Ryder Alternative Fuels Innovation

Drive What Matters – with Sustainable Efficiencies

Why Natural Gas?

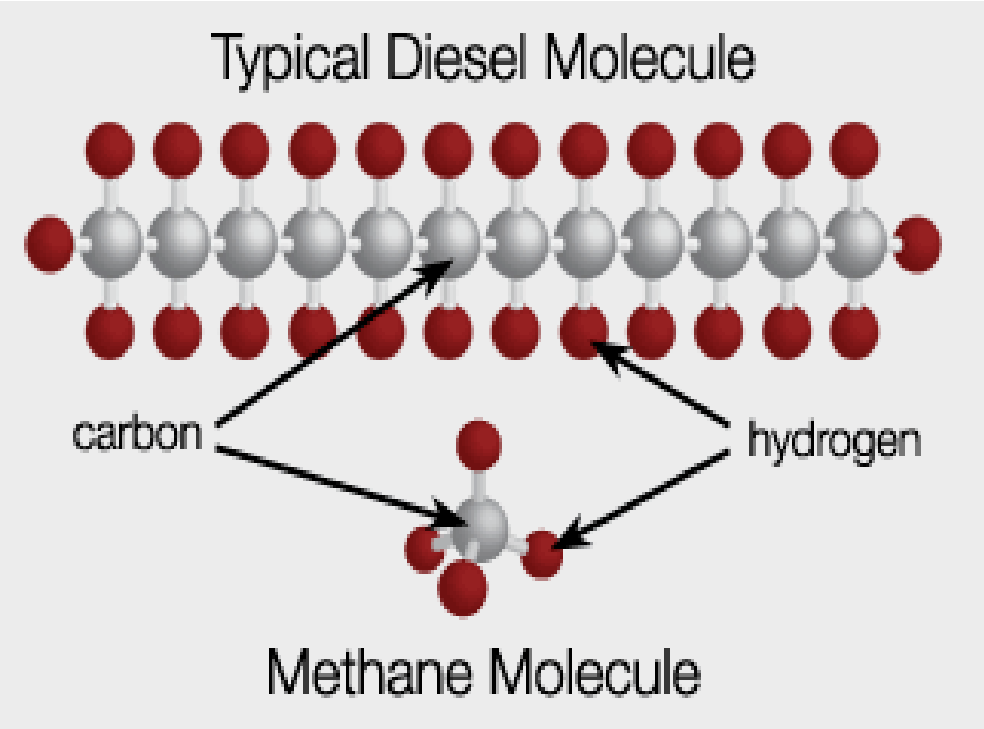
Environment

Abundant

Future

Fuel Cost Savings

How Can Natural Gas Burn Cleaner than Diesel?



Diesel fuel and the other fossil fuels, are chemically complex. They contain higher proportions of carbon and hydrogen. (C12 H26)

Natural gas has a simple chemical make-up: one molecule of carbon and four molecules of Hydrogen. (C H4)

That's what makes it burn so cleanly.

Ryder natural gas fleet innovation program

- Investing in Natural Gas since 2009
- Deep knowledge base
  - Fuel station networks, design and layout
  - Natural Gas engine technology
  - Facility design and layout
  - Facility modifications required to maintain compliance to NFPA & NEC regulations
- Customer access to fleet innovation:
  - Latest natural gas fleet technology
  - CNG & LNG fueling infrastructure
  - Maintenance & roadside services
  - Safety and technical expertise
  - Substitute vehicles

NG Engine Technology

- Dedicated Fuel
  - Uses 100% natural gas
  - Spark ignited combustion
  - May eliminate need to utilize DPF's or ATD's for EPA '10 Compliance
  - CNG or LNG
  - Currently offering Cummins ISL-G, Cummins ISX-G, and GM PT-V8 6.0L Vortec CNG

- Dual Fuel
  - Uses a mix of diesel and natural gas
  - Ratio varies, but typically 85% to 90% NG (aftermarket conversions only half as efficient).
  - Compression combustion, uses diesel pilot burn for ignition source
  - Potentially more complex after-treatment (DPF, SCR, DEF, NG)
  - CNG or LNG
  - Formerly offered in Westport HD GX (15L) using LNG

Initial Natural Gas Projects

Alternative Fuel Fleets

Fuel Network

Maintenance and Roadside Service

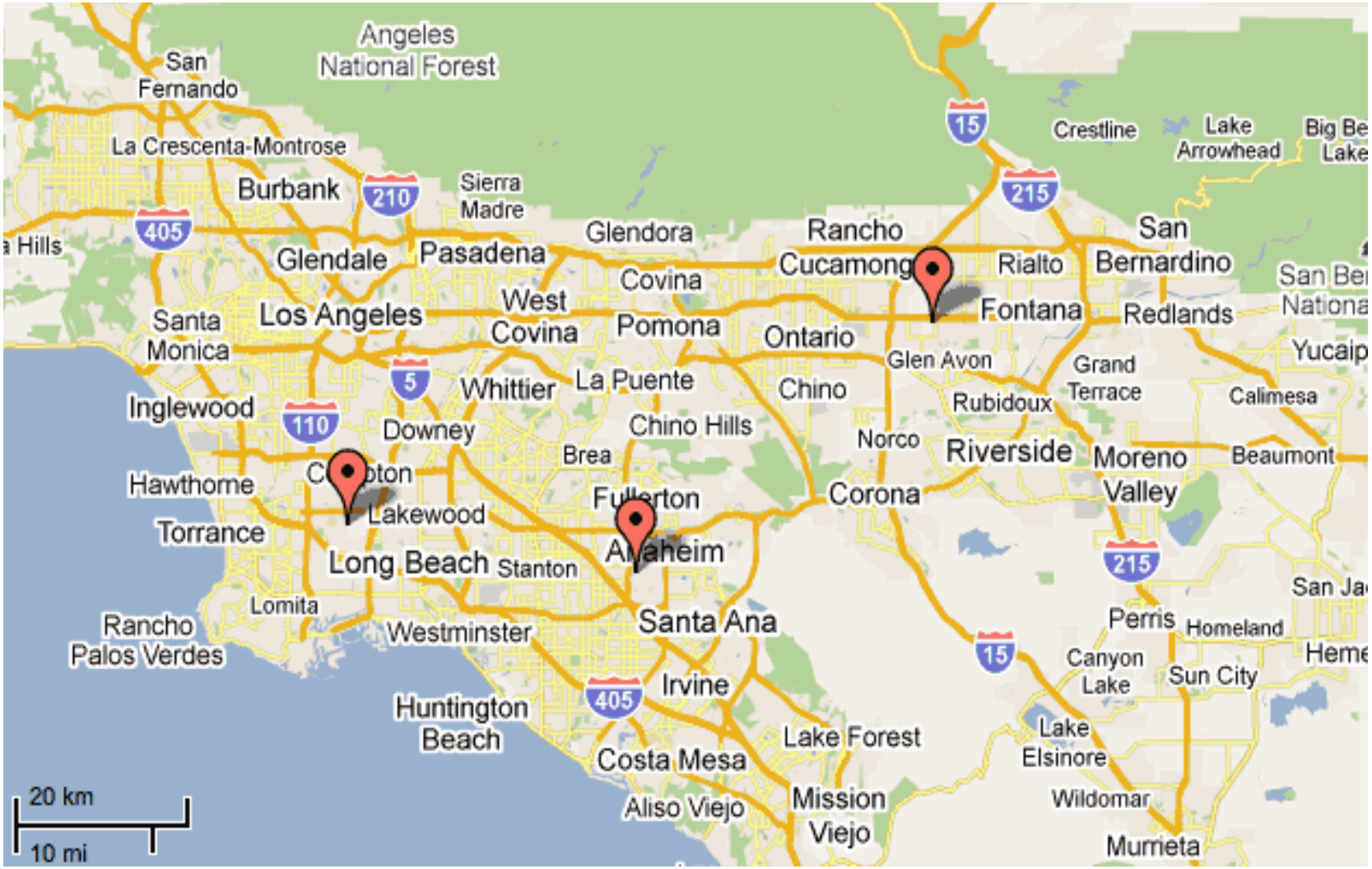
Natural Gas Innovation makes sustainable efficiencies simple

- **Southern California - SANBAG Project**

Cooperative project between Ryder, SANBAG, Department of Energy, AQMD, SCAG and California Energy Commission.

- ✓ 202 natural gas powered commercial vehicles.
- ✓ 3 Natural Gas Compliant Maintenance Facilities
- ✓ 2 Natural Gas Refueling Stations

Ryder Natural Gas SANBAG Network



Ryder LNG/CNG Capabilities (California)

450 + HD NGVs in Service – 21M+ miles operated!

Alternative Fuel Fleets

Fuel Network

Maintenance and Roadside Service

- **Southern California - SANBAG Project**
  - 3 NFPA Compliant Maintenance Facilities
    - Orange
    - Rancho Dominguez
    - Fontana
  - 2 LCNG Refueling Stations
    - Orange
    - Fontana
  - Public access!
- **Michigan**
  - Livonia
  - Grand Rapids
- **Arizona**
  - Tucson
- **California**
  - West Sacramento - Complete
  - Santa Fe Springs – coming soon
- **Coming Soon - Texas**
  - Dallas / Ft. Worth
  - Houston
- **Complete - Louisiana**
  - Shreveport
- **Complete - Georgia**
  - Atlanta
- **Complete – West Virginia**
  - Charleston

Ryder Service Location Network

Early Equipment Offerings

Expanded Ryder LNG/CNG Vehicle Capabilities

Ryder/Quantum Vehicle Innovation

Equipment

ISL G

- CWI JV
- 8.9 Liter
- Spark Ignited
- 250-320 hp
- 660-1000 lb/ft

ISX12 G

- CWI JV
- 11.9 Liter
- Spark Ignited
- 320-400 hp
- 1150-1450 lb/ft

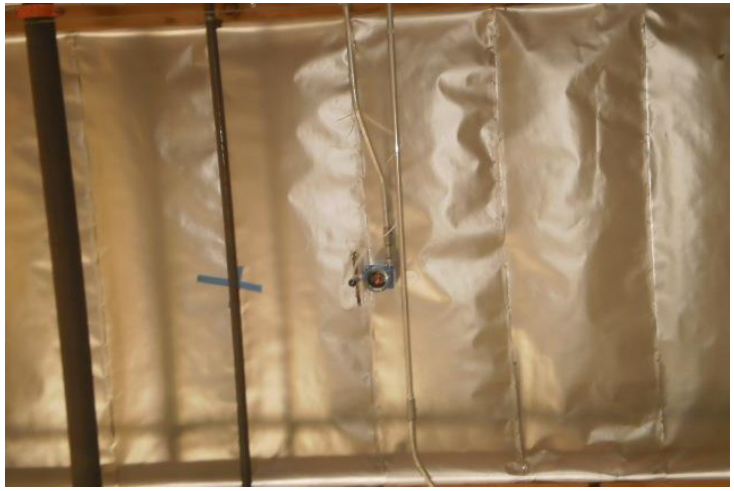
How Far Can You Go?

CNG			
Tank Size	**Mounting**	**Weight (wet)**	**Range**
45	Rail	900	202
90	Rail	1800	403
60	Back of Cab	1350	269
75	Back of Cab	2000	336
100	Back of Cab	2600	448
120	Back of Cab	3300	538

LNG			
Tank Size	**Mounting**	**Weight (wet)**	**Range**
120 x 2	Rail	1770	672
150 x 2	Rail	2150	840

140 DGE X 5.8 MPG X 0.75 = 610 Miles

Capital Expenditures for Retrofit of Shops



Capital Expenditures for Retrofit of Shops

Natural Gas Obstacles

- Vehicle Investment Premiums with unknown residual values
- Excessive FET Exposure (investment driven)
- Higher vehicle weights limits cargo payload
- Fuel Tax Inequalities
- Driver Efficiency Headwinds (HOS/Range)
- Limited Engine Portfolio/Limited OEM Competition
- Increased investment in Diesel platforms dramatically improving fuel economy performance.

Leaders In Natural Gas

Ryder

Ryder's NGVs Pass 20 Million Miles

FLEETS&FUELS Business Intelligence for Clean Transportation Professionals

March 31, 2014 in *CNG*, *LNG*, *NGVs* by *Rich Piellisch* |

More than 500 Trucks Serving More than 40 Customer Operations

UPS

Bloomberg News

UPS Sees 40% Savings by Switching Long-Haul Fleet to Natural Gas

By Ehren Goossens July 25, 2013 Share Tweet

FedEx

Top Stocks

FedEx going green with cheaper natural gas

The CEO says 30% of the shipping company's long-distance trucks could make the switch within 10 years.

By Trefis Mar 14, 2013 2:40PM

P&G

P&G to Convert 20 Percent of Its For-Hire Truck Loads to Natural Gas

P&G Invests in Growth of Natural Gas Industry by Awarding Loads to Eight Natural Gas Transportation Carriers

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Thursday, June 27, 2013 8:00 am EDT

Fuel Efficient Specifications

Arthur J. Trahan

Sr. Manager

Technical Support

National Accounts

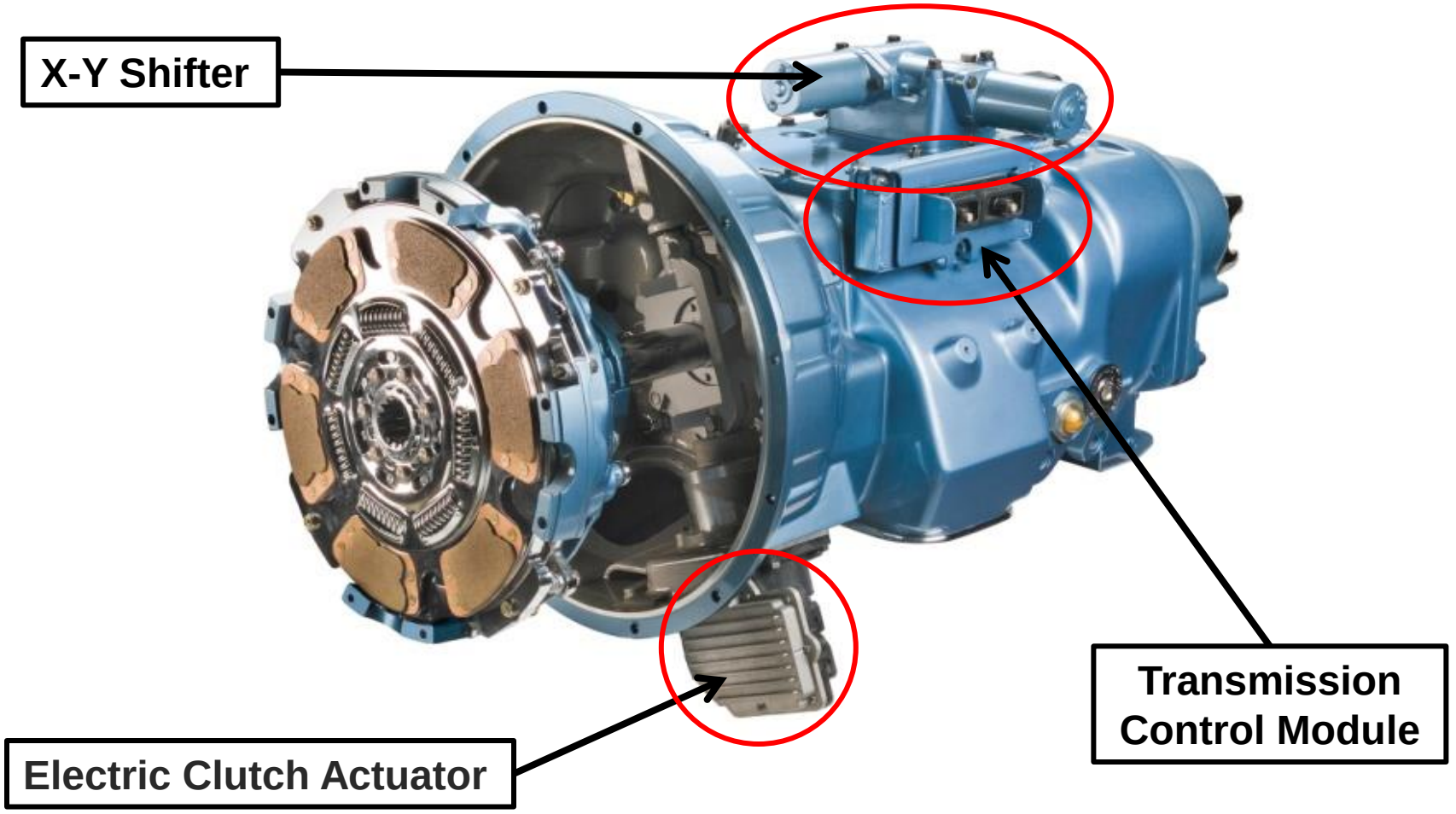
Vehicle Specifications - Improving MPG

- Transmissions
  - Manual - Automated
  - Overdrive
  - Direct Drive
- Axle Ratios
  - “Gear Fast Run Slow”
  - Today’s Axle Ratios for Fuel Economy
- Engine Selection
  - Horse Power
  - Torque
- Controls
  - Progressive Shifting
  - Gear Down Protection

Specifications – Transmissions - Automated

- An automated mechanical transmission (AMT) is a manual transmission that uses a computer to determine when the gear ratio changes need to occur and a servo-mechanism to perform the shifts. Most of today's AMTs also use the AMT's computer to determine when the clutch needs to be operated and a servo-mechanism to operate the clutch. The clutch pedal is removed and the vehicle is operated very much like an automatic transmission equipped vehicle.
- Benefits: Less acquisition cost than an automatic transmission and no shifting distraction. You should get better fuel economy than a manual or an automatic transmission. Less driver training.
- Disadvantage: Higher acquisition cost than a manual transmission.

Eaton - UltraShift *PLUS*



Automated Transmission

UltraShift *PLUS*

Intelligent Adaptive Shifting:

- Automatically selects the appropriate starting gear and makes all shift decisions based on:
  - **Grade**
  - **Vehicle Weight**
  - **Engine Torque**
  - **Throttle Position**

Overdrive Vs Direct Drive Transmission

Direct Drive transmissions are most efficient because the power is transmitted directly through the transmission. There are no countershafts used that would increase the parasitic load. Because of this efficiency, due to less parasitic loss, direct drive transmission will result in a 2%-3% gain in fuel economy.

Over Drive transmissions are less efficient due to gear meshes in top gear, along with counter shafts and energy losses from churning oil.

Running a 10 speed Over Drive transmission one gear down (or in 9th gear) for a two lane operation results in a high cruise speed RPM and is not recommended.

The term parasitic loss is often applied to devices that take energy from the engine in order to enhance the engine's ability to create more energy. In the internal combustion engine, everything, including the drive line, causes a parasitic loss. Bearings, oil pumps, piston rings, valve springs, flywheels, transmissions, drive shafts, and differentials also rob the system of power.

An oil pump, being used to lubricate the engine, is a necessary parasite that consumes power from the engine (its host).

- Axle Ratios

Axle Ratios – Balanced Spec

Performance – 3.55	Balanced – 3.42	Fuel Economy – 3.36

Engines develop peak torque at lower RPMs and rear axle ratios still run “fast.”

An example is a tractor with a 3.42 axle ratio, overdrive transmission running at 65 MPH the engine would run at **1390 RPM**.

Detroit Diesel DD15
Torque Range 1100 to 1500 RPM
Peak Torque 1100 RPM

One more example is a tractor with a 3.42 axle ratio, overdrive transmission at 65 MPH the engine would now run at **1390 RPM**.

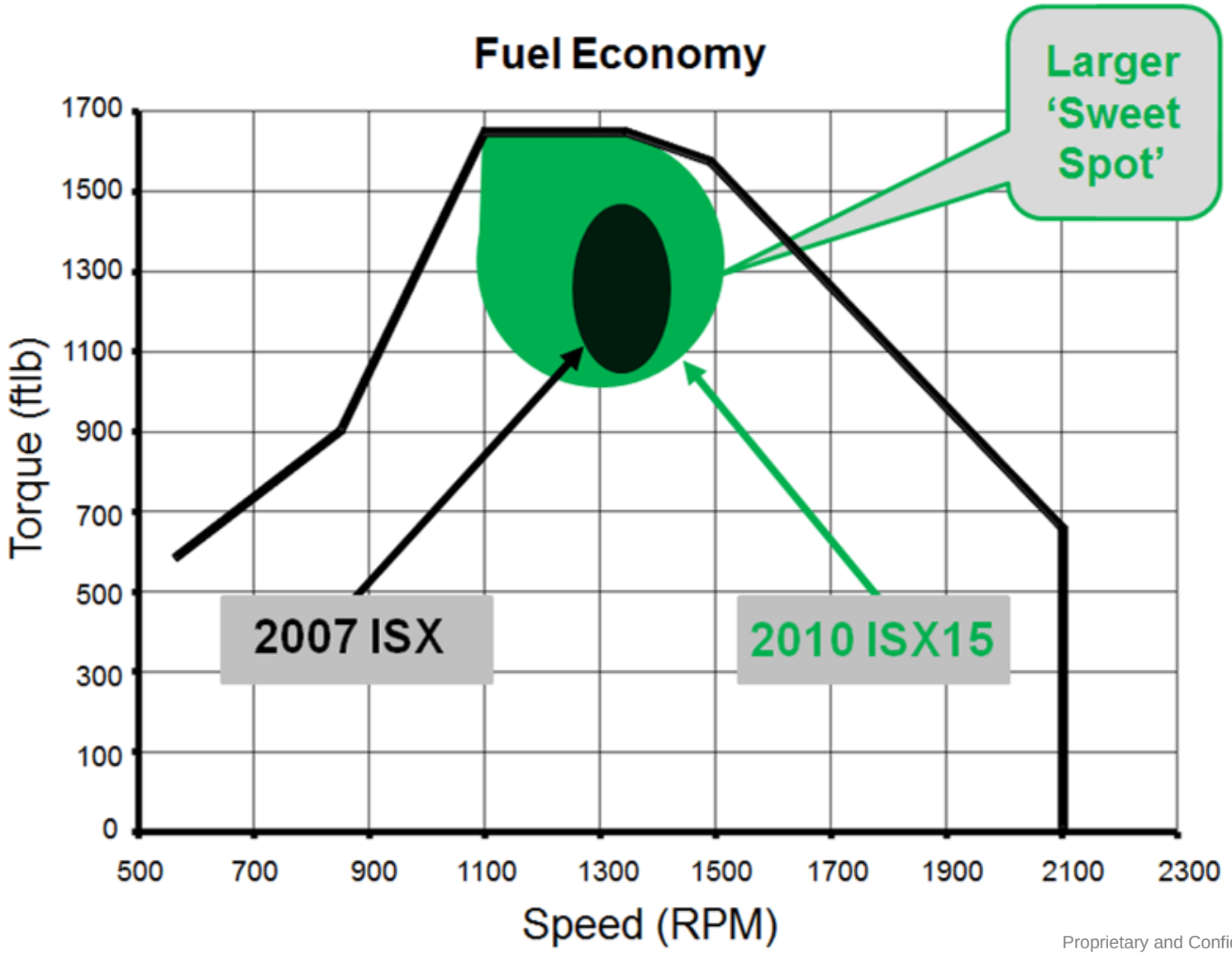
Cummins ISX
Torque Range 1100 to 1500 RPM
Peak Torque 1100 RPM

- Engine Selection

Engine Selection

- Torque and Horsepower
  - Torque = Startabilty and Gradeabilty
  - Horsepower = Road Speed
  - Engine and axle ratio must be selected to allow for operation in the “sweet spot” at cruise speed.
- Road speed change of 3 MPH could require an axle ratio change

Engine Selection



Engine Selection

Cummins ISX EPA 2010

Peak torque engine speed is now at 1100 RPM

Fuel Economy: **1370 RPM** @ 65 MPH cruise speed - 1650 lb ft ratings for the fuel efficient spec.

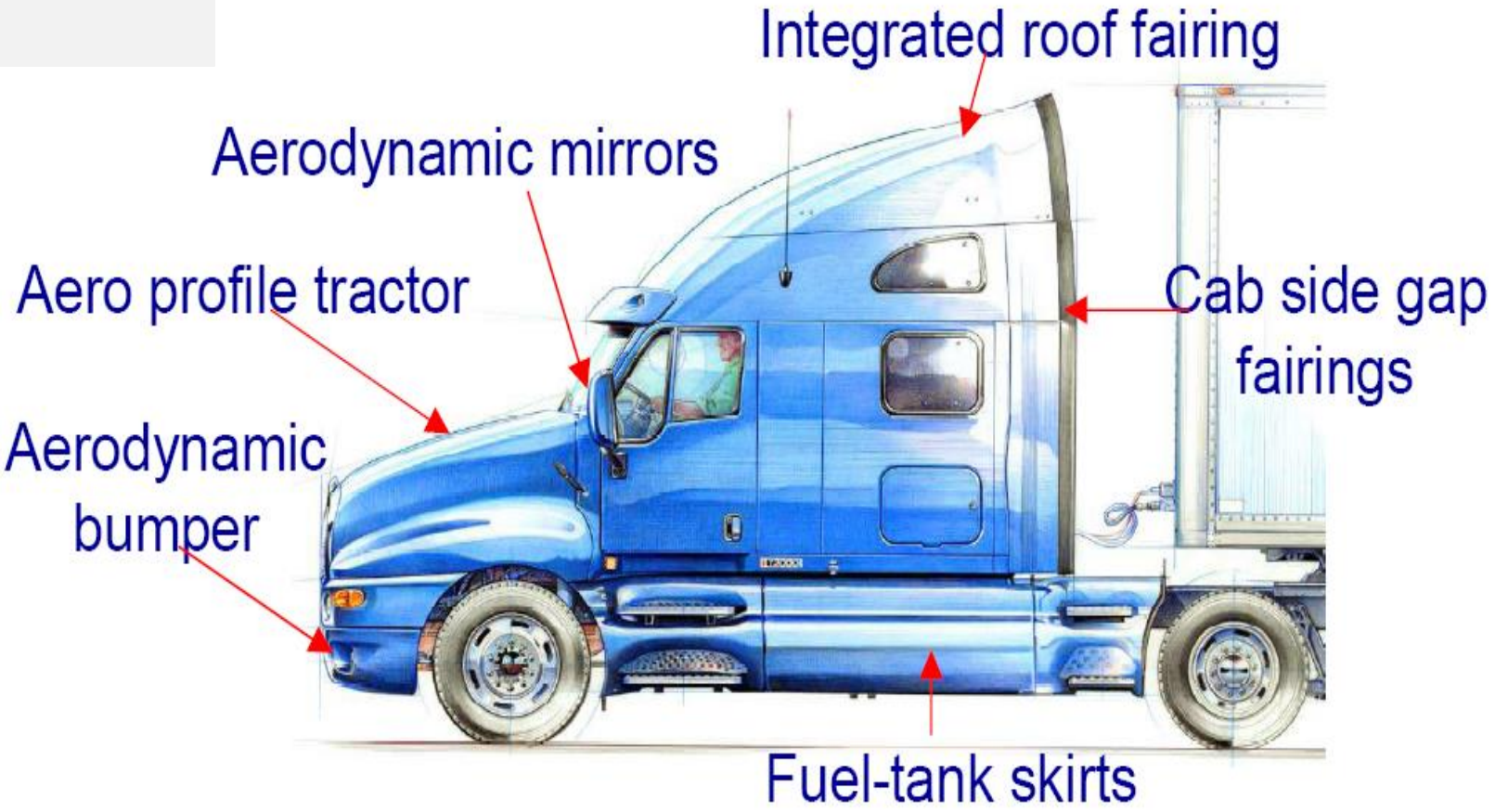
Balanced: **1400 RPM** @ 65 MPH cruise speed - balanced fuel economy and performance spec.

Tire Rev per mile		Rear ratio		Transmission ratio		Top Speed wanted	/	60	=	Engine RPM
512	X	2.47	X	1	X	65	/	60	=	1370
512	X	3.42	X	0.74	X	65	/	60	=	1404

Controls

- Gear Down Protection
- Progressive Shifting
- Road Speed
- Cruise Speed
- Idle Shutdown

Tractor Aerodynamics



2014 Regulations

EPA Greenhouse Gas

NHTSA Fuel Efficiency

Greenhouse Gas Regulation Rulemaking Framework

Two Major Components to Regulation

Engine Regulations

Structured Very Similar to Past Regulations

Introduce a CO2 Emission Level Requirement

CO2 Emission Reduction is Only Achieved Through Diesel Fuel Consumption Reduction

Vehicle Regulations

Imposed Upon Vehicle Manufacturers

Introduce a CO2 Emission Level Requirement Based Upon an Efficiency Concept

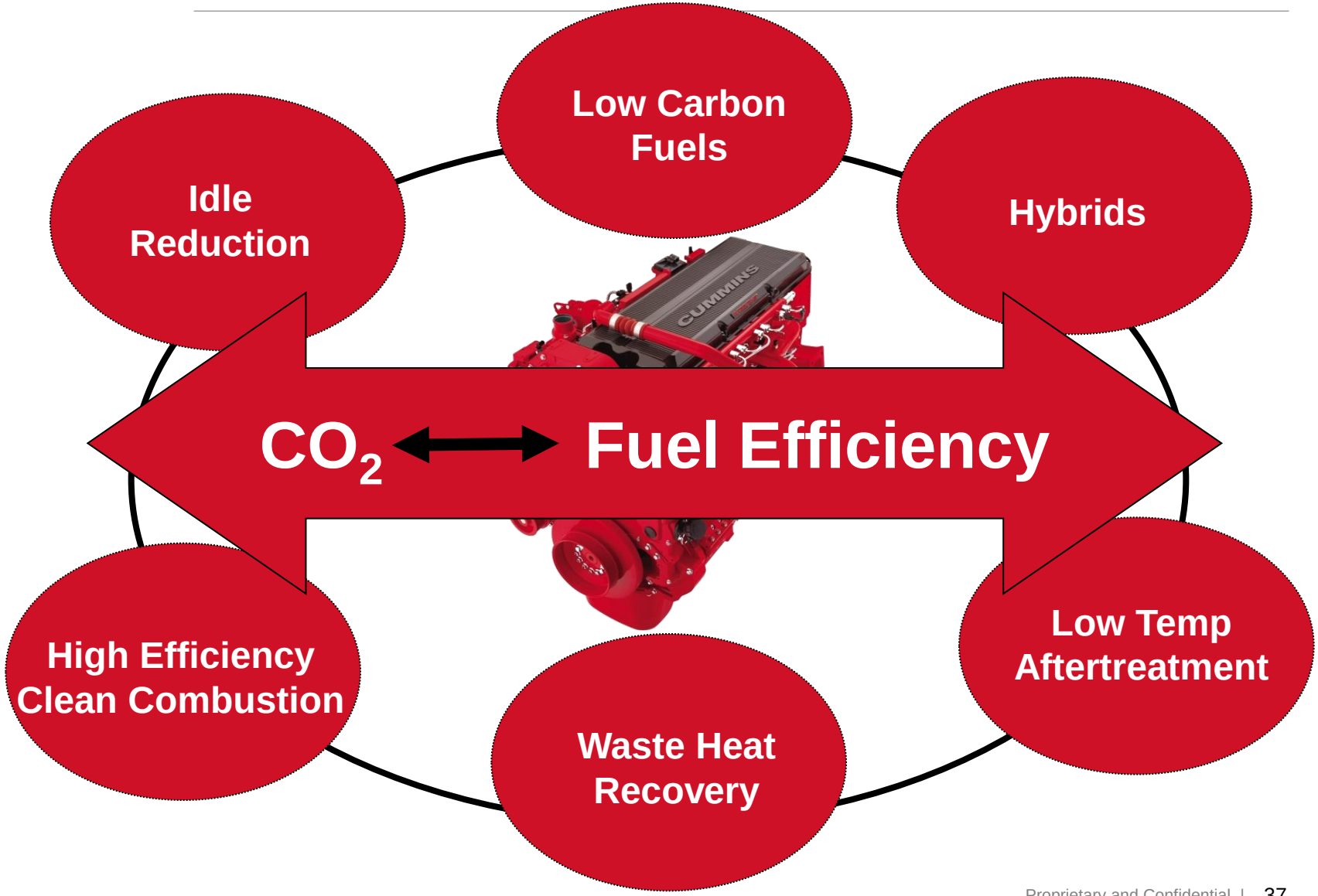
CO2 Requirement Based Upon a Gram per Ton-Mile Scale

Simulation is Used to Determine Vehicle Output

EPA & NHTSA Set Heavy Duty Fuel Economy Standards

- The Environmental Protection Agency and the National Highway Traffic Safety Administration in August of 2011 released the fuel economy and green house gas emission standards for commercial trucks.
- The goals of the standards are to reduce fuel use by commercial trucks and by doing so, lower carbon dioxide emissions.
- Tractor-trailer units are required to reduce fuel and CO2 by 20% by model year 2018.
- Tractor-trailer rigs are divided into nine categories, depending on their configuration. Each category has a different emission or fuel standard target, to account for the different operating characteristics.
- For example, by 2017, the fuel economy standard for a Class 7 day cab with a low roof is 10.2 gallons per 1,000 ton-miles, but a Class 8 sleeper with a high roof must meet a 7.1 gallons per 1,000 ton-miles standard.

Reducing CO_2



Use Existing Programs

Fuels
Reduced carbon intensity
Bio Diesel, CNG, LNG

Power Supply
"Active"

Engines
Existing Emission Program
Efficiency, Reduced Carbon Fuels
Hybrids / Waste Heat Recovery

Power Demand
"Passive"

Vehicles
Tractor & Trailer – Smartway
Transmissions / Axles / Tires
Aerodynamics

Fleets / Operators
Incentives for low GHG vehicles
Logistics, Driver training & aids

Highways / Infrastructure
Highway Construction / Congestion
Speed limits
Gross Vehicle Weight

Potential Fuel Saving Technologies

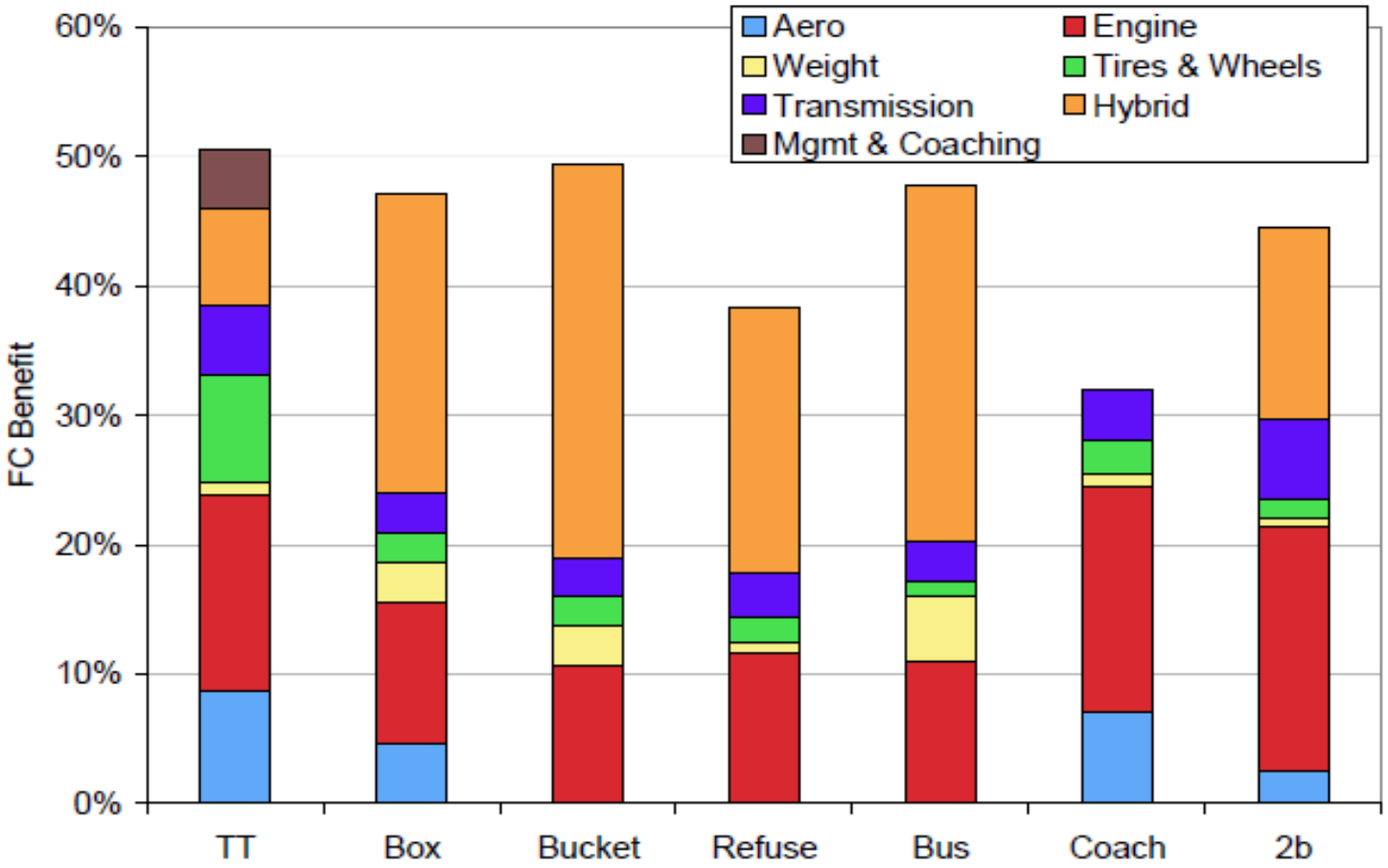


FIGURE S-1. Comparison of 2015-2020 new vehicle potential fuel-saving technologies for seven vehicle types: tractor trailer (TT), Class 3-6 box (box), Class 3-6 bucket (bucket), Class 8 refuse (refuse), transit bus (bus), motor coach (coach), and Class 2b pickups and vans (2b). SOURCE: TIAX (2009) at ES-4.