LMOA Fuels, Lubricants & Environmental Committee

October 10, 2024

Chris Miller
Chair
Wabtec CORPORATION

Steve Fritz
Vice Chair
SwRI SOUTHWEST RESEARCH INSTITUTE

Fuels, Lubricants, & Environmental

- Committee Membership
  - 39 Members
  - 30 Different Companies
  - 7 North American Freight, Short Line, and Passenger Railroads
  - 3 OEM Engine Manufacturers
  - 7 Major Oil, Fuel and Petrochemical Companies
  - 3 Research and Testing Laboratories
  - Various Consultants, Engineering Firms and Industry Representatives

- Wide Range of Disciplines
  - Technical – Chemists, Scientists, Engineers, Technologists
  - Executive – Managers, Directors, Research & Development

- Vast Area of Expertise
  - Sales
  - Research & Development
  - Engineering / Technology
  - Chemical, Mechanical, Environmental

New Members (10)

Nathan Gawin
Technical Sales Manager - Canada
Shell & Whitmore Reliability Solutions

David Gray
Industry Liaison Advisor
Infineum USA

Alex Hesse
Sr. Mechanical Engineer
Amtrak

John Pettingill
R&D Product Specialist
HF Sinclair

Dilani Abeywickrama
Locomotive Fleet Leader
Canadian National Railway

Josh Horner
Sr Manager Mechanical Engineering
Canadian National Railway

Christine Marshall
Supply Chain / Fuel Sourcing
Union Pacific Railroad

Michael Cleveland
Director of Market Strategy
Peaker Services

Damir Hasagic
VP Strategy and Growth
Veridapt

Replacing Dave Pelletier

Mike Blumenfeld, Ph.D.
Industrial Lubricants Principal
ExxonMobil

Winter Meeting

- January 24 in Newark, DE
  - Toured Innospec America's Fuel Testing and Applied Research Facility
  - Special thanks to:
    - Innospec
      - Suzanne Golisz
      - Randy Garver
      - Abbie Uhler

Summer Meeting

American Refining Group, Inc.

- August 14 Bradford, PA
  - Tour American Refining Group
    - Refinery
    - QC Lab
    - R&D Lab
  - Special thanks to:
    - ARG Team
      - Luke Rawding
      - Nicole Butler
      - Pete Griffin

140+
Years the refinery has operated to create quality products.

11,000
Barrels per day rated refinery.

120+
Petroleum products available across numerous industries.

RSI 2024 Presentations

- **CARB In-Use Locomotive Regulations**
  - Steve Fritz, Southwest Research Institute

- **Tier 4 Locomotive Incentive Grant Funding**
  - Michael Cleveland, Peaker

- **Biofuels and Low Temperature Properties**
  - Suzanne Golisz, Innospec

- **Biodiesel Handling & Blending**
  - Rajani Modiyani, Chevron REG

- **Railroad GHG Emissions Accounting with Biofuels**
  - Wayne Kennedy, Kennedy Consulting

CARB In-Use Locomotive Regulation

Steve Fritz - Southwest Research Institute (SwRI)
Brett Amen – Union Pacific

Railway Interchange 2024 LMOA Technical Program
October 2024

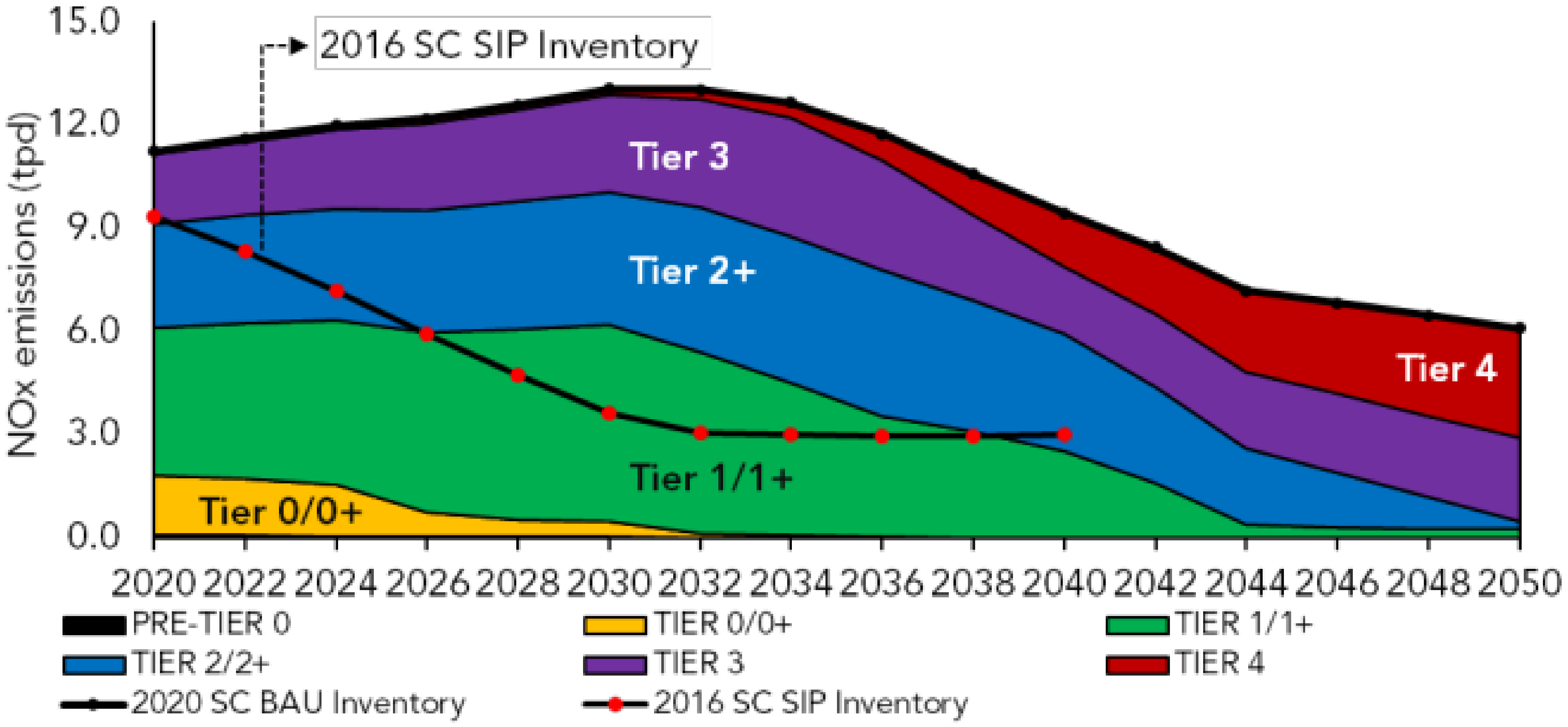
UNION PACIFIC
SwRI
SOUTHWEST RESEARCH INSTITUTE

Outline

- Problem: RR’s & Air Pollution
- Regulatory Updates: EPA – CARB – AAR + ASLRRA – STB - Congress
- CARB In-Use Locomotive Regulation
  - Spending account example
  - **Regulation elements affecting LMOA members**
- Current status

Problem Statement: Railroad Emissions Not Decreasing

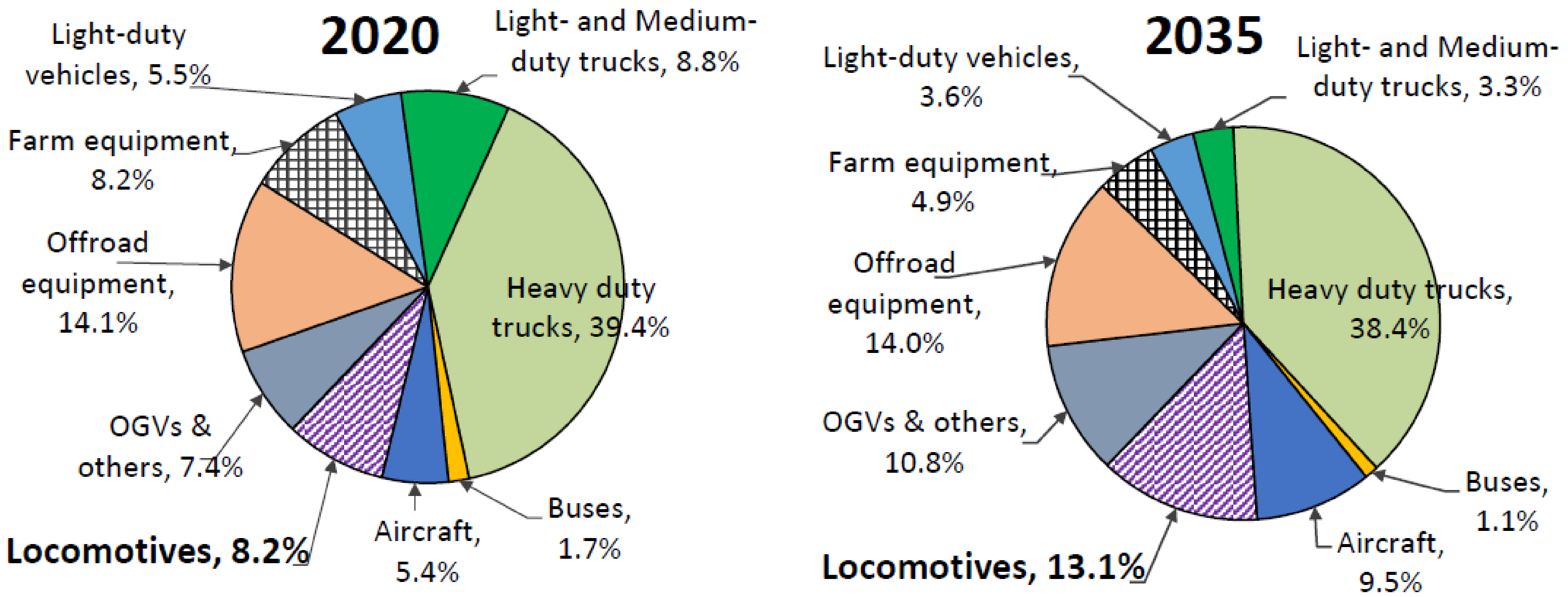
NOX Emissions Inventory for the South Coast Air Basin



Source: CARB 2021 Line-Haul Locomotive Emission Inventory (Feb. 2021)

How Much Air Pollution from Locomotives?

Figure 2: NOx Emission Contribution by Sector in 2020 and 2035[4]



2021 CARB Locomotive Inventory

Source: CARB 2021 Line-Haul Locomotive Emission Inventory (Feb. 2021)

CARB In-Use Locomotive Regulation Timeline

- 2022
  - April – EPA responds to CARB's 2017 letter requesting implementation of Tier 5
    - *Essentially "thank you for your input, we're working on it….."*
  - November – CARB hearing on proposed In-Use Locomotive Regulation
- 2023
  - April – 2nd CARB hearing + vote => approved
  - June – AAR + ASLRRA file lawsuit against CARB
  - October – CARB Final Regulatory Order Complete (legal review)
  - November – CARB letter to EPA requesting authorization
    - *"to request that the United States Environmental Protection Agency (EPA) grant California an authorization, pursuant to section 209(e)(2) of the federal Clean Air Act (CAA), for California's Non-Road Program in light of the recent addition of In-Use Locomotive Regulation (Locomotive Regulation)."*

CARB In-Use Locomotive Regulation Timeline

- 2024
  - January – Effective date of CARB regulation (only implication for CY2024 is you can generate credits using a ZEL)
  - February – Federal Register Notice for EPA Public Hearing on March 20
  - March – EPA Public Hearing
  - April – STB issues Statement to EPA on CARB's regulation (*"They can't do that"*)
  - July – US Congress Subcommittee on Railroads, Pipelines, and Hazardous Materials holds hearing on CARB's In-Use Locomotive Regulation
  - July – HR8998 Department of the Interior, Environment, and Related Agencies Appropriations Act, 2025
    - *Amendment No. 75 – Prohibits any funds made available by this Act from being used by the Environmental Protection Agency to approve a waiver for the California Air Resources Board's In-Use Locomotive Regulation.*
  - Sept. 12 - *Congressman Troy E. Nehls (R-TX-22) introduced the Stop California from Advancing Regulatory Burden Act, or the Stop CARB Act. Senator Mike Lee (R-UT) is leading the Senate companion to this legislation.*
  - Oct. 1 – AAR Lawsuit "stayed" (put on hold) by Judge pending EPA decision
    - U.S. District Judge Daniel Calabretta denied the industry's motion for summary judgment, and
    - partially granted California's motion, striking down the challenge to idling requirements due to lack of standing.

Locomotive Regulation Summary

Spending Account	• Annual funding requirement based on locomotive emissions. • Funds used for cleaner locomotive technologies
In-Use Operational Requirements	• Beginning in 2030, only locomotives less than 23 years old operate in State • 2030 and 2035 ZE operational requirements
Idling Requirement	• Idling prohibited over 30 minutes (unless exempt)
Recordkeeping and Reporting	• Annual locomotive reporting ~~by California Air District~~

CARB

6

Applicability

- This regulation applies to "any locomotive operator that operates a locomotive in the State of California."
  - Meaning the railroad operating the locomotive
  - Not the owner of a given locomotive
  - Not the lessor

Spending Account

- "Use fee" => goes into RR-held escrow account
- Based on Tier and activity in California (MWh or fuel used)
- $ then used for Tier 4 or "Zero Emission Locomotive" purchases
- BNSF & UP estimate annual "use fee" ≈ $800M annually, each…..

Spending Account Calculation Per Locomotive [$]

$$= \{(\text{Weighted Factor}) \times (\text{PM EF [g/bhp-hr]}) + (\text{NOx EF [g/bhp-hr]})\} \times (\text{Annual Factor}) \times (\text{Usage [MWhs]})$$

Year	Weighted Factor	Annual Factor
2026	13.1	92.6
2027	13.1	96.2
2028	13.1	99.9
2029	13.1	103.8
2030	13.1	107.3
2031	13.1	111.4
2032	13.1	115.8
2033	13.1	120.4
2034	13.2	125.1
2035	13.2	130.1
2036	13.2	135.1
2037	13.2	140.6
2038	13.2	146.4
2039	13.2	152.1
2040	13.2	158.5
2041	13.2	164.8
2042	13.2	171.5
2043	13.2	178.5
2044	13.2	185.7
2045	13.2	193.3
2046	13.3	201.2
2047	13.3	209.6
2048	13.4	218.5

Spending Account Example

- T0+ 2,000 THP GP38-2 that uses 50,000 gallons diesel annually

CARB Regulation fee estimates				T0+	T0+					
		Annual	Funding	SW Nox	SW PM	Fuel Cost	Use Fee/Fuel $	Annual	CARB-calc	Avg. MWh/
Year	PM WF	Factor	$ Annual	g/hp-hr	g/hp-hr	at $4/gal		Gallons	MWhr	day
2023	13.1	83.2	$ 550,135	10.0	0.13	$ 200,000	2.8	20,000	226	0.62
2024	13.1	85.6	$ 566,004			$ 200,000	2.8	30,000	339	0.93
2025	13.1	89.0	$ 588,485			$ 200,000	2.9	40,000	452	1.24
2026	13.1	92.6	$ 612,289			$ 200,000	3.1	50,000	565	1.55
2027	13.1	96.2	$ 636,093			$ 200,000	3.2	60,000	678	1.86
2028	13.1	99.9	$ 660,558			$ 200,000	3.3	70,000	791	2.17
2029	13.1	103.8	$ 686,346			$ 200,000	3.4	80,000	904	2.48
2030	13.1	107.3	$ 709,489			$ 200,000	3.5			
2031	13.1	111.4	can no longer operate in California							

Notes:

- $ Goes up every year
- After 2030, can no longer operate in California

In-Use Operational Requirements

- Starting in 2030:
  - Any locomotive >23 years old not permitted in California
    - Examples for 2030:
      - Anything built before 2007
      - Early T2 EVO & ACe & T1+ EMD SD70M or AC4400
    - Unless "operated in a ZE configuration" or remanufactured to Tier 4
- Also in 2030
  - Switch, industrial and passenger locomotive operators
  - With engine build date 2030 and newer => ZE only
    - e.g., any new locos need to be ZE starting in 2030
- 2035 Freight Line-Haul

Details: Idle Reporting

- "Locomotive Operator" responsible for reporting any locomotive Idling event >30 minutes with the locomotive stationary:
  - Where?
  - When?
  - For how long?
  - Why?
  - Conceptually, most AESS-equipped locomotives will have the individual components necessary to track this information (GPS, AESS system status, etc.) but will require software updates and remote downloads and database tracking of this information.
  - How to track for "foreign" locomotives operated within the State?

Locomotive Registration & Reporting

- Starting Jan. 1, 2025
- CARB working on online reporting system
- Any locomotive operated in the State needs to be Registered with CARB
  - Within 30 days of entering State
  - $175 per locomotive per year registration fee
    - Except ZE and historic locomotives
  - How to handle/track "foreign" locomotives?
  - Lots of information required that may not be readily available
    - Locomotive serial number
    - EPA engine family
    - Engine serial number
    - Last remanufacture date
    - EPA Certification data (NOx and PM)

Tracking Usage in California

- Starting Jan. 1, 2025
- For each locomotive operating in California
- Track MWh or alternatively, fuel used – simple, right?
  - Gross MWh or Traction MWh or Net Traction?
  - CARB points to EPA without clearly specifying
    - EPA emissions regulations focus on Gross power, so consider this the default
      - What do your locomotives track/display?
  - MWh totals displayed on locomotives is often "wrong"
  - How to track "foreign" locomotives (i.e., from other railroads)
  - Tracking fuel consumption is alternative approach
    - For operations within California
    - "Good luck with that….."
    - CARB conversions from gallons to MWh

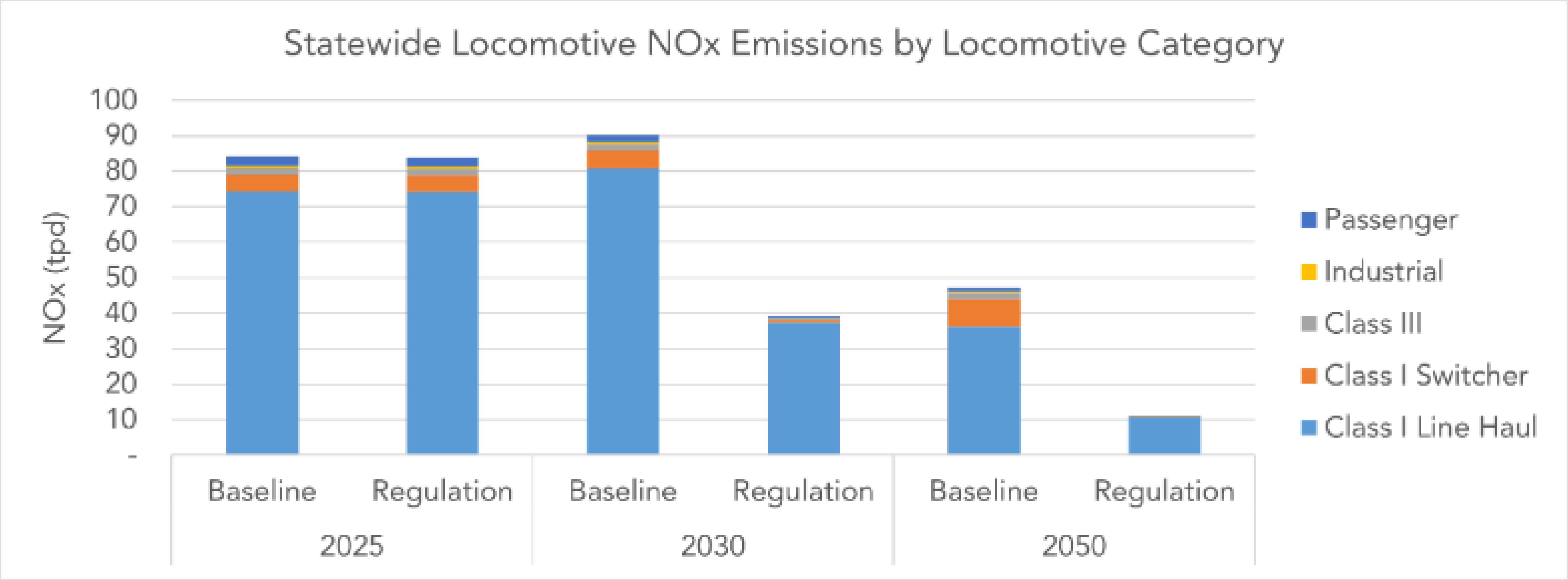
Table 1: Fuel Consumption Conversion Table

Locomotive Type	Rated Horsepower	Conversion Factor
Freight Line Haul	≥4,000	0.0155 MWh/gallon
Freight Line Haul	2,301-3,999	0.0137 MWh/gallon
Switcher	≤2,300	0.0113 MWh/gallon
Industrial	All	0.0113 MWh/gallon
Passenger	All	0.0155 MWh/gallon

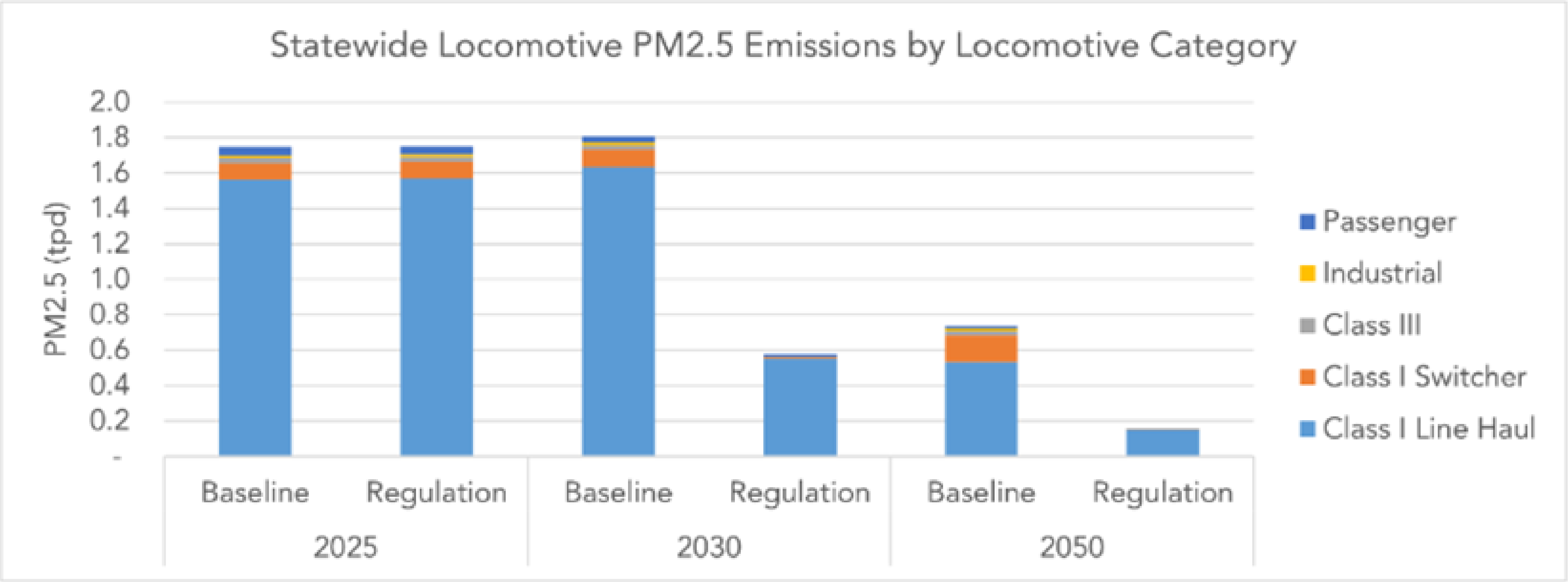
Non-Compliance

Non-Compliance: Section 2478.16 covers non-compliance, penalties, and right of entry. Although monetary penalties are not specified, each individual violation of each section of the regulation, for each locomotive, for each day, is a separate offense. In other words, not being ready to start monitoring all locomotives your railroad operates in California starting on January 1, 2025, could add up quickly.

CARB Estimates of Locomotive NOx reductions



CARB Estimates of Locomotive PM2.5 reductions



Conclusions

- CARB in-use locomotive regulation intended to accelerate the reduction of locomotive emissions in California
- Compliance responsibility falls on locomotive operators
- Lot's of "back office" tracking requirements starts Jan. 1, 2025
  - Locomotive registration for any locomotive operating in the State
  - MWh or fuel use in California
  - Any stationary Idling event > 30-minutes
- "Stay tuned":
  - EPA approval/disapproval/partial "acceptance" of CARB regulation
  - AAR/ASLRRA lawsuit status
- LMOA members: Expect an influx of Tier 4 and ZE locomotives
  - Training, tooling, maintenance support

Thank You for Your Attention!

Steven G. Fritz, PE
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Powertrain Engineering Division
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T4 Locomotive Incentive Grant Funding

Railway Supply Institute LMOA Technical Program

October 10, 2024

Background

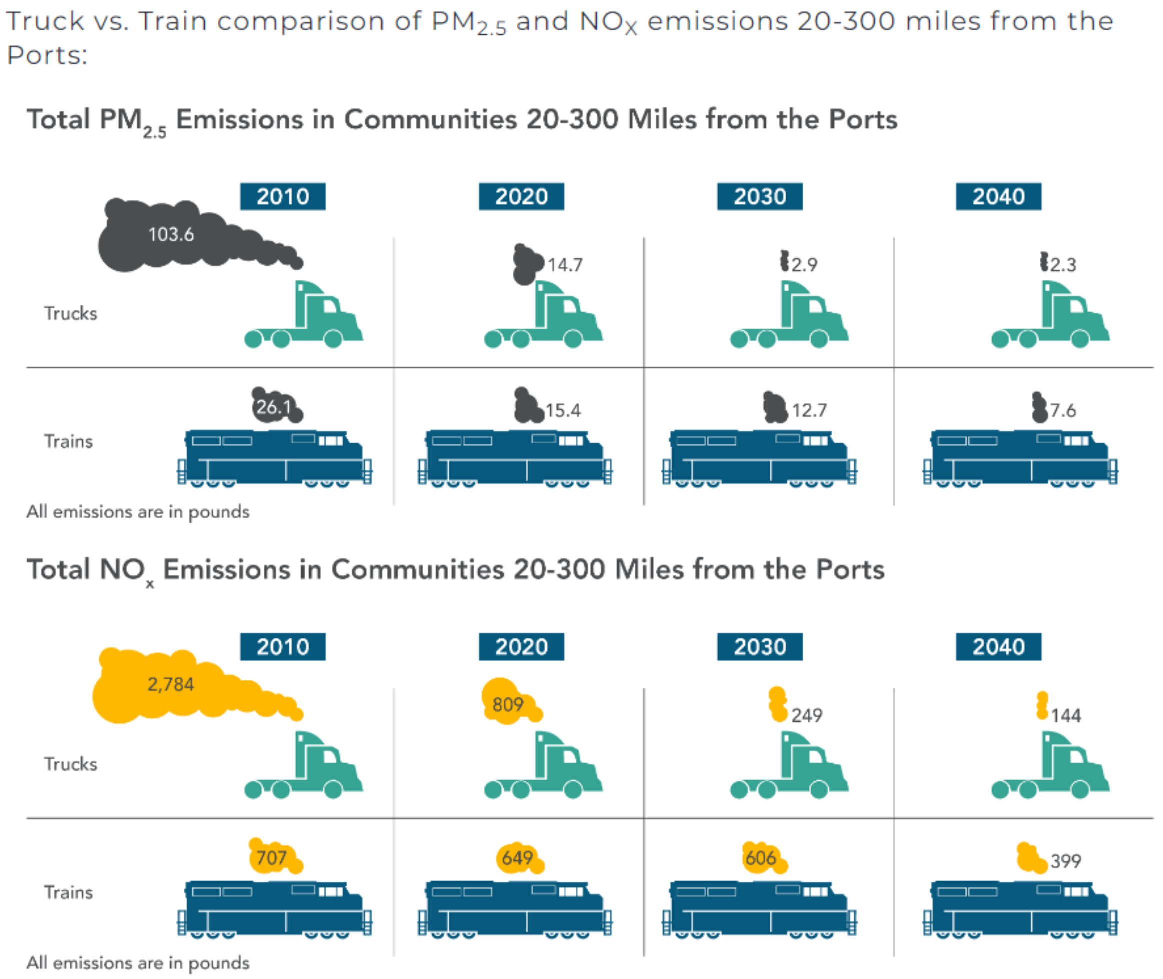
- EPA mandated T4 emissions regulations were first put into effect for the rail industry in 2015. At the time, both the EPA and CARB expected significant turnover to T4 compliant models, similar to adoption rates seen in other industries.
- Due to the format of the regulatory framework, many locomotive operators have elected to utilize less costly methods of improving emissions performance such as DC-to-AC conversions. This has resulted in limited adoption of T4 technology.
- In light of this, the EPA and CARB are actively looking at incentives and further regulations to improve overall T4 adoption.
- This presentation will focus on the incentive programs currently available to assist operators in upgrading their fleets to meet T4 emissions compliance.

Team Members

- Southwest Research Institute (SwRI): Steven Fritz
- Zero Emissions Locomotive Technologies (Z-Eltech): Tom Mack
- Higher Power Industries: Mark Duve
- Peaker Services Inc (PSI): Michael Cleveland
- Cummins: Jon Meinhardt

Grant Funding Rational

- Legacy locomotive engines can account for a substantial amount of NOx emissions in a selected operating environment, making improvements highly cost effective.
- This is especially true in urban areas where on-highway diesel emissions regulations have significantly reduced NOx and particulate matter (PM) output in the last decade.
- To prevent locomotives from producing heavily outsized emissions, grant funding is being introduced to help meet targets.



Courtesy of California Air Resource Board

Understanding Grant Structures

There are typically 6-7 parties involved in the grant process. Its important to understand who they are and what their rolls and goals are.

1) Funding Agency: The entity that has control over the funds (CARB, EPA, FRA, etc)
2) Awarding Agency: The entity that reviews projects and applicants to determine who receives support.
3) Applicant/Awardee: Typically a public agency or non-profit that collaborates with railroads on projects.
4) Railroad/Operator: Recipient of the funds responsible for meeting grant requirements.
5) Supplier: Technology provider to the Railroad.
6) Contractors: 3rd parties suppliers or providers who update equipment to operate with the new technology.
7) Consultants: Work with railroads to ensure necessary requirements and administrative duties are met.

Grant Funding Programs

Multiple grant funding programs are currently available, at both the federal and state levels, for operators to utilize.

Federal Programs

- CRISI (Consolidated Rail Infrastructure and Safety Improvements)
- DERA (Diesel Emissions Reduction Act)
- PIDP (Port Infrastructure Development Program)
- CMAQ (Congestion Mitigation and Air Quality Improvement Program)
- Cummins-EPA Settlement

State Programs

- CARB (California Air Resources Board)
  - Carl Moyer Program
  - Proposition 1B Goods Movement Emission Reduction Program
- Texas – TCEQ/TERP (Texas Commission on Environmental Quality/Texas Emissions Reduction Plan)
- VW Mitigation Funds

Selected Examples for Funding

Below are a few of the more popular grant programs available, that will be discussed in further detail on the following slides.

- **CRISI**: Funds projects that improve safety, efficiency, and environmental performance of rail infrastructure, including locomotive upgrades.
- **DERA**: Supports projects that reduce diesel emissions through the replacement or repowering of older locomotives with cleaner technologies.
- **PIDP:** Supports projects in Ports, including electrification, replacements and retrofits, and infrastructure.
- **VW Mitigation Funds**: State-specific programs under the Volkswagen settlement aimed at mitigating excess NOx emissions, including funding for locomotive upgrades.
- **Cummins-EPA Settlement:** Federal mitigation projects will focus on upgrading outdated locomotive engines with newer, cleaner technologies and implementing idle reduction measures.

Consolidated Rail Infrastructure and Safety Improvements (CRISI)

- Goals:
  - Safety, asset improvement, sustainability, infrastructure transformation
- Funding Availability:
  - $1-$2 billion
  - Federal match anywhere from 50%-80% of cost
- Applicant Eligibility:
  - Amtrak and intercity rail carriers
  - Class II and III railroads
  - Rail carriers and OEMs in partnership with public entities
- Eligible Project Criteria:
  - New or rehab locomotives resulting in significant emissions reductions
  - Upgrades to Tier 2, Tier 4, or alternative energy source

A stripped-down EMD GP38-2 switcher locomotive waits to be repowered into a new Tier 4 switcher.

Diesel Emission Reduction Act (DERA)

- Goals:
  - Improve emissions in non-attainment zones
- Funding Availability:
  - Up to $100 million per year
  - Provides average coverage of 25%-40% of project cost
- Applicant Eligibility:
  - Cities, counties, municipalities working to reduce emissions of older equipment
  - Regional authorities with jurisdiction over air quality
  - Nonprofits and institutions that provide pollution reduction or education
- Eligible Project Criteria:
  - Covers all equipment utilizing diesel engines (not just locomotives)
  - Vehicle or engine replacements
  - Verified exhaust reduction retrofits and idle reduction strategies

Port Infrastructure Development Program (PIPD)

- Goals:
  - Improve safety, efficiency, and reliability of goods movement around ports
- Funding Availability:
  - Managed by DOT Maritime Administration
  - $2.25 billion from 2022-2026
  - Will match up to 80% of project cost
- Applicant Eligibility:
  - Port authorities
  - State and political subdivisions
  - Industries working with above listed groups
- Eligible Project Criteria:
  - Improves operational capabilities of ports
    - Includes environmental improvements, equipment updates, training, and retrofits

Congestion Mitigation and Air Quality Improvement (CMAQ)

- Goals:
  - Provide funding to state and local governments for transportation projects that meet requirements of the Clean Air Act
- Funding Availability:
  - FY 2024 funding is $2.4 billion
  - Will fund anywhere from 50%-80% of project cost
- Applicant Eligibility:
  - Applicants are picked by state/local governments and metropolitan planning organizations (MPOs) based off local criteria
- Eligible Project Criteria:
  - Projects that reduce congestion and improve air quality especially in locations that do not meet minimum air quality standards.

Volkswagen Emissions Mitigation Trust

- Goals:
  - Offset excess NOx emissions created through installation of defeat devices on MY 2009 - MY 2016 diesel vehicles
- Funding Availability:
  - $2.7 billion across US
    - $55 million specifically for freight and marine projects in California
  - Up to $1.62 million (~50% coverage) for replacement/repower of a locomotive
- Applicant Eligibility:
  - Locomotive and switcher operators
- Eligible Project Criteria:
  - New or rehab of locomotives resulting in significant NOx reductions

Cummins-EPA Emissions Mitigation Settlement

- Goals:
  - Offset NOx emissions from RAM truck products build from MY 2013- MY2019
- Funding Availability:
  - $70 million for locomotives from 2024-2029
- Applicant Eligibility:
  - Yard and Road switcher operators looking to upgrade pre-Tier 2 locomotives
  - Cannot be in the state of California
  - Projects spread evenly across 10 EPA geographic regions
- Eligible Project Criteria:
  - Upgrade of pre-Tier 2 locomotives to Tier 4
  - Upgrade to fully electrified power

Strings Attached to Grant Funding

- Funding is often tied to fiscal year cycles and has to be used within specified windows.
- Comparison of expected new equipment emissions to existing equipment emissions is often required in the submission phase and must be accurate.
  - Reporting of fuel consumption and energy utilization for a new locomotive can be required for years after a project is completed
- All grants are reimbursement grants so money has to be spent or project milestones met before the award is received.
- Cost overruns and unused funds are generally not reimbursable.
- Grants often contain Buy America provisions
- Most grants stipulate equipment operation in a

specified area for a defined period

Recommendations

1. Strategic Project Planning and Alignment
2. Build Collaborative Partnerships
3. Maintain Awareness of Incentive Grant Opportunities
4. Understand Grant Requirements and Conditions
5. Continuous Improvement and Adaptation
6. Invest in Training and Capacity Building

Conclusions

- Awareness of grant opportunities is crucial for stakeholders involved in emissions reduction initiatives.
- Knowing and understanding the requirements and associated timelines is key to successfully bidding and implementing grant funding.
- Financial incentives are an integral part of efforts to transition to cleaner locomotive technologies. Achievement of ambitious targets set by federal and state agencies will require grant funding and it is in every railroad's best interest to understand how best to apply for and utilize that funding.

Thank you!

Questions & Discussion

Biofuels and Low Temperature Properties

October 10, 2024

Suzanne Golisz (Innospec)
Stephanie Jaworski (Imperial Oil)
Vu Tran (Infineum)

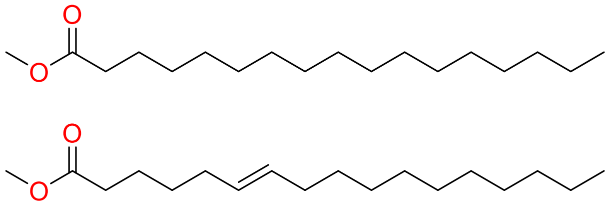
Agenda

- Overview
  - Biodiesel and renewable diesel explained
  - US biofuel consumption and production
- Low temperature properties
- Biofuels and their blends (BX, RX, and RX/BX)
- Strategies to use biofuels in low temperatures
- Recommendations

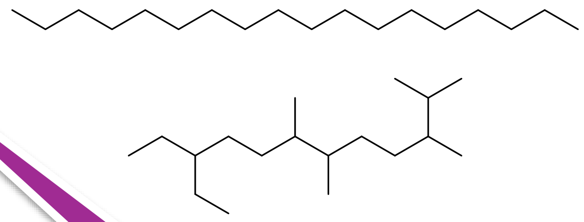
Biodiesel and renewable diesel explained

Feedstock	Vegetable oils, animal fats, waste cooking oil	
Process	Transesterification	Hydroisomerization
Product	Biodiesel (FAME)	Renewable Diesel (RD or HDRD)
Fuel Cost	Dependent	Dependent
Efficiency	7-10% increase in fuel consumption	3-7% increase in fuel consumption
Emissions	Increased NOx, PM flat, Reduced net CO_2	Reduced NOx, PM, net CO_2

Biodiesel

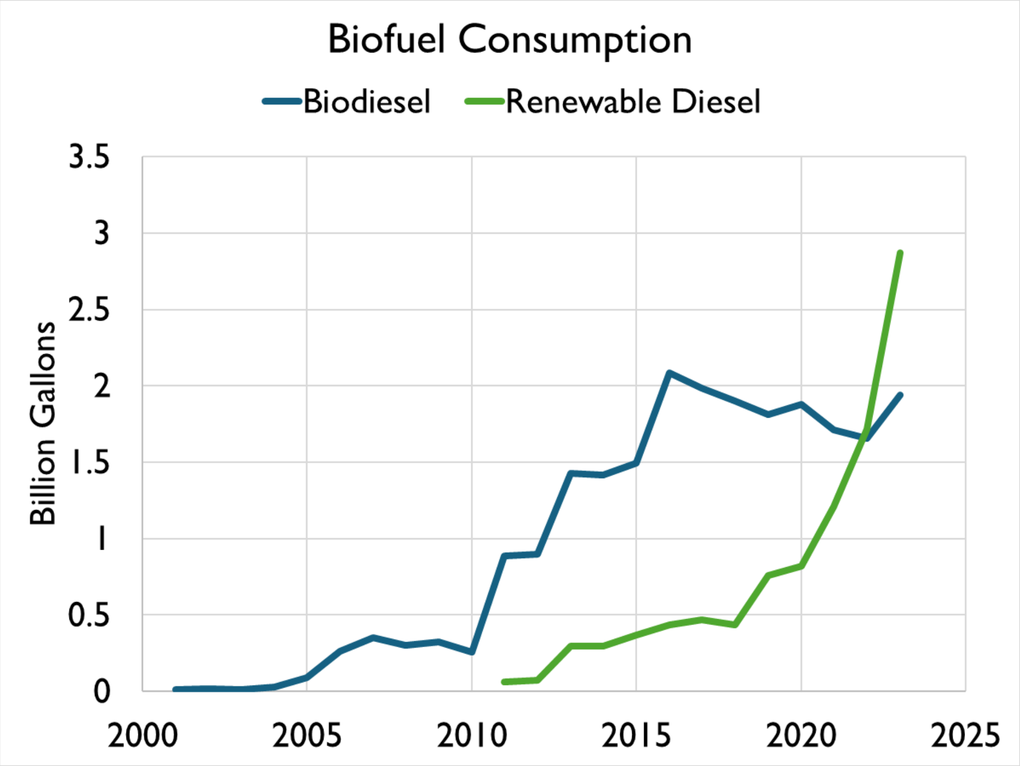


Renewable Diesel

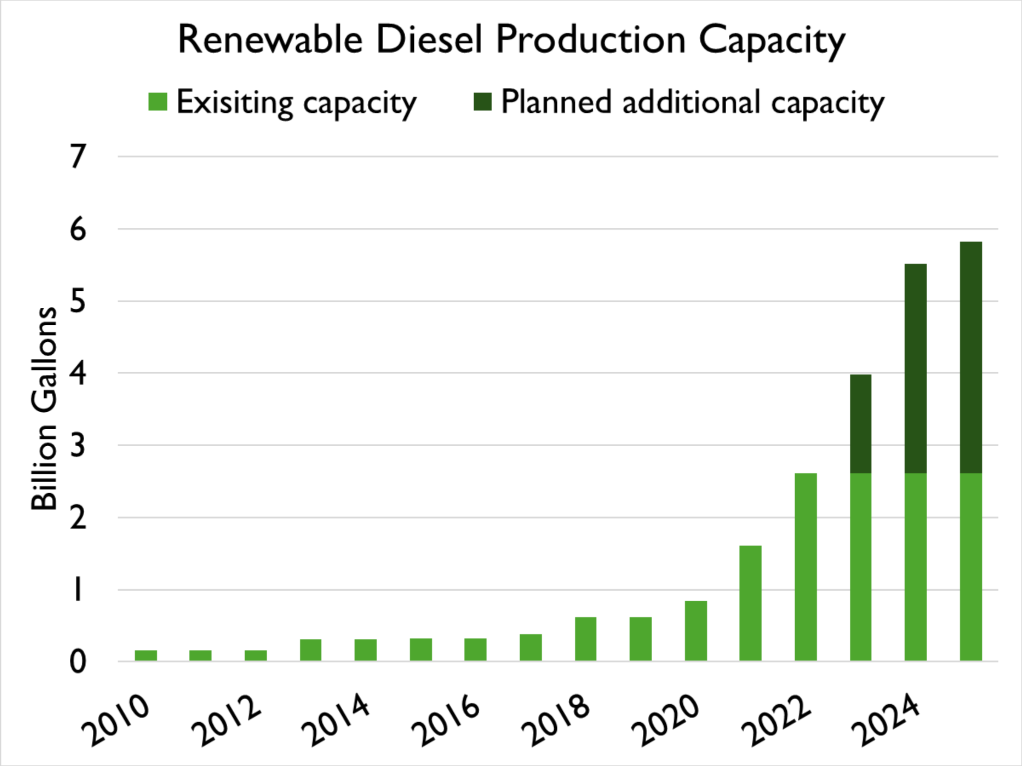


Plants that make RD also make SAF

US biofuel consumption and production



In 2023, US renewable diesel consumption surpassed biodiesel consumption



US renewable diesel capacity could more than double through 2025

https://www.eia.gov/todayinenergy/detail.php?id=60281
https://www.eia.gov/todayinenergy/detail.php?id=55399

Low temperature properties

Cloud Point (CP)

ASTM D2500, D5771, D5772, D5573, D7683 or D7689

- The temperature at which the smallest observable cluster of crystals first appears in a fuel upon cooling under prescribed test conditions

Cold Filter Plugging Point (CFPP)

ASTM D6371

- This test employs rapid cooling conditions and is intended to represent the performance of a typical light duty vehicle

Low-Temperature Flow Test (LTFT)

ASTM D4539

- This test employs slow cooling process and is considered more representative of the more severe fuel systems found in North American heavy-duty trucks

Pour Point (PP)

ASTM D97, D5949 or D5950

- The temperature at which a fuel contains so many clusters of crystals that it becomes gel-like and will no longer flow

Biodiesel and low temperature properties

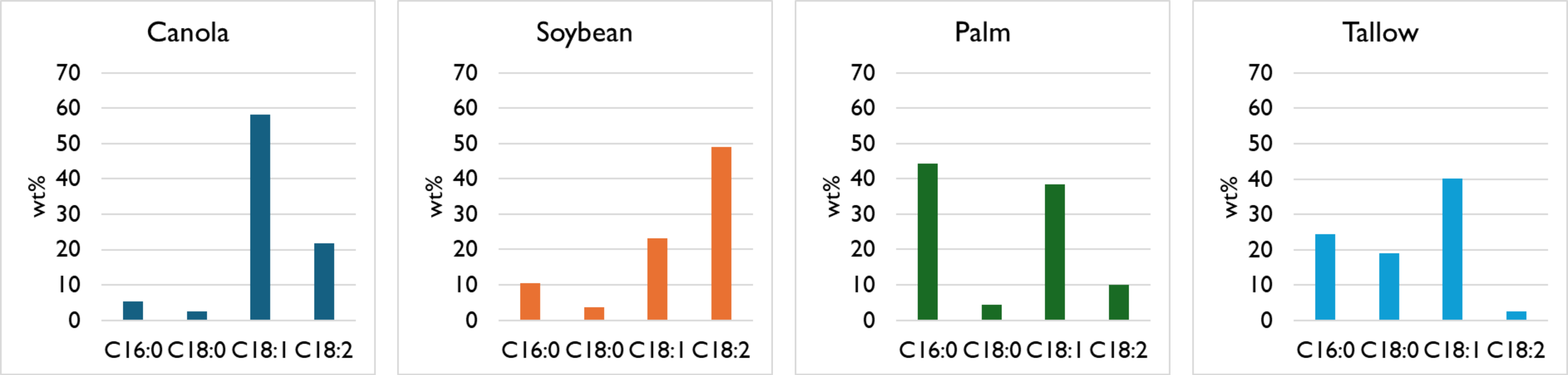
- The low temperature properties of biodiesel are primarily related to the feedstock (i.e. fatty acid distribution)

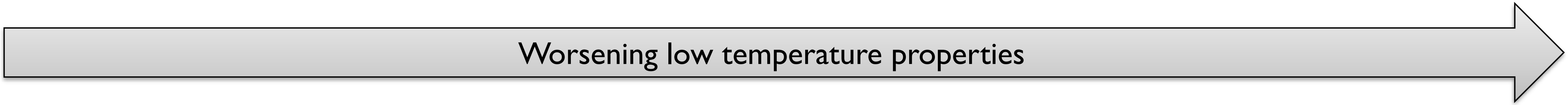
Property	Canola	Soybean	Palm	Tallow
Cloud Point (CP) ASTM D2500, °C (°F)	-3 (27)	2 (36)	15 (59)	20 (68)
Cold Filter Plugging Point (CFPP) ASTM D6371, °C (°F)	-6 (21)	-3 (27)	13 (55)	10 (50)
Low Temperature Flow Test (LTFT) ASTM D4539, °C (°F)	-4 (24)	0 (32)		19 (66)
Pour Point (PP) ASTM D97, °C (°F)	-4 (25)	-1 (30)	12 (54)	13 (56)

Kinast, J.A. 2003. Production of biodiesel from multiple feedstocks and properties of biodiesel and biodiesel/diesel blends. Golden, CO: National Renewable Energy Laboratory. NREL/ DR-510-31460. https://www.nrel.gov/docs/fy03osti/31460.pdf
Dunn. R.O.; Moser, B.R. Cold Weather Properties and Performance of Biodiesel. In The Biodiesel Handbook 1st ed.; Knothe, G., Krahl, J., Van Gerpen, J., Eds. AOCS Press 2010; pp 147-203. DOI: https://doi.org/10.1016/C2015-0-02453-4

Biodiesel and low temperature properties

- Low temperature properties worsen as saturated fatty acids increase

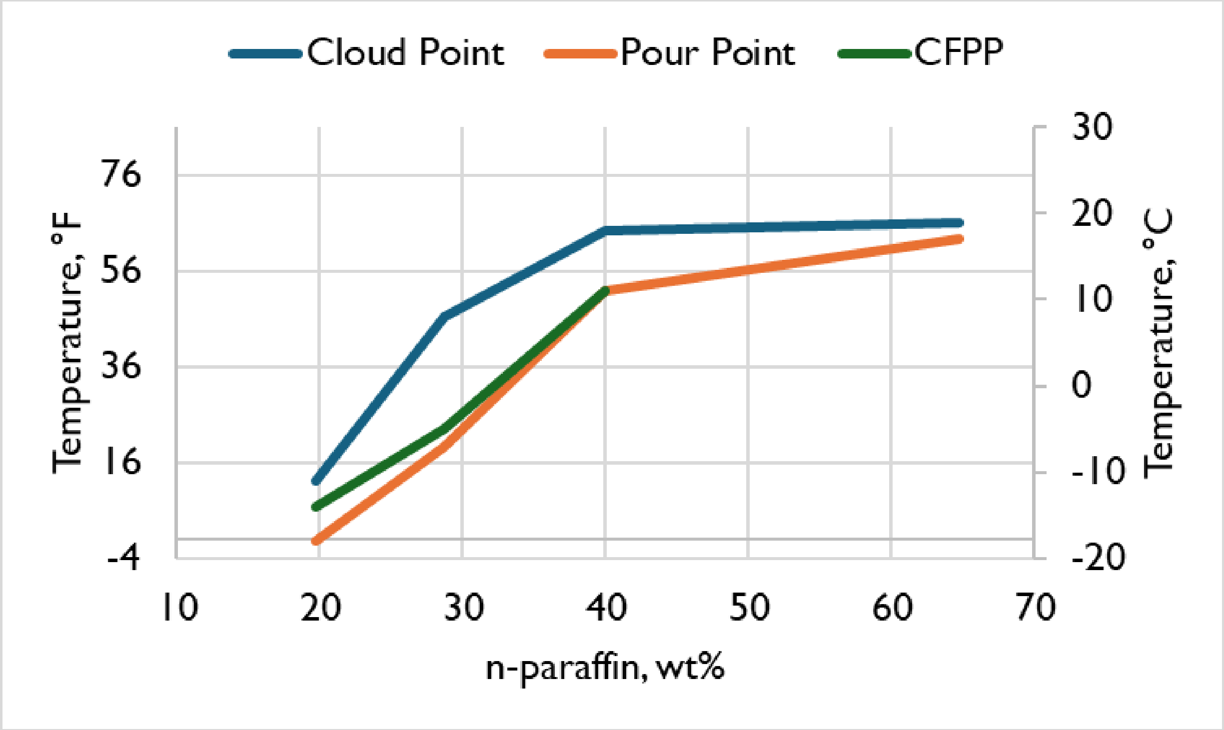




Kinast, J.A. 2003. Production of biodiesel from multiple feedstocks and properties of biodiesel and biodiesel/diesel blends. Golden, CO: National Renewable Energy Laboratory. NREL/ DR-510-31460. https://www.nrel.gov/docs/fy03osti/31460.pdf
Kim, J.-K.; Yim, E.S.; Jeon, C.H.; Jung, C.-S.; Han, B.H. Cold Performance of various biodiesel fuel blends at low temperature. Intl. J. of Auto. Tech. 2012, 13, 293-300. https://doi.org/10.1007/s12239-012-0027-2

Renewable diesel and low temperature properties

- The low temperature properties of renewable diesel are primarily related to the processing conditions



↓ Low temperature properties

↓ n-Paraffins

↑ Isomerization

↓ Yield

↑ Cost

Best low temperature properties
=
$$$$

Šimáček, P.; Kubička, D.; Kubičková, I.; Homola, F.; Pospíšil, M.; Chudoba, J. Premium quality renewable diesel fuel by hydroprocessing of sunflower oil. Fuel, 2011, 90 (7), 2473-2479. https://doi.org/10.1016/j.fuel.2011.03.013

Blends of biofuels

- The low temperature properties of BX blends do not blend linearly
- The low temperature properties of RX blends do not blend linearly
- Eutectics have been observed for both BX and RX blends
- Blends of renewable diesel and biodiesel (RX/BX)
  - Renewable diesel is typically at a higher proportion than biodiesel
  - Renewable diesel is a poor solvent due to high paraffin content
  - Filter plugging above the cloud point possible due to the reduced solvency of biodiesel constituents in the renewable diesel matrix

Low-temperature operability approaches

United States

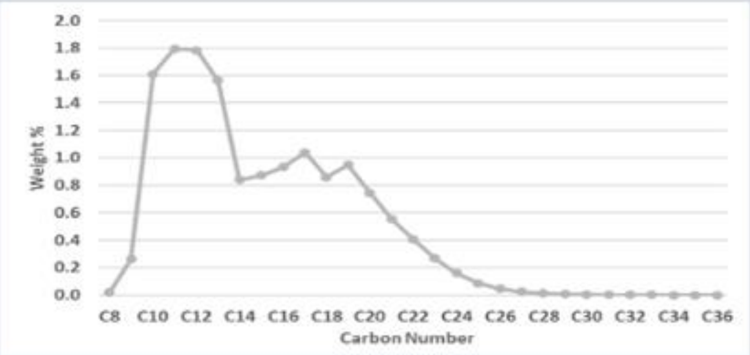
- ASTM D975 suggests that low temperature properties and values be agreed upon between the fuel supplier and purchaser
- Recommended test methods:
  - Cloud Point
  - *Low Temperature Flow Test (LTFT)
  - *Cold Filter Plugging Point Test (CFPP)
- Appendix X5 in D975 includes tenth (10^{th}) percentile minimum monthly air temperatures that can be used for estimating required temperatures

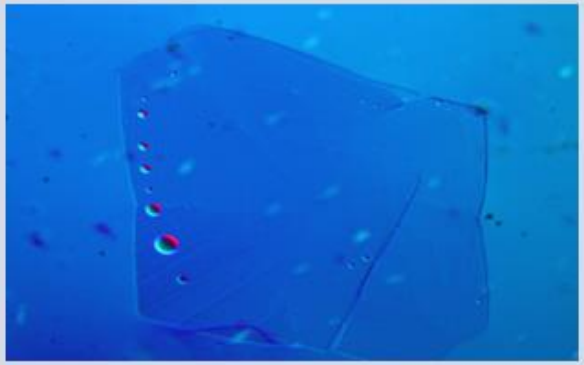
Canada

- Per Canadian General Standards Board (CGSB) 3.517/3.520, low-temperature flow properties are designed to give satisfactory performance at the temperatures indicated by the 2.5% low-end design temperature data for the period and location of intended use.
- Accepted test methods :
  - Cloud point
  - *Low-temperature flow test (LTFT)

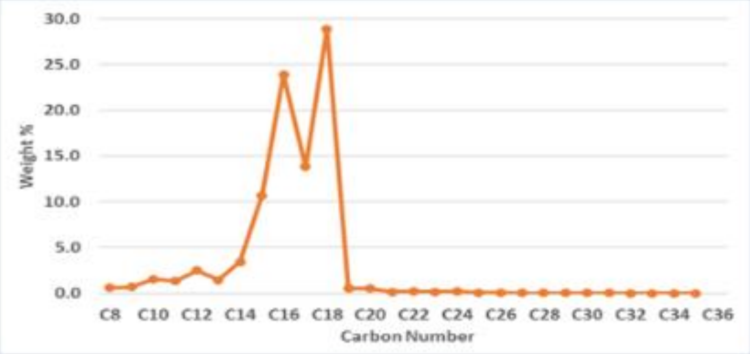
*Recommended test if additives are used

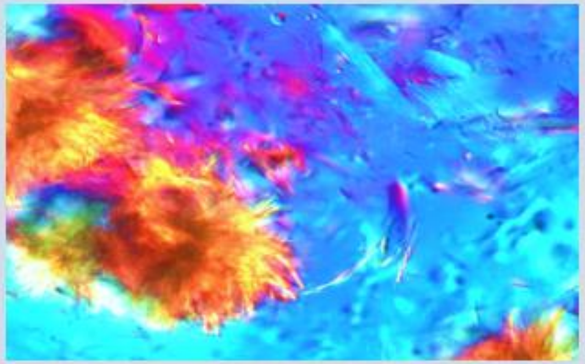
Diesel fuel composition and wax crystals





Typical diesel n-Alkane distribution and large plate-like wax crystal formed as temperature goes below cloud point.



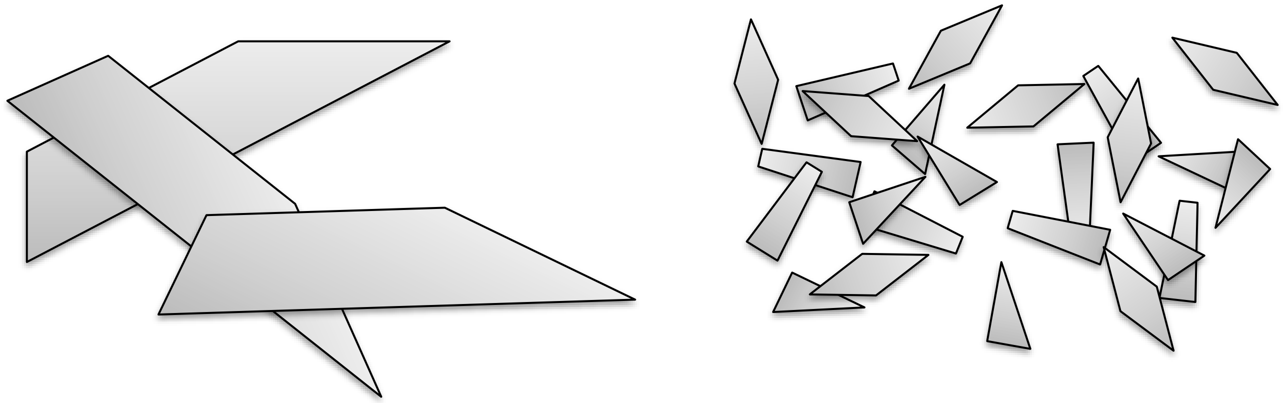


Typical high cloud point RD's n-Alkane distribution and uncontrolled wax crystal growth as temperature goes below cloud point.

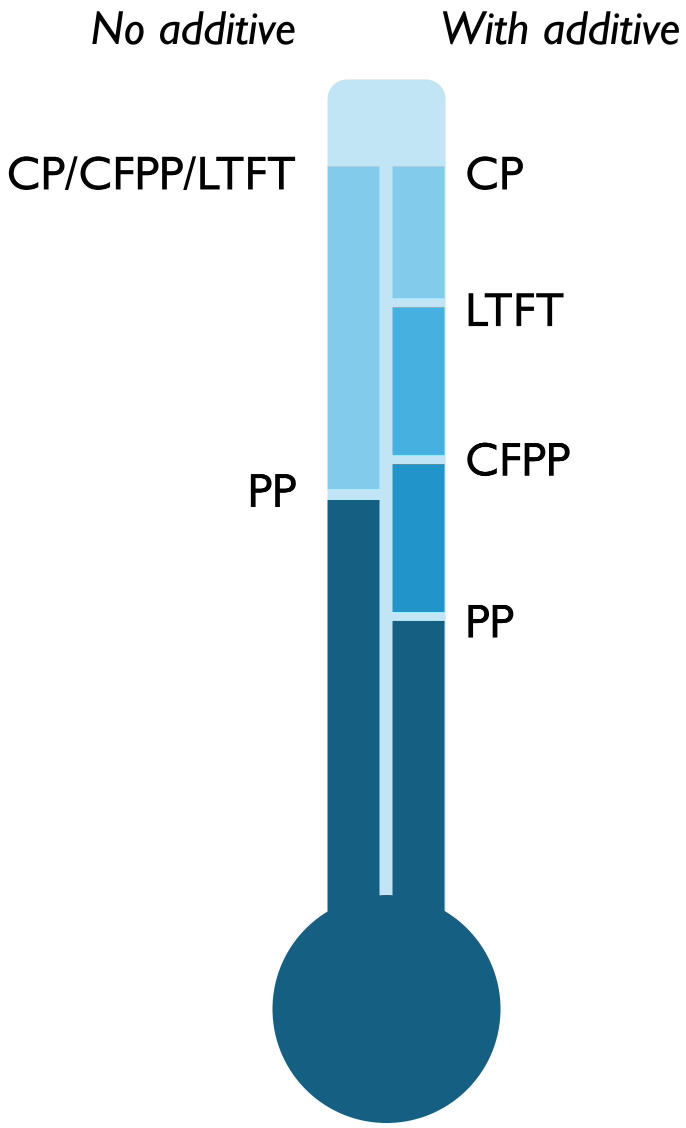
- The difference in composition helps to explain why biofuels, in general, have higher low temperature properties than diesel
- Renewable diesel is NOT a “drop in” fuel for diesel
- Wax crystals can plug filters in the fuel distribution system
- Additives can enable the use of biofuels in colder climates

Role of additives

- Cold flow improver additives can reduce the CFPP, LTFT, and PP of biofuel containing blends
- These additives modify the wax crystals to reduce their size and prevent agglomeration



No additive *With additive*



Recommendations

- The low temperature properties of specific biofuels and biofuel blends should be understood or tested prior to their use
- Depending on the location of use, the low temperature properties must meet the specification (Canada) or the agreed upon target between the supplier and the purchaser (United States). Work with your fuel supplier to ensure that the low temperature properties of your fuel are appropriate for the region and period of intended use.
- Additives can be used to improve the low temperature properties of some biofuels or biofuel-containing blends. Work with your additive supplier to ensure that the chemistry of the additive is appropriate for biofuels.

Biodiesel Handling and Blending Recommendations

Railway Supply Institute

LMOA - FUEL, LUBRICANTS AND ENVIRONMENTAL COMMITTEE

October 10, 2024

Cautionary statement

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This presentation contains forward-looking statements relating to Chevron's operations and energy transition plans that are based on management's current expectations, estimates and projections about the petroleum, chemicals and other energy-related industries. Words or phrases such as "anticipates," "expects," "intends," "plans," "targets," "advances," "commits," "drives," "aims," "forecasts," "projects," "believes," "approaches," "seeks," "schedules," "estimates," "positions," "pursues," "may," "can," "could," "should," "will," "budgets," "outlook," "trends," "guidance," "focus," "on track," "goals," "objectives," "strategies," "opportunities," "poised," "potential," "ambitions," "aspires" and similar expressions are intended to identify such forward-looking statements. These statements are not guarantees of future performance and are subject to certain risks, uncertainties and other factors, many of which are beyond the company's control and are difficult to predict. Therefore, actual outcomes and results may differ materially from what is expressed or forecasted in such forward-looking statements. The reader should not place undue reliance on these forward-looking statements, which speak only as of the date of this presentation. Unless legally required, Chevron undertakes no obligation to update publicly any forward-looking statements, whether as a result of new information, future events or otherwise.

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Outline

- Biodiesel value proposition
- Need to discuss biodiesel handling and blending
- Biodiesel supply chain and blending mechanisms
- Biodiesel properties and handling recommendations
- Blending mechanism options and considerations
- Executive summary
- Q&A

Biodiesel Value Proposition

Biodiesel is recognized as a viable pathway to lower carbon intensity today

Lower Carbon Intensity

- Reduction in GHG significant to achieve 2030 targets and beyond
- Reduction in PM
- NOx neutral up to certain blend ratios

Availability

- Domestic supply and ability to deliver via rail and trucks using company assets
- Strategic customers looking for supply assurance potentially resulting in long-term contracts

Affordability

- Federal and state incentives
- Ability to use existing infrastructure and assets
- Lowest TCO alternative available

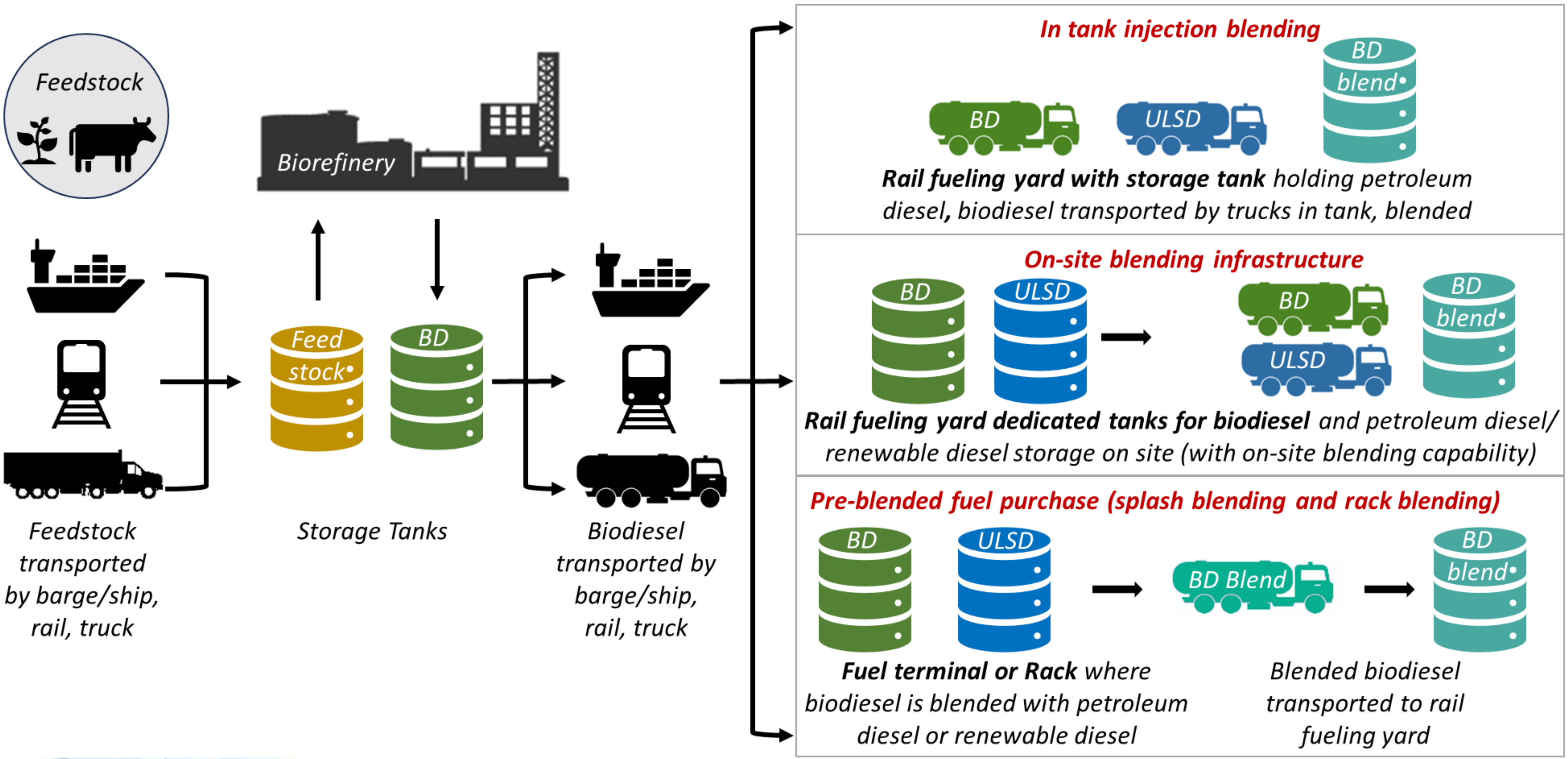
Science-Based GHG Reduction Targets

Union Pacific	BNSF Railway	CN	CPKC	Norfolk Southern	CSX
50.4% by 2030	30% by 2030	43% by 2030	36.9% by 2030	42% by 2034	37% by 2029

Need to discuss biodiesel handling and blending

- Railroads are currently using more biofuels driven by SBTi-based GHG reduction targets
- Policy landscape is also driving adoption of biodiesel via incentives like sales tax, low carbon fuel standard credits, etc.
- OEMs are in process of approving biodiesel blends up to B20, further bolstering the need for clarity on the subject of handling biodiesel
- Biodiesel industry has seen significant progress in terms of production processes, quality standards and experiences based on increased use
- While the overall experience with handling biofuels has been positive, there have been opportunities for improvements that provide shared learnings, guidance and recommendations

Biodiesel supply chain and blending mechanisms



Fuel handling and specifications

- **ASTM Standard**
  - D975 B0-B5
  - D7467-20a B6-B20
  - D6751 B100
- **Periodically inspect tanks** for water and sediment to ensure the quality and performance of the fuel
- **Review material compatibility** of tanks, coating and gasket/hoses
- Temporary **additional filtration during start up** may be needed
  - Biodiesel has solvent properties that could disperse existing sediment and contamination in existing piping and tank systems
- 30-micron and 10-micron **filtration system** in succession and a primary and secondary means of filtration for fuel dispensers

Fuel quality considerations and tests

- Energy density differences in biodiesel blends (up to B20) impacts on power, torque and fuel economy are **less than 2%**, depending on the diesel fuel and duty cycles
- The ASTM minimum limit for B100 Cetane number is set at 45
- Biodiesel has excellent lubrication quality; 2% biodiesel almost always imparts adequate lubricity to biodiesel blends
- Blends are evaluated for **oxidation stability** using the **EN15751** test procedure
    - ASTM minimum requirement for OSI is 6 hours
- National Biodiesel Accreditation Program for fuel quality is BQ-9000
- **ASTM B100 Cold Soak Filterability Test** and the Canadian CGSB's Cold Soak Filter Blocking Tendency test are both useful for determining the presence of potentially problematic levels of sterol glucosides (SGs)

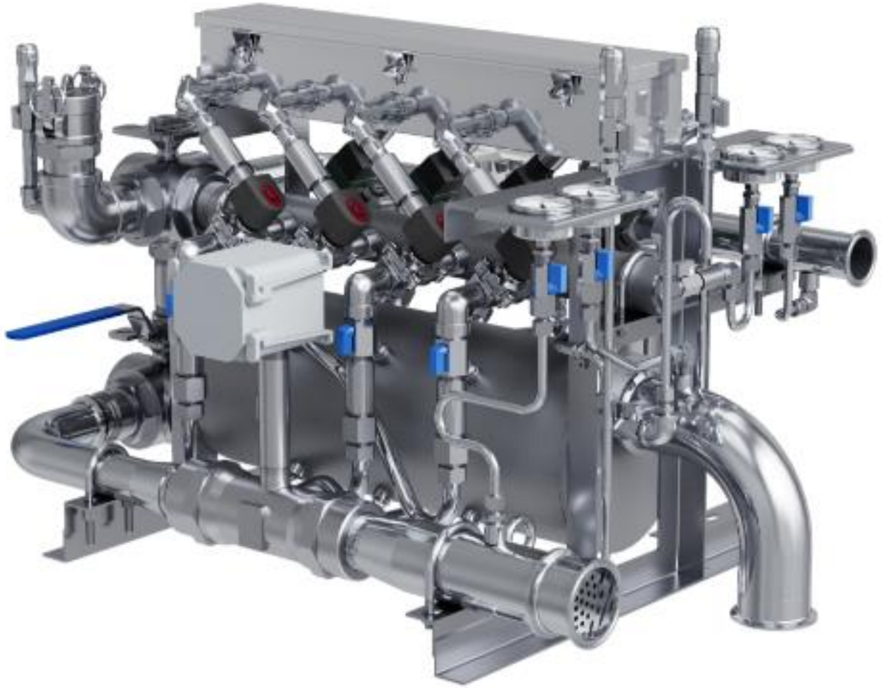
Blending method 1: Injection blending in bulk tank at terminal

Advantages

- Best economics on biodiesel values due to direct purchase from biorefinery
- Operational flexibility and ease of implementation
- Usually, no need for special infrastructure and allows you to use existing infrastructure
- Easy integration of fuel delivery operations
- Best control of biofuel quality and other attributes and complete traceability

Disadvantages

- Blending requires careful management of timing of diesel and biodiesel deliveries, especially during cold weather
- Occasional testing may be needed to ensure desired blending is being achieved



Biodiesel Blending System

Photo source: Biofuel Blending System | Veeder-Root

Blending method 2: Splash blending in tanker truck

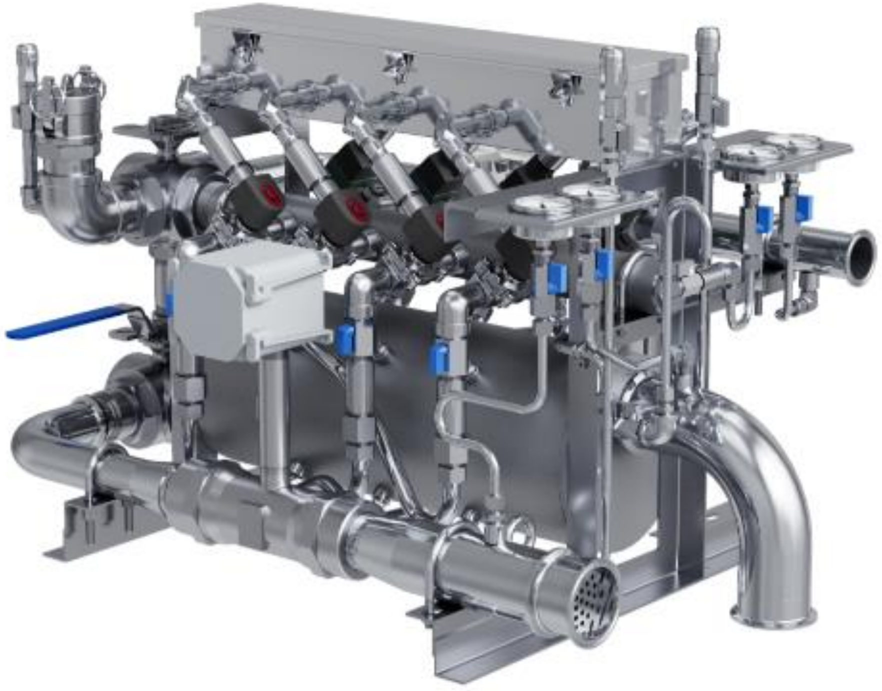
Advantages	• Flexibility and ease of implementation • Typically, no need for special infrastructure • Easy integration of fuel delivery operations
Disadvantages	• Testing may be needed to ensure desired blend levels are achieved. • Limited traceability of quality and other attributes needed for record-keeping

Fuel terminal truck rack with multiple fuel tanks

Photo source iStock

Blending method 3: Inline blending on site

Advantages	• Best economics due to direct purchase • Flexibility to achieve desired blend rates • Best control of quality and traceability • Allows you to manage your desired blend in real-time
Disadvantages	• Requires additional injection equipment to achieve onsite blending along with additional biofuel tankage. • Special blending equipment could require capital investment (USDA HBIIP Funding Available)

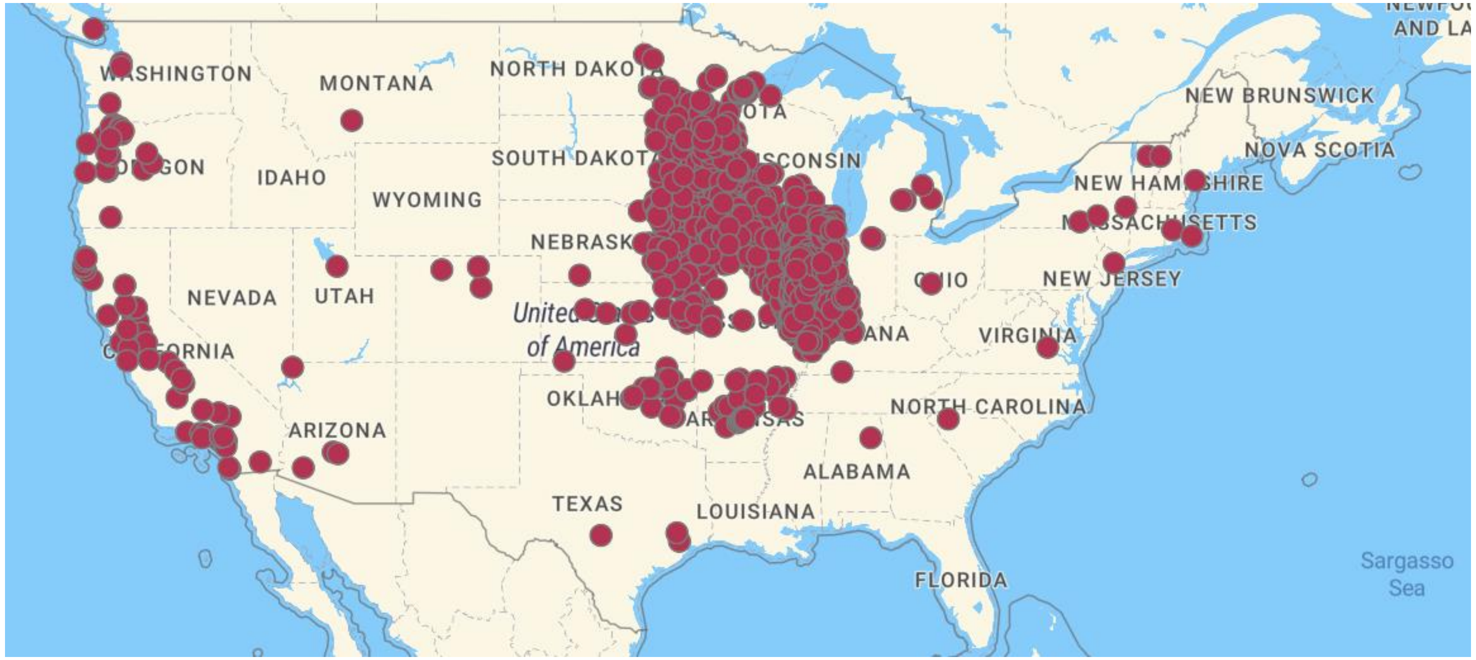


Biodiesel Blending System

Photo source: Biofuel Blending System | Veeder-Root

Blending method 4: Rack blending at third-party terminal

Advantages	• Ease of implementation • Usually no need for special infrastructure • Easiest integration of fuel delivery operations • High confidence in blend ratios
Disadvantages	• Availability and flexibility limited dependent on terminal capability • Little to no traceability of quality and other attributes needed for record-keeping • Reliance on fuel terminals for quality of biofuel supplied



Biodiesel (B20 and above) fueling stations in the United States and Canada

Source: Alternative Fuels Data Center: Biodiesel Fueling Station Locations (energy.gov)

The AFDC is a resource of the U.S. Department of Energy's Vehicle Technologies Office.

Summary

- Biodiesel is a viable pathway to lower carbon intensity today
- Handling, blending and quality aspects are specific to individual use case
    - Location, desired blend levels and supply consideration
- Understanding modern day biodiesel specifications and quality parameters are key to successful implementation of biodiesel
- Industry has made significant progress to support adoption
    - Approving increased biodiesel blends
    - Implementing high-quality production standards at biorefineries
    - Infrastructure and additives options have been developed to handle unique situations
    - Quality program and testing support with robust knowledge base is widely available
- Committee recommends that railroads work closely with their fuel, technology, additives and infrastructure providers to find the best fit approach for implementation of biodiesel blends

LMOA Fuels, Lubricants & Environmental Committee

Railroad GHG Emissions Accounting with Biofuels

October 10, 2024

Steve Fritz — SOUTHWEST RESEARCH INSTITUTE

Veronica Bradley — Clean Fuels ALLIANCE AMERICA

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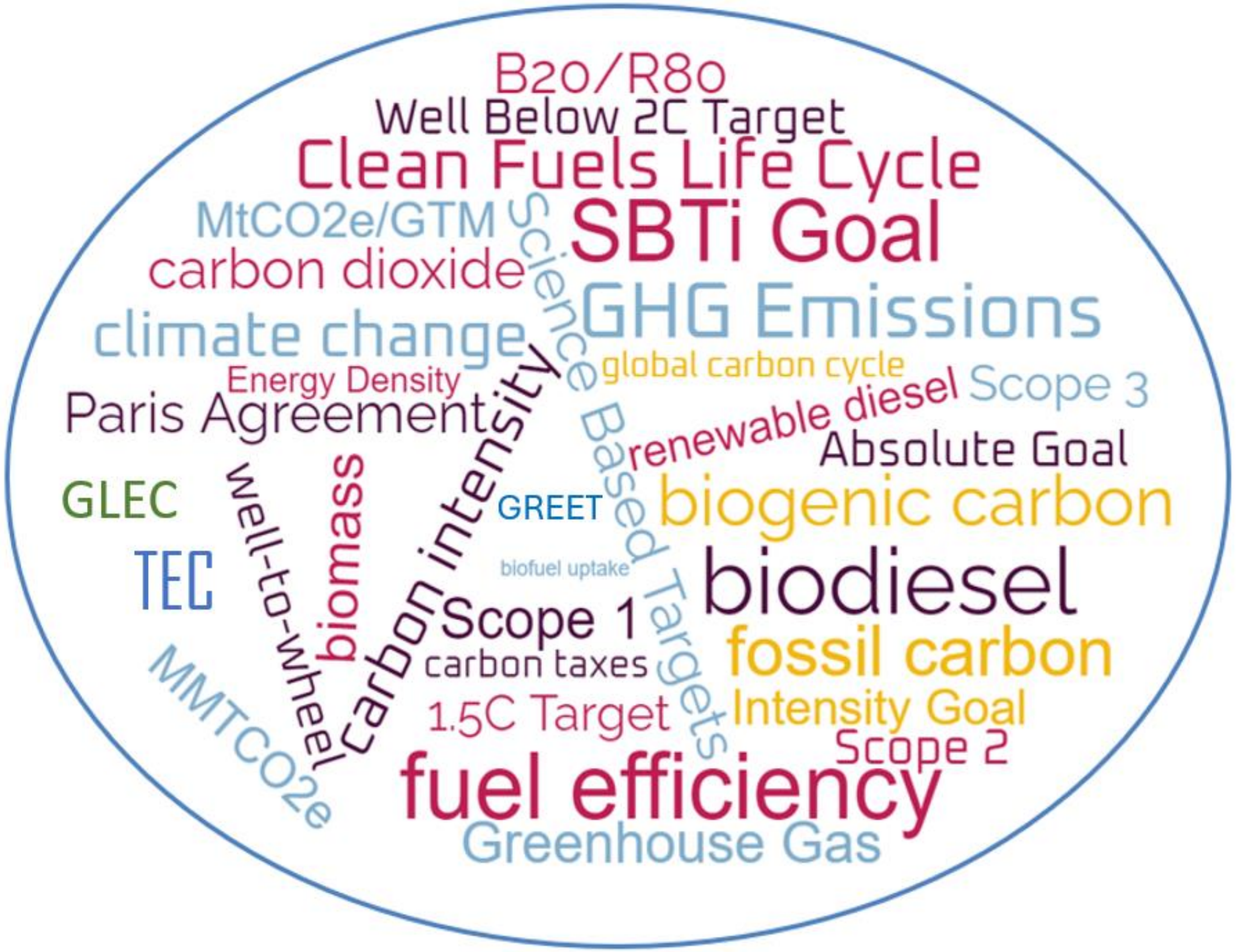
Presentation Outline

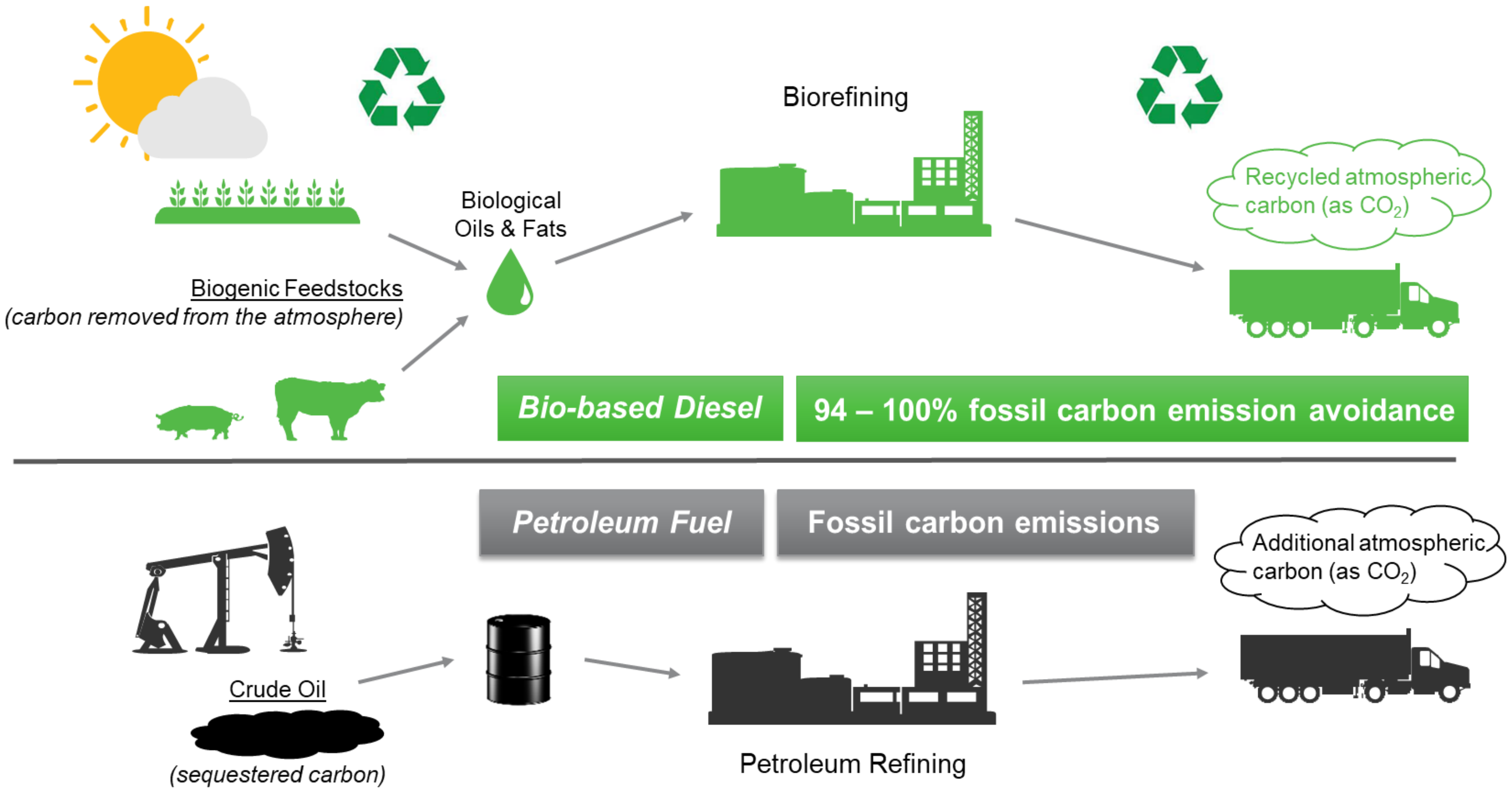
- What's the Focus for Rail?
- Fossil Fuel versus Biogenic Carbon – What's the Difference?
- SBTi Scope Emissions and Reduction Goals for the Industry
- Historical Fuel Efficiency and Industry Performance to SBTi Goals
- Current Biofuels Uptake for Class I Railroads
- A Biofuels GHG Accounting Example
- Recommendations for the Industry and Conclusions

What's The Focus for Rail?



- GHG accounting is challenging even before introducing biofuels
- Biofuels have a host of differences compared to regular #2 diesel
  - Carbon Intensity (CI) score
  - Lower energy volume
  - Broad spectrum of feedstocks
  - Transportation distance
  - Production methodology
- Each railroad has varying uptake performance from <1% to >6%
- Standardization on how to approach may be required…

Fossil Fuel versus Biogenic Carbon



Different Origins and Implications for the Global Carbon Cycle

<u>Biogenic Carbon</u>

Released from the combustion of

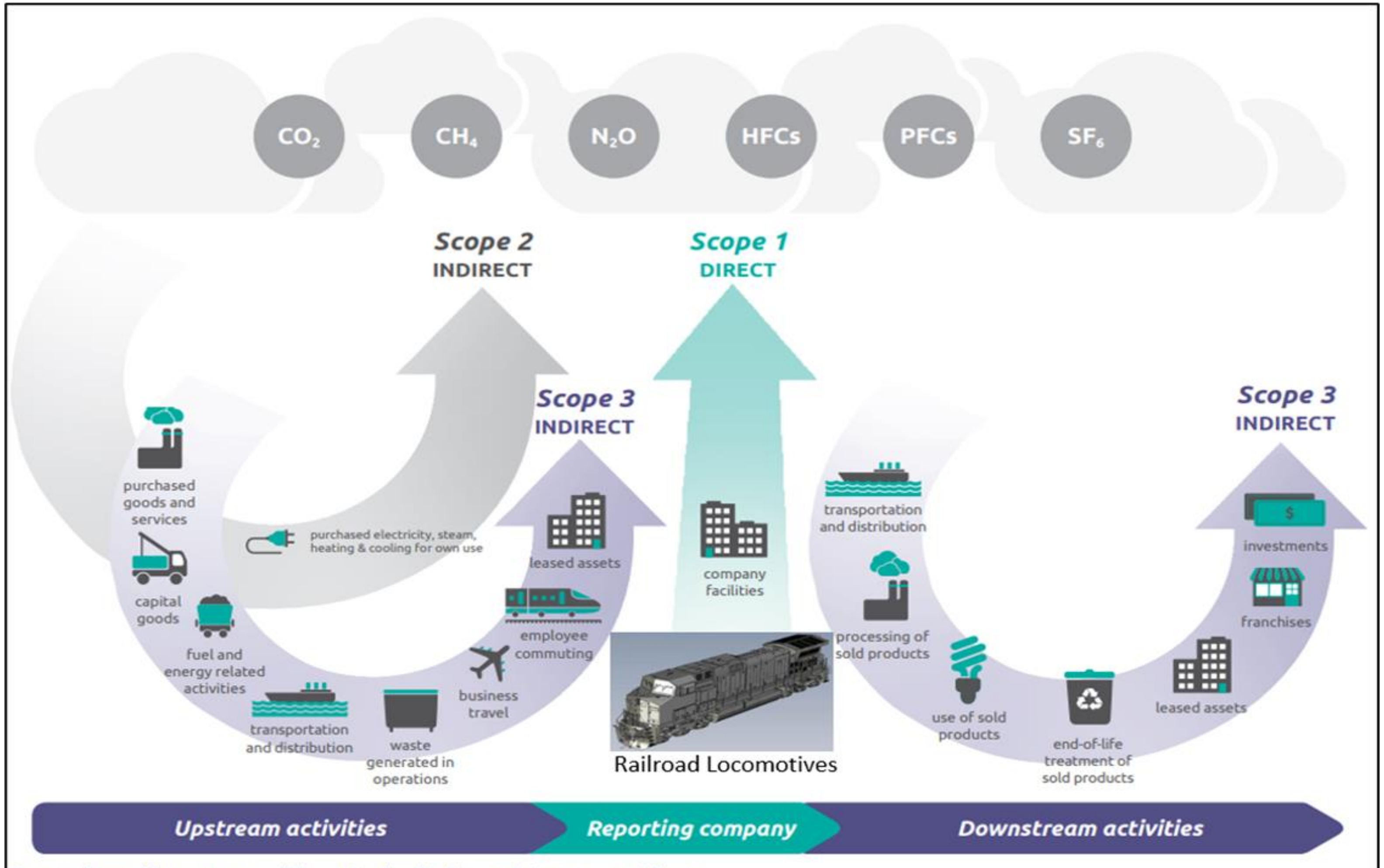
1. Biomass
   a. Wood
   b. Crops
   c. Non-petroleum waste

<u>Fossil Fuels</u>

Released from the combustion of

1. Crude Oil (derivative products include Diesel / Gasoline / Jet Fuel / Propane / Kerosene)
2. Natural Gas
3. Coal

Corporate Inventory for Emissions of a Railroad



Source: https://www.epa.gov/climateleadership/scope-3-inventory-guidance

<u>Three Different Scopes Considered</u>:

- Scope 1 covers direct emissions from owned sources (tank-to-wheel emissions from locomotives)
- Scope 2 covers indirect emissions from purchased services such as electricity, heating and cooling
- Scope 3 covers all other indirect emissions that occur in the value chain such as the disposal of railroad ties, rails and wheels – it also includes the well-to-tank (upstream portion) of diesel fuel including extraction, production and transportation

Science Based Targets by Railroad

Company Name	Full target language	Company Temperature	Scope	Target Value	Type	Base Year	Target	Date Published
BNSF Railway	BNSF Railway commits to reduce absolute scope 1 and 2 and well-to-wheel locomotive GHG emissions 30% by 2030 from a 2018 base year*. *The target boundary includes biogenic emissions and removals from bioenergy feedstocks.	Well-below 2°C	1+2	30%	Absolute	2018	2030	2023-05-25
Canadian National Railway Co	CN commits to reduce scope 1 and 2 GHG emissions 43% per gross ton miles by 2030 from a 2019 base year*. CN commits to reduce scope 3 GHG emissions from fuel and energy related activities 40% per gross ton miles by 2030 from a 2019 base year. *The target boundary includes biogenic emissions and removals from bioenergy feedstocks.	Well-below 2°C	1+2	43%	Intensity	2019	2030	2021-07-21
CSX Corporation	CSX commits to reduce scope 1 and 2 GHG emissions intensity 37% per million gross ton miles by 2029 from a 2014 base year.	Well-below 2°C	1+2	37%	Intensity	2014	2029	2020-01-01
Norfolk Southern Corporation	Norfolk Southern commits to reduce scope 1 and 2 GHG emissions 42% per million gross ton-miles (MGTM) by 2034 from a 2019 base year*. *The target boundary includes biogenic emissions and removals from bioenergy feedstocks.	Well-below 2°C	1+2	42%	Intensity	2019	2034	2021-07-29
Union Pacific Corporation	Union Pacific commits to reduce absolute scope 1 and 2 GHG emissions 50.4% by 2030 from a 2018 base year.* Union Pacific also commits to reduce scope 3 GHG emissions from purchased goods and services, capital goods, and fuel and energy-related activities 50.4% within the same timeframe. *The target boundary includes land-related emissions and removals from bioenergy feedstocks.	1.5°C	1+2	50%	Absolute	2018	2030	2024-03-28
CPKC	CPKC commits to reduce scope 1, 2, and 3 well-to-wheel locomotive GHG emissions 36.9% per gross ton-miles by 2030 from a 2020 base year.	Well-below 2°C	1+2+3	37%	Intensity	2020	2030	2023-11-23

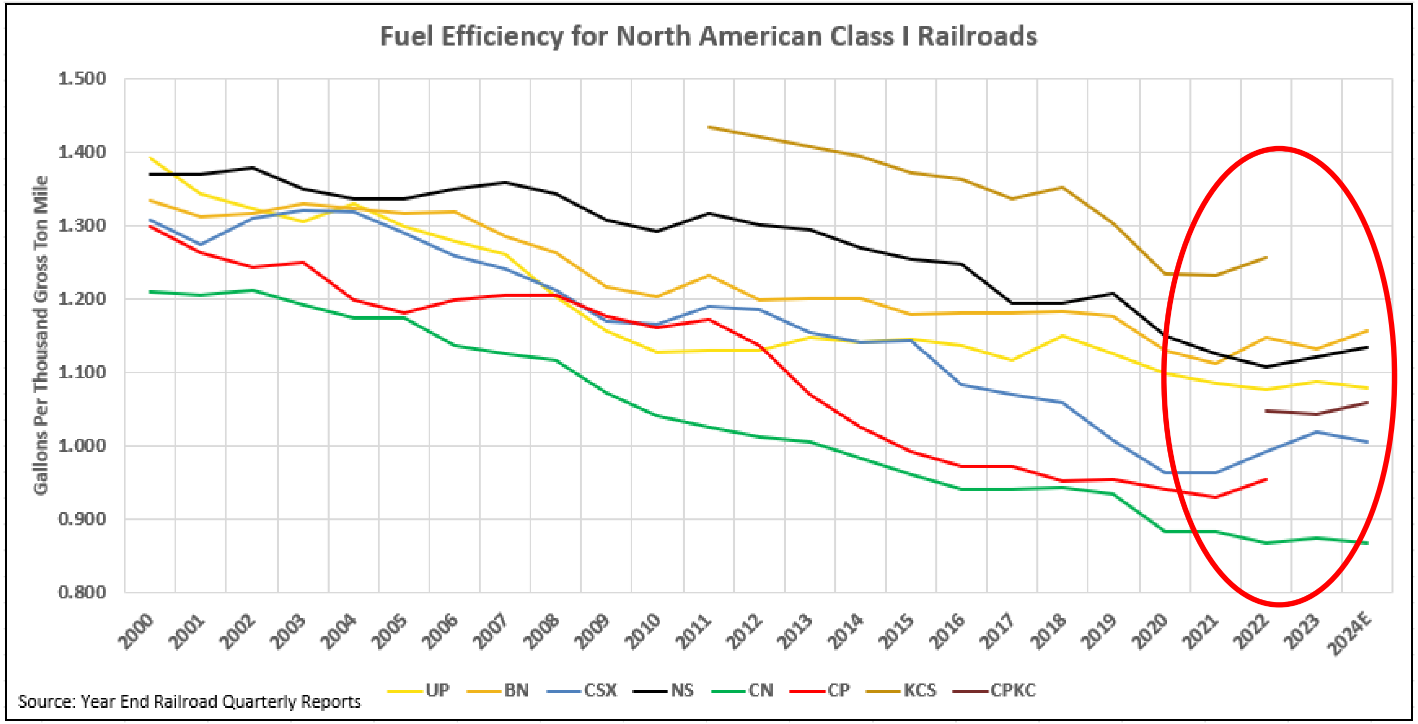
Highlighting some key differences including:

- Absolute vs Intensity goal
- Well-below 2°C vs 1.5°C
- Number of Scopes
- Base year
- Target year

Note – all railroads (except UP) will need to restate their goals to a 1.5° C within 5 years of their published goal

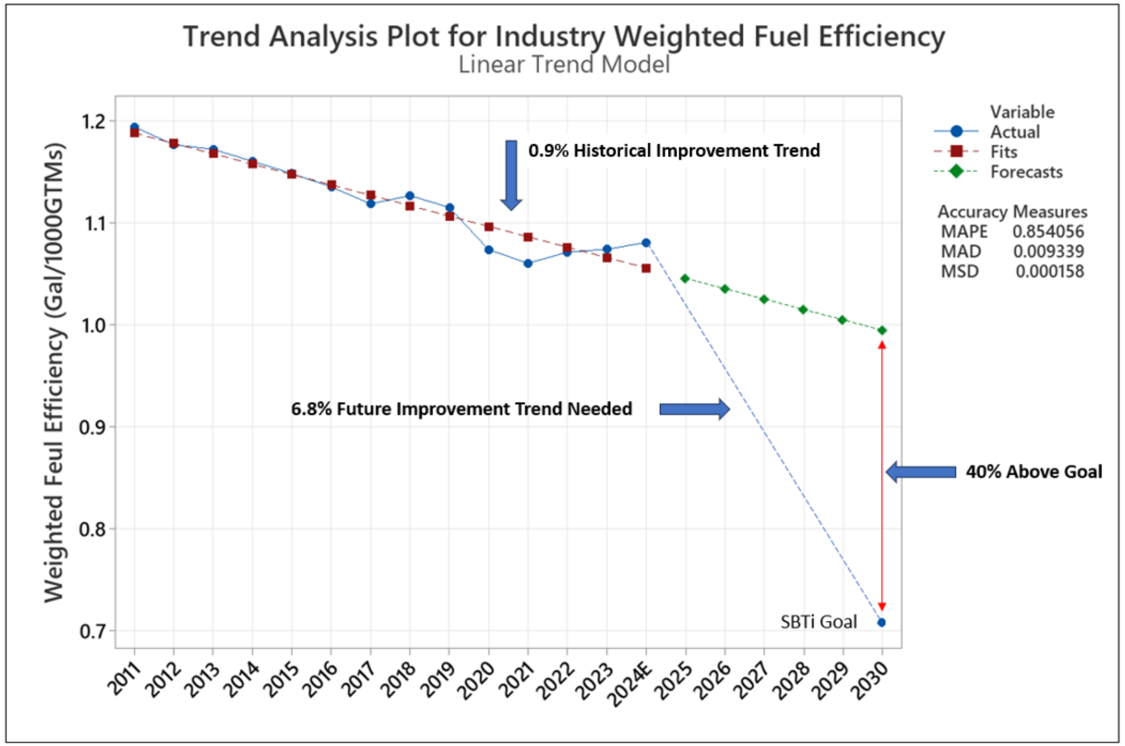
Various Goals, Types and Scopes for Each Railroad – All Very Aggressive

Historical Fuel Efficiency versus Future Need

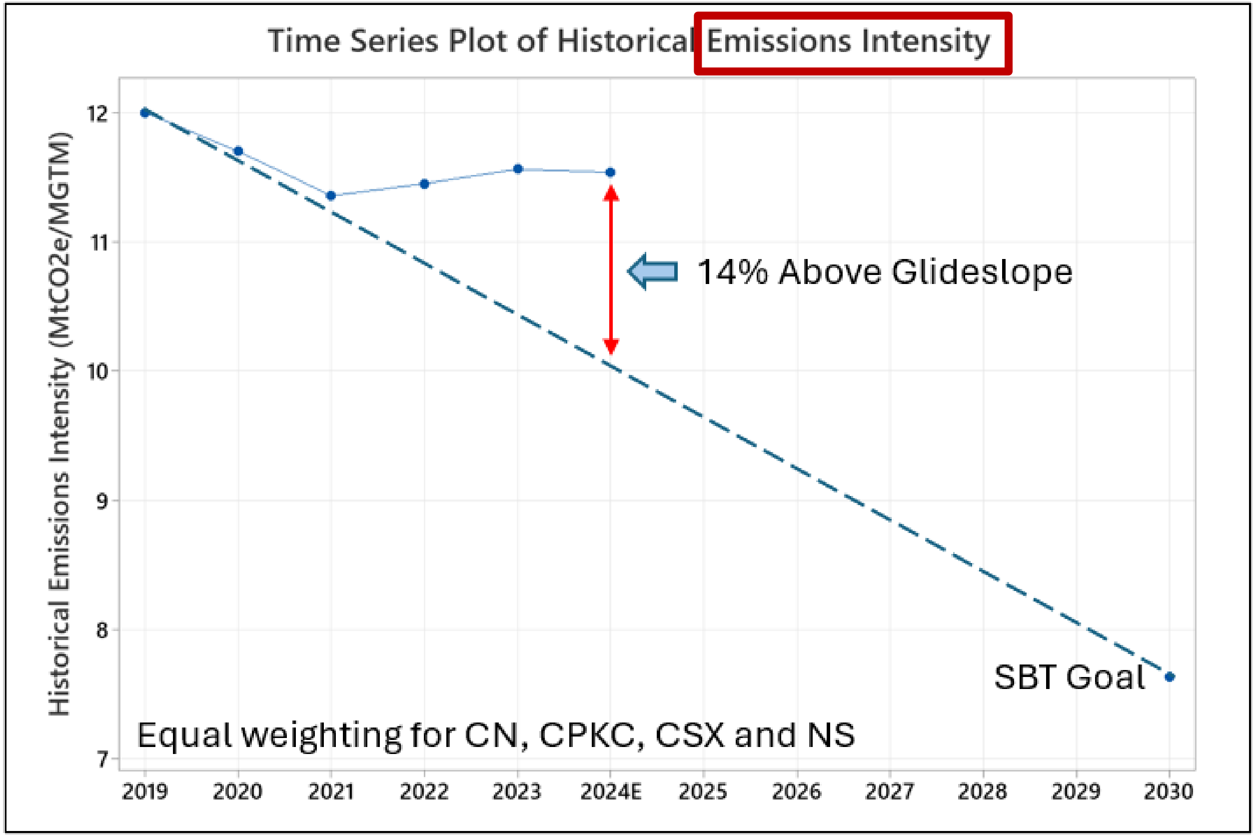


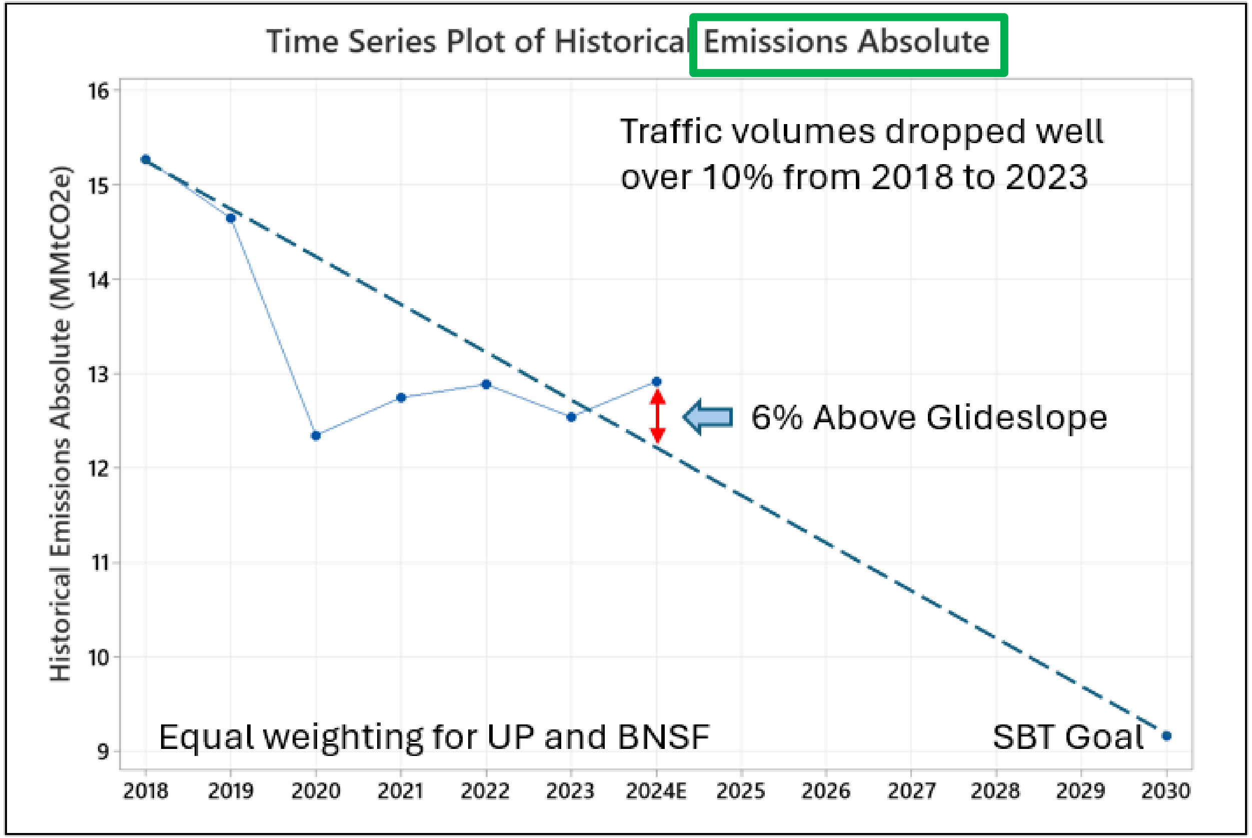
Gradual improvement – though flat performance the last 3 years

Current efforts challenged to meet 2030 goals



How Railroads Are Performing to SBT Goal





Recent Years Have Seen Degradation to Glideslope
Future Gains Are More Challenging

Traffic Volume Drop Has Helped Thus Far
Though Not a Long-Term Strategy

Industry Uptake of Biofuels

Railroad	Current Percentage	Future Percentage Goal by Target Year	Comments
UP	6.1% (2023)	20% by 2030	Mid-term goal of 10% average blend by 2025
NS	0.8% (2022)	20% by 2034	Goal announced January 2024 in their Climate Transition Plan (CTP) document release
CN	4.2% (2022)	None published	Testing a 100% Biofuel blend with Chevron REG
CPKC	1.4% (2022)	None published	Listed as a potential future measure in Climate Strategy
CSX	0.2% (2022)	None published	Testing B20 and will increase uptake once Wabtec testing approves the use of B20/R80 by 3Q 2026
BNSF	Not Published	None published	Testing B20 and have made statements that biofuels could reduce their emissions by as much as 20%

UP and CN are the current uptake leaders with both announcing B20 goals by 2030

Eastern US railroads both under 1% average blend

CPKC middle of the pack with BNSF not having published any specific figures though suggests a potential future role

A Wide Variation of Uptake by Railroad Though Some Commonality of Goals for the Future

A Simplified Accounting Example

Scope 1 for 1M gallons of B100

EPA Emissions Factor (EF) = 9,450 MT CO2
*Methane (using EPA EF) = 22.4 MT CO2e
*Nitrous Oxide (using EPA EF) = 68.9 MT CO2e

Total Scope 1 = 91.3 MT (metric tons) CO2e
(excludes 9,450 MT of direct CO2)

Scope 3 Category 3 Well-to-Wheel Minus Tank-to-Wheel or (22.0 – 0.8) = 21.2 g/MJ which calculates to = 2,769 MT CO2e

Life Cycle Well-to-Wheel emissions:
Scope 1 + Scope 3 Category 3 = 2,860 MT CO2e

Scope 1 for 1M gallons of Petroleum Diesel

Combined EF for CO2, CH4, N2O using Well-to-Wheels (WTW) GLEC = 10,307.5 MT CO2e

Scope 3 Category 3 for WTW GLEC EF = 12,455 MT CO2e

Life Cycle Well-to-Wheel emissions:
Scope 1 + Scope 3 Category 3 = 22,762.5 MT CO2e

87.4% Reduction in Life Cycle Emissions

* Emission factors for Methane and Nitrous Oxide for locomotives are not well documented and default EPA EF may not be representative and may overstate Scope 1 emissions – future testing is recommended

Impact on GHG Emissions Reduction by Blend

Biodiesel Blend	Life Cycle GHG Emissions Reduction Percentage	SBTi Reduction Goal for 1.5C	Average SBTi Reduction Goal for <2.0C
B100	87.4%	50.4%	37.8%
B50	43.7%		
B40	35.0%		
B30	26.2%		
B20	17.5%		
B10	8.7%		

Only one RR with a 1.5C currently

All other RRs at a <2.0C currently

Assuming pure fuel efficiency* will be more challenging to achieve in the future, relying on biofuels to do the heavy lifting can achieve large reductions

* How many more gallons of biofuels will be required for the same amount of pulling power compared to regular diesel?

There is a Strong Case for Pursuing Higher Blends of Biofuels to Meet SBT Goals

Recommendations for the Industry

- Railroads should adopt a single, widely recognized biofuel accounting methodology to simplify internal and external emissions reporting
- Aligning with a standard methodology enhances comparability and transparency in decarbonization efforts
- Railroads should drive consensus on handling assumptions, especially when specific information, like fuel pathways, is unknown
- Directly sourcing biofuels from producers is recommended to improve the accuracy of emissions accounting and reduce supply chain complexity
- If simplifying the supply chain remains challenging, a tiered methodology using different emission factors based on supply chain transparency could be agreed upon within the industry

Conclusions

- Biofuels are essential for railroads to meet their 2030 science-based targets (SBTs)
- Pure fuel efficiency gains are insufficient for railroads to achieve these targets
- Several Class I railroads aim for biofuel blends of B20 or higher by 2030, with Canadian railroads facing annual required increases
- Soy-based biodiesel significantly reduces life cycle GHG emissions by 76% compared to petroleum diesel
- There is no standardized method for calculating carbon intensity (CI) scores for biofuels across various pathways and programs
- Market-based approaches, like book-and-claim systems, are being developed to track biofuel usage and could help railroads manage costs and avoid double counting emission benefits

RSI 2025 Paper Topics (Tentative)

- CARB In-Use Locomotive Regulations Update – Steve Fritz
- RNG… What is going on? – Tom Mack
- Future of Locomotive Engine Oils – Tom Gallagher
- Hydrogen in Rail & Infrastructure – Tom Mack
- Carbon Intensity (CI) in the Real World – Wayne Kennedy/Damir Hasagic
- JOINT PAPER - Decarbonization 2050! How to be Prepared – Graciella Trillanes / Jerainne Heywood

New MVP

- Thanks to Steve Fritz for his help as Vice Chair! New Vice Chair is Michael Cleveland!
- Congratulations to Suzanne Golisz!