



After Diesel: Options for Cleaner Trucks, Trains, and Ships

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Southwest Research Institute

Transportation – land Use – Environment Connection

Lake Arrowhead - California

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Outline

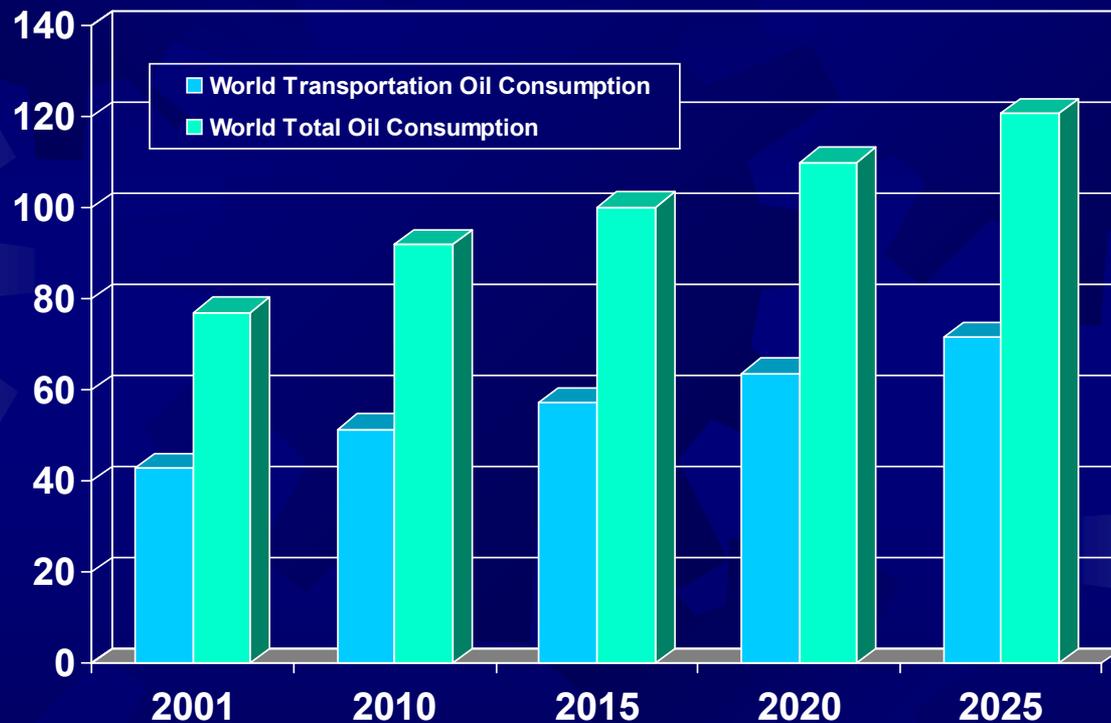
- ★ The Energy Supply Factor
- ★ The Environmental Factor
- ★ The Technology Factor
- ★ The Economical Factor
- ★ Transportation Technology Projections
- ★ Introducing the HEDGE Concept
- ★ Summary/Conclusion



The Energy Supply Factor



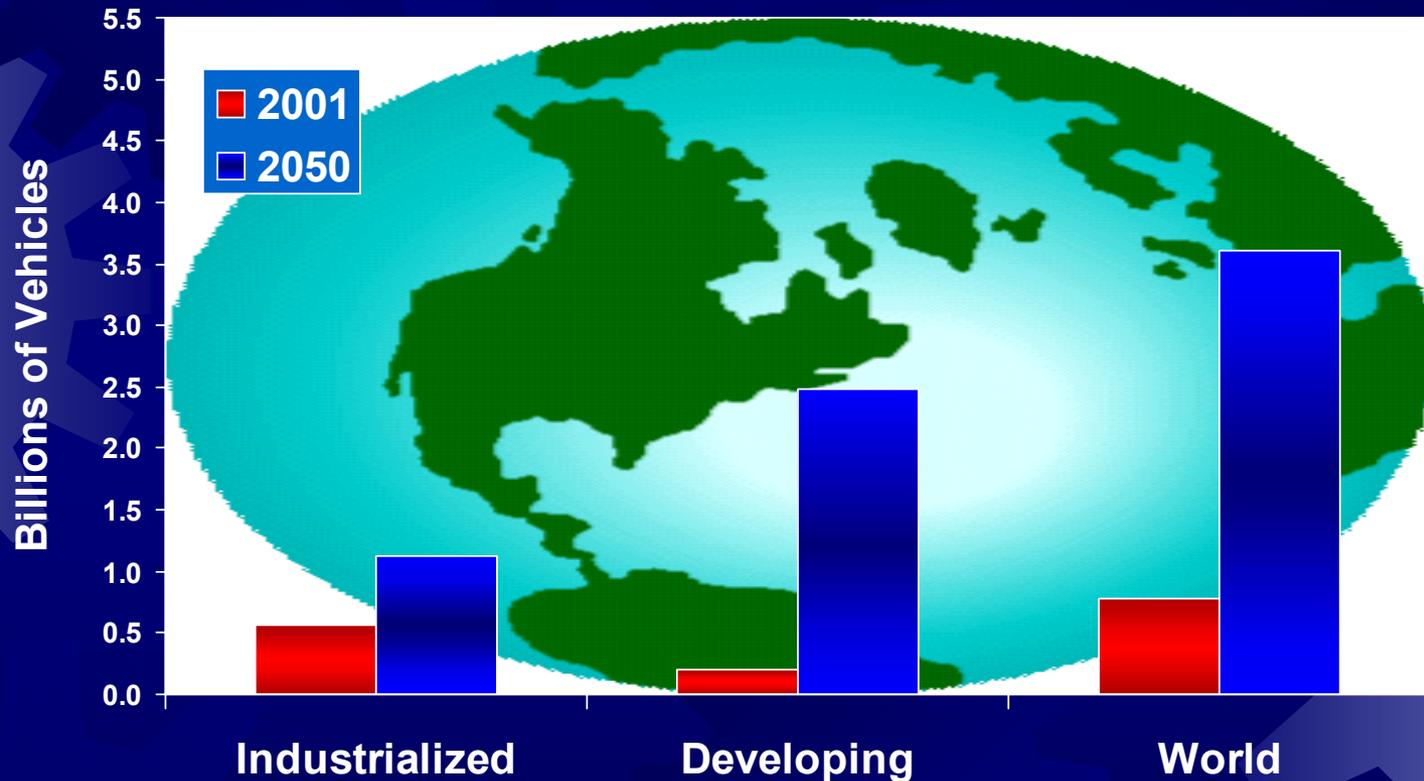
Projection for Oil Demand



Source: EIA International Energy Outlook 2003, 2004 (DOE/EIA-0484 (2003), DOE/EIA-0484 (2004))



The Role of Developing Countries



Source: EE Analytic Team



The Rising Cost of Energy

Prices for Oil Head Back to Record Levels

Saudi Call for More Output Does Not Impress Markets

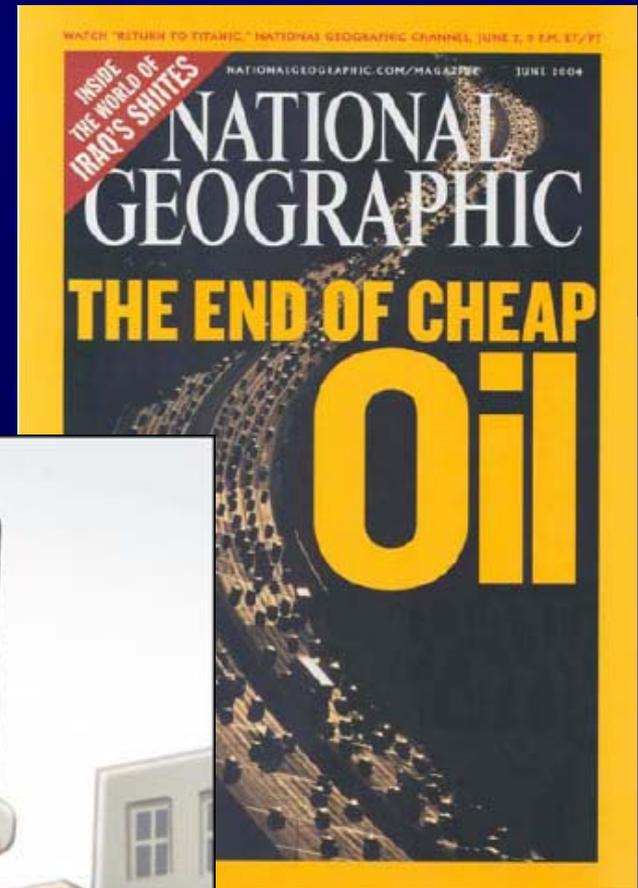
By JONATHAN WEISMAN
Washington Post Staff Writer

Oil prices climbed back into record territory yesterday after energy traders slung off pledges by Saudi Arabia to increase production and focused instead on OPEC discord and the shutdown of a major oil platform in the Gulf of Mexico.

Gasoline prices, meanwhile, continued their steady upward march. Pump prices for regular unleaded gasoline increased 4.7 cents in the past week, to a national average price of \$2.064 a gallon, the Energy Department's Energy Information Administration said yesterday.

Regular unleaded prices rose nearly a penny in Maryland to an average of \$2.015, while Virginia prices climbed 1 cent to \$1.934, according to the AAA motor club survey. Experts said it's likely gasoline prices will keep rising as the United States heads into the vacation-heavy summer driving season, re-

“Experts said it’s likely gasoline prices will keep rising...”



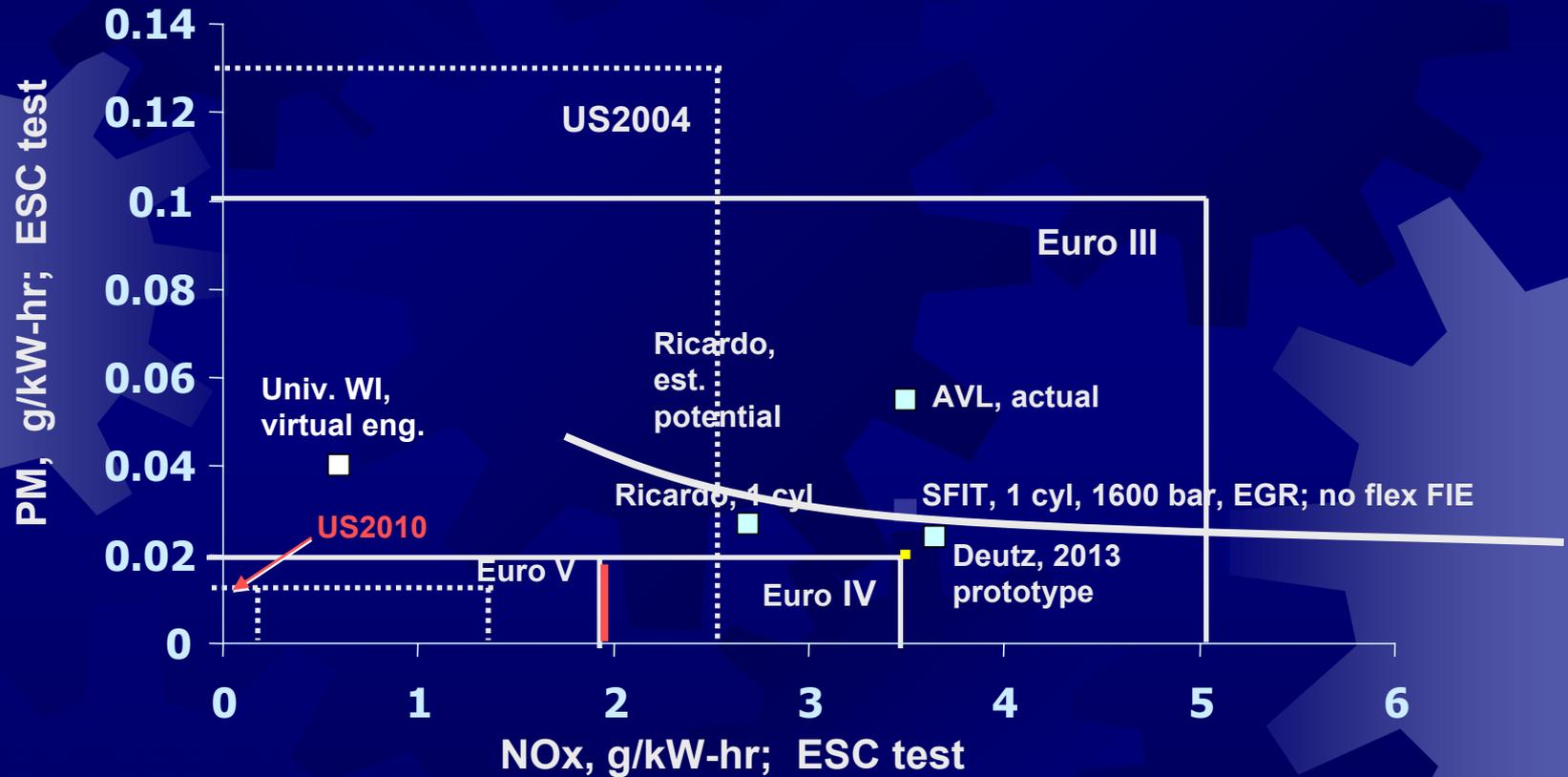
The Environmental Factor



Communities Around the World Are Demanding Clean Air



Regulatory Agencies Are Responding With Tight Limits



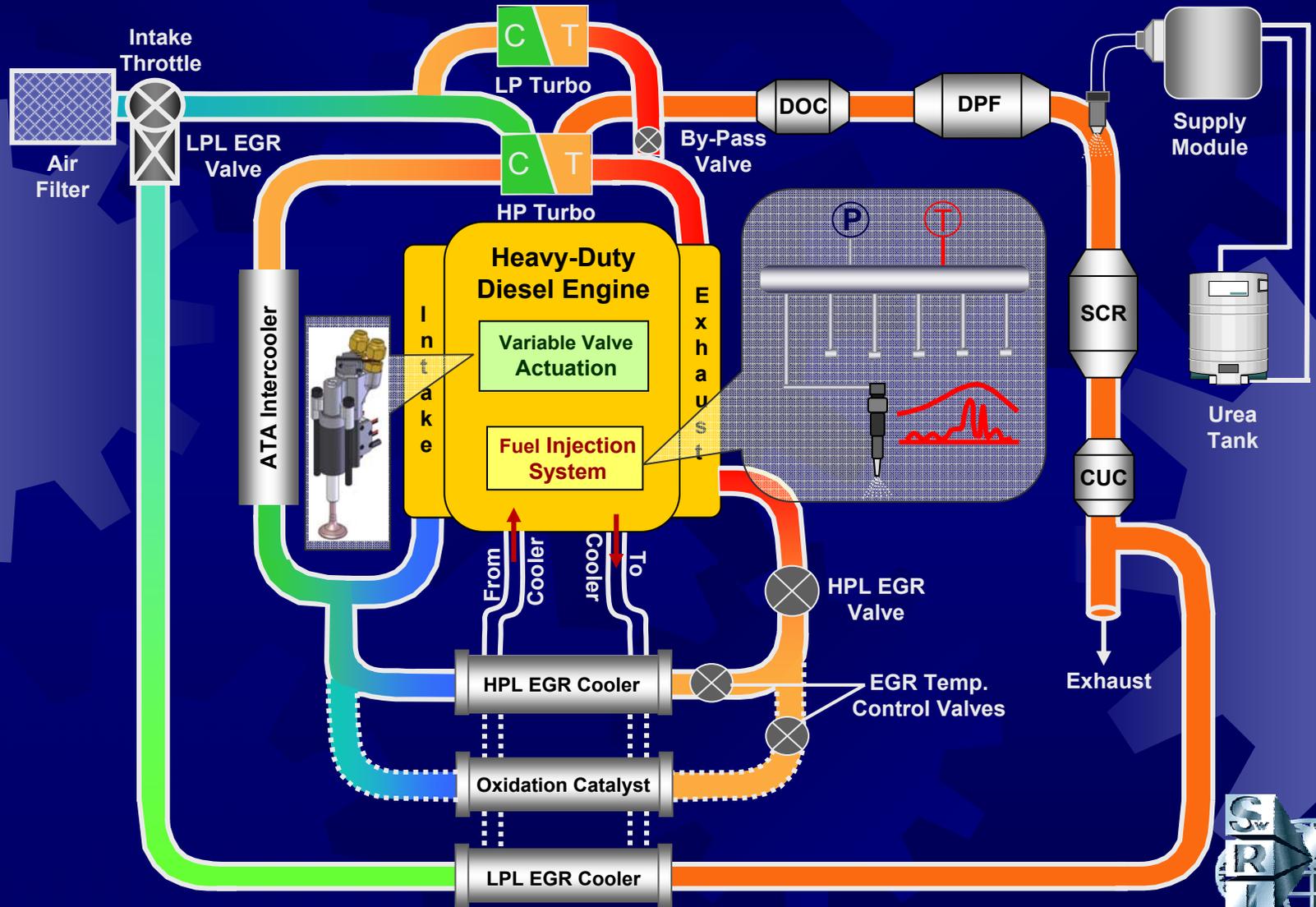
Japan 2005 = Euro V (2008)
Magdi Khair October 2006



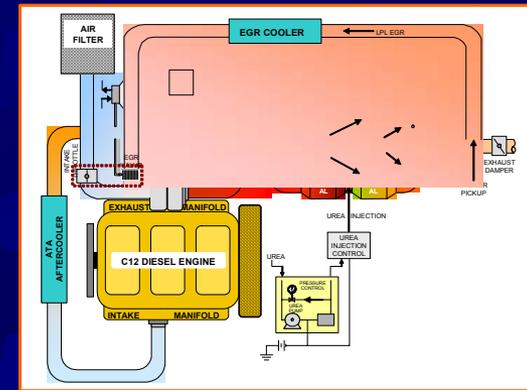
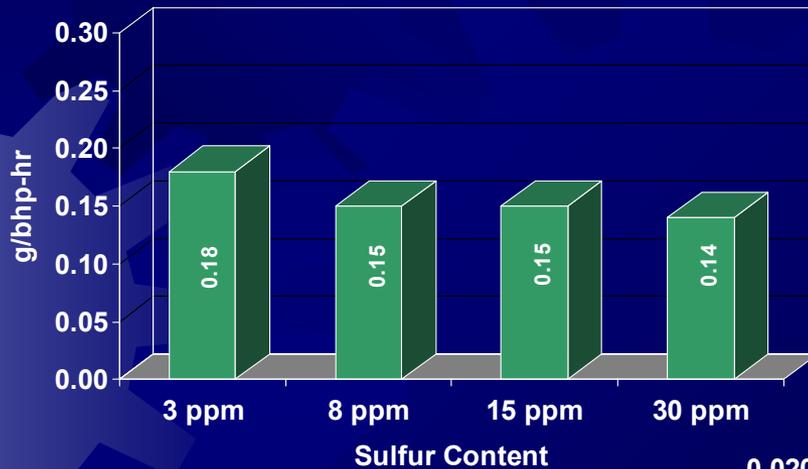
The Technology Factor



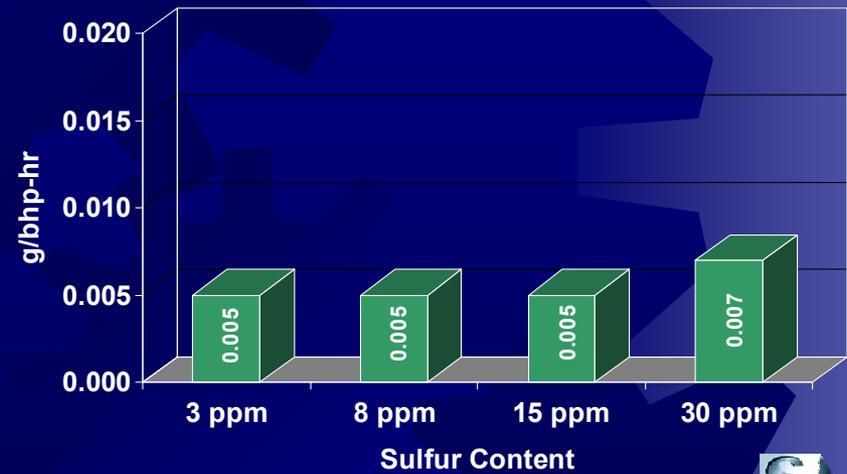
Evolution of Diesel Technology



Are Diesels Capable of Extremely Low Emissions?



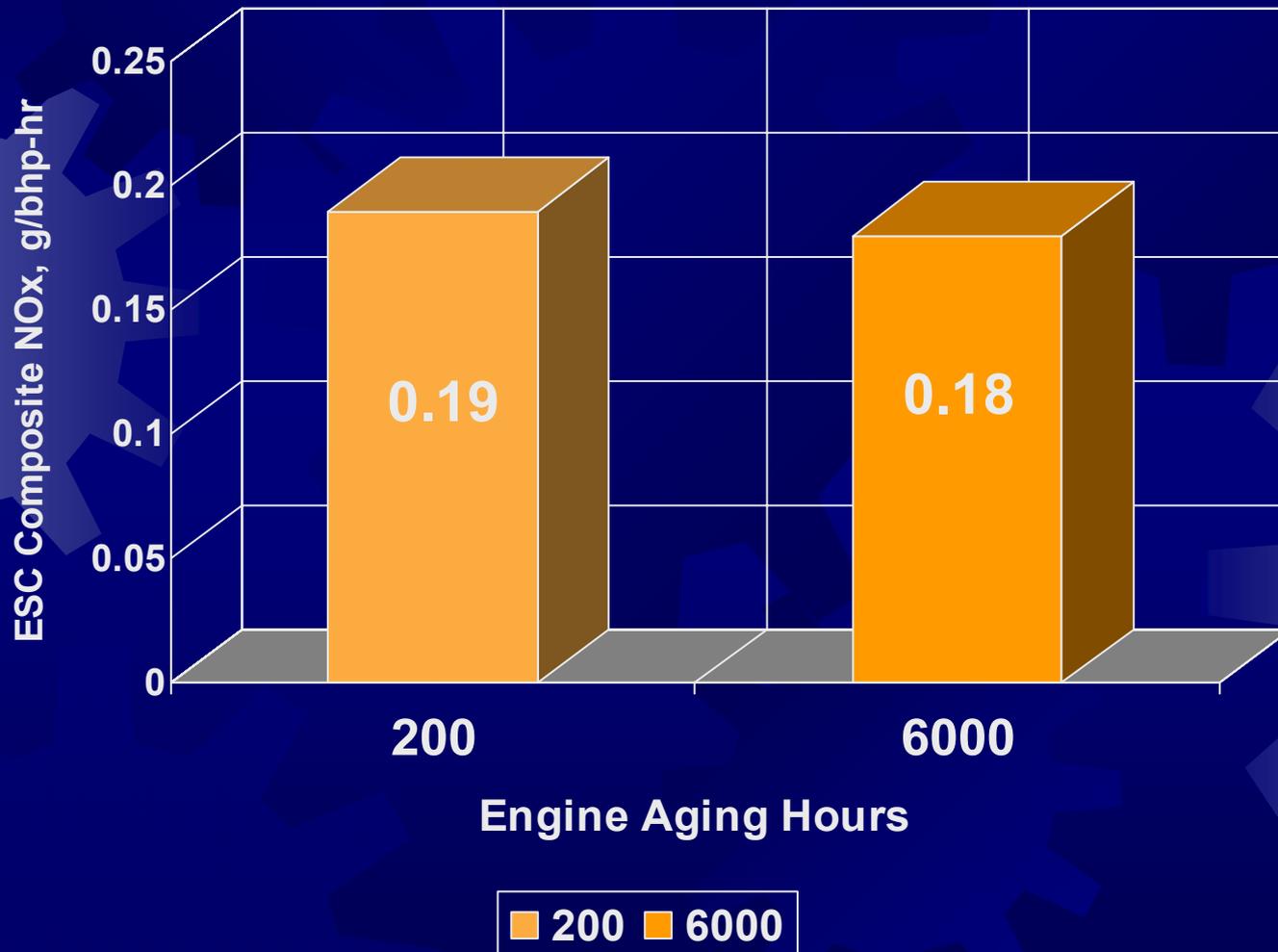
2010 = 2007 + SCR



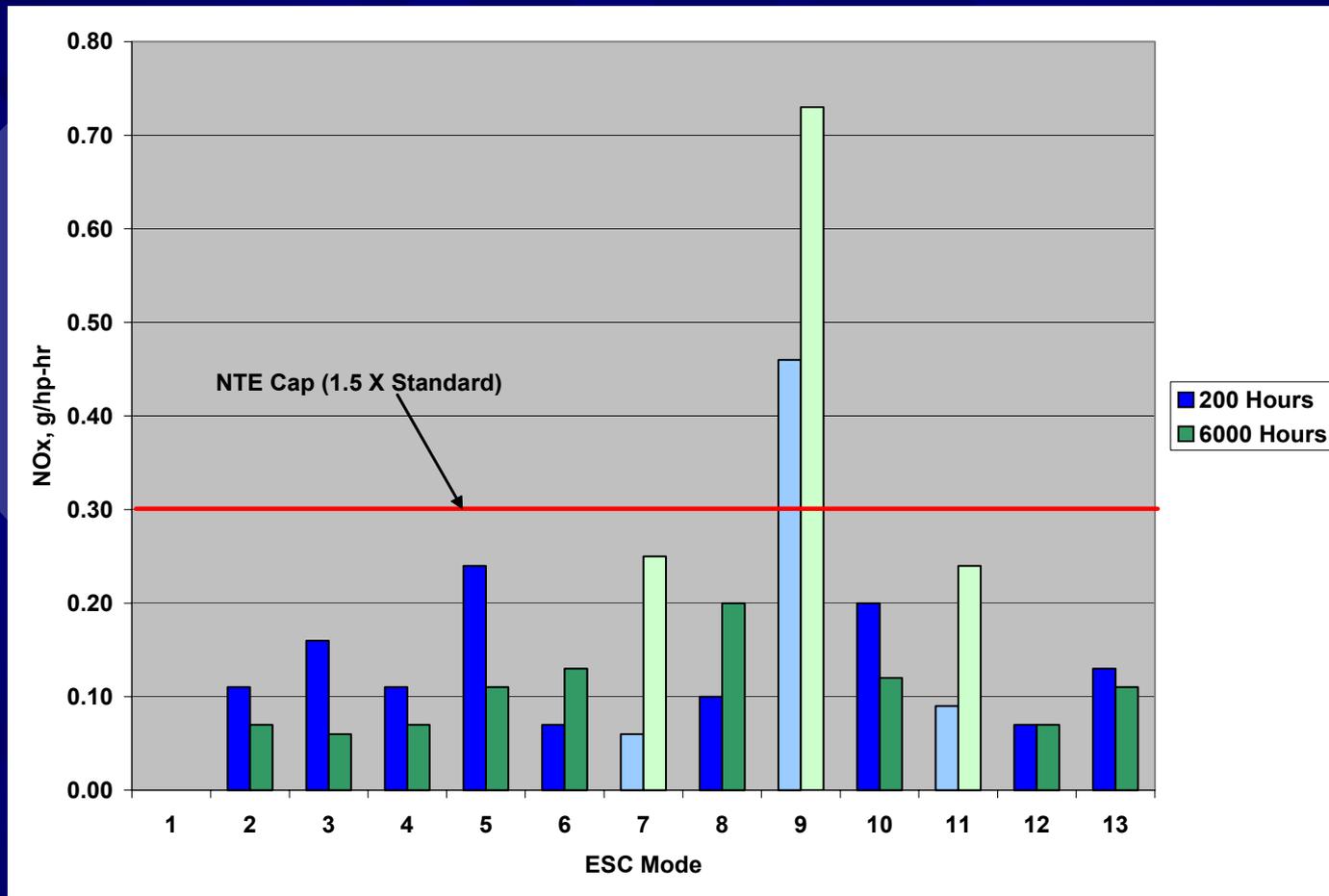
APBF-DEC Heavy-Duty SCR Project



How About Emission Control System Durability?



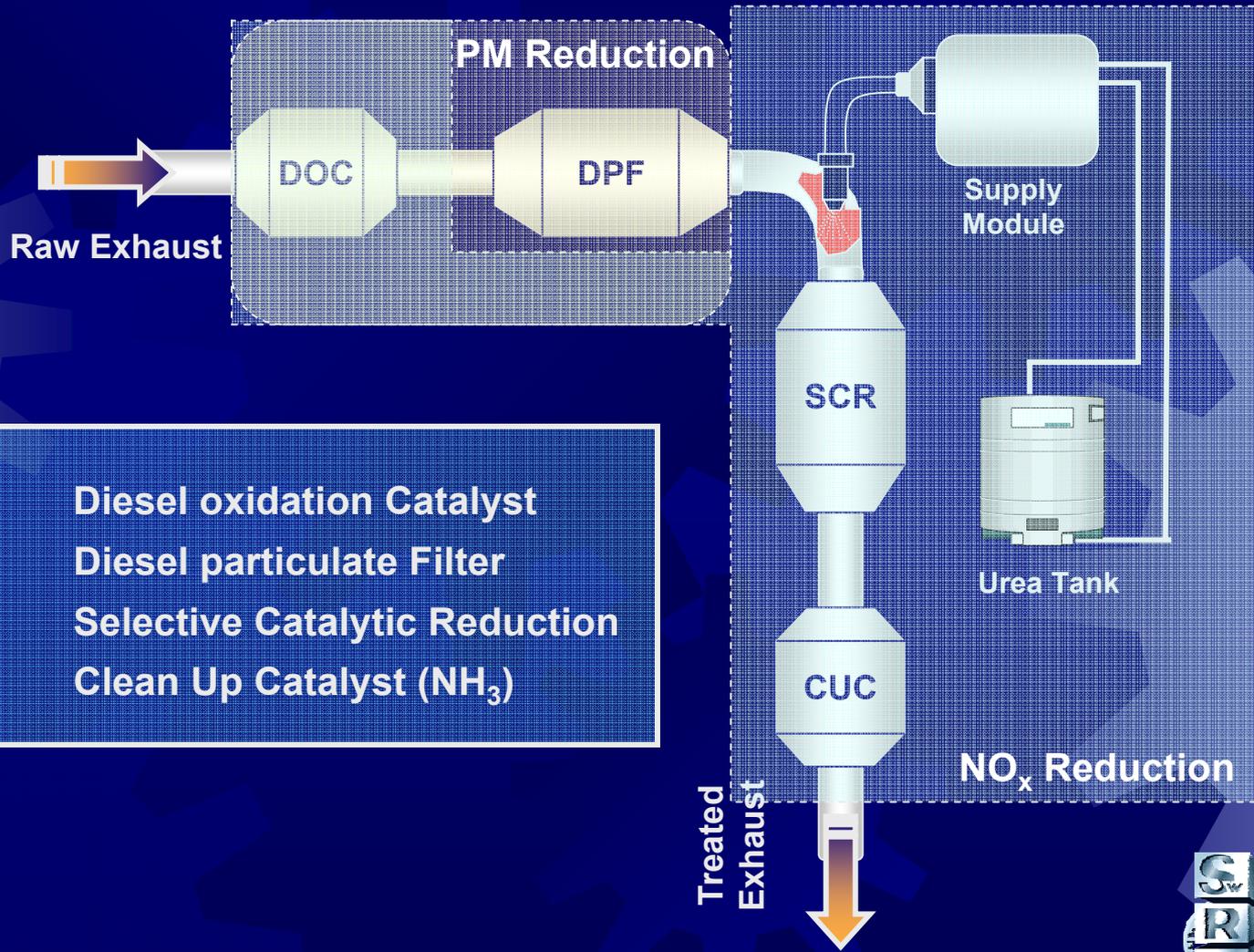
How About The Not-To-Exceed Regulatory Constraints?



The Economical Factor



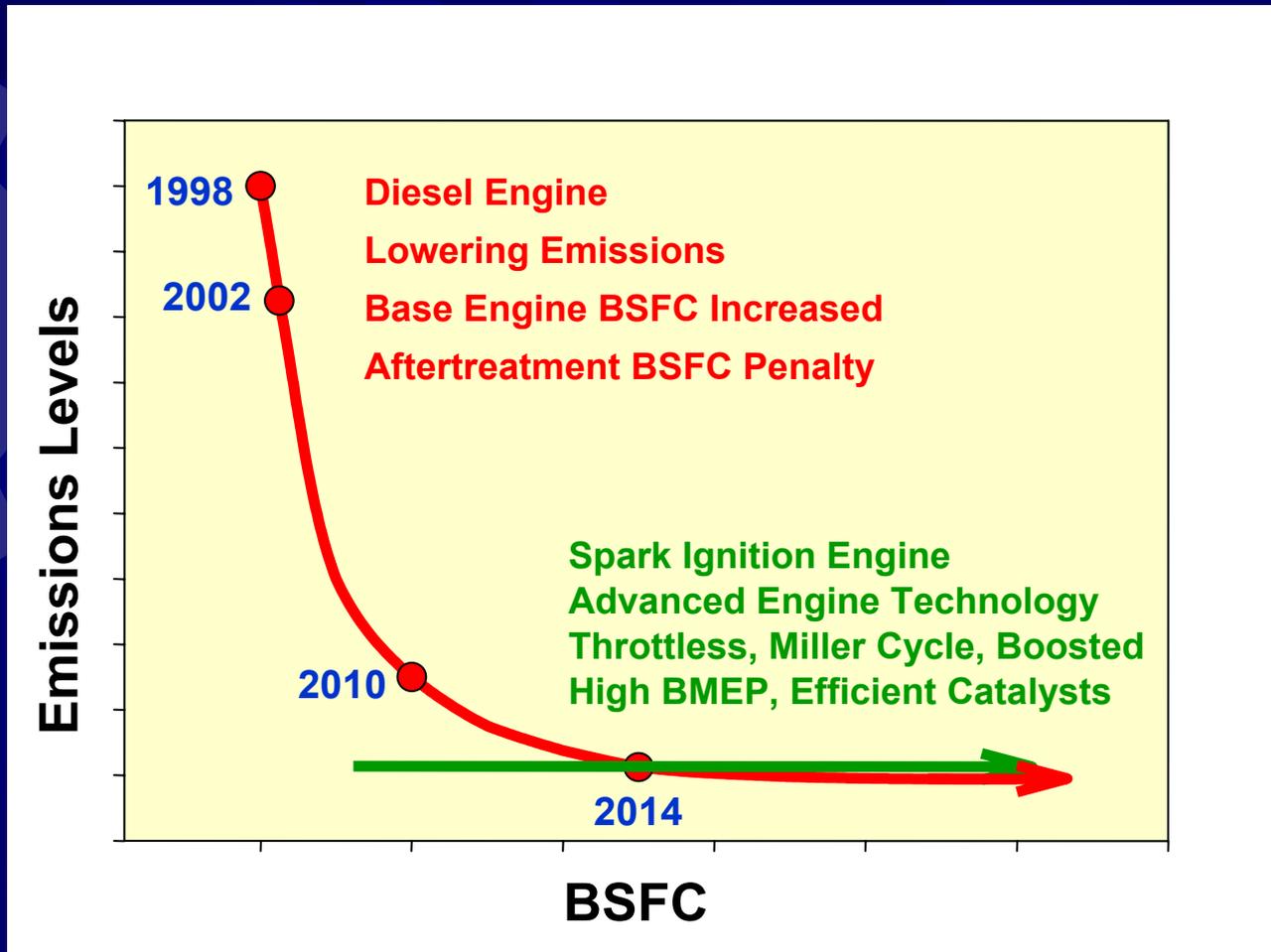
What it Takes to Make it Work?



- DOC: Diesel oxidation Catalyst
- DPF: Diesel particulate Filter
- SCR: Selective Catalytic Reduction
- CUC: Clean Up Catalyst (NH₃)



At What Emissions Level Do Efficiencies Converge?



Cost Analysis of Diesel Controls

<u>Technology</u>	<u>2002/2004</u>	<u>2007</u>	<u>2010</u>	<u>2014</u>
VGT/Boost	500	1500	1500	1500
EGR Valve	150	150	150	150
EGR Cooler	200	200	200	200
Advanced Injection	500	500	500	500
Variable Valves	NA	NA	700	1200
PM Filter	NA	1800	1800	1800
LNT	NA	NA	1800	2000
Controls	300	300	400	800
Actuator/Sensors	200	250	350	500
TOTALS	\$1850	\$4700	\$7400	\$8650



Transportation Technology Projections



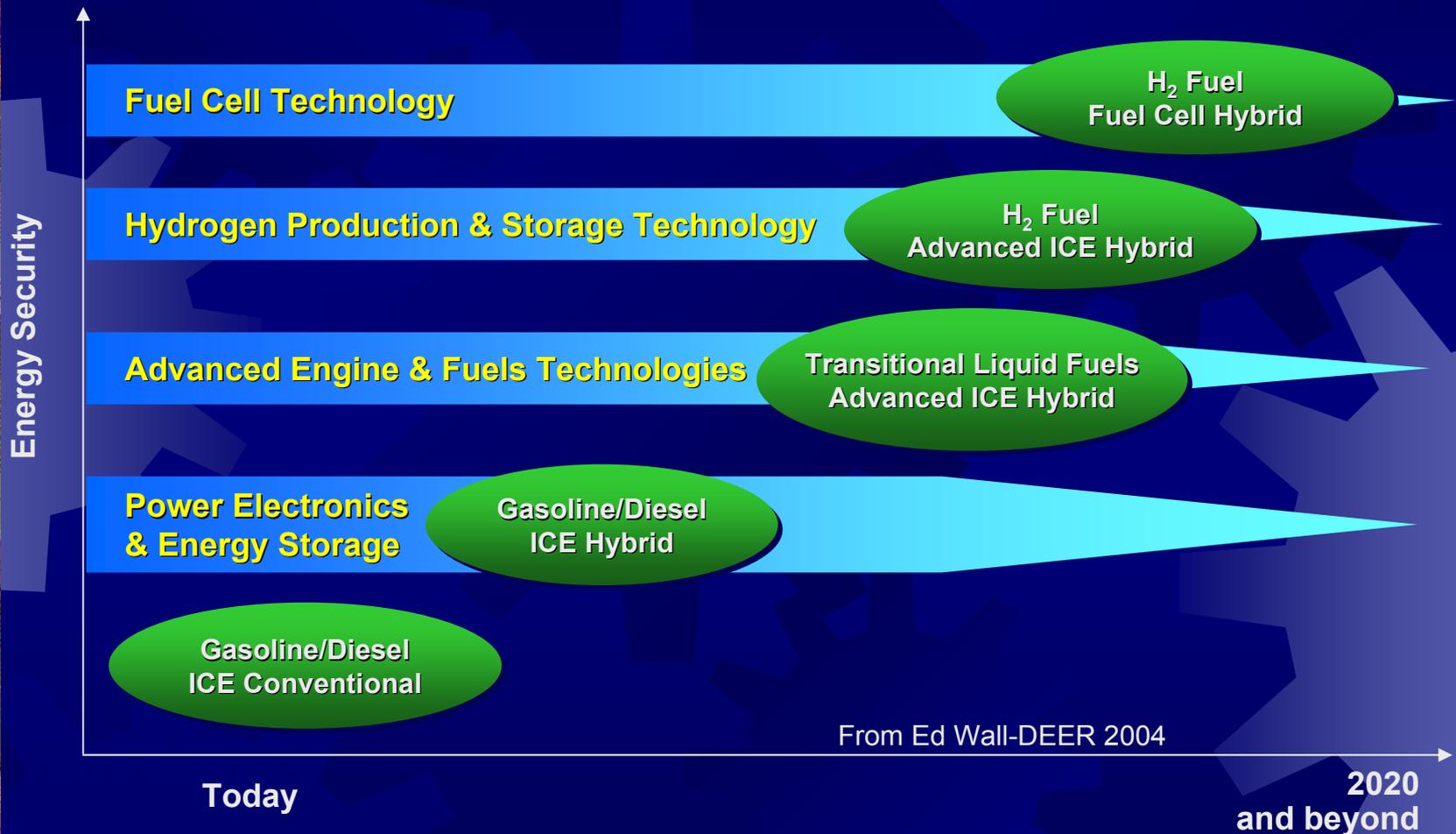
What is Needed for the Future

A prosperous future where energy is clean, abundant, reliable, and affordable.

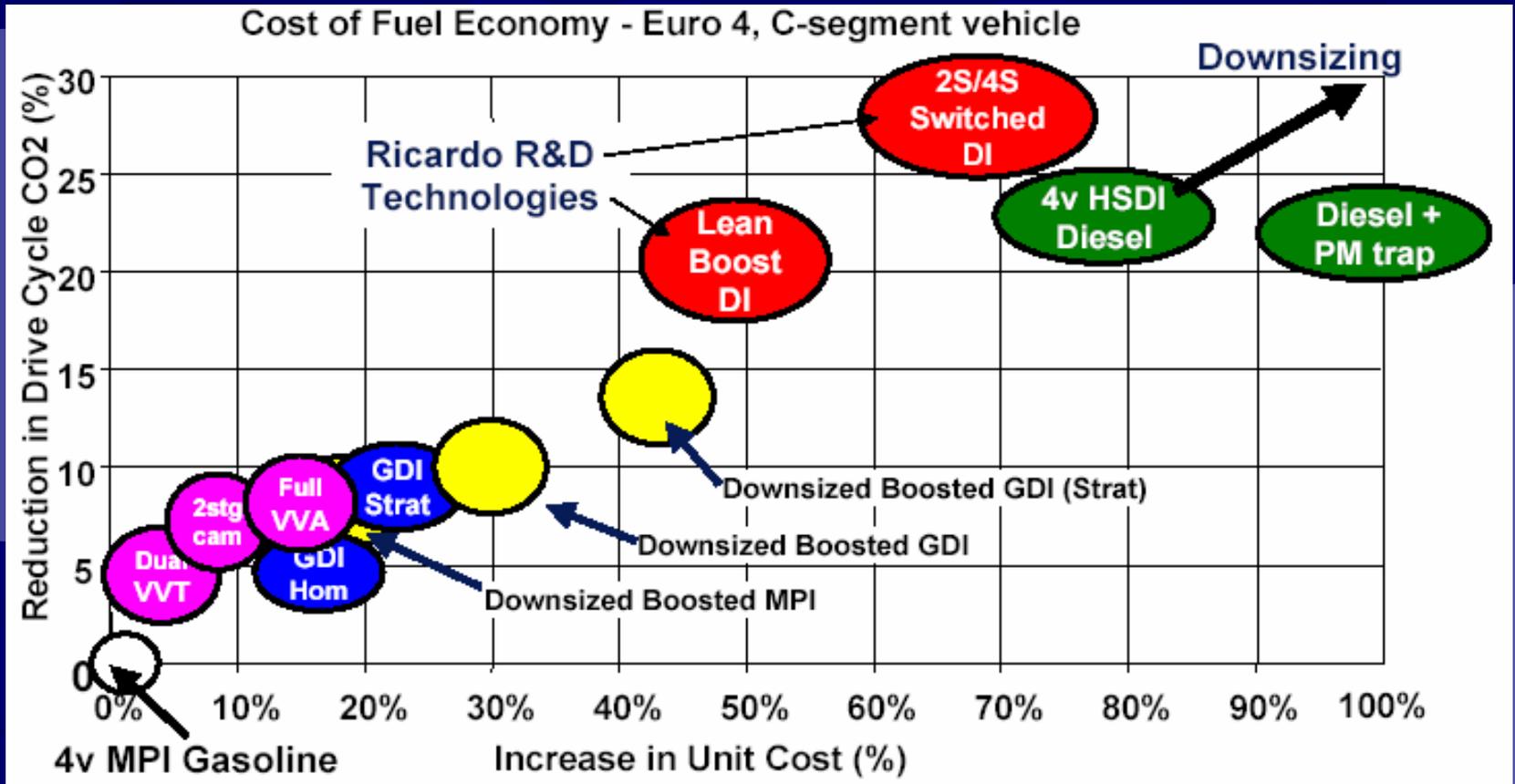
Specifically, an energy future where: ... *Our trucks, trains, & ships* will be more efficient and will be powered by a variety of clean domestic fuels and technologies that free us from dependence on foreign supplies of energy.



A Long Term Projection



An Evolutionary Type Projection



Introducing the HEDGE Concept

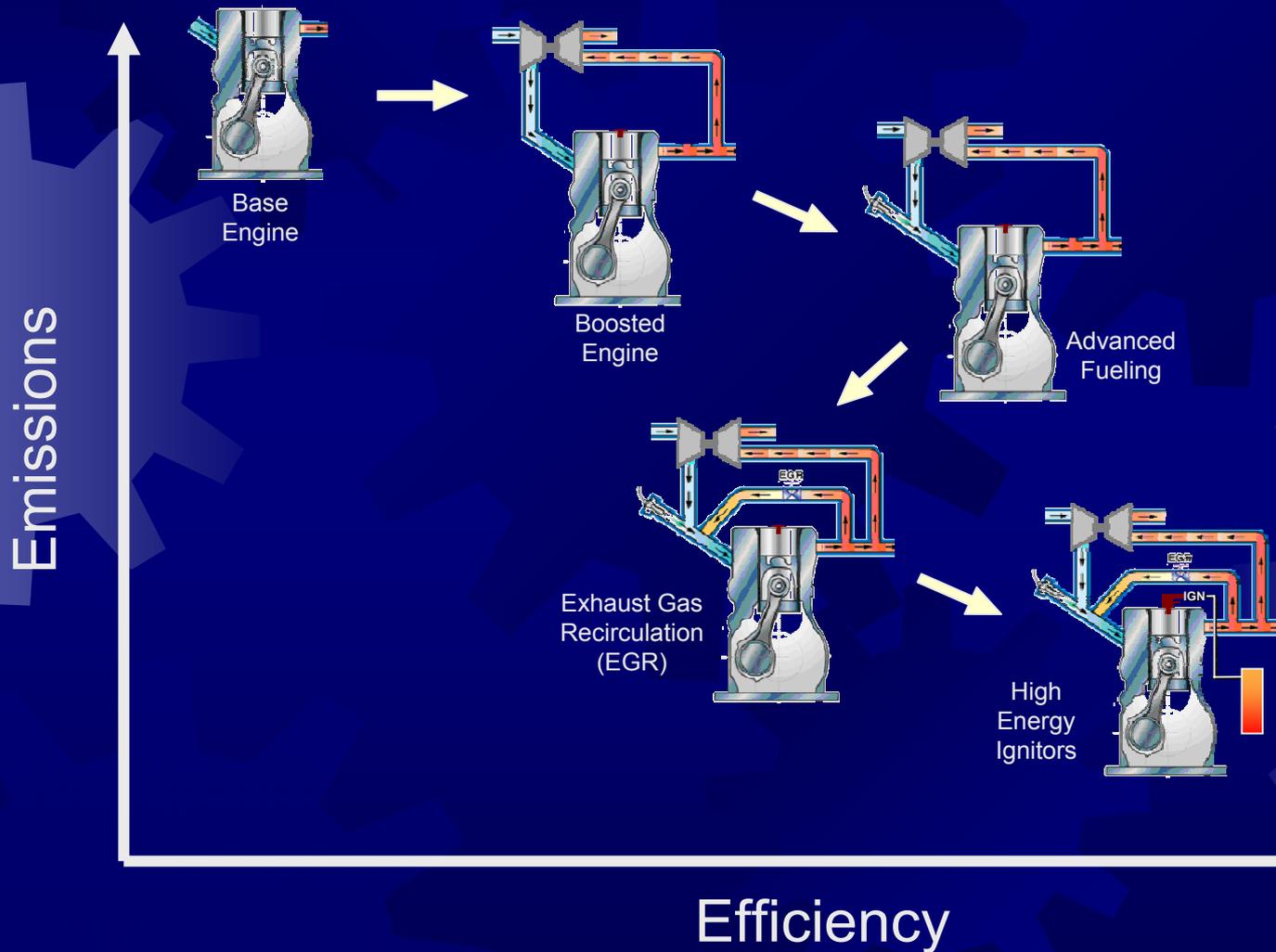


What is HEDGE?

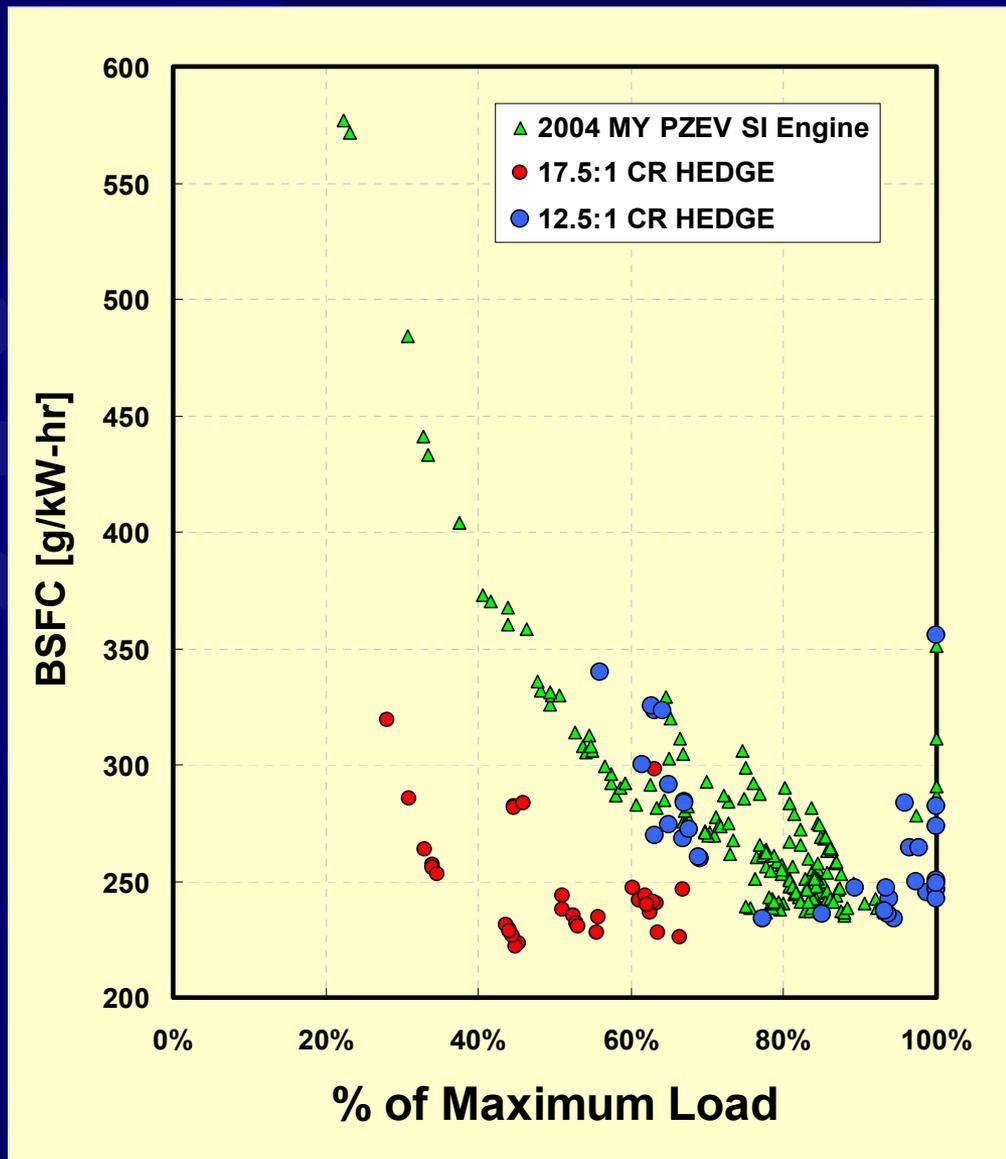
- ★ High Efficiency Dilute Gasoline Engine
- ★ Inheriting Some of the Gasoline Low Emissions Attributes
- ★ Inheriting Some of Diesel's High Efficiency Attributes
- ★ Benefiting From Existing Fuel Infrastructure
- ★ Incremental/Evolutionary Technology Change
- ★ Cost Advantage Potential
- ★ Using Existing manufacturing Infrastructure



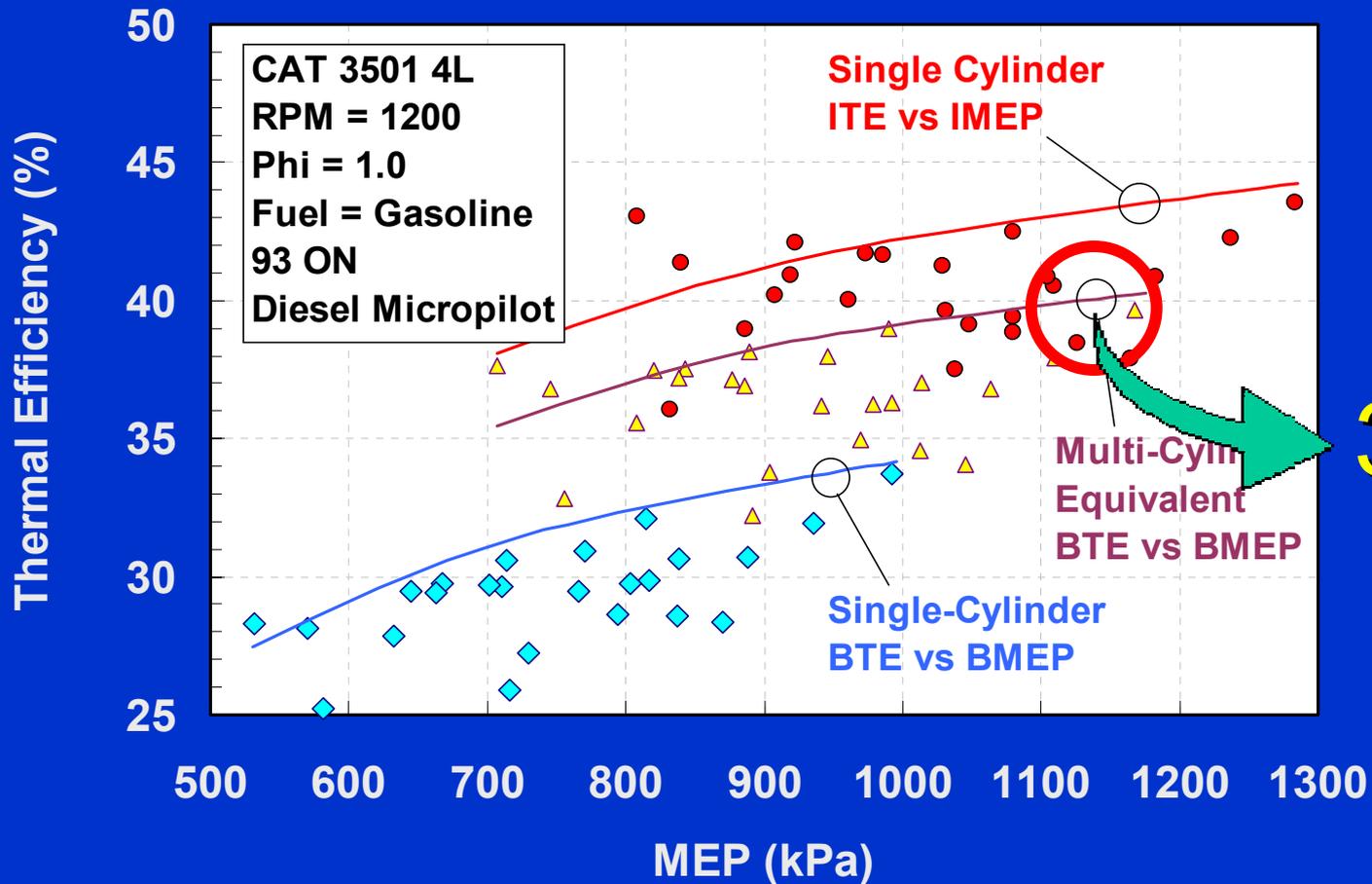
Description of HEDGE



Early Results Prove Concept Validity



HEDGE Thermal Efficiency



Summary & Conclusions



Summary & Conclusions

- **There is Global Pressure on Energy Supply**
- **Developing Countries Continue to Exert Pressure on the Energy Supply as They Evolve Into Industrialization**
- **The Quest For Cleaner Air is Adding Pressure Onto Future Transportation Technologies**
- **While Long Term May Be For Fuel Cell & Hydrogen Economy, Short and Mid-Term Solutions Will Be Evolutionary**
- **SwRI's HEDGE Concept is Proving That Diesel's Economy at Gasoline's Low Emissions Levels Are Achievable**



Thank You



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