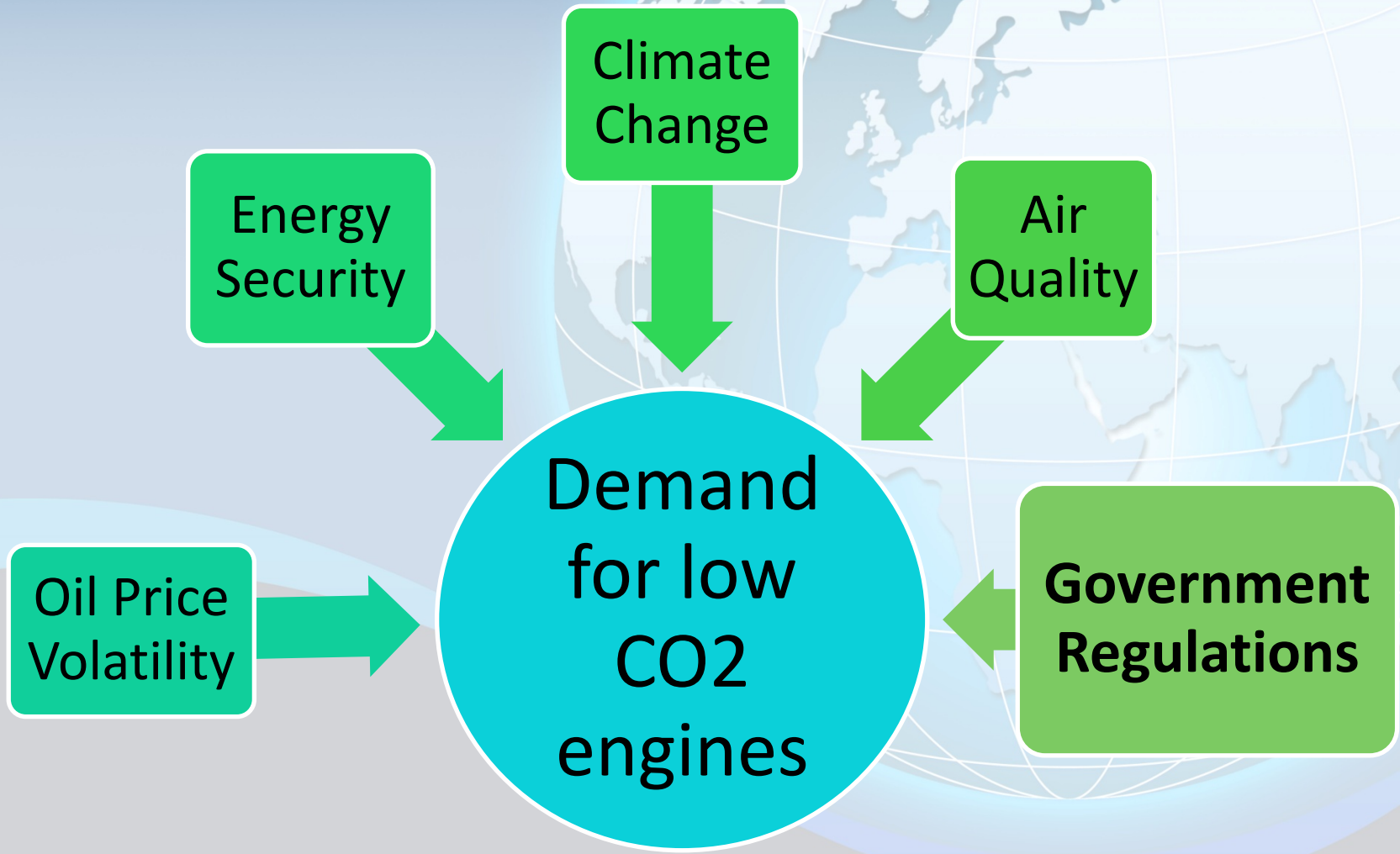
Developments in High Efficiency Engine Technologies

DEER 2012

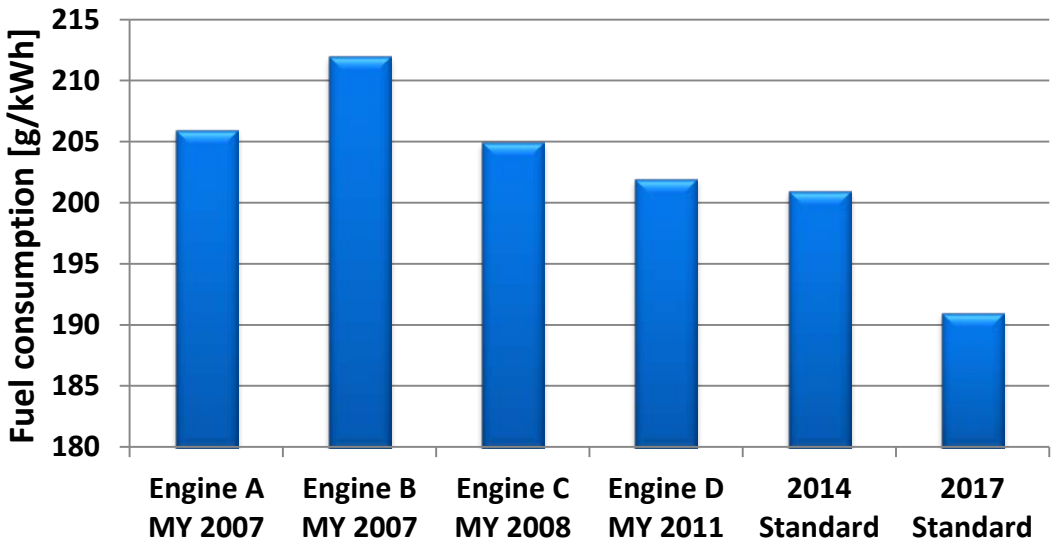
Southwest Research Institute®

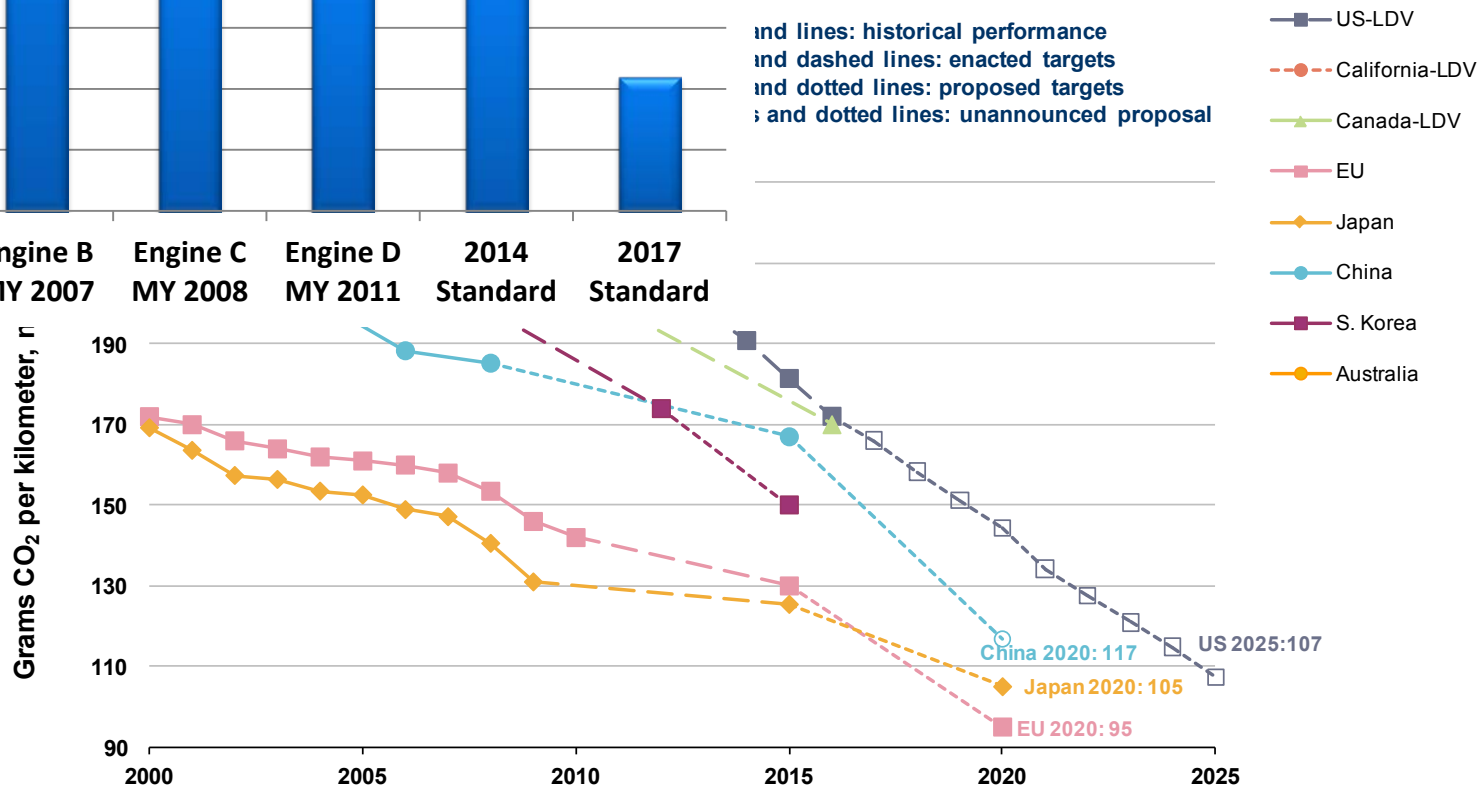
San Antonio, Texas

Drivers for High Efficiency



CAFE – not just for light duty anymore

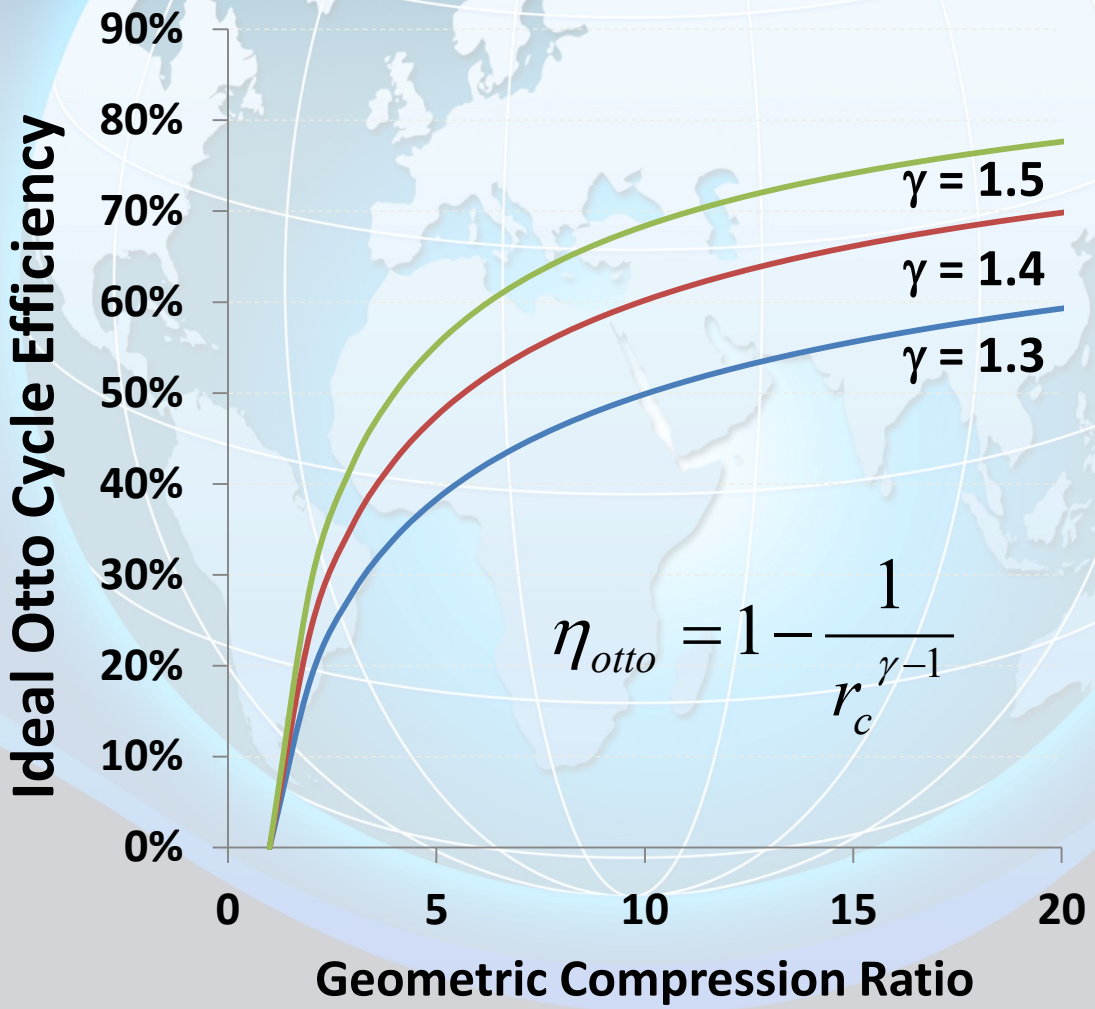




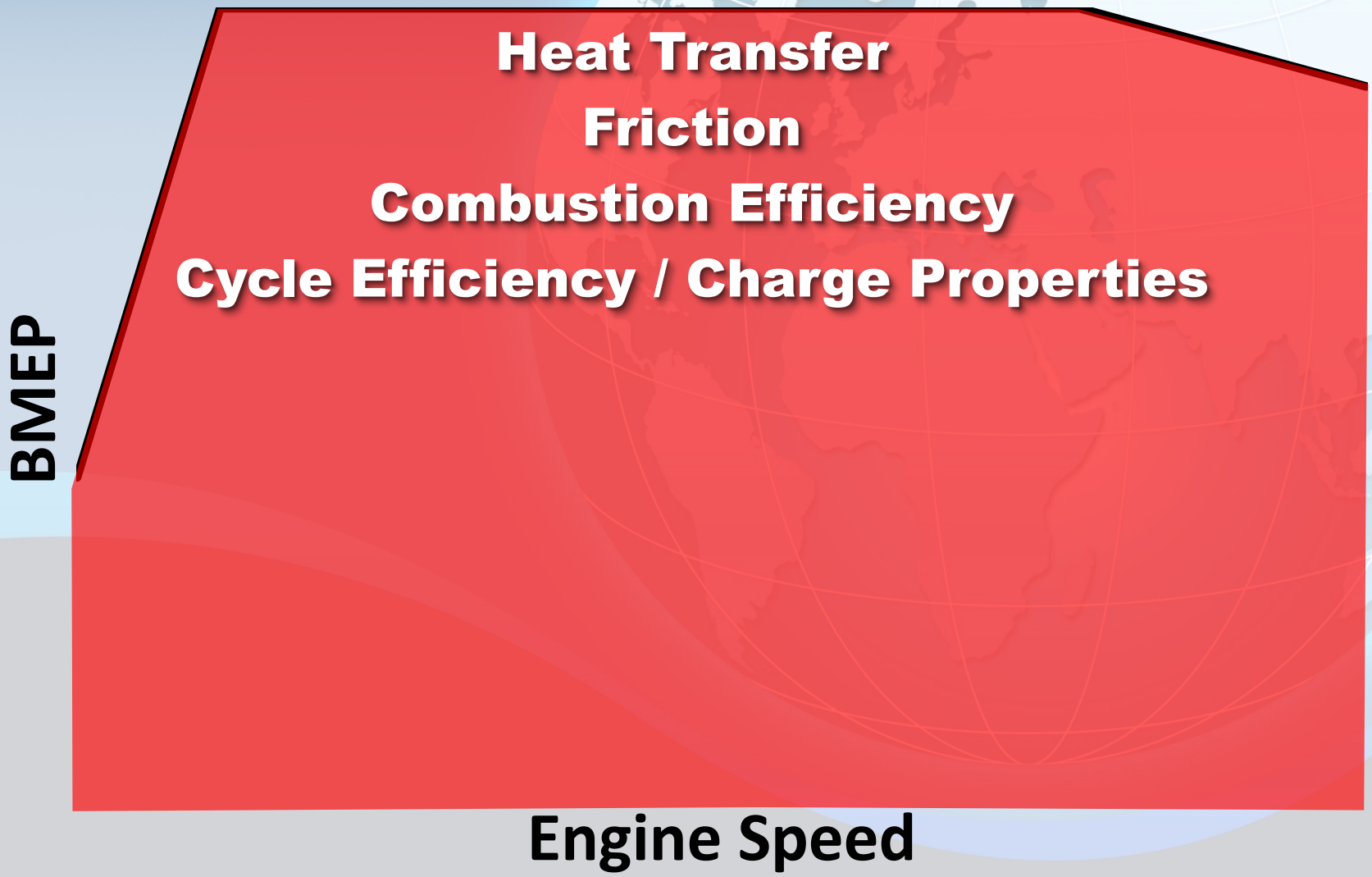
[1] China's target reflects gasoline fleet scenario. If including other fuel types, the target will be lower.
[2] US and Canada light-duty vehicles include light-commercial vehicles.

Fundamental Efficiency Drivers

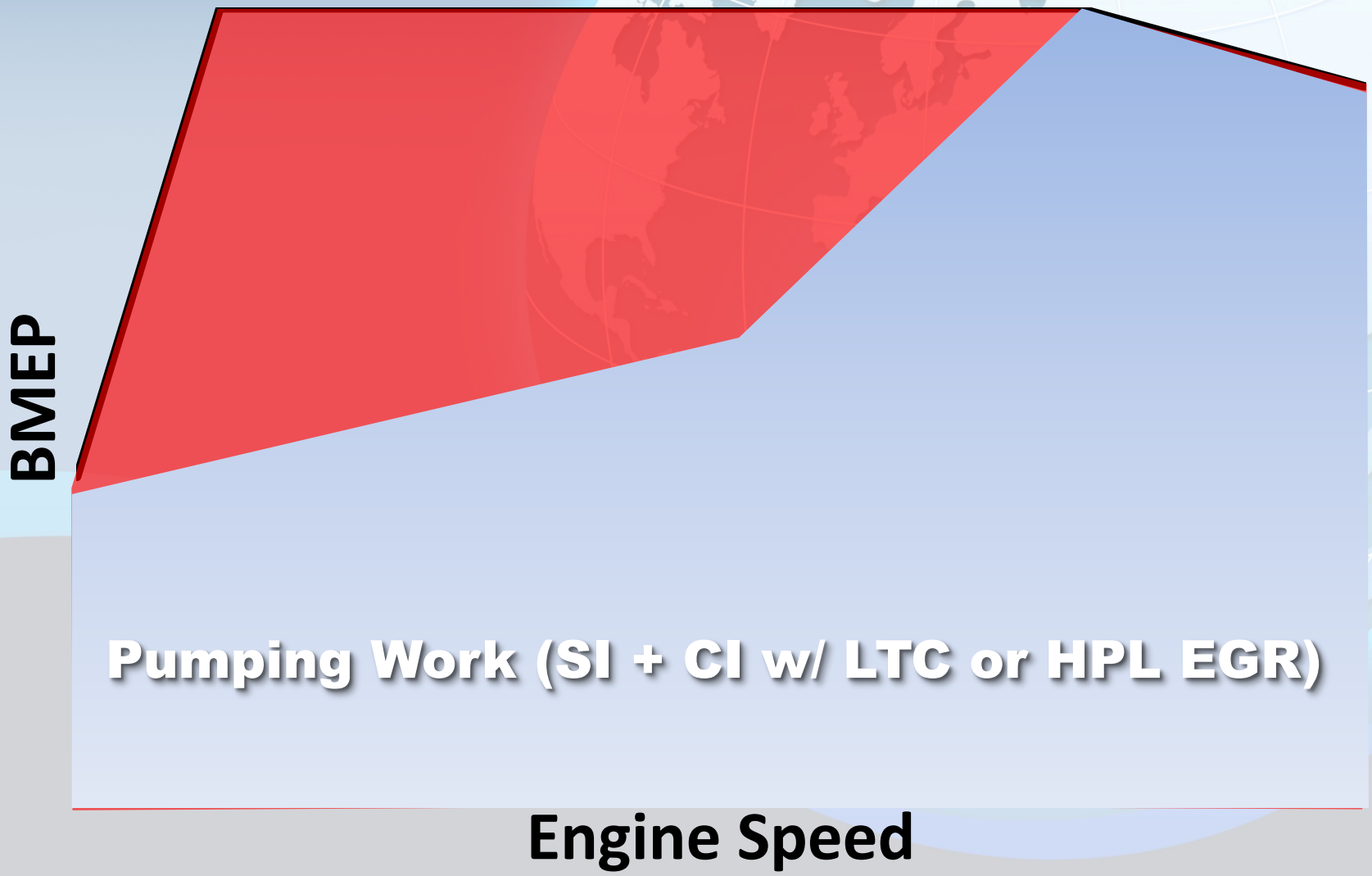
- Sets the ceiling for the engine
- Gamma is a function of
  - Charge composition
  - Temperature
- In the real-world, high compression ratios have some unwanted side effects



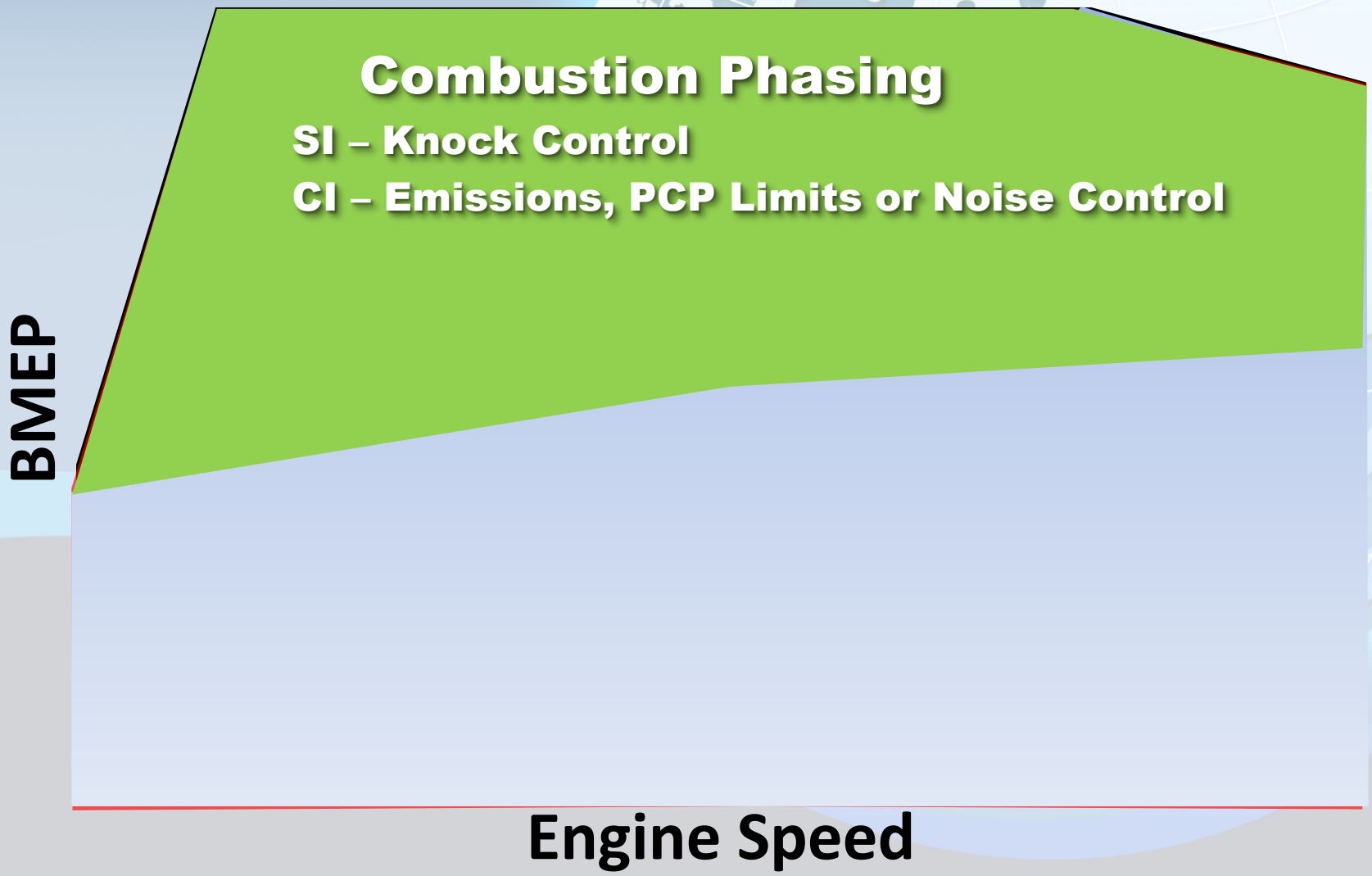
Sources of Real-World Losses in IC Engines



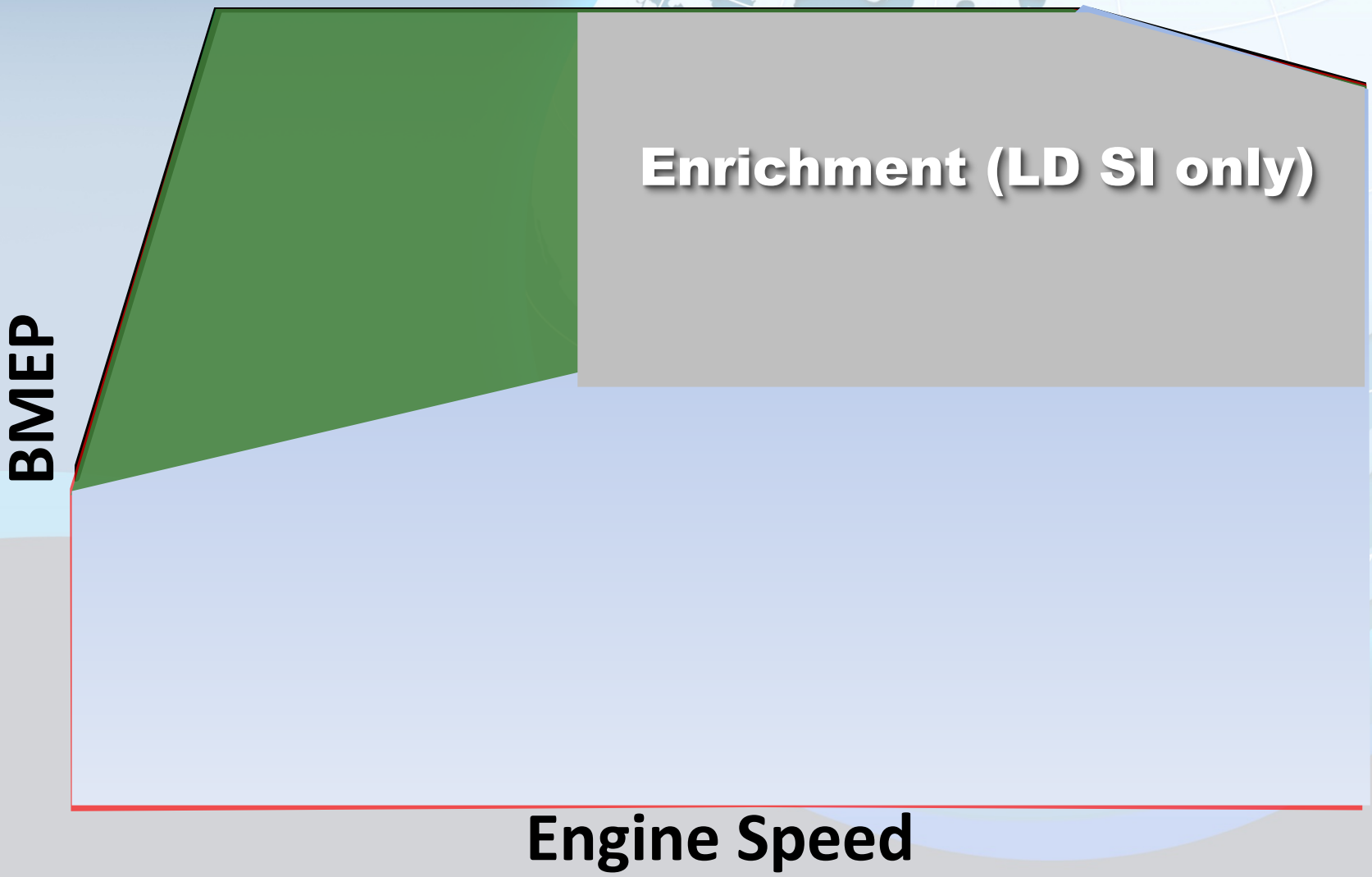
Sources of Real-World Losses in IC Engines



Sources of Real-World Losses in IC Engines

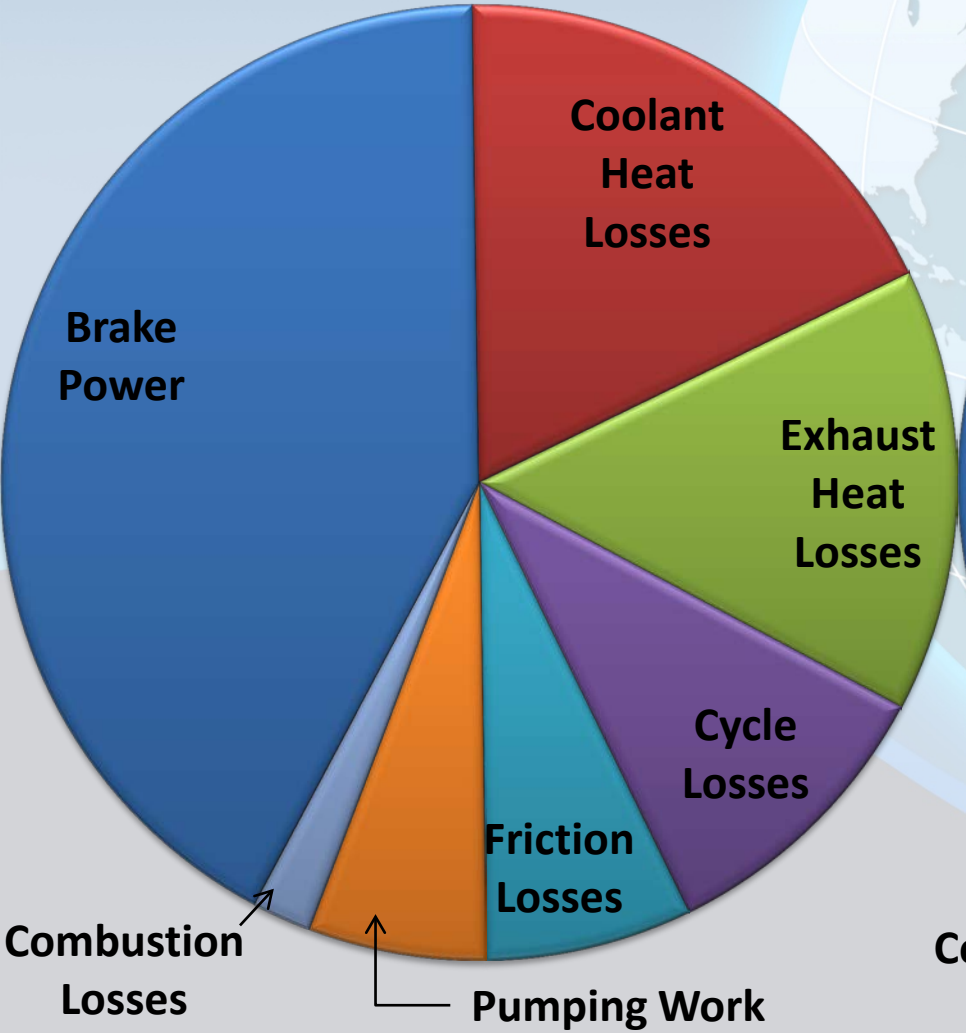


Sources of Real-World Losses in IC Engines

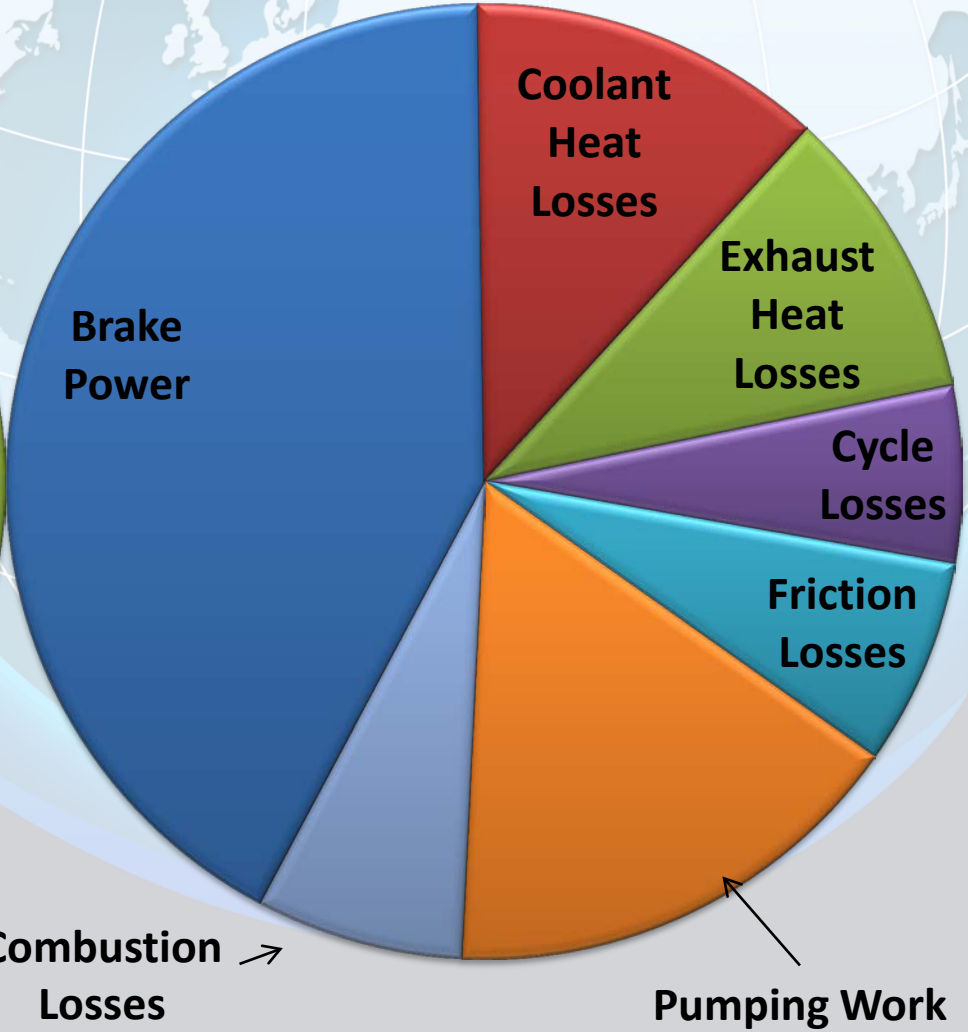


Two Paths to High Efficiency

Hot Combustion



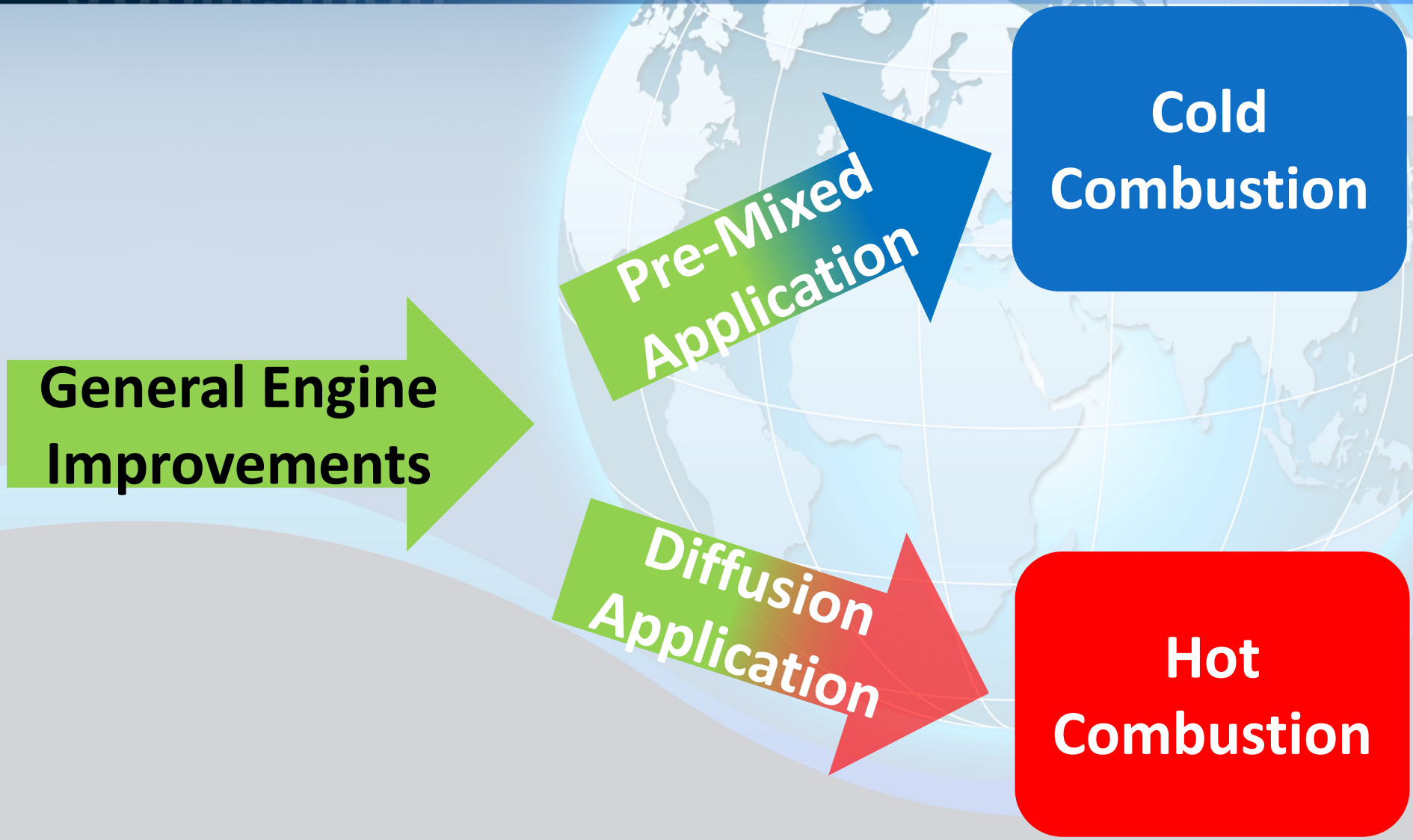
Cold Combustion



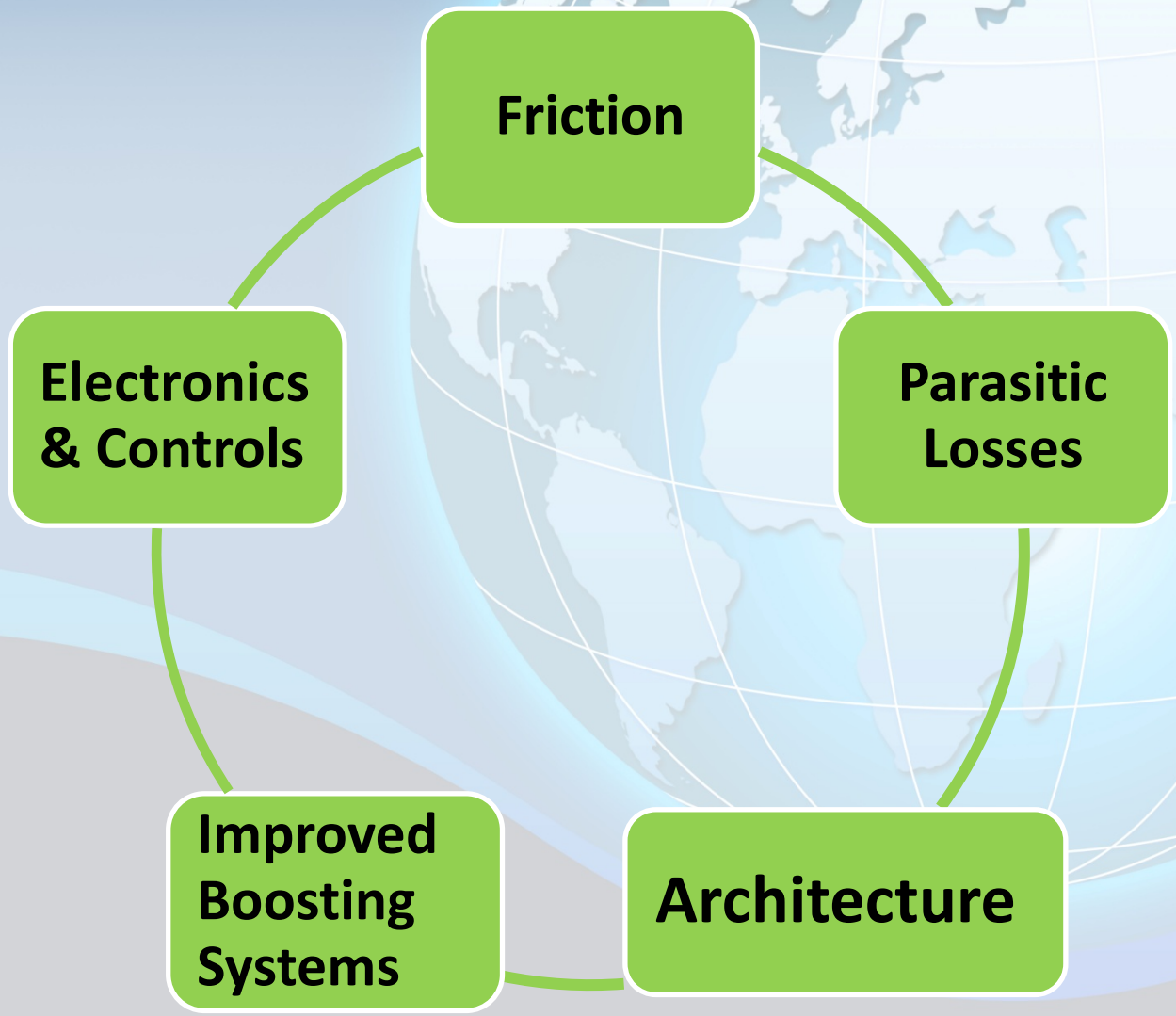
Hot vs Cold Combustion

	Cold	Hot
Heat Transfer Losses	++	- -
Combustion Phasing	+ (++ for SI)	0 (- - for SI)
Charge Properties	+	0
Emissions (engine-out)	+	-
Emissions (cycle or tailpipe)	0	+
Boosting	- -	++
Engine Control	-	+
Hardware Requirements (e.g. PCP)	-	0
Waste Heat Recovery Potential	- (LPL EGR) + (HPL EGR)	+
Enrichment (SI only)	++	- -

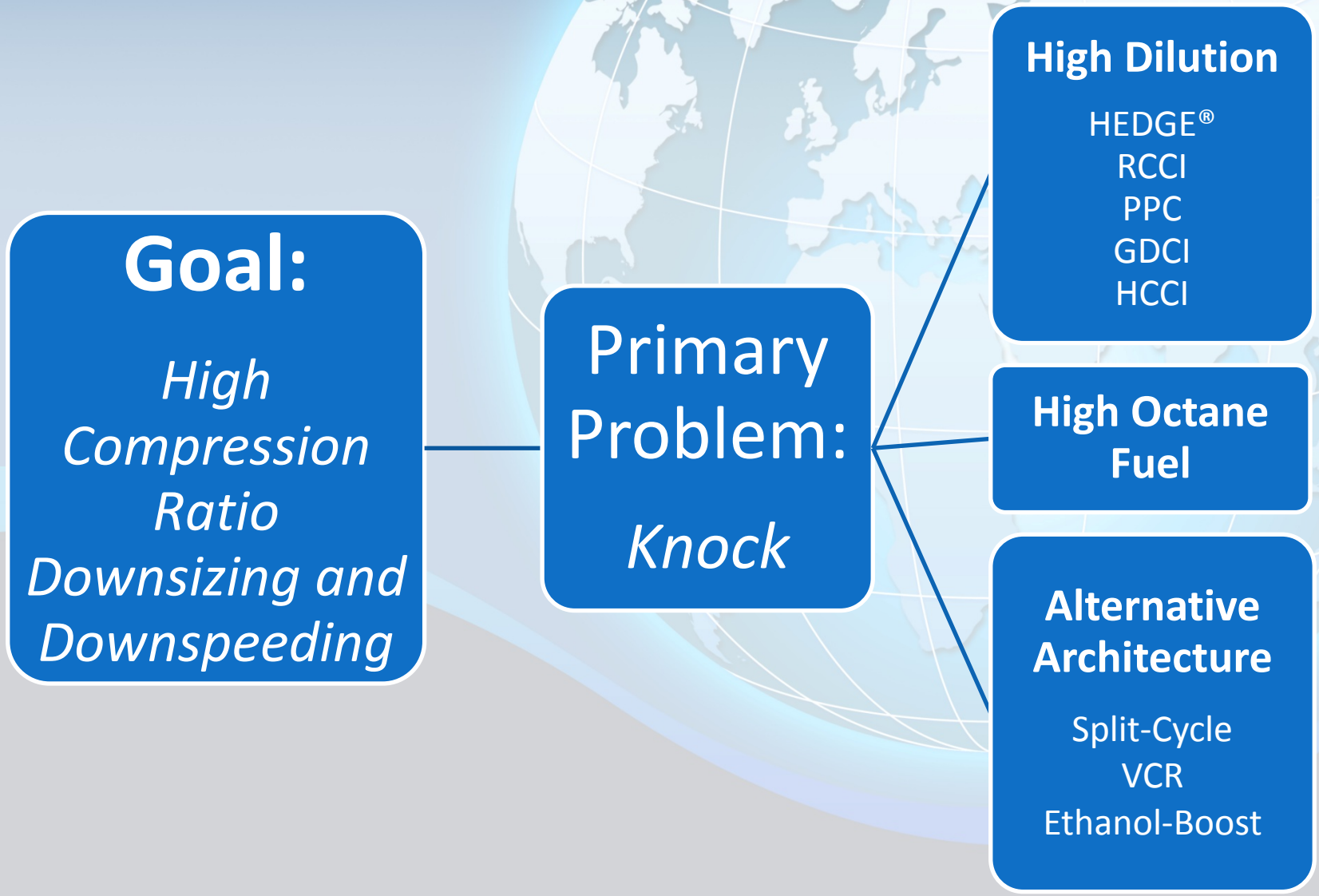
Path to High Efficiency May Depend on Application



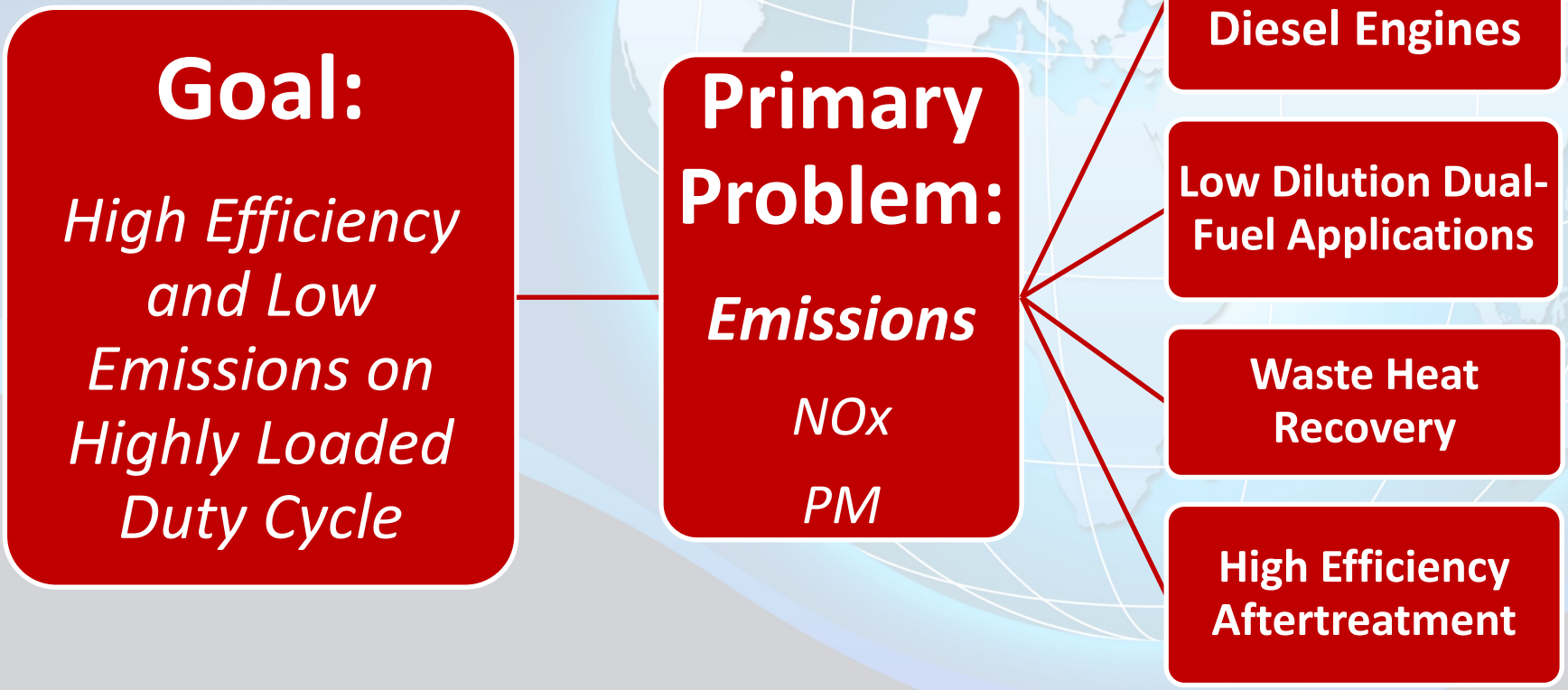
General Engine Improvements



Research Goals and Topics for Pre-Mixed Combustion

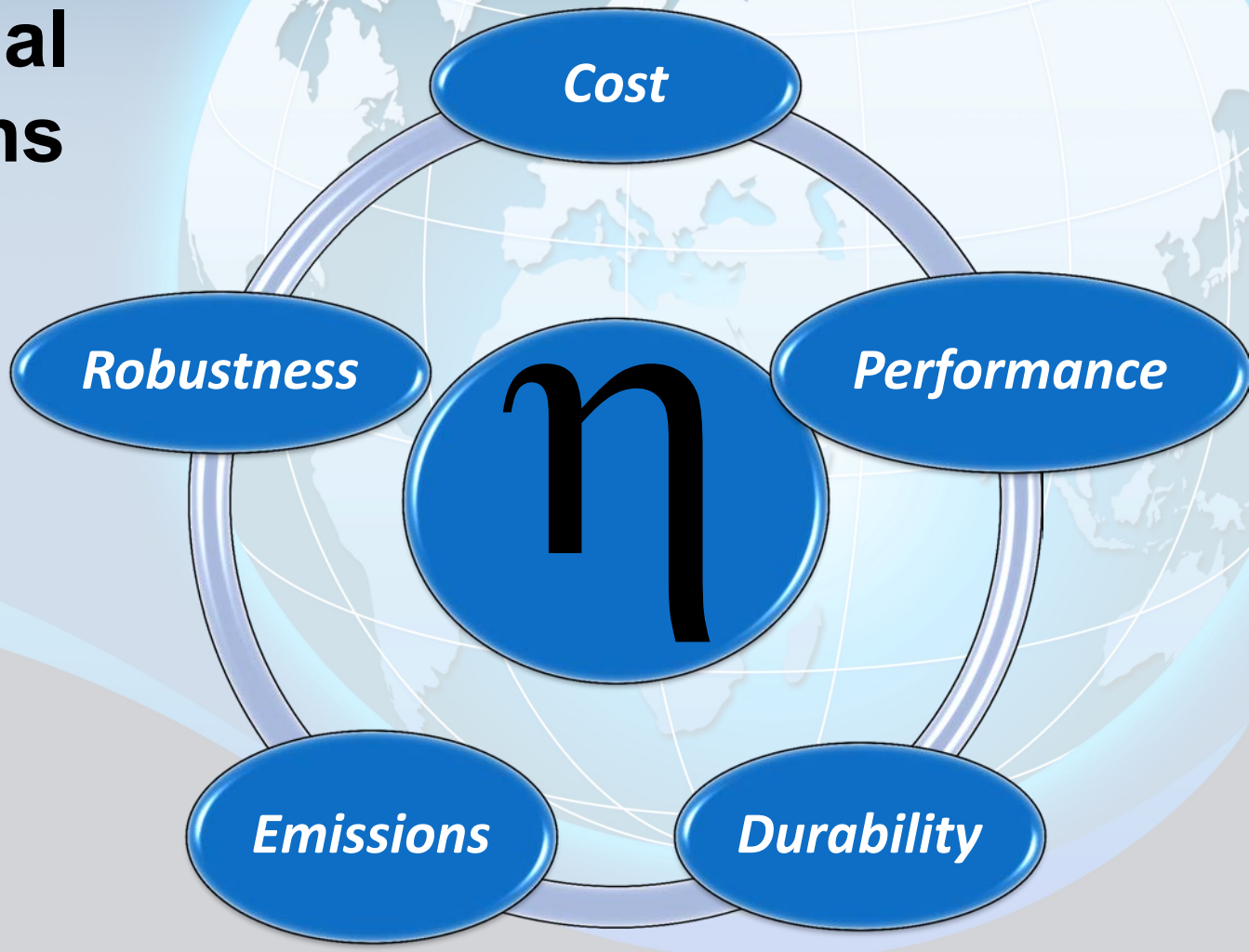


Research Goals and Topics for Diffusion Combustion



What's Next?

- Many potential configurations to address these challenges
- Industry assessment required



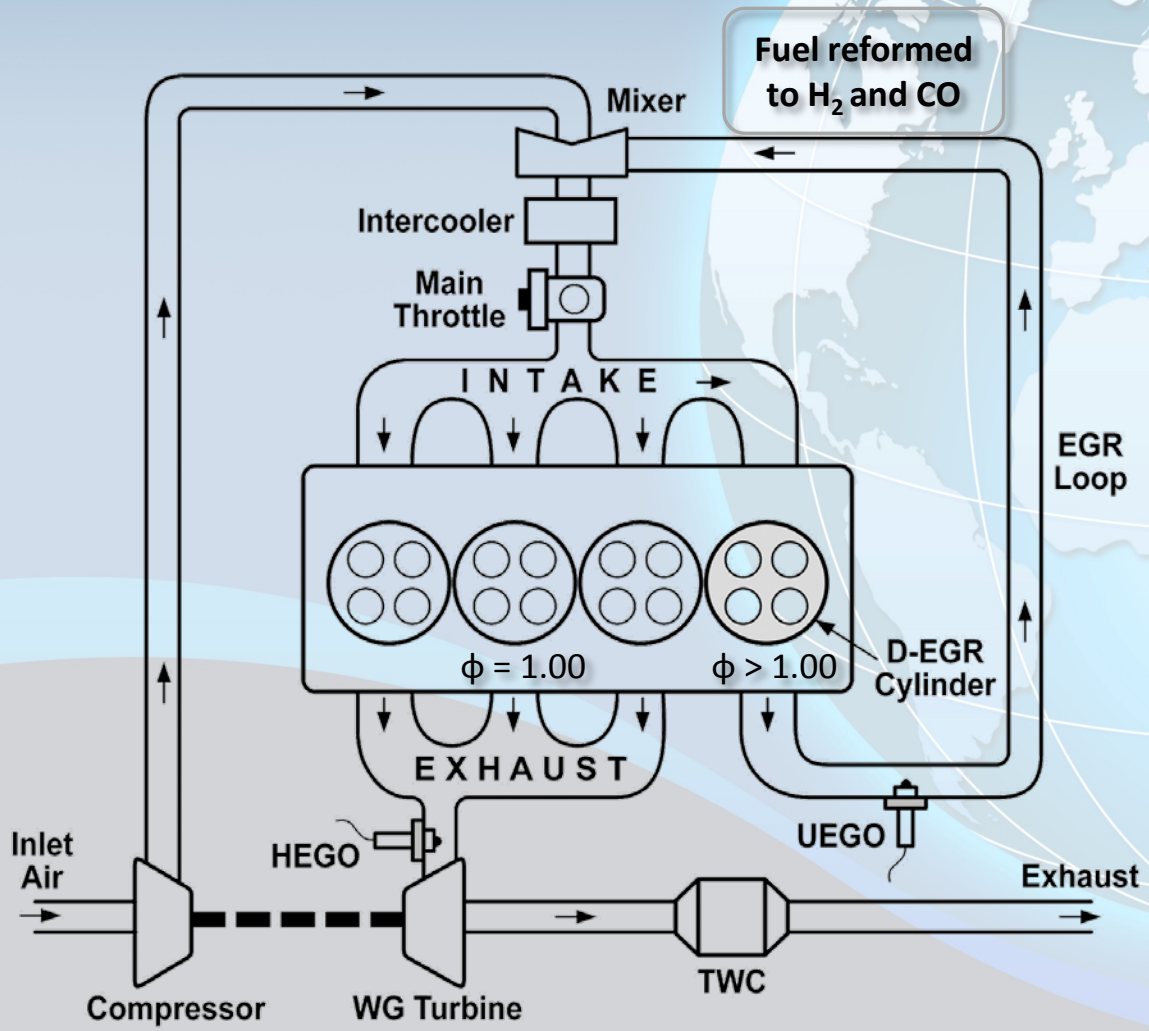
Introduction to SwRI's Dedicated EGR Concept

DEER 2012

Southwest Research Institute®

San Antonio, Texas

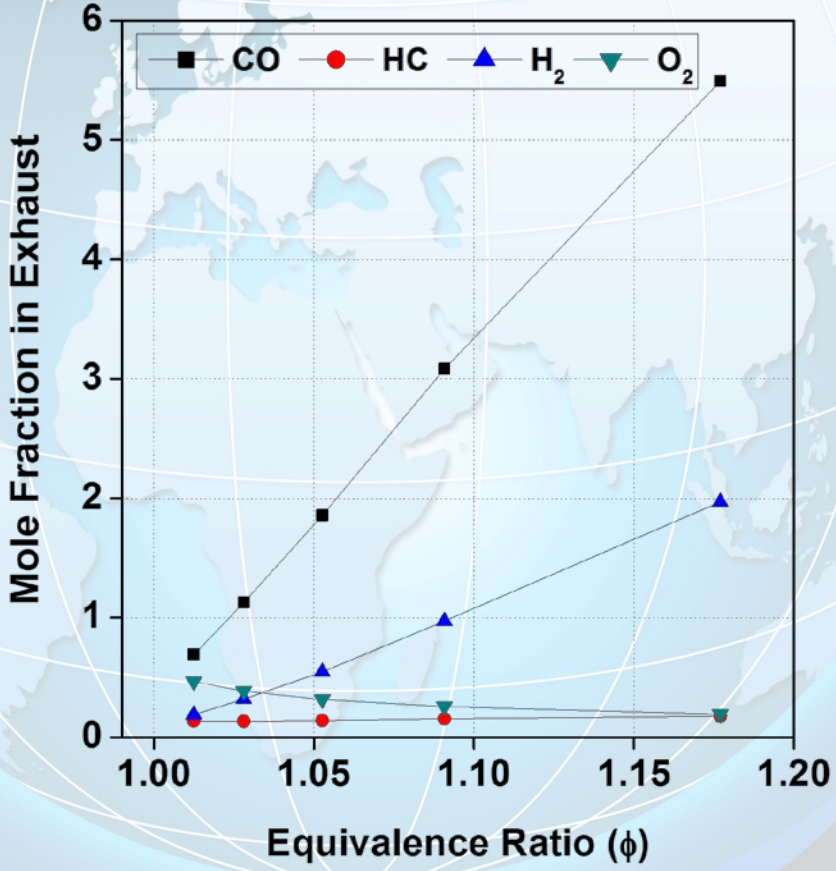
What is Dedicated EGR (D-EGR)?



D-EGR combines **highly effective emissions control** technologies and **high efficiency potential** of gasoline reformate technologies

In-cylinder Reformation

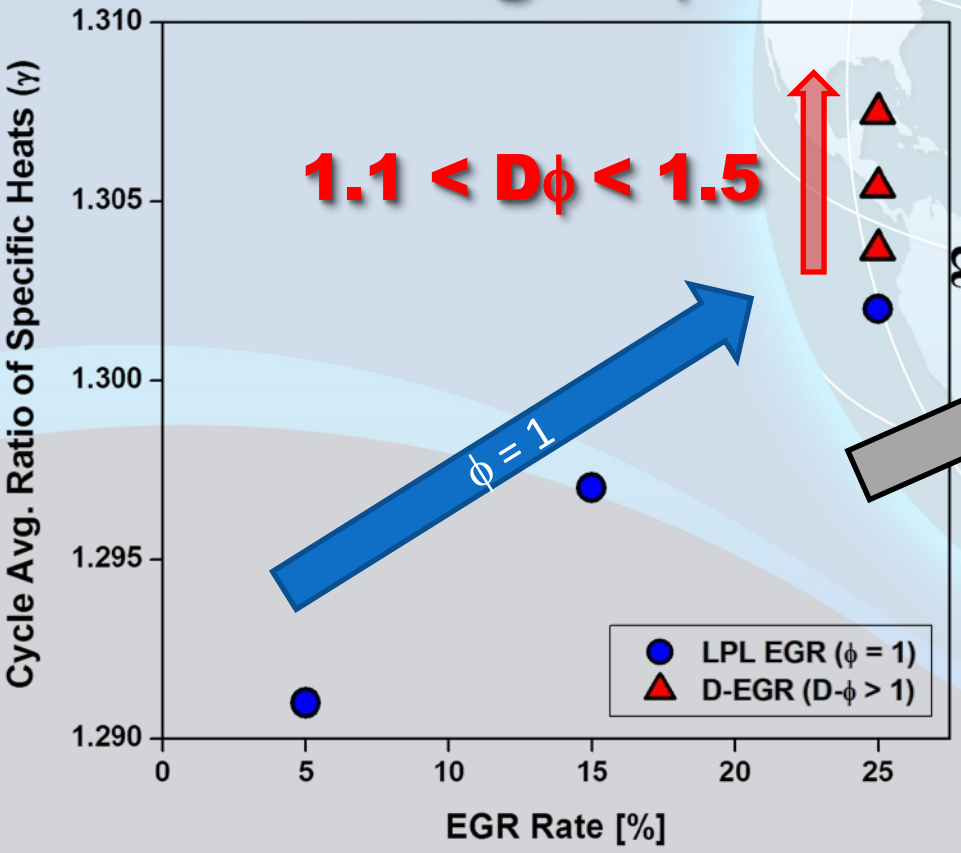
- Rich combustion yields high levels of CO and H_2
- In-cylinder reformation may be more efficient than external reformation
  - Work still extracted from combustion
  - All effort occurs inside the engine block
    - Safer
    - More easily packaged
- Previous work (SAE paper 2007-01-0475) indicated that H_2 levels required for combustion optimization are not as high as previously thought

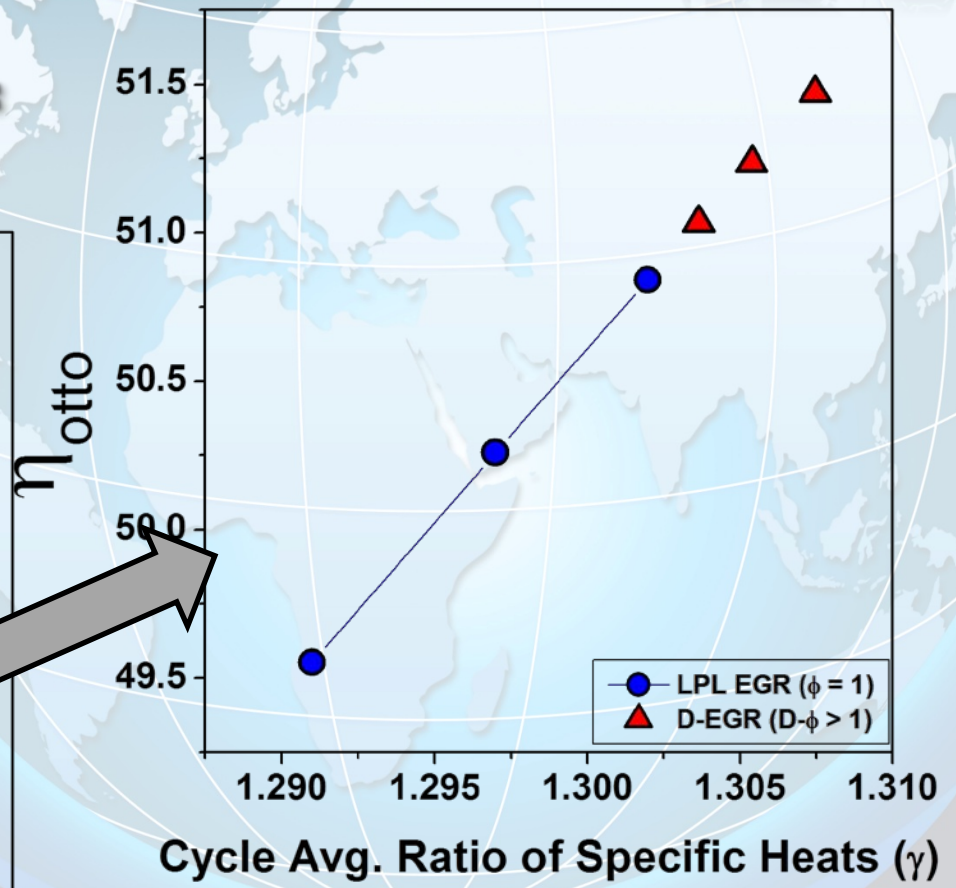


SAE Paper 2009-01-0694

Impacting the Working Fluid with D-EGR

Cool combustion + dilution + reformate = higher γ





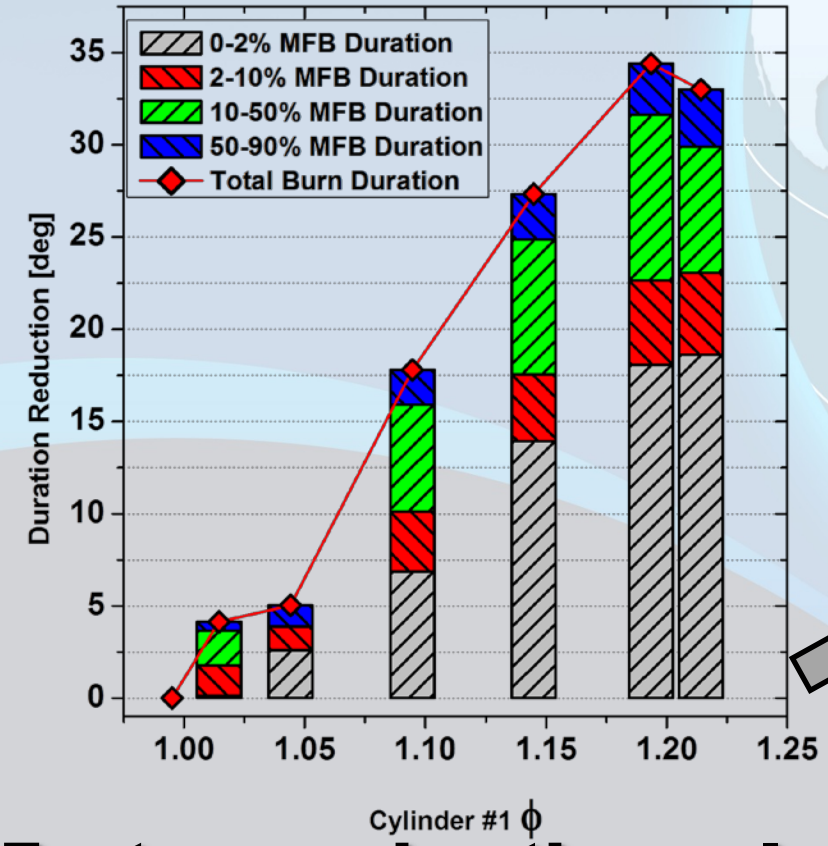
Higher γ = Improved η_{otto}

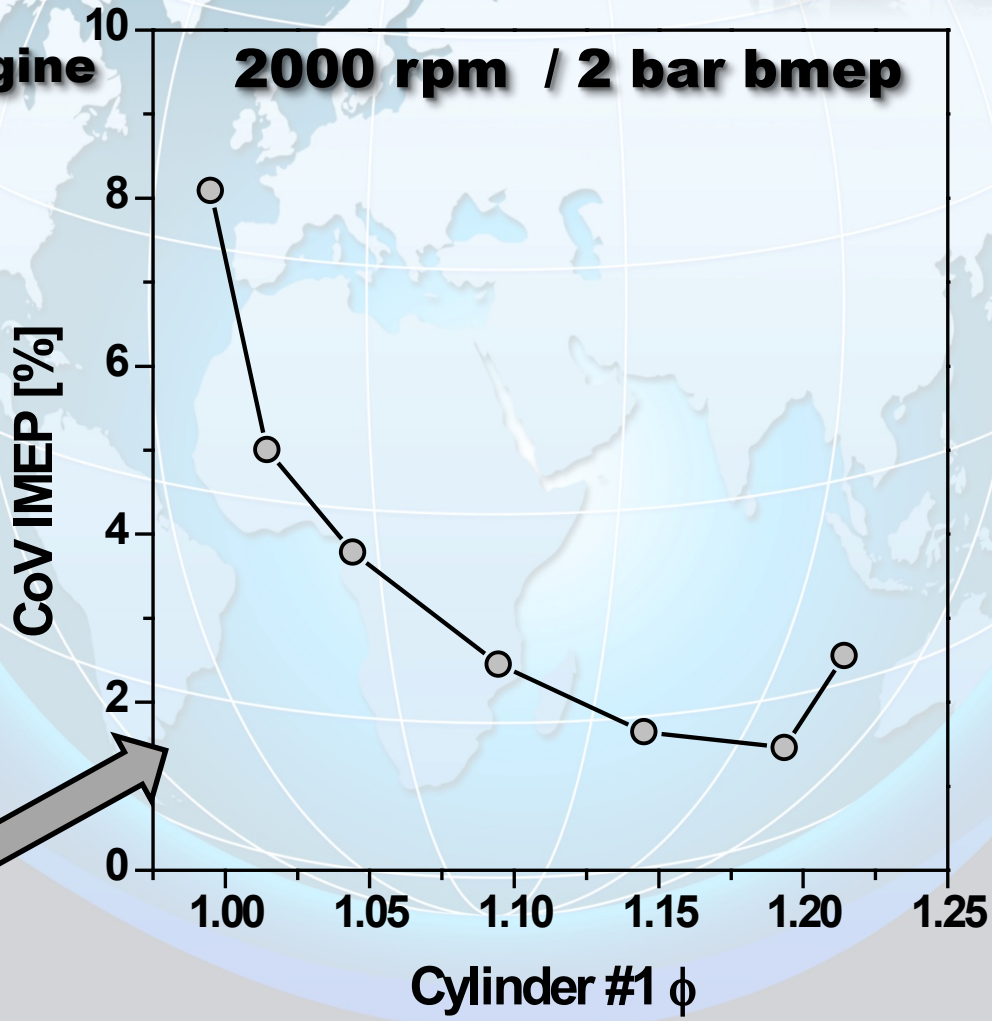
Enabling High EGR Tolerance

Test Platform

2006 MY 2.4 L Chrysler World Engine

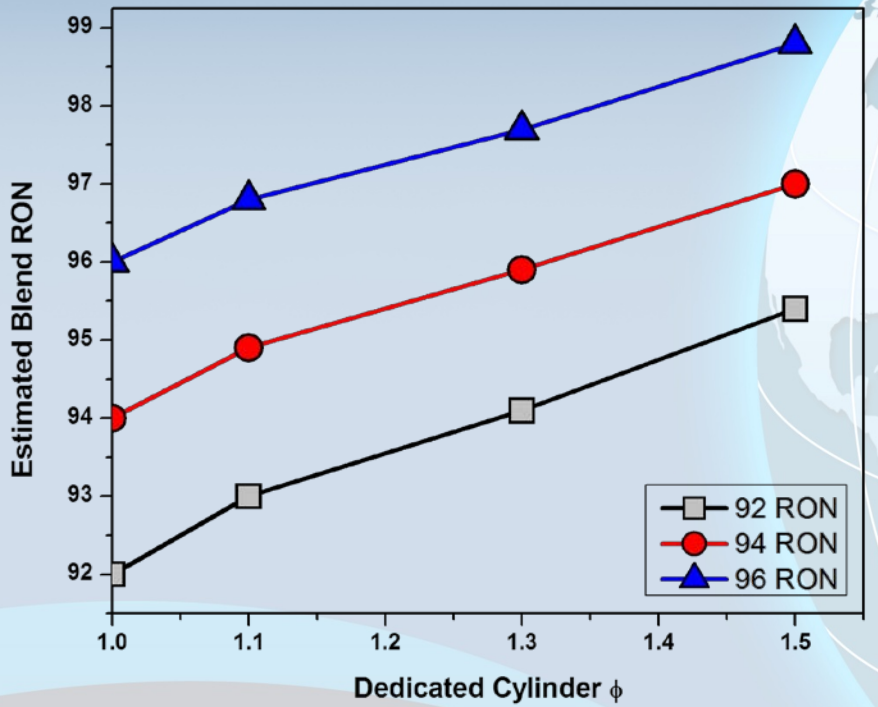
14:1 CR





Faster combustion = Improved Stability at 25% EGR

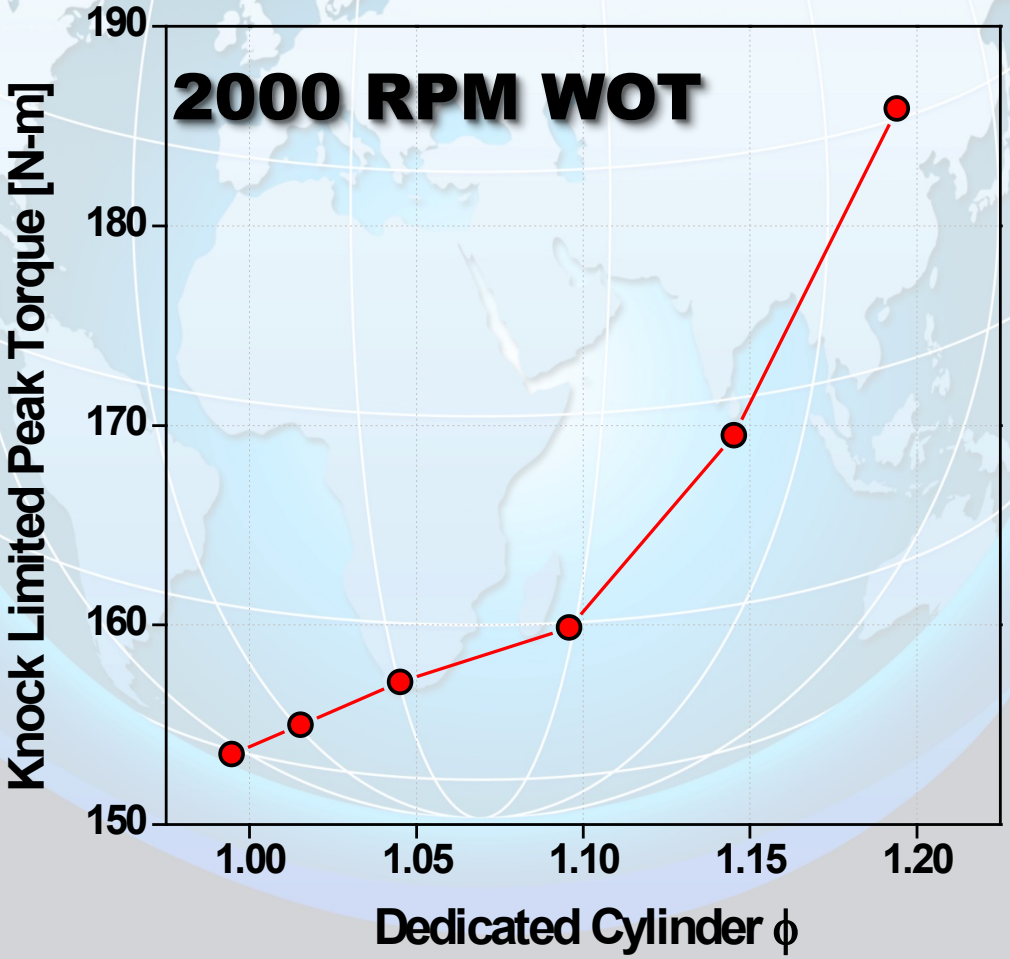
Increased Knock Resistance



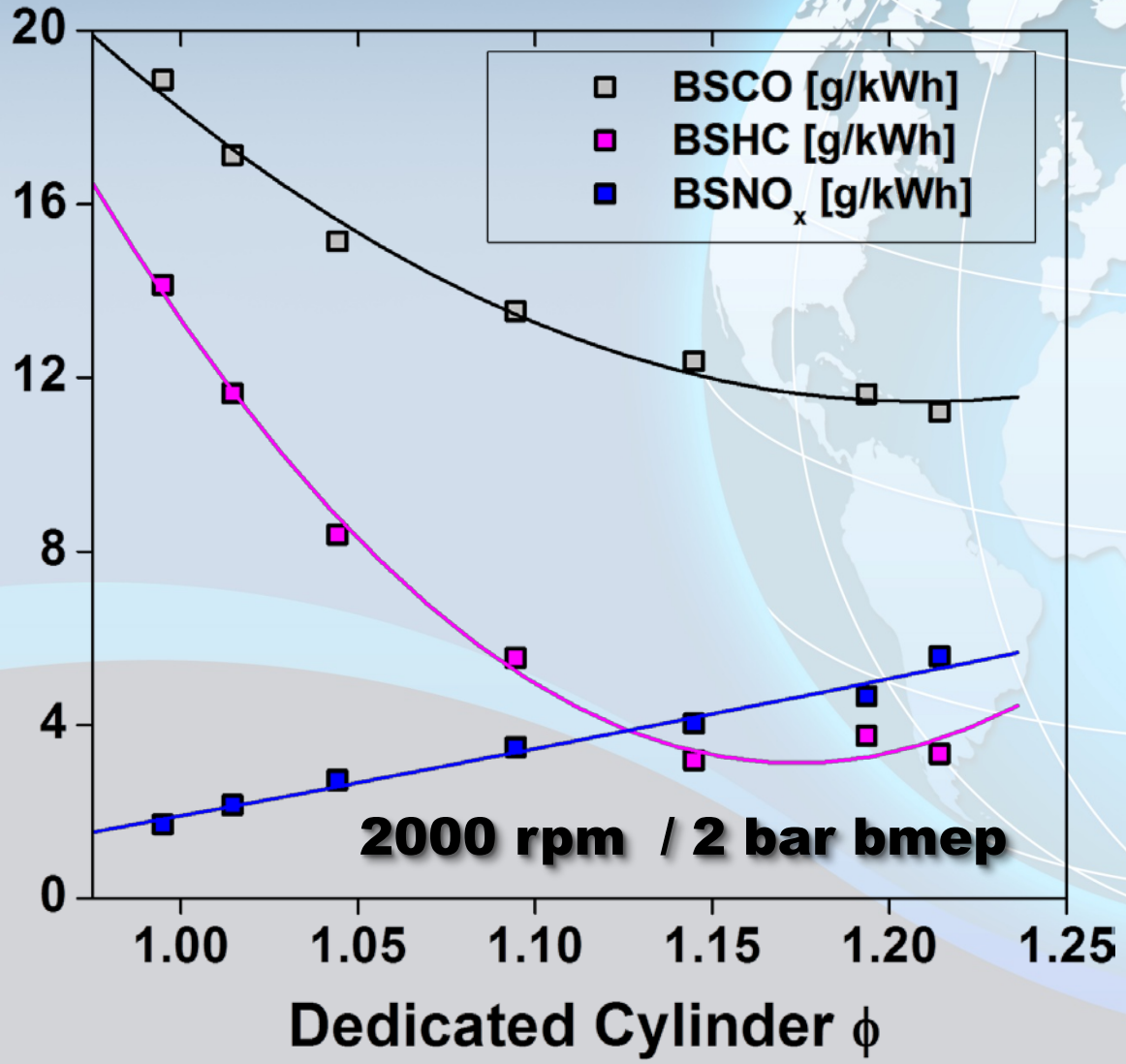
Reformate Impact on Effective RON

+

Faster Burn Rates = Improved Knock Tolerance



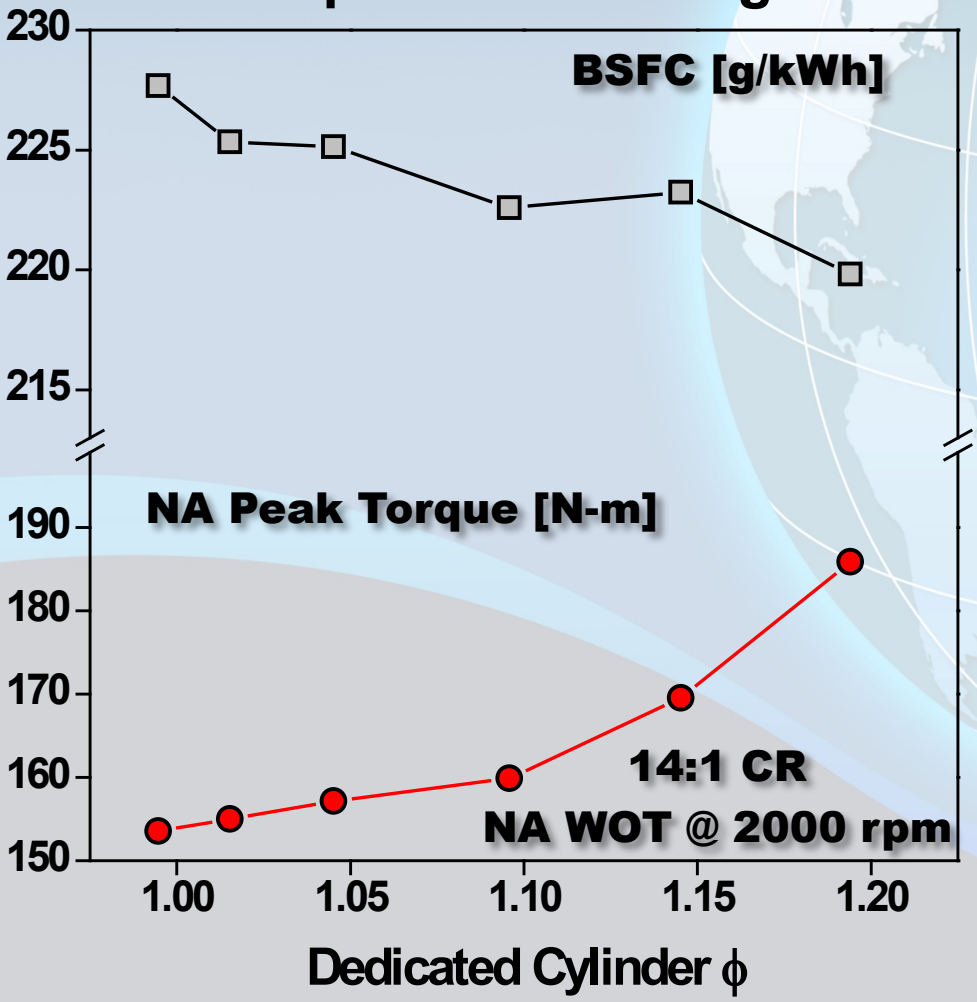
Reduced Emissions

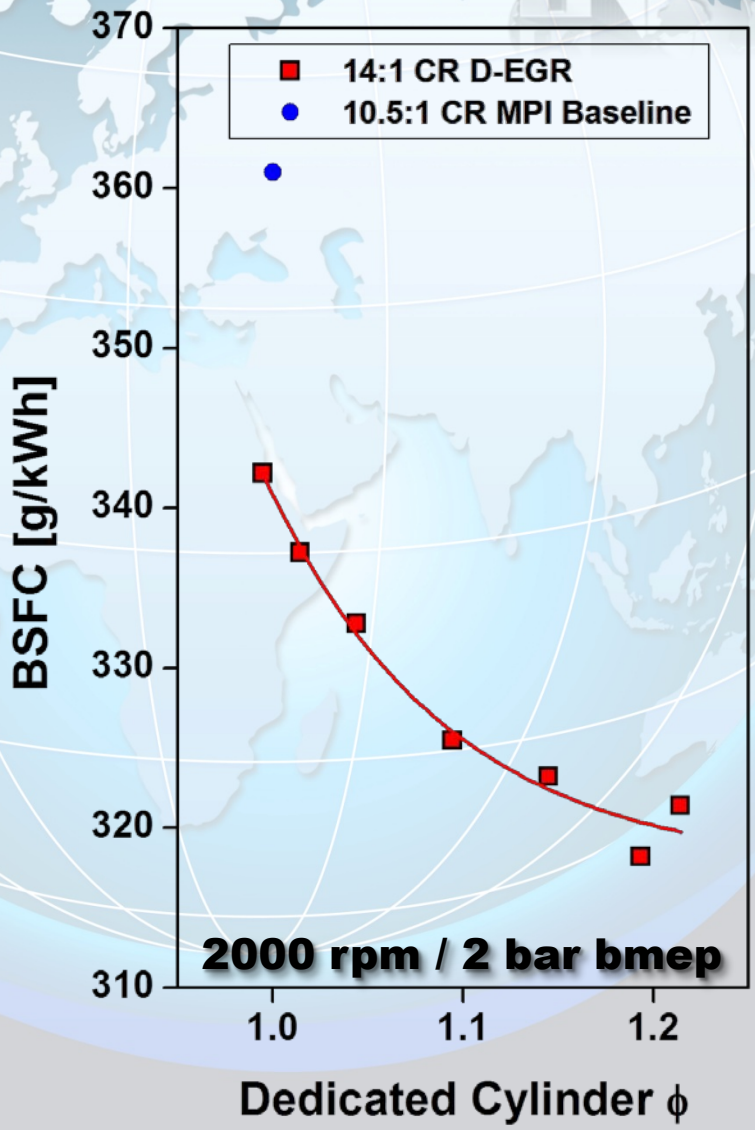


- Combustion efficiency returns to nearly non-dilute levels
- Reformate improves HC and CO emissions
- NOx emissions increase slightly
  - Still ~ ¼ of non-dilute case

Improved Fuel Consumption

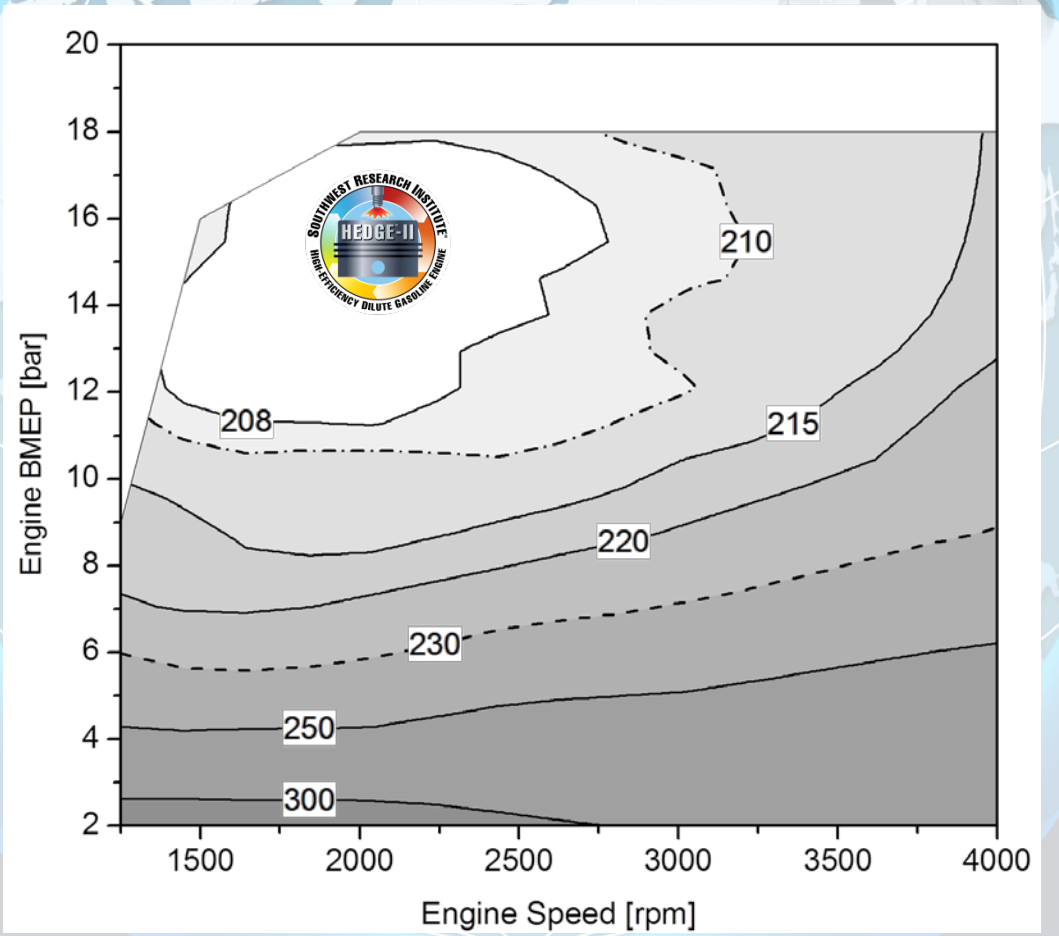
- BSFC improves considerably across speed / load range





Most Recent Results

- **2.0 L L4 TC MPI Application**
  - **12.5:1 CR**
  - **Advanced ignition system**
  - **Average D-EGR cylinder ϕ = 1.3**
- **Mean BSFC improvement : ~ 12-15%**
- **Best BTE to date : <u>> 41%</u>**
- **Best BSFC at 2000 rpm / 2 bar bmep : <u>315 g/kWh</u>**
- ***Lower BSFC than a Tier II Bin 2 diesel with GDI performance and ultra-low emissions / no PM***



What is Next for D-EGR?

- SwRI will be applying the D-EGR concept to new platforms in HEDGE III program
  - 2.0 L TC GDI engine
    - 25% D-EGR
  - L6 MD CNG application
    - 33% D-EGR
- Internal funding has been received for demonstration of D-EGR concept on a 2012 MY Buick Regal
  - GOAL : 20% improvement in MPG over NA baseline

Thank You

Southwest Research Institute®