

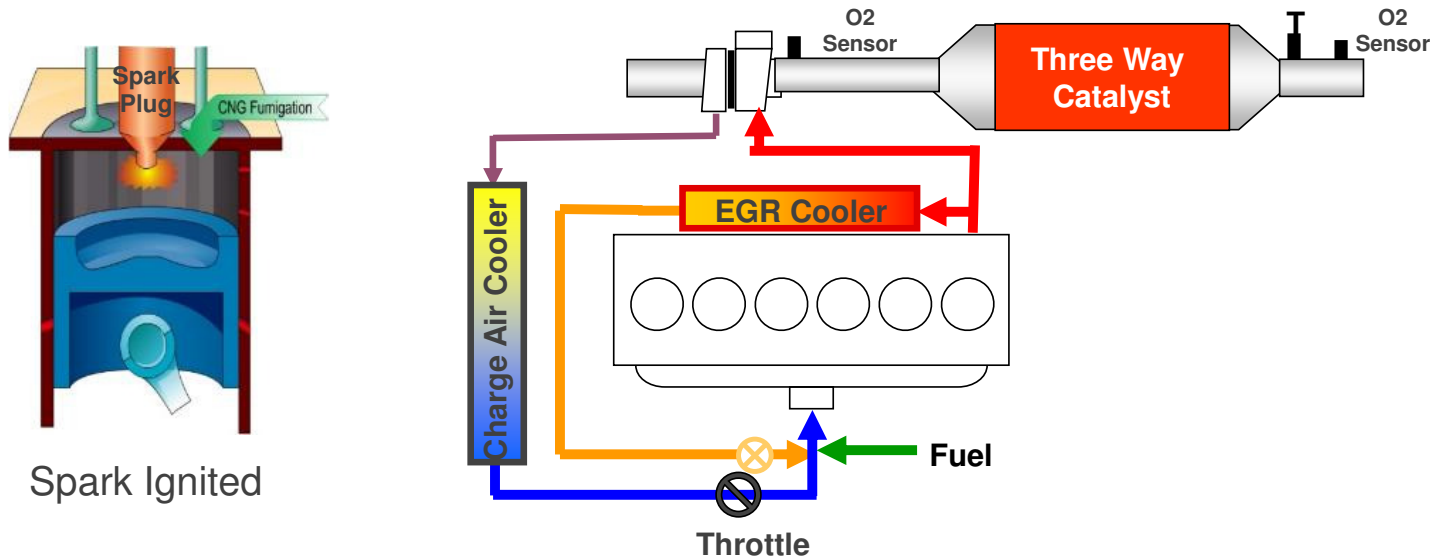


Natural Gas FAQs

Justin Loyear

2.26.2022

Cummins Natural Gas Engine Architecture



- Cummins Westport engines feature spark ignition with Stoichiometric / EGR combustion
- This combustion technology was introduced in 2007 with the ISL G, the first heavy duty engine to meet the EPA 2010 standards (0.2 g/bhp-hr NO_x, 0.1 g/bhp-hr PM)
- **SEGR Technology is capable of lower emissions, particularly NO_x**
- Cummins Westport engines are factory built, dedicated natural gas engines that are based on Cummins diesel engine platforms with over 80% parts commonality

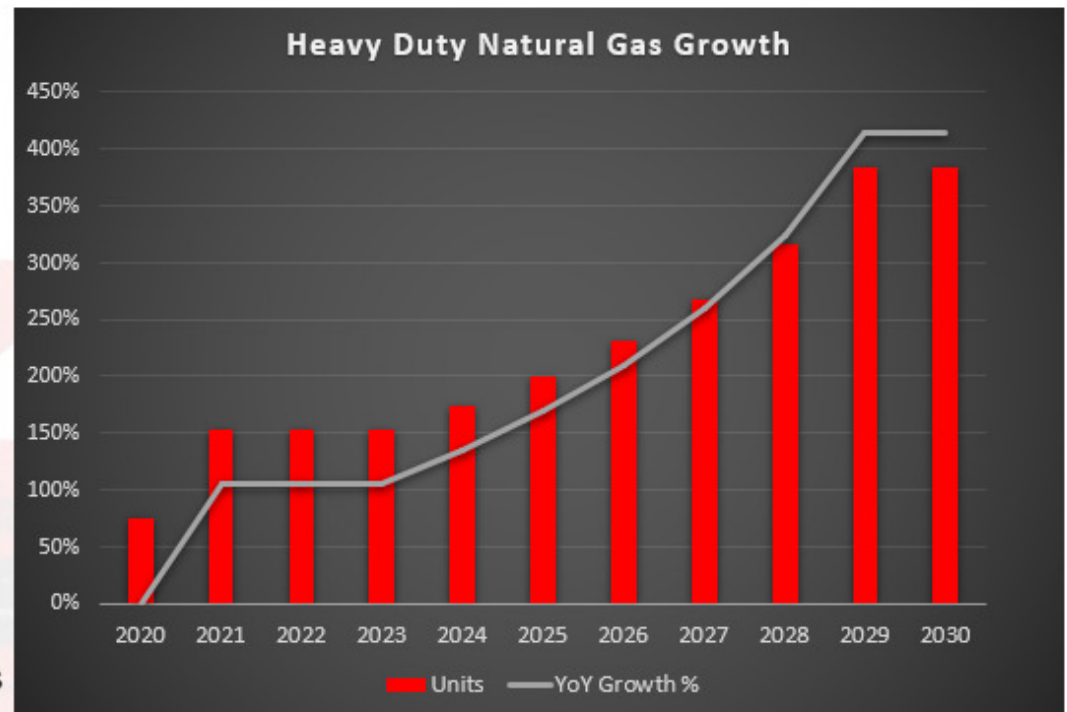
Three Way Catalyst Aftertreatment

- Similar to catalyst on gasoline passenger cars
- Packaged as a muffler with vertical or horizontal mount
- Weighs ~100 pounds
- Benefits:
 - More reliable, no downtime
 - Maintenance-free, no filters to clean or replace
 - No active regeneration required
 - No SCR fluid or maintenance or costs







HD Natural Gas – Future Growth

- Increasing regulatory stringency for GHG
- EPA / CARB requirements
 - alone don't address CO₂ reduction plans
- ESG driving higher demand for private fleets
 - ESG Declared Initiatives and Optics
- Natural gas a critical technology on the path to sustainability & zero emissions
- Renewal Natural Gas (RNG) enables Natural Gas products to be carbon negative based on source
- Growth coming in the regional / long-haul segments



Natural Gas Engine Platforms

Stoichiometric EGR, Emissions Leading

Engine Name	B6.7N	L9N	ISX12N	X15N
Engine Plant	Rocky Mount, NC	Rocky Mount, NC	Jamestown, NY	Jamestown, NY
Image				
Displacement	6.7 litre	8.9 litre	11.9 litre	14.5 litre
Power Range	200 – 240 hp	250 – 320 hp	320 – 400 hp	Up to 500 hp
Torque Range	520 – 560 lb·ft	660 – 1000 lb·ft	1150 – 1450 lb·ft	Up to 1850 lb-ft
GVWR	33,000 lbs	66,000 lbs	82,000 lbs	105,500 lbs
Criteria Emissions Level	Certified to CARB Optional Low NOx 0.02 g/bhp-hr			
Fuel Compatibility	Renewable (biomethane) natural gas, compressed natural gas or liquified natural gas			
Carbon Reduction	70% to > 300% (carbon negative) reduction depending on biomethane source			
Service & Warranty	Cummins Distributors & Dealer Network			

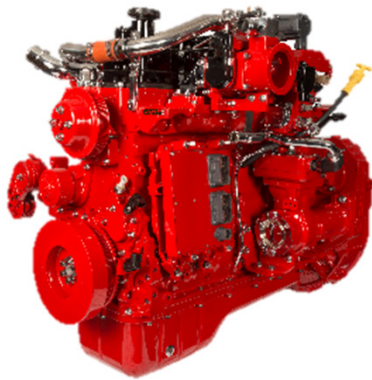
Anticipated availability in 2024.

Still need OEMs.

Frequently Asked Questions

- **Q: How much more is a natural gas truck?**
 - A: The incremental cost is mostly associated with the fuel system which generally range between \$30K to \$50K.
- **Q: What will be my fuel economy be on a natural gas truck?**
 - A: For the same duty cycle (e.g. route, terrain, weather, driver, idle, etc.) fuel economy will be reduced by 15%-20% due to a lower compression ratio, fuel injection and a throttle. A good way to think about fuel economy is to compare the cost/mile between natural gas and diesel.
- **Q: How about maintenance cost?**
 - A: Fleets report similar or lower maintenance compared to their diesel fleet when the recommended maintenance cycle is followed and approved parts used.
- **Q: Is maintenance different?**
 - A: Mostly no. The biggest difference are the spark plugs. Don't forget there's no DPF to deal with.
- **Q: What about performance?**
 - A: For applications up to 82,000 lbs, fleets report (with 2,000 lb weight exemption) report excellent performance when the drivetrain has been properly configured.

2021 North America Product Line



B6.7N™

6.7L

Peak Rating: 240 hp / 560 lb-ft torque
33,000 lb. GVW

School bus/MD Truck/Shuttle
bus/Sweeper/Yard spotter

EPA/ARB Low NOx
0.1 g/bhp-hr (50% reduction)



L9N™

8.9L

Peak Rating: 320 hp / 1000 lb-ft torque
66,000 lb. GVW

Refuse/Transit/Regional P&D
Truck/Mixers

EPA/ARB Near Zero NOx
0.02 g/bhp-hr (90% Reduction)



ISX12N™

11.9L

Peak Rating: 400 hp / 1450 lb-ft torque
80,000 lb. GVW

Regional Haul Truck
Tractor/Refuse

EPA/ARB Near Zero NOx – 0.02
g/bhp-hr (90% Reduction)

B6.7N™

■ Key Product Attributes:

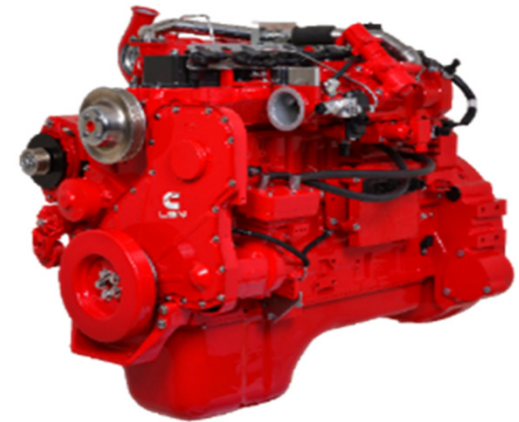
- Displacement – 6.7 Liters (540 CU IN)
- Peak rating 240 hp / 560 lb-ft torque
- Recommended use up to 33,000 lb. GVW
- Maintenance-free and fluid free Exhaust Treatment System
- The B6.7N engine platform has been in service since 2016
- Utilizes Cummins diesel engine block and major hardware set designed for extended service life
- Target applications: School bus, urban delivery trucks, yard spotters, panel delivery trucks,



L9N™

■ Key Product Attributes:

- Displacement – 8.9 Liters (540 CU IN)
- Peak rating 320 hp / 1,000 lb-ft torque
- Recommended use up to 66,000 lb. GVW
- Maintenance-free exhaust aftertreatment system
- The L9N platform has been in service since 2007
- Utilizes Cummins diesel engine block and major part hardware set designed for extended service life
- Target applications: refuse, transit bus, concrete mixer, beverage delivery

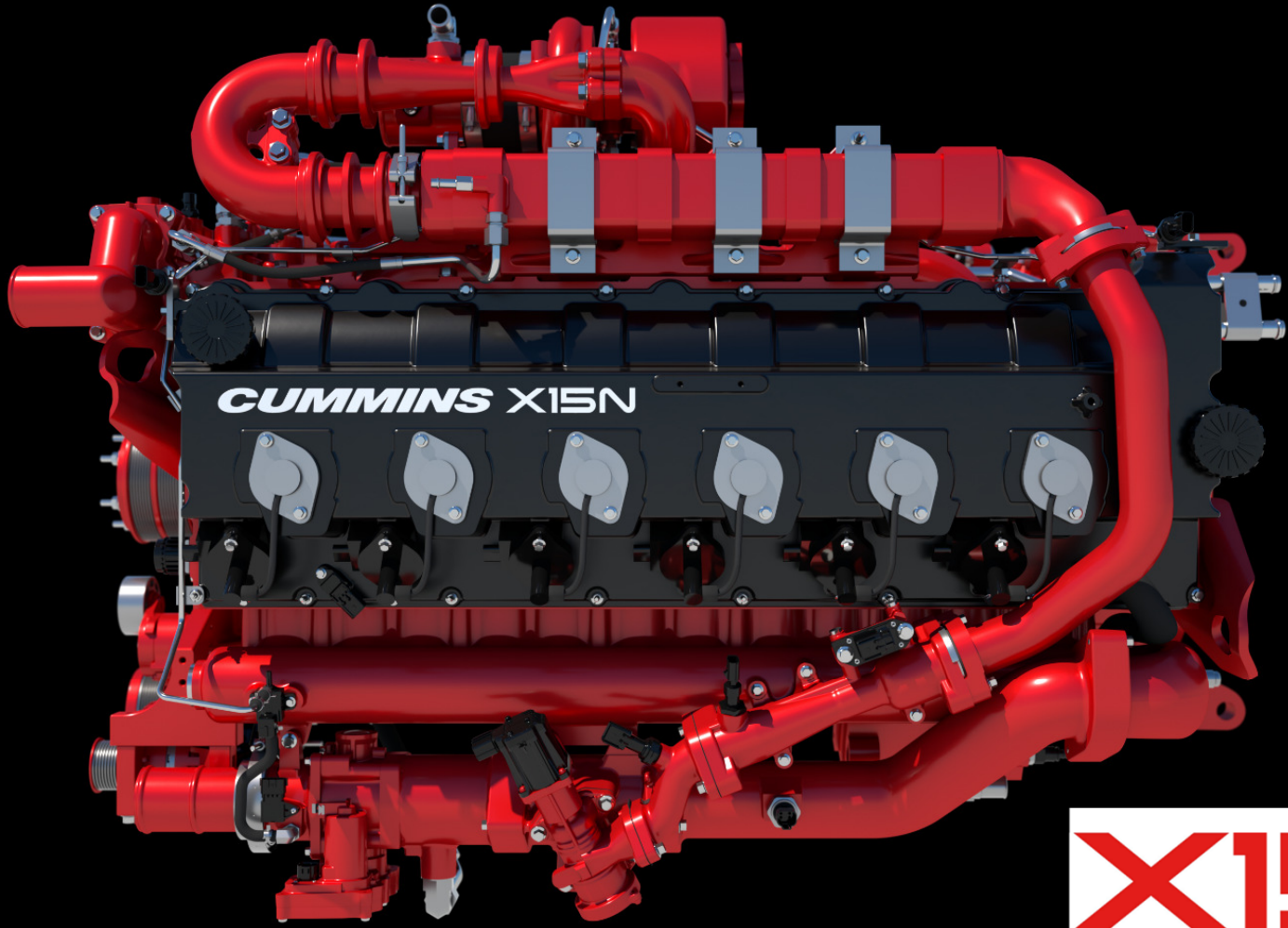


ISX12N™

■ Key Product Attributes:

- Displacement – 11.9 Liters (762.2 CU IN)
- Peak rating 400 hp / 1,450 lb-ft torque
- Recommended use up to 80,000 lb. GVW
- Maintenance and fluid free Exhaust treatment system
- The 12L platform has been in service since 2013
- Utilizes Cummins diesel engine block and major part hardware set designed for extended service life
- Target applications: LTL, vocational, mail carriers, beverage delivery, bulk haulers, urban operations, cement mixers, waste transfer trucks, port drayage trucks, bulk dairy

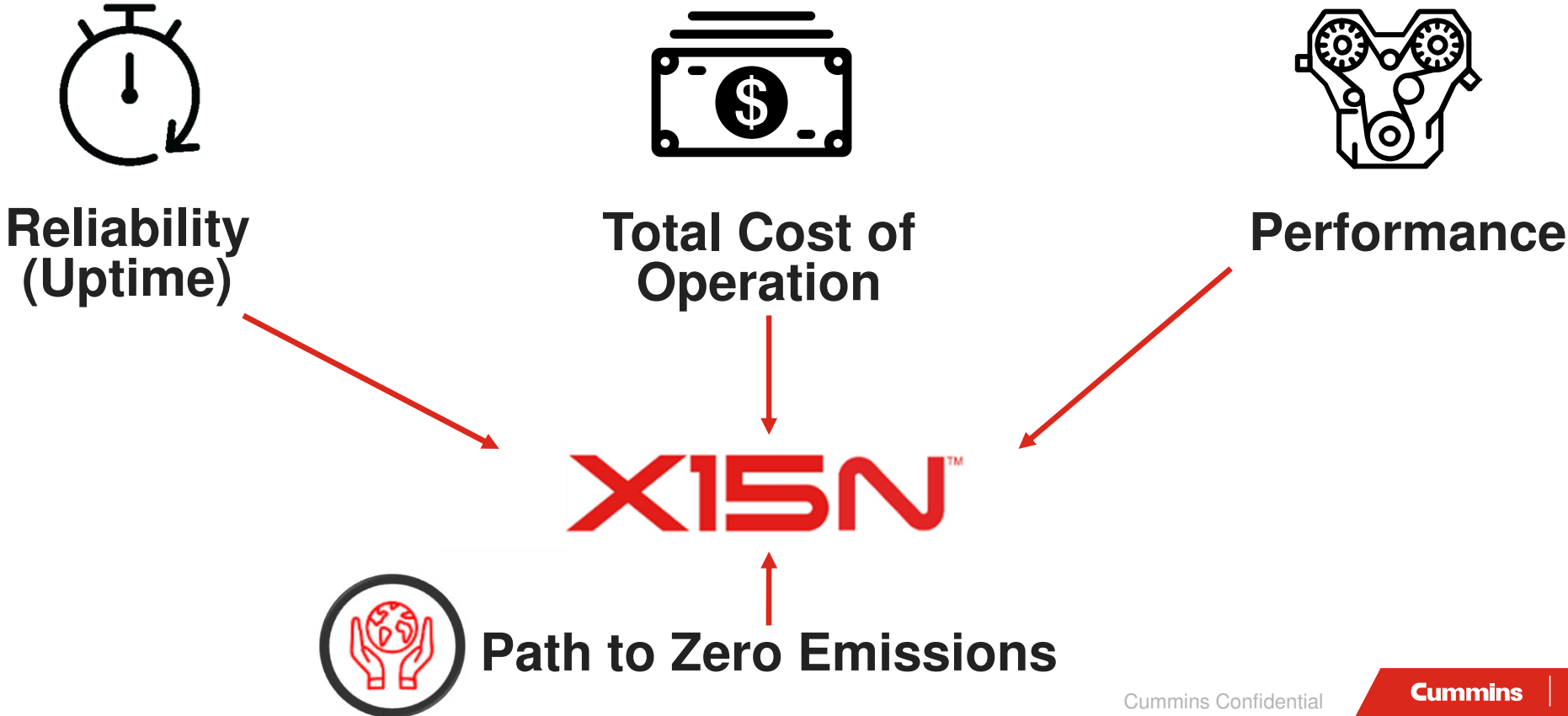




X15NTM

The Future of Natural Gas Power

Cummins X15N Value Drivers



Cummins X15N Value Drivers



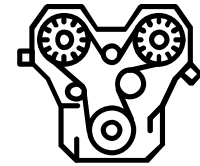
Reliability (Uptime)

- 50+ years of Natural Gas knowledge and know-how integrated into Uptime design
- 60k units forecasted to be in customer hands globally by 2024
- Reliability-enabling Digital features
- Cummins service & support network



Total Cost of Operation

- Up to 10% GHG/FE improvement
- Increased oil drain intervals
- Increased spark plug life
- Lower weight than ISX12N to enable increased payload
- Cummins resale value



Performance

- Increased power / torque
- Up to 500hp/1850lb-ft
- Broader peak torque speed band
- Improved transient response
- Increased braking power
- Endurant Transmission Integration

X15N Product Introduction

Design and deliverables to be confirmed through pending and final verification

X15N™

- ❖ Industry-first & market-defining **Big Bore Natural Gas** Powertrain
- ❖ Capable to **meet stringent CARB24/27 and future EPA NOx** regulations
- ❖ **Compact 15 Liter** –
 - ❖ *500+ lbs less than current 15L diesel*
 - ❖ *200 lbs lighter than the current ISX12N*
- ❖ Up to a **10% Fuel Economy/GHG improvement** over ISX12N
- ❖ 12L-15L Diesel matching ratings - **up to 500hp & 1850lb-ft** of torque
- ❖ Compact **passive TWC aftertreatment** system
- ❖ **Integrated with Industry HD transmissions** – Endurant and Allison
- ❖ Incorporates Cummins **Powertrain Features & Strategies**
- ❖ Potential for **Carbon Negative Solution with RNG**

Exhaust System

- Stage I Three-Way Catalyst mounted close to engine exhaust outlet

Base Engine

- EPA and CARB
- Rear Geartrain
- Advanced combustion management

Air Handling

- Dual Wastegate Turbocharging
- Advanced Cooled EGR

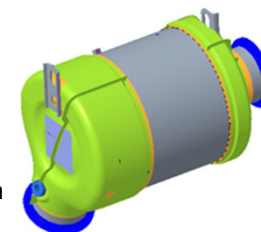
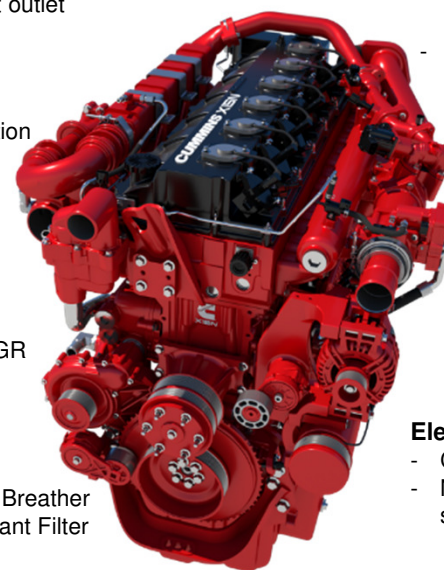
Lube and Cooling

- Closed Crankcase Breather
- Elimination of Coolant Filter

Exhaust System

- Stage II Chassis Mounted Three-Way Catalyst

Compact Design



Vehicle Integration

- Compact 15L
- Integrated with Endurant (& Allison) transmissions
- Full powertrain feature suite

Fuel System

- Next generation fuel system
- Integrated with vehicle fuel system partners

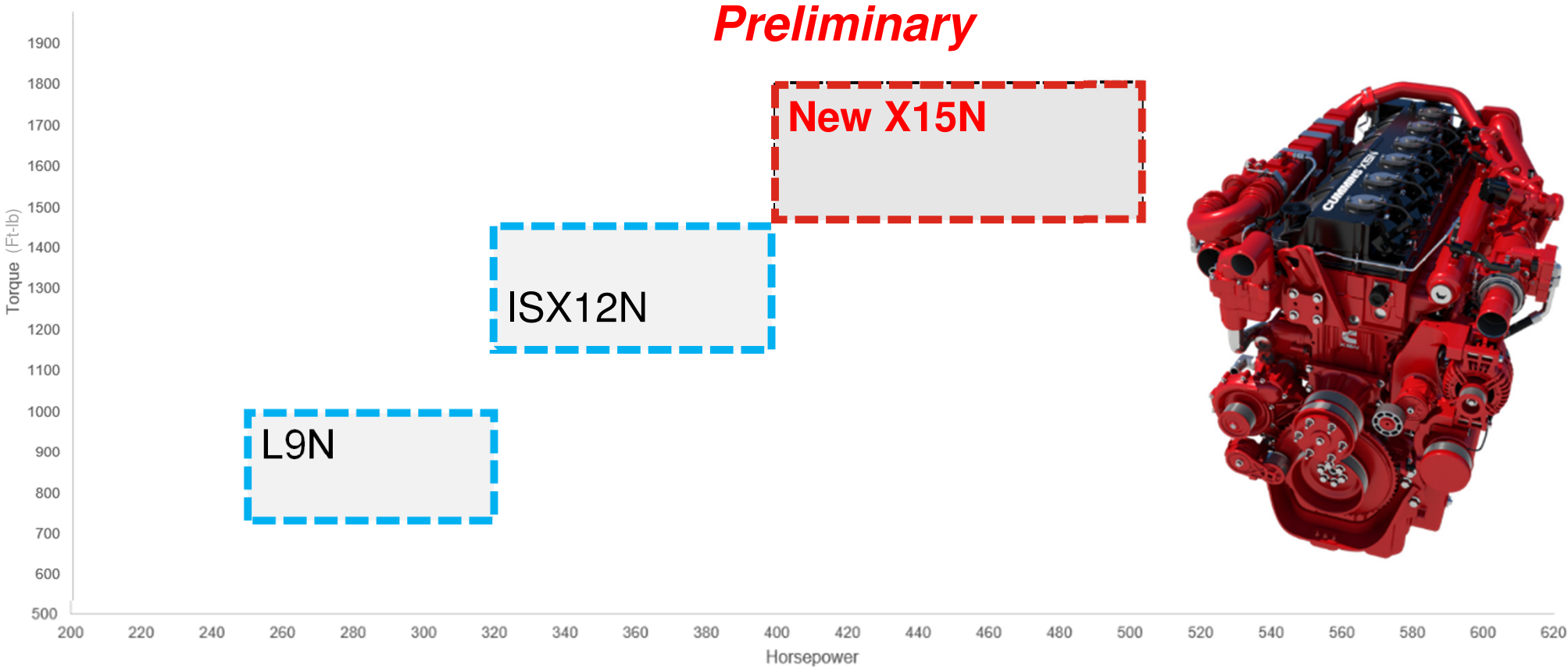
Electronics System

- CM2380 ECM
- Next generation connectivity solutions

Passive AT System

Cummins Confidential

X15N Platform Ratings vs. ISX12N and L9N

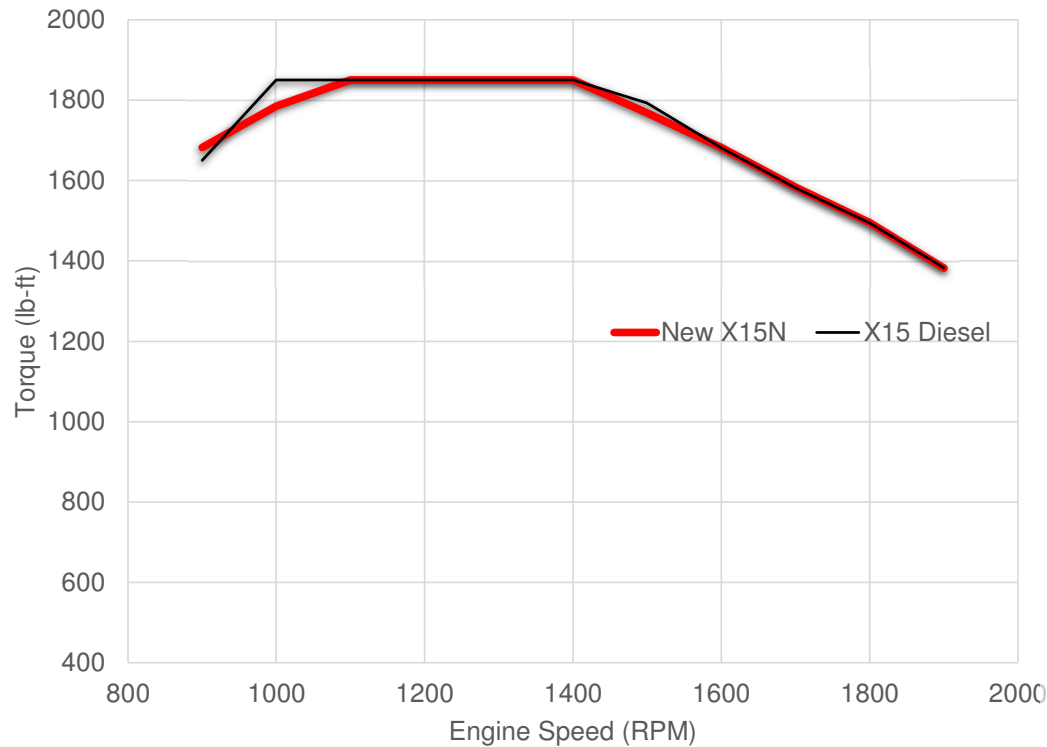




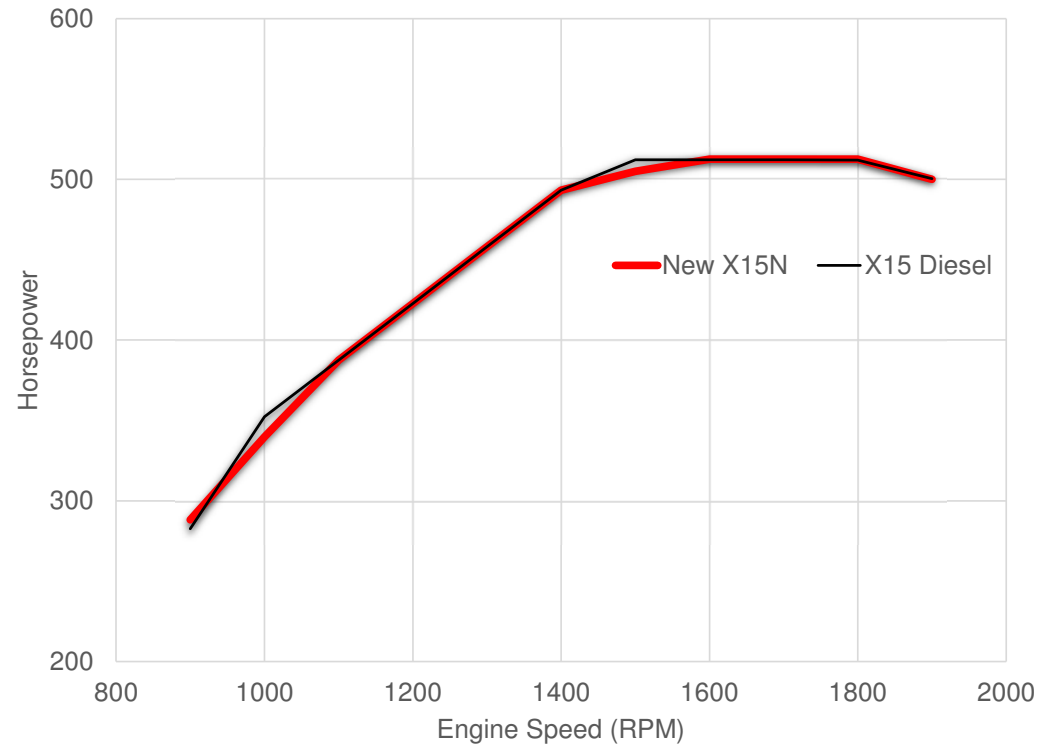
Cummins 15L Natural Gas Powertrain

Preliminary

Torque Curve Comparison

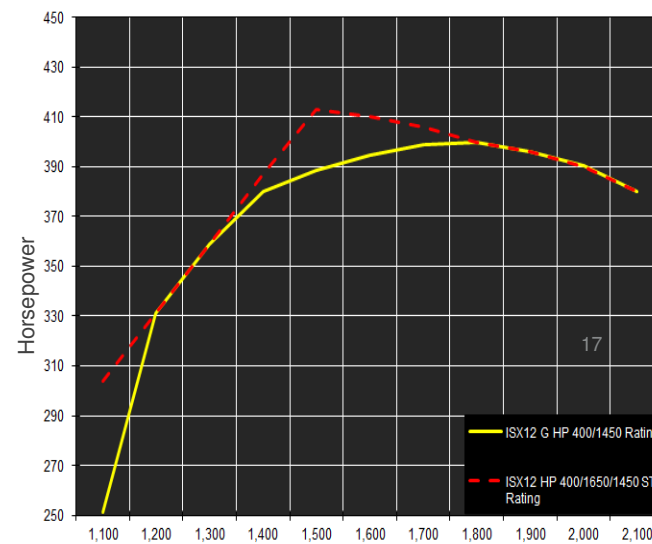
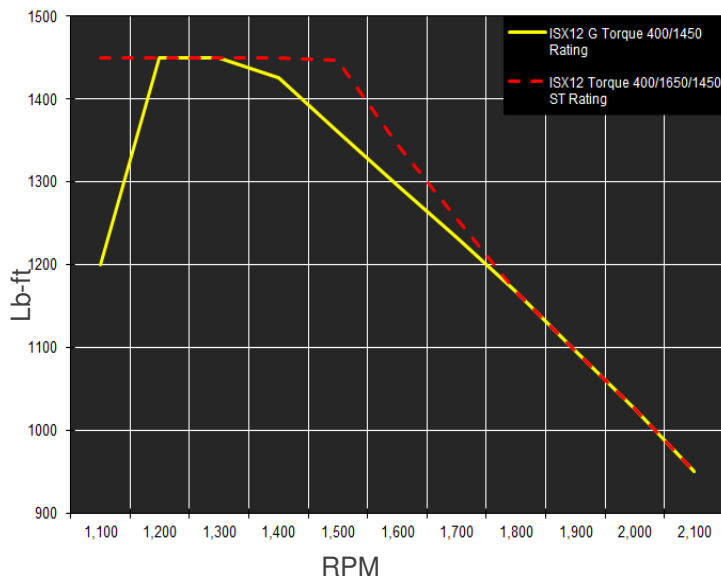


Power Curve Comparison



ISX12N: Performance Similar to diesel

	ISX12		ISX12N	
Horsepower	310-425 HP	231-317 kW	320-400 HP	239-298 kW
Peak Torque	1150-1650 lb-ft	1559-2237 N-m	1150-1450 lb-ft	1559-1966 N-m
Torque at Idle	800 lb-ft	1085 N-m	700 lb-ft	949 N-m
Aftertreatment	DPF + SCR		Three Way Catalyst	
Engine Brake Performance	Optional 380 HP @ 2100 RPM		Optional 240 HP @ 2100 RPM	



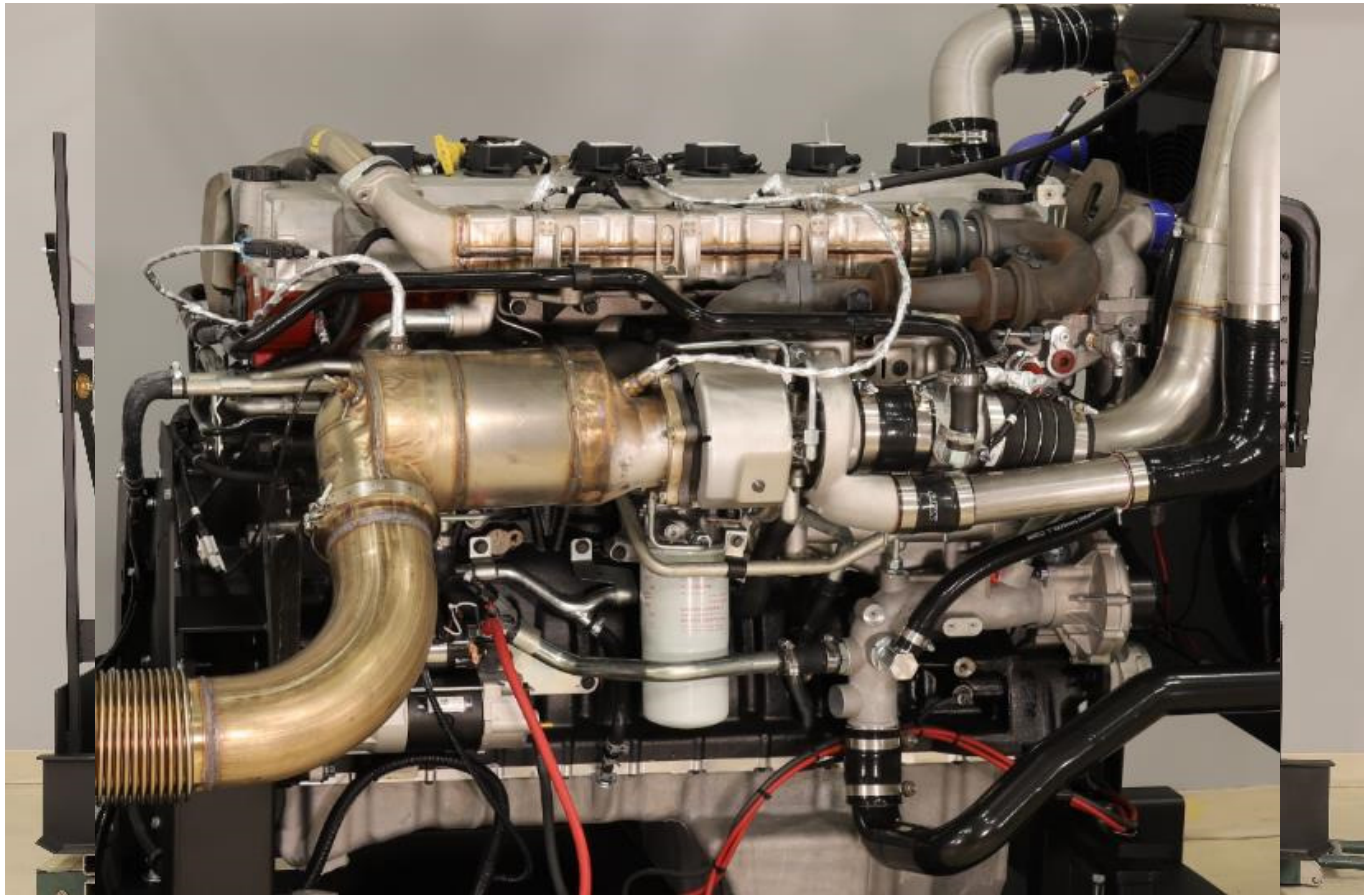
X15N™

Sneak Peak



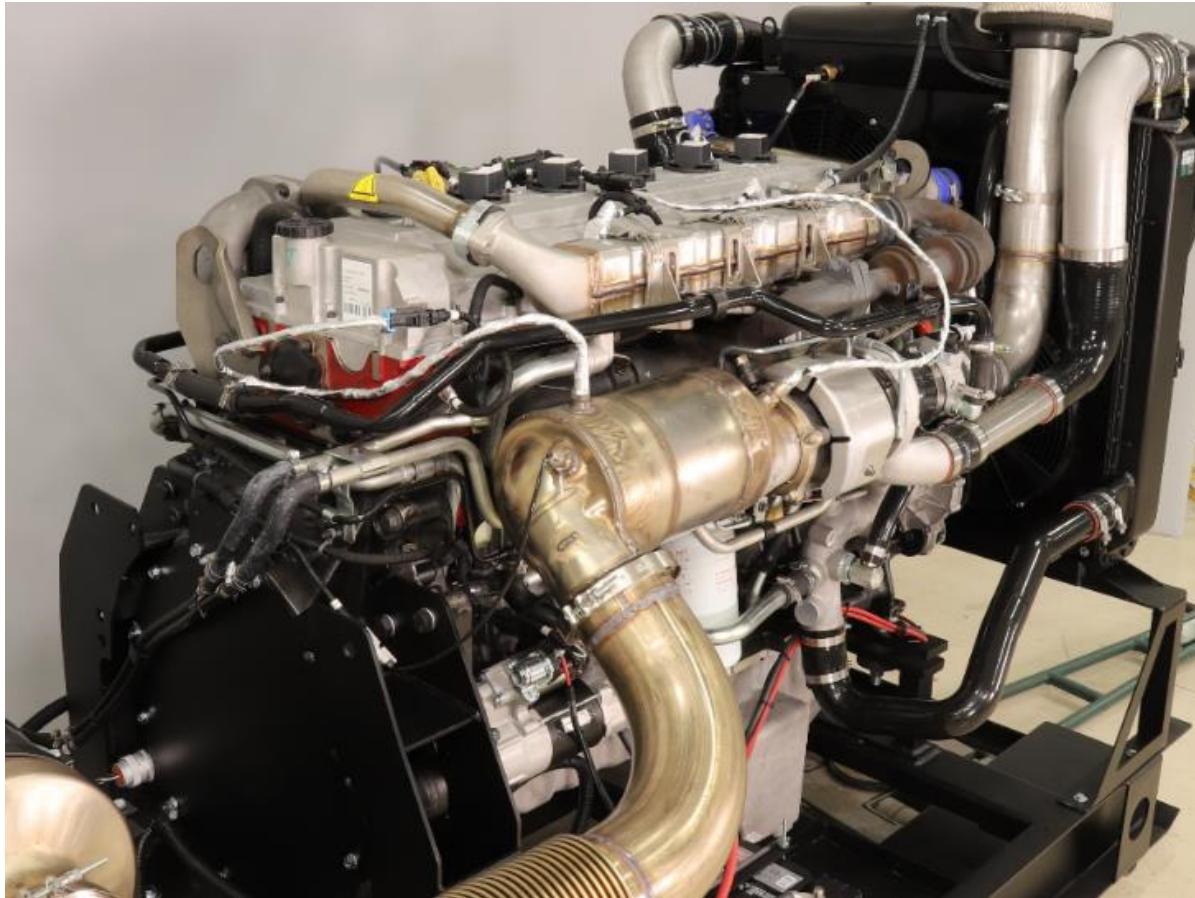
X15N™

Sneak Peak



X15N™

Sneak Peak



General Engine Maintenance

		ISB6.7G & B6.7N	ISLG & L9N	ISX12G & ISX12N
Oil & Filter (CES20092)	Hours	750	1,000	1,000
	Part #	3937736	3401544	4367100
Spark Plugs	Hours	750	1,500	1,000*
	Part #	4376564	5473009	4309391
Fuel Filter	Hours	1,000	1,000	1,000
	Part #	3607140	3607140	3607140
Valve Adjustment	Hours	1,500	1,000 2,000 ongoing	1,000 initial 3,000 ongoing
Crankcase Breather	Hours	2,000	2,000	10,000
	Part #	5288839	5288839	4389517
Ignition Coil Extension	Hours	5,000	10,000	10,000
	Part #	5402163	5265337	4387015
Standard Coolant	Hours		2,000	6,000
Coolant Filter	Hours	NA	500	1,500
	Part #	NA	WF2071 (w/DCA4+) WF2074 (no additive)	WF2126 (w/DCA4+) WF2127 (no additive)

* If greater than 35% duty cycle, reduce Spark Plug interval to 750hrs

Maintenance Best Practices

- Keep idle to a minimum.
- Perform maintenance on time based on engine hour intervals.
 - If mileage intervals are needed, check overall average vehicle speed including idle time.
 - If the engine is running it is using up spark plug and oil life.
 - Spark plug and oil changes performed on time have a drastic impact on reducing unplanned downtime
- Use genuine Cummins parts
 - Spark plugs, filters, and all other components have been validated to meet Cummins design standards and to keep the engine meeting or surpassing emissions certification.
- Use CES 20092 spec oil
 - Take advantage of longer drain interval
- Check for and install latest ECM calibration at every spark plug change
 - Calibrations have been historically released 2+ times a year
- If Equipped, Drain the low pressure fuel filters every day.

Driver Tips for Natural Gas Engines

- **Throttled Engine**
 - Vehicle acceleration from stand still may experience slight “delay” vs diesel engines.
 - Throttled engine makes the accelerator feel different and driver will get used to it.
- **Engine Noise**
 - Natural Gas engines are much quieter than diesel. Many times the driver will hear the air compressor which is new to them.
- **Turbo Type**
 - ISX12N uses a waste gate style turbocharger. Sometimes, pressure release occurs with a “Chuff” noise.
- **Engine Performance / Brake**
 - Power curves are different on the ISX12N vs diesel. Torque and Horsepower come higher in the RPM range.
 - Engine braking is less powerful due to lower compression ratio.

Natural Gas Engine Oil Specifications

CES 20085*

Sulfated Ash Level 0.7-0.9%

Calcium 1,800 – 2,300 ppm

Phosphorous 700 – 900 ppm

Zinc 800-1,000 ppm

CES 20092**

Sulfated Ash Level 0.7-0.9%

Calcium 1,200 maximum ppm

Phosphorous 800 maximum ppm

No specification for Zinc**



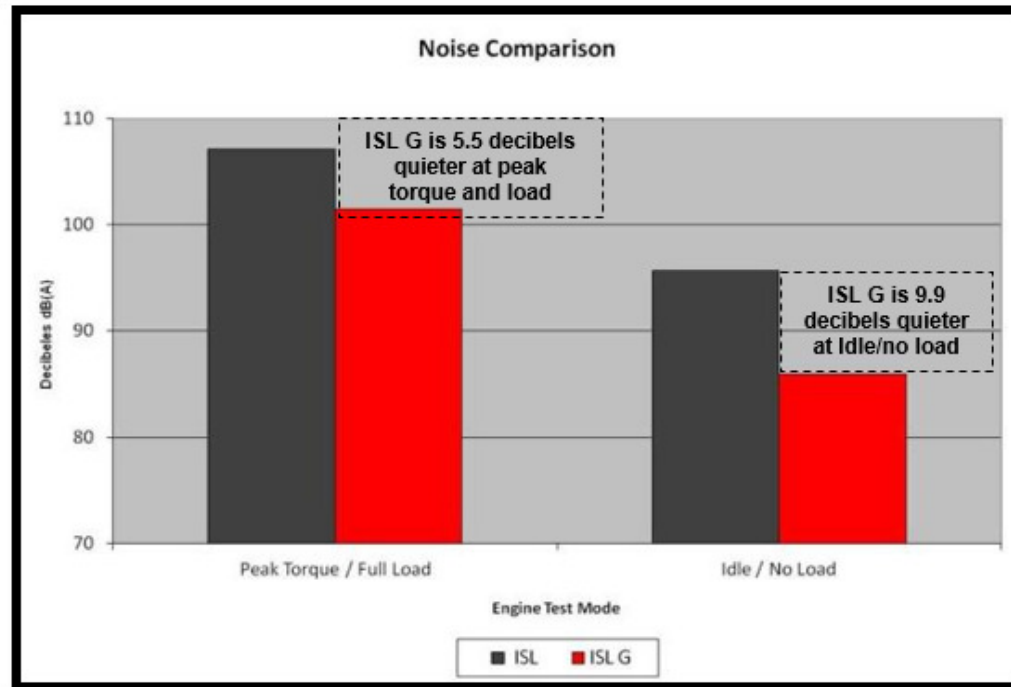
*CES20085 was obsoleted by Cummins 12/31/2019 and is no longer recommended to use.

Clean, Quiet Engine Operation

Spark ignition provides quiet operation

Communities notice the natural gas noise advantage.

ONE Diesel engine idling is louder than **TEN** natural gas engines idling together



OEM Availability



ISX12N



L9N



NOVABUS



B6.7N



Availability, Options and Spec'ing

Regular Production Availability via Assembly Line Build



Fuel System Options

- Fleets can choose their fuel system provider such as Momentum (Cummins partner) or Agility
- Back of cab and side rail systems available, depending on range requirements

Spec'ing

- Insist that the fleet work with its OEM truck dealer AND Cummins to properly spec the truck
- Spec'ing like a diesel will result in a poor user experience

Natural Gas Engine Applications



Q+A

