

**EVERY  
ALTERNATIVE.**

**Cummins Westport Inc.  
2009 and Beyond**

A scenic landscape photograph showing a range of snow-capped mountains under a blue sky with scattered clouds. The foreground consists of rolling green hills.

# Cummins Westport

## A Cummins JV Company

- CWI is a 50:50 joint venture company based in Vancouver, BC
  - Cummins Inc. - world's largest builder of commercial diesels
  - Westport Innovations Inc. - world leader in gaseous fuel engine technology
- CWI offers 6 to 9 litre alternative fuel automotive engines. (CNG, LNG, LPG)
- Engines are manufactured by Cummins.
- Local parts and service support through Cummins Distributor network.

# Why Natural Gas Engines for Buses & Trucks?

## Emissions Leadership

- Meet Regulated 2010 EPA Emissions today
- Lower greenhouse gas emissions



## Economic Benefits

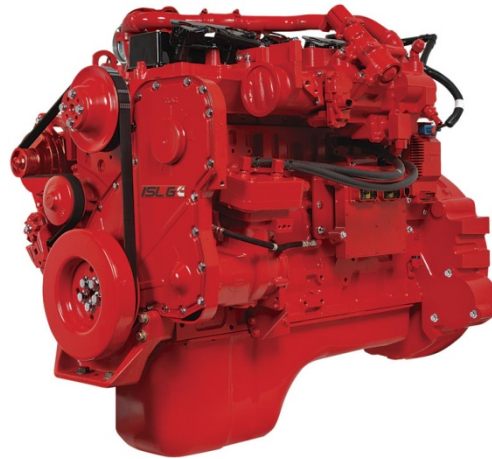
- Improved Reliability
- Improved Efficiency
- Lower total fuel costs

## Energy Security

- Reduced reliance on oil
- Biomethane capable
- Pathway to hydrogen

# 2010 North American Product Line

## **ISL G**



**8.9 Litre**

**250-320 hp**

**660-1000 lb-ft**

**2010  
Compliant**

**Possible  
additional ratings**

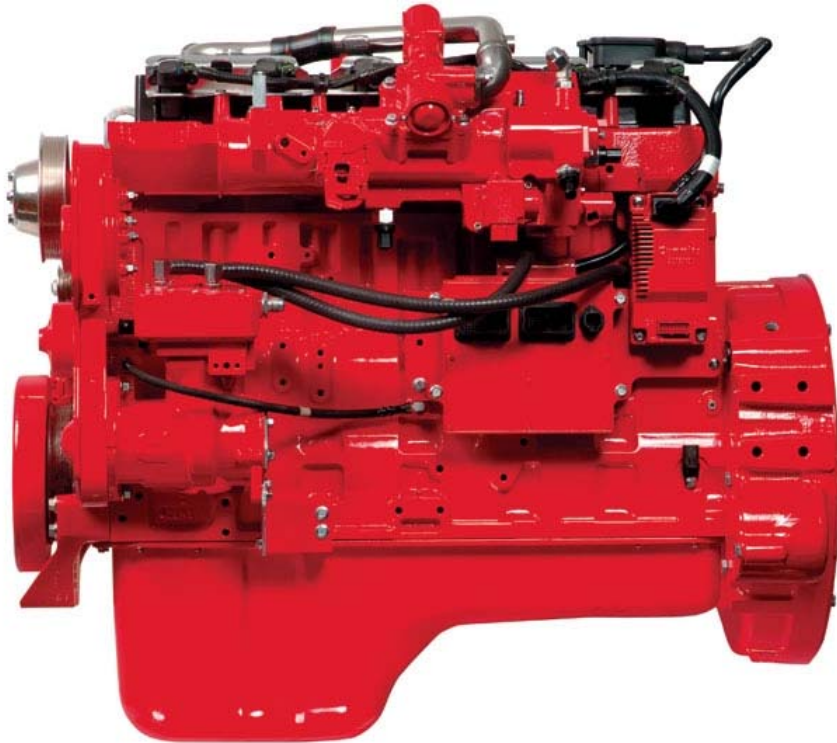
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**The Stoich Technology**



# Next Generation Natural Gas Technology

## Stoichiometric Featuring Cooled EGR



- 8.9 litre stoichiometric EGR engine
  - ratings 250- 320 hp
- Lowest emissions with use of maintenance free TWC
- Improved clutch engagement torque
  - Improved fuel economy
  - Diesel like Performance Reliability and Durability
- Cummins diesel parts

*Meets 2010  
NA Emission  
Standards*

**ISL G**

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# The Two Key Emission Technologies for 2008 ISL G Natural Gas Engines & Beyond

- Cooled Exhaust Gas Recirculation (CEGR) **Cummins**

- Three Way Catalyst

**Cummins  
Emissions Solutions**

# ISL G Applications

Truck



Specialty



Bus



REFUSE



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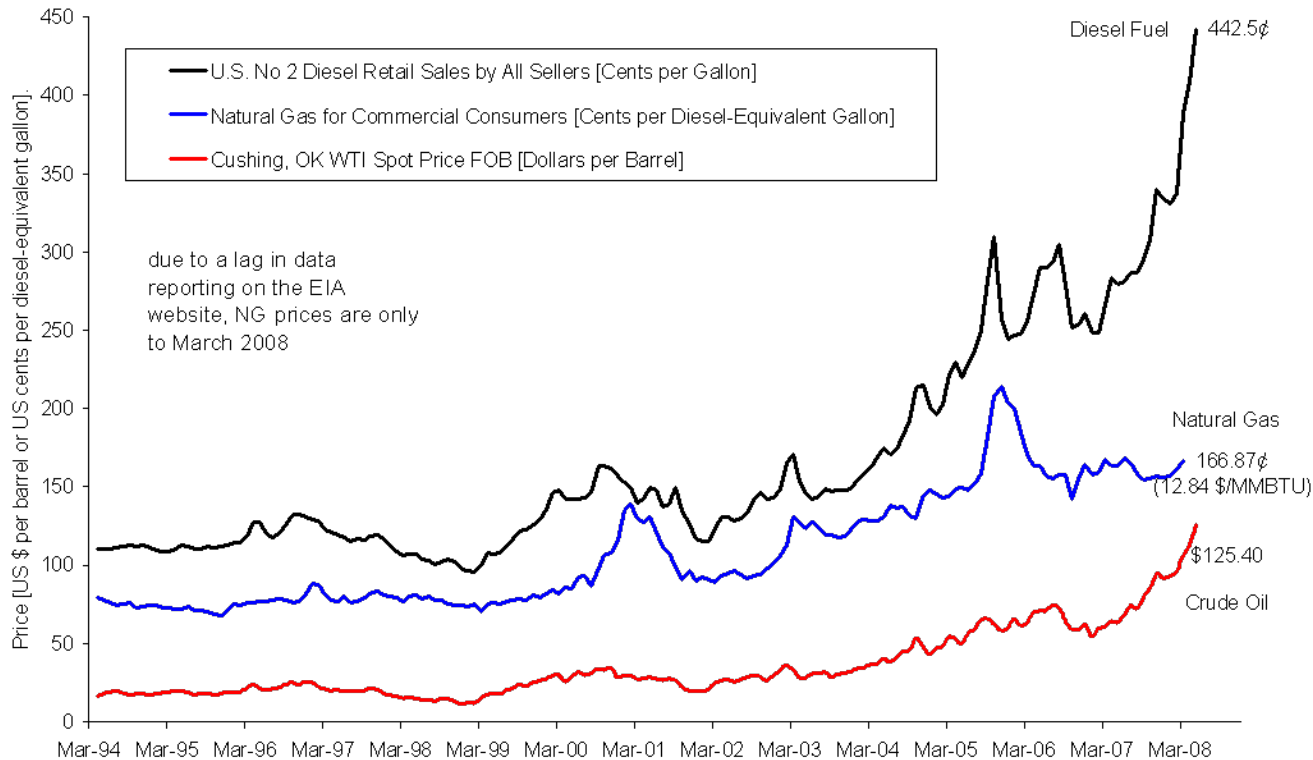
**Economics**



# Natural Gas Fuel Costs Less

- Diesel and natural gas prices follow a fairly predictable pattern in relation to crude oil prices with natural gas being less expensive than diesel fuel
- When crude oil prices rise, natural gas prices tend to rise *less* than diesel prices do, widening the price gap
- If anything, at today's higher crude oil prices natural gas prices are *less* than this historical relationship

**Price History for Crude Oil, Diesel Fuel, and Pipeline Natural Gas for Commerical Customers**



data source: US DOE Energy Information Administration

# Natural Gas: Key Economic Drivers

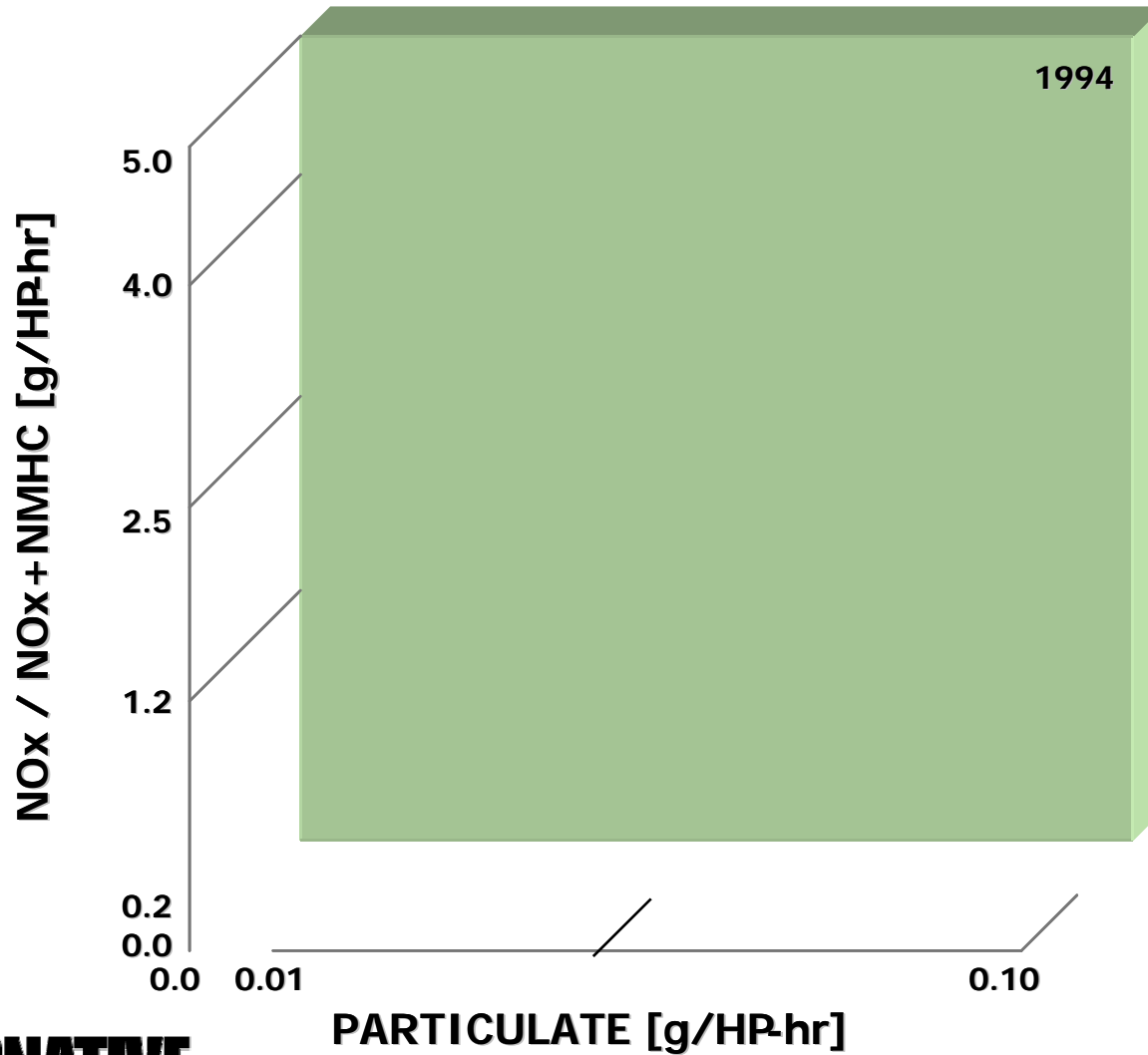
1. **Six fold increase in engine reliability/durability since 2001**
2. **NG is closing maintenance cost gap**
3. **Fuel cost savings can be significant**
4. **NG's lower cost contributes to lower LCC**
5. **CWI Fuel economy gap closing**
  - 17% in 2005
  - 10% in 2007
  - 7% in 2010

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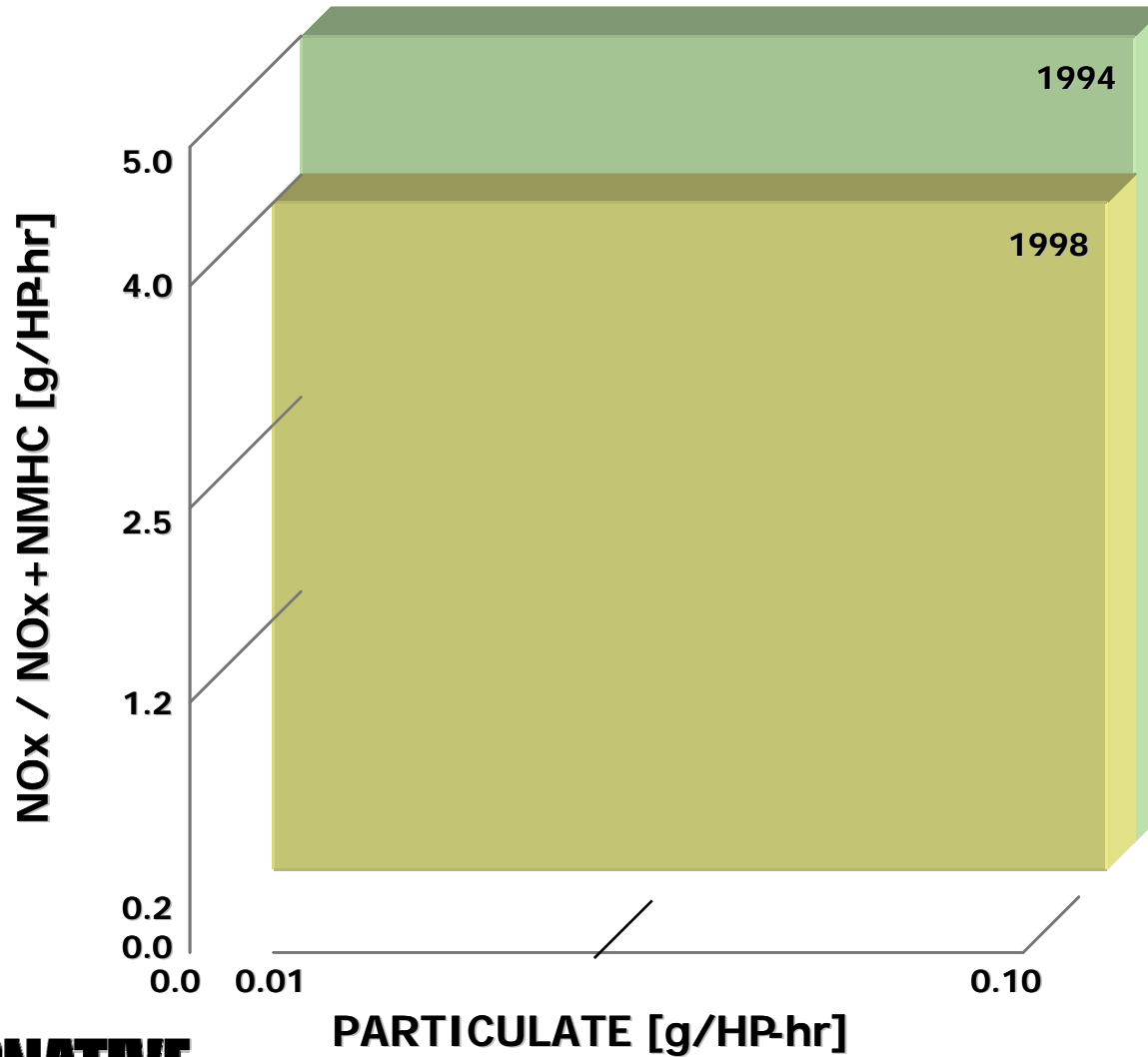
**2009 and Beyond**

A wide-angle landscape photograph of a mountain range. The foreground shows rolling green hills with sparse vegetation. In the middle ground, a range of rugged mountains is partially covered in snow. The sky is a clear, vibrant blue with scattered, light-colored clouds.

# EPA Regulated Emissions Targets

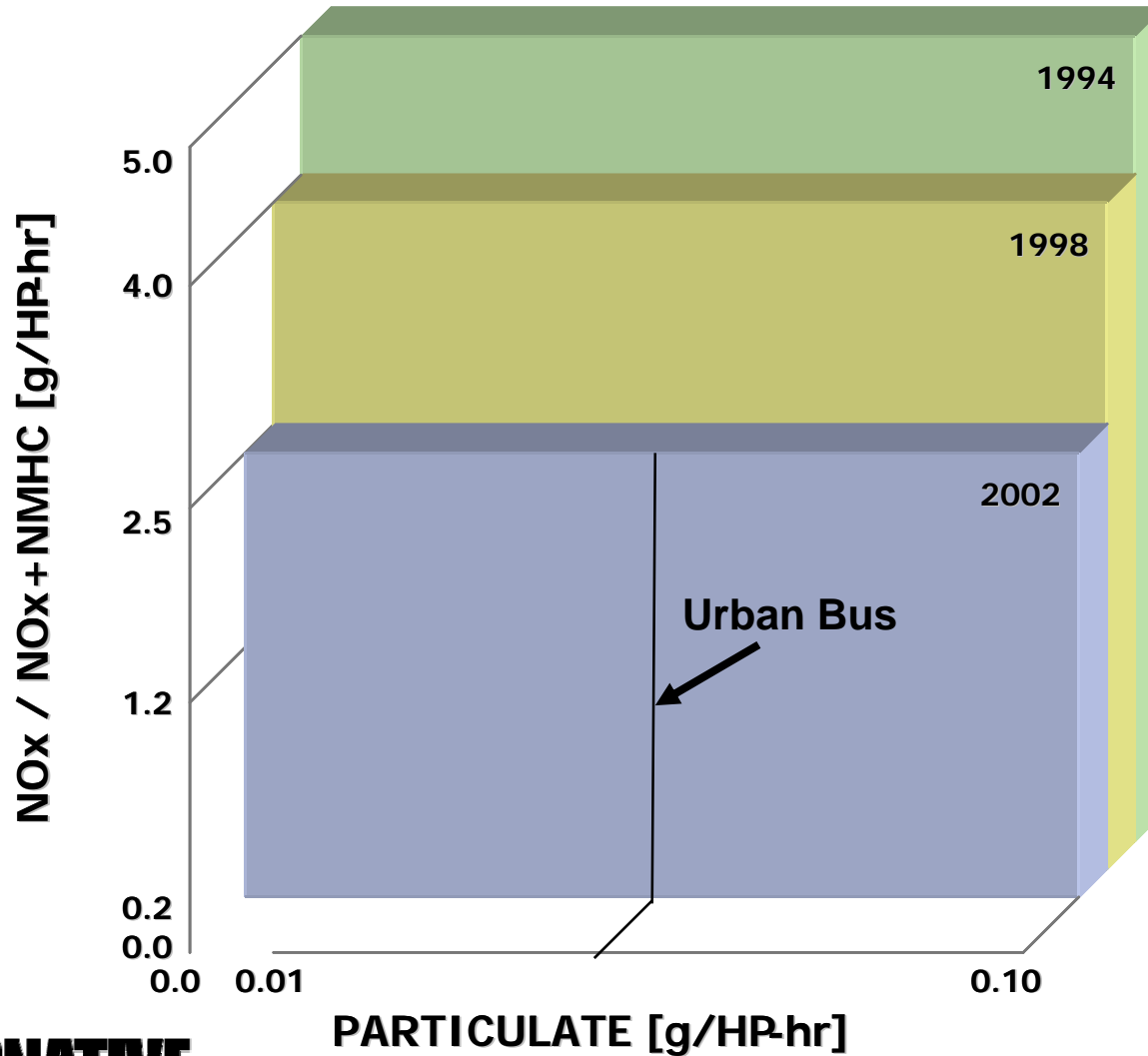


# EPA Regulated Emissions Targets

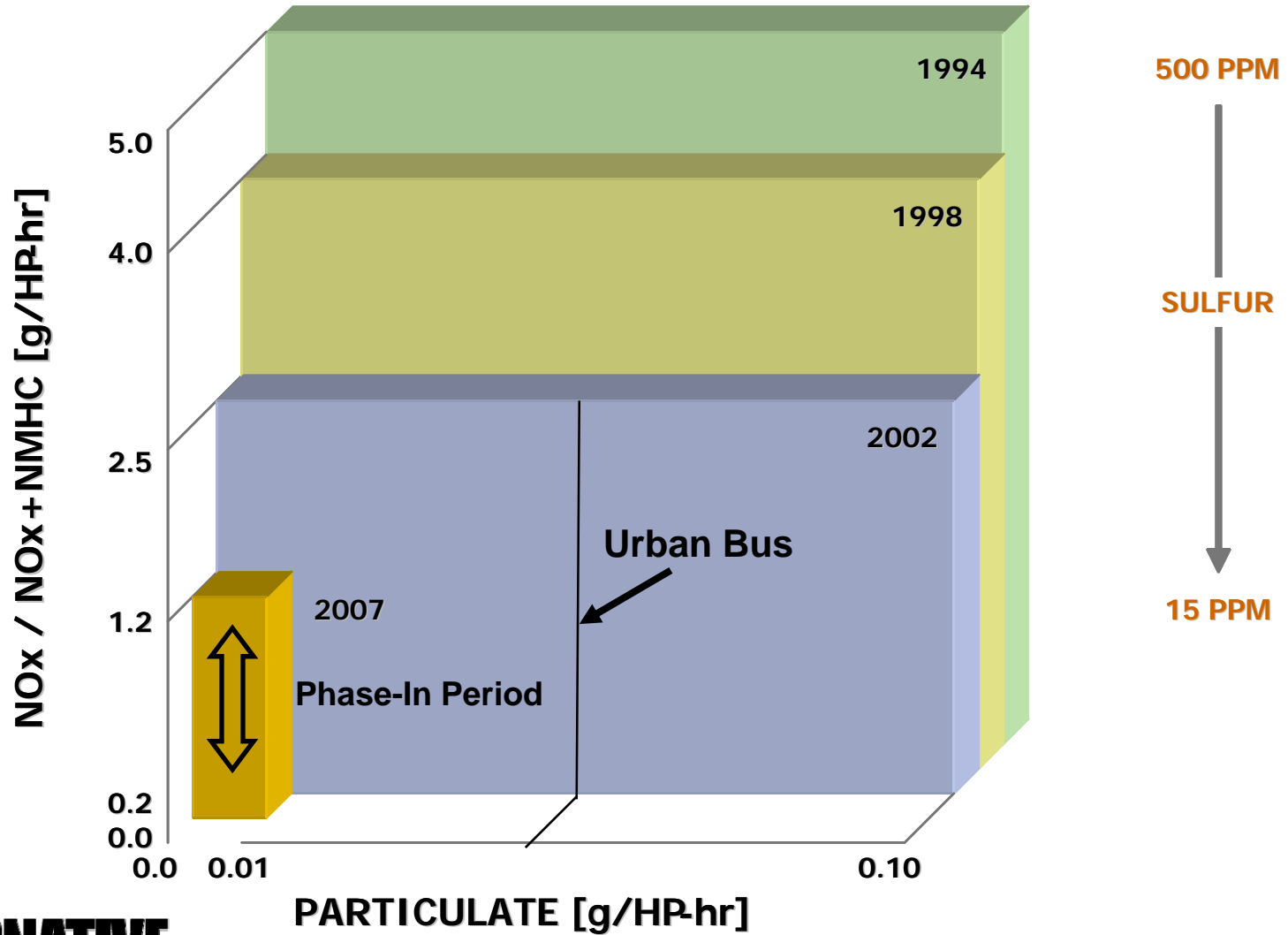


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# EPA Regulated Emissions Targets

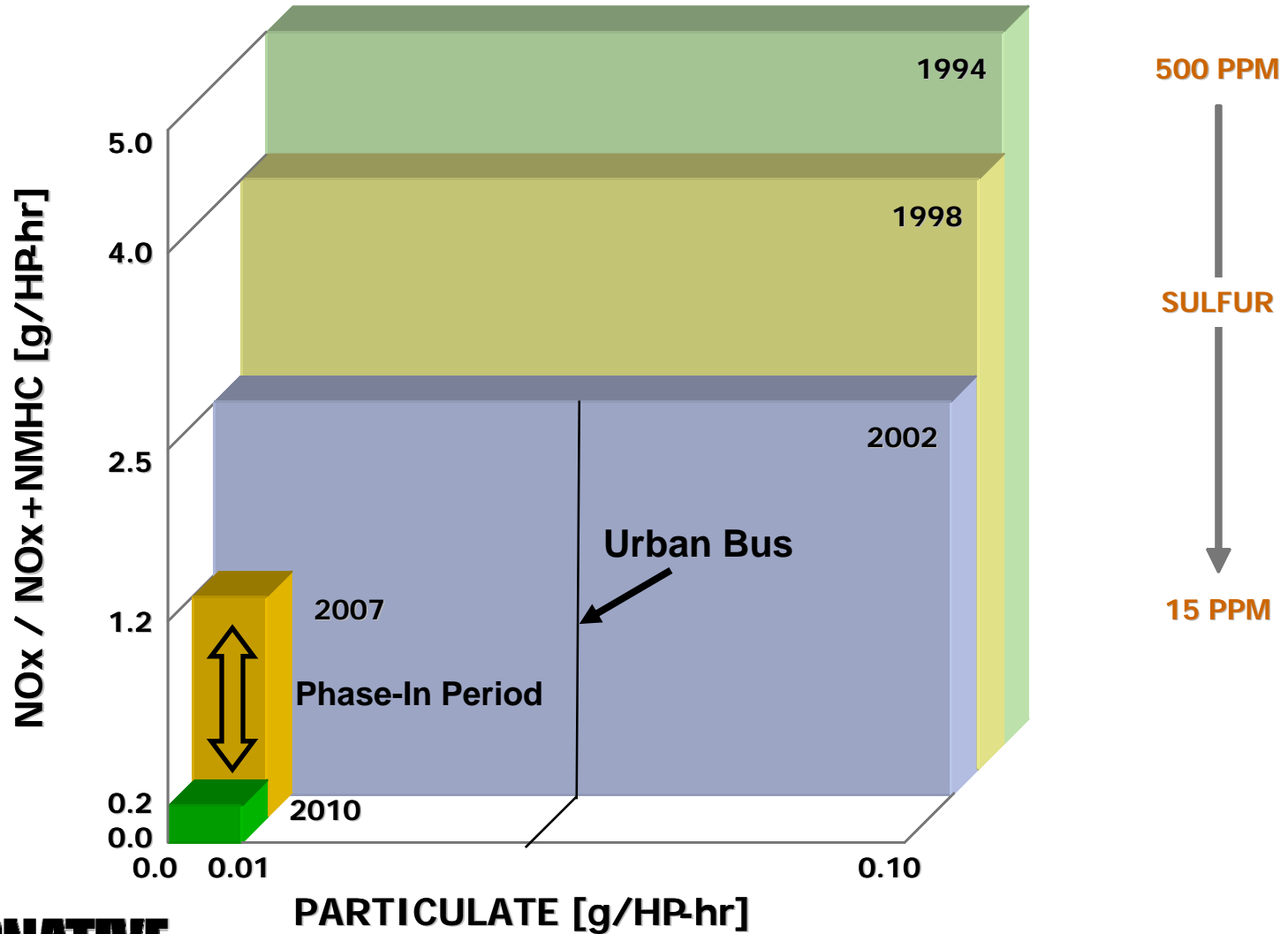


# EPA Regulated Emissions Targets





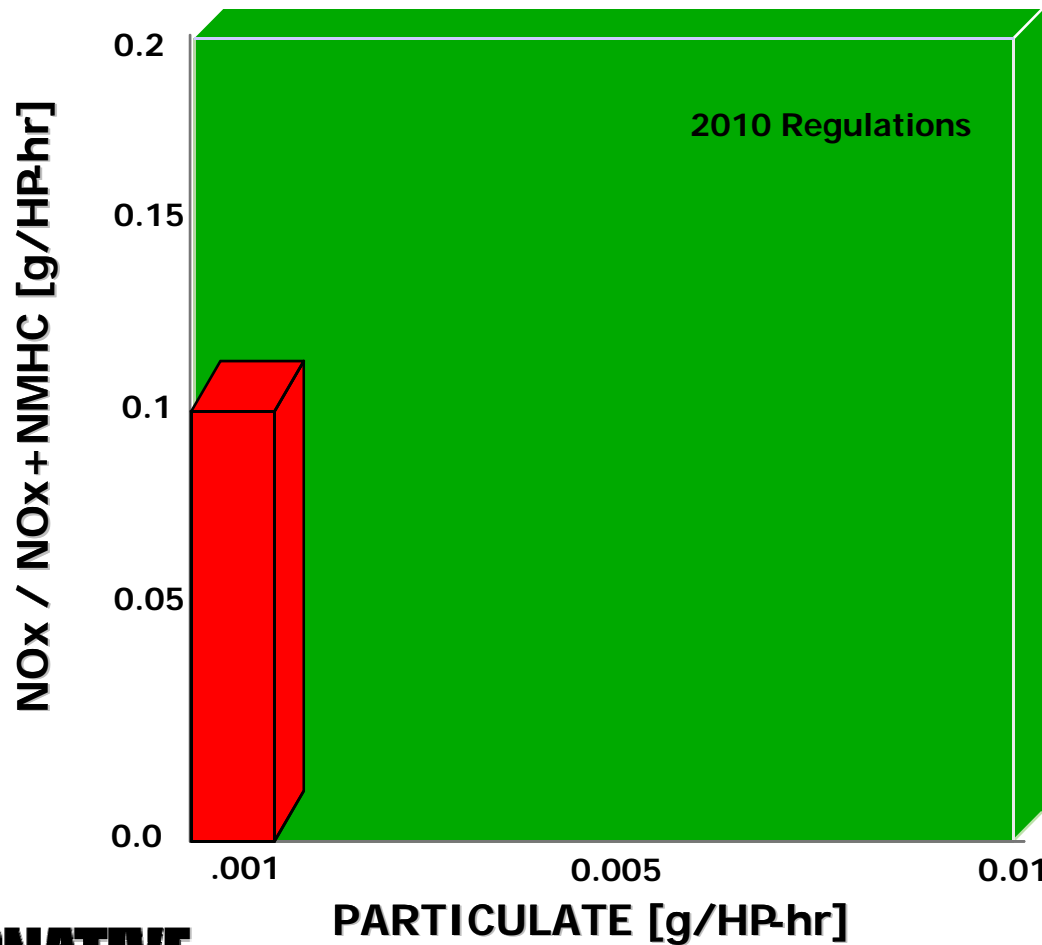
# EPA Regulated Emissions Targets



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# Where Can Stoich EGR Go?

Post 2010  
Capability



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# Where Can Stoich EGR Go?

## California Air Resources Board (CARB) Certification Reading Below the Line

|      | NMHC |      | NOx |      | CO   |      | PM    |       |
|------|------|------|-----|------|------|------|-------|-------|
|      | FTP  | EURO | FTP | EURO | FTP  | EURO | FTP   | EURO  |
| STD  | 0.14 | 0.14 | 0.2 | 0.2  | 15.5 | 15.5 | 0.01  | 0.01  |
| CERT | 0.13 | 0.04 | 0.1 | 0.01 | 1.2  | 0.4  | 0.009 | 0.000 |

FTP: Federal Test Procedure [ transient and steady state ]

EURO: Euro III European Steady-State Cycle

STD: standard or emissions test cap

CERT: certification level

# Where Can Stoich EGR Go?

## CARB Exec Order – Reading Below the Line

|      | NMHC |      | NOx |      | CO   |      | PM    |       |
|------|------|------|-----|------|------|------|-------|-------|
|      | FTP  | EURO | FTP | EURO | FTP  | EURO | FTP   | EURO  |
| STD  | 0.14 | 0.14 | 0.2 | 0.2  | 15.5 | 15.5 | 0.01  | 0.01  |
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# What is over the Horizon ?

- LCNG
- LFG to LNG
- HCNG









# NA GHG Life Cycle Assessment Models

- **REET**
  - Background
    - Greenhouse gases, regulated, emission and energy use in transportation (REET) is a US based model
    - Created by Dr Michael Wang and the Argonne national laboratory
  - Limitations
    - Models light duty vehicles (GVW between 6,000-8,500 lbs)
    - V 1.7 has U.S data only
    - No regional capabilities
- **LEM**
  - Background
    - Created by Mark Deluchhi from the University of California, Davis
    - Many different vehicle pathways - mini buses, scooters, bikes, light/heavy duty vehicles)
  - Limitations
    - Does not have many alternative fuel pathways
    - Does not have detailed contaminant outputs
- **GHGenius**
  - Background
    - Developed for NR Can (Natural Resources Canada)
    - Derivative of LEM
    - Can model regional areas in Canada, US, Mexico and India
    - Has many fuel pathways



# GHG Well to Wheel for Urban Bus - GH Genius

## Post 2010 Results (Vancouver, Canada)

|             | Extraction  | Processing   | Transportation and storage  | End user  | Total        |
|-------------|---|--|---|---|--------------|
| Natural Gas | <br>115 g/km   | <br>49.5 g/km   | <br>53.9 g/km | <br>1,183.9 g/km | 1,402.4 g/km |
| Diesel      | <br>268.8g/km | <br>179.5 g/km | <br>9.7 g/km | <br>1,353.7g/km | 1,811.7 g/km |

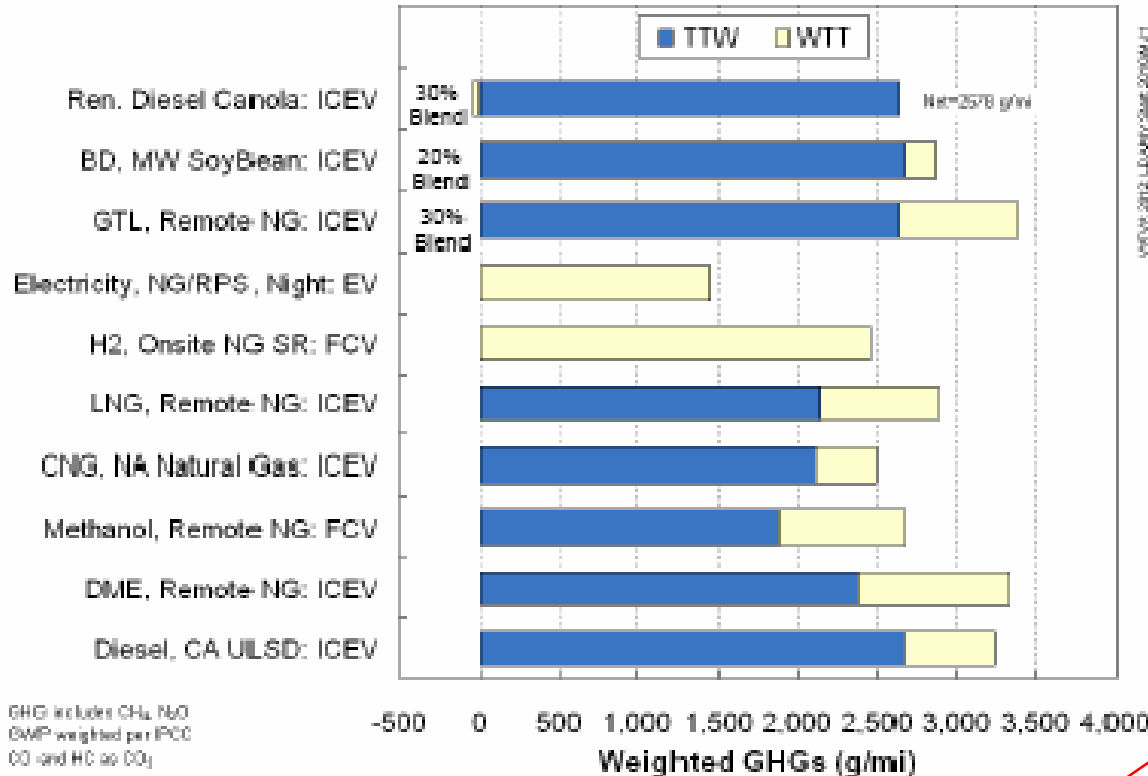
22.6% GHG reduction

Including vehicle material and assembly - 21.9% GHG

Source: [http://www.nrcan.gc.ca/es/etb/ctfca/PDFs/GHGenius/gh\\_genius\\_pamphlet0405\\_e.html](http://www.nrcan.gc.ca/es/etb/ctfca/PDFs/GHGenius/gh_genius_pamphlet0405_e.html)

# GHG - Bio Fuel Impact

## The road to a clean and energy sustainable world?



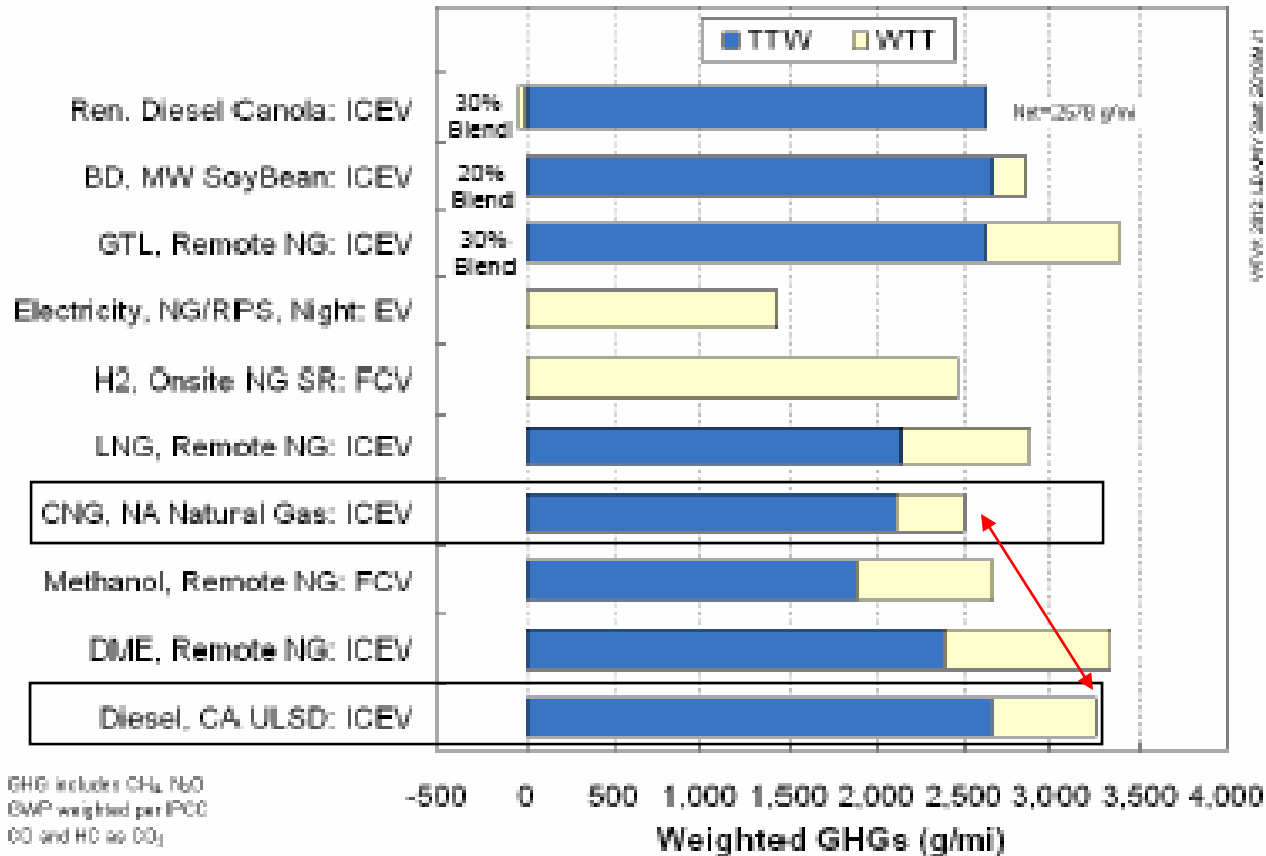
Bio Fuel improves GHG impact:  
**Biomethane: 75-200% reduction**

Source: [http://www.nasca.org.uk/assets/biogas\\_as\\_transport\\_fuel\\_june06.pdf](http://www.nasca.org.uk/assets/biogas_as_transport_fuel_june06.pdf)

**CNG - 22 - 23% GHG reduction**

# GHG Well to Wheel for Urban Bus - GREET

## 2012 Results (California)



22 - 23% GHG reduction

Source: CEC-600-2007-004-REV

# Conclusions

- The economics of vehicle operations are shifting
- Energy/Highway Bill funding makes Natural Gas a Bargain.
- NG fuel prices can be significantly lower than diesel
- Some businesses will profit from the opportunity.

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**Chris Young**  
**[Chris.young@cummins.com](mailto:Chris.young@cummins.com)**