


*THE FASTEST AND MOST COST-EFFECTIVE PATH FOR
DECARBONIZING HEAVY-DUTY APPLICATIONS*



ClearFlame
ENGINE TECHNOLOGIES

Green Drives – Naperville, IL
Technology Summary – May 17th, 2023



**Sustainability starts with
the heart of our economy
DIESEL ENGINES**



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VA 007 362831

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POWER TECHNOLOGIES

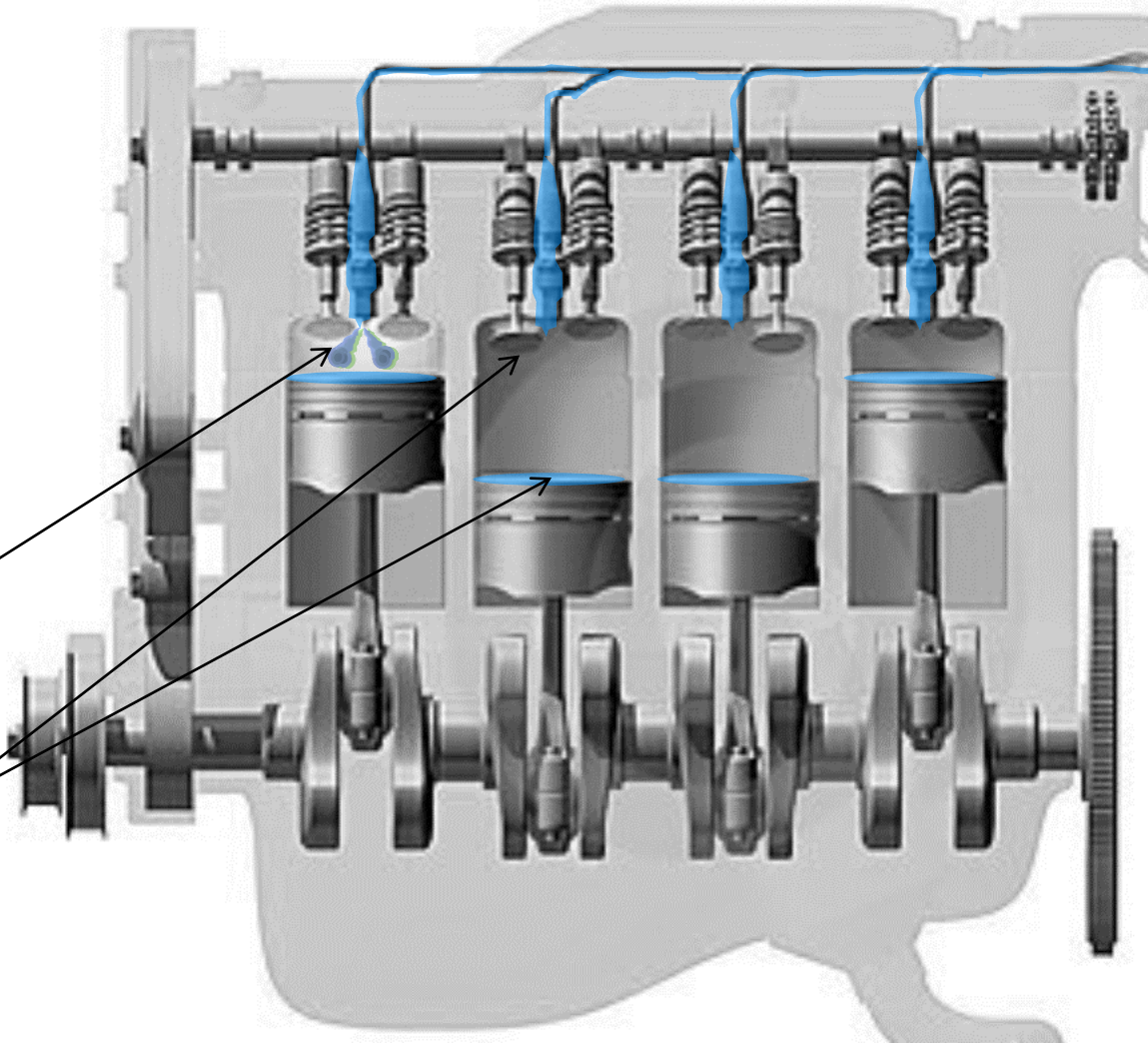
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ClearFlame's Technology

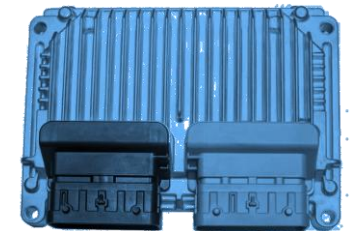
High temperature combustion enables a fuel-adaptable engine

Diesel-style combustion preserves engine performance

Thermal protection ensures component durability



100% alternative fuel maximizes economic and environmental benefits



ClearFlame ECU replaces OEM ECU

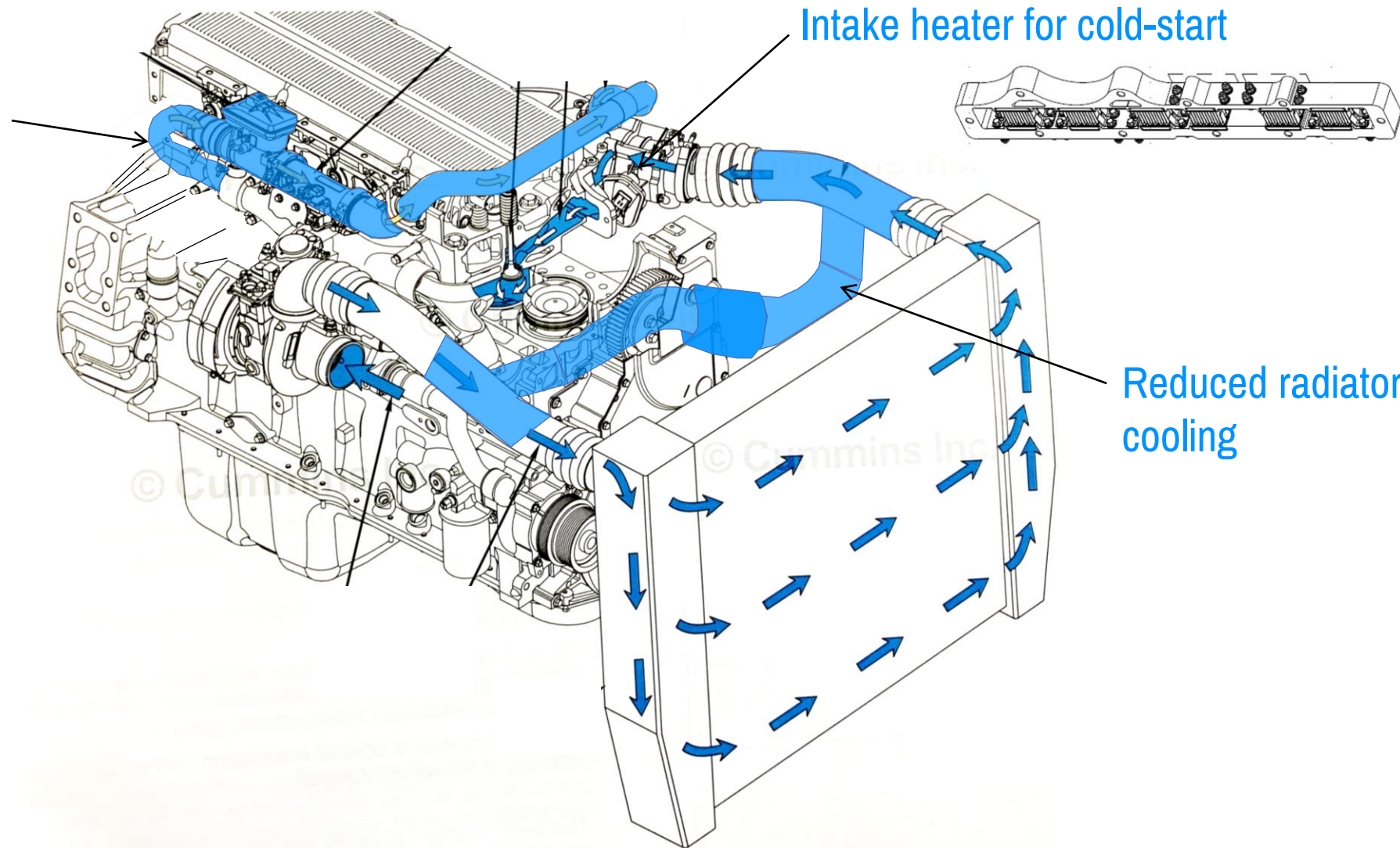


Simple air-handling changes to enable high temperatures

No EGR cooler

Intake heater for cold-start

Reduced radiator cooling

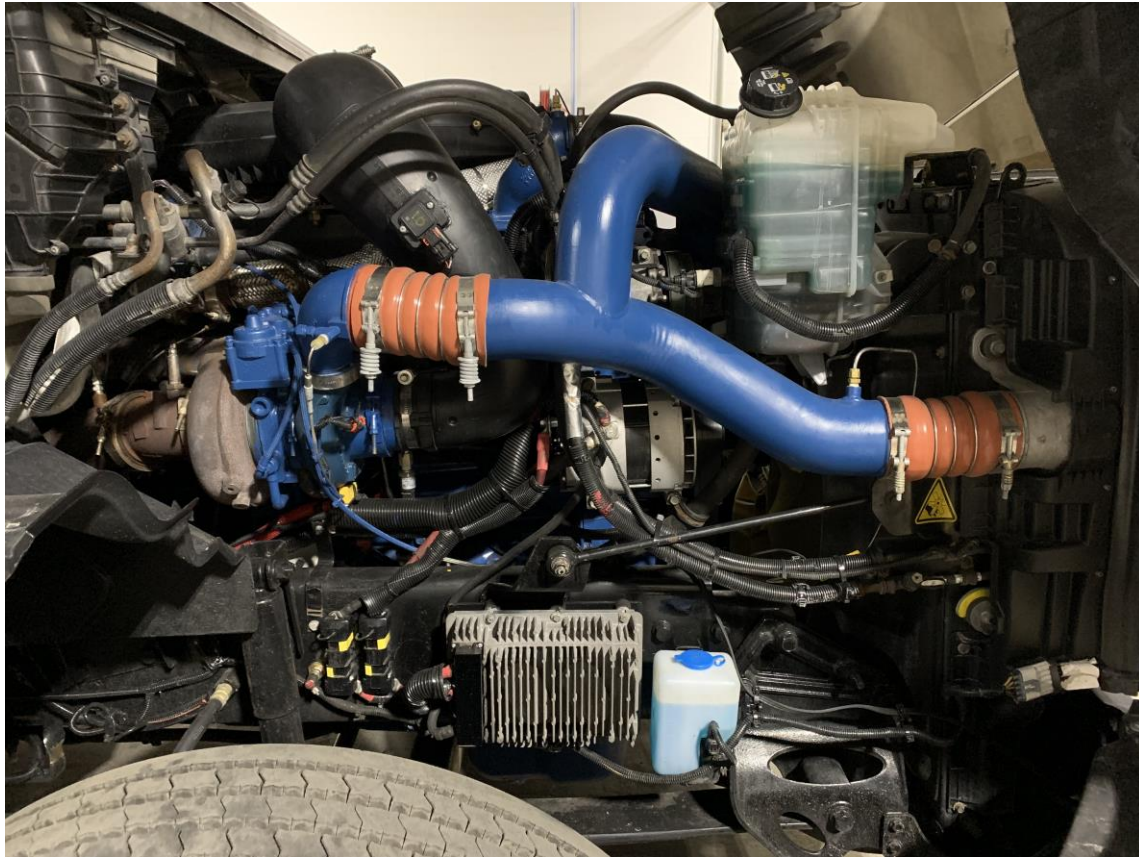


Vehicle-level changes:





Under Hood View:



Turbocharger Side



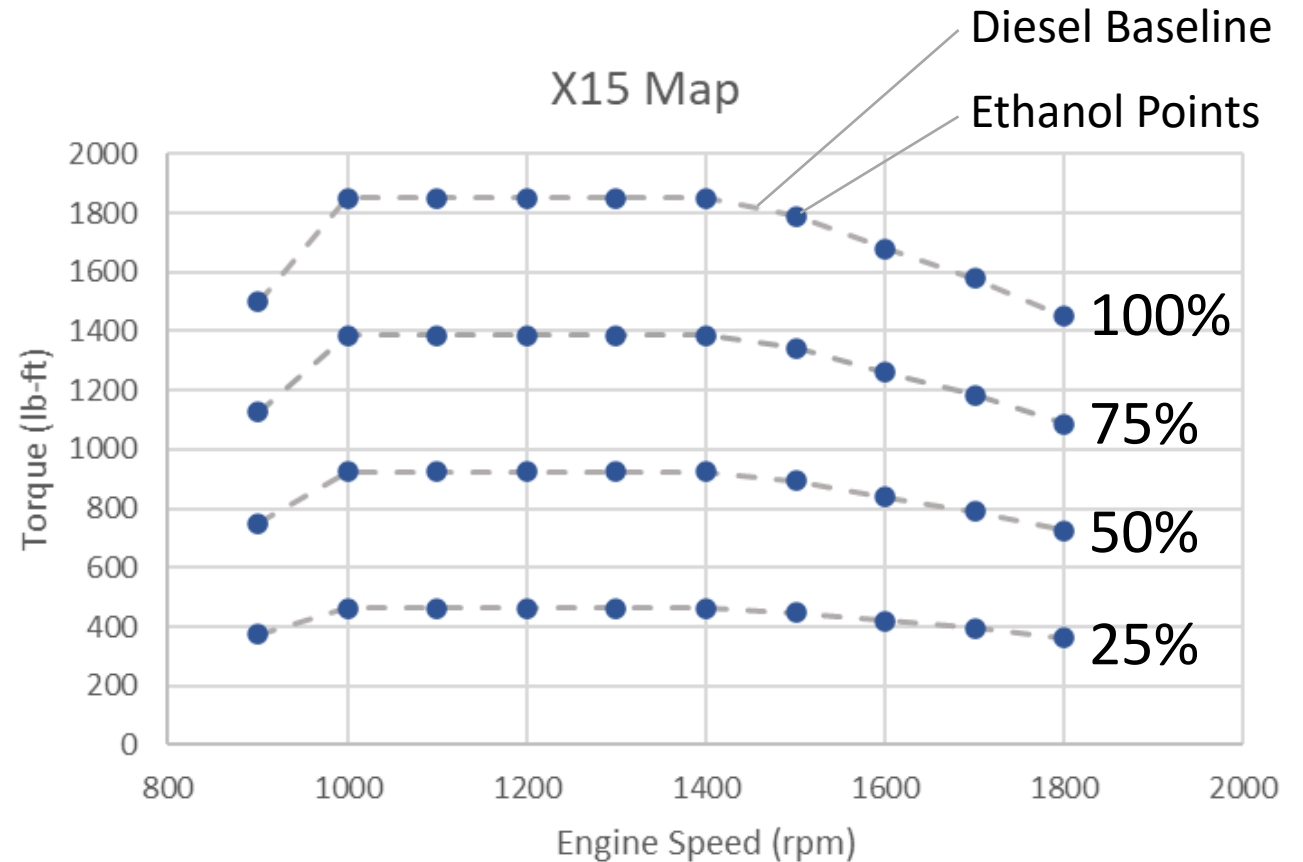
Air Intake Manifold Side





Full Torque and Power Matching Production Diesel Calibration

- Equivalent power and torque to the base diesel platform
- Identical transient response and operability to diesel
- Emissions profile of whatever fuel is used



What is the Ideal Alternative to Diesel Fuel?



Low Cost



Low Carbon



**Performance
& Operability**

+



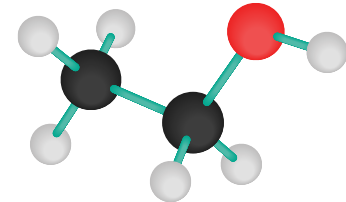
**Scale &
Availability**



Fuel adaptability to leverage soot-free fuels

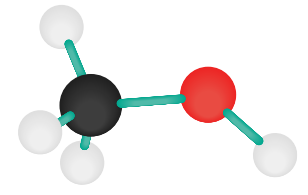


Works with water or gasoline content too



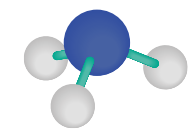
Ethanol

Established market opportunity



Methanol

International expansion with no hardware change



Ammonia

Long-term renewable hydrogen carrier

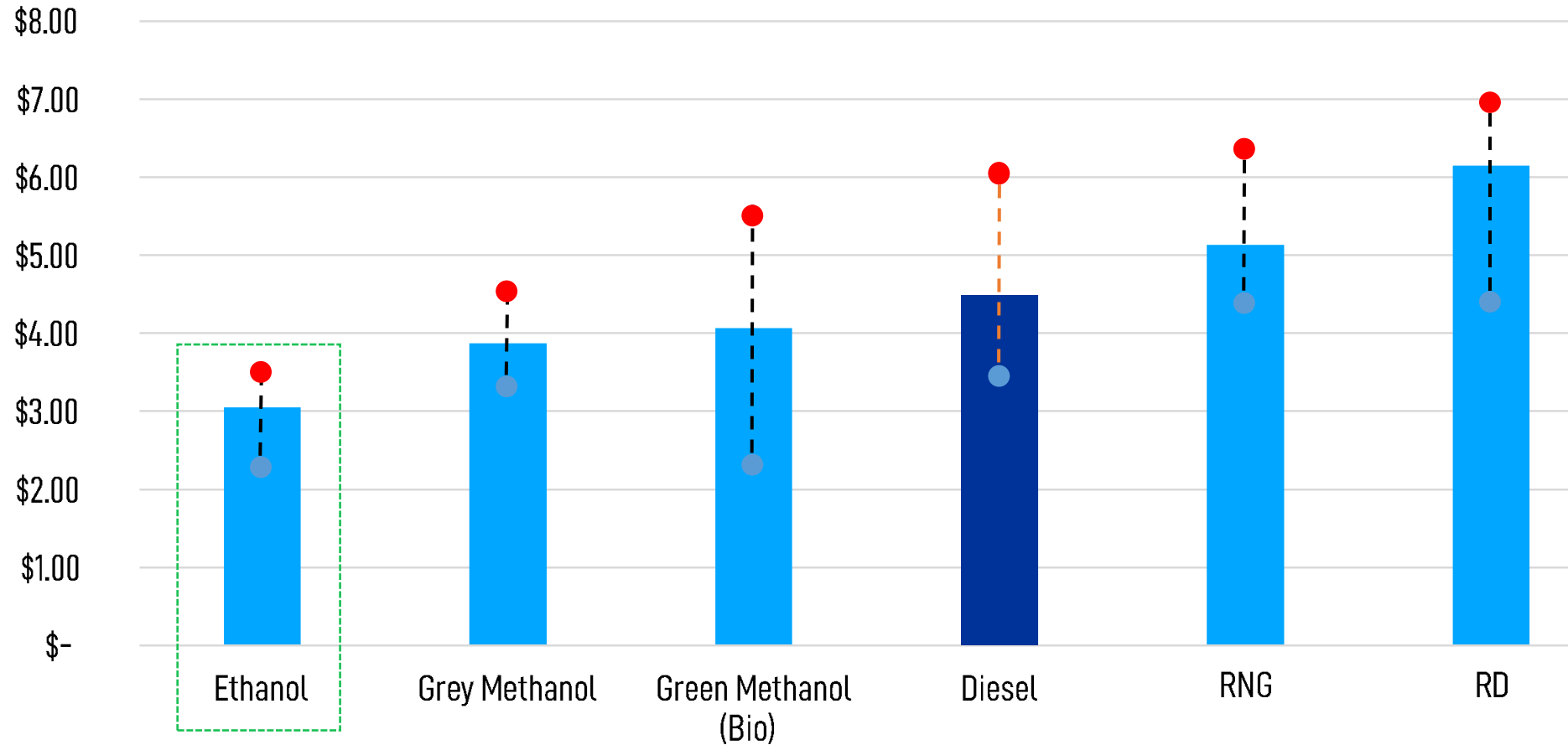
Easily adaptable to both current and future fuels





Ethanol and Green Methanol are the Lowest Cost Alternative Fuels

Diesel Gallon Equivalent Price

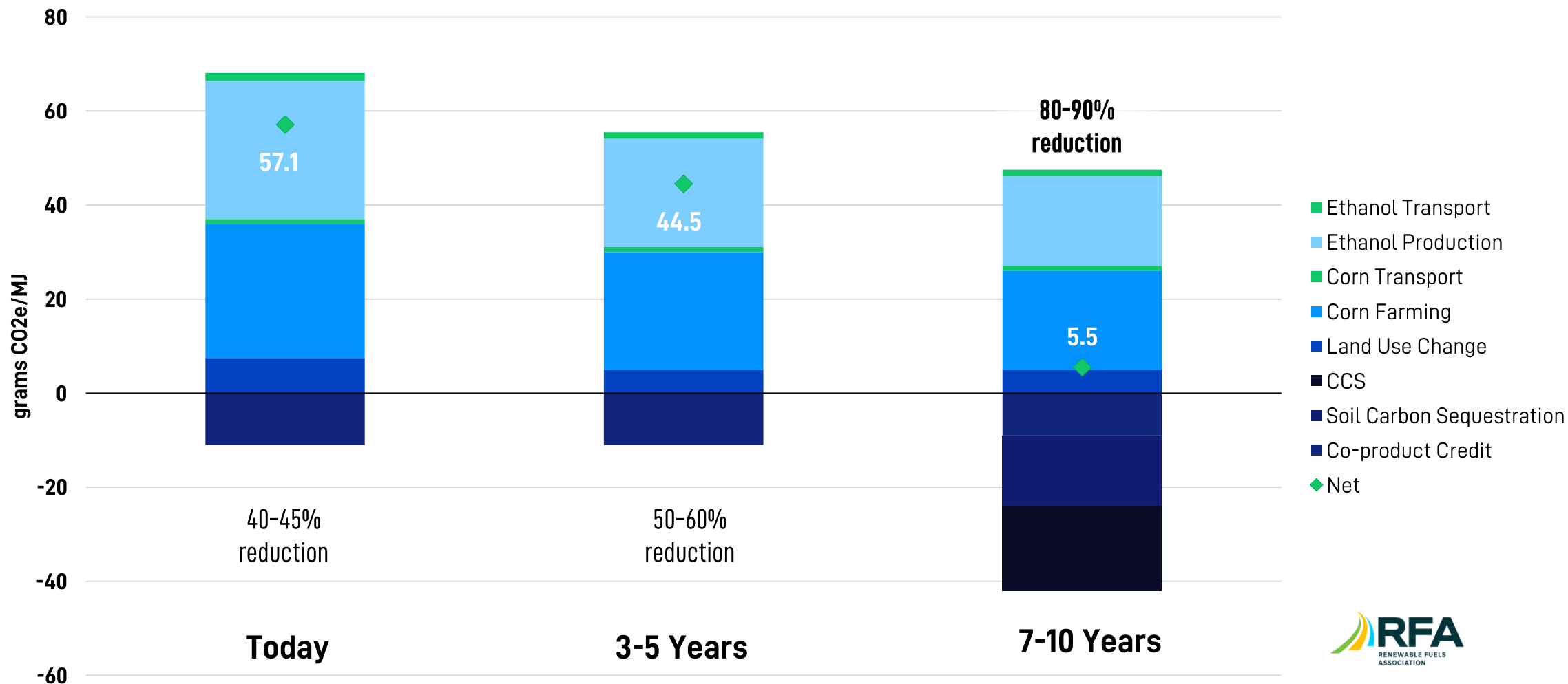


● High Estimate/Range
● Low Estimate/Range



Ultra Low Carbon Ethanol is Coming

Grain Ethanol Carbon Intensity: Today and Tomorrow



Key Benefits

Retrofit diesel engines to reduce emissions

- Cuts CO₂ lifecycle emissions 61% more than EV
- Eliminates soot, reaches upcoming NOx requirements with less aftertreatment

Diesel performance - but at less cost

- Lowest Total Cost of Ownership of all options
- Limited retraining of nearly 300,000 US diesel mechanics
- Trucking ROI - 18-months



ENGINEERING TRANSFORMATIONAL INNOVATIONS

for people, planet and profit



Long-Haul Trucking

Mining

Power Generation

Agriculture