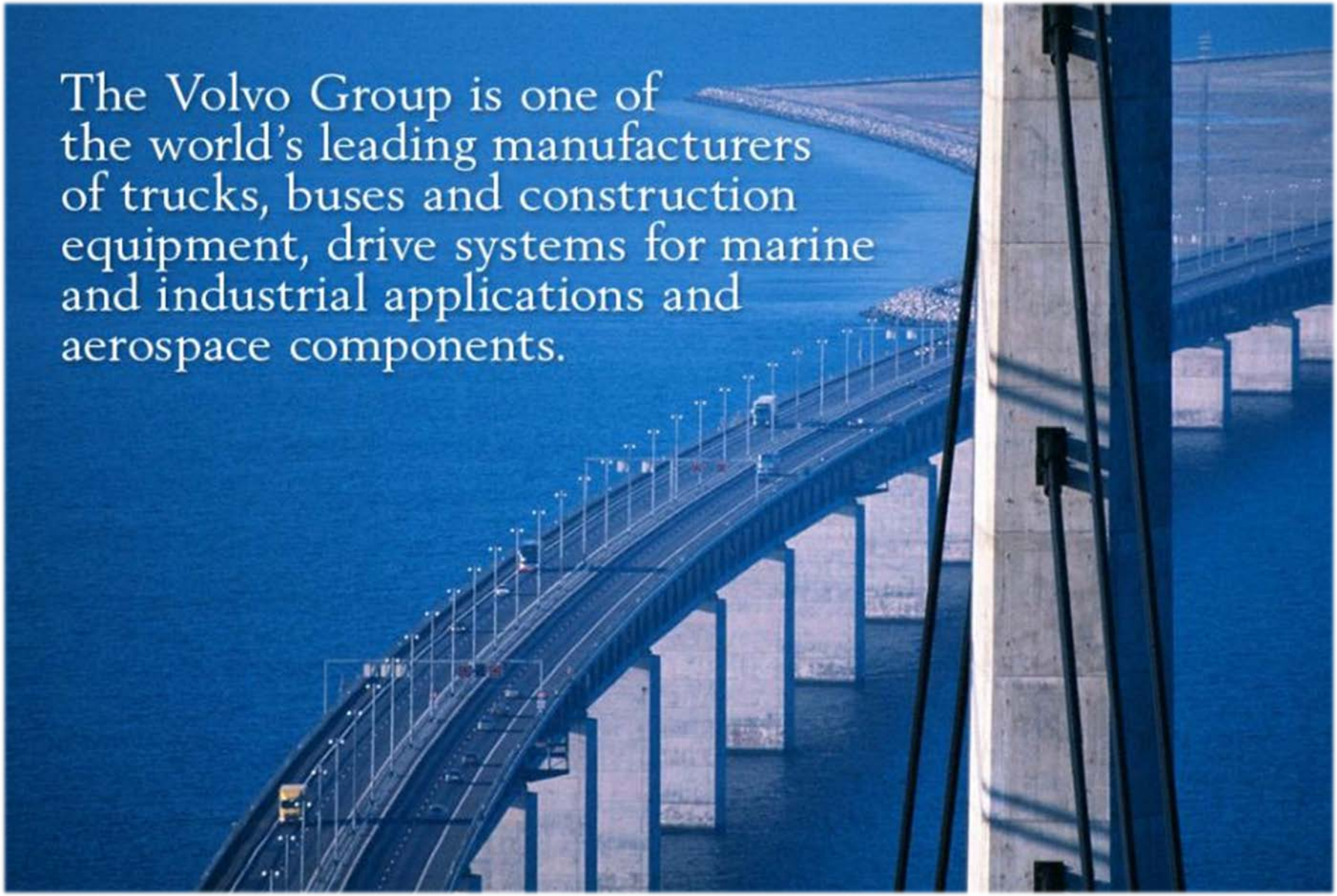
View from the Bridge

Commercial Vehicle Perspective

DEER 2012

Anthony Greszler
Volvo Group Truck Technology


The Volvo Group is one of
the world's leading manufacturers
of trucks, buses and construction
equipment, drive systems for marine
and industrial applications and
aerospace components.

Volvo Group 2012

Trucks

Volvo | Renault | Mack | UD | Eicher

Construction Equipment

Volvo | SDLG

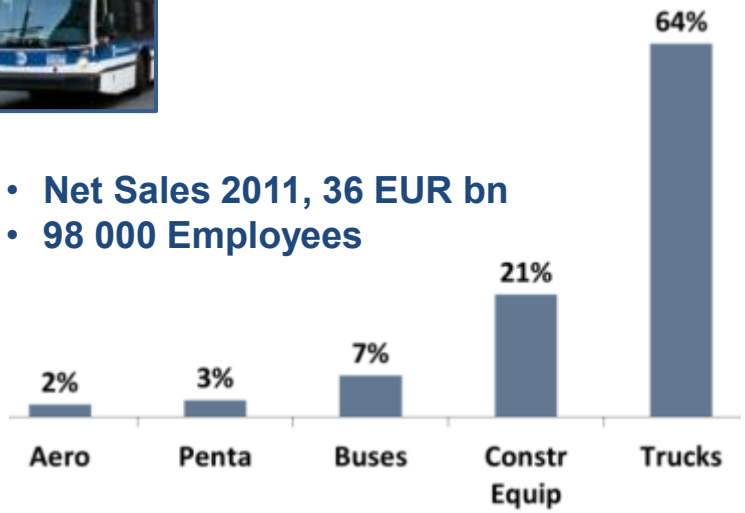
Buses

Volvo | Prevost | Nova Bus

Volvo Penta

Volvo Aero

- Net Sales 2011, 36 EUR bn
- 98 000 Employees



Light-Duty vs Heavy-Duty Technology

Heavy trucks are not big cars

- **Personal** – Emotional, pleasure
- Most fuel is used to **move the vehicle** Typically 1.6 passengers & light cargo.
- Heavily used in **urban** areas.
- **Spark** ignited **stoichiometric** engines.
- Key Emerging Opportunities
  - Hybrid
  - Electrification
  - SI engine efficiency or dieselization
  - Ethanol
  - Hydrogen?
  - Reduced weight & Down-sizing

- **Commercial** – business, profit
- Most fuel is used to **move cargo** volume and/or weight
- Heavily used on open **highways**.
- **Compression** ignited **lean burn** engines
- Key Emerging Opportunities
  - Integrated aerodynamics
  - Exhaust energy recovery
  - Logistics and vehicle management
  - Bio, renewable, synthetic diesel
  - Natural gas
  - Longer, heavier- increased capacity

Forecasting

"There are two kinds of forecasters:

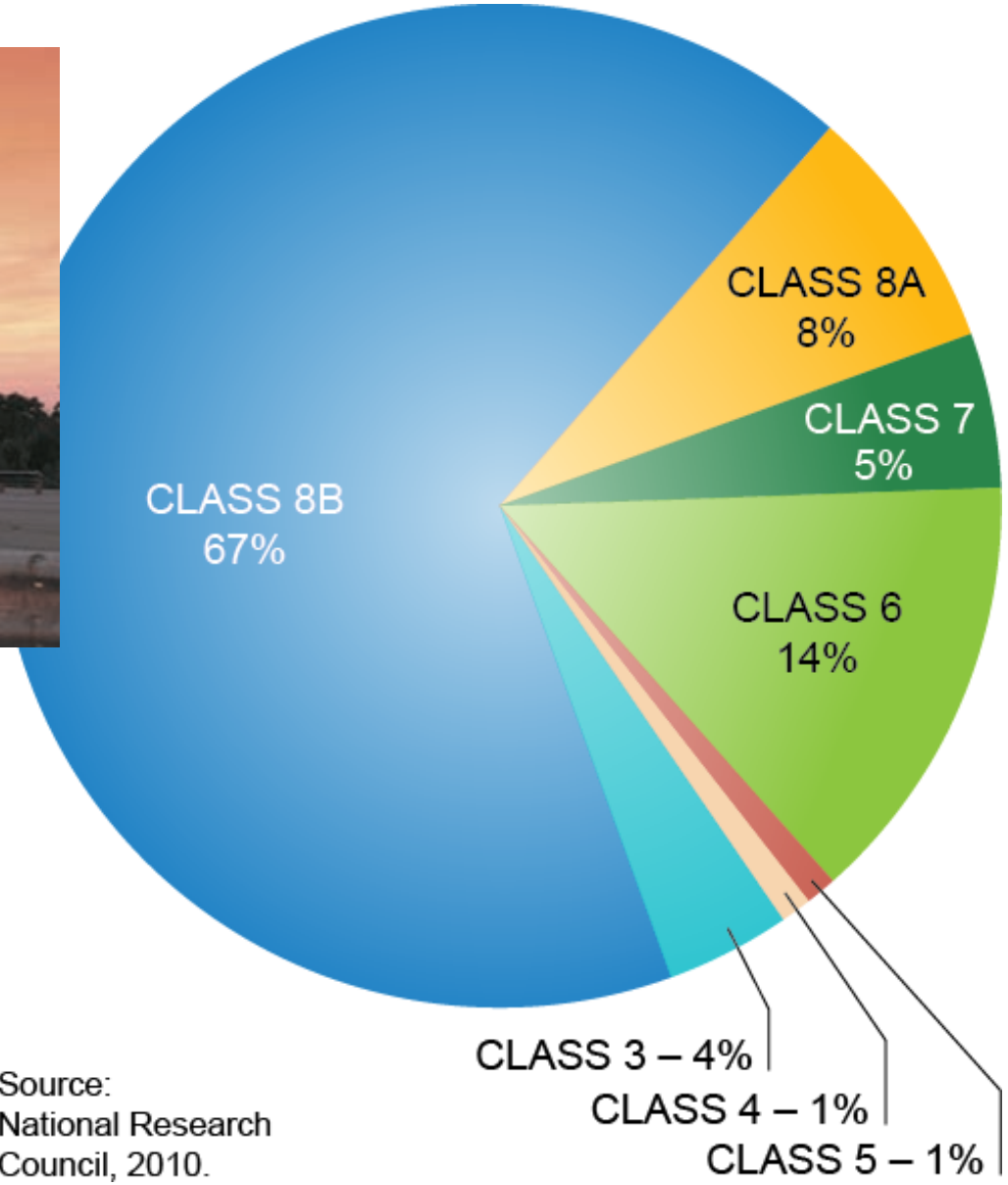
those who don't know, and those who don't know they don't know."

John Kenneth Galbraith put it (*Wall Street Journal*, Jan 22, 1993)

"There are two kinds of forecasts:

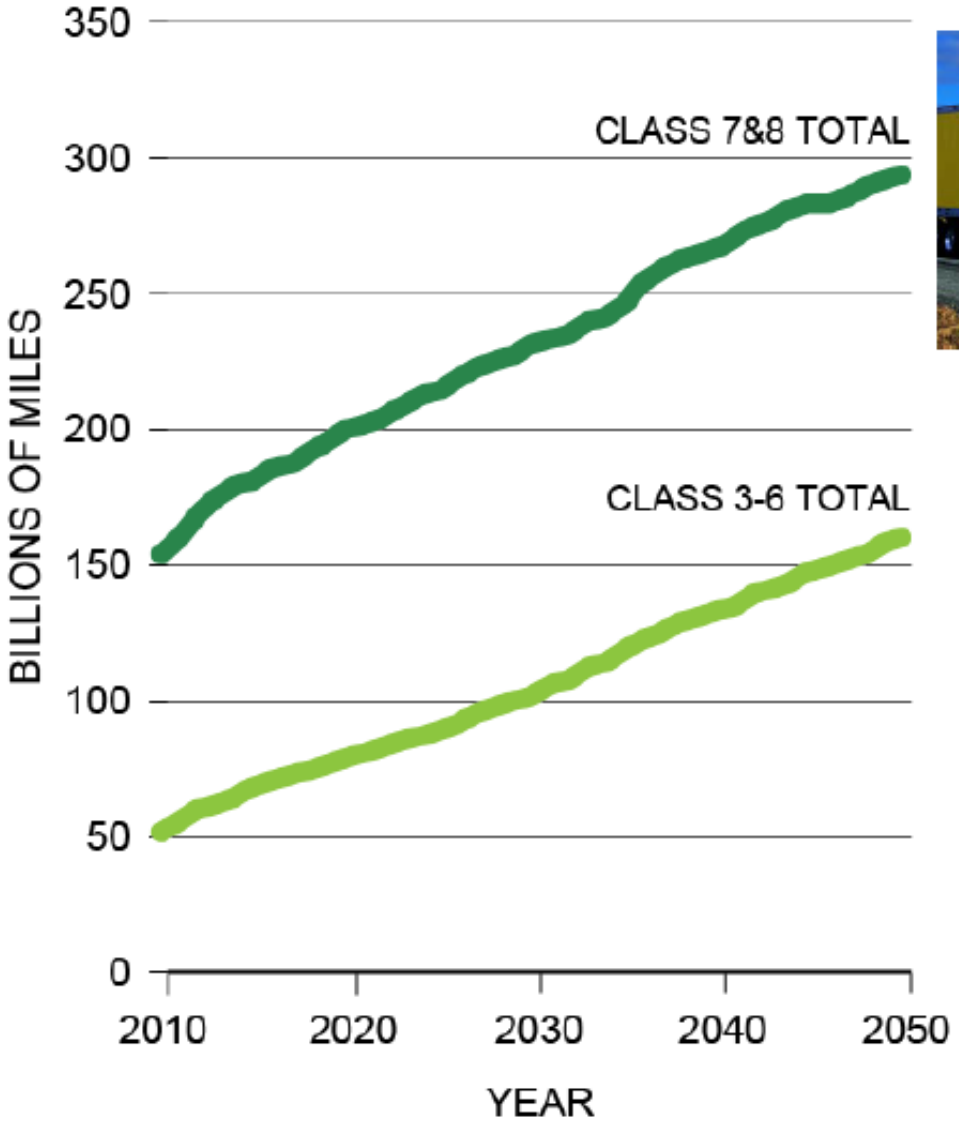
Wrong and Lucky”

Volvo Materials Planner



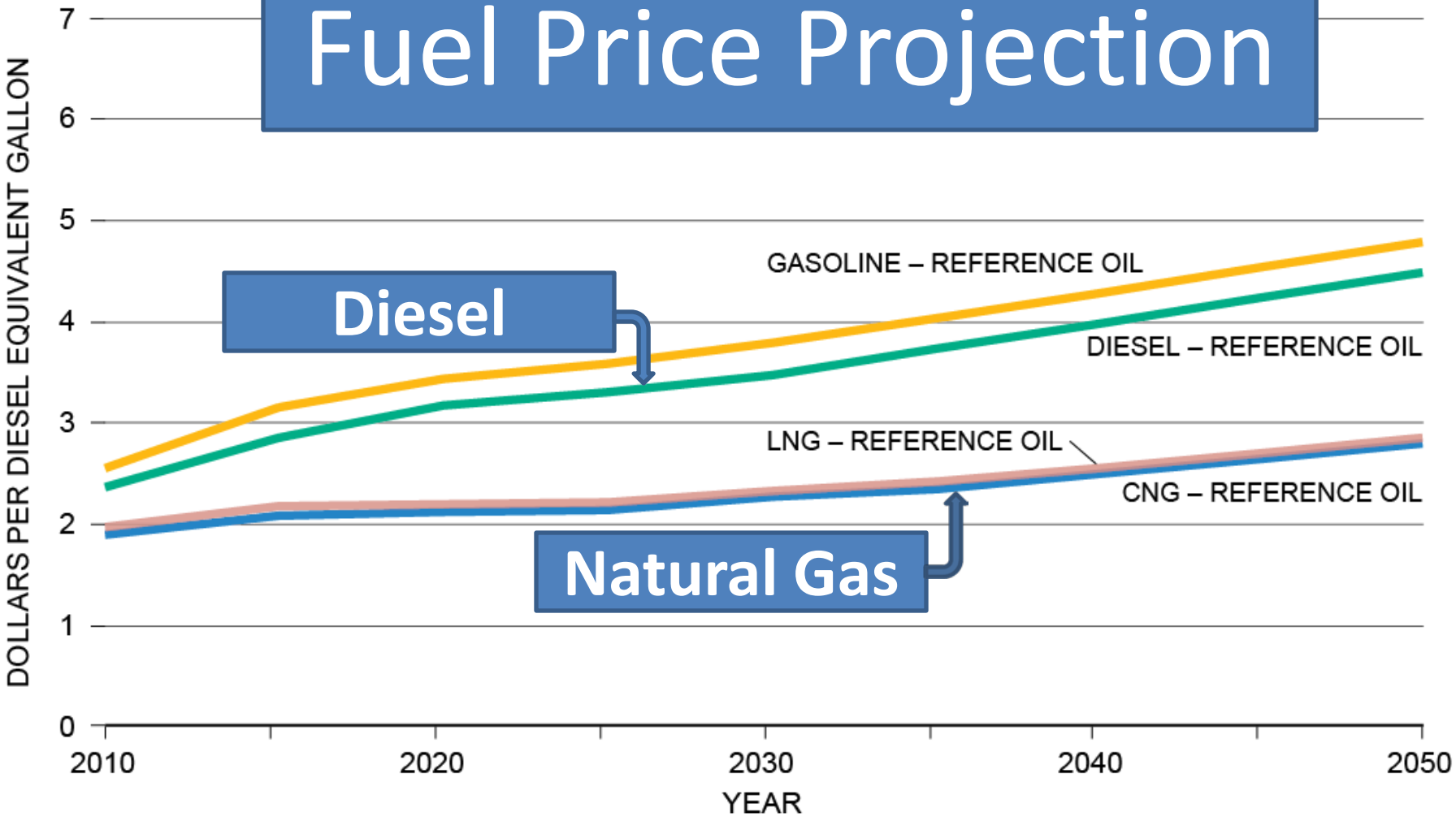
Source:
National Research
Council, 2010.

HD/MD Truck Fuel Consumption Shares



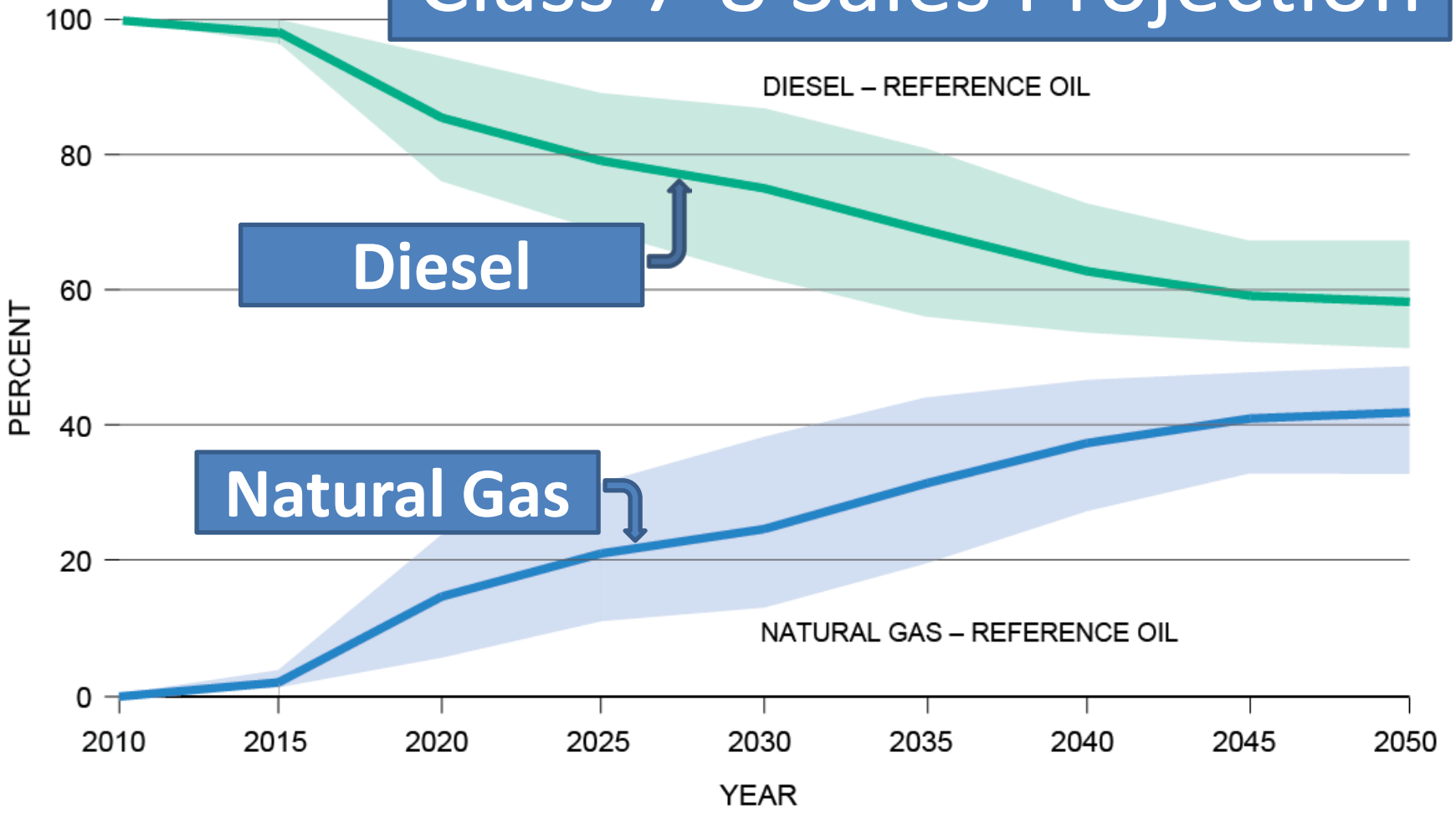
Annual Vehicle Miles Traveled for Heavy-Duty Vehicles

Fuel Price Projection



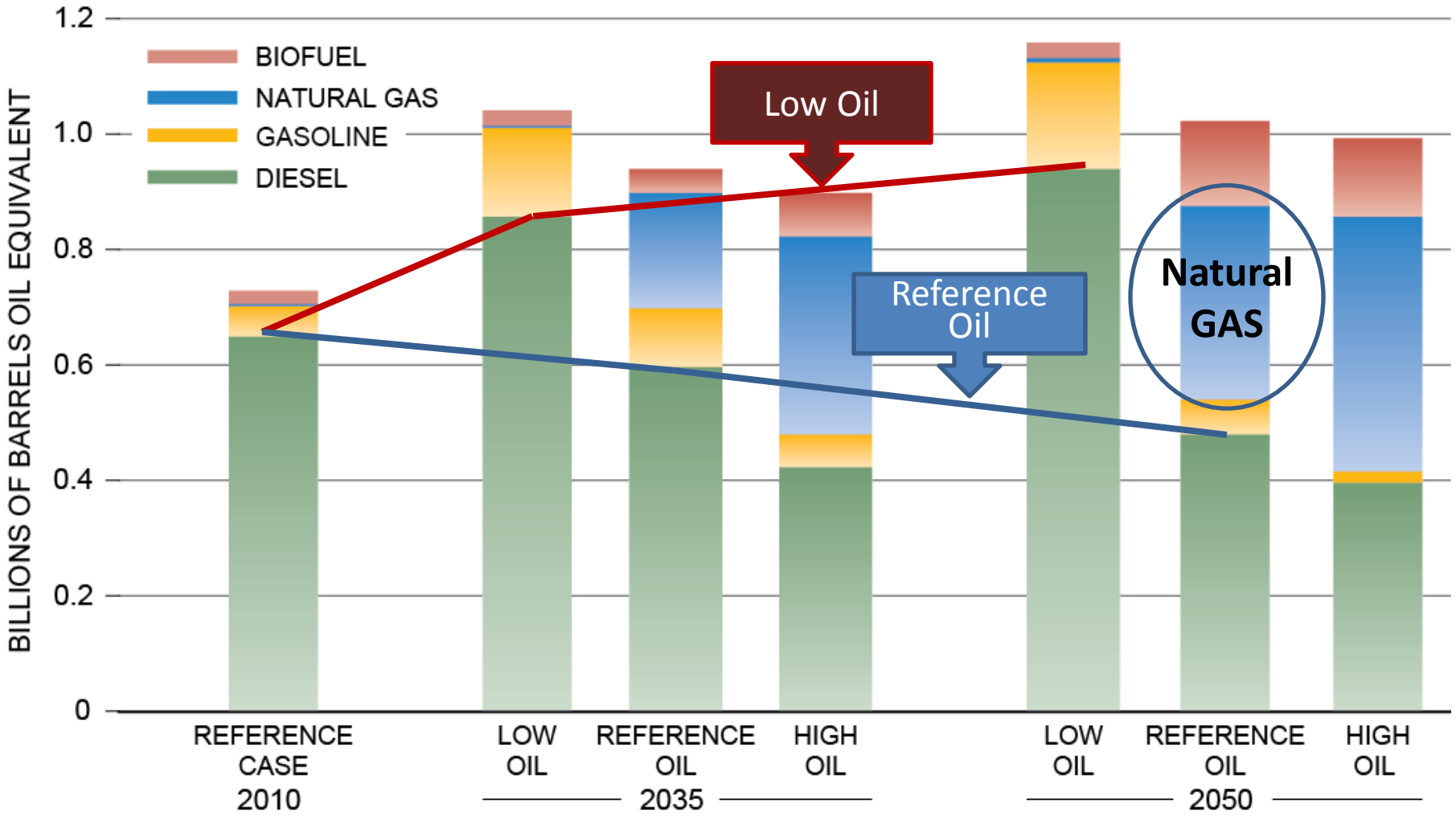
Dispensed Fuel Price Assumptions – Reference Oil Price Case

Class 7-8 Sales Projection

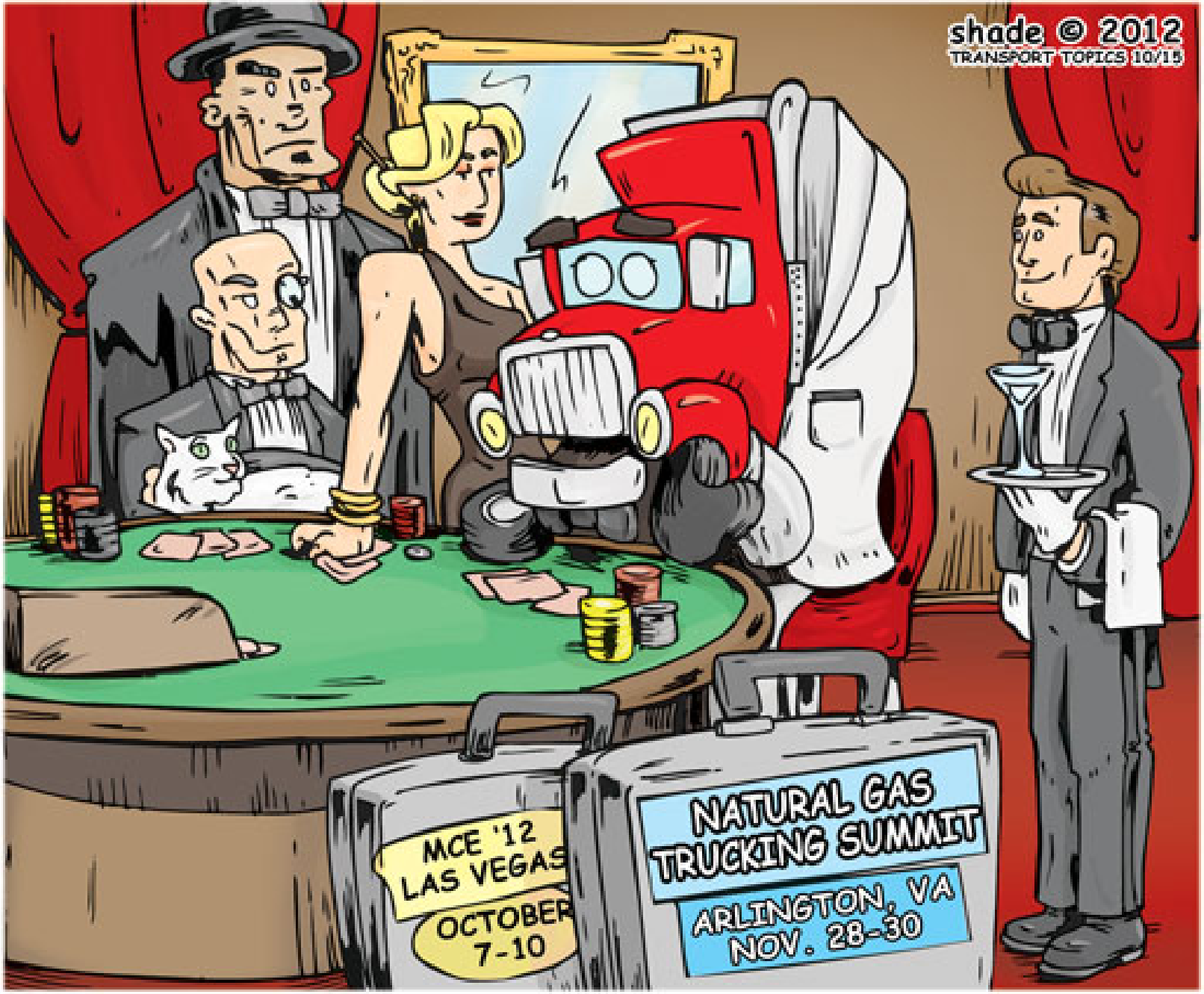


Class 7&8 Combination Market Shares of New

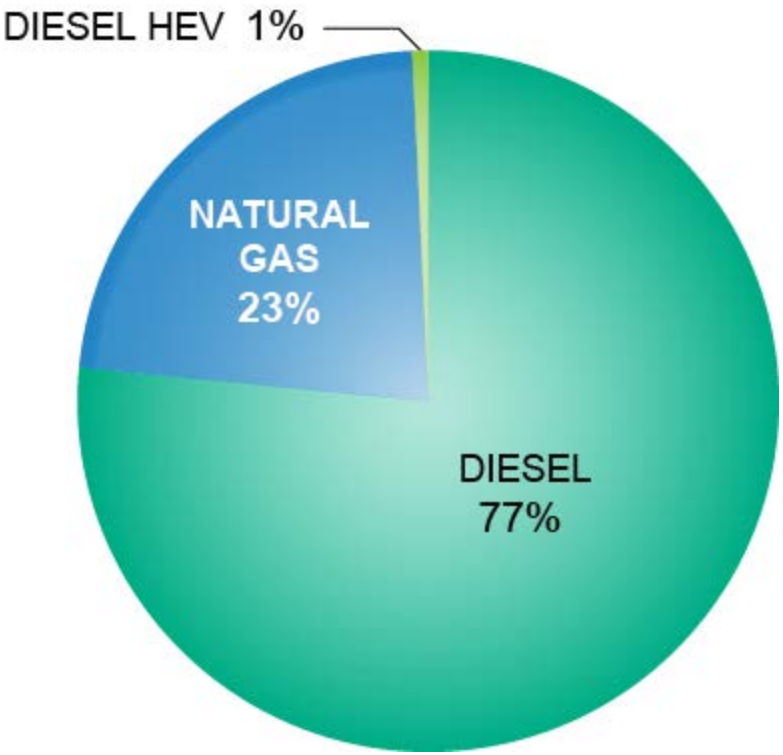
Diesel and Natural Gas Trucks – Reference Oil Price Case



Heavy-Duty Truck Energy Use by Fuel Type



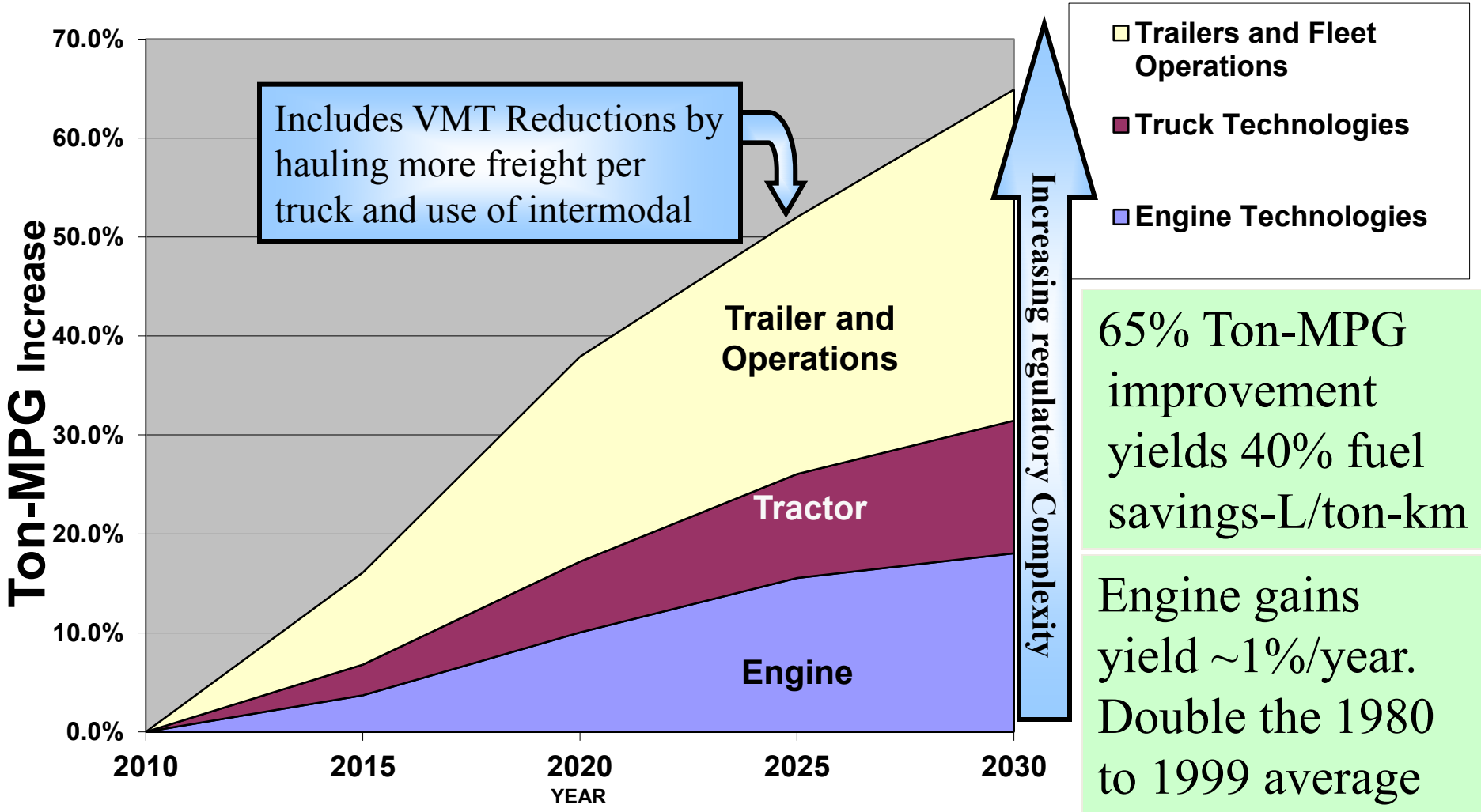
"MAKE MINE NATURAL GAS, LIQUEFIED NOT COMPRESSED."



Fleet Composition Class 7&8 Vehicles in 2050 – Reference Oil Price Case

"Diesel engines will remain the powertrain of choice for (heavy duty) vehicles for decades to come because of their power and efficiency. There are, however, opportunities to improve the technology. Significant fuel economy improvements in diesel powered trucks are possible. Indeed, the fuel economy (mpg) for new Class 7&8 HD vehicles, which consume more than 70% of the fuel in the trucking fleet, could be doubled."

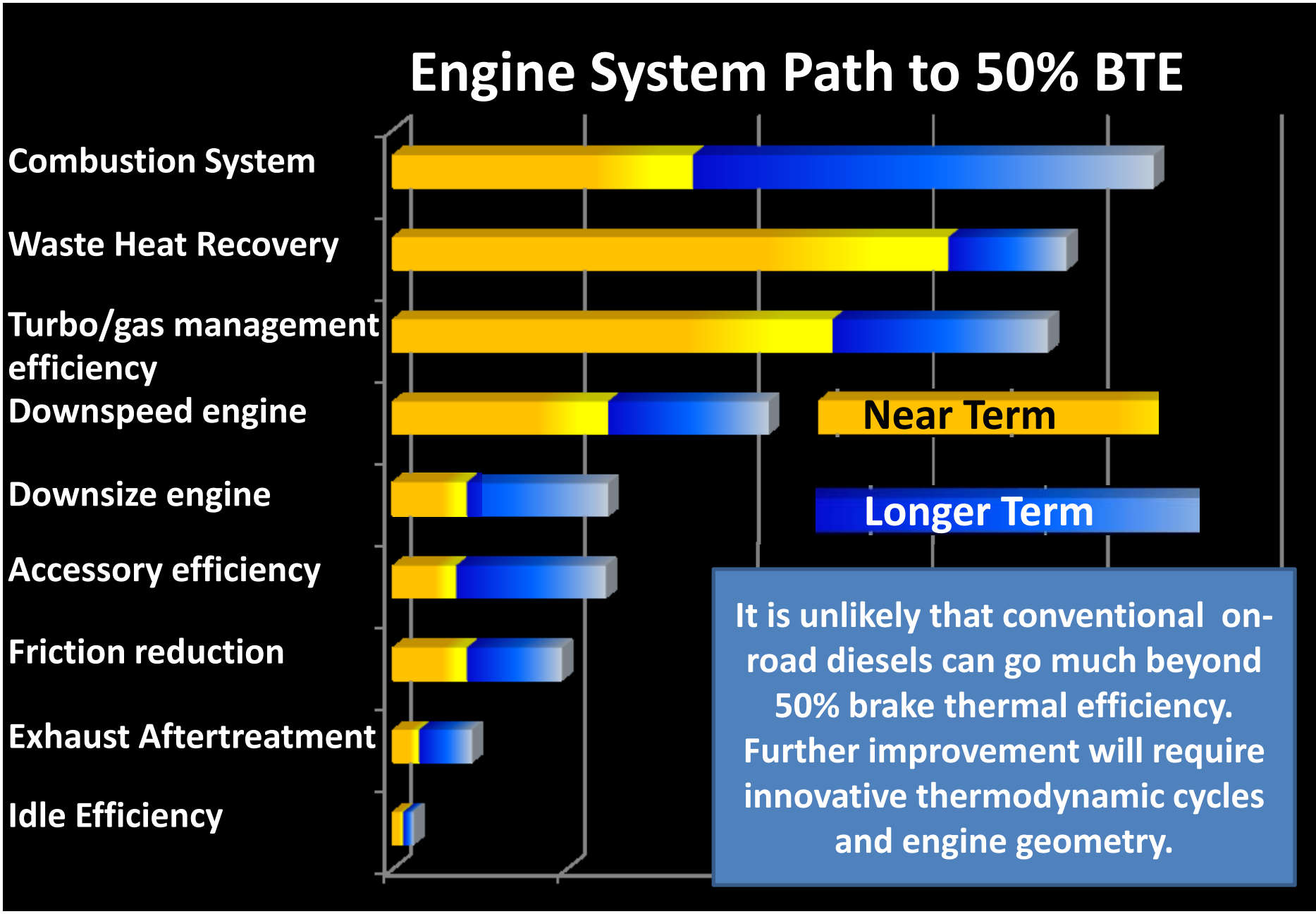
Class 8 Ton-MPG - A Prospective Scenario Via Vehicle Efficiency Gains and VMT Reductions



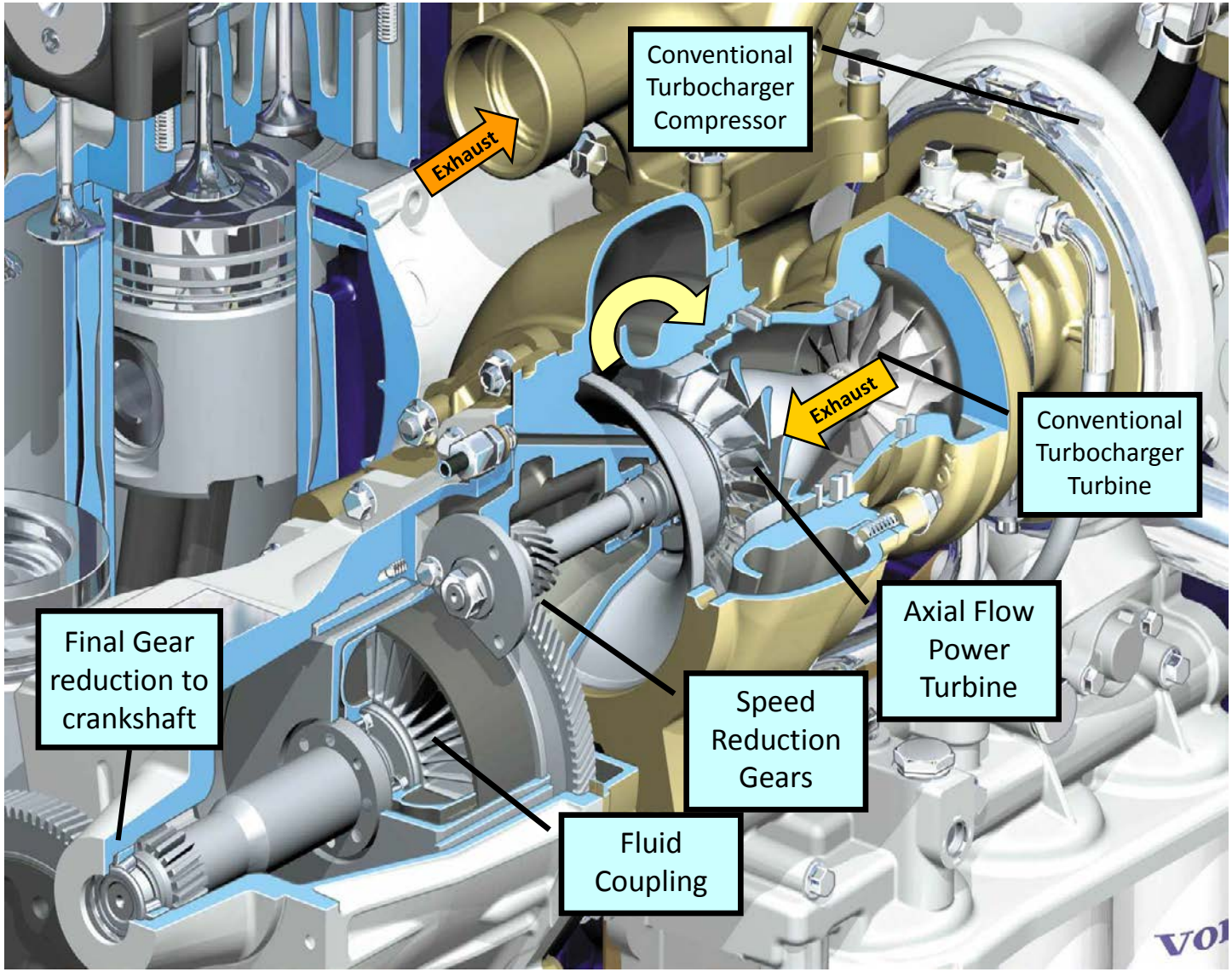
65% Ton-MPG improvement yields 40% fuel savings-L/ton-km

Engine gains yield ~1%/year. Double the 1980 to 1999 average

Engine System Path to 50% BTE

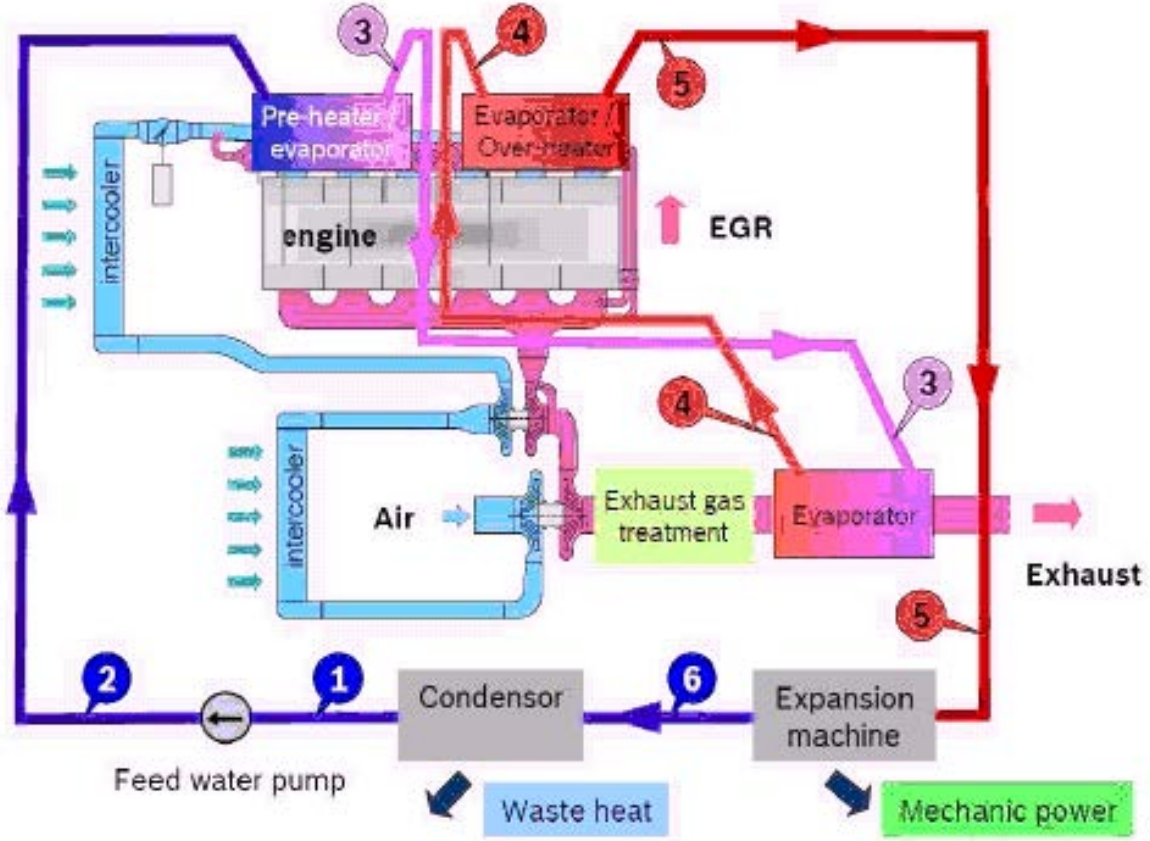


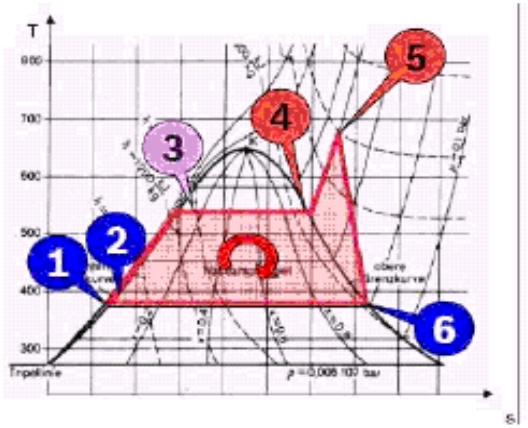
Turbo-Compounding:
Essentially a turbine engine added to the diesel



2 - 4% Fuel Efficiency Benefit in Long-haul Application

Rankine Waste Heat Recovery System: Essentially a steam cycle engine added to the diesel

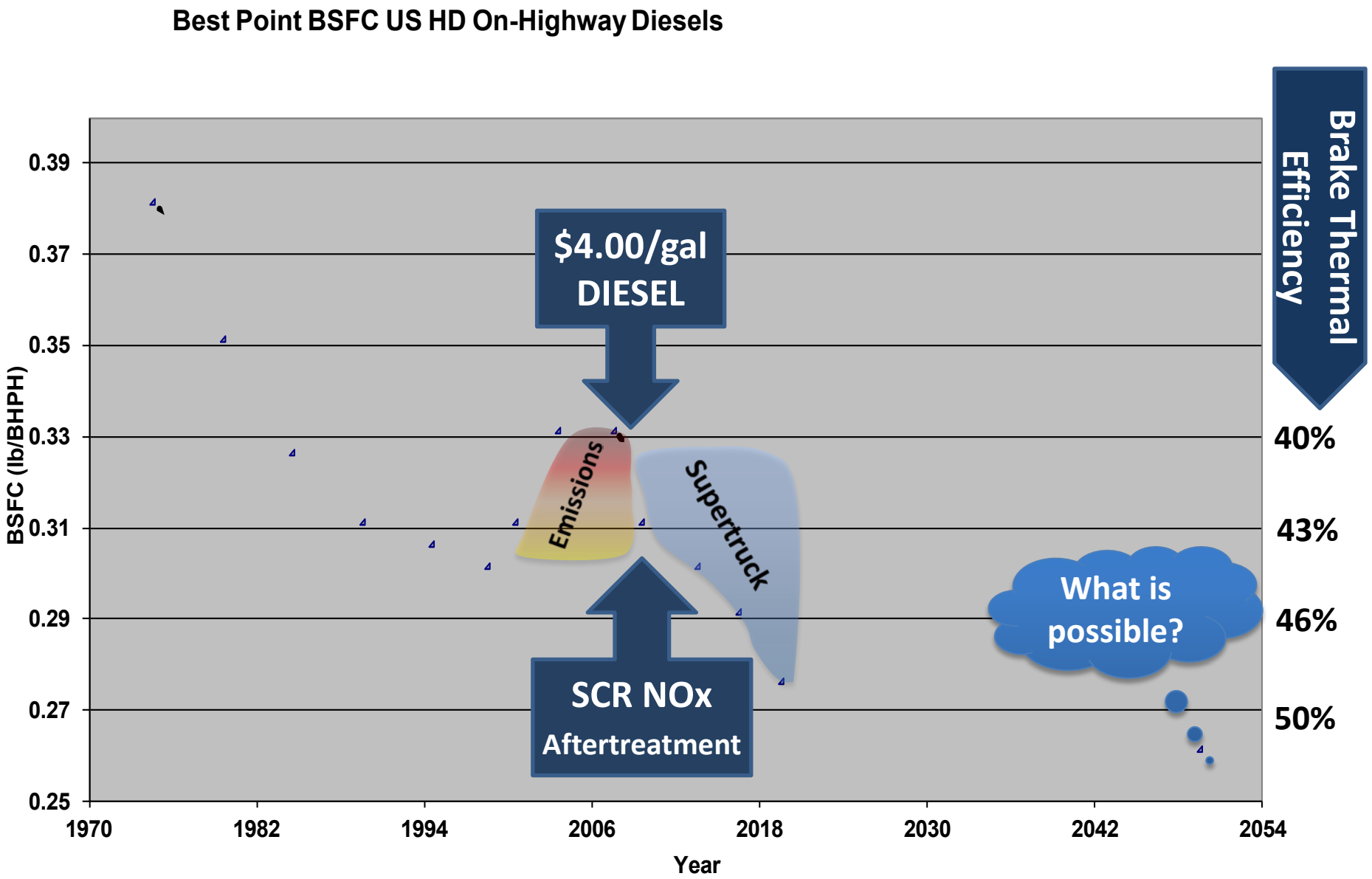




1 → 2: compression, pumping
2 → 5: preheating, evaporating, overheating
5 → 6: power generation
6 → 1: condensation

Note: complexity, packaging and weight.

Expect 4-5% improved efficiency at US road load conditions.
Maximum efficiency benefit is limited by low temperature heat rejection capability

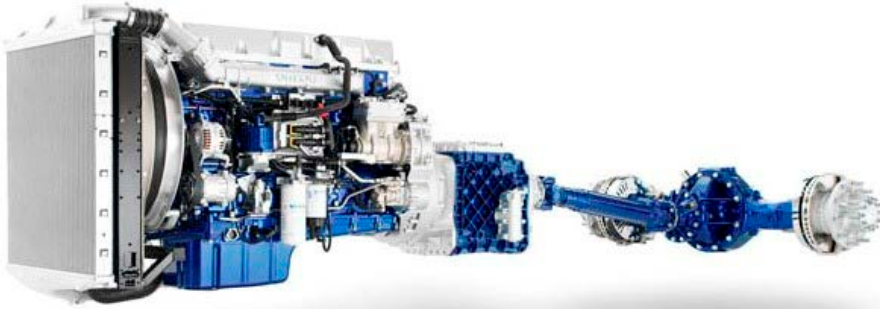

Best Point BSFC US HD On-Highway Diesels
BSFC (lb/BHPH)
0.39
0.37
0.35
0.33
0.31
0.29
0.27
0.25
1970
1982
1994
2006
2018
2030
2042
2054
Year
$4.00/gal DIESEL
Emissions
Supertruck
SCR NOx Aftertreatment
What is possible?
Brake Thermal Efficiency
40%
43%
46%
50%

Propulsion System – not Engine

… powertrain experts agree that IC engines have to be looked at more as "propulsion systems" rather than freestanding components. That way powertrain teams increasingly can solve problems by looking at the entire transmission and driveline, rather than only the engine.

2012 CAR Management Briefing Seminars

Aug. 8, 2012 Drew Winter, WardsAuto



SuperTruck

Volvo Energy Efficient Vehicle

Why is complete vehicle integration so important?

VISION 2012 INNOVATION EVENT REALITY

- Improved combustion System
- Turbo Compound
- Narrow Band & Downspeeding
- Rankine Waste Heat Recovery

20%

- ADAS
- E-horizon
- Driver Coaching

5% (bonus)

- Trailer skirts
- gap & rear fairings
- wheel covers

15%

- Lightweight trailer & tractor
- Composite materials

4,000 lbs

- Idle Reduction
- Improved Auxiliaries

5%

- Rear/Side view cameras
- Ride height control
- wheel & chassis fairings

3%

- Low friction hubs & tires
- Carrier Lube Level control
- High efficiency 6X2
- Low viscosity lubricants

7%

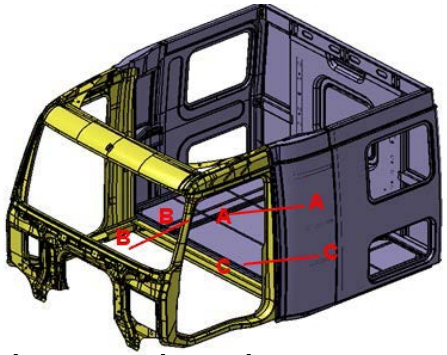
Contact Information:
pascal.amar@volvo.com

VOLVO

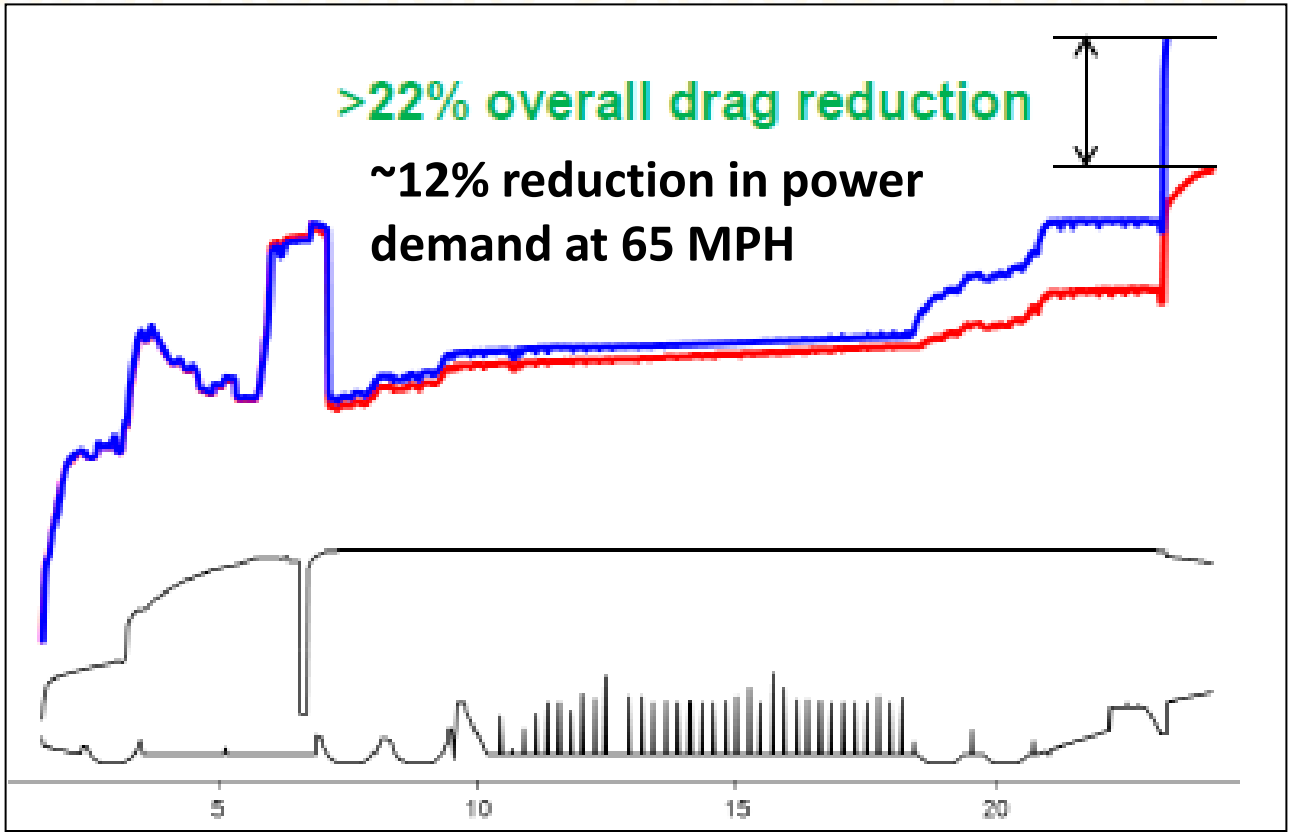
Total Vehicle System Design

Accessory Power Reduction

Lightweight intelligent efficient drivetrain

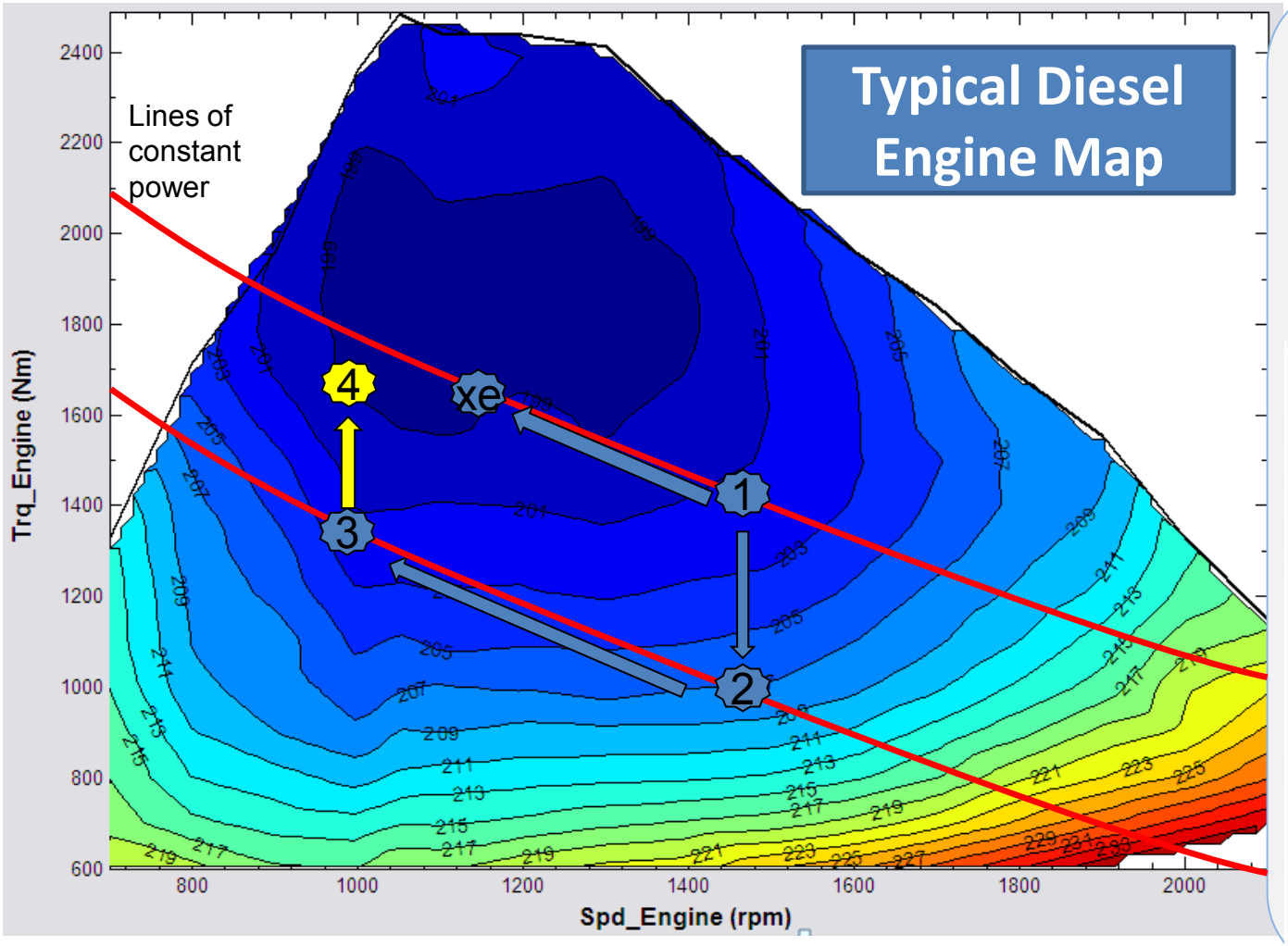


Lightweight Chassis and Cab Materials



Vehicle Aerodynamic Drag Reduction

Engine Efficiency Impact of Integration



1. Cruise operating point
   2010 Baseline

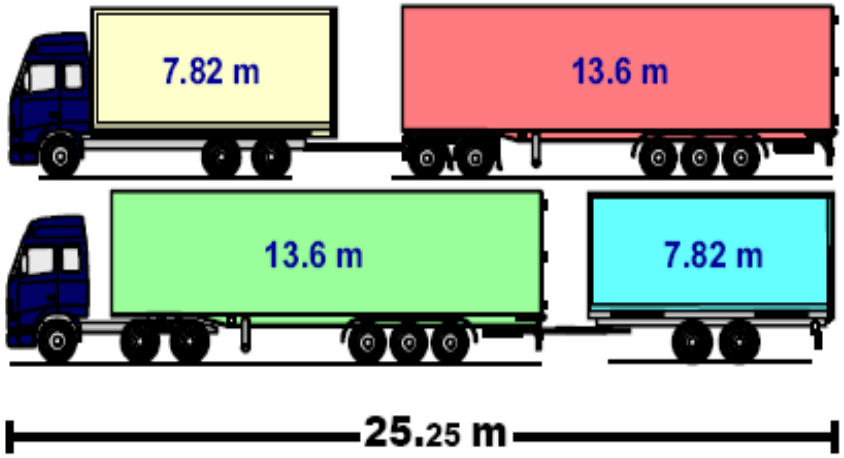
- Volvo XE13 & Mack Super Econodyne – Down-speeded engine, enabled by integrated AMT & high torque yields 3% FE

Total Vehicle System Design

Using system engineering, an integrated vehicle design will yield major improvements in features and fuel economy.

Longer Combination Trucks

Single Biggest Potential Efficiency Gain via Lower VMT



Sweden and Finland allowing rigs up to 25.25 m vs 18.75 m in rest of EU (14-20% less fuel)
US limits trailers to 53' (16.2 m)

Quote – Ontario, Canada Ministry of Transport

LCVs are a win-win-win. They are good for the economy, good for the environment and improve highway safety. They can move goods at a lower cost and with fewer greenhouse gas emissions than single-trailer trucks and, under carefully controlled conditions, more safely.

Fuel saving for longer US combinations (with volume limited freight- per ATRI study)

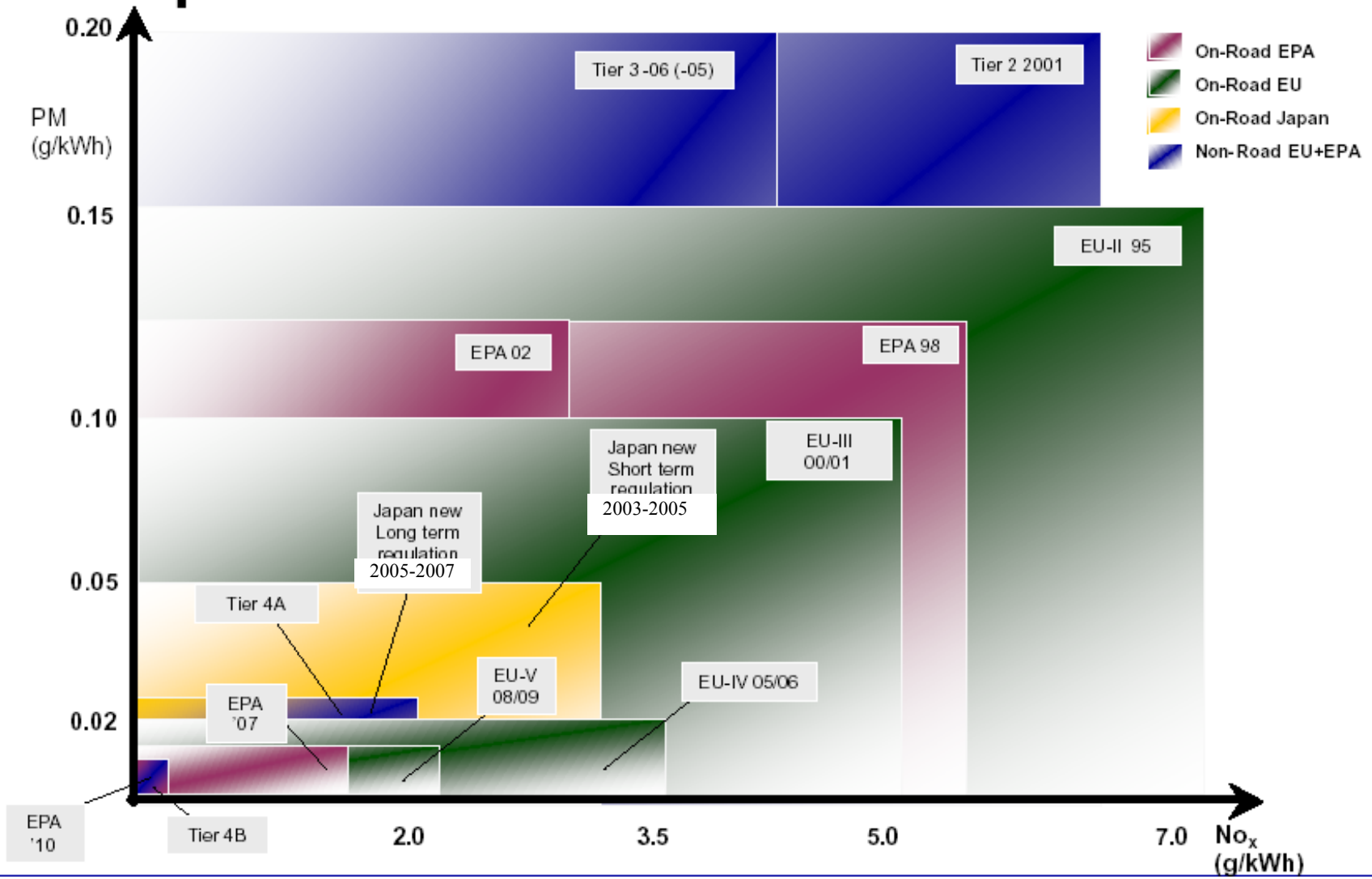
6-axle Tractor-Semitrailer

Rocky Mountain Double (RMD)

Triple Trailer Combination (TRPL)

Turnpike Double (TPD)

Map for Emission Standards 1995-2010



And just when we thought it was safe to rest on our achievements in diesel emissions: A new California 'Vision for the Future'

What are the Solutions?

- Large trucks
  - Double fuel economy
  - Decrease NOx standard for new truck engines to ~0.05 g/bhp-hr by 2020
  - Widespread use of drop-in biodiesel (low carbon)
  - Introduction of advanced powerplants such as hybrids and fuel cells
  - Improved goods movement

Conclusions

- **Significant potential improvements are possible but market is complex with multiple players requiring coordinated approach.**
- **Engine and vehicle technologies are already quite advanced, but many available efficiency features are only slowly gaining acceptance (especially for trailers)**
  - **There are no feasible single technology options with huge benefits**
  - **Economic barriers (efficiency feature cost vs. fuel cost)**
  - **Regulatory barriers (length, weight, safety)**
  - **Infrastructure barriers (alternative fuels, congestion, truck stops, IT, docks, terminals, etc.)**
- **Efficiency needs to be measured in terms of moving freight, not moving trucks.**
- **We lack a comprehensive freight policy**
  - **Fuel supply/cost, fuel & vehicle taxes, fuel alternatives, infrastructure, intermodal, metropolitan freight delivery, size/weight consistency, speed, safety, data collection and analysis**
- **Freight growth will continue to outpace efficiency improvements without clear policy direction and coordination between vehicle manufacturers, carriers, fuel suppliers, shippers, and policy makers.**

Thank you for your attention