



# Achieving Affordable Decarbonization of the U.S. Locomotive Fleet to Net-Zero Emissions by 2045 Using a Diesel-RNG Dual Fuel “No Tender” Solution

PRESENTED BY:

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CEO & President



ASLRRRA Locomotive Power Panel



ACCELERATING THE PACE TO  
**TOTALZERO**

# OptiFuel's Successful Diesel-CNG Dual Fuel Locomotive Program at the Indiana Harbor Belt (IHB) Railroad

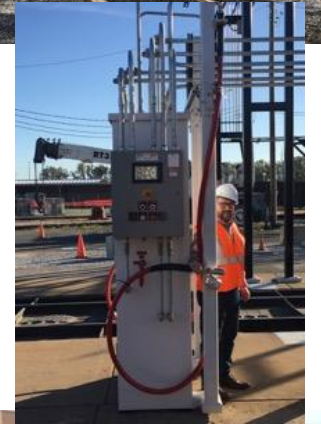
OptiFuel built four dual fuel locomotives that have successfully been in service for over five years. These locomotives have achieved both FRA concurrence and EPA approval, and they are refueled onsite

- **Converted CAT C18 Tier 4 Interim engines (750 hp) to dual fuel mode, achieving EPA certification**
- **First company to obtain FRA concurrence with CNG storage onboard the freight locomotive**
- **Integrated CNG/RNG refueling equipment into existing diesel refueling islands in just 9 months**

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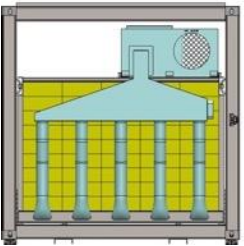
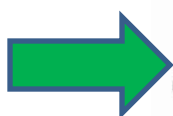
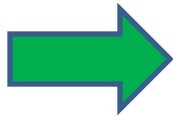
<https://optifuelsystems.com/media>

to see a video of the refueling of the CNG locomotive at the IHB Railroad



# OptiFuel Has a Current Contract With Sierra Northern Railway (SNR) to Provide the Modular Fuel Cell, Hydrogen Storage, and Battery Modules for Their Hydrogen Switcher Locomotive Program

- SNR/GTI has a contract with the California Energy Commission (CEC) to develop and test a 1500 hp Hydrogen freight locomotive and achieve FRA concurrence – will meet CARB’s ZERO tailpipe emissions requirements
- SNR has been awarded an additional contract to build three more Hydrogen locomotives
- Designed to operate in switcher and road switcher operations – see SNR for more information



Lithium Battery QD Module



Hydrogen Fuel Cell QD Module



H<sub>2</sub> On-deck Storage QD Module



**Completed in 1 Hour and 45 Minutes:**

## **Installation of Battery, Fuel Cell, Hydrogen Storage, and Cooling Modules on the Sierra Northern Railway Hydrogen Switcher Locomotive**

OptiFuel's Use of Modular Engineering and ISO-Locks Ensures Exceptional Speed, Value, and Consistency for Customers



**ASLRRRA Locomotive Power Panel**



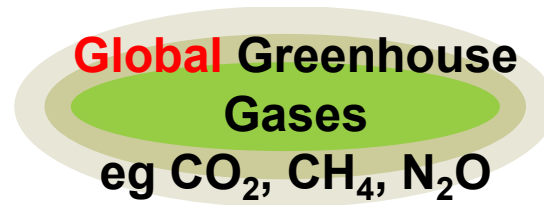
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# The Importance of Recognizing and Differentiating Between the Two Types of Emissions: Criteria Pollutants vs Greenhouse Gases

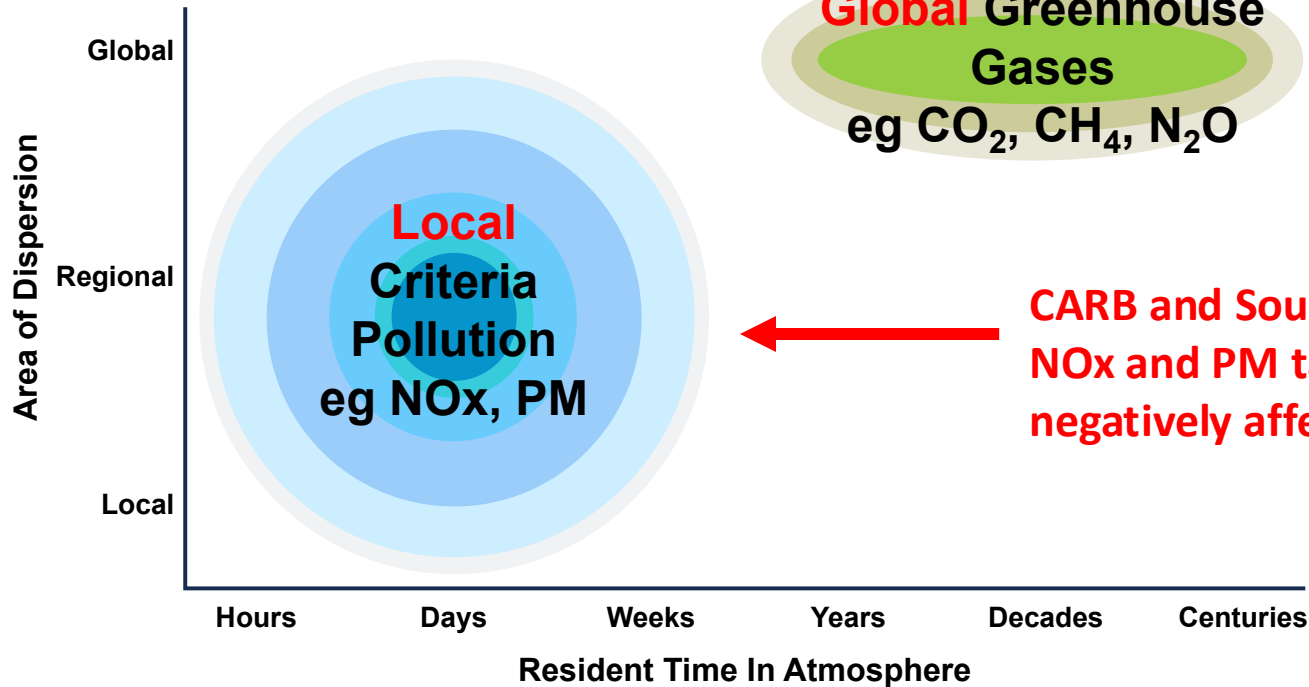
**LOCAL** Criteria pollutants (emissions) that create smog and ozone causing negative health effects are:

- **NOx - Nitrous Oxides**
- **PM - Particulate Matter**
- **CO - Carbon Monoxide**
- **NMHC – Non-Methane Hydro-Carbons**

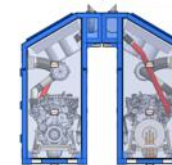
**Class 1 SBTi Net-Zero Emission Targets are based on Greenhouse Gas (GHG) emissions, which significantly impact climate change – GHG requirements will be coming to all railroads in EPA Tier 5**



**Solution:** Select or blend with clean fuels to reduce GHG emissions

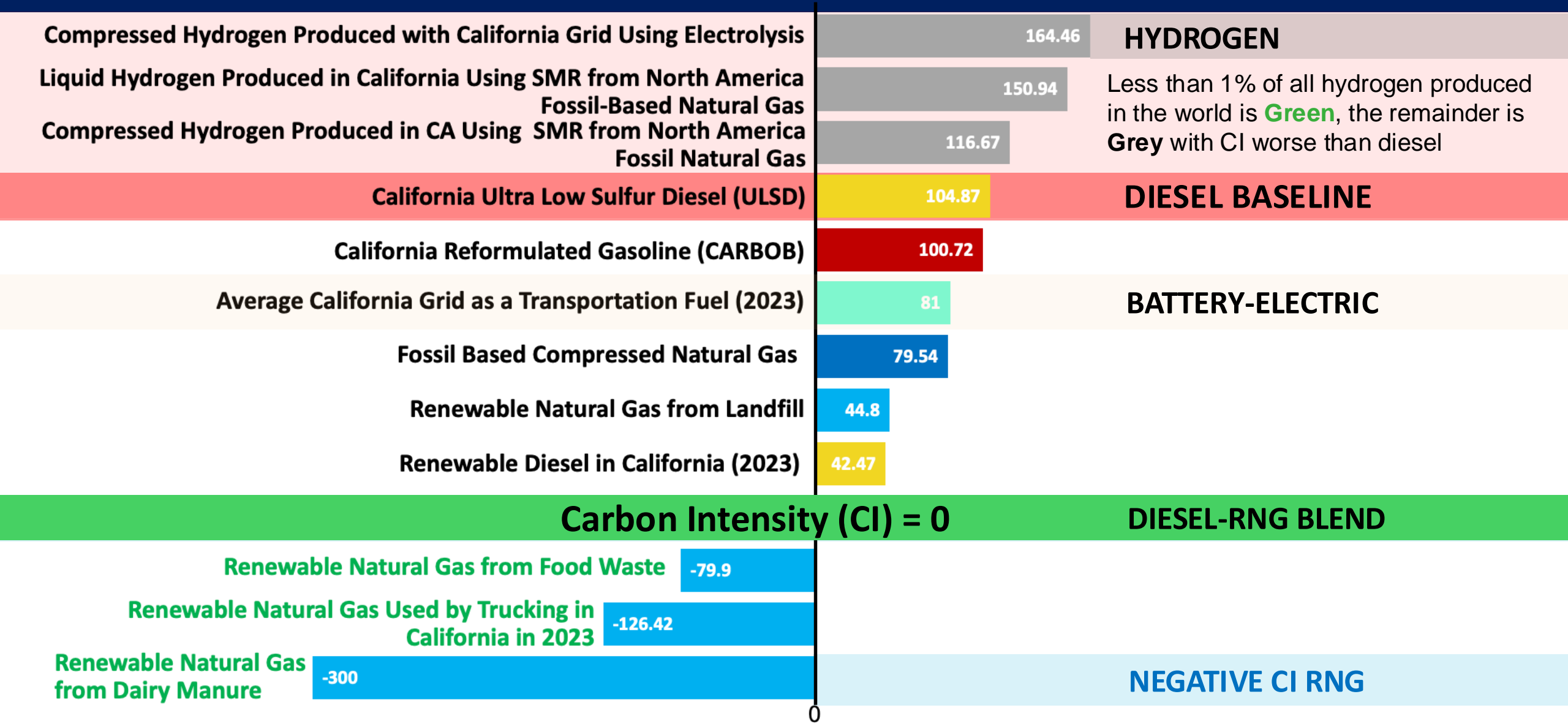


**CARB and South Coast AQMD locomotive requirements are based on NOx and PM tailpipe emissions ONLY, criteria pollutants which negatively affect public health**



**Solution:** Implement modern power system technology to effectively eliminate these harmful emissions

# Fuel Choices for Managing GHG Emissions in Rail: Lowest Technical and Cost Risk is to Blend Negative CI Renewable Natural Gas (RNG) with Diesel in Advanced Ultra Low-NOx Diesel Engines – Minimal Operation Changes Required by the Railroads



Source: CARB 2022 Carbon Intensity (CI) Lookup Table for Gasoline and Diesel and Fuels that Substitute for Gasoline and Diesel (gCO<sub>2</sub>eq/MJ)

# The Physics Behind Battery and Fuel Storage Significantly Impacts Cost, Operations and Public Safety in Line Haul Operations - Use of a Tender Should be the Last Option

**Increased Risk with Tenders:** The use of tenders for line haul operations introduces higher risks, adding congestion and hazardous materials to railways that reduce public safety

Tenders for battery, hydrogen, or RNG storage, are costly to build, test, refuel, and operate. Note that even catenary systems would require battery tenders to guarantee 24/7 operation

**RNG is the Perfect Zero Emissions Fuel:**

- The ONLY Negative Carbon Intensity Fuel
- Organic waste feed stock available to produce around 35 billion DGE annually
- Transported through the 3-million-miles U.S. natural gas pipeline network

An **ideal solution** would combine the zero NOx, PM, and GHG emissions of RNG-powered locomotives with the cost, operational, and safety advantages of diesel-powered locomotives – **no tender required**



## DIESEL

Two Tier 4, 4500 hp diesel line haul locomotives, each holding 4,700 gallons of diesel, will go 1,500 miles.



## RNG

Two 5600 hp RNG-Electric line haul locomotives, each holding 2,500 DGEs of RNG, and ONE 11,800 DGE RNG tender, will go approximately 2,500 miles.



LA → CHICAGO  
without refueling!



## L-HYDROGEN

Two 4500 hp hydrogen fuel cell line haul locomotives, each holding 350 kg of hydrogen, and Two 5,000 Kg liquid hydrogen tenders, will go approximately 1,500 miles.



## G-HYDROGEN

Two 4500 hp hydrogen fuel cell line haul locomotives, each holding 350 kg of hydrogen, and Four 2,250 Kg gaseous hydrogen tenders, will go approximately 1,500 miles.



## BATTERIES

Two 4400 hp 100% battery line haul locomotives, each with 2,400 kW-hr of battery storage and Eight 8,000 kW-hr battery tenders, will go approximately 750 miles.



# Total-Zero™ Diesel-RNG Dual Fuel Line Haul Locomotive - No Tender Required!

- ✓ Can be retrofitted to any existing switcher or line haul platform
- ✓ Near Zero NOx
- ✓ Zero PM
- ✓ Zero GHG emissions

OptiFuel's Diesel-RNG Dual Fuel locomotives will enable railroads to **select any blend of RNG and diesel to achieve their SBTi targets for GHG emissions**





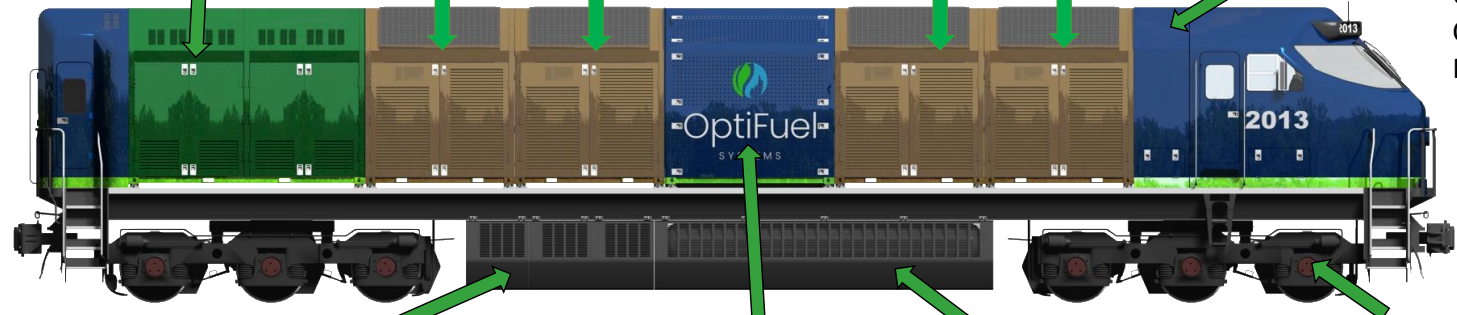
# OptiFuel's Total-Zero™ 5000 hp Diesel-RNG Dual Fuel Hybrid Line Haul Locomotive is Scheduled to Begin Testing in 2025 at FRA's TTC



- CAF AC Traction System Inverters
- Dynamic Braking Grid
- 500 hp LFP Batteries with Regenerative Braking



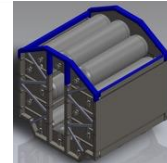
Baseline: Eight 690 hp Diesel-RNG Dual Fuel Quick-Power™ QD Modules (5,500 hp total)



Bathroom

Crashworthiness Cab and Platform

Below deck RNG/H2 Onboard Storage QD Modules with 500 DGE of RNG



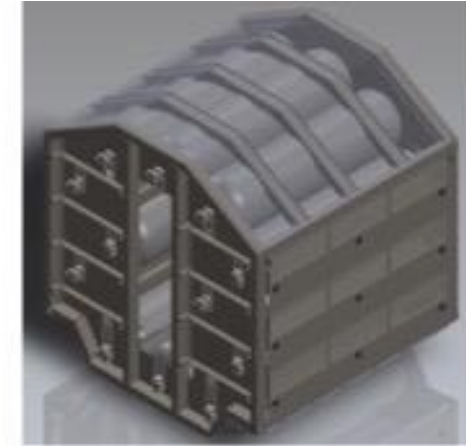
RNG Onboard Storage QD Module with 1,000 DGE of RNG

4,500 Gallons of Diesel

Six CAF AC Traction Motor and Gearbox Combos

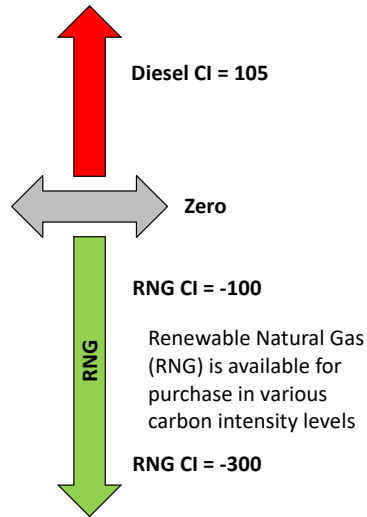
# NEW \$18,417,681 Program (\$11,671,781 CRISI AWARD) Will Fund Full FRA Concurrence of Our Zero Emission Diesel-RNG and Hydrogen Switcher and Line haul Locomotives

- New CRISI-funded program with ENSCO engineering at FTA's TTC facilities to validate the reliability, crash worthiness, and FRA concurrence of OptiFuel's **RNG/Hydrogen Onboard Storage Modules** for switchers and line haul alternative fueled locomotives to support our 5000 hp Diesel-RNG Dual Fuel Hybrid Line Haul Locomotive testing at FRA's TTC and SNR Hydrogen Switcher programs in 2026 and 2027
  - The onboard storage systems will undergo accelerated impact and vibration testing to simulate 1 million miles of revenue service
  - Demonstrate the **survivability** of an RNG/hydrogen onboard storage module on a line haul locomotive when hit by a Class 7 truck at a rail crossing
  - Demonstrate a **rapid gas-release system** on the module for major accidents with fire
- Design and install RNG and Hydrogen fixed and mobile refueling systems at TTC integrated with diesel refueling, develop new refueling standards, safety and hazard processes, and refueling procedure – all based on OptiFuel's integrated Diesel-RNG and hydrogen refueling experience at IHB and SNR
- Develop processes and documentation for training railroad industry professionals, first responders, emergency managers, safety engineers, and planning and permitting officials on gaseous fuel motive power operations, maintenance, safety, and incident mitigation - the outcomes will support safe implementation of these environmentally friendly alternative fuel locomotives in the United States



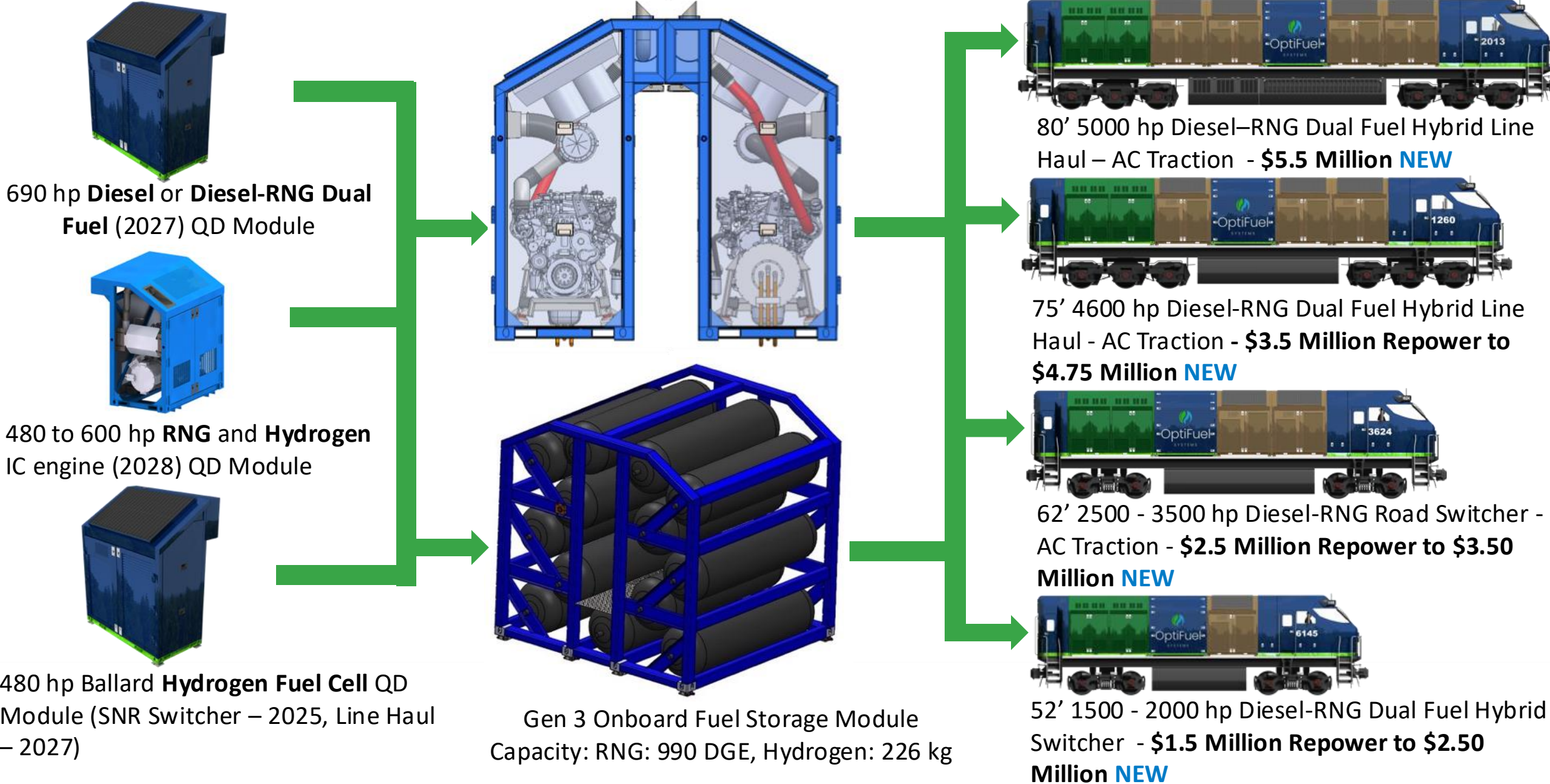
# OptiFuel Total-Zero™ Diesel-RNG Dual Fuel Locomotives Dramatically Reduce CARB Spending Account Fines by a **Factor of 16** Compared to **Tier 4** Diesel Locomotives

- Comparison table of CARB annual spending account fines with OptiFuel Total-Zero™ Diesel-RNG Dual Fuel Locomotive vs. Tier 4 Diesel
- **HUGE BENEFIT** with OptiFuel Total-Zero™ Diesel-RNG Locomotives – **ZERO** GHG emissions by using diesel that has a carbon intensity of 105 blended with 25% to 35% of RNG with a **NEGATIVE 200 to 300** carbon intensity



Locomotive Type and EPA Emission Tier	Fuel	EPA Standard - NOx (g/bhp-hp)	EPA Standard - PM (g/bhp-hr)	Gallons Used in California Annually	Annual Spending Account Fines Per Fiscal Years	GHG CARBON INTENSITY (gCO2eq/MJ)
<b>FY 2027 Operating</b>						
Pre-Tier 0 Switcher	Diesel	17.4	0.44	20,000	\$503,613	105
Tier 4 Switcher	Diesel	1.3	0.02	20,000	\$33,960	105
OptiFuel TOTAL-ZERO Switcher	Diesel-RNG	0.035	0.005	20,000	\$2,185	0
Tier 4 Switcher	Diesel	1.3	0.02	50,000	\$84,899	105
OptiFuel TOTAL-ZERO Switcher	Diesel-RNG	0.035	0.005	50,000	\$5,462	0
Tier 4 Line Haul	Diesel	1.3	0.02	150,000	\$349,365	105
OptiFuel TOTAL-ZERO Line Haul	Diesel-RNG	0.035	0.005	150,000	\$22,478	0
<b>FY 2035 Operating</b>						
Tier 4 Switcher Diesel	Diesel	1.3	0.02	20,000	\$45,986	105
OptiFuel TOTAL-ZERO Switcher	Diesel-RNG	0.035	0.005	20,000	\$2,970	0
Tier 4 Switcher Diesel	Diesel	1.3	0.02	50,000	\$114,964	105
OptiFuel TOTAL-ZERO Switcher	Diesel-RNG	0.035	0.005	50,000	\$7,424	0
Tier 4 Line Haul	Diesel	1.3	0.02	150,000	\$473,083	105
OptiFuel TOTAL-ZERO Line Haul	Diesel-RNG	0.035	0.005	150,000	\$30,551	0
<b>FY 2045 Operating</b>						
Tier 4 Switcher Diesel	Diesel	1.3	0.02	20,000	\$68,325	105
OptiFuel TOTAL-ZERO Switcher	Diesel-RNG	0.035	0.005	20,000	\$4,412	0
Tier 4 Switcher Diesel	Diesel	1.3	0.02	50,000	\$170,811	105
OptiFuel TOTAL-ZERO Switcher	Diesel-RNG	0.035	0.005	50,000	\$11,031	0
Tier 4 Line Haul	Diesel	1.3	0.02	150,000	\$702,897	105
OptiFuel TOTAL-ZERO Line Haul	Diesel-RNG	0.035	0.005	150,000	\$45,392	0

# OptiFuel Total-Zero™ Diesel-RNG Switchers Will be Shipping in 2026 and Line Haul Locomotives in 2027 for 2024 and 2025 CRISI GRANTS – All With FRA Concurrence





# OptiFuel

SYSTEMS

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📍 [OptiFuelSystems.com](https://OptiFuelSystems.com)

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