STATE OF CALIFORNIA
AIR RESOURCE BOARD

Proposed In-Use Locomotive Regulations; Notice of Proposed Rulemaking	**)**	**Public Hearing Date: November 17, 2022**

COMMENTS FROM OptiFuel Systems LLC

November 7, 2022

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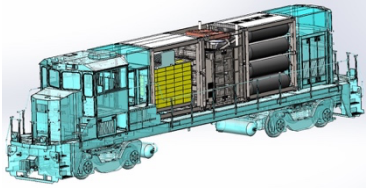
Introduction

OptiFuel provides zero emissions products (NOx, PM, CO_2) for decarbonizing rail, marine, microgrid and power generation applications with innovative, cost-efficient, and sustainable solutions utilizing bio-fuels, including both renewable natural gas (RNG) and hydrogen. OptiFuel is the only U.S. freight locomotive manufacturer that has experience in the design, operation, maintenance, and refueling for all types of EPA and FRA approved low and zero emission locomotives – dual fuel (diesel, CNG), RNG-Hybrid, hydrogen-hybrid, battery-electric.

- Previous
  - In 2019, delivered four Indiana Harbor Railway FRA and EPA approved Diesel-CNG (dual fuel) switcher locomotives and installed a FRA ap proved CNG/RNG locomotive refueling station – Tier 4; CO_2 eq. Carbon Intensity: 100 to 85

- Current
  - $5.2 DOE funded RNG-Hybrid 6,000 hp Line Haul locomotive to design and testing at FRA's TTC, and put into service – **ZERO** NOx, PM and NMHC emissions; CO_2 eq. Negative Carbon Intensity: **-523 to** 30

  - Under a $2.5 million contract with Sierra Northern Railway, designed and build the hydrogen storage module, the battery storage module and the hydrogen fuel cell module for the CEC Hydrogen-Battery Switcher Locomotive - **ZERO** NOx, PM and NMHC emissions; CO_2 eq. Carbon Intensity: 40 to 100



  - FY2022 Collaboration Agreement with FERROCARRILES ARGENTINOS SOCIEDAD DEL ESTADO (FASE), Argentina national railroad, to work together to decarbonize the passenger and freight locomotives in Argen tina (over 1,500 locomotives) over the next 6 years using OptiFuel's **Total-**

Zero™ RNG-Hybrid switcher and line haul locomotives, 10,000 DGE RNG tender cars, and RNG fueling stations around the country.

In addition, OptiFuel is the only company that has experience in:

- The only U.S. freight locomotive manufacturer that is has designed and built freight locomotives that carry FRA approved onboard high pressure (5,000 pis) gas storage systems on the actual locomotive – the four locomotives at IHB now have been in service for almost 4 years with no problems with the onboard CNG storage. The Tier 3 locomotives for East Coast Railroad use separate LNG ISO containers on an existing well car.
- The only U.S. freight locomotive manufacturer to designing and building a hydrogen-battery switcher freight locomotive that must meet all of the FRA requirements and pass the requirements of the independent Hydrogen Safety Plan. The R&D-based hydrogen locomotive built for Canadian National in Canada does not meet any of the FRA requirements.
- The only U.S. freight locomotive manufacturer that is has designed, built and installed a alternative fuel (CNG/RNG locomotive refueling station approved by FRA at IHB.

The Proposed Regulations Unreasonably Restrict the Definitions Of "Zero Emission (ZE) Locomotive" And "Zero Emission (ZE) Capable Locomotive"

The proposed regulations would restrict the definitions of ZE locomotives and ZE-capable locomotives to those "that never emit any criteria, toxic, or GHG pollutant from any onboard source of power at any power setting." That overly restrictive definition will unreasonably exclude ZE-equivalent technologies – such as RNG-Hybrid locomotives that have EPA rail engines emission qualified of 0.00 g/bhp-hr for NOx, 0.000 g/bhp-hr for PM and 0.00 g/bhp-hr for NMHC – from operating in California for no good reason.

RNG-fueled combustion engines used in steady-state in a RNG-hybrid configuration, including those being developed for use in locomotives, are ZE-equivalent. The net result is that RNG-fueled combustion engines emit criteria pollutants at ZE- equivalent levels and the GHG emissions are significantly better with a Negative CI.

Notwithstanding that well-understood fact, the proposed regulations seemingly go out of their way to prohibit the deployment of that promising ZE-equivalent technology in any locomotives operating in California. The following excerpt from CARB's ISOR makes that clear:

> [S]ome types of locomotives are called ZE locomotives outside of the [definitions of the] Proposed Regulations even though they are onboard power systems that use combustion engines. It is possible for some combustion engine technologies to achieve 0.00 g/bhp-hr for NOx and 0.000 g/bhp-hr for PM after rounding. However, even if the rounded result shows zero, PM and NOx emission rates may not be truly zero. It is important to establish that these forms of power are not considered ZE in the Proposed Regulation.

(ISOR, p. 97.)

CARB's position that locomotive engines having emission profiles that round to zero (all the way to 3 or 4 decimal places) nonetheless cannot be considered equivalent to ZE locomotives is inherently unreasonable. Indeed, if emissions measurement systems and protocols cannot detect any emissions, then neither will the relevant emissions inventories or receptors. Thus, CARB's assertion that "it is important" to prohibit the use of such clearly ZE-equivalent options has no reasonable justification or rationale behind it. Moreover, CARB should not adopt rulemakings that authorize only certain technology options (battery-electric locomotives) while effectively banning others (internal-combustion locomotives) where the emissions profiles of those technology options is the same and equivalent to zero. Rulemakings should set standards that are technology-neutral; they should not be the forum for picking technology "winners" and "losers." Accordingly, CARB needs to revise the relevant definitions to allow for the use of combustion engines that have emission profiles that round to 0.00 g/bhp-hr for NOx and 0.000 g/bhp-hr for PM.

The Proposed Regulation Eliminates the Use of RNG-Hybrid Solutions, Yet Provides No Alternative Solution for Switcher and Line Haul Locomotives That are Physically Possible, Are Commercial Available, or Cleaner that RNG-Hybrid Locomotives in a Well-to-Wheel Analysis.

The CARB proposes that all future all switcher locomotives should be battery electric. However, there are not commercially available 100% battery-electric switcher locomotives on the market. Currently, Progress Rail has built a prototype GT38JC 2.1 MWhr switcher that is 59ft long, cost $3.4 million, and can operate for 8 to 15 hours before recharging overnight.

One problem is that around 25% of the short lines in California have rail yards that will only work on 45 to 50ft long switchers due to the tight turns. Always every freight railroad goes for 5 to 7 days before refueling – recharging every night will increase labor cost.

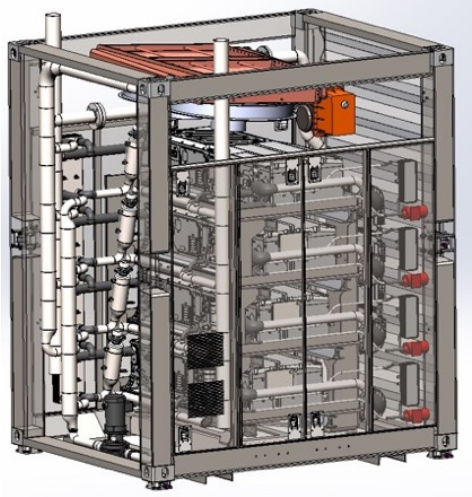
Lithium batteries require 50 times the volume to store energy than diesel fuel. Mature lithium-ion technology is fast approaching limits to how energy-density, charging time and cost can be improved – no new technology coming. **The manufacturing of a 2,400 kW-hr lithium battery pack creates the same CO2 as running a switcher locomotive for 4 years burning 12,000 gallons of diesel a year** (based on CO2 emissions created to manufacture an 80 kW-hr battery pack on a Telsa Model 3). Battery-electric switchers will always be more expensive than other options – even hydrogen-hybrid switcher locomotives.

Batteries start degrading the moment they are employed and are a very expensive storage solution with a short life of 8 to 10 years (In a Telsa, the warranty is 8 years with a 70% battery retention and is voided for damage on bad roads (high shock or vibrations)). The operating environment on a locomotive is critical to consider – lithium batteries need to operate around 70 degrees F. with multiple chiller and heater systems and need shock isolation systems. Currently, there is zero data that a battery-electric locomotives will be any lower operating, maintenance, and refurbishment cost than diesel locomotives.

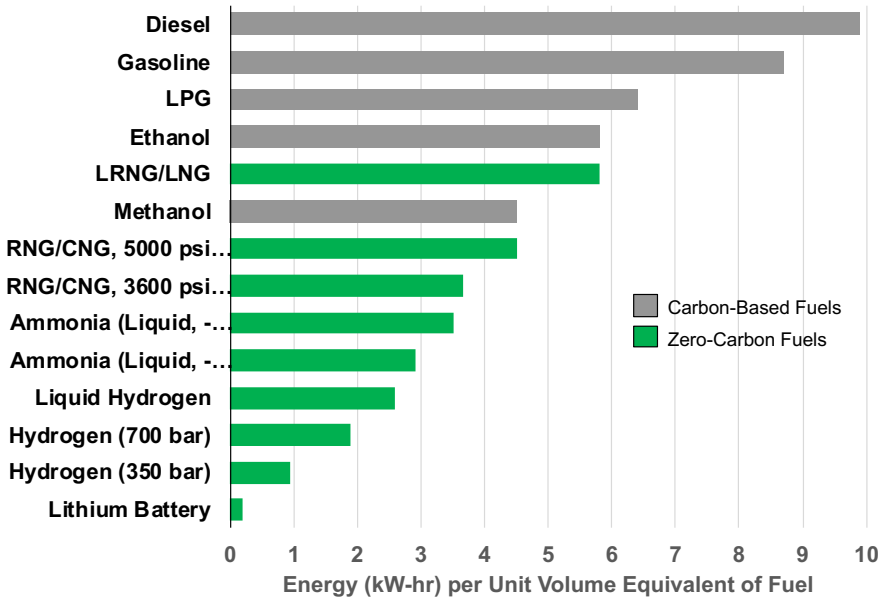
With the precarious availability of traditional grid power in California, and no commercial solutions for "end of life recycling or disposal" of large multi-megawatt battery packs, this creates a real problem for the total life cycle cost and sustainability goals for railroads.

90% of the emissions of the 35,000 locomotives in the U.S, are linehaul locomotives, yet, in **Appendix F, Technology Feasibility Assessment for the Proposed In-Use Locomotive Regulation** of the proposed regulations, CARB essentially admits that there is no hydrogen line haul locomotive available on the commercial market. In fact, the only hydrogen freight locomotive even in design phase is the CEC Hydrogen-Battery Switcher Locomotive program that OptiFuel is leading the design and that locomotive has only two 100 kW fuel cells and has a speed up to 10 miles an hour. Other hydrogen locomotives are passenger locomotives programs with the fuel cells are distributed in a several EMU coach trainsets.

A typical line haul locomotive requires 4,400 of hp or 3,300 kW or continuous power, is 75" long and carries 5,000 gallons of diesel. It will require thirty-three (33) of Ballard's new Generation 8 hydrogen fuel cells (each cost $200K) to produce 3,300 kw of power. It is possible to package four of the fuel cells into a 120" long, 80" wide and 120" tall fuel cell module. To produce 3,300 kw of power, it will require eight of the fuel cell modules (each with 4 fuel cells) and other modules such as the cab, electronics, etc. and that will require a 120 feet long line haul locomotive to hold everything. AAR does not allow any locomotive to be over 80ft in length.

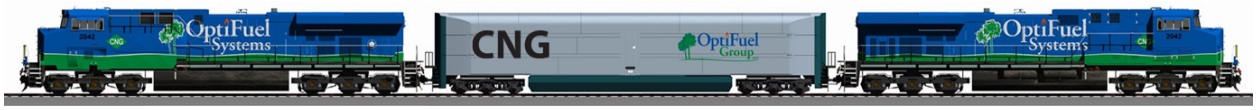


Hydrogen requires 11 times the volume to store energy compared to diesel. The rail and trucking industry have already evaluated the use of LNG vs CNG for refueling and both decided not to uses LNG since it was not as safe as CNG. The same thing will also happen with liquid hydrogen vs 350 and 750 bar hydrogen for the same reasons. It this moment, that is now activities to develop a hydrogen tender car that will meet the FRA tender standards for crash worthiness.



Below is a apple-to-apples comparison of two 4,400 hp line haul locomotives, each carrying 5,000 gallon s of diesel vs two 6,000 hp RNG-Hybrid locomotives, two 3,000 ho Hydrogen-battery locomotives, and two 4,500 hp battery-electric locomotives.

DIESEL Baseline : Two 4,400 hp linehaul locomotives, each holding 5,000 gallons of diesel
Estimated Total Cost: **$7 million** (30-year life)
In Production



RNG- Hybrid Baseline : Two 6,000 hp Total-Zero™ RNG-Hybrid linehaul locomotives, each holding 2,500 DGE of RNG and **One** 10,500 DGE RNG powered tender that provides an additional 3,000 hp of tractive effort
Estimated Total Cost: **$10 million** (30-year life for locomotive and tender)
In production in 2025

HYDROGEN Baseline: Two 75” 3,000 hp linehaul locomotives, (cannot put 4,400 hp on a standard 75’ locomotive using current hydrogen fuel cell technology – need 120’ locomotive)
Extra storage required for diesel-equivalent power with hydrogen: **Three** 3,000 Kg H2 tenders plus **One** 1,500 kW-hr battery tender
Estimated Total Cost: **$23 million** (10-year life for fuel cells and batteries)
In Production: TBD if at all

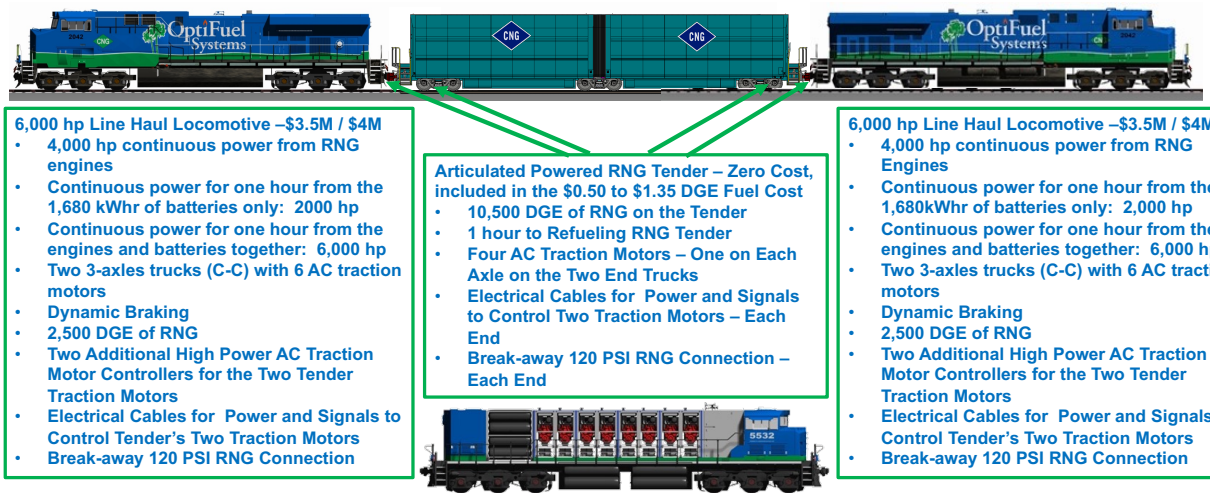
BATTERY-ELECTRIC Base: Two 4500 hp locomotives, each with 2,400 kW-hrs of batteries that can operate at full power for 8 hours
Extra storage required for diesel-equivalent power with batteries: **Eight** 3,500 kW-hr battery tenders
Estimated Total Cost: **$30 million** for 8 hours operation at full power (10-year life for batteries)
In Production: TBD if at all

The Proposed Regulations and the Associated Appendix F, Technology Feasibility Assessment for the Proposed In-Use Locomotive Regulation Purposedly Ignored a Low Risk, Low Cost, Zero NOx and PM Emissions Solution for Switcher and Line Haul Locomotives

The last two years, the CARB staff has ignored any other solution other than battery-electric for locomotives even they were well aware that **OptiFuel had Rail Certified from EPA** the Cummins ISX12 engine in steady-state mode with emissions of 0.00 g/bhp-hr for NOx, 0.000 g/bhp-hr for PM and 0.00 g/bhp-hr for NMHC. The CARB staff was also aware that that engine running RNG can have a negative CI.

The CARB staff has received four Press Releases from OptiFuel Systems about their new **Total-Zero™** RNG-Hybrid locomotive products yet excluded any information in Appendix F. The only information that was included in Appendix F was incorrect. On page 44, paragraph 1 included this comment: "The Gas Technology Institute, partnering with OptiFuel received $2.6 million to develop and demonstrate a 4,300 hp diesel dual-fuel locomotive."

OptiFuel did not get a contract develop a diesel dual fuel locomotive. OptiFuel was award a $5.2 million DOE contract to build a pre-production Renewable Natural Gas (RNG) hybrid 6,000 hp line-haul locomotive, shown below.



The headings on the 7/22/2020 Press Release, that many of the CARB staffer received, said:

OptiFuel Combats Climate Crisis with Testing of Preproduction Renewable Natural Gas Hybrid Line-Haul Locomotive Reducing Emissions to ZERO and Reducing Their Fuel Expenses by 50%

40% of the U.S. Population in Urban and Environmental Justice Communities Will

Directly Benefit from Zero Criteria Pollutants and CO2 Emissions, While Railroads Significantly Reduce their Carbon Footprint

CARB staff also ignored additional OptiFuel Press Releases: **OptiFuel Obtains U.S. EPA, Tier 4 Rail Certification for 100% Natural Gas Engine That Emits Zero NOx and PM and Significantly Reduces Fuel Cost** (2/14/2020); **Production of Zero Criteria Emission Freight Locomotives From 1,200 to 2,400 Hp** (11/19/2020); and **OptiFuel Secures Agreement to Transition Argentina's 400 Freight Locomotive Fleet from Diesel-Power to Zero-Emission Power** (7/12/2022). My question is why did not the CARB staff did include any information on OptiFuel RNG-Hybrid products in Appendix F.?

For the last two years, CARB Staff has been telling Class 1, 2 and 3 railroads that OptiFuel's RNG-Hybrid locomotives will not be approved under the Proposed Regulations, significantly eliminating OptiFuel's business opportunities in California and other states. Yet at the same time, CARB clearly has stated that RNG has a major role in reducing GHG in their long-term plans, just not in transportation. That does not make any technical sense since RNG is the perfect fuel to replace diesel in heavy horsepower systems that need to carry a large amount of fuel onboard the mobile platform.

Conclusion

The proposed in-use locomotive regulations should not be approved as drafted because they unreasonably restrict the definitions of ZE and ZE-capable locomotives to exclude all combustion-engine technologies, including RNG-Hybrid technologies, that can achieve emission levels that are equivalent to zero for both switcher and linehaul locomotives. Accordingly, OptiFuel requests that the Board direct staff to revise the proposed regulations to address this issue of primary concern.

Respectfully Submitted,

OptiFuel; Systems LLC