



Sustainable

TRANSPORTATION

U.S. DEPARTMENT OF
ENERGY | Energy Efficiency &
Renewable Energy

Natural Gas Engine R&D Activity

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2018 NGVTF – Downey, CA

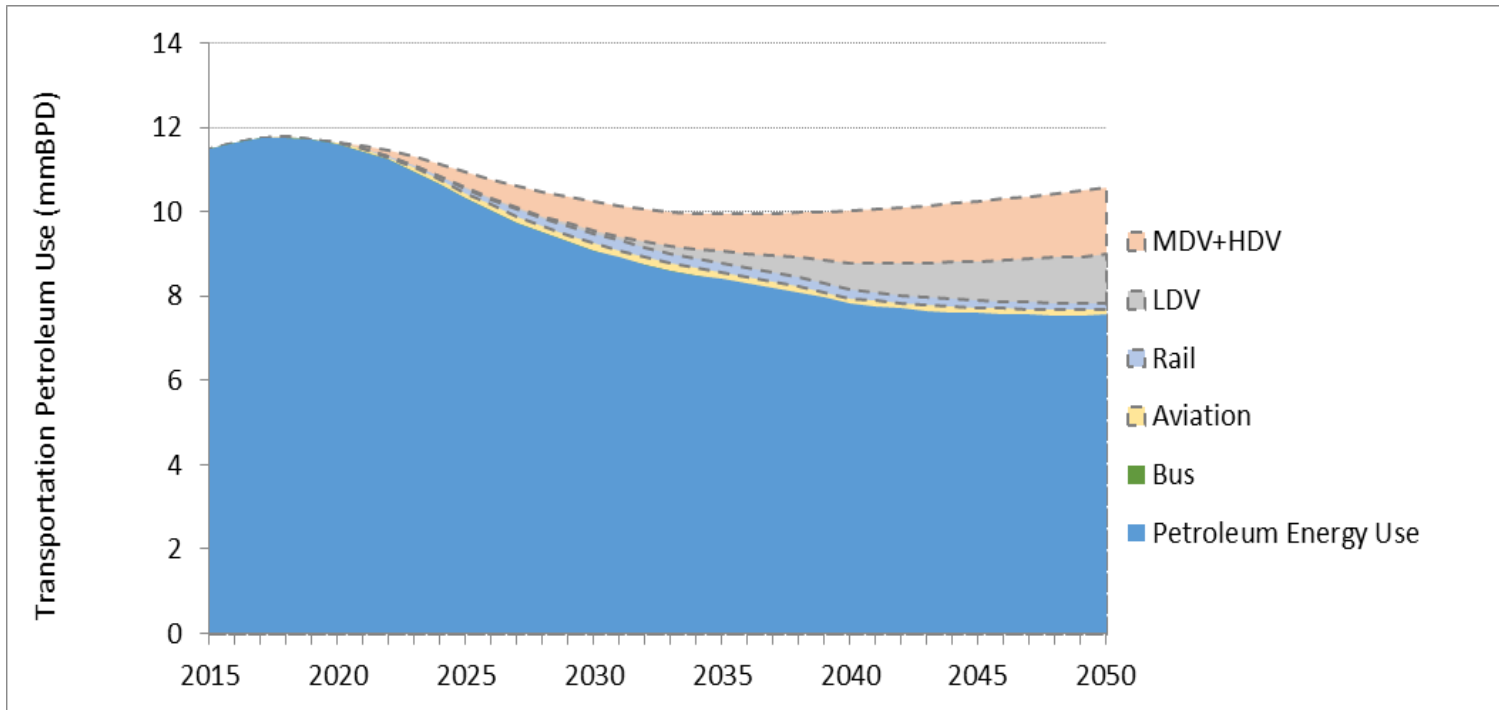
February 2018

VTO Advanced Engine and Fuels R&D Update

- **Program Emphasis**
- **Highlights from NG workshop, held July 2017 at NREL**
- **FOA update**
- **National lab research**

National Lab Study on Natural Gas in Transportation

- 2013-2014: Group formed to explore increase NG use in transportation
- Potential exists to shift future NG exports to domestic consumption in transportation
- 2.5 Million BBL/D reduction in petroleum usage
- Reduction in “levelized cost of driving” could promote economic growth
- Minimal effect on GHG (on life-cycle basis)



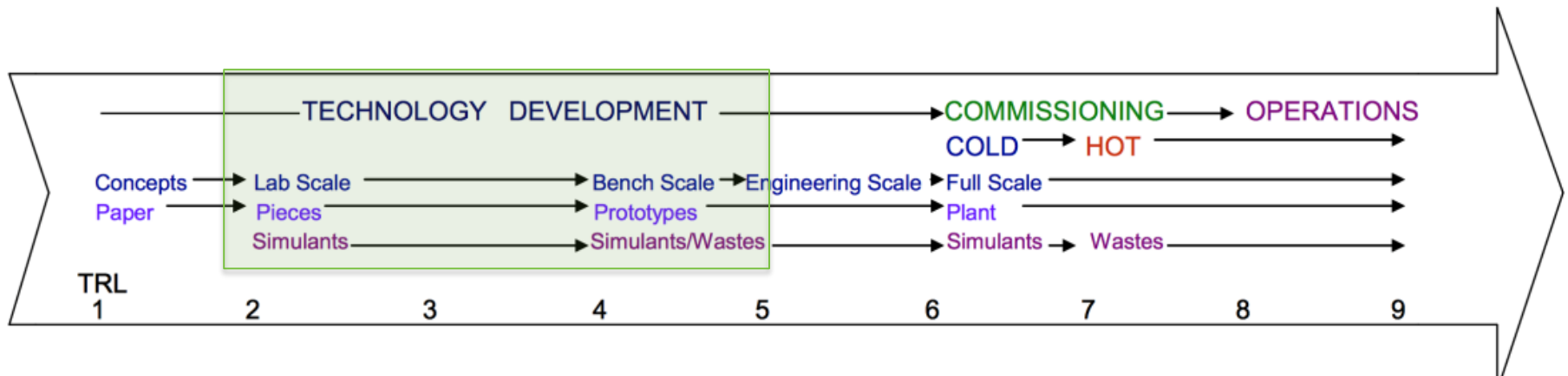
New Policy Drivers

OMB Memo on Research and Development Priorities

“American Energy Dominance -

... Agencies should invest in **early-stage**, innovative technologies that show promise in **harnessing American energy resources** safely and efficiently. Federally-funded energy R&D should continue to reflect an **increased reliance on the private sector to fund later-stage research, development, and commercialization of energy technologies**... **Working in tandem, the Government and the private sector can promote the nation’s economic growth**

What does ‘early-stage’ mean? Technology Readiness Level (TRL) 2-4

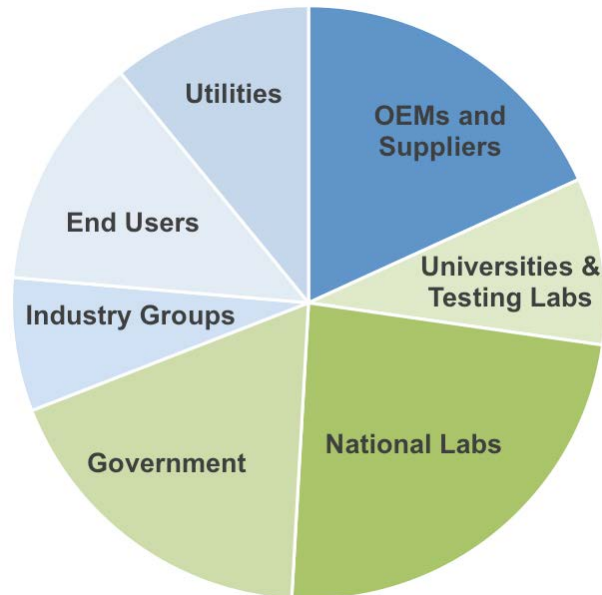


Natural Gas Vehicle Research Workshop

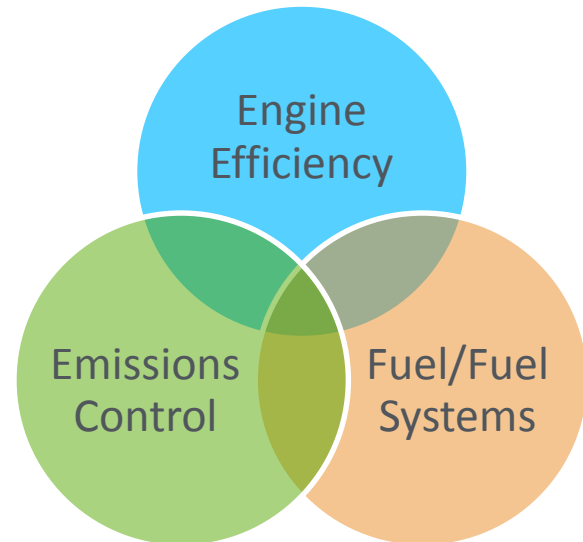
July 25th, 2017
Golden, CO



55 participants



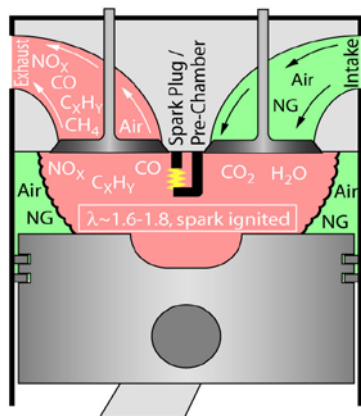
Workshop structured by subject area for MD and HD natural gas engines and vehicles



Reaching for “Diesel-Like” Efficiencies

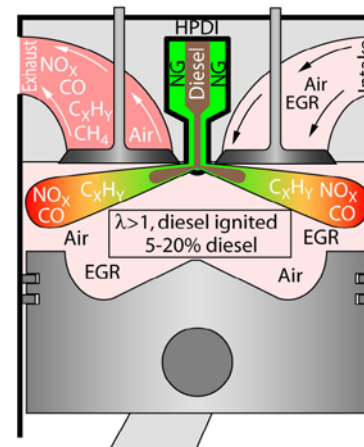
- Improved understanding of in-cylinder chemistry/physics to enable predictive simulation.
- Advanced ignition systems needed to enable highly dilute operation
- Low-Temperature Combustion concepts offer possibility of higher efficiency than diesel. Need better understanding of mode switching, ability to handle emissions at low-exhaust temperatures.

High efficiency available in production; trade-offs in economics, emissions



Lean Premixed Spark Ignition

- Port/DI, premixed or stratified, EGR
- Oxy-catalyst
- ~43% efficiency
- 100% NG



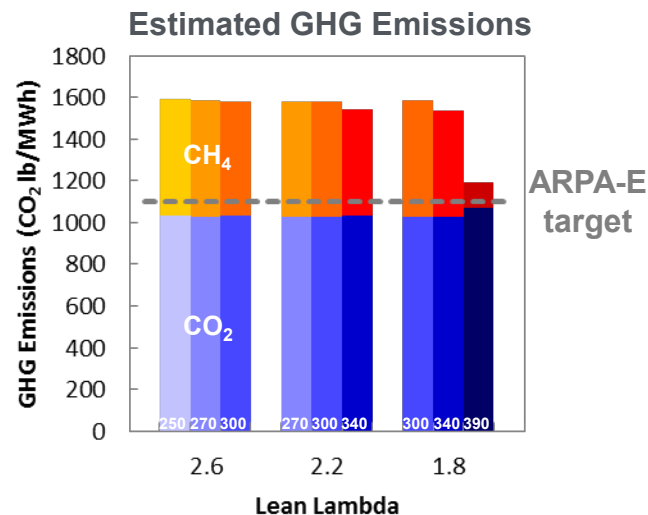
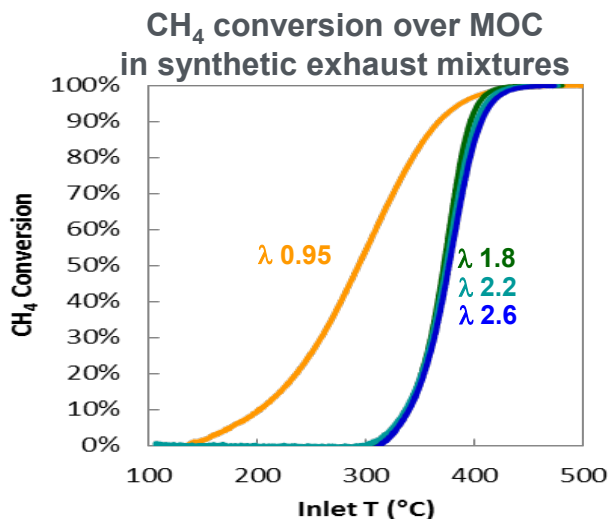
Direct Injection Diesel Pilot

- DI stratified/jets NG+diesel, EGR
- Catalyzed DPF, Urea SCR
- ~46% efficiency
- ~90% NG

Emission control strategies to enable efficiency

- Significant catalyst R&D needed to address methane oxidation
- Low-temperature emission control is needed to enable more efficient engines
- Ultra-low NO_x drives market, but is more challenging with efficient engines
- Unique catalyst durability issues

ARPA-E
GENSETS
Program



Medium/Heavy-Duty, On-Road Natural Gas Engine R&D

The programmatic goal is to enable natural gas engines that can cost-effectively achieve diesel-like efficiency while meeting current and future emissions standards.

- Fundamental experiments and modeling to understand fuel mixing and combustion for improved engine design
- Advanced ignition systems to enable highly-efficient dilute combustion
- Fundamental catalysis research for after-treatment solutions to meet emission standards with advanced technology.

FOA Issue Date:	10/11/2017
Amendment 000001	11/29/2017
Informational Webinar:	10/23/2017 11:00 AM ET
Submission Deadline for Concept Papers:	11/8/2017 5:00 PM ET
Anticipated Date for Concept Paper Recommendation Notifications	11/30/2017
Submission Deadline for Full Applications:	1/11/2018 5:00 PM ET
Expected Timeframe for EERE Selection Notifications:	March 2018
Expected Timeframe for Award Negotiations	May 2018

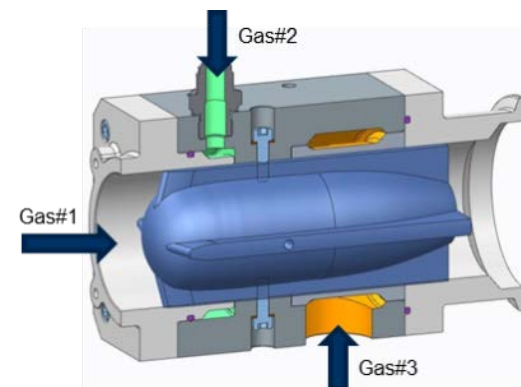
On-Going DOE funded Projects



BOSCH (HECO-SING) High-Efficiency, Cost-Effective, Spark Ignited Natural Gas

Partners: U. Mich, PNNL, Borg Warner, WeiChai

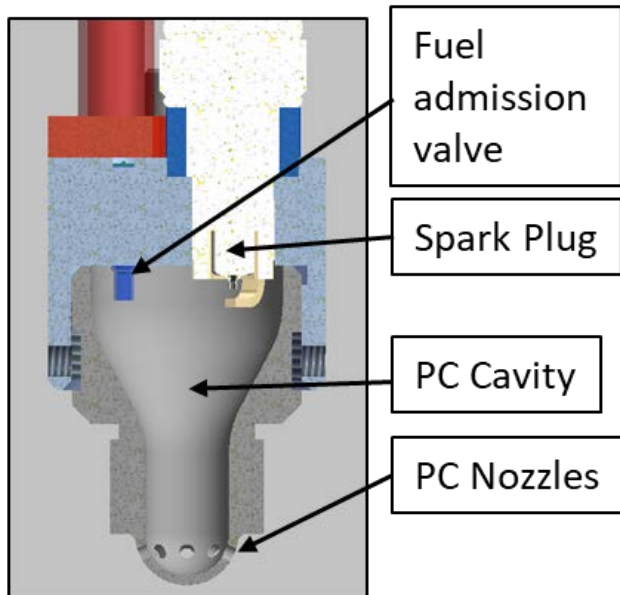
- Advanced fuel injection
- High Energy Ignition to enable high EGR and lean operation
- Toggling between rich and lean operation allows for cost-effective passive SCR aftertreatment that is ultra-low NO_x capable.
- Peak BTE target of 42% (~39% as of June 2017)



Details available in Annual Progress Reports and Annual Merit Review Slides
<https://energy.gov/eere/vehicles/vehicle-technologies-office>

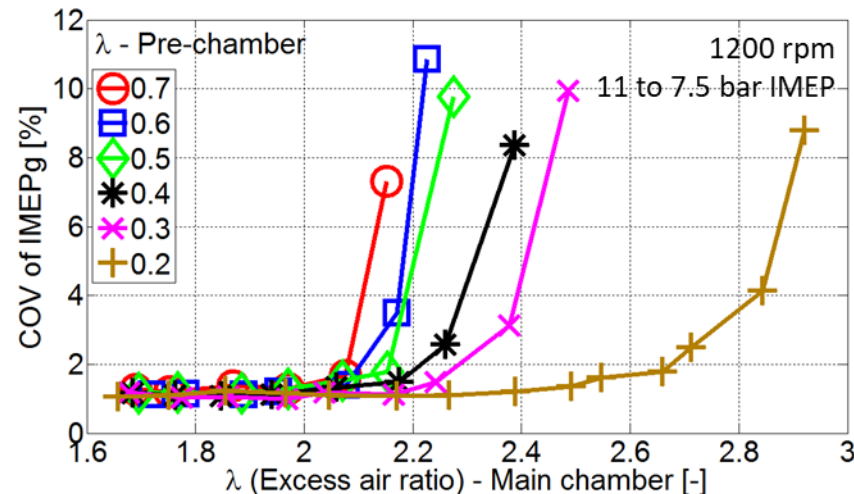
Collaborative National Lab Natural Gas Research

“Fundamental In-Cylinder and Emissions Control Advancements for Higher Efficiency Medium/Heavy-Duty Natural Gas Engines”



Focused on pre-chamber spark-ignition (PCSI)
Extending lean-dilution limit

- Extending EGR limit
- Shorten burn duration



Collaborative National Lab Natural Gas Research

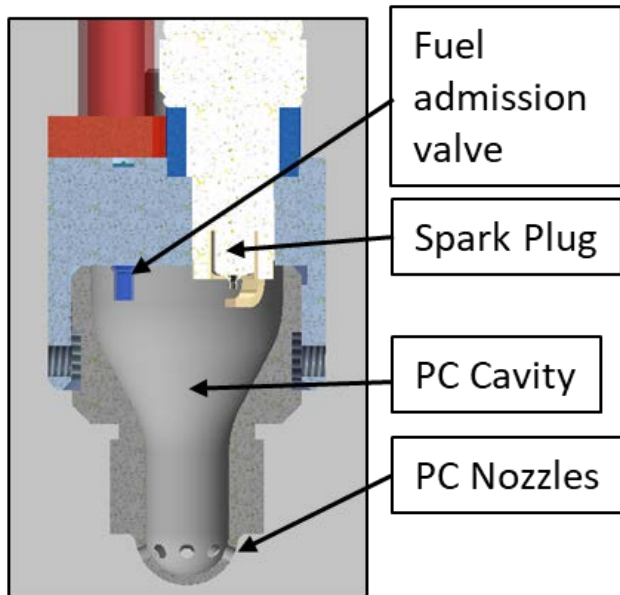
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Argonne
NATIONAL LABORATORY

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

OAK RIDGE
National Laboratory

Sandia
National
Laboratories



- Integrated research plan that capitalizes on existing expertise and core capabilities at four DOE national laboratories
 - Metal and optical engine experiments
 - In-cylinder simulations using computational fluid dynamics (CFD) and chemical kinetics
 - Bench-scale ignition experiments and simulations
 - Emissions controls experiments

Thank You

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<https://energy.gov/eere/vehicles/vehicle-technologies-office>