competitions can be fun and don't need to have a financial incentive – a ballcap or a jacket will do
- A particular Class I started a program called Fuel Masters and it improved the fuel efficiency standard of 8,000 engineers by 6-7%
- While there was a financial incentive long term, the competition started with just ranking performance (no reward) and that got most everyone involved at test locations testing the concept
- Scorecards were also developed for each engineer so they could see and track their fuel savings progress / skill
- Territory "fog charts" were created to help solidify best practices
- The best engineers ended up being mentors to the newer ones
- Their safe train handling skills also improved along with fuel savings and gave them a renewed pride in their craft

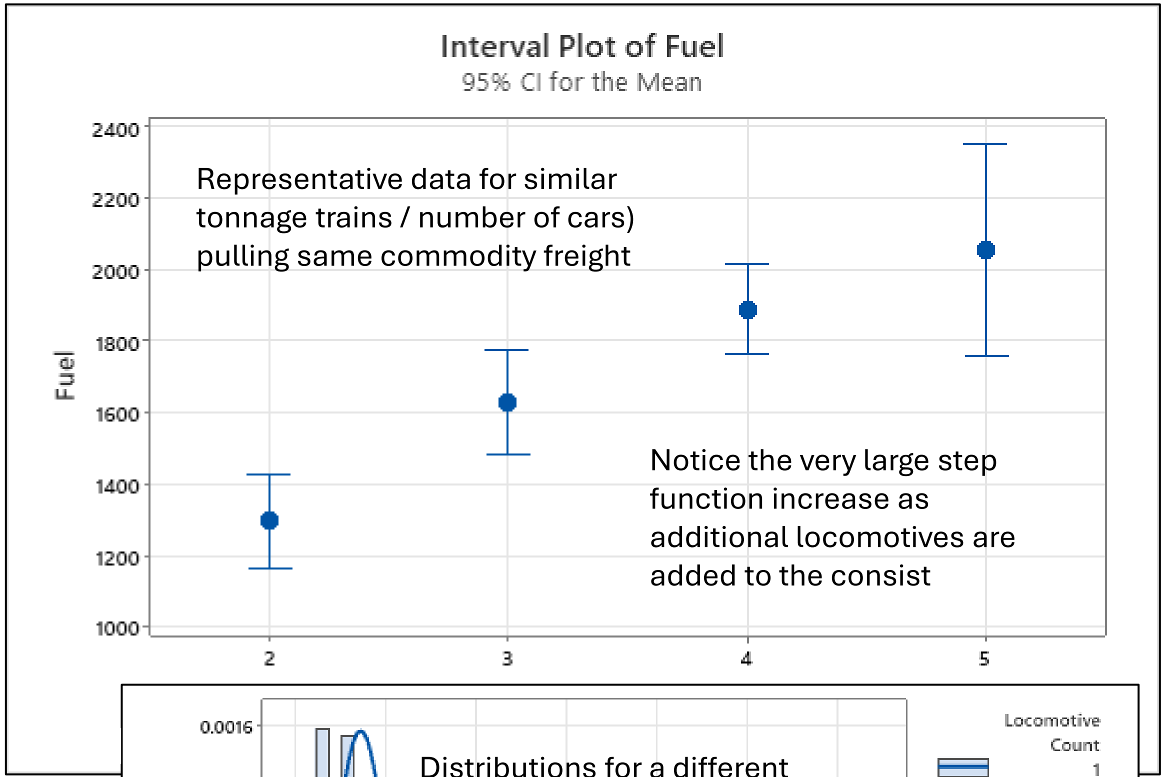


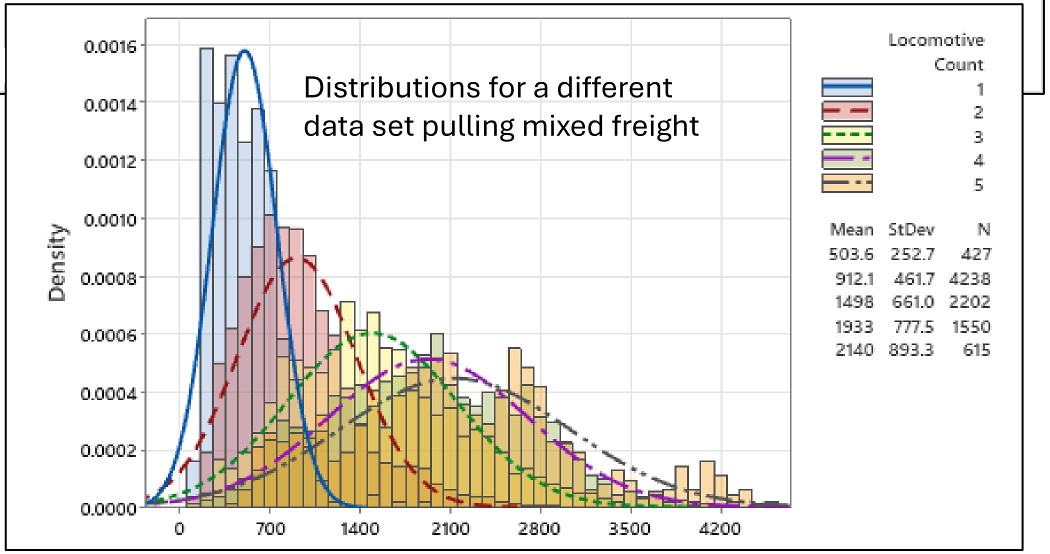




Horsepower Per Trailing Ton Reduction

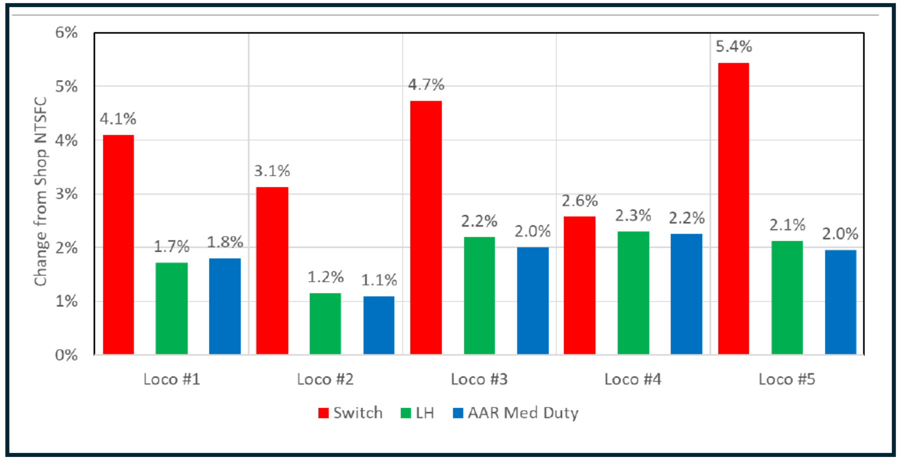




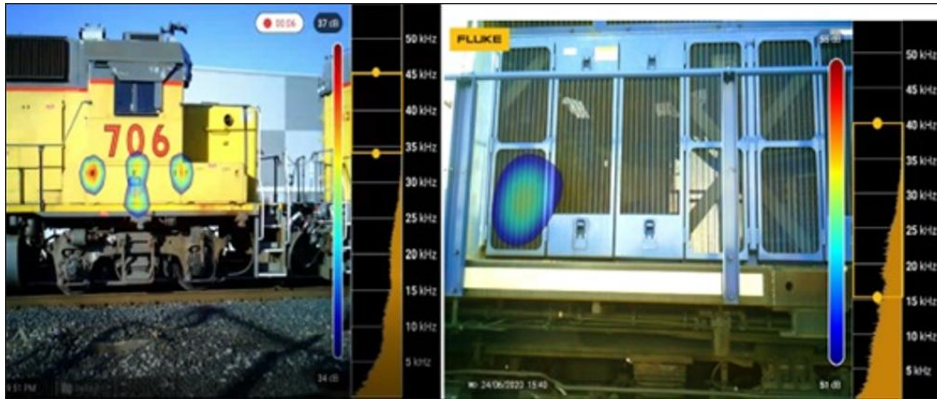


- ➢ The total consist fuel consumption is heavily dependent on the number of locomotives in the consist pulling the train
- ➢ Excess power is the #1 fuel "waster" and costs nothing to correct
- ➢ Many railroads (regardless of size) choose to put more locomotives on the train than is needed to move the freight for a variety of reasons:
  - An insurance policy in case of locomotives failing enroute
  - Moving power from point A to B
  - We've always done it this way
  - Train handling and DPU considerations
  - Building the consists for the worst-case scenario instead of the actual train, that might have 50% fewer cars than usual

Locomotive / Train Air Leaks



Source: LMOA Paper October 12, 2022 – GHG Emissions Reduction for North American Railroads, Figure 6, page 208 – S. Fritz, C. Stoos, W. Kennedy



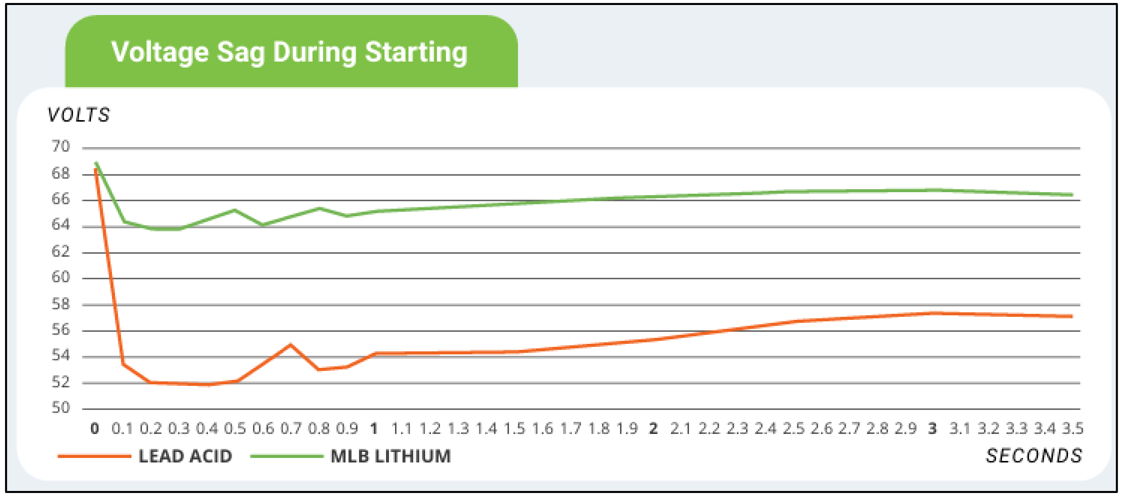
Source: LMOA Paper October 12, 2022 – Autonomous Detection of Compressed Air Leaks on Trains, Figure 15, page 149 – C. Stoos, H. Spidle and J. Janssen

- Air leaks in compressed air systems represent a significant (and overlooked) source of fuel waste
- SwRI conducted rigorous testing and discovered fuel penalty ranging from 3-5% on switcher duty cycle locomotives with a 30 SCFM brake pipe leak.
- A 60 SCFM simulated air leak (allowable per FRA CFR Part 232) measured as high as a 14% fuel penalty depending on duty cycle
- Identifying these leaks (and fixing them) during field testing showed fuel savings up to 43 gallons per day in reduced AESS idle time
- Autonomous air leak detection systems are being developed through FRA funding (Rail Safety IDEA Project 48) through the TRB
- Future systems can be either integrated into existing inspection portals or current handheld fluke meters in a maintenance shop environment

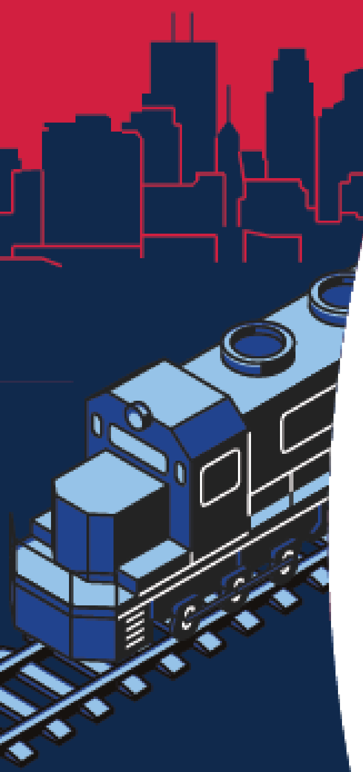
Lithium-Ion Locomotive Starter Battery

- ➢ AESS equipped locomotives will see more benefit
- ➢ Improved availability and startability with reduced fuel consumption due to no more dead / flat lead acids
- ➢ Operational lifespan is x2 to x3 depending on field application / workload / locomotive duty cycle
- ➢ Requires zero maintenance, smaller weight / size
- ➢ Reduction in waste/labor due to fewer replacements
- ➢ Improved safety – no more watering, acid burns, cab fumes, corrosion of battery box or box rebuilds
- ➢ Smart battery that always has "one last start"

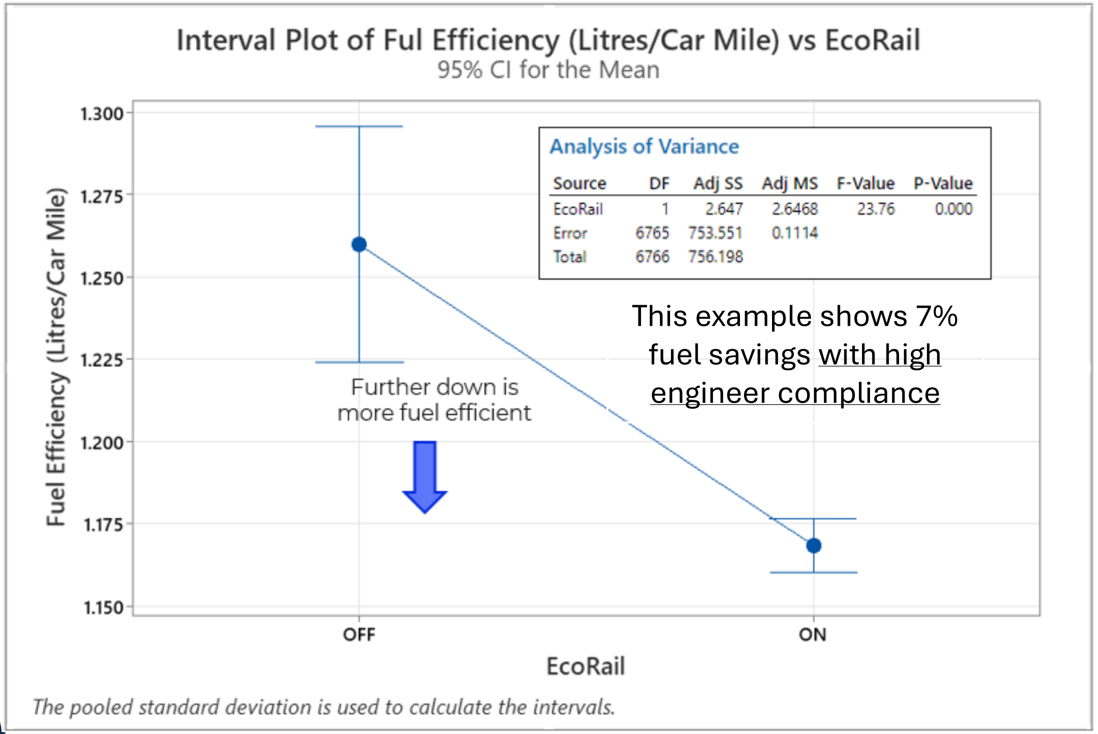
- ➢ Significantly less voltage sag protects starter components / quicker starts
- ➢ 10-year life depending on application
- ➢ Reduced recovery cost / delay due to lead acid battery "Dead Won't Start" situations
- ➢ 2nd battery could handle hotel loads
- ➢ Add a dedicated air compressor to handle air leaks

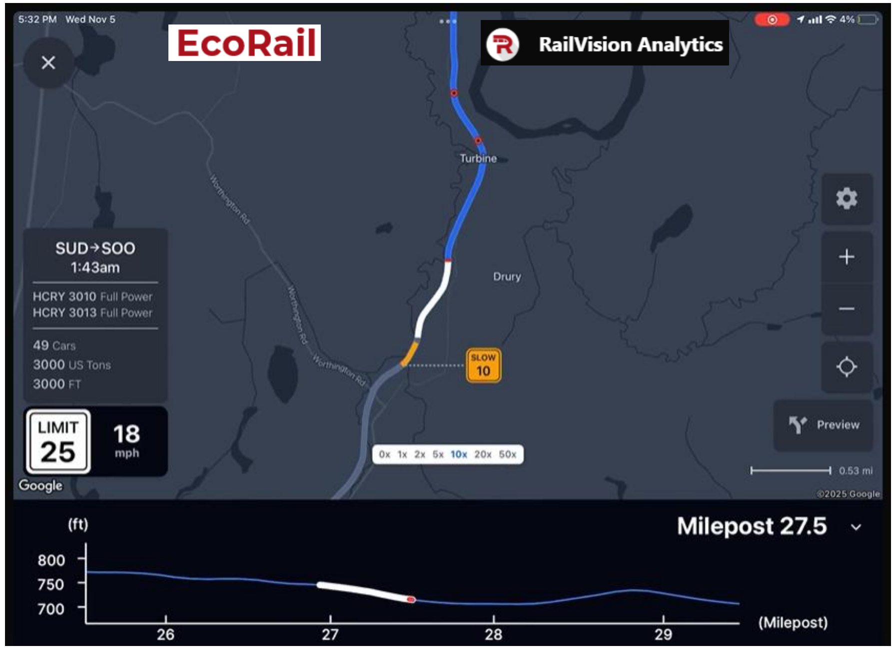


Energy Management System – Tablet



- Tablet driven (no hookups required) and portable
- Real time throttle guidance using AI optimization
- Shows terrain elevation and train position
- Slow orders, speed limits and grade crossings
- Assists crew/engineer in safe, efficient operation
- Reduces fuel consumption and protects velocity



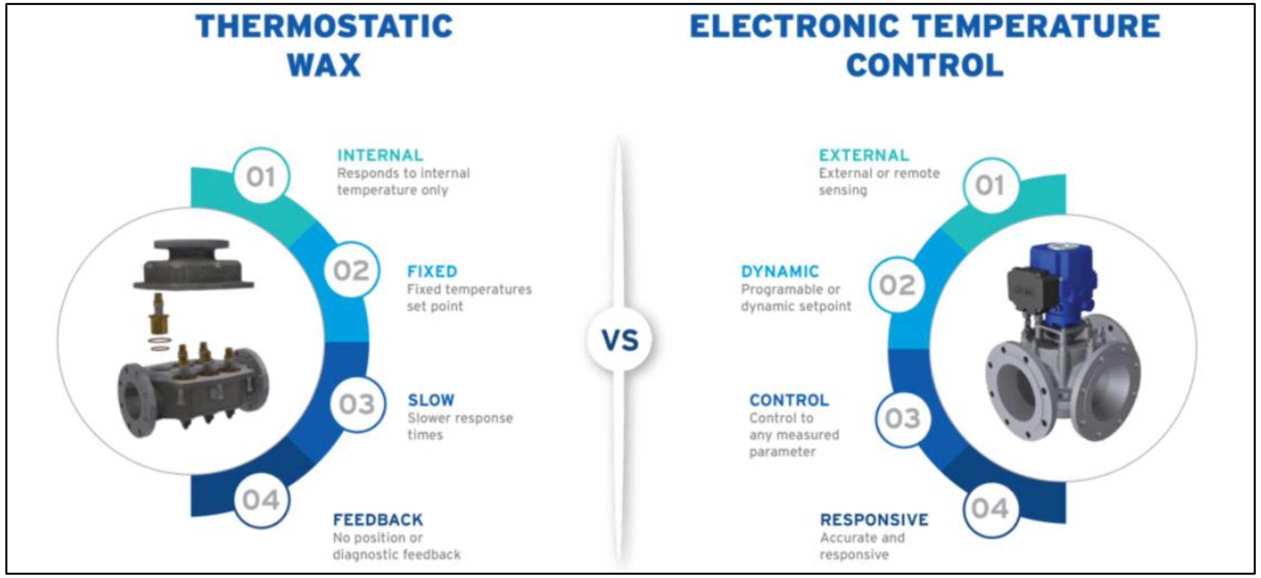


- Several shortlines / passenger rails using
- A wide range of fuel saving percentages
- Ranging from low to mid single digits
- Locomotive engineers like the interface
- Portable and requires just a Tablet
- An inexpensive version of Trip Optimizer
- Fuel savings are compliant dependent

Water Control Valve Technology

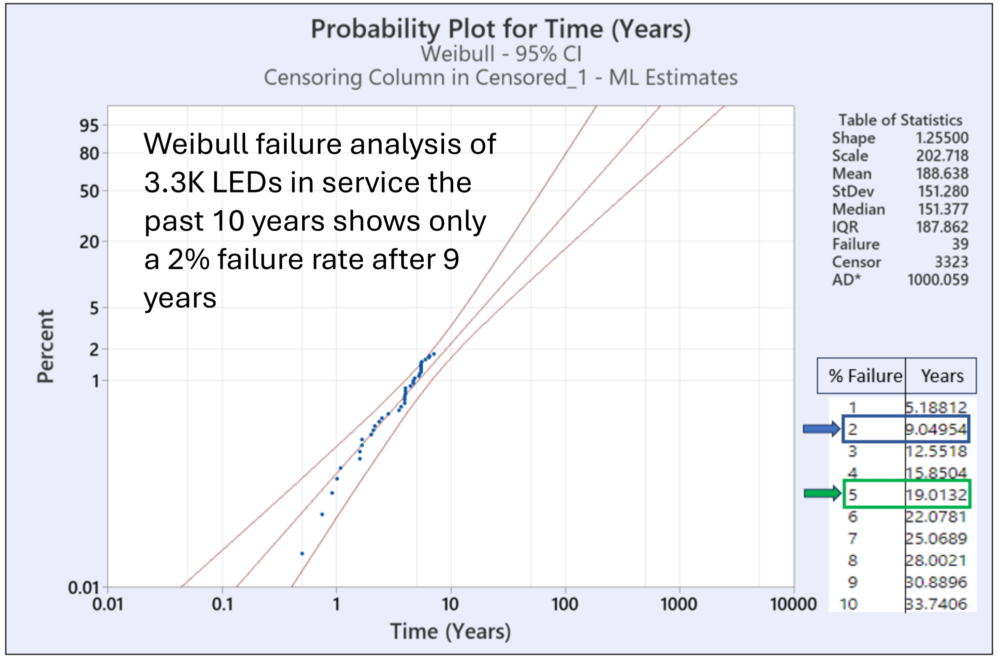
- Diesel engines consume significantly more fuel when cold
- Faster engine warm-up equates to lower fuel burn at starting
- For frequent engine shutdown, with high idle to warm up – this can equate to significant fuel savings in the 2-4% range
- Prevents overcooling, reduces unneeded heat rejection and improves thermal efficiency
- This results in ongoing fuel savings throughout operations, not just during warm up periods

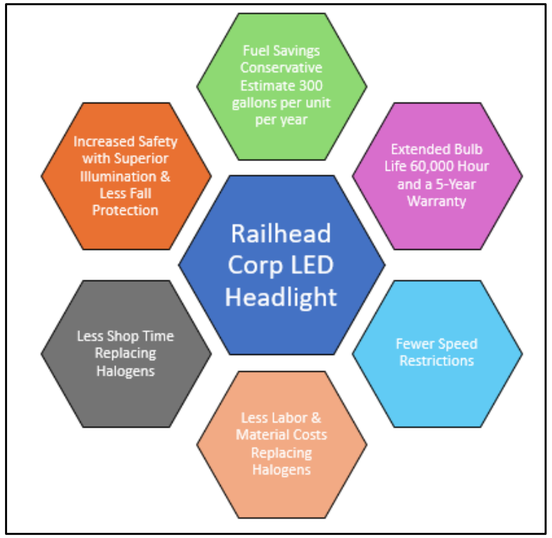
- 50% faster engine warm-up time
- Reduced soot emissions
- Split charge air cooling from jacket water to increase fuel efficiency
- Provides innovative bypass valve technology / improved steady state
- Reduces issues with frozen air lines



https://www.amot.com/en/applications/transportation/locomotive/

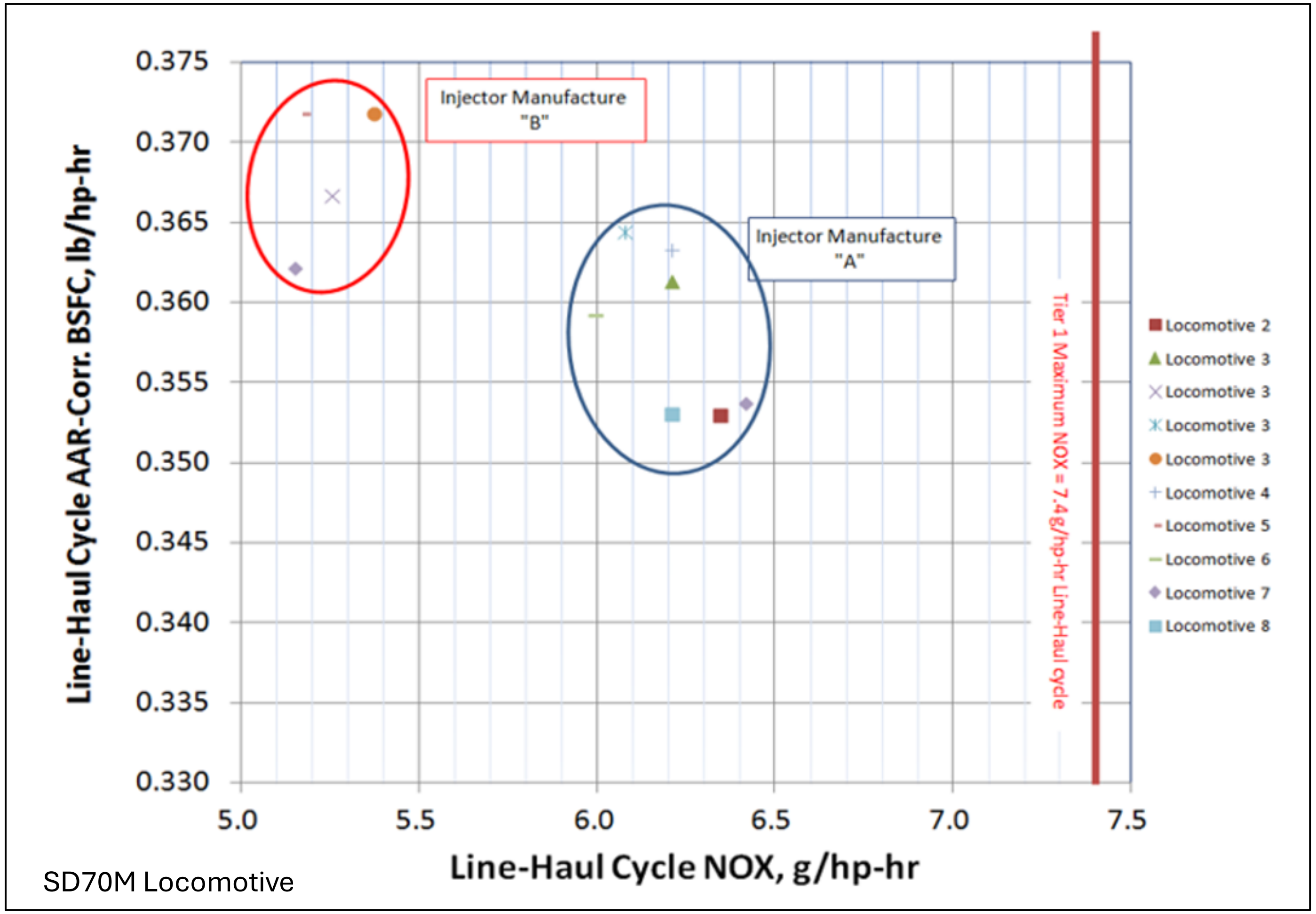
LED Headlight Technology





- Significantly higher upfront costs, but also a much longer lifespan
- Fuel savings through 1.2kW lower parasitic load (approx 300 gallons/year)
- Safety enhancements thru a more uniform light pattern / fewer changeouts (fall protection for roof mounted headlights)
- Less downtime and maintenance costs thru fewer changeouts
- Reliability & Safety main lead with fuel benefit secondary
- This technology has been more successful with shortlines compared to Class I railroads
- Though recently, a major Class I is testing 1,200 LEDs on 300 locomotive units
- No issues with winter service as railroads in northern Quebec have been using for years
- Very popular with a small fleet of HFC locomotives at CPKC and CSX

Injector Contribution to Fuel Savings

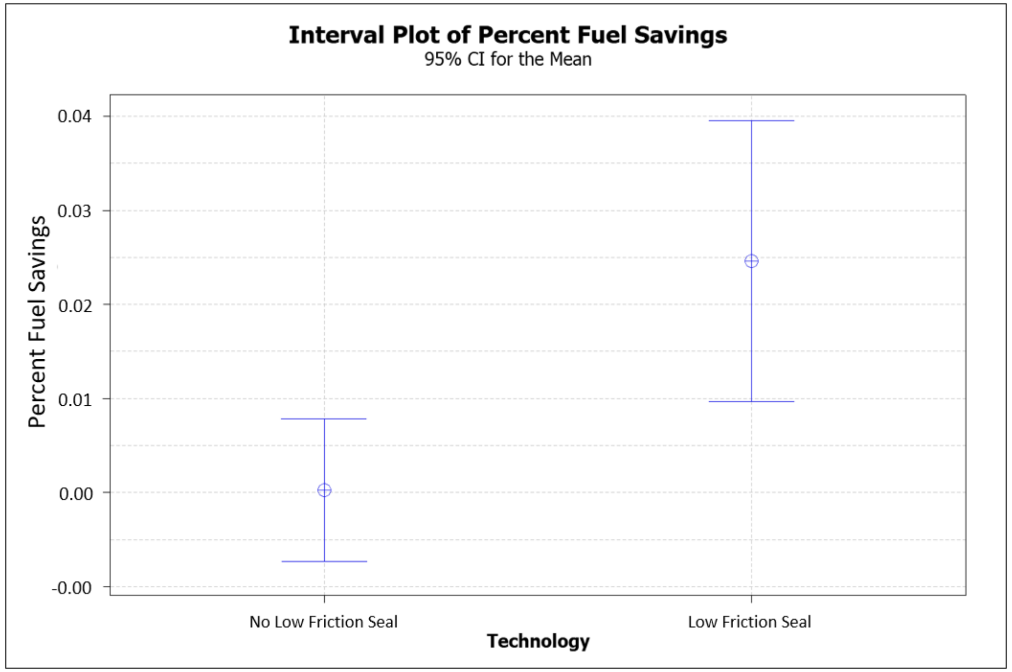


Source: LMOA Paper October 12, 2022 – GHG Emissions Reduction for North American Railroads, Figure 6, page 208 – S. Fritz, C. Stoos, W. Kennedy

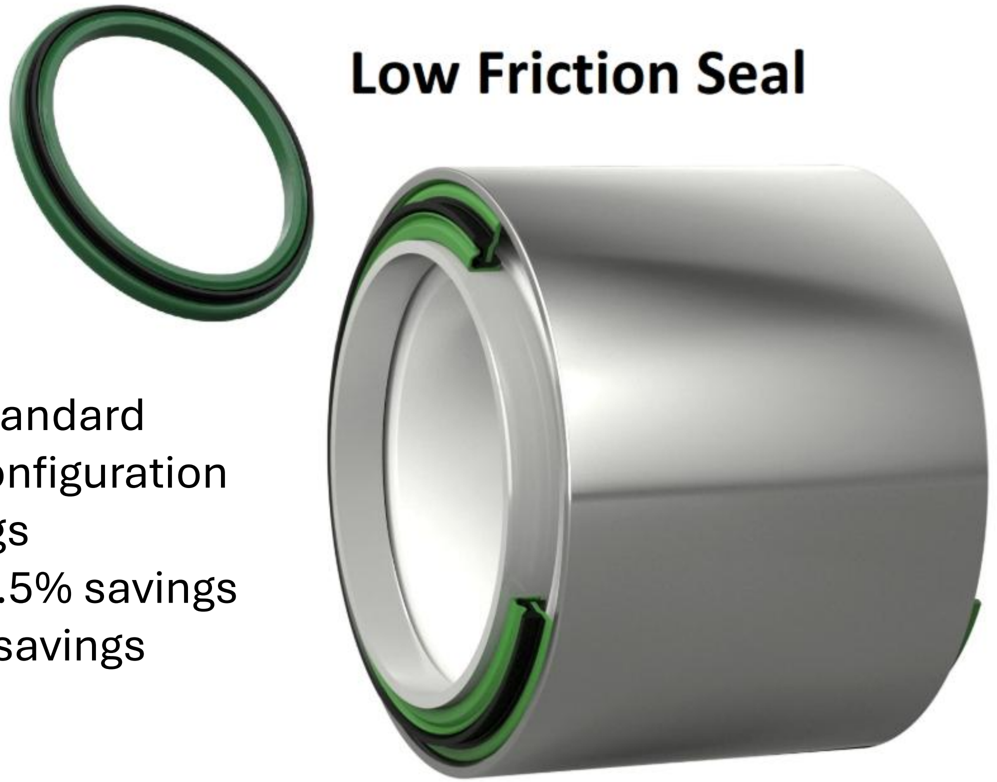
- Various brand injectors may look the same
- Some injectors are lower cost (for a reason)
- Not all injectors operate as fuel efficiently as the original OEM specified type
- Testing at SwRI revealed a 3% fuel penalty for a non-OEM fuel injector
- If the lowest cost option is attractive, make sure the performance is similar to the OEM specified type
- What you save with the lower cost part you may waste several times more expense in added fuel burn

Every Situation is Unique – Do the Math and See the Difference

Low Friction / Torque Wheel Bearing Seals



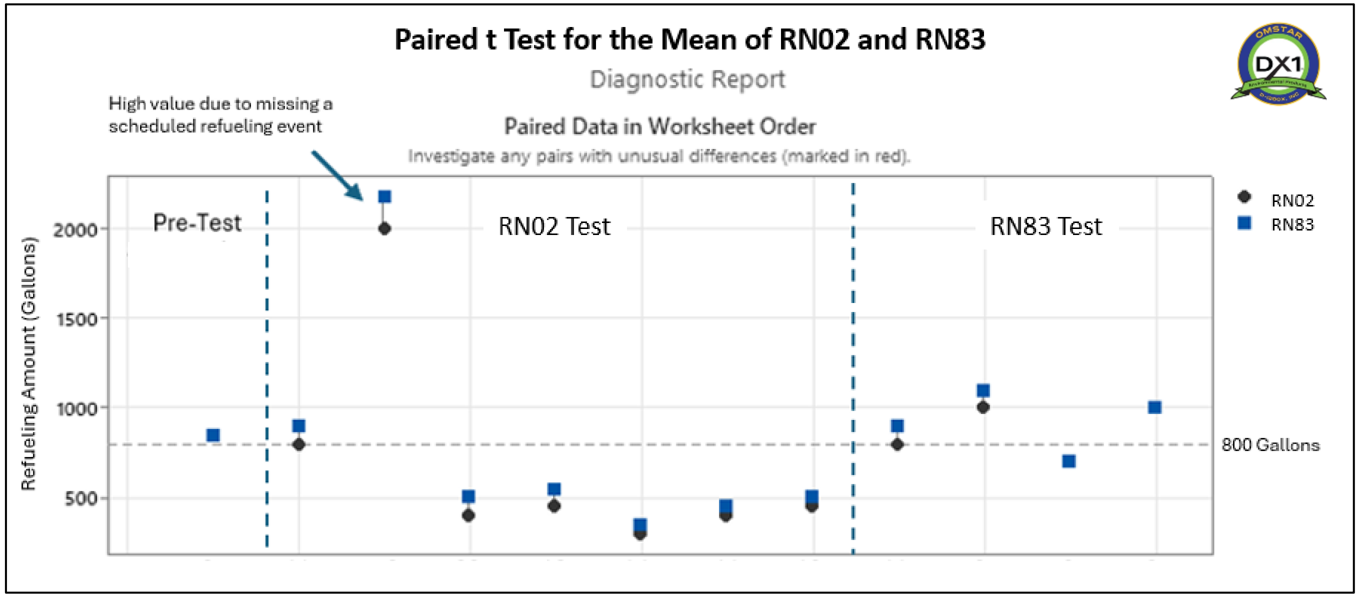
- Reduces parasitic losses / rolling resistance
- Runs cooler extending grease life
- Reduces water / contamination ingress
- Lower risk of hot-box conditions
- Longer seal and bearing life
- Lower seal torque provides fuel savings



- Test on revenue grain train service (unit train)
- Two new train sets, one equipped, the other standard
- Same territory, train length and horsepower configuration
- Tested for one year to allow for seasonal swings
- At typical Class I railroad speeds, measured 2.5% savings
- Slower speeds would see a lower level of fuel savings

Fuel and Engine Oil Lubricant

- Test protocol slaved two units together, same make, model and vintage, B23-7 GE units
- Units were refueled together weekly and refueling amount was recorded (similar throttle notch)
- Pre-test, both units were consuming roughly the same amount of fuel

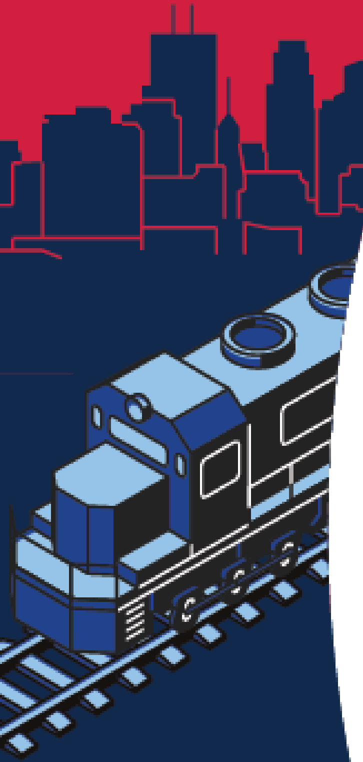


- Separation in refueling amounts post-test revealed level of fuel savings in mid single digits
- 2nd unit was then dosed and the refueling amounts once again normalized
- Weekly refueling amount driven by varying work done during that week

- Ester based lubricant acts as a friction modifier, cetane improver and combustion catalyst
- Addresses engine souping (wet stacking), injector cleaning and engine friction
- Cumulative fuel efficiency benefit for older locomotives is feasible given the combination effect
- Secondary benefits are engine runs quieter/smoother, starts quickly, white smoke (less carbon), cleaner oil and extension of oil life based on ongoing oil analysis

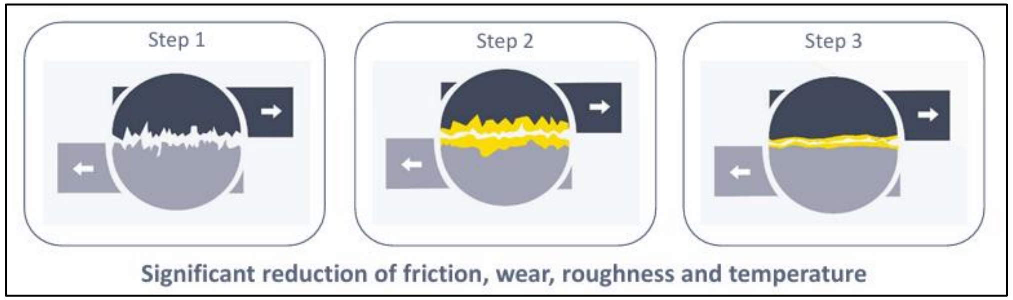
VERY SMALL SAMPLE SIZE

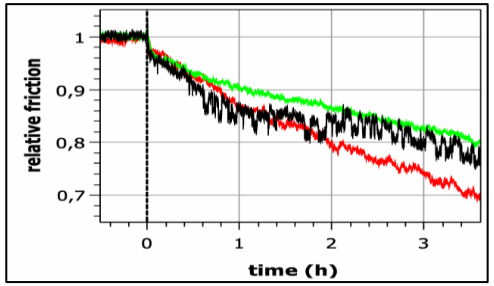
Rewitec Engine Oil Friction Modifier



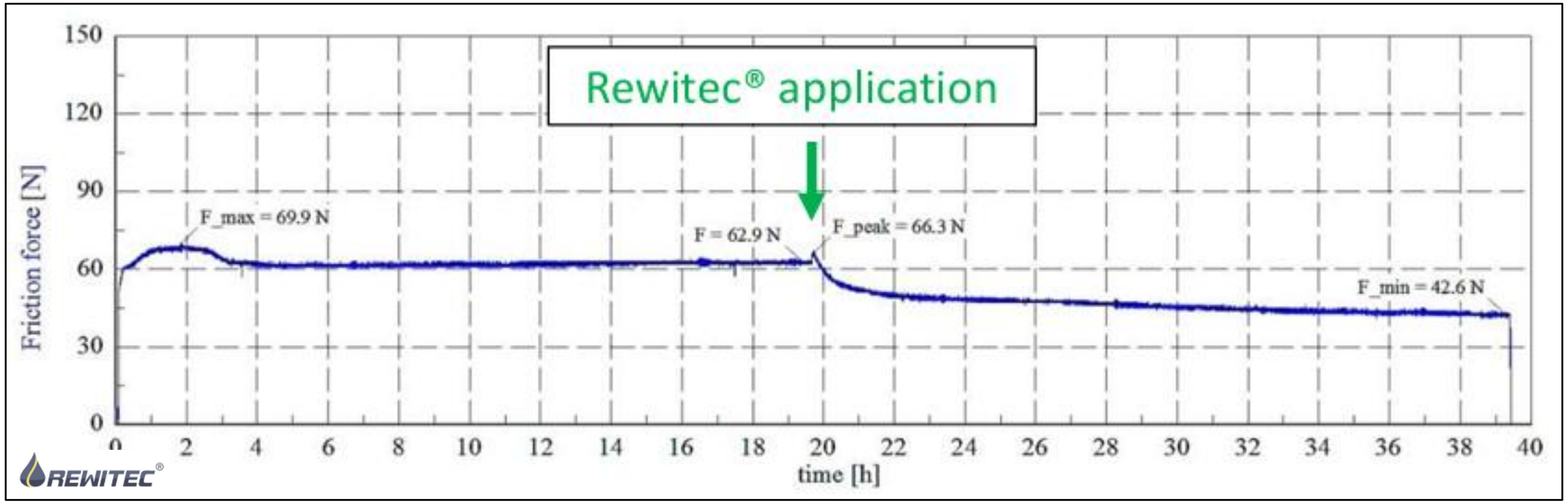
- German product popular in marine diesel engine and wind energy gearbox applications
- Internal engine friction reduction of 35-45% and temperature reduction of 5-10%
- Fuel savings analysis on a marine diesel generator (similar size to locomotive engines) showed a 3.8% fuel savings on a 2-year test
- The additive functions by using silicate particles to form a metal-silicate repair layer on surfaces
- EMD 2-stroke engine cylinder liners and bearings would see significant benefit here

Phyllosilicate based particle additive

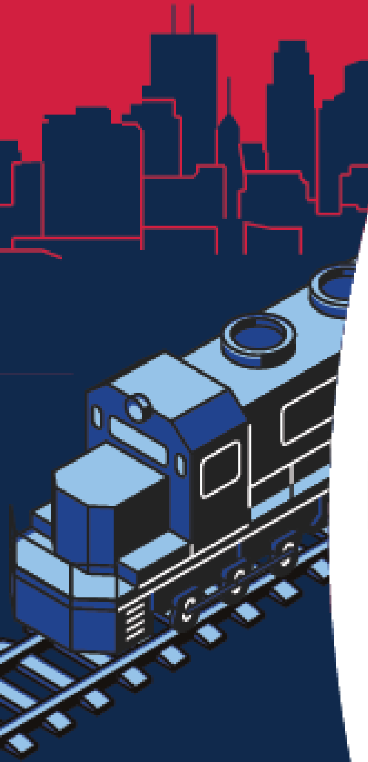


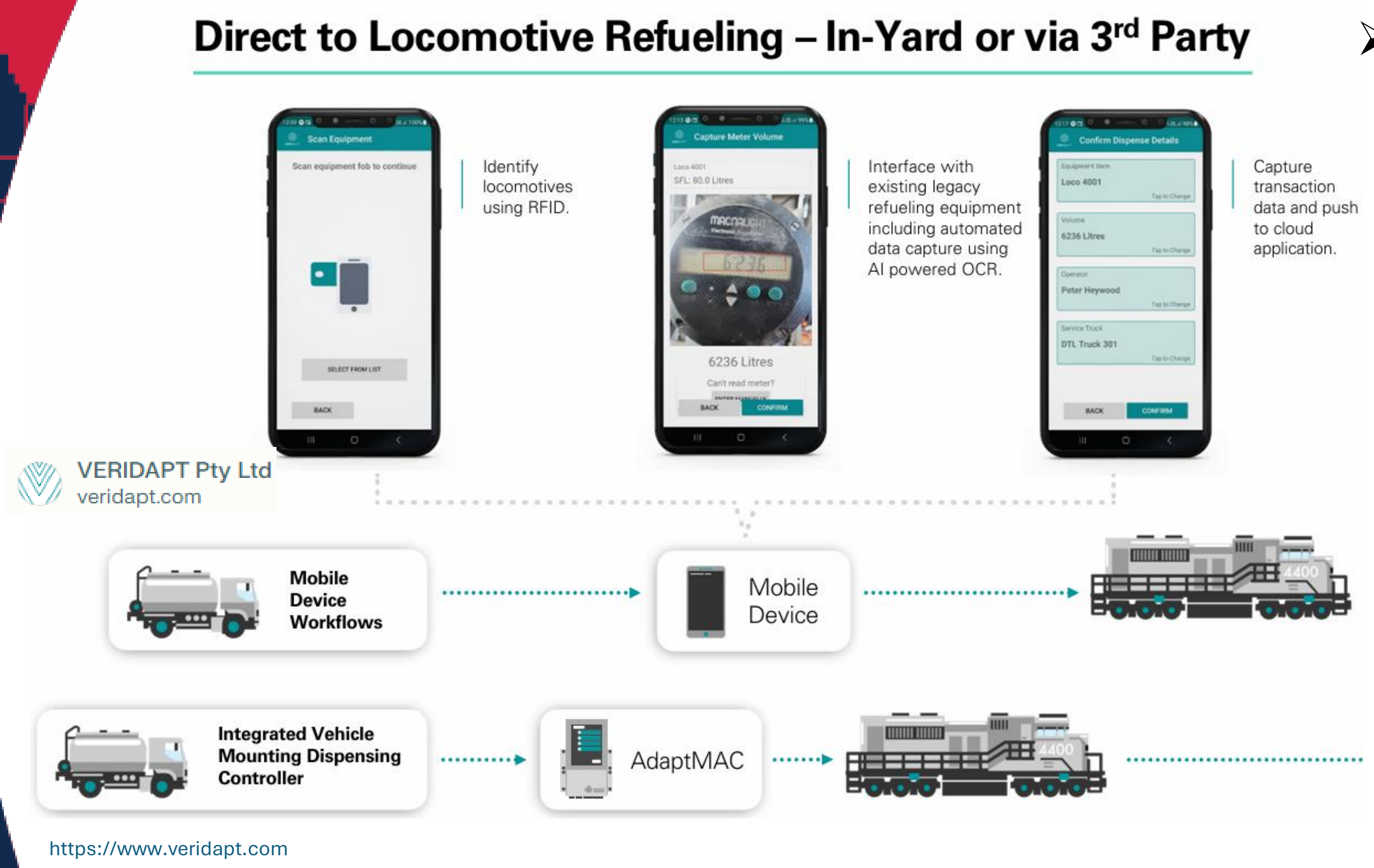


- No locomotive test performed to-date so unknown level of fuel savings compared to marine diesel engine



Fuel Management Systems (FMS)





- An integrated platform that delivers:
  - Supplier delivery verification
  - Burn rate anomaly detection
  - Theft / fraud elimination
  - Refueling strategy optimization
  - Integration with ERP & SAP
  - Easy month-end reconciliation
  - Reduced administrative overhead
- Helps to quickly identify:
  - Storage tank leaks
  - Supplier delivery shortfalls
  - Operational inefficiencies

- Typical payback periods (assuming a 4-7% enabled fuel) utilizing FMS ranges from 1-2 years
- Seamlessly manages emissions calculation tracking and biofuel blend usage
- A proven track record with Class I railroads and railroads in Australia and South America

High Speed Refueling / Zero Spill

https://mpltechnology.com/spillx_fueling

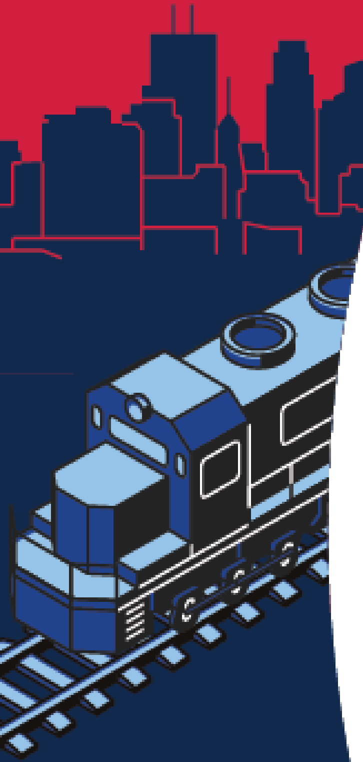
1. Technology Overview: SpillX by MPL Innovations

The SpillX system adapts **aviation refueling technology** for the rail environment. Unlike traditional "splash fill" or standard automatic shut-off nozzles which often face backpressure issues or "fail permissive" (leaking when they shouldn't), SpillX uses a **positive lock, dry-break connection**.

- **Mechanism:** The nozzle and receiver (locomotive tank port) must be mechanically locked together before the internal valves open. Conversely, the valves must fully close before they can be unlocked/disconnected.
- **Pressure Handling:** The system is designed to handle higher pressures without "line hammer" (pressure spikes), enabling the high 600 GPM flow rate without foaming or splashing.
- **Zero Spill:** The "dry break" design ensures that when the nozzle is disconnected, the fuel path is sealed at both the hose and the tank instantly.

- Effectively cuts refueling time by 50% with refueling speeds between 500-600 GPM
- Dry-break aircraft refueling technology reduces any disconnect fuel spillage from existing pints to just < 5 mL
- Eliminates major spills from overfill situations (AAR estimates $100 per gallon in remediation, labor and fines)
- Two major Class I's have tested
- One Class I has adopted citing network velocity gains, fuel savings from eliminating spills and risk mitigation as primary benefits / drivers
- Easily fitted onto DTL trucks

Biofuels to Reduce GHG Emissions



Environmental Imperative: Proven Emissions Reductions

The environmental case for biofuel adoption by short lines is compelling and supported by extensive testing data. Federal Railroad Administration research conducted on EMD locomotives—the workhorses of many short line operations—demonstrates that B20 biodiesel delivers substantial emissions reductions across multiple pollutant categories. In rail yard testing, B20 achieved a 58% reduction in carbon monoxide, 45% reduction in particulate matter, and 6% reduction in carbon dioxide emissions compared to ultra-low sulfur diesel. Over-the-rail testing showed even more impressive results, with B20 reducing hydrocarbon emissions by 59%, carbon monoxide by 50%, and particulate matter by 26%.

These reductions are particularly significant for short lines because most operate older Tier 0, Tier 1, and Tier 2 locomotives that lack the sophisticated emissions aftertreatment systems required under Tier 4 standards. While Class I railroads have gradually modernized their fleets, short lines often rely on locomotives manufactured between 1973 and 2008—equipment that represents some of the highest-emitting units in the rail sector. By adopting B20 or higher blends, short lines can achieve emissions reductions comparable to or exceeding those from expensive locomotive rebuilds, without the capital investment required for new equipment.

Implementation Pathway and Best Practices

Short lines considering biofuel adoption should pursue a phased implementation approach. The initial phase involves assessing current fuel consumption, storage infrastructure, and supplier options. Engaging fuel suppliers early in the process enables short lines to understand local biofuel availability, pricing, seasonal specifications, and delivery logistics. Many fuel distributors now offer biodiesel and renewable diesel blends as standard products.

Clean Fuels ALLIANCE AMERICA

- Not a pure fuel savings strategy (in fact there may be slightly more gallons consumed due to the lower energy content of biofuels)
- An excellent method to reduce GHG emissions (and other criteria pollutants) to meet Science Based Target goals (for short lines that participate)
- Ability to claim environmental leadership
- Class I's have funded extensive testing with and leadership with some adopting up to 10% blends with goals to reach 20% by 2030
- Supply chain is fairly well established with economic incentives in place

Summary and Conclusions

- Prioritize high ROI / quick payback technologies such as AESS
- Leverage low-cost and high impact operational practices such as engineer scorecards (competition) and reducing HPTT
- Address parasitic losses and hidden waste such as air leaks, Li+ batteries, LED’s, premium injectors, control valves and bearing seals
- Adopt technologies incrementally with proven vendor solutions
- Stack technologies to achieve cumulative fleet-wide fuel efficiency improvements

QUESTIONS?

THANK YOU!

Wayne A. Kennedy
Principal Consultant, Kennedy Consulting
wayne@kennedyconsultant.net

KENNEDY CONSULTING
402-312-0713