

Surface Transportation Board Hearing | September 16-17, 2024
Docket No Ep 775: Growth in the freight rail industry

Testimony of Cynthia Heinz, Board Member, OptiFuel Systems
TO BE DELIVERED VERBALLY WITH EXHIBITS

Beyond Incremental: Harnessing Supplier innovation for sustainable growth

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INTRODUCTION

I'm Cynthia Heinz, a Board Member at OptiFuel Systems, a startup focused exclusively on zero emission locomotives and refueling solutions. The company has deep technical expertise in natural gas, hydrogen, diesel, battery, dual-fuel, and hybrid power system technologies.

Thank you for this opportunity to speak, and for the gift of your time. Today, I'd like to spend a few minutes exploring the pivotal role that startups can play in this complex environment - and where perhaps these contributions can intersect synergistically with some of the goals you have all set forth today. Our discussion will center around two of my favorite topics—innovation and money—but through a route that might offer some surprising insights.

In 2023, global investments in the energy transition away from fossil fuels reached a record \$1.8 trillion. Yet almost none of these funds were directed toward the rail sector - a 200-year old industry operating on 100-year old locomotive technology that we are critically dependent on for 1/3 of our U.S. exports.

U.S. rail is the most efficient freight transportation network in the world. It supports nearly \$219 billion in economic output, moves over 1.6 billions tons of freight each year, drives nearly 1% of all U.S. employment, and is nearly 10 times more efficient than European freight rail.

Unfortunately, the U.S. rail network is at risk. Efficiency & performance are rapidly declining. Railroads are experiencing increasing market share losses to trucking due to issues with reliability, emissions, on-time performance, and response time.

U.S. economic vitality, competitiveness, & national security hinge on our locomotive technology. The U.S. railroad network boasts one of the most remarkable biographies. It's a masterpiece of logistics, strategy, and infrastructure, fueled by brilliant technology. And while the focus of this presentation today will be on strategies to leapfrog the constraints imposed by obsolete technologies, the reason we are discussing these constraints is not that the current technology is flawed. Quite the opposite. The technology we've relied on for over a century has proven its value with remarkable staying power.

Since the 1800s, U.S. railroads have heavily invested in modernizing their infrastructure and locomotive fleets, spending six times more than the average U.S. manufacturer. Until 2015, there was no resistance to new locomotive purchases. So if we are seeing pushback now, we need to understand why.

The U.S. freight locomotive fleet relies on two diesel power system technologies developed in the 1920s. Both technologies face obsolescence risk, compounded by scarce repair parts and increasingly ineffective tune-ups. These U.S. locomotives produce over 40 million tons of greenhouse gases annually and emit high levels of harmful criteria pollutants (NOx & PM). While Class I Railroads have committed to reaching zero emissions by 2050, they are currently forced into limiting measures—such as retiring old assets, avoiding purchasing new locomotives, and running longer trains—which constrain both growth and service.

There has been a steep decline in new locomotive purchases compared to retirements since the introduction of Tier 4 in 2015. To regain market share from trucking and drive growth in intermodal traffic, railroads need affordable, nimble locomotives that are highly efficient, durable for extended operation, and deliver dramatically lower emissions.

CATALYZING CHANGE: Creating an option so compelling that inaction becomes unthinkable.

If zero-emission locomotives could match or exceed diesel performance, be deployed with minimal impact to operations, improve uptime, boost profit margins, be affordable enough for railroads to maintain existing capex budgets and equipment replacement cycles, and include a complete refueling infrastructure with zero-emission fuel at a price comparable to diesel, Class I railroads would line up to replace their fleets, right? This is startup thinking.

The question is... how do we get there? How do we ensure the energy transition in rail doesn't disrupt operations or compromise our supply chain's integrity? And most importantly, how do we make it not just greener, but better? When we talk about innovation in rail, the real benchmark is whether we can do it better. And by better, I mean cheaper, faster, cleaner, and safer. Can we match the ingenuity of our predecessors with solutions that blend cutting-edge equipment, practical collaboration, and optimal use of existing resources? Can we reinspire the resiliency and economic vitality of the U.S. railroad network for the century ahead of us? But when every technology seems to come up high on price & short on performance, what do we do?

Moments like this offer a prime opportunity for startups and established industries to collaborate. Startups, unburdened by legacy constraints, can rapidly develop and iterate solutions that connect and meet the needs of entire ecosystems of stakeholders. They have the ability to spot untapped opportunities, drive meaningful change, and catalyze action. By working together,

transformation can be rapid, cost-effective, and create unmatched competency - not unlike the last great transformation in rail.

In 1920, creating the world's most efficient freight rail network demanded synergistic integration of fuel production, bulk transport, refueling infrastructure, and interoperable technology. From the 1920s to the 1950s, U.S. crude oil production surged as railroads transitioned from steam to diesel, parallel to the construction of crude oil pipelines & the rise of gas-powered vehicles, which enabled efficient fuel transport & created a robust fuel supply chain that supported the needs of the railroads. Over a period of 30 years, steam locomotives were phased out while diesel refueling infrastructure was built in stages to align with the deployment of new locomotives along specific routes. During the transition, steam and diesel locomotives could operate together within a single train consist.

The Secret to Innovation & Growth in Rail is to leverage the broader market's strengths first:

1. Energy production in sync with demand
2. Energy transport & infrastructure
3. Ease the transition by minimizing disruption

OptiFuel Systems

Over the past decade, OptiFuel has evolved from a visionary startup into a leader in sustainable locomotive technology. Today, OptiFuel is not just redefining what's possible for zero-emission railroads but also proving the viability and profitability of cleaner alternatives. OptiFuel has created durable and reliable locomotives that achieve both GHG and criteria emissions (NOx and PM) targets. Designed for outstanding efficiency and 24/7 performance,

these locomotives enable railroads to improve profitability, comply with regulations, and lead the way in helping customers achieve their emissions goals.

The future of U.S. rail hinges on being nimble, responsive, reliable, and emissions-free. OptiFuel Total-Zero™ Locomotives feature a modular design that introduces new efficiencies for railroads, like 95% operating uptime and on-track engine replacement in about an hour. Modularity enables the efficient assembly of locomotives in power ranges from 800 hp to 5600 hp, allowing for tailored solutions that meet the specific needs of different railroads. By incorporating smaller, more efficient engines and generators alongside hybrid power systems, OptiFuel locomotives offer quicker responsiveness, diesel-equivalent power, and superior performance. Modularity also allows for efficient trials, customization, and the flexibility to future-proof operations. This adaptability reduces risk and encourages railroads to explore new technologies, providing them with the ability to test and swap power systems as needed.

Startups excel at rapid optimization. Today, OptiFuel is advancing FRA concurrence for its second- and third-generation fuel storage systems, along with EPA certification for its third-generation power system. The company's Total-Zero™ line haul locomotive is in production, with concurrence testing beginning next year (2025).

OptiFuel partners with leading suppliers to integrate state-of-the-art technologies with innovative solutions to ensure superior performance, production scale, & long-term support.

1. Since 2018, OptiFuel and Cummins have collaborated on adapting the Cummins X12 and X15 truck engines for optimal performance in rail operations and seamless integration into OptiFuel locomotives.
2. To enhance performance with hybrid power, OptiFuel integrated the most efficient off-the-shelf LFP battery technology available today, with a design that ensures easy

replacement and upgrades to more advanced battery technologies as they become available.

3. OptiFuel then tackled size constraints by developing a proprietary generator that optimizes power output while minimizing dimensions.

The Result:

- Smaller engines extract more horsepower from less efficient alternative fuels, with the X15N delivering diesel-equivalent power.
- The X15N engine combines affordability, a 30-year lifespan, continuous performance, quiet operation, and near-zero emissions.
- RNG, diesel, and hydrogen versions of the X15 offer fuel flexibility.
- Hybrid power technology enhances fuel economy by 20%.
- Partnerships between startups like OptiFuel and established technology leaders like Cummins ensure customers receive the most advanced and reliable technology, backed by extensive support, manufacturing scale, and cost efficiency.

OptiFuel's X15N powered locomotives ensure near-zero criteria emissions even if operated on fossil fuels - clearing the track of pollutants to safeguard health in local communities.

Compliance with CARB regulations requires eliminating NOx and PM emissions. Use of biodiesel and renewable diesel do not reduce or eliminate these criteria emissions.

While OptiFuel Total-Zero™ locomotives resolve emissions, offer significant improvements in fuel economy & reliability, enable nimble operations for driving intermodal growth, and de-risk the transition to clean energy through flexible adaptation of various power systems, these

enhancements don't address the crucial issue of interoperability that has always been central to U.S. railroads' success.

The biggest questions still remain:

1. Can clean power match diesel's range in line haul operations?
2. Is there sufficient energy supply, and how will it be procured?
3. What will the cost be?

Can Clean Power Match Diesel's Range in Line Haul Operations?

Since renewable energy is less efficient than diesel, railroads would need to carry additional tender cars to store enough fuel to match diesel's range in line haul operations. Battery power, in particular, required extensive storage, with eight tender cars of batteries only allowing for about half the distance of a diesel locomotive. This would disrupt operations, leading to its immediate cancellation as a viable line-haul option. Since both hydrogen and RNG could achieve the minimum distance of 1500 miles, they remained under consideration.

Since RNG is more efficient to store than hydrogen, OptiFuel prioritized RNG-powered equipment for line haul tests. With each iteration, they enhanced performance, ultimately achieving a breakthrough. While railroads would need to carry one tender car, OptiFuel's RNG locomotives could travel nearly 1,000 miles farther than diesel locomotives.

By working together, we can iterate innovations to enhance operations at every turn. At OptiFuel, we're ready to listen. Railroads asked, "What more can a tender car achieve?" This led us to develop a powered tender car capable of tackling steep terrains like the Cajon Pass without the need for a helper locomotive.

Is there a sufficient supply of clean energy for rail, how will it be procured?

OptiFuel's approach to tackling the energy supply question was laser-focused, concentrating on market developments that could either cut fuel costs or generate new revenue opportunities. OptiFuel Asked: Is there anything that has happened in the past 100 years that could make the fuel supply chain more efficient?

One thing stood out immediately. Throughout the 1950s and 1960s, the U.S. invested heavily into the construction of a 3 million-mile network of pressurized pipelines that transport over 30 trillion cubic feet of compressed natural gas (CNG) annually. Over 95% of the natural gas used in the U.S. is transported from well to market entirely via pipeline, compared to 80% for crude oil and diesel. The world's most efficient fuel distribution system is hidden just next to the tracks in the railroad rights-of-way. Adding CNG/RNG pumps connected to these pipelines at railroad fuel stations would be highly cost-effective and could also eliminate ~71,500 tanker truck loads of fuel from roads each year.

U.S. production of emissions-free Renewable Natural Gas (RNG) is at an all-time high, continually increasing pipeline availability. Produced from waste rather than fossil fuels, RNG is chemically identical to CNG, enabling railroads to refuel from pipelines and operate emissions-free.

- RNG production methods are well established.
- Monetization of the environmental attributes enables attractive payback periods.
- RNG is injected directly into natural gas pipelines as a standard business practice.
- Modular deployment of production equipment through co-ops with railroads ensures aligned supply, offers stable fixed-cost pricing, and creates new revenue opportunities for participating railroads.

- Robust federal and state incentives are available to boost RNG production, with potential opportunities to extend these credits to the rail sector.

RNG offers the highest reduction in greenhouse gas (GHG) emissions among locomotive power options and also the lowest cost. Transitioning to RNG-powered locomotives could save Class I railroads an estimated \$3.8 billion in fuel cost each year.

Refueling Infrastructure

OptiFuel built the world's first CNG/RNG fuel station for a railroad in 2018. The Indiana Harbor Belt Railroad has been using this prototype station for over 5 years. For Class I railroads, OptiFuel is scaling up with larger stations, each able to dispense about 260,000 gallons of RNG per day. Refueling Class I line-haul operations is expected to require 60 fuel stations over a 15-30 year period. The plan employs a modular approach for deploying equipment and infrastructure, ensuring a scalable solution that aligns with the annual deployment of new locomotives by Class I railroads.

What's Next

Next year, OptiFuel will begin line haul demonstration & concurrence testing at the FRA's Technology Transportation Center (TTC) in Pueblo, CO.

The role of venture capital is to identify and support the visionaries and transformative ideas that will become essential in the years to come. This is that moment. As we reflect on OptiFuel's 10-year journey, we see a convergence of history, leading technologies, strategic thinking, and meticulous planning. Startups like OptiFuel need the partnership of Class I railroads, just as U.S. rail needs the innovation and bold action that companies like OptiFuel

bring. We've done the heavy lifting to make a transition that once seemed distant, now within reach.

What does OptiFuel need from Class I railroads? Commitments for 1-million-mile testing. The knowledge contribution, participation, and scale of Class I railroads are crucial for testing, refining, and advancing this next leg of the journey. Together, we can ensure that the U.S. rail industry not only remains competitive but leads the world in sustainable, efficient, and forward-thinking transportation.

Thank you for the opportunity to present this perspective to the Board and to each of you.

BEYOND INCREMENTAL HARNESSING SUPPLIER INNOVATION FOR SUSTAINABLE GROWTH

SURFACE TRANSPORTATION BOARD HEARING | SEPTEMBER 16-17, 2024
GROWTH IN THE FREIGHT RAIL INDUSTRY



ACCELERATING THE PACE TO
TOTALZER 

INTRODUCTION

Cynthia Heinz, Venture Capital Investor & Board Member



I'm Cynthia Heinz, a Board Member at OptiFuel Systems - a startup focused exclusively on zero emission locomotives and refueling solutions. The company has deep technical expertise in natural gas, hydrogen, diesel, battery, dual-fuel, and hybrid power system technologies.

Thank you for this opportunity to speak, and for the gift of your time. Today, I'd like to spend a few minutes exploring the pivotal role that startups can play in this complex environment - and where perhaps these contributions can intersect synergistically with some of the goals you have all set forth today.

Our discussion will center around two of my favorite topics—innovation and money—but through a route that might offer some surprising insights.



2022 Letter to CEO's

"THE DECARBONIZATION OF THE GLOBAL ECONOMY IS GOING TO CREATE THE BIGGEST INVESTMENT OPPORTUNITY OF OUR LIFETIME. IT WILL ALSO LEAVE BEHIND THE COMPANIES THAT DON'T ADAPT, REGARDLESS OF WHAT INDUSTRY THEY ARE IN."

LARRY FINK

Chairman & CEO, Blackrock

In 2023, global investments in the energy transition away from fossil fuels reached a record \$1.8 trillion. Yet almost none of these funds were directed toward the rail sector - a 200-year old industry operating on 100-year old locomotive technology that we are critically dependent on for 1/3 of our U.S. exports.

U.S. rail is the most efficient freight transportation network in the world.

Powered by strategic planning, interoperability, private investment, and the world's leading locomotive technologies

Invention of the steam engine ● 1712

Invention of the steam locomotive ● 1804

Steam locomotives begin operating on U.S. Rail ● 1829

96 YEARS OF STEAM POWER ●



Invention of the diesel engine ● 1897

Invention of diesel-electric locomotive engine ● 1917

Diesel-Electric locomotives begin operating on U.S. Rail ● 1925

99 YEARS OF DIESEL POWER ●

2024

?

2050

> Supports nearly \$219 billion in economic output

> Moves over 1.6 billion tons of freight annually, accounting for 40% of freight transportation and 1/3 of all U.S. exports

> Drives nearly 1% of all U.S. employment

> Nearly 10 times more efficient than European freight rail

Risks:

> Efficiency & performance are rapidly declining

> Railroads are experiencing increasing market share losses to trucking due to issues with reliability, emissions, on-time performance, and response time

U.S. economic vitality, competitiveness, & national security hinge on our locomotive technology.

The U.S. railroad network boasts one of the most remarkable biographies. It's a masterpiece of logistics, strategy, and infrastructure, fueled by brilliant technology. And while the focus of this presentation today will be on strategies to leapfrog the constraints imposed by obsolete technologies, the reason we are discussing these constraints is not that the current technology is flawed. Quite the opposite. The technology we've relied on for over a century has proven its value with remarkable staying power.

Since the 1800s, U.S. railroads have heavily invested in modernizing their infrastructure and locomotive fleets, spending six times more than the average U.S. manufacturer. Until 2015, there was no resistance to new locomotive purchases. So if we are seeing pushback now, we need to understand why.



The U.S. freight locomotive fleet relies on two diesel power system technologies developed in the 1920s.

Both technologies face obsolescence risk, compounded by scarce repair parts & increasingly ineffective tune-ups

GE

circa 1925

Diesel Engine: Ingersoll-Rand

Electrical Equipment: General Electric

Integrator & Original Supplier: ALCO

Current Supplier: Wabtec

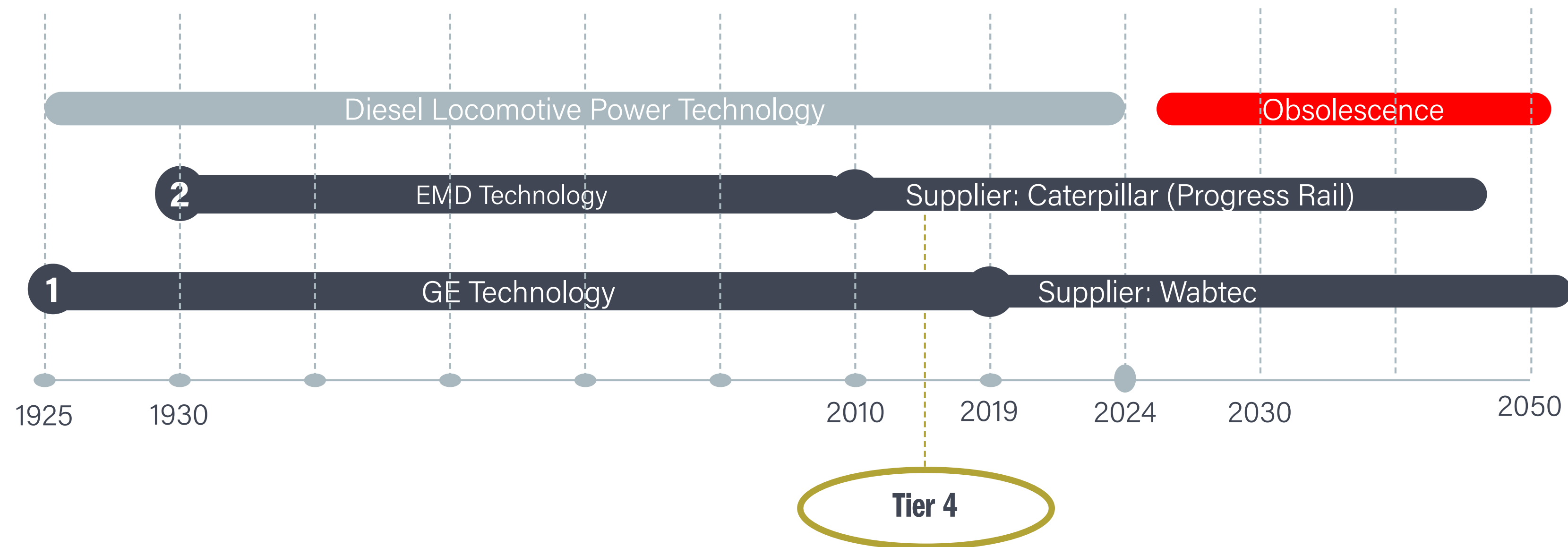
EMD

circa 1930

Diesel Engine: General Motors

Electrical Equipment: Electro-Motive Company

Current Supplier: Caterpillar (Progress Rail)



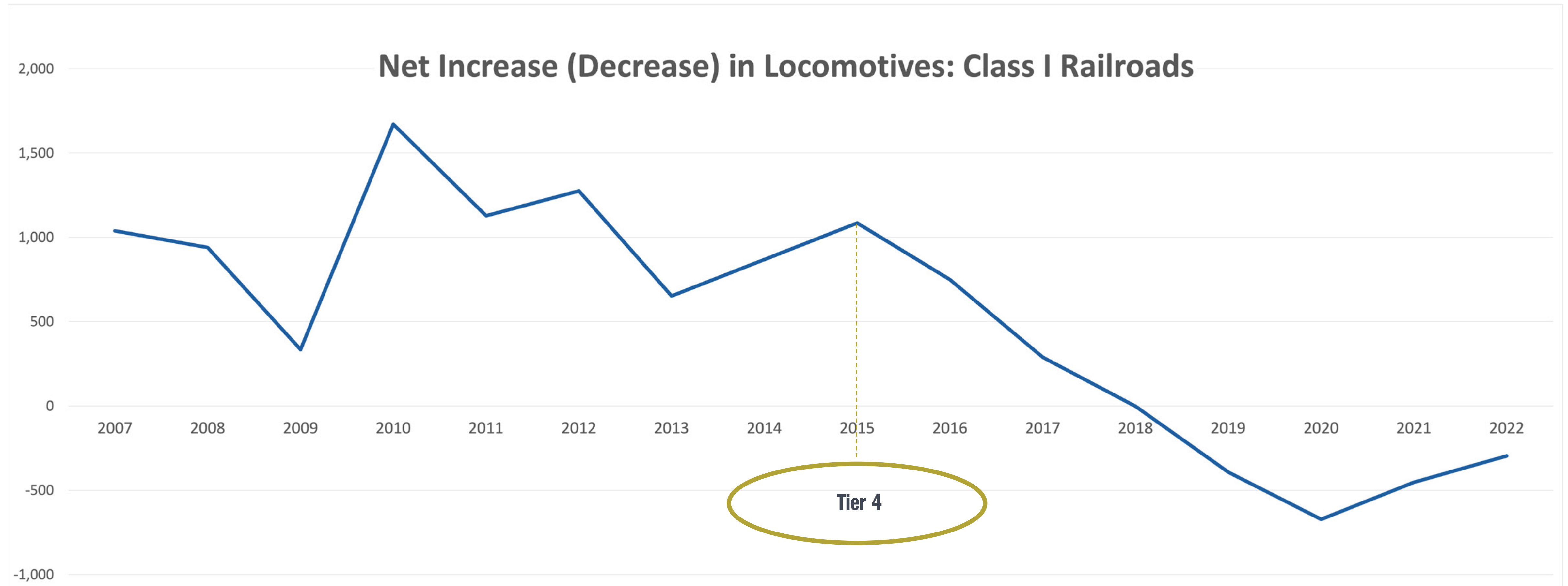
These U.S. locomotives produce over 40 million tons of greenhouse gases annually and emit high levels of harmful criteria pollutants (NOx & PM).

A photograph of a freight train moving from left to right. The lead locomotive is blue with its headlights on. It is followed by several yellow locomotives. Thick black smoke is billowing from the smokestacks of the locomotives, filling the upper half of the frame. The train is pulling several yellow freight cars. The background shows green trees under a grey, overcast sky.

While Class I Railroads have committed to reaching zero emissions by 2050, they are currently forced into limiting measures—such as **retiring old assets, avoiding purchasing new locomotives, and running longer trains**—which constrain both growth and service.

There has been a steep decline in new locomotive purchases compared to retirements since the introduction of Tier 4 in 2015.

Outdated locomotive technologies are falling behind and failing to meet modern demands





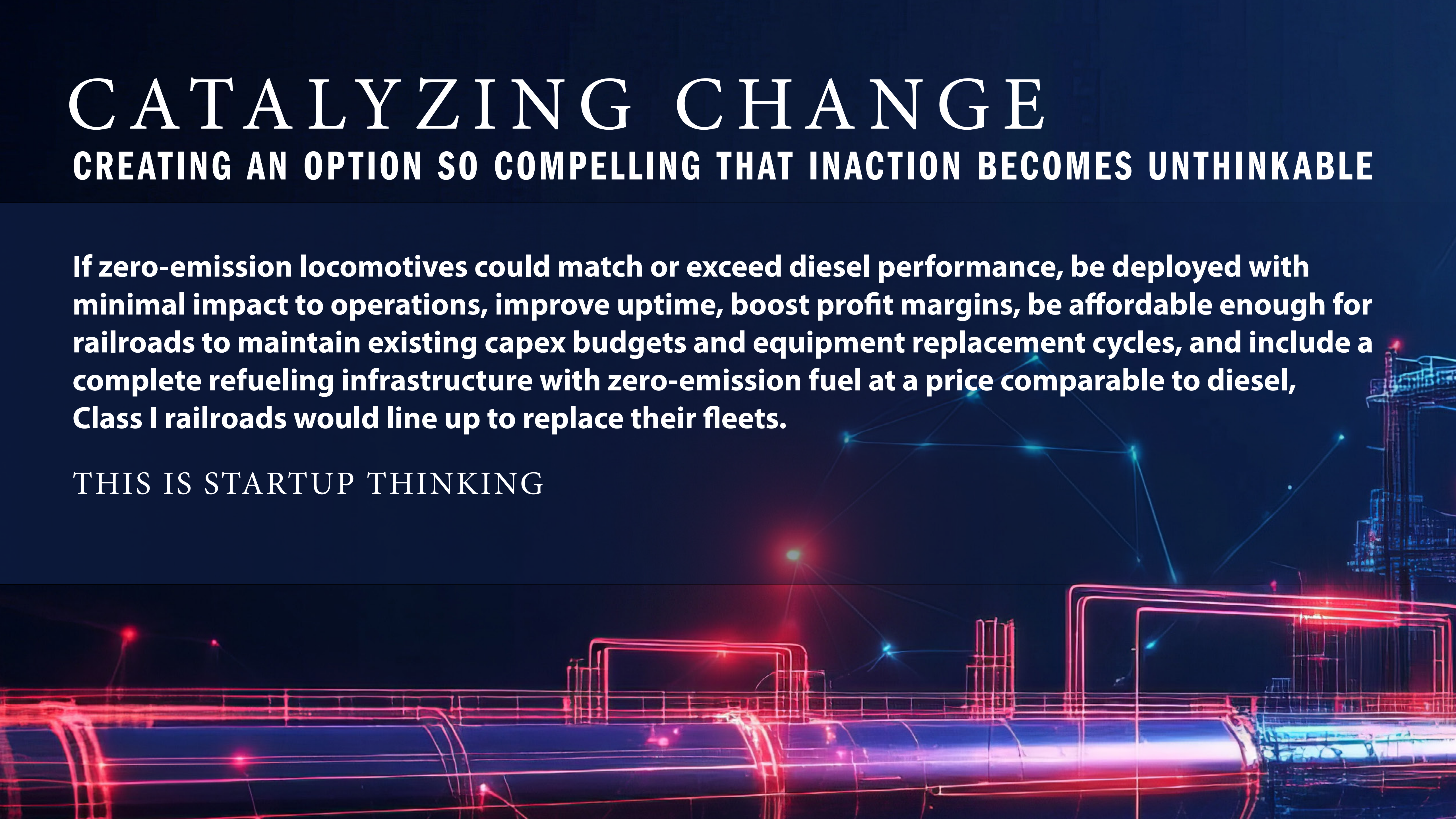
To regain market share from trucking and drive growth in intermodal traffic, railroads need affordable, nimble locomotives that are highly efficient, durable for extended operation, and deliver dramatically lower emissions.

CATALYZING CHANGE

CREATING AN OPTION SO COMPELLING THAT INACTION BECOMES UNTHINKABLE

If zero-emission locomotives could match or exceed diesel performance, be deployed with minimal impact to operations, improve uptime, boost profit margins, be affordable enough for railroads to maintain existing capex budgets and equipment replacement cycles, and include a complete refueling infrastructure with zero-emission fuel at a price comparable to diesel, Class I railroads would line up to replace their fleets.

THIS IS STARTUP THINKING



The question is... how do we get there?

How do we ensure the energy transition in rail doesn't disrupt operations or compromise our supply chain's integrity? And most importantly, how do we make it not just greener, but better?

When we talk about innovation in rail, the real benchmark is whether we can do it better. And by better, I mean cheaper, faster, cleaner, and safer. Can we match the ingenuity of our predecessors with solutions that blend cutting-edge equipment, practical collaboration, and optimal use of existing resources? Can we reinspire the resiliency and economic vitality of the U.S. railroad network for the century ahead of us?

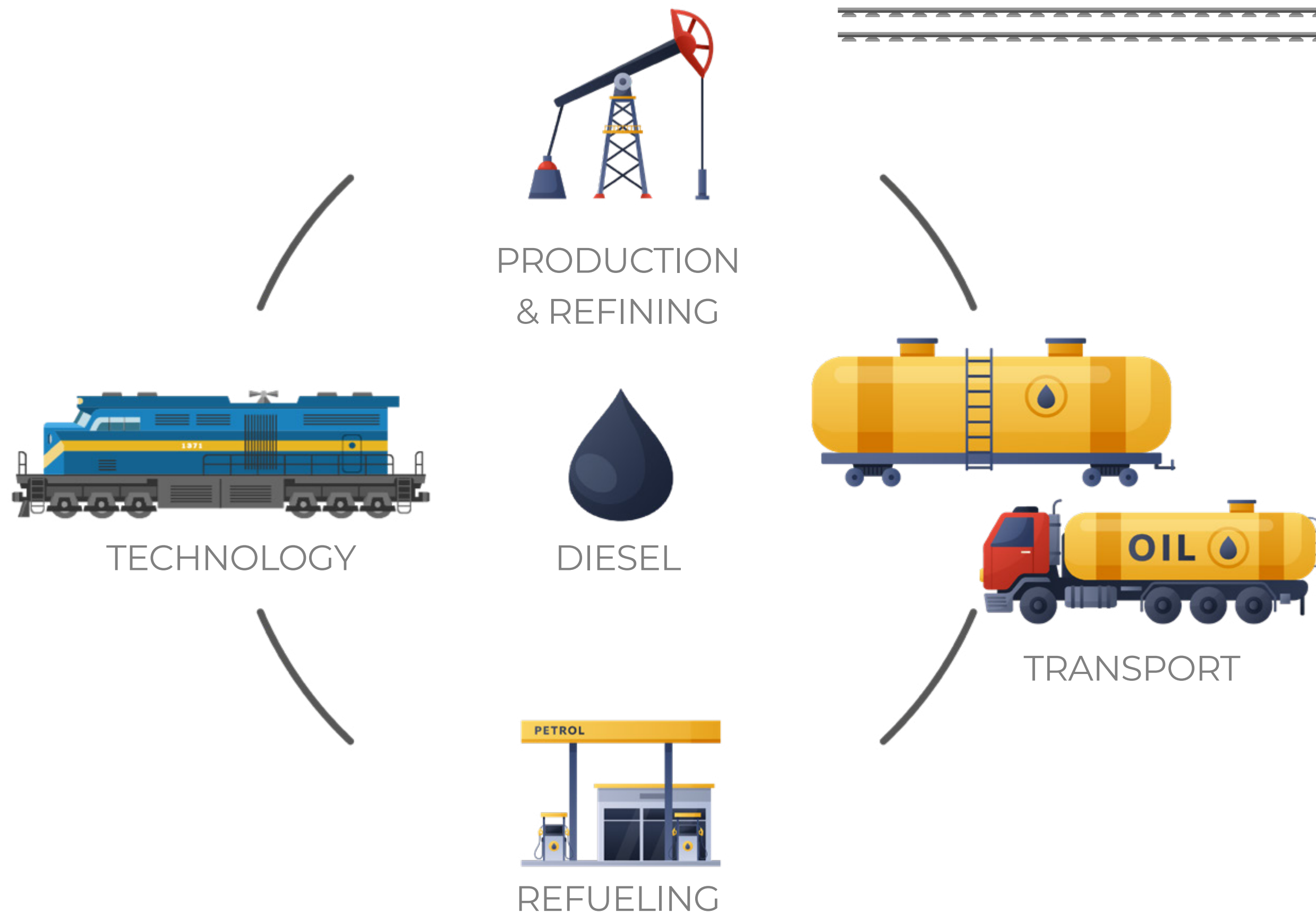
But when every technology seems to come up high on price & short on performance, what do we do?

Moments like this offer a prime opportunity for startups and established industries to collaborate. Startups, unburdened by legacy constraints, can rapidly develop and iterate solutions that connect and meet the needs of entire ecosystems of stakeholders. They have the ability to spot untapped opportunities, drive meaningful change, and catalyze action. By working together, transformation can be rapid, cost-effective, and create unmatched competency - not unlike the last great transformation in rail.

The Year was 1920...

Creating the world's most efficient freight rail network demanded synergistic integration of fuel production, bulk transport, refueling infrastructure, and interoperable technology.

Key Elements in the Energy Transition from Steam-Power to Diesel-Power

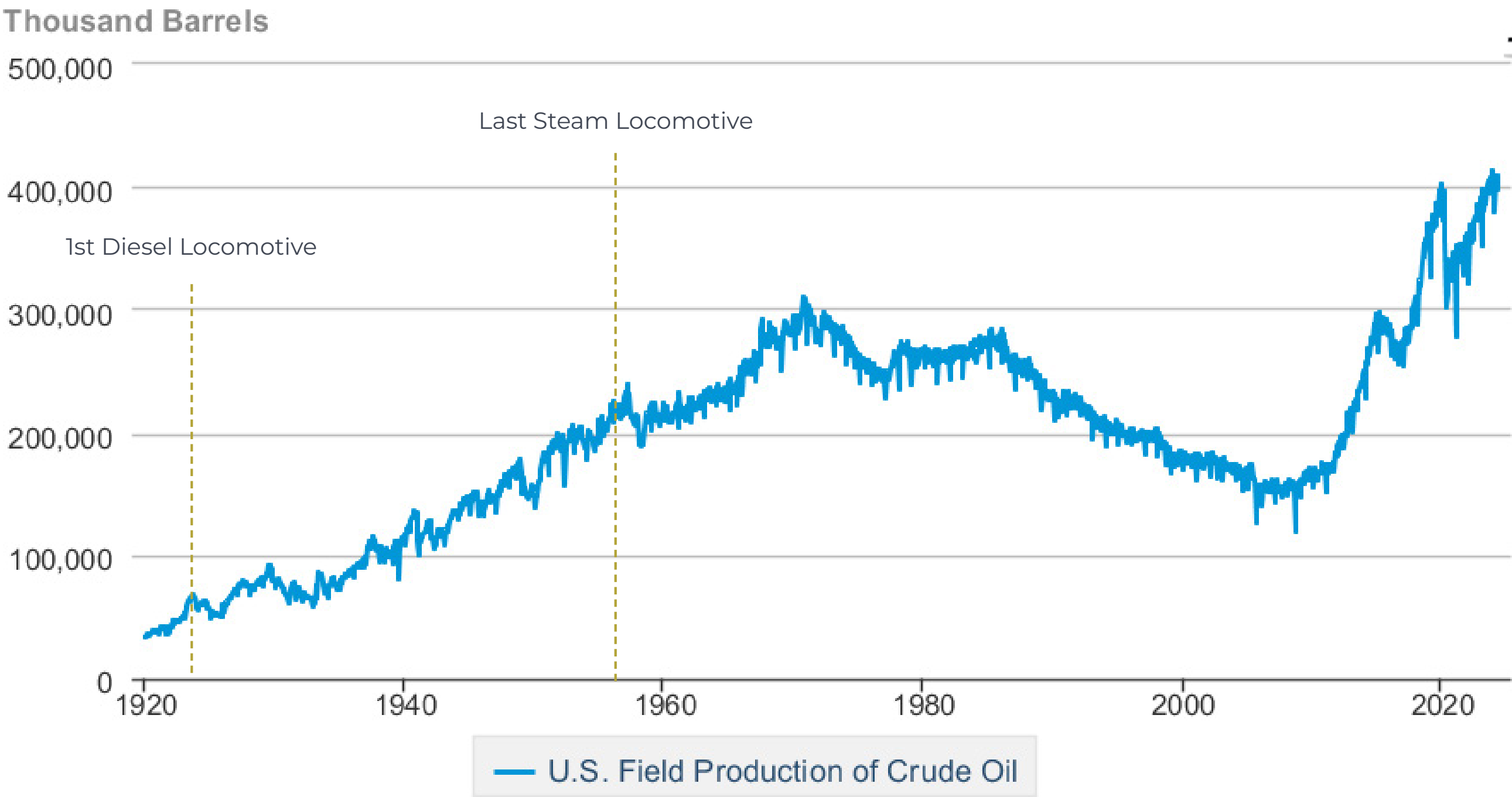


- > **Leverage Existing Assets:** 254,251 miles of existing track for steam locomotives.
- > **Fuel Supply:** Development of a robust crude oil production system to ensure a steady and reliable source of fuel.
- > **Transport Logistics:** Efficient transportation of bulk fuel by both truck and rail to ensure timely and reliable delivery to railroads.
- > **Refueling Infrastructure:** Establishment of large-capacity fuel stations strategically located along tracks to facilitate seamless refueling operations.
- > **Technology Integration:** Innovation in diesel locomotive technology provided the necessary power, distance, efficiency and affordability, ensuring that trains could travel long distances over rough terrain.
- > **Interoperability:** Diesel powered locomotives also enabled critical interoperability, allowing locomotives to operate across various networks, be shared between

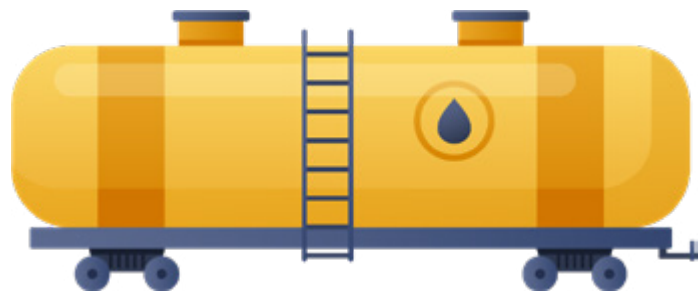
Aligned Fuel Production, Fuel Transport Network, & Fuel Station Infrastructure

From the 1920s to the 1950s, U.S. crude oil production surged as railroads transitioned from steam to diesel, parallel to the construction of crude oil pipelines & the rise of gas-powered vehicles, which enabled efficient fuel transport & created a robust fuel supply chain that supported the needs of the railroads.

U.S. Field Production of Crude Oil



NEW ASSETS FOR FUEL TRANSPORT



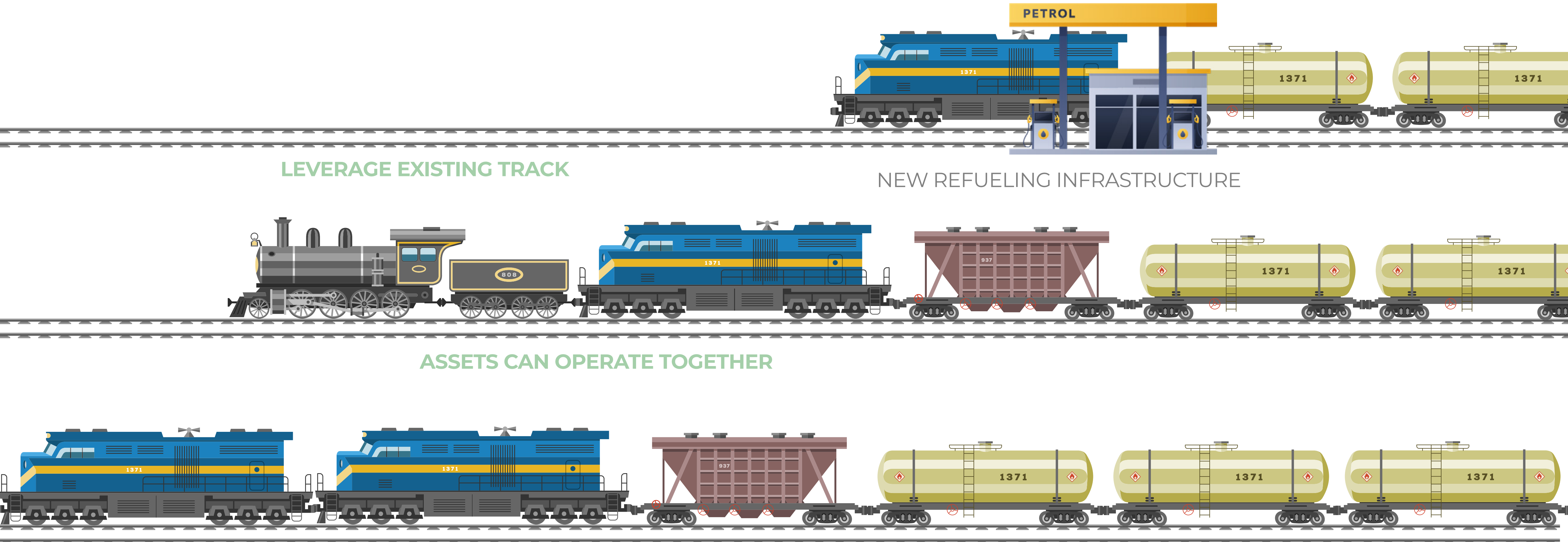
LEVERAGE EXISTING TRACK



NEW REFUELING INFRASTRUCTURE

Meticulously Planned Implementation

Over a period of 30 years, steam locomotives were phased out while diesel refueling infrastructure was built in stages to align with the deployment of new locomotives along specific routes. During the transition, steam and diesel locomotives could operate together within a single train consist.



The Secret to Innovation & Growth in Rail

LEVERAGE THE BROADER MARKET'S STRENGTHS FIRST

1. CRUDE OIL PRODUCTION IN SYNC WITH DEMAND

By the 1920s, established crude oil production methods, coupled with major early 20th-century discoveries, ensured a steady supply. This abundant production was crucial for the energy transition, fueling automobiles, trains, and ships, and supporting widespread industrial innovation.

2. FUEL TRANSPORT & REFUELING INFRASTRUCTURE

Advancements in gas-powered automotive technology at the time & crude oil pipeline construction enabled efficient transport of diesel fuel to railroads. Strategically deployed fuel stations prevented disruptions to routes and train schedules.

3. EASE THE TRANSITION BY MINIMIZING DISRUPTION

Innovators effectively leveraged existing track infrastructure and ensured a smooth transition by meticulous planning of deployments & enabling simultaneous operation of both old and new technologies.

BEYOND INCREMENTAL

CATALYZING CHANGE

FROM 2013 TO TODAY

Over the past decade, OptiFuel has evolved from a visionary startup into a leader in sustainable locomotive technology. Today, OptiFuel is not just redefining what's possible for zero-emission railroads but also proving the viability and profitability of cleaner alternatives.



OptiFuel has created durable and reliable locomotives that achieve both GHG and criteria emissions (NOx and PM) targets. Designed for outstanding efficiency and 24/7 performance, these locomotives enable railroads to improve profitability, comply with regulations, and lead the way in helping customers achieve their emissions goals.



Affordable Zero-Emission Locomotives

The future of U.S. rail hinges on being nimble, responsive, reliable, and emissions-free.



Modular Engineering

OptiFuel Total-Zero™ Locomotives feature a modular design that introduces new efficiencies for railroads, like 95% operating uptime and on-track engine replacement in about an hour.



- > **Enhanced Reliability:** Multi-engine design boosts reliability, achieving over 95% operating uptime.
- > **Nimble Operations:** Small, efficient engines & hybrid power systems enable agile operations in ports and intermodal settings, with precision algorithms optimizing load balancing and engine performance.
- > **Reduced Operating Costs:** By minimizing engine workload & integrating durable, proven technologies, OptiFuel's technology significantly lowers lifetime maintenance expenses compared to traditional diesel locomotives.
- > **Quick On-Track Replacement:** Full modules can be replaced directly from the track in under an hour.
- > **Continuous Operation:** Equipment is built for 24/7 use with no need for resting or recharging. Advanced multi-engine systems ensure uninterrupted operation, even in the event of engine failure.
- > **Future-Proof:** Modular design enables quick adjustments in horsepower or fuel type, keeping your fleet adaptable and technologically advanced.

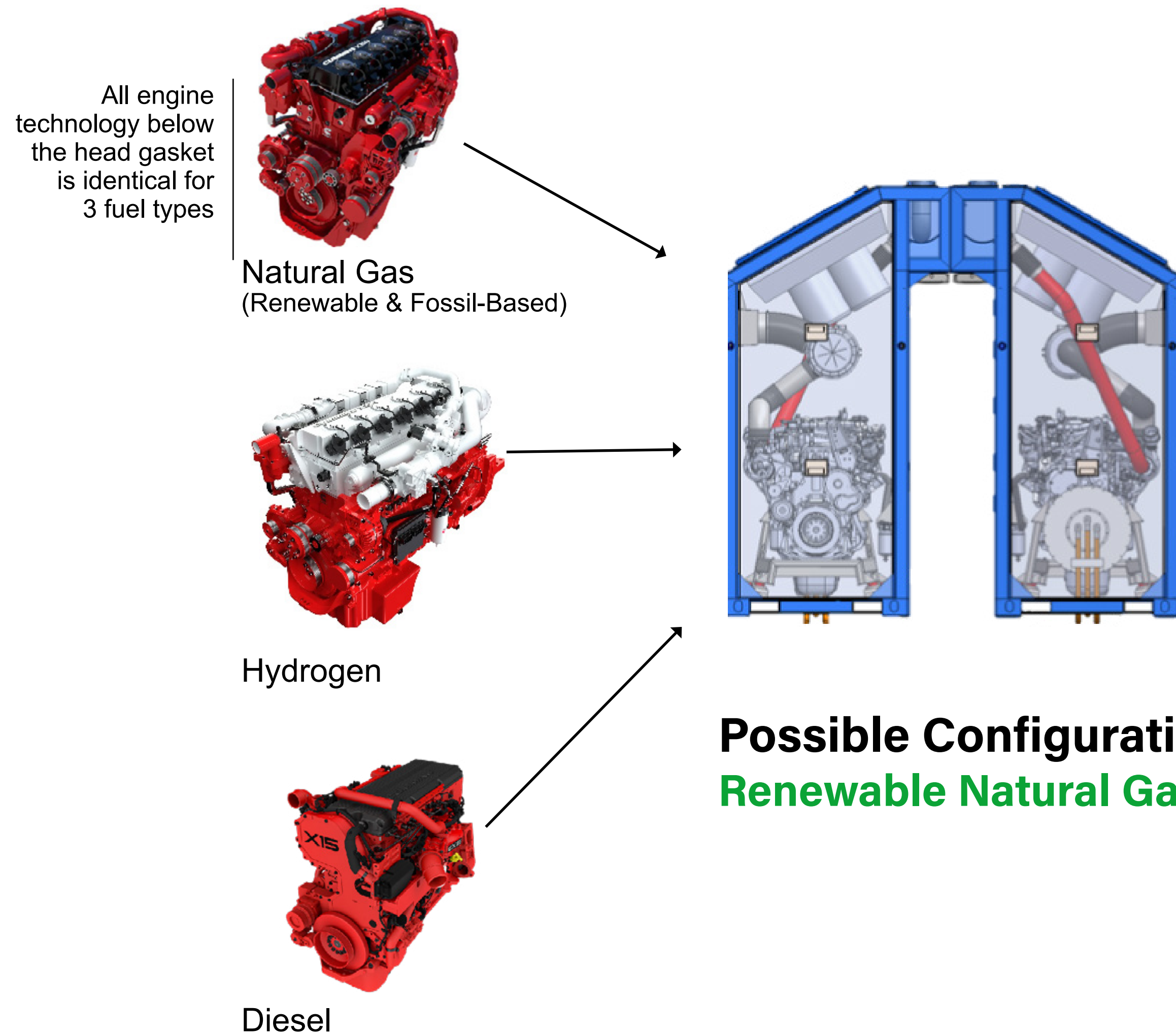
Modularity enables the efficient assembly of locomotives in power ranges from 800 hp to 5600 hp, allowing for tailored solutions that meet the specific needs of different railroads. By incorporating smaller, more efficient engines and generators alongside hybrid power systems, OptiFuel locomotives offer quicker responsiveness, diesel-equivalent power, and superior performance.

OptiFuel Total-Zero™ Locomotives | Retail Price ~\$1000 - \$1500 per hp unit



800 hp —————→ **up to 5600 hp**

Modularity also allows for efficient trials, customization, and the flexibility to future-proof operations. This adaptability reduces risk and encourages railroads to explore new technologies, providing them with the ability to test and swap power systems as needed.



Video: [See how OptiFuel builds a modular locomotive](#)



Possible Configurations:

Renewable Natural Gas, Hydrogen IC, Hydrogen Fuel Cell, Diesel, Battery-Electric

Startups excel at rapid optimization

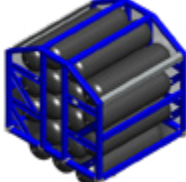
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Modular Fuel Storage System



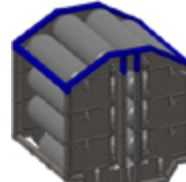
Gen 1
Concurrence



Gen 2
in process

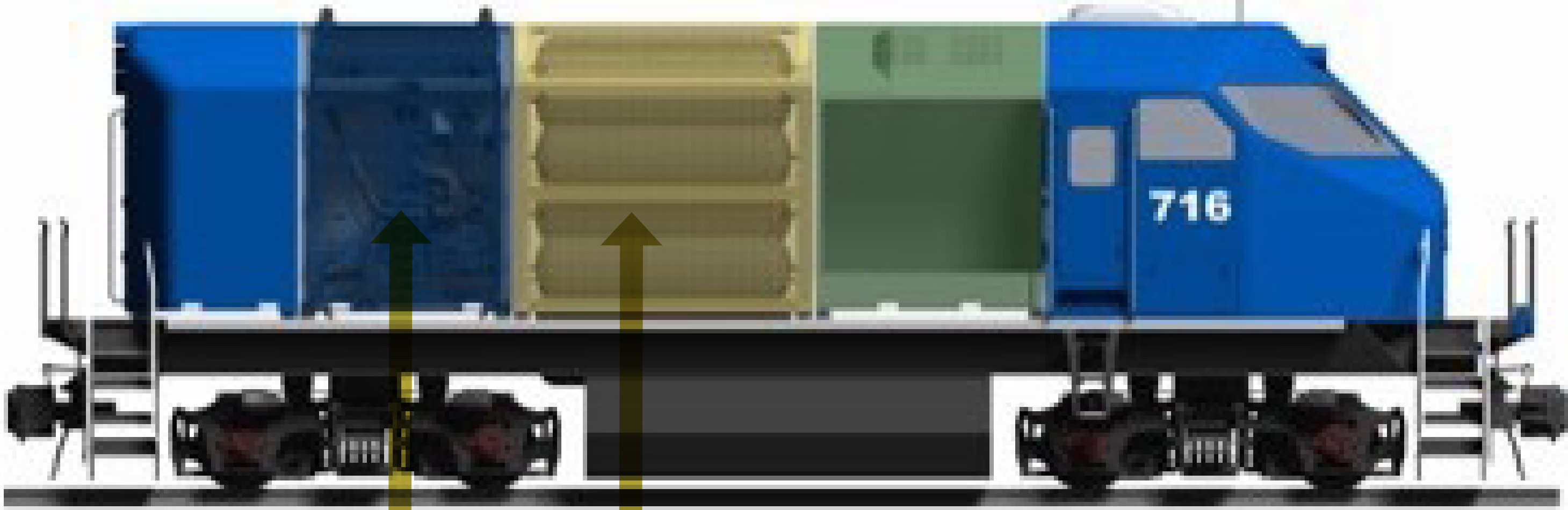


Gen 3
in production



Gen 4
pre-production

Switcher Locomotives: Available in ranges from 800 hp to 2300 hp

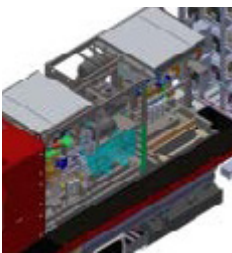


Power Module

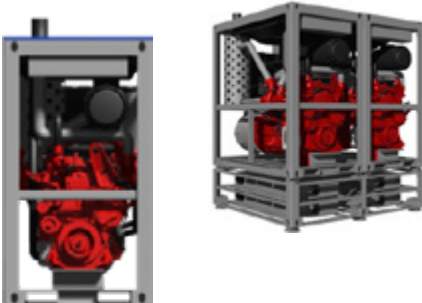
Fuel Storage Module



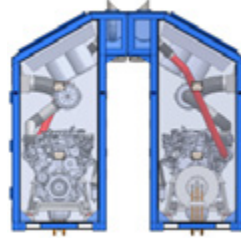
Locomotive Power System



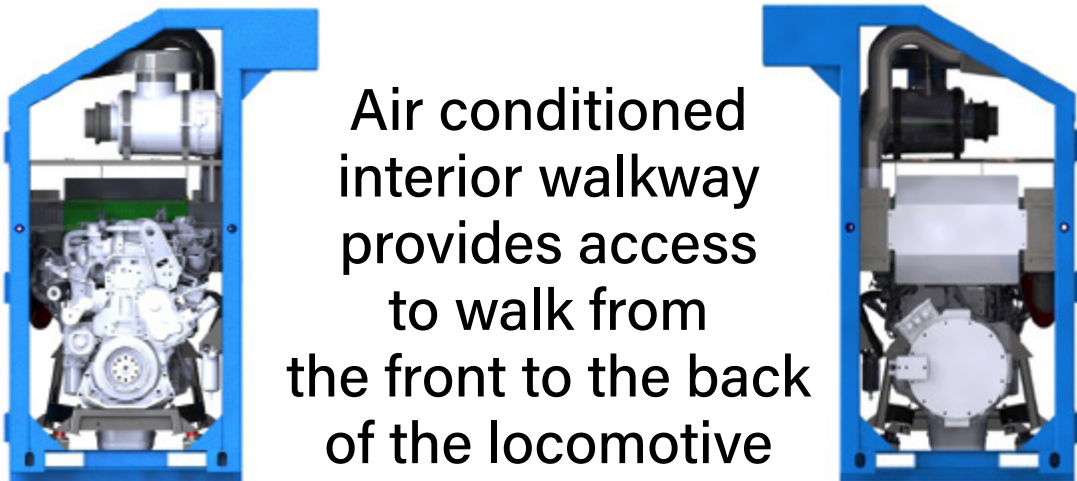
Gen 1 - complete
Dual-Fuel
Tier 4



Gen 2 - complete
NOx: 0.00
PM: 0.00



Gen 3 - in process
Expected:
NOx: 0.05
PM: 0.005



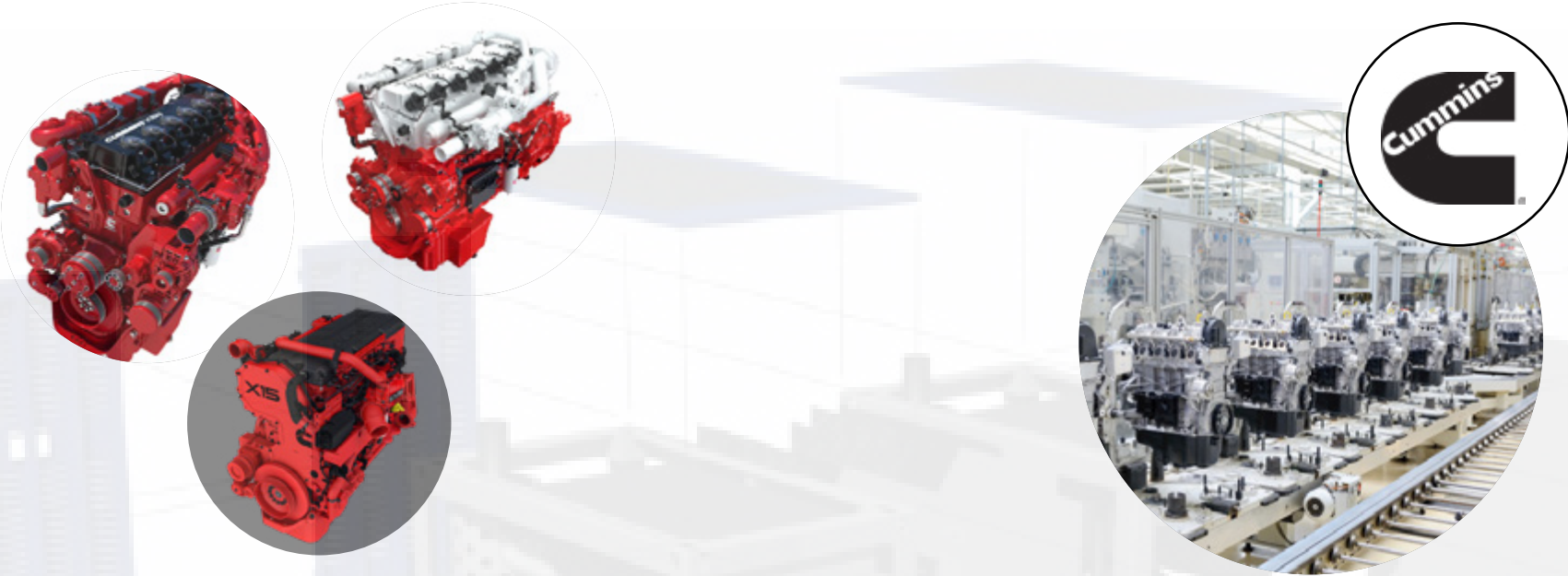
Power Modules



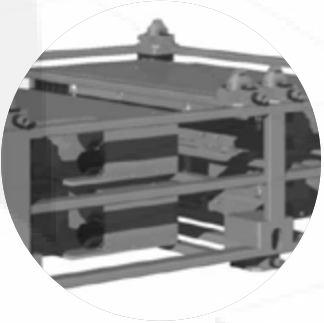
World-Class Partnerships

OptiFuel partners with leading suppliers to integrate state-of-the-art technologies with innovative solutions to ensure superior performance, production scale, & long-term support.

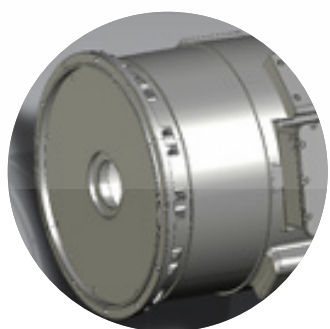
1. Since 2018, OptiFuel and Cummins have collaborated on adapting the Cummins X12 and X15 truck engines for optimal performance in rail operations and seamless integration into OptiFuel locomotives.



2. To enhance performance with hybrid power, OptiFuel integrated the most efficient off-the-shelf LFP battery technology available today, with a design that ensures easy replacement and upgrades to more advanced battery technologies as they become available.



3. OptiFuel then tackled size constraints by developing a proprietary generator that optimizes power output while minimizing dimensions.



The Result:

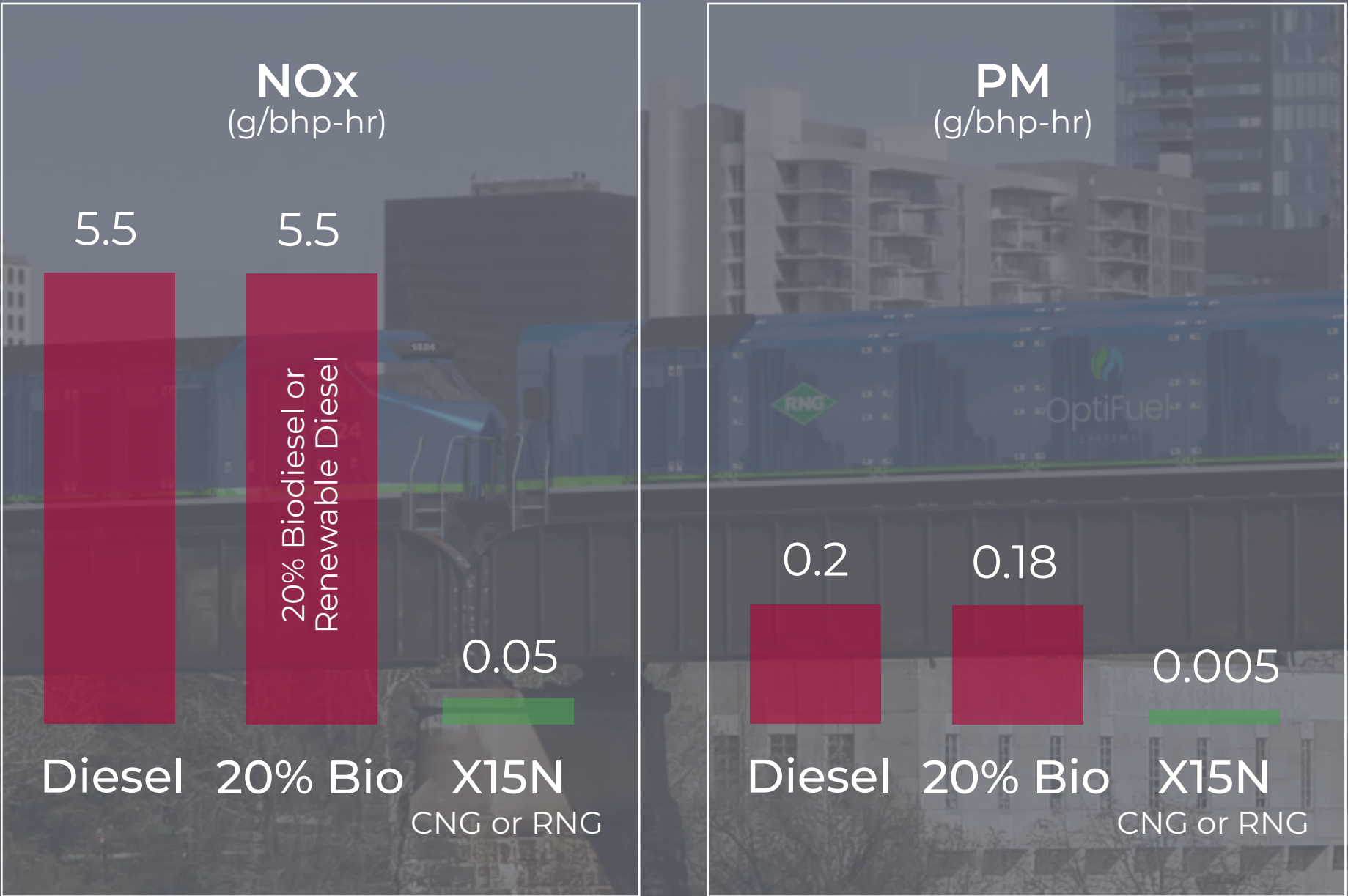
- > Smaller engines extract more horsepower from less efficient alternative fuels, with the X15N delivering diesel-equivalent power.
- > The X15N engine combines affordability, a 30-year lifespan, continuous performance, **quiet operation**, and **near-zero emissions**.
- > RNG, diesel, and hydrogen versions of the X15 offer **fuel flexibility**.
- > Hybrid power technology **enhances fuel economy** by 20%.
- > Partnerships between startups like OptiFuel and established technology leaders like Cummins ensure customers receive the **most advanced and reliable technology, backed by extensive support, manufacturing scale, and cost efficiency**.

OptiFuel's X15N powered locomotives ensure near-zero criteria emissions even if operated on fossil fuels - clearing the track of pollutants to safeguard health in local communities

Compliance with CARB regulations requires eliminating NOx and PM emissions. Use of biodiesel and renewable diesel do not reduce or eliminate these criteria emissions.

Local Criteria Emissions

Nitrous oxides (NOx) and particulate matter (PM) are “criteria emissions”—local pollutants that linger in the air and can cause a range of serious health issues



Diesel locomotive engines produce approximately 110x more NOx and 40x more PM than than OptiFuel-Cummins X15N locomotive power systems.

But the story doesn't end here.

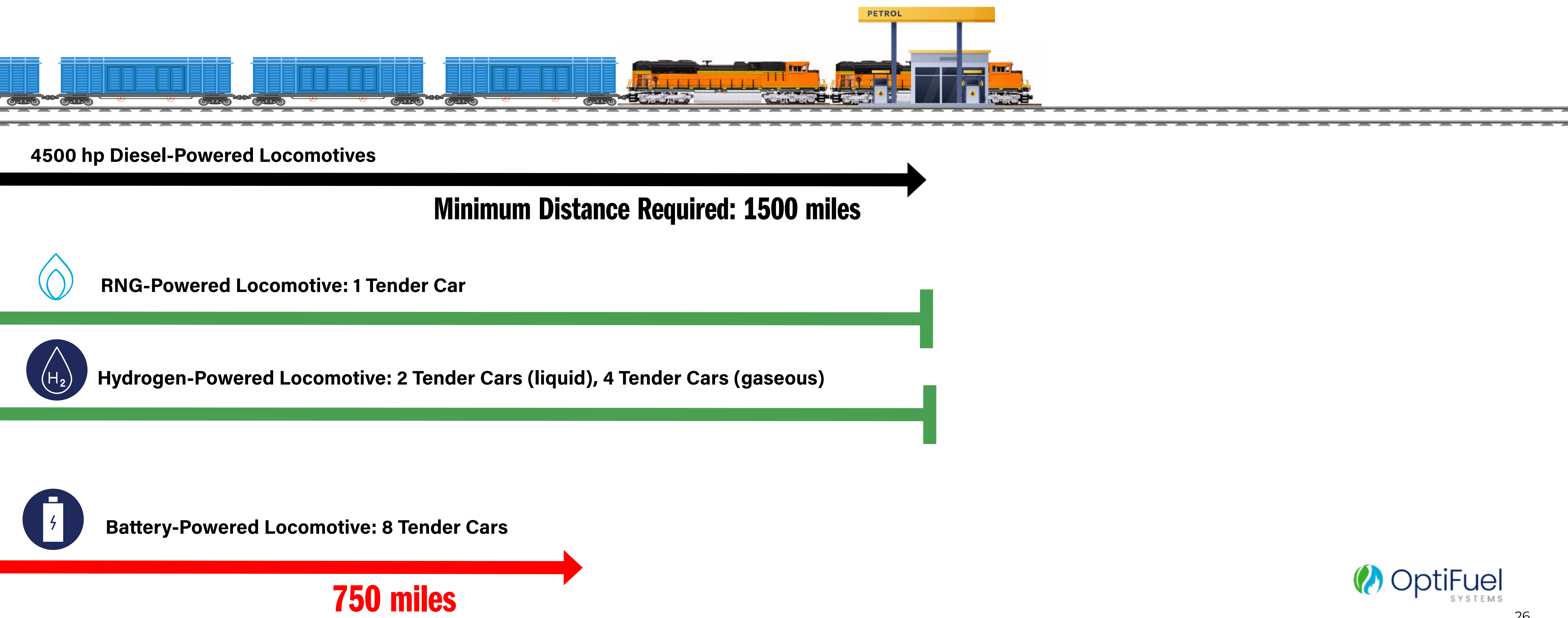
While OptiFuel Total-Zero™ locomotives resolve emissions, offer significant improvements in fuel economy & reliability, enable nimble operations for driving intermodal growth, and de-risk the transition to clean energy through flexible adaptation of various power systems, these enhancements don't address the crucial issue of interoperability that has always been central to U.S. railroads' success.

The biggest ^{Advantages} questions still remain:

- **Can clean power match diesel's range in line haul operations?**
- **Is there sufficient energy supply, and how will it be procured?**
- **What will the cost be?**

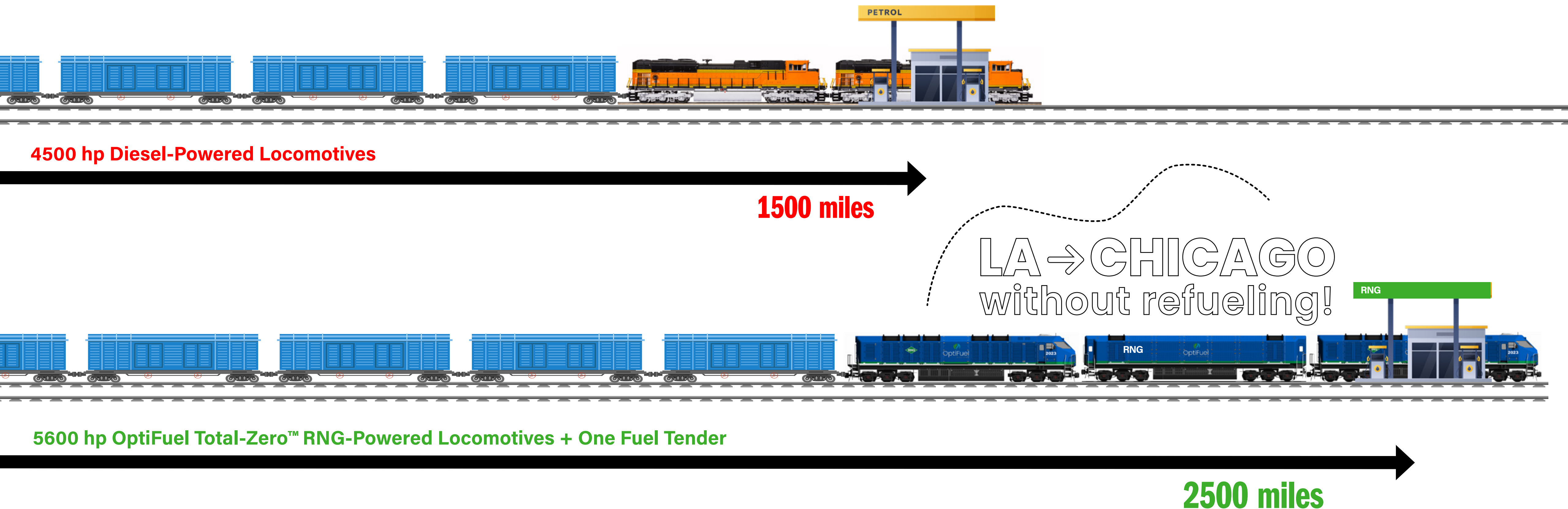
Since renewable energy is less efficient than diesel, railroads would need to carry additional tender cars to store enough fuel to match diesel's range in line haul operations.

Battery power, in particular, required extensive storage, with eight tender cars of batteries only allowing for about half the distance of a diesel locomotive. This would disrupt operations, leading to its immediate cancellation as a viable line-haul option. Since both hydrogen and RNG could achieve the minimum distance of 1500 miles, they remained under consideration.



Since RNG is more efficient to store than hydrogen, OptiFuel prioritized RNG-powered equipment for line haul tests. With each iteration, they enhanced performance, ultimately achieving a breakthrough. While railroads would need to carry one tender car, OptiFuel's RNG locomotives could travel nearly 1,000 miles farther than diesel locomotives.

Mission Accomplished!



TRIAL PERFORMANCE RESULTS: OptiFuel Total-Zero™ RNG Line Haul Locomotives vs Diesel
Digital Trials: Live Testing starts in 2025



A high-angle photograph of a blue freight train traveling through a desert canyon. The train is composed of several blue locomotives and flatcars carrying large shipping containers. Some containers are white with the Maersk logo, and others are red with the Hyundai logo. The train is curving along the tracks, which are set into the side of a steep, eroded hill. In the background, more trains are visible on parallel tracks further up the canyon. The landscape is arid, with sparse vegetation and rugged, brown hills under a clear blue sky.

By working together, we can iterate innovations to enhance operations at every turn.

We're Ready to Listen

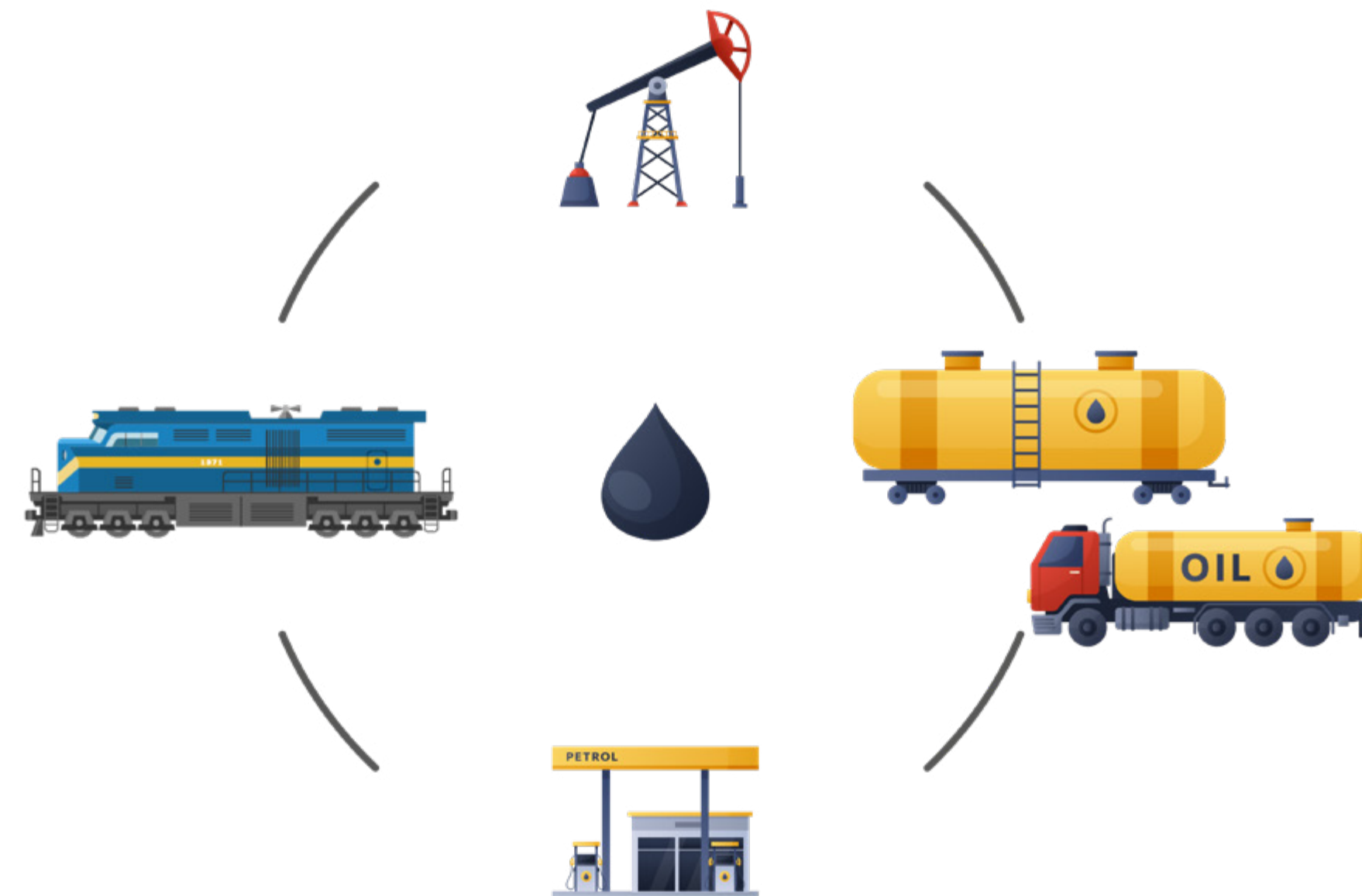
Railroads asked, "What more can a tender car achieve?" This led us to develop a powered tender car capable of tackling steep terrains like the Cajon Pass without the need for a helper locomotive.

Is there a sufficient supply of clean energy for rail, and how will it be procured? What will this cost?

OptiFuel's approach to tackling the energy supply question was laser-focused, concentrating on market developments that could either cut fuel costs or generate new revenue opportunities.

OptiFuel Asked:

Is there anything that has happened in the past 100 years that could make this more efficient?



One thing stood out immediately.

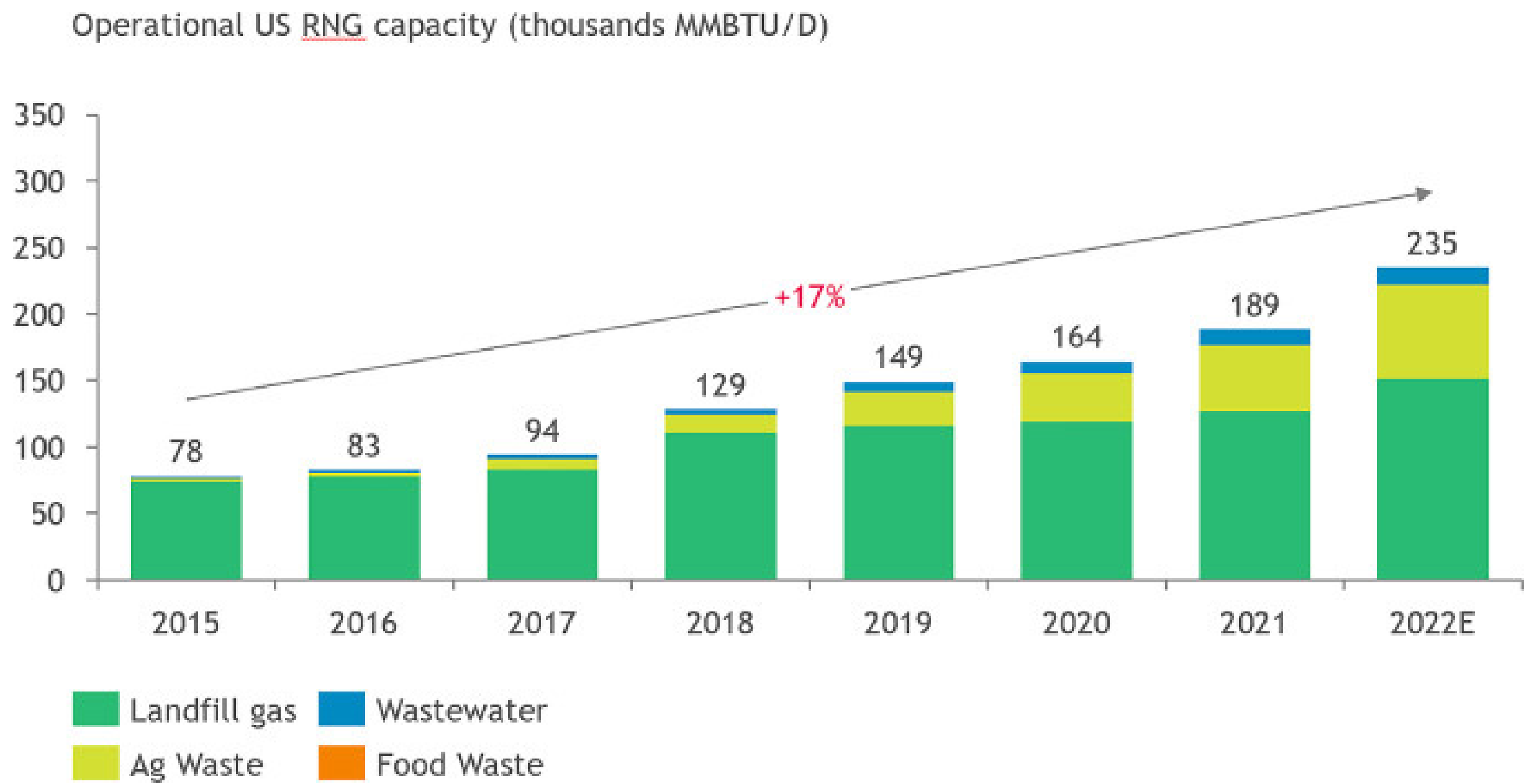
Throughout the 1950s and 1960s, the U.S. invested heavily into the construction of **a 3 million-mile network of pressurized pipelines that transport over 30 trillion cubic feet of compressed natural gas (CNG) annually.**

Inconcievably Efficient Transport

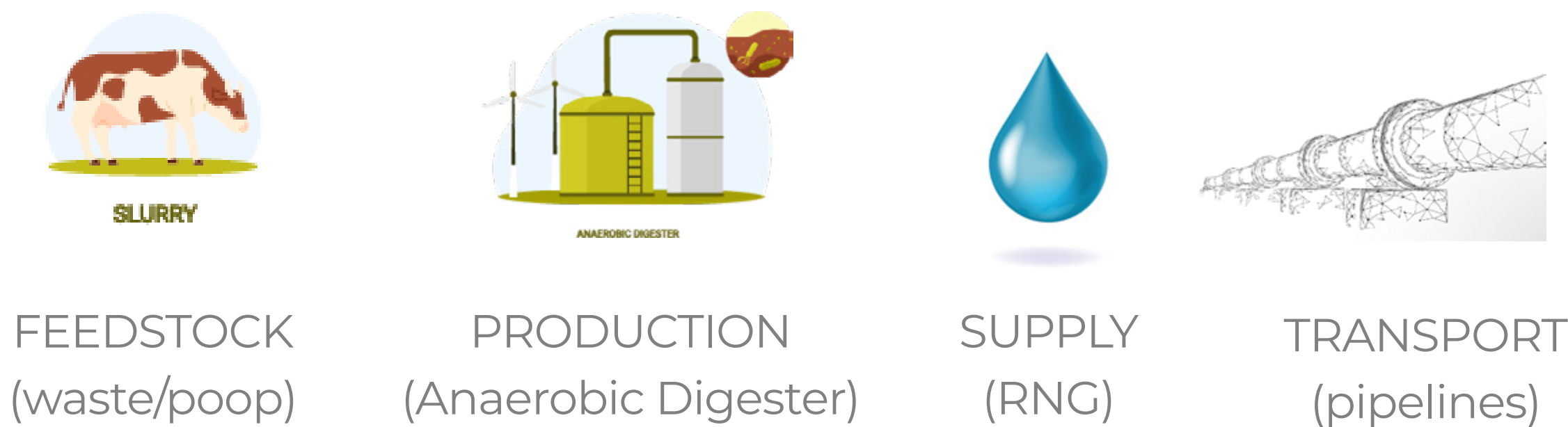
Over 95% of the natural gas used in the U.S. is transported from well to market entirely via pipeline, compared to 80% for crude oil and diesel. The world's most efficient fuel distribution system is hidden just next to the tracks in the railroad rights-of-way. Adding CNG/RNG pumps connected to these pipelines at railroad fuel stations would be highly cost-effective and could also eliminate ~71,500 tanker truck loads of fuel from roads each year.

Natural Gas: 300,000 miles of mainline, Crude/Diesel: 150,000 miles (Source: [API](#))

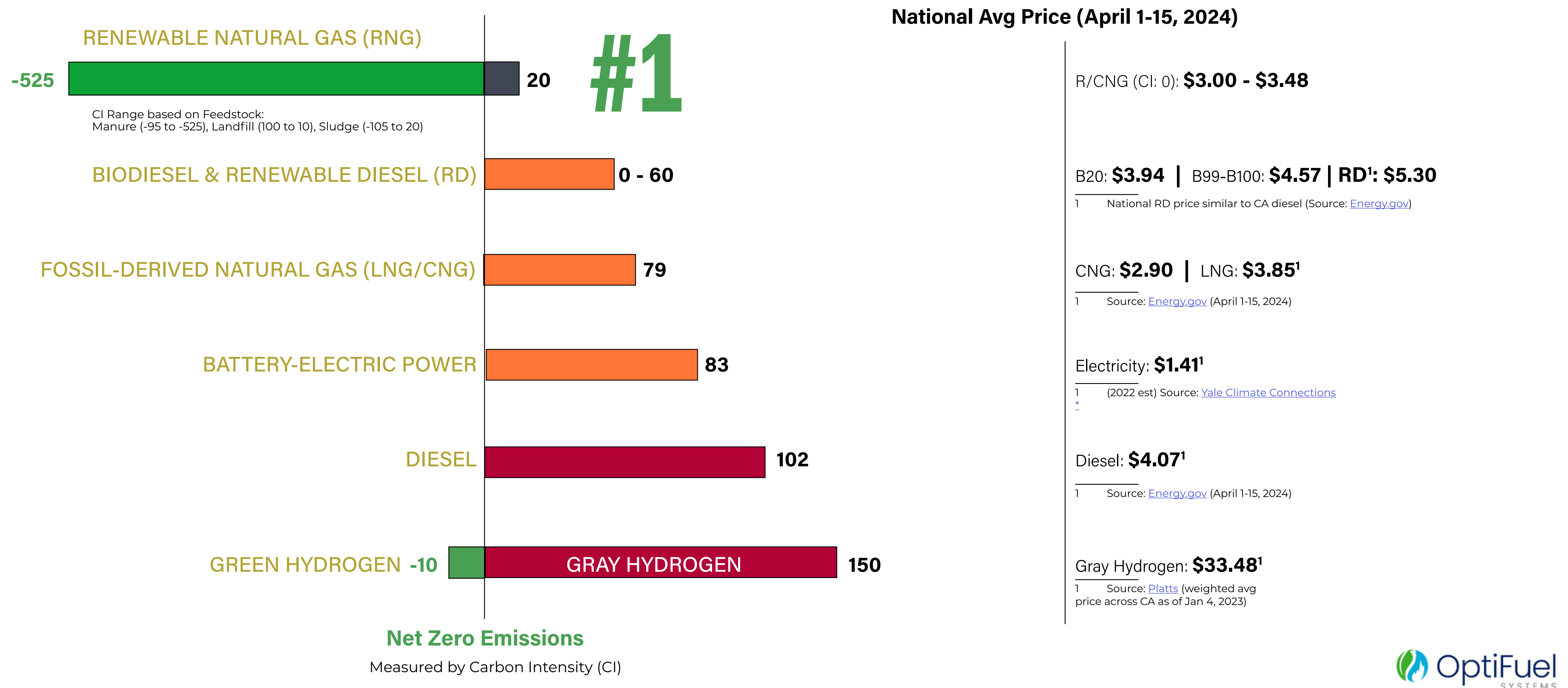
U.S. production of emissions-free Renewable Natural Gas (RNG) is at an all-time high, continually increasing pipeline availability. Produced from waste rather than fossil fuels, RNG is chemically identical to CNG, enabling railroads to refuel from pipelines and operate emissions-free.



- > RNG production methods are well established.
- > Monetization of the environmental attributes enables attractive payback periods.
- > RNG is injected directly into natural gas pipelines as a standard business practice.
- > Modular deployment of production equipment through co-ops with railroads ensures aligned supply, offers stable fixed-cost pricing, and creates new revenue opportunities for participating railroads.
- > Robust federal and state incentives are available to boost RNG production, with potential opportunities to extend these credits to the rail sector.



RNG offers the highest reduction in greenhouse gas (GHG) emissions among locomotive power options and also the lowest cost.

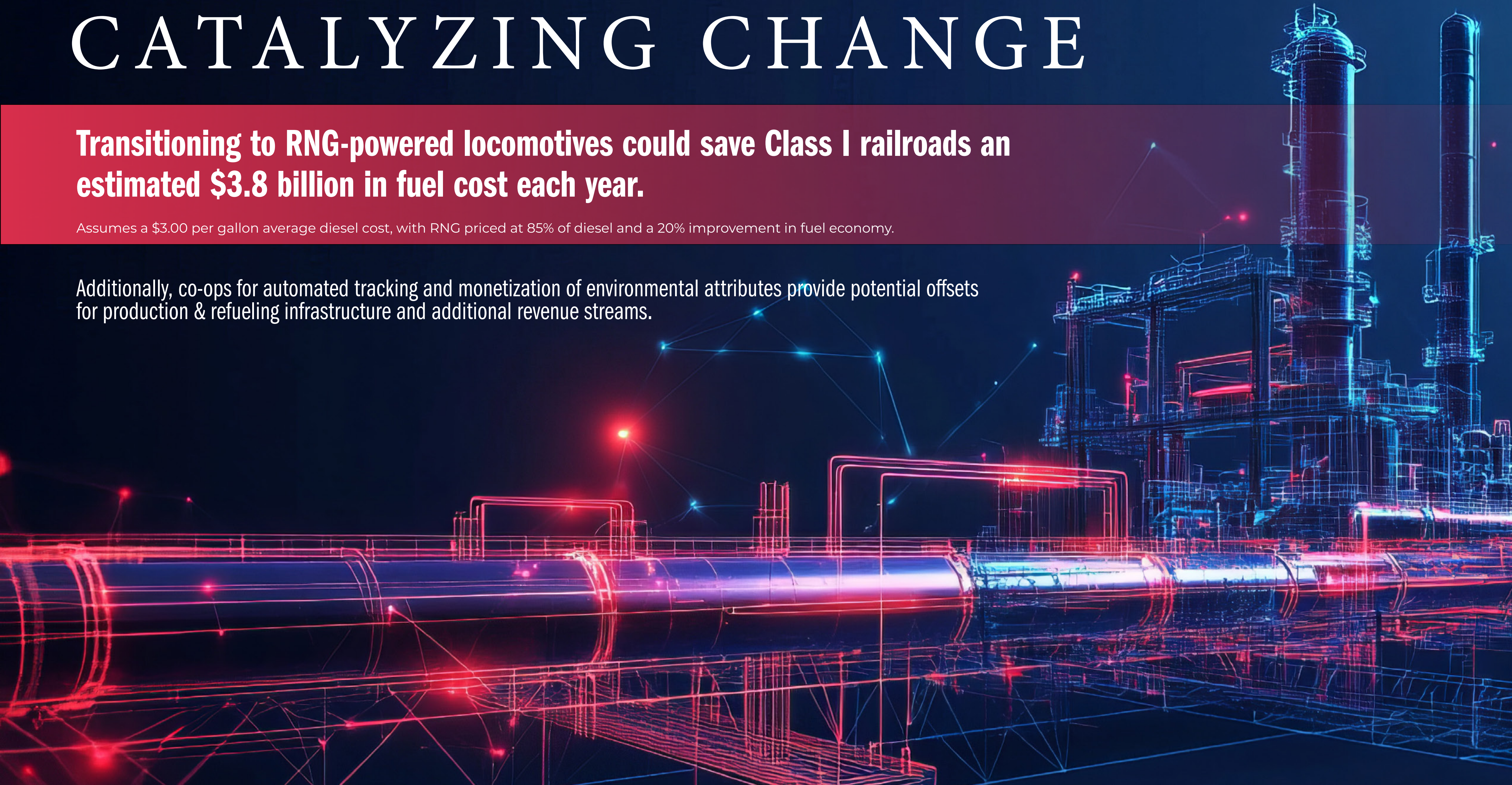


CATALYZING CHANGE

Transitioning to RNG-powered locomotives could save Class I railroads an estimated \$3.8 billion in fuel cost each year.

Assumes a \$3.00 per gallon average diesel cost, with RNG priced at 85% of diesel and a 20% improvement in fuel economy.

Additionally, co-ops for automated tracking and monetization of environmental attributes provide potential offsets for production & refueling infrastructure and additional revenue streams.

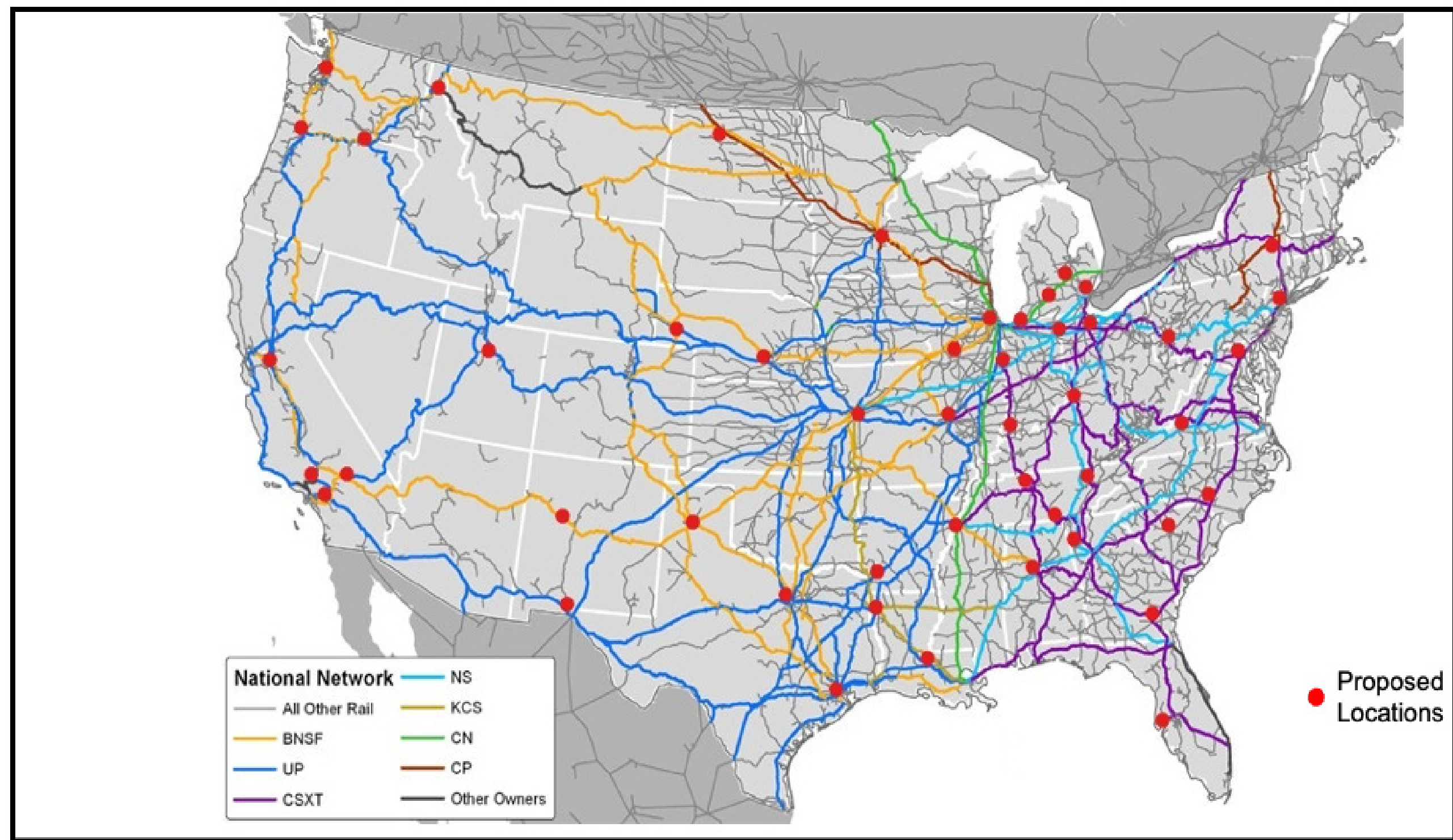


What about refueling infrastructure?

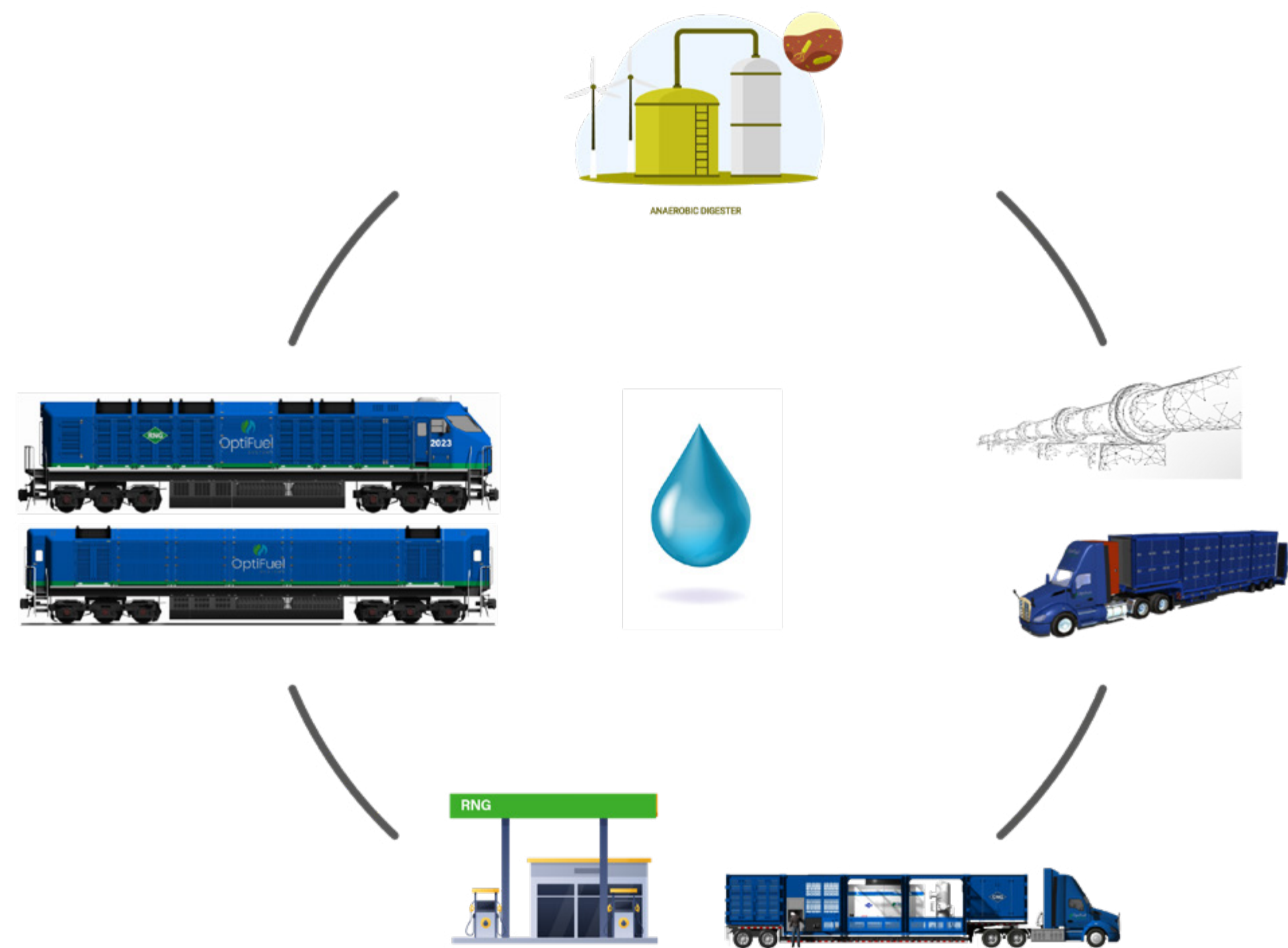
OptiFuel built the world's first CNG/RNG fuel station for a railroad in 2018. The Indiana Harbor Belt Railroad has been using this prototype station for over 5 years. For Class I railroads, OptiFuel is scaling up with larger stations, each able to dispense about 260,000 gallons of RNG per day.



Refueling Class I line-haul operations is expected to require 60 fuel stations over a 15-30 year period. The plan employs a modular approach for deploying equipment and infrastructure, ensuring a scalable solution that aligns with the annual deployment of new locomotives by Class I railroads.



Next-Generation Rail Supply Chain



Next year, OptiFuel will begin line haul demonstration & concurrence testing at the FRA's Technology Transportation Center (TTC) in Pueblo, CO

- > **1 Exceptional Startup**
- > **10 Years of Research, Planning, Development & Certification**
- > **2 Amazing Short Line Railroads who led with Early Adoption**



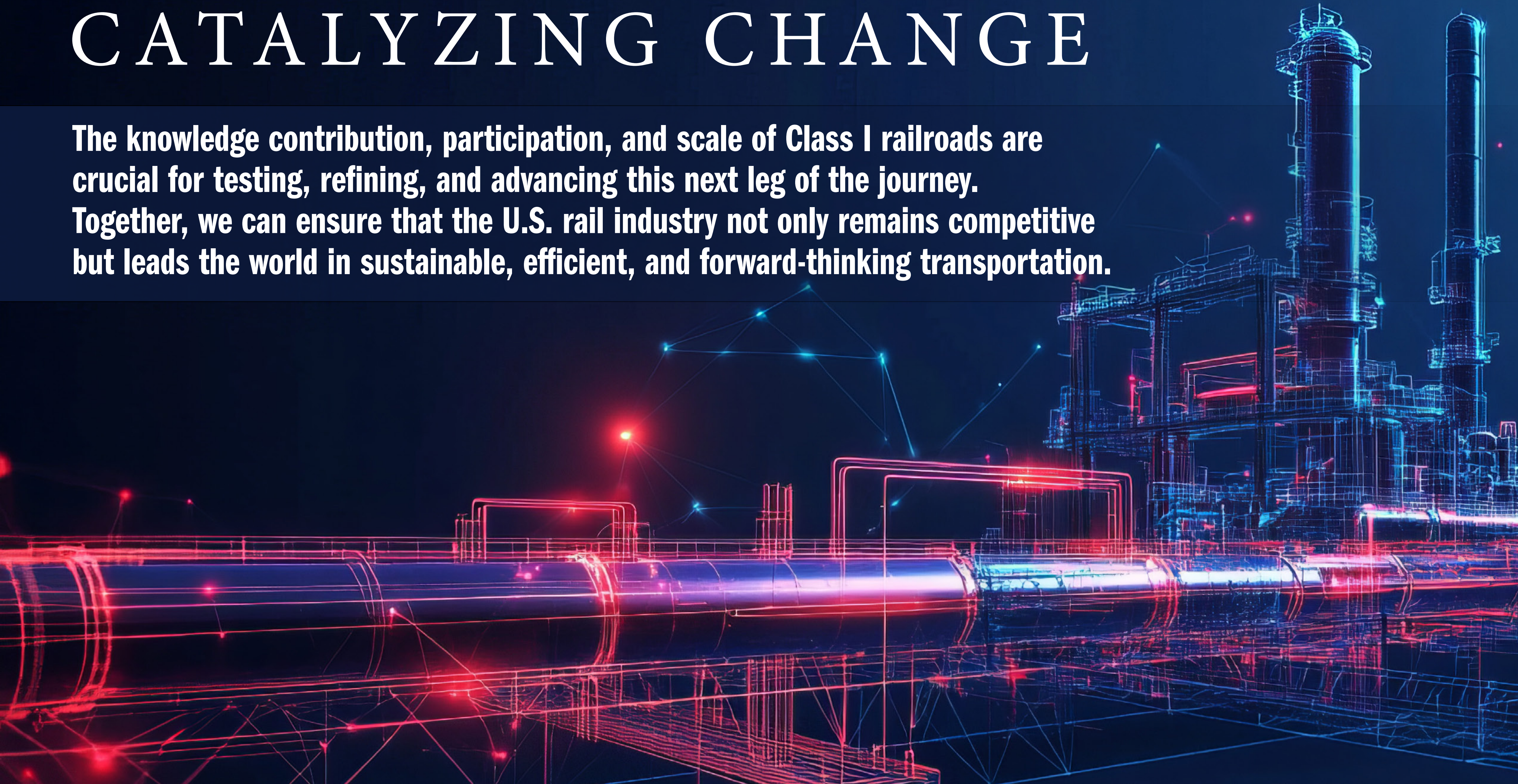
The role of venture capital is to identify and support the visionaries and transformative ideas that will become essential in the years to come. This is that moment. As we reflect on OptiFuel's 10-year journey, we see a convergence of history, leading technologies, strategic thinking, and meticulous planning. Startups like OptiFuel need the partnership of Class I railroads, just as U.S. rail needs the innovation and bold action that companies like OptiFuel bring. We've done the heavy lifting to make a transition that once seemed distant, now within reach.



> Commitments for 1-million-mile testing with Class I railroads

CATALYZING CHANGE

The knowledge contribution, participation, and scale of Class I railroads are crucial for testing, refining, and advancing this next leg of the journey. Together, we can ensure that the U.S. rail industry not only remains competitive but leads the world in sustainable, efficient, and forward-thinking transportation.



BEYOND INCREMENTAL

HARNESSING SUPPLIER INNOVATION FOR SUSTAINABLE GROWTH

Thank you for the opportunity to present this perspective to the Board and to each of you.

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