DOCKETED	
Docket Number:	19-ERDD-01
Project Title:	Research Idea Exchange
TN #:	230458
Document Title:	Scott D. Myers Comments - Decarbonizing Transportation Assets in the Rail and Marine Markets
Description:	N/A
Filer:	System
Organization:	Scott D. Myers
Submitter Role:	Public
Submission Date:	10/31/2019 11:52:20 AM
Docketed Date:	10/31/2019

Comment Received From: Scott D. Myers
Submitted On: 10/31/2019
Docket Number: 19-ERDD-01

Decarbonizing Transportation Assets in the Rail and Marine Markets

OptiFuel Systems LLC, is a five-year-old systems integration company focusing on developing natural gas (NG) and hybrid heavy horsepower systems, onboard NG storage systems, and NG refueling systems for the rail and marine markets. OptiFuel developed, tested and produced the locomotive dual fuel engine, CNG power conversion systems, the on-board CNG storage systems, and the CNG refueling station that allows locomotives at Indiana Harbor Belt Railroad (IHB) to operate on CNG â€“ all approved by FRA. Cummins and OptiFuel have reached agreement for OptiFuel to use of the ISX12N 400 hp engine for off-road market including rail and marine. OptiFuel expects to have the EPA certifications with the ISX12N 400 hp for rail and marine sectors in the next 30 days. In the rail and marine market, the ISX12N will be used as a generator in steady-state operations. The EPA and CARB steady-state emission values are 00.0 for NOx, PM and NMHC. If RNG is used as the fuel, the CO2 emissions values will be 00.0. The other advantage of our hybrid designs for switcher locomotives is that the diesel equivalent gallons (DGE) of CNG is reduced by 40% compared to the original number of gallons using diesel, reducing emissions also. Attached is a presentation on our products that was giving this week at the 2019 NGVAmerica Annual Meeting & Industry Summit.

CEC is planning to put out an RFP (see attachment) to demonstrate a fuel cell locomotive next year. It is based on a study from Argonne Lab called "Total Cost of Ownership for Line Haul, Yard Switchers and Regional Passenger Locomotives â€“ Preliminary Resultsâ€□.

The study from Argonne Lab is pretty flawed. For instance, it says that the switcher locomotives need to only carry 100 gallons of Hydrogen (88 gallons of diesel equivalent) a day and can refuel every day. 95% of switcher go from the refueling yard for multiple days and need to carry at least 750 gallons of fuel between refueling. There is not a railroad that could operate requiring refueling every day. The study assumes that the diesel cost is $3.00 a gallon, yet the Class I railroads have paid an average of $2.38 per gallon of diesel over the last 11 years. It also assumes that the tender car will be carry H2 at 10,000 psi, a pressure that FRA will never approve. FRA will never approve H2 on a locomotive due the explosive nature of H2. It took FRA 4 years to approve the OptiFuel CNG on-board storage systems on the Indiana Harbor Belt Railroads locomotives and CNG is safer than gasoline or diesel during equipment fires.

CEC is proposing to use the funds that were set-aside for natural gas R&D program to demonstrate a hydrogen fuel cell locomotive that was no market or practical use over the next 20 years. Not only is the affordability cost of the technology and H2 fuel production is many years away, the limited store capacity of H2 due to physics will make sure that we will never see H2 line haul locomotives in our life-time.

OptiFuel could provide CEC with a Zero NOx, PM and CO2 emission switcher running Renewable Natural Gas for around $2 million in 1 year and the fuel cost less will be less than $2 a DGE, compare to H2 at $10 to $12 kg (1.1 kg = 1 DGE). In addition, the locomotive will carry

800 DGE of RNG on-board, will meet all current FRA and AAR requirements including crash worthiness, and is already approved for use with CNG or RNG.

Additional submitted attachment is included below.

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SUSTAINABLE TRANSPORTATION

Decarbonizing Transportation Assets in the On-road, Rail and Marine Markets with Innovative, Cost-Efficient, and Sustainable Renewable Natural Gas Hybrid Solutions

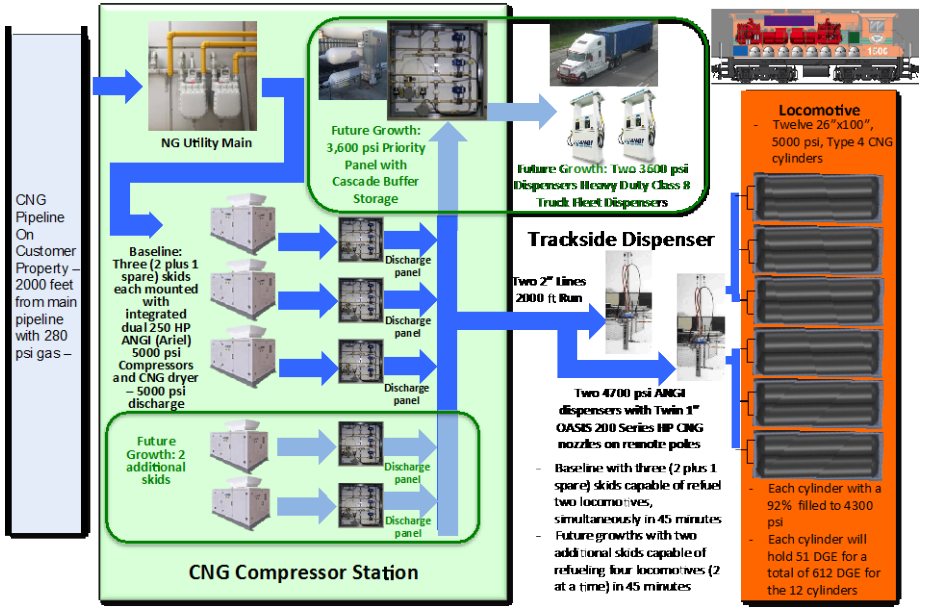
2019 NGVAmerica Annual Meeting & Industry Summit

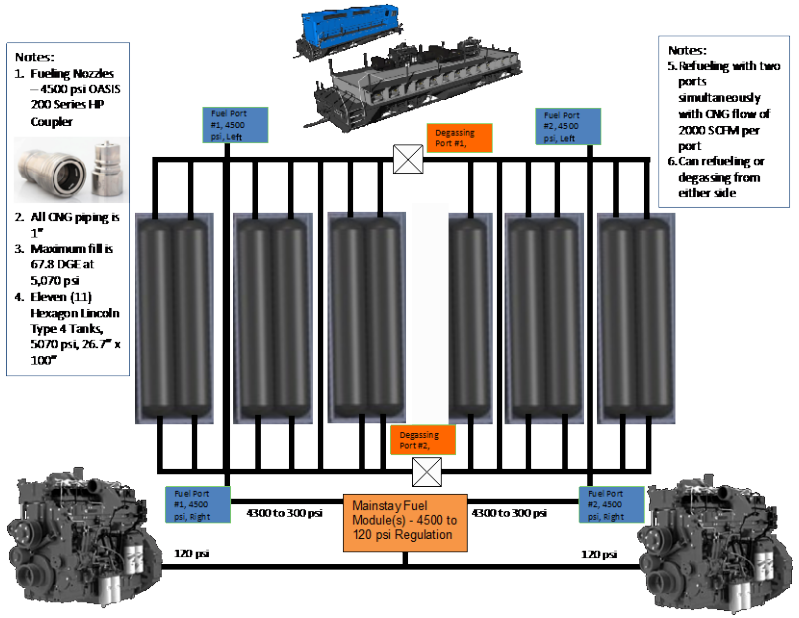
Reduce OpEx, Increase Market Competitiveness & Meet Sustainability Goals

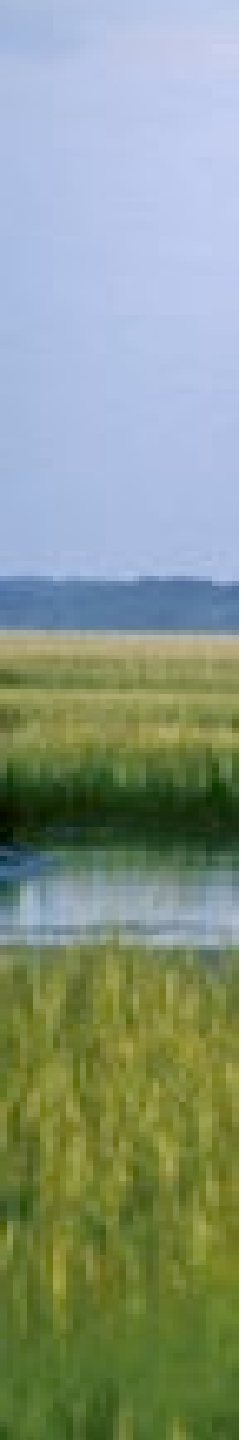
- OptiFuel Systems LLC, is a five-year-old systems integration company focusing on developing natural gas (NG) and hybrid heavy horsepower systems, onboard NG storage systems, and NG refueling systems for the rail and marine markets
- OptiFuel developed, tested and produced the locomotive engine, CNG power conversion systems, the on-board CNG storage systems, and the CNG refueling station that allows locomotives at Indiana Harbor Belt Railroad (IHB) to operate on CNG – all approved by FRA
- IHB pays less than $0.70 Diesel Gallon Equivalent (DGE) for the CNG – they pay around $2.40 for their diesel fuel

Current IHB CNG Refueling Equipment Supports Two Locomotives At A Time And Can Refuel Both In 30 to 45 Minutes – The First Of Its Kind In The World

- The 11, 5000 psi CNG cylinders providing 700 DGE, refueling equipment standard ANGI, ANGI CNG dispensers modified
- The dispensing is automatic and will work on either side
- Just snap the 1” inch nozzle on the CNG hose on the refueling port, push the start button and the rest is automatic until the CNG cylinders are full
- The ID tag on the locomotive connects to the refueling dispenser thru dynamics RF communications
- Filling is monitored in real-time in the cab and in the IHB office with a full SCADA design







"California will meet its 2030 climate targets more than three decades late, in 2061, and could be more than 100 years late in meeting its 2050 target if the average rate of emissions reductions from the past year hold steady, according to a new study tracking more than a decade of environmental and economic indicators in the state.." – ***Green Car Congress– October 08, 2019***

"Transportation (14%). Low-emission cars are great, but cars account for a little less than half of transportation-related emissions today—and that share will shrink in the future. More emissions come from airplanes, cargo ships, and trucks. Right now we don't have practical zero-carbon options for any of these." – ***The blog of Bill Gates, "Climate change and the 75% Problem" – October 17, 2018***

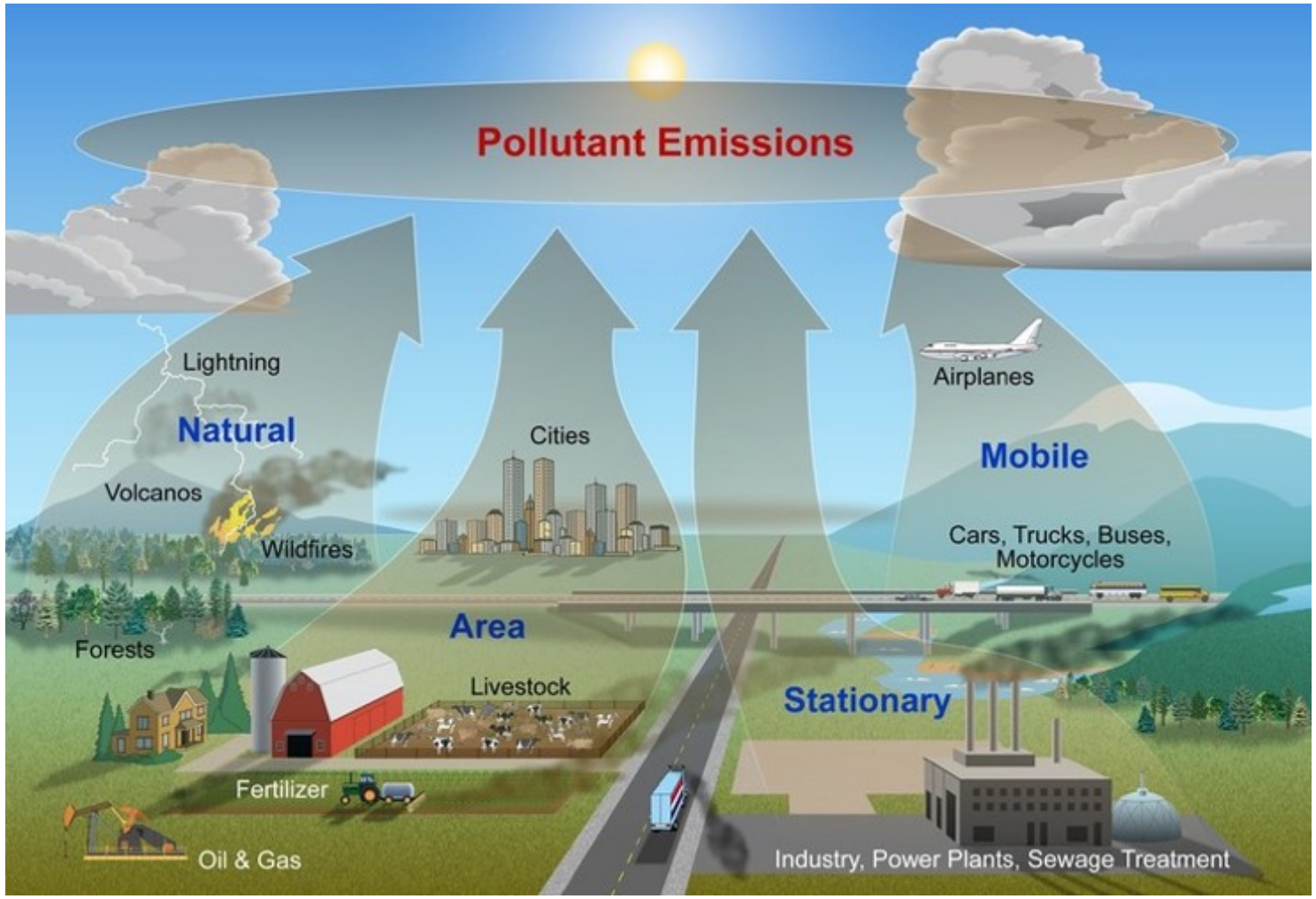
"… the ICE, and IC engine research have a bright future, in contrast with some widely distributed media reports… The power generation and the vehicle and fuel industries are huge, representing trillions of dollars (US) per year in turnover, with a massive infrastructure. We are certainly in revolutionary times, but it is clear that power generation sources will not become fully renewable and transport will not become fully electric for several decades, if ever. However, research to improve efficiency and methods to reduce dependence on fossil fuels are exciting directions for future IC engine research.

It is very likely that highly efficient "fully flexible" engines with hybridized solutions will be a big part of sought-after efficiency improvements, as well as emission/GHG reductions. Finally, it must be acknowledged that, in practice, people select their choice of powertrain based on numerous factors, including cost. " – ***"International automotive researchers emphasize the importance of continued development of the internal combustion engine", Reitz et al., Green Car Congress – October 09, 2019***

"But transportation is where all the candidates still have the biggest blind spot. They're happy to talk about electric vehicles, but there's often little else of substance in their transportation plans. The exception, again, is Sanders. Ahead of the CNN climate town hall, Curbed's Urbanism Editor Alyssa Walker wrote that only Sanders has a transportation plan that goes into detail on measures beyond electric vehicles, including expanding public transportation, promoting transit-oriented development in cities and increasing residential density. Even Sanders' plan doesn't go far enough — but it goes much farther than anyone else's.." – ***Paris Marx, "Bernie Sanders' Climate Change Plan is Radical and Expensive — Which is Why it Could Work" – Sept 21, 2019***

Focused On Existing Proven Affordable Technologies And Solutions That Can Reduce US GHG Emissions 50% In 15 Years With Aggressive Policies And Incentives

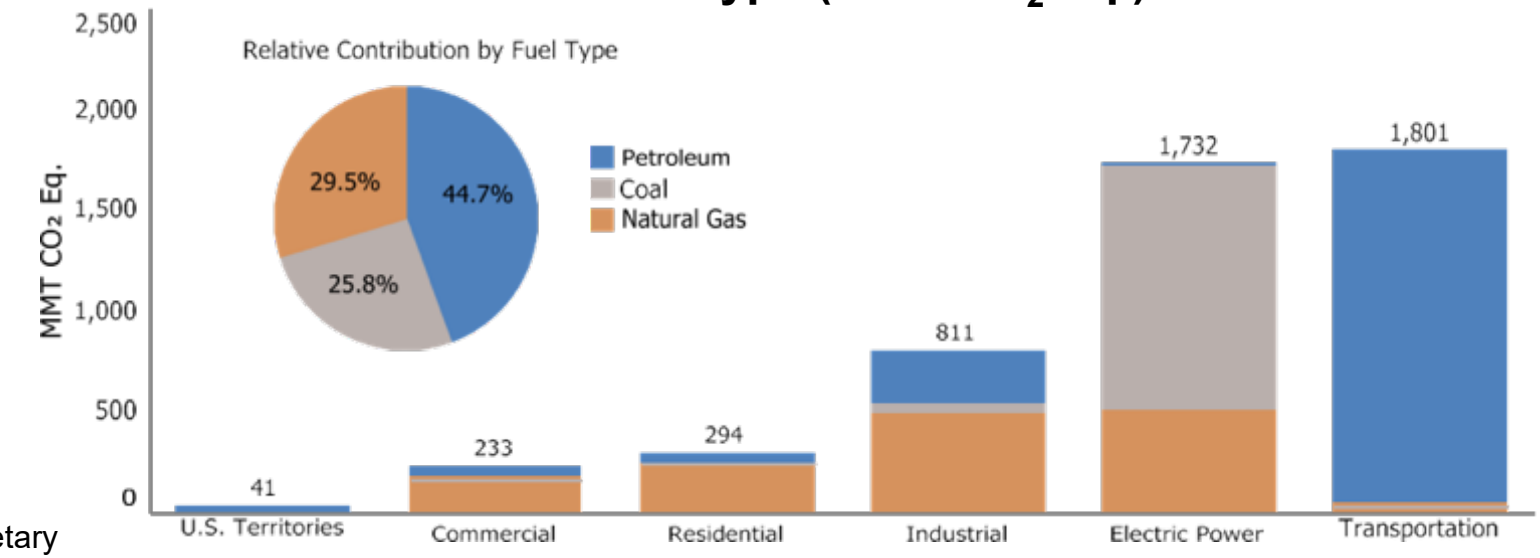
- Environmental emissions that create smog and ozone cause negative health effects
  - **NOx - Nitrous Oxides**
  - **PM - Particulate Matter**
  - **CO - Carbon Monoxide**
  - **NMHC – Non-Methane Hydro-Carbons**
- The primary greenhouse Gas (GHG) that affect climate change
  - **CO_2 – Carbon Dioxide**
  - **NO_2 – Nitrous Oxide**
- **System approaches to reduce CO_2 emissions will also reduce NOx, PM, and CO emissions at the same time**



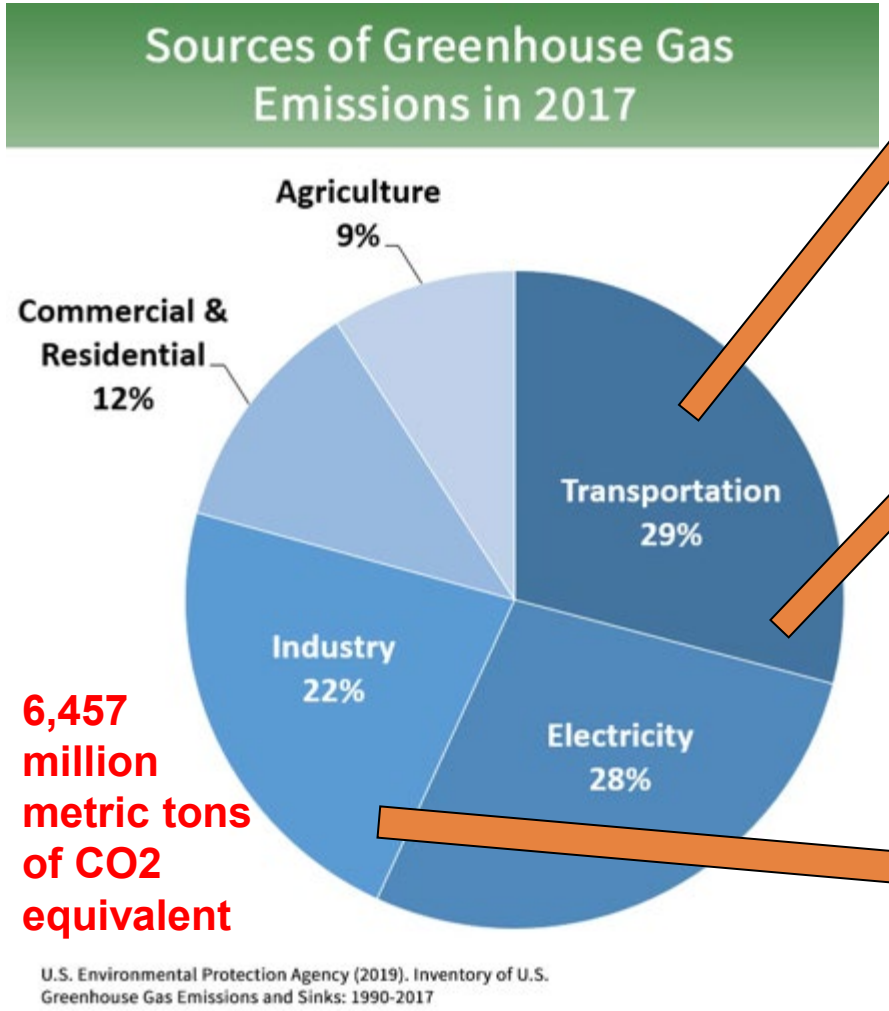
Focus on Eliminated Greenhouse Gas Emissions From Combustion of Petroleum in the Transportation Sector and Non-Transportation Mobile in the Industrial Sector

- There are four possible strategies that could be employed to reduce GHG emissions from the transportation sector and non-transportation mobile in the industrial sector:
  - Reduce the total volume of transportation and non-transportation mobile activities;
  - **Shift transportation activity to modes that emit fewer GHGs per passenger-mile or ton-mile**;
  - **Reduce the amount of energy required to produce a unit of transport and non-transportation mobile activities (that is, increase the energy efficiency of each mode); or**
  - **Reduce the GHG emissions associated with the use of each unit of energy**

2017 CO_2 Emissions from Fossil Fuel Combustion by Sector and Fuel Type (MMT CO_2 Eq.)



Converting Transportation Assets From Gasoline and Diesel to RNG Blend Can Reduce Annual CO_2 EQ. Emissions by 1,840 MMT

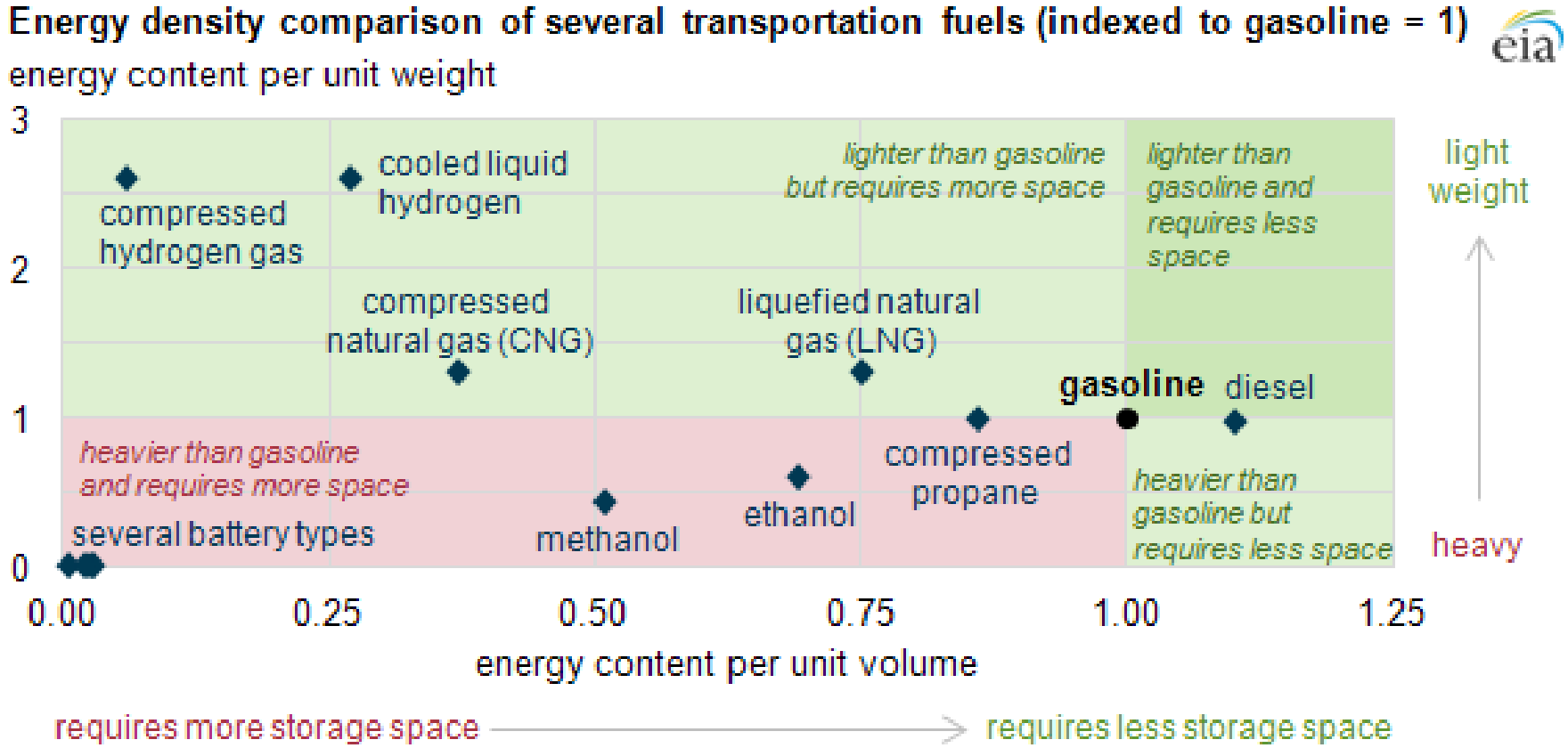


	Fuel Volume (billion gallons)	CO_2 Tg (MMT)
Gasoline	**128.9**	**1,146.10**
Light-Duty Vehicles	**116.8**	**1,079.30**
Passenger Cars	84	766.3
Light-Duty Trucks	32.7	313
Recreational Boats, Motorcycles, Buses & Medium/Heavy-Duty Trucks	**6.4**	**66.8**
Diesel	**59.4**	**693.5**
Light-Duty Vehicles	**1.8**	**18.7**
Passenger Cars	0.4	4.4
Light-Duty Trucks	1.4	14.3
Buses	**1.8**	**17.9**
Medium- and Heavy-Duty Trucks	**38.2**	**388.3**
Rail	**4.5**	**38.4**
Ships and Boats	**2.5**	**33.5**
Non-Transportation Mobile (Agricultural, Construction, etc.)	**12.6**	**196.7**
Jet Fuel & Aviation Gasoline	**17.8**	**174.8**

Source: United States Environmental Protection Agency, Green Vehicle Guide
: "Fast Facts on Transportation Greenhouse Gas Emissions 1990-2017", EPA-420-F-19-047, June 2019,

Trucks, Rail, Off-road, And Marine Assets that Require Large Operation Time and Distances Cannot Use Battery Electric Power Due to Volume, Weight and Cost Constraints of Battery Storage

- EXAMPLE: In freight rail, line haul locomotives carry 5,000 gallons of diesel fuel
  - **Currently, at commercial battery packs cost around $180 per kWh, replacing 5,000 diesel gallon of storage would require three battery storage tender railcars that will cost over $25 million, would require replacement in 10 years, and would require a 200 MW power source to recharge in 1 hour**



Converting Heavy Duty Transportation Assets From Diesel to RNG Will Reduce Annual CO_2 EQ. Emissions by 1,840 MMT

Foundational Fuel for Replace Gasoline and Diesel – Battery-Electric & RNG/NG Blends

	Fuel Volume (billion gallons)	CO_2 Tg (MMT)
Gasoline	**128.9**	**1,146.10**
Light-Duty Vehicles	**116.8**	**1,079.3**
Passenger Cars	84	766.3
Light-Duty Trucks	32.7	313
Recreational Boats, Motorcycles, Buses & Medium- and Heavy-Duty Trucks	**6.4**	**66.8**
Diesel	**59.4**	**693.5**
Light-Duty Vehicles	**1.8**	**18.7**
Passenger Cars	0.4	4.4
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Buses	**1.8**	**17.9**
Medium- and Heavy-Duty Trucks	**38.2**	**388.3**
Rail	**4.5**	**38.4**
Ships and Boats	**2.5**	**33.5**
Non-Transportation Mobile (Agricultural, Construction, etc.)	**12.6**	**196.7**

Source: United States Environmental Protection Agency, Green Vehicle Guide
: "Fast Facts on Transportation Greenhouse Gas Emissions 1990-2017", EPA-420-F-19-047, June 2019,

Transportation Fuel	Carbon Intensity (CI) Values (gCO_2e/MJ)	Average CI of RNG	Average CI of 50%/50% Blend of RNG and Fossil NG
Diesel	**102.01**		
Gasoline	**98.47**		
Biodiesel from Midwest soy beans	19.11 to 54.05		
Corn ethanol	77.52		
Natural Gas (fossil based)	**78.36**		
Sugarcane ethanol	40.47 to 51.33		
Hydrogen Fuel Cell Vehicles	**35.33 to 60.40**		
Electric vehicles (300 mile range)	**30.95**		
Renewable Diesel	**17.29 to 49.88**		
Landfill gas (RNG)	**11.26 to 18.11**	**Average CI of RNG is -87**	**Average CI of Blend is 0**
Wastewater biogas (RNG)	**7.75**		
Biogas from food and green Waste (RNG)	**- 22.93**		
Dairy Biogas (RNG)	**-276.24**		
Swine Biogas (RNG)	**-370**		

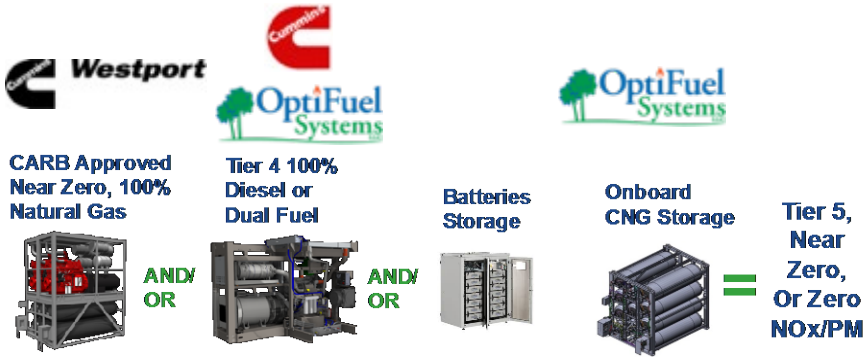
Source: California Low Carbon Fuel Standard: 17 CCR 95488 - Table 6; California Air Resources Board, "LCFS Illustrative Fuel Pathway Carbon Intensity - Determined using CA-GREET 2.0", presented September 17, 2015

The Diesel Engine for Used in Transportation in Urban City Areas Around the World Will be Phased Out Over the Next 10 to 20 Years

- It will be very hard to get to cleaner emission with 100% diesel – development cost in the hundreds of millions even if it would work
- In locomotives:
  - Heavy EGR, heavy PM filter approach by Progress Rail and Wabtec to get to Tier 4 reducing fuel economy compared to Tier 3 and require more maintenance – reached the limit using heavy EGR
  - SCR approach by Cummins to get to Tier 4 is more efficient and has fuel economy better than Tier 3, but requires Diesel Exhaust Fluid (DEF)
- Fortunately, with the Cummins Westport ISX12N 400 hp engine and Renewable Natural Gas (or CNG/RNG Blends), there is a solution now
- Cummins and OptiFuel have reached agreement for use of the ISX12N 400 hp engine for off-road market
- OptiFuel is moving ahead with EPA certifications for rail and marine with the ISX12N 400 hp

The Cummins Westport ISX12N Can Be Used With Hybrid Technology to Produce Near Zero and Zero Emission 7/8 Trucks, Line-haul Locomotives, and Marine Craft

- The ISX12N natural gas engine meets **Near Zero** emissions when used in a transient mode such as used in a standard Class 7/8 trucks or parallel hybrid natural gas Class 7/8 trucks
- The ISX12N natural gas engine meets **Zero** emissions when used in a steady state mode such as in natural gas hybrid series powered Class 7/8 trucks, locomotives and marine crafts
- By combining a Tier 4 diesel with one or more existing Zero, CARB approved, 100% natural gas engines and an onboard CNG storage system, a natural gas hybrid line haul locomotive can meet **Near Zero** emission standards
  - Run on Idle and Notches 1 to 3/4/5 on 100% natural gas, then use a 100% diesel engine, dual fuel engine and/or battery storage to provide remaining power in Notches 4/5 up to 8 - the lower notches are essentially Zero emissions and the higher notches are Near Zero



Tier Level	Model	NOx (g/bhp-hr)	PM (g/bhp-hr)	GHG (g/bhp-hr)	NMHC (g/bhp-hr)	Available Effective Date
NEAR ZERO	ISX12N 400 hp	**0.02** (Transient)	**0.01** (Transient)	**CO_2 – 502** **CO – 1.5** **CH_4 – 0.19**	**0.01** (Transient)	2018
NEAR ZERO	ISX12N 400 hp	**0.00** (Steady State)	**0.00** (Steady State)	**CO_2 – 429** **CO – 0.21** **CH_4 – 0.16**	**0.00** (Steady State)	2018
4 Line Haul	QSK60 2800 hp	**0.80**	**0.01**	**CO – 0.1**	**0.02**	2017

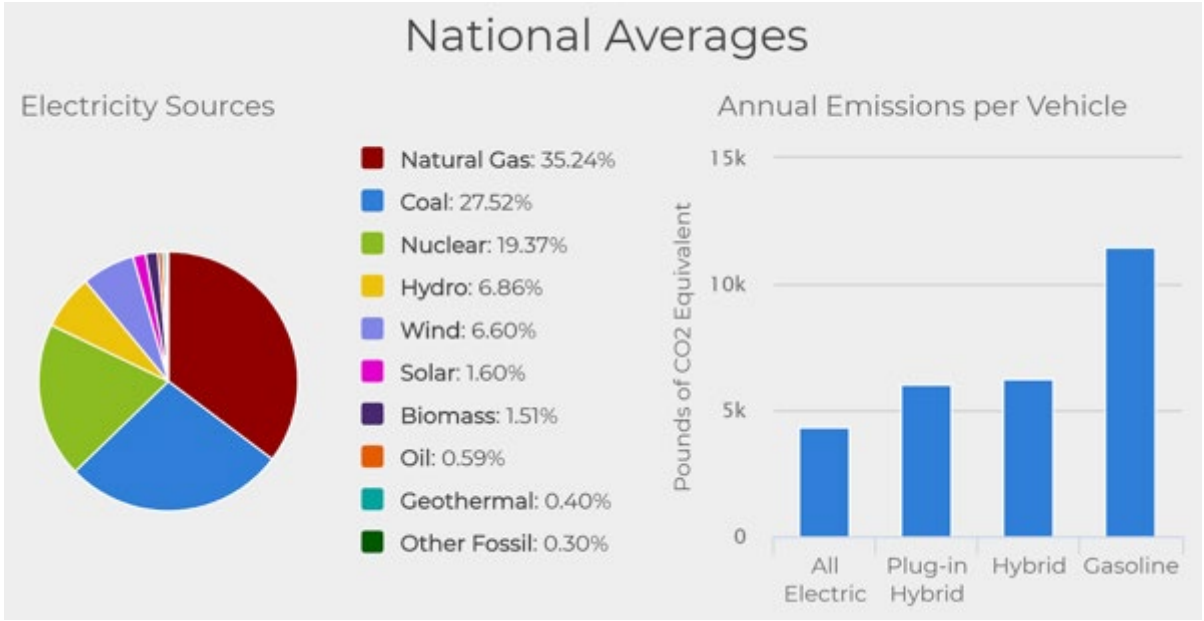
With New Sources of RNG Coming Online Around the US, It is Now Possible to Produce Heavy Horsepower, Affordable, On-road and Off-road Vehicles That Produce NEGATIVE CO_2 Emissions

Transportation Assets	NOx Emissions (g/bhp-hr)	PM Emissions (g/bhp-hr)	CO_2 Emissions MMT CO_2 Eq.	Comments
400 Hp Class 7/8 Trucks with a range of 750 miles on RNG	0.02	0.01	0.00	• Already in production
535 Hp Class 7/8 Hybrid Parallel Drive Trucks with a range of 750 miles on RNG	Less than 0.02	Less than 0.01	0.00	• Use BAE Hybrid parallel drive system to provide an additional 135 hp for long haul trucking on hills and mountains • Hybrid parallel drive system already tested • Most components already in production • For drayage operations, can use electric drive for low speeds when in the port
1,600 Hp Switcher RNG Hybrid Locomotives	0.00	0.00	0.00	• ISX12N are used in Steady State Mode • Can carry 1000 DGE of RNG on-board • Can use electric drive for very low speeds • Cost no more than a diesel locomotives
4,300 Hp Line Haul RNG Hybrid Locomotives	0.06	0.00	0.00	• ISX12N are used in Steady State Mode • Can carry 1000 DGE of RNG on-board • Can use electric drive for very low speeds • Cost no more than a diesel locomotives • Interfaces to 14,000 DGE RNG tenders
2,600 to 6,000 RNG Hybrid Tugboats, Towboats & Ferries	0.05	0.00	0.00	• All components already in production • Can be electric only in port or harbor

Note: OptiFuel Designs in Blue Section

A Hybrid/Plug-in Hybrid Vehicle Running on CNG Will Have CO_2 Emission As Low as a Battery-Electric Vehicle (BEV) – A Hybrid Vehicle Run on RNG Can Have No CO_2 Emissions

- There is already a U.S. network to provide CNG/RNG refueling – saving trillion required to create a natural electric grid to recharging BEVs
- A CNG hybrid vehicle will have a range over 300 miles and can be refueled in 10 minutes at a cost of around $1 per gallon
- A CNG hybrid vehicle cost no more than a standard gasoline vehicle



Source: Department of Energy, Alternative Fuels Data Center: "Emissions from Hybrid and Plug-In Electric Vehicles", https://afdc.energy.gov/vehicles/electric_emissions.html

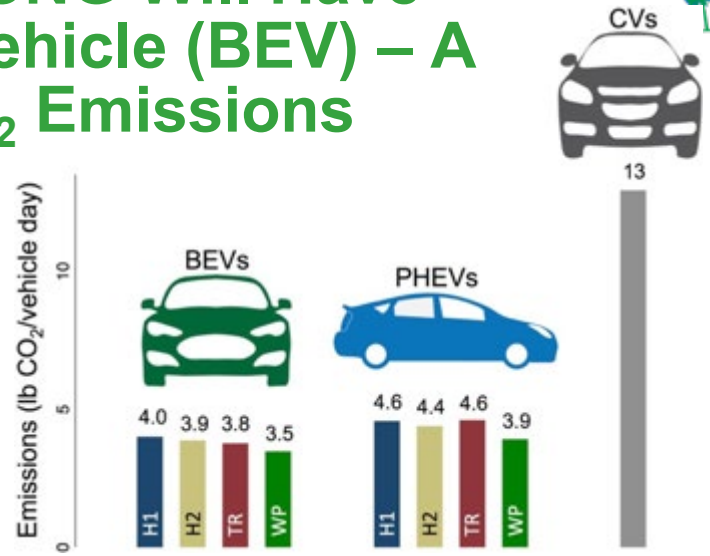


Figure 17. Comparison of total BEV and PHEV emissions with emissions from a conventional vehicle on a low carbon grid.

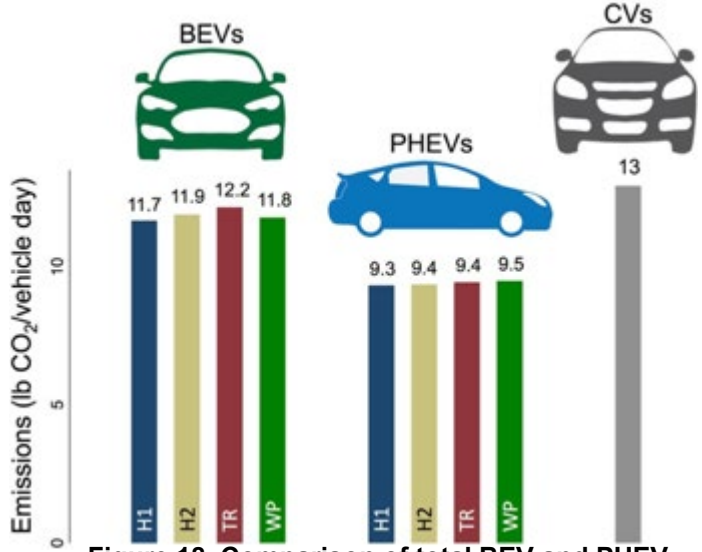
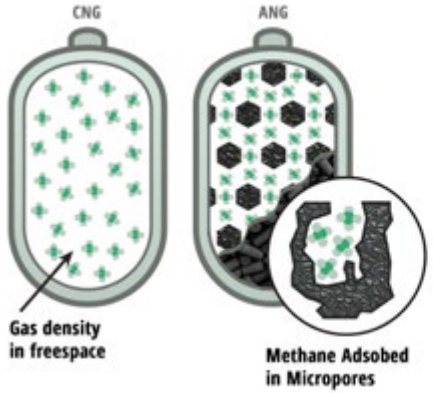


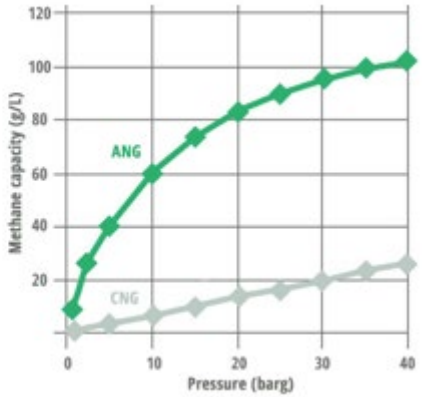
Figure 18. Comparison of total BEV and PHEV emissions with emissions from a conventional vehicle on a high carbon grid

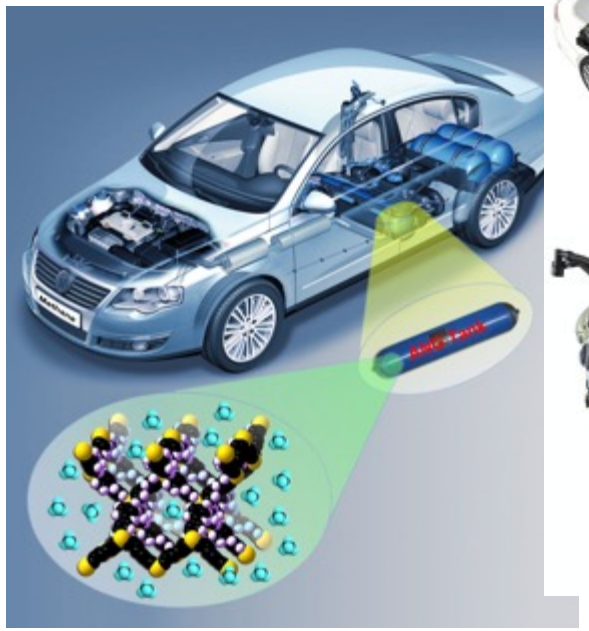
Source: National Renewable Energy Laboratory: "Emissions Associated with Electric Vehicle Charging: Impact of Electricity Generation Mix, Charging Infrastructure Availability, and Vehicle Type", NREL/TP-6A20-64852, April 2016

All of the Technology is Available to Build CNG/RNG Hybrid Cars, SUVs, and Light Duty Trucks That Will Have a Range Beyond 300 Miles, Operate with Very Low CO_2 Emissions, Can be Refueling in 5 to 10 Minutes, and Use a Fuel That Cost of Around $0.70 to $1.00 a Gallons

- Adsorbed Natural Gas (ANG) technology can be put into conformable spaces in the chassis
  - The use of a highly porous adsorbent material to densely store natural gas molecules at pressures of **900 psig** and below – **allows all-night refueling at home or 10 minute at any fueling station that has a CNG pipe line near by**
  - Under controlled depressurization, these molecules release and exit the storage system in response to the demand of the vehicle's engine
- New 1.5L, 130 hp, TGI EVO natural gas engines developed by Volkswagen in 2018 are perfect for hybrid or plug-in hybrid vehicles – already available in Golf and Polo cars in Europe







With the New Natural Gas Engines from Cummins, Most of the Existing OEMs in the U.S. Already Sell Class 4/5/6/7/8 Trucks Up to 400 Horsepower That Can Operate on RNG, Eliminating CO_2 Emissions

OptiFuel Systems

B6.7N

- Thomas Built Buses: Saf-T-Liner C2
- ARBOC Specialty Vehicles: Shuttle Bus
- Freightliner Custom Chassis: Shuttle Bus
- TICO: Yard Spotter

L9N

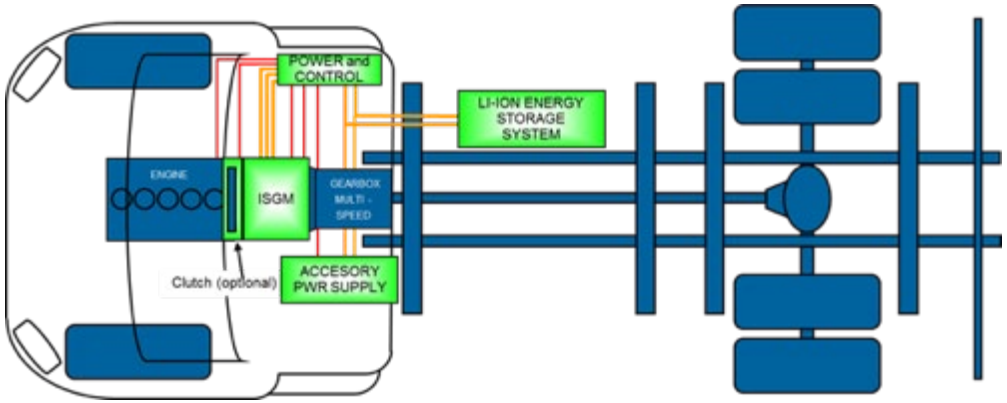
- Autocar: ACX - Xpeditor; ACMD - Xpert
- Freightliner: 114SD; M2 112
- Mack: Terra Pro; LR
- Peterbilt: Various
- Kenworth: Various
- Blue Bird: All American RE
- Gillig: Low Floor; Low Floor BRT; Low Floor BRT Plus
- New Flyer: Xcelsior
- Nova Bus: LFS
- Thomas Built Buses: Saf-T-Liner HDX

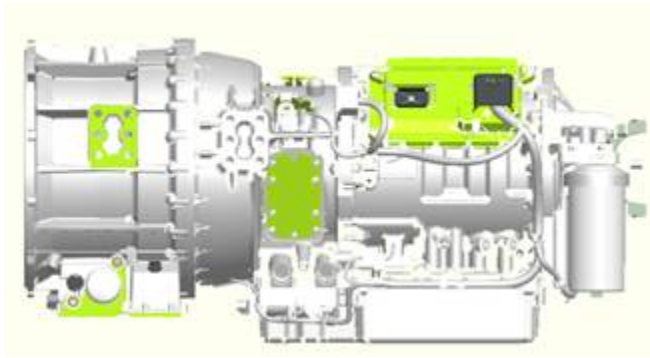
ISX12N

- Autocar: ACX - Xpeditor
- MCI: Commuter Coach
- Mack: Pinnacle
- Peterbilt: Various
- Freightliner: 114SD; Next Gen Cascadia
- Volvo Trucks: VNL
- Kenworth: Various

PARALLEL DRIVE: BAE Hybrid Integrated Drive Unit (IDU) Boost the Driveline Power by Up to 100 kW / ~135 Hp for the 30% of the Class 8 Trucks That Need More Than 400 Hp Going Cross Country

- **Near Zero emission Class 7/8 truck with 535 Hp of total power and 750 miles between CNG/RNG refueling**
- The IDU works with a battery pack, a 400 Hp ISX12N Near Zero natural gas engine, and transmission to boost the driveline power by up to 100 kW / ~135 Hp to augment power from the ISX12N to achieve desired transient performance to go up hills and mountains with heavier loads
  - Power management Integrated Starter, Motor, Generator (ISG) architecture with energy storage system (ESS) added
  - ISG mounted between ISX12N engine and transmission
  - Multi-Speed gearbox (automatic transmission with torque converter)
  - Small sealed battery pack for under vehicle environment (submersion, dirt, debris…)
  - *Optional Isolation clutch between ISG and the engine*
    - Electric accessories to support engine-off modes including **slow speed, electric-only movement**
- System is right-sized and right-priced for long haul Class 7/8 trucks – less CO_2 emissions, cost less than a serial electric Class 7/8 truck, and uses less number of expensive batteries that will need to be replaced





Class 1 Railroads Bought 4,284,478,680 Gallons Of Diesel Fuel in 2018 at an Average Cost of $2.38 per Diesel Gallon – a Fuel Cost of $10.2 Billion!

- There are 39,000 freight locomotives in the US with an average age of more than 25 years
  - These locomotives annually emit 2,431,500 tons of NOx, PM , HC, and CO emissions
  - These locomotives annually emit 38 million metric tons (MMT) of CO_2 emissions

- **Converting 39,000 locomotives to natural gas will reduce 98% of environment emissions annually (42,800 tons) and save Class 1 Railroads $5 Billion in fuel cost annually**
- **Using a NG/RNG Blend for fuel can reduce CO_2 emissions by 100% - eliminating 38 MMT of CO_2 annually**
- **The fuel reduction saving can be passed on to the shippers and consumers**

The Future is Now With Affordable, Near Zero or Zero Emissions Trains That Can Operate In Urban Areas

- Supports the use of frequent, faster, shorter trains that operate with lower fuel and labor cost in order to increase market shares from trucking

Obstacle Detection System Can Detect People a Mile Away

Cost the Same as Tier 4 Diesel Locomotive

Multi-Engine Hybrid Power Reduces Fuel Usage by 20% to 40%
- Only Requires Yearly Maintenance
- Can Operate With Partial Power if One Engine Fails
- Cost Less Than Single Big Engine

1,200 hp Powered CNG Tender With 3 Axle Trucks With AC Traction Has Zero Emissions

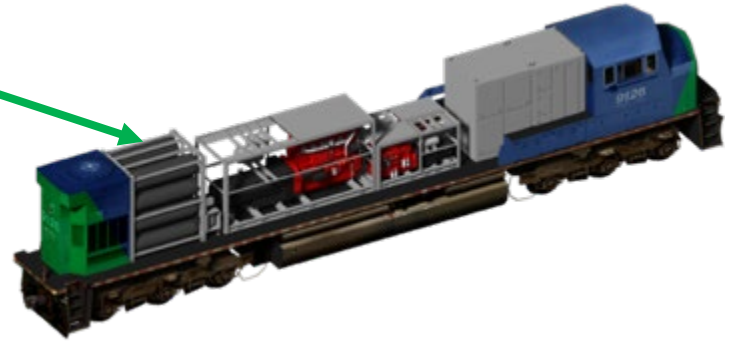
Using CNG:
- Cost is $1.25 a Diesel Gallon Equivalent (DGE)
- The Cost Includes the Cost of the CNG Tenders and All CNG Refueling Equipment
- Can Operate With CNG or Renewable Natural Gas (RNG)

4,300 hp Line Haul Natural Gas Hybrid Locomotive Has Near Zero Emissions – 5,500 hp Total with Locomotive and Powered Tender

9,000 DGE of CNG on the Tender provide a Range of 5,000 to 6,500 Miles Before Refueling – 1 hour to Refueling CNG Tender

1,000 DGE of CNG on the Locomotive and 5,000 gallons of Diesel

Modern High Speed Engine Compared to Medium Speed Engines:
- 20% lower in cost
- 70% smaller on size
- Almost all markets except rail have gone to high speed engines



Technology Exists to Automate the Refueling and Car Coupling, Eliminating Labor Cost

A NG/RNG Hybrid Approach Can Be Used For Switching, Line Haul, and Transit/Passenger Locomotives Using the Appropriate EPA Duty Cycles

OptiFuel Systems

- ***These NG/RNG hybrid locomotives cost no more or less than existing diesel locomotives***

Zero Emissions 1,600 hp. Switcher

- 1,600 hp Switcher Locomotive
- **NOx/PM:0.00 g/bhp-hr at all notches**
- **ZERO CO_2 with RNG or CNG/RNG Blend**
- **100% CNG/RNG** powered
- 1,000 DGE of CNG/RNG onboard

Tier 5 Emissions for 3300 hp. Line Haul / Transit

- 3,300 hp Line Haul / Transit Tier 5 Locomotive
- **Using CNG to reach Tier 5 – NOx:0.199 g/bhp-hr, PM:0.00**
- **Can reach ZERO CO_2 with RNG or CNG/RNG Blend**
- Horsepower weighted and duty cycle weighted fuel per gallon usage is **77% CNG/RNG and 23% diesel** with a 50% Idle Reduction System
- 5,000 gallons of diesel and 1,000 DGE of CNG/RNG onboard

Zero Emissions 2,000 hp. Switcher

- 2,000 hp Switcher Locomotive
- **NOx/PM:0.00 g/bhp-hr at all notches**
- **ZERO CO_2 with RNG or CNG/RNG Blend**
- **100% CNG/RNG** powered
- 1,000 DGE of CNG/RNG onboard

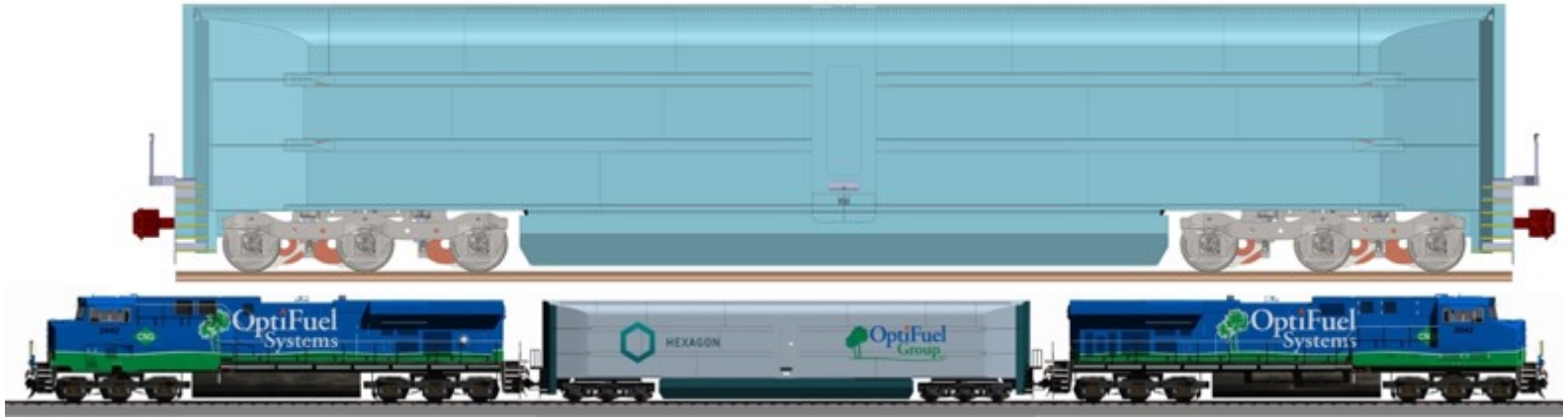
Tier 5+ Emissions for 4,300 hp. Line Haul

- 4,300 hp Line Haul Tier 5 Locomotive
- **Using CNG to reach Tier 5 – NOx:0.06 g/bhp-hr, PM:0.00**
- **Can reach ZERO CO_2 with RNG or CNG/RNG Blend**
- Horsepower weighted and duty cycle weighted fuel per gallon usage is **84% CNG/RNG and 16% diesel** with a 50% Idle Reduction System
- 5,000 gallons of diesel and 1,000 DGE of CNG/RNG onboard
- Can increase the substitute rate to over **94%** by converting the diesel engine to duel fuel

Powered NG/RNG Tender Using Four ISX12N Zero Emissions Engines to Provide Another 1,600 Hp of Additional Tractive Effort

- The use of CNG/RNG tenders will require less refueling stops, less equipment, less people, increasing overall system velocity, lower dwell time, and will reduce environmental concerns with potential liability and cost issues
- The railroads will not have to worry about maintenance, repairs or refueling of the CNG/RNG tenders and they can return partially filled tenders

- Non-Powered CNG/RNG tender holds a MAXIMUM of 13,500 DGE
  - Can be interfaced to two 4,200 Hp Tier 5 OptiFuel locomotives, two Tier 3 SD70AC locomotives or two Tier 3 ES44AC locomotives, all running with dual fuel

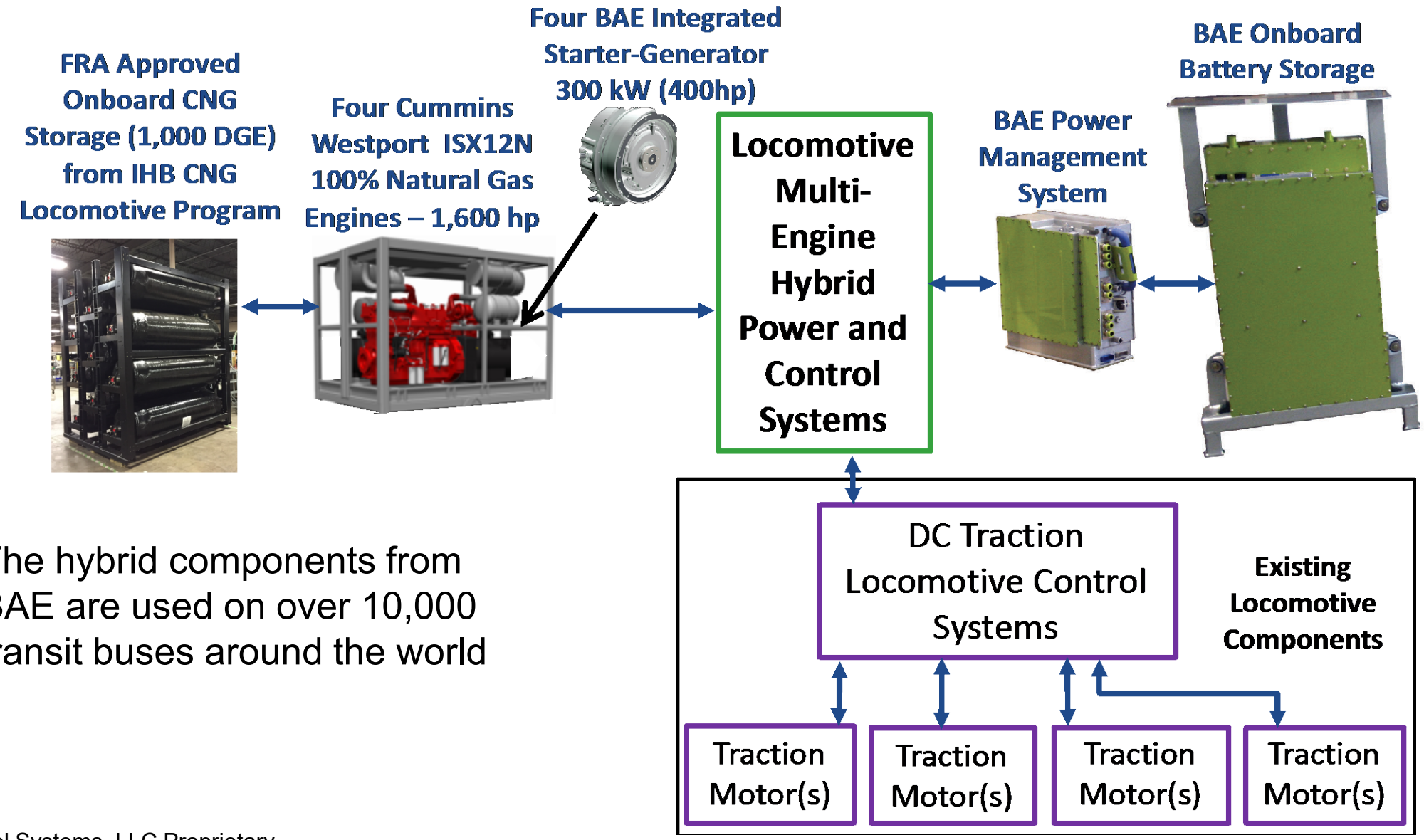


- 1,600 Hp. **POWERED** CNG/RNG tender holds a MAXIMUM of 9,000 DGE
  - Near Zero Emissions, 100% CNG/RNG engines provide 1,600 Hp to power 4 axles with AC traction motor
  - Can be interfaced to one or more locomotives supporting wired and wireless distributed power

Goal for a Future Program – Zero Emissions 1,600 Hp Switcher

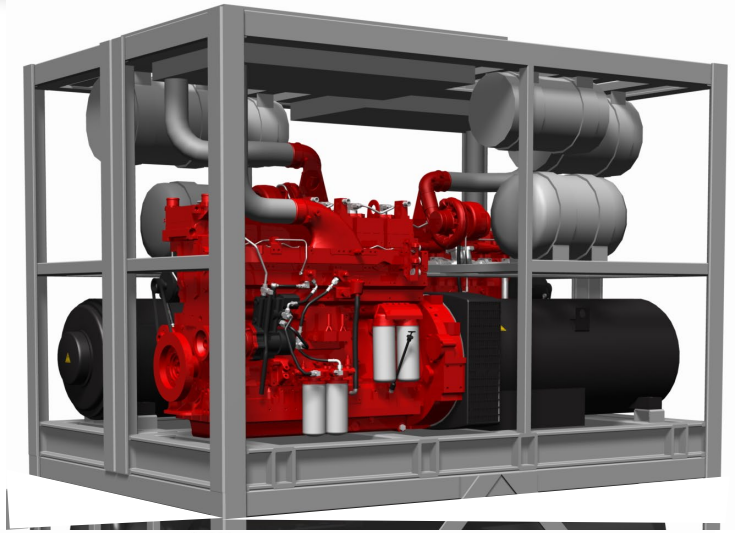
- Replace 12 Tier Pre-0 1,600 hp switcher locomotives in the Port of Houston with new ZERO emission natural gas hybrid locomotives
- Be the leader for the Port of Houston for reducing air quality emissions
- Besides reducing emissions and improving air quality, the goal is to reduce annual fuel cost by 30% to 50%
- Try to achieve a 5 year payback and 10-year internal rate of return appropriate with capital programs – TERP program will provide up to 80% grant funds
- 1,600 hp Switcher Locomotive
  - **NOx/PM:0.00 g/bhp-hr** at all notches
  - **100% CNG** powered
- To avoid issues with FRA, will use design already approved for the IHB railroad program
- Use existing Railpower platform from the UP program - GP38 length
- Cab, frame, coupler pockets, etc. will meet all existing FRA crashworthiness specification
- 1000 DGE of CNG/RNG onboard
- Will essentially have new locomotives

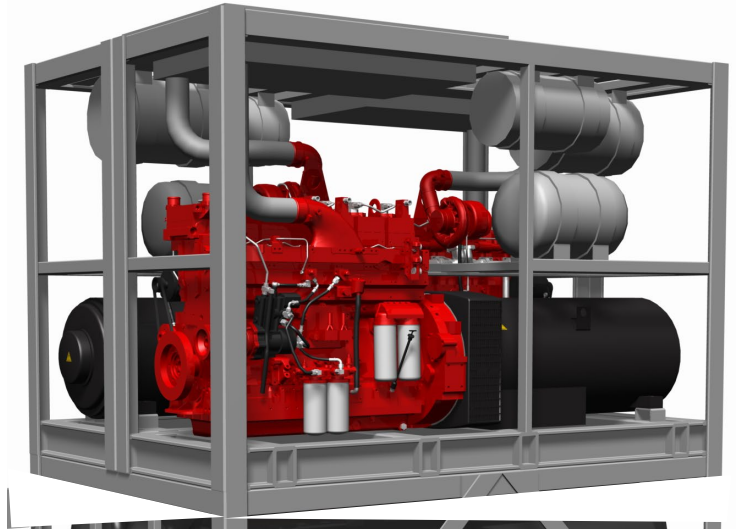
System Design of the 1,600 hp CNG/RNG Hybrid Switcher Locomotives Showing the Off-the-Shelf Components



- The hybrid components from BAE are used on over 10,000 transit buses around the world

For a 1,600 Hp Switcher, Two 800 hp. Modular Engine Pods (2 Engines in each Pod) and Natural Gas System Will Include a Free 5 Years Maintenance and 5 Year Warranty - Rest of Locomotive 2 Years





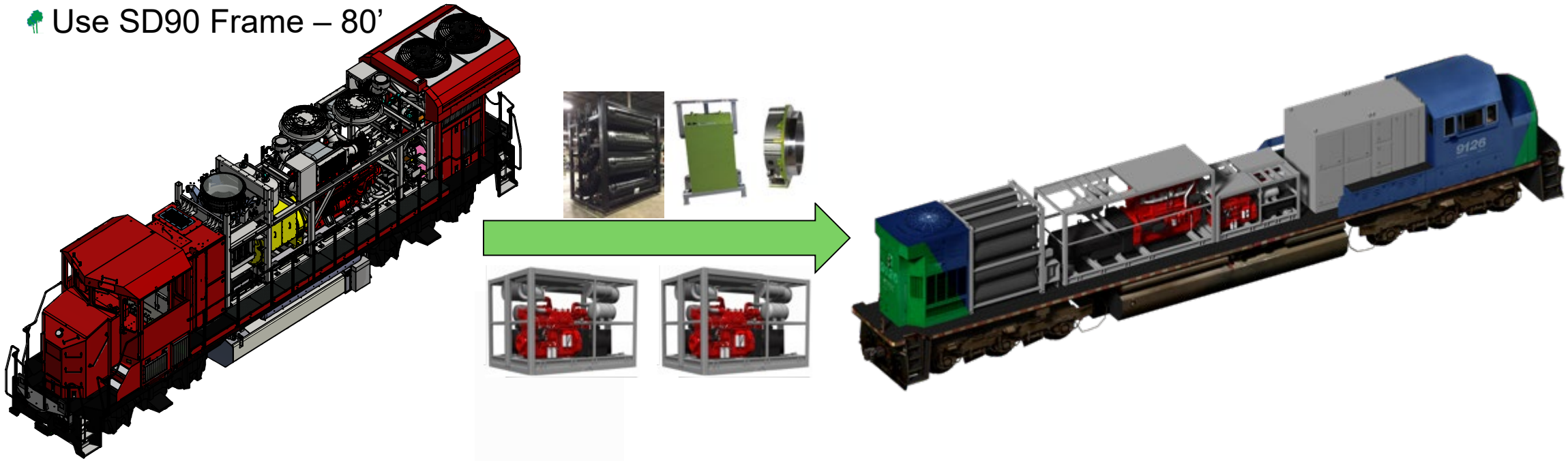
Annual Engine Performance Parameters	Engine #1 HP ISX12N	Engine #2 HP ISX12N	Engine #3 HP ISX12N	Engine #4 HP ISX12N
Total Rated Hp	400	400	400	400
Avg. Annual Hp	56	56	56	56
Avg. Load Factor Percentage	14%	14%	14%	14%
Avg. Annual Engine Running Hours	1,685	1,685	1,685	1,685
Avg. Annual Engine Running Percentage	30%	30%	30%	30%

The WATCO 1,600 hp RNG Hybrid Switcher Locomotives Will Have ZERO NOx and PM Emissions

1600 HP SWITCHER LOCOMOTIVE - Quad ISX12N	Total Annual Hours With AESS System	NOx g/bhp-hr	PM g/bhp-hr	CO g/bhp-hr	NMHC g/bhp-hr
Normal Idle	1993	0.00	0.00	0.21	0.01
Dynamic Brake	0	0.00	0.00	0.21	0.01
Notch 1	1102	0.00	0.00	0.21	0.01
Notch 2	1093	0.00	0.00	0.21	0.01
Notch 3	516	0.00	0.00	0.21	0.01
Notch 4	320	0.00	0.00	0.21	0.01
Notch 5	320	0.00	0.00	0.21	0.01
Notch 6	133	0.00	0.00	0.21	0.01
Notch 7	18	0.00	0.00	0.21	0.01
Notch 8	71	0.00	0.00	0.21	0.01
EPA DUTY CYCLE WEIGHTED	5,567	0.00	0.00	0.21	0.01

Near Zero Emissions Line Haul Locomotives Operating with CNG/RNG Can Be Built NOW With Current Technology By Using Existing, Proven Engines At Various Horsepower Levels

- **Railpower already building single engine Tier 4, 2,700 Hp QSK60 locomotives – NOx:0.8 g/bhp-hr, PM:0.01**
- Natural gas hybrid approach **for 4,300 hp Line Haul using a combination of engines – NOx:0.06 g/bhp-hr, PM:0.00**
- Horsepower weighted and duty cycle weighted fuel per gallon usage is **84% CNG/RNG and 16% diesel** with a 80% Idle Reduction System
- 5,000 gallons of diesel and 1,000 DGE of CNG/RNG onboard
- Use SD90 Frame – 80’



System Design of the 4,300 hp CNG/RNG Hybrid Line Haul Locomotives Showing the Off-the-Shelf Components

FRA Approved Onboard CNG Storage (1,000 DGE) from IHB CNG Locomotive Program

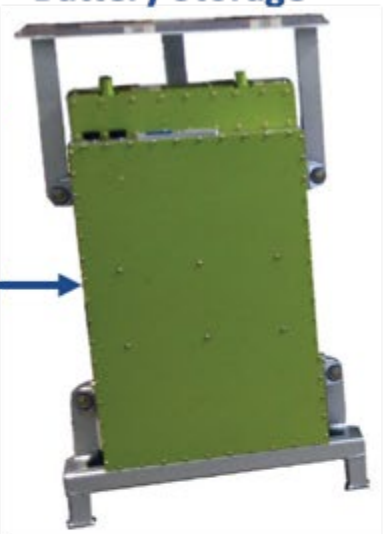
Four Cummins Westport ISX12N 100% Natural Gas Engines – 1,600 hp

Four BAE Integrated Starter-Generator 300 kW (400hp)

Locomotive Multi-Engine Hybrid Power and Control Systems

BAE Power Management System

BAE Onboard Battery Storage



Railpower Packaged Tier 4 Cummins 100% Diesel Engine – 2700 hp.

Onboard Diesel Storage

Energy Recovery from Traction Motors

AC/DC Traction Locomotive Control Systems

Existing Locomotive Components

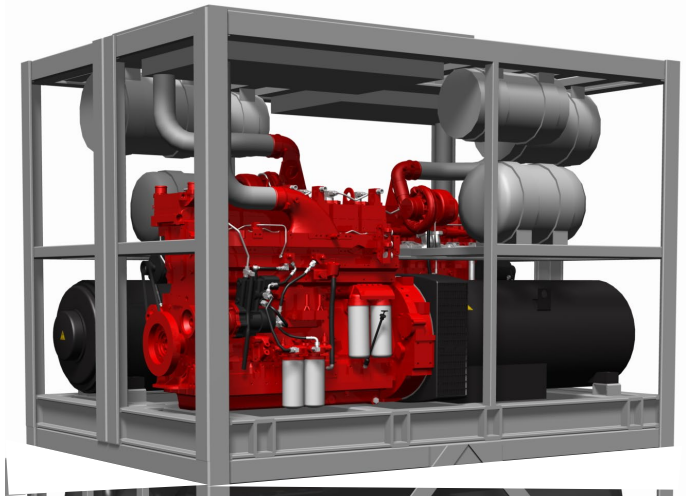
Traction Motor(s)

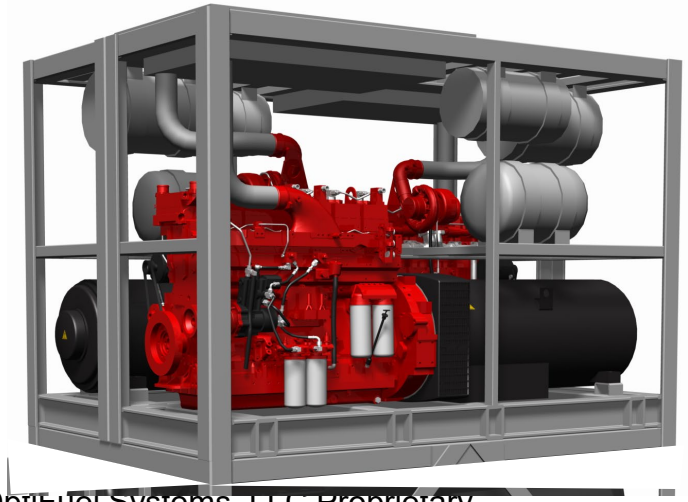
Traction Motor(s)

Traction Motor(s)

Traction Motor(s)

Two 800 hp. Modular Engine Pods (2 Engines in each Pod, Natural Gas System and a Single Tier 4 QSK60 Engine Pod Will Include a Free 5 Years Maintenance and 5 Year Warranty - Rest of Locomotive 2 Years





Annual Engine Performance Parameters	Engine #1 HP ISX12N	Engine #2 HP ISX12N	Engine #3 HP ISX12N	Engine #4 HP ISX12N	Engine #4 HP ISX12N
Total Annual Hours	4,506	3,251	2,759	1,225	2,366
Percentage Annual Hours	100.00%	72.15%	61.24%	27.18%	52.52%
Total Rated Hp	400	400	400	400	2,700
Avg. Annual Hp	228	228	228	228	1,090
Load Factor Percentage	57%	57%	57%	57%	40%
Avg. Annual Engine Running Hours	2,935	2,935	2,935	2,935	2,366
Avg. Annual Engine Running Percentage	65%	65%	65%	65%	53%

The 100% Diesel, Tier 4, QSK60 Engine Is Only Used 28% of the Time (Notches 4 to 8) Where it is Very Clean - At Idle and Notch 1 to 3, It is Not Used

- ***By combining the different power sources, the average emission is very low – way below Tier 5***

4300 HP LINE HAUL LOCOMOTIVE - Quad ISX12N and Tier 4 QSK60 Engines	Total Annual Hours With ESS System	NOx g/bhp-hr	PM g/bhp-hr	CO g/bhp-hr	NMHC g/bhp-hr
Normal Idle	764	0.00	0.00	0.21	0.00
Dynamic Brake	0.00	0.00	0.00	0.00	0.00
Notch 1	491	0.00	0.00	0.21	0.01
Notch 2	491	0.00	0.00	0.21	0.01
Notch 3	393	0.00	0.00	0.21	0.01
Notch 4	333	0.04	0.00	0.19	0.00
Notch 5	287	0.15	0.00	0.14	0.00
Notch 6	295	0.15	0.00	0.13	0.00
Notch 7	227	0.13	0.00	0.14	0.00
Notch 8	1,225	0.09	0.00	0.14	0.01
EPA DUTY CYCLE WEIGHTED		0.05	0.00	0.18	0.01

The Larger Sea Crossing Ship Companies Are Already Building LNG Powered Ships, But No Affordable Tier 4/5 Natural Gas Engines for the Coastal and Inland Market

- Ship builders are already building new ocean-going vessels that are powered with LNG using very large micro-pilot dual fuel engines (>10,000 Hp, $1 million or more) from Wartsila
- Offshore rigs and associated working boats are shifting to natural gas due to ever-tightening federal air quality regulations
- Companies are already gearing up to spend hundreds of millions on LNG production and fueling facilities to serve U.S. inland marine industry
- Large dual fuel engines being used by the new 300 ft. LNG powered workboats in the Gulf are too large and too expensive for use by the towboat and tugboat industry in the U.S. inland waterways

The Marine Market Is Perfect For Dual Fuel Due To The Large Amount Of Fuel Used

- There are over 5,000 tugboats, towboats (push boats), and working boats in harbors, in inland waterways, and off-shore on the Gulf Coast
  - A majority of them are 30 to 50 years old and will need to be replaced over the next 10 years with multiple 19 to 50 liter engines
  - Depending on size, towboats can consume from 15,000 to 90,000 gallons of diesel fuel every 14 days – a perfect market for LNG and dual fuel
  - New tug and tow boats designs are 1,500 hp to 6,000 hp with multi–engines, hybrid, electric drive configurations

TOWBOAT Configurations With Cummins QSK19DF and ISX12N Engines	Cost of Diesel Fuel for Original EMD Engine(s) Configuration Running a Full Year (8,760 Hours at 90% Power, $3.30 per Gallon of Diesel)	Cost of Dual Fuel with Cummins Engine Configurations Running a Full Year (8,760 Hours at 90% Power, $3.30 per gallon of Diesel, $1.60 DGE LNG, 80% Substitution)	Annual Fuel Savings Running on Dual Fuel (70% Substitution) Instead of Original EMD Engines	Estimated Delta Cost of Dual Fuel System Including LNG Storage	Payback Period in Years
Three QSK19DF and four QSX12N – 2,400 Hp	$3,800,389	$2,024,955	$1,775,434	$1,100,000	0.62
Four QSK19DF and four QSX12N – 3,200 hp	$7,667,064	$4,085,229	$3,581,836	$1,550,000	0.43
Seven QSK19DF and four QSX12N– 5,600	$5,111,376	$2,723,486	$2,387,890	$1,450,000	0.61

Only Need Three Hull Sizes, Two Engine Sizes, and Use Standard Subcomponents to Reduce Production Cost for Hybrid CNG/RNG/LNG Powered Tug and Tow Boats

- Our goal for the entire boat is 70% to 80% substitution of the natural gas and Tier 4 or better emissions, with no need for SCR
- Current standardized towboat / tugboats approach for coastal and inland marine markets
  - 2,400 Hp: Small Hull 78' x 32' x 11' - Powered by **three Tier 3 Cummins Tier 3 QSK19 Dual Fuel and four Zero ISX12N**
  - 3,200 Hp: Medium Hull 90' x 36' x 11' - Powered by **four Cummins Tier 3 QSK19 Dual Fuel and four Zero ISX12N**
  - 5,600 Hp: Large Hull 120' x 42' x 11' - Powered by **seven Cummins Tier 3 QSK19 Dual Fuel and four Zero ISX12N**

Small Hull – 2,400 Hp – Onboard LNG 3000 DGE, 20 ft ISO Containers on Deck

Medium Hull – 3,050 Hp – Onboard LNG 3000 DGE, 20 ft ISO Containers on Deck

Large Hull – 4,650 Hp - Onboard LNG 9000 DGE, Three 20 ft ISO Containers on Deck

Tender Barge – 15,000 DGE of LNG

Contact

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