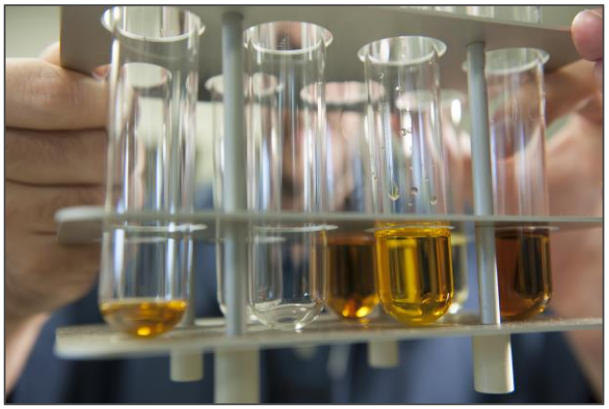
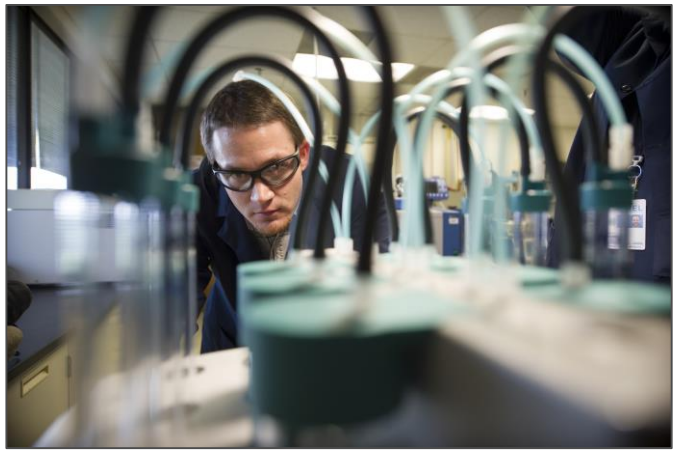
Co-Optima

Fuels R&D

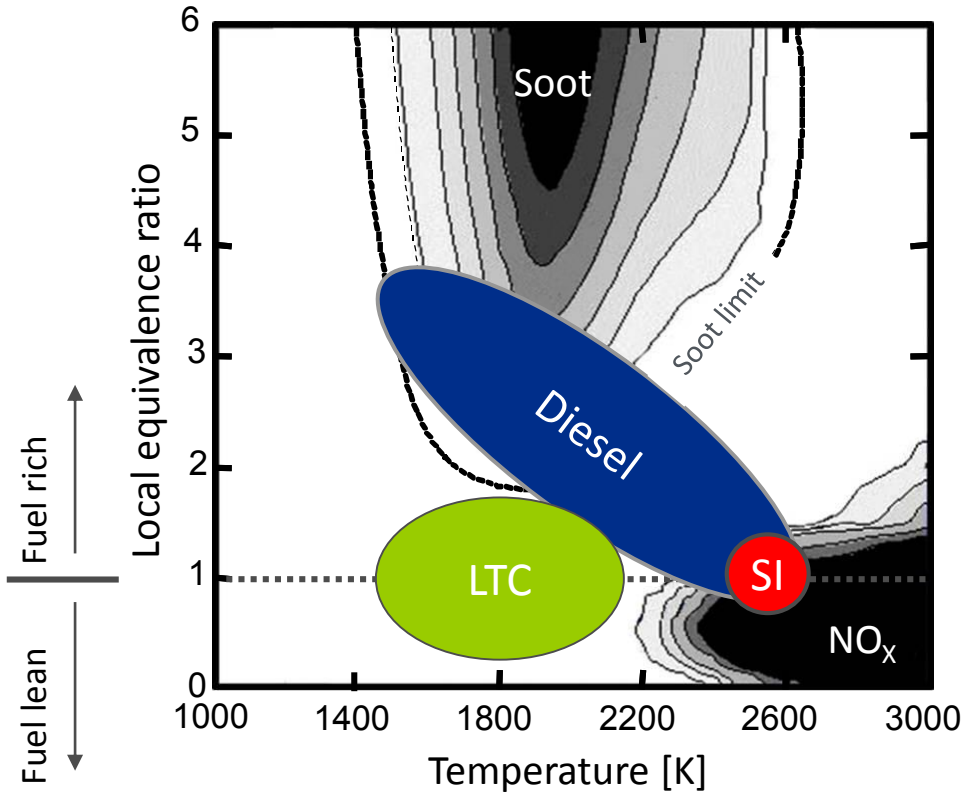




Expanding the use of alt fuels and fuel-controlled combustion

Advanced Combustion Strategies

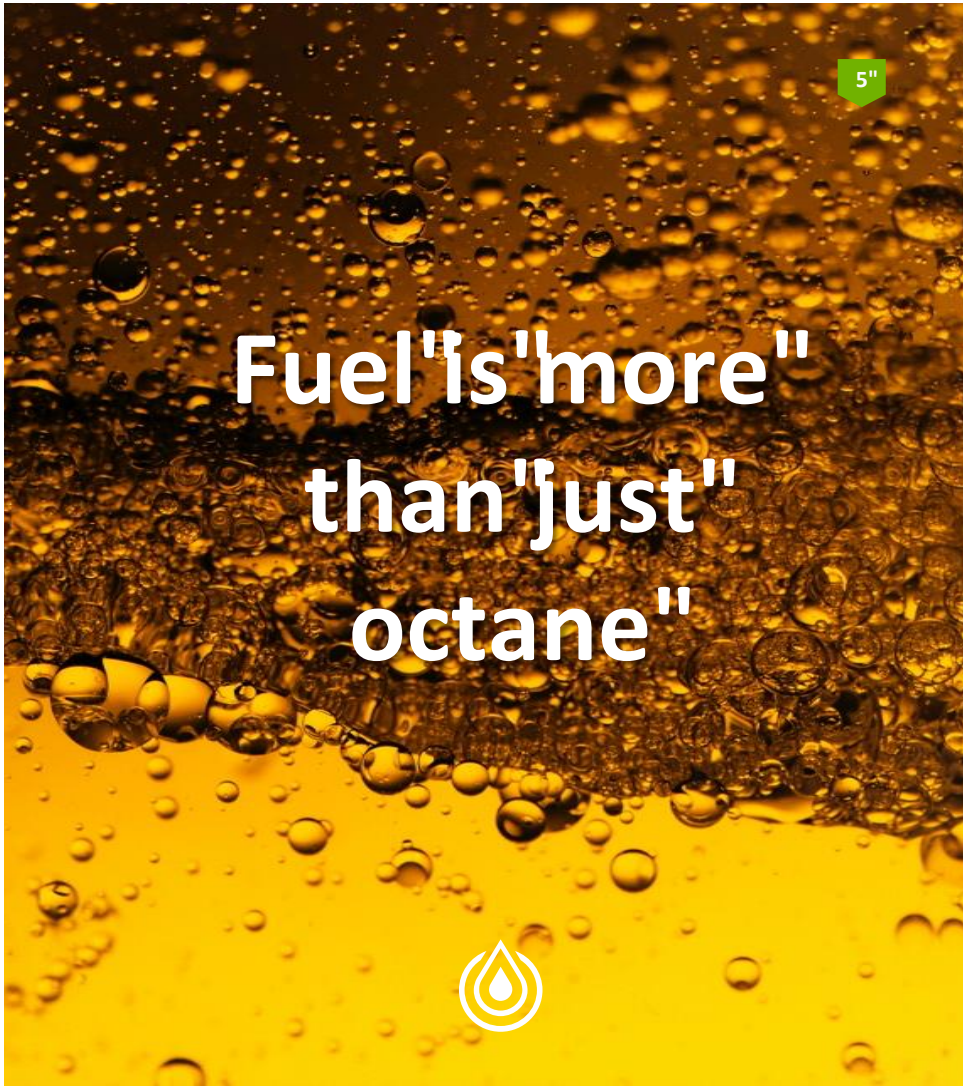
- Low temperature
- Dilute gasoline
- Clean diesel



Potential to improve efficiency by 20-35%

Current Fuels Constrain Engine Design

RON viscosity MON volatility cloud point bulk modulus of compressibility Wobbe index heating value sensitivity heat of vaporization soot precursor formation PMI flammability limits smoke point cetane number T50 heat of combustion flame stretch ignition limits C/H ratio strain sensitivity density specific heat ratio naphthene level Markstein length T10 surface tension flash point T90 exergy destruction olefin level energy density sulfur level laminar burning velocity diffusivity drivability index flame speed aromatics level oxygenate level



***Additional* 15-20% fuel economy improvement possible**

Engines Will Be Around for Decades

New fuels open up engine design options

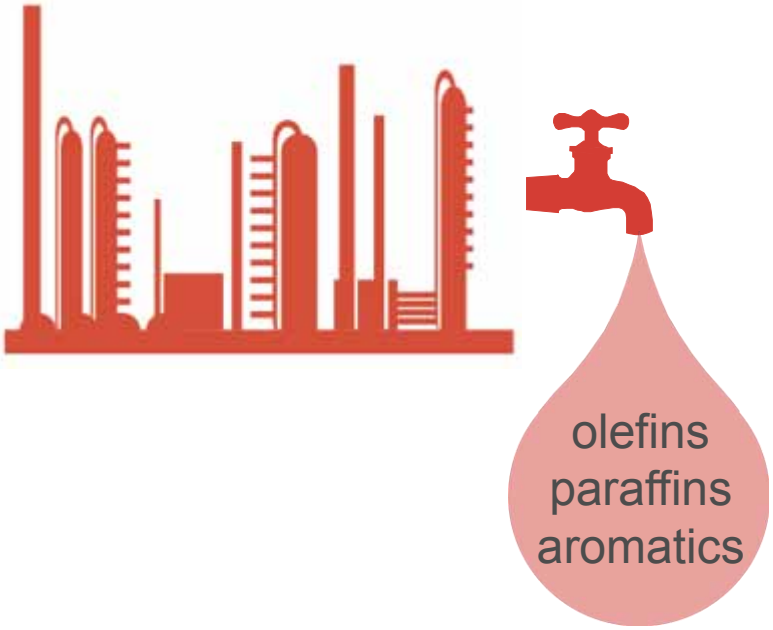
6

boost level
ignition energy
valve lift
downsizing
tumble ratio
powertrain design
fuel stratification
ignition timing
compression ratio
air/fuel ratio
hybridization
swirl ratio
heat exchanger design
valve timing
injector design
cylinder deactivation
injection timing
direct injection
real time controls
EGR ratio
number of injections
injection pressure
charge temperature
on-board reforming
injection duration
on-board separation
valve overlap
turbulence
downspeeding

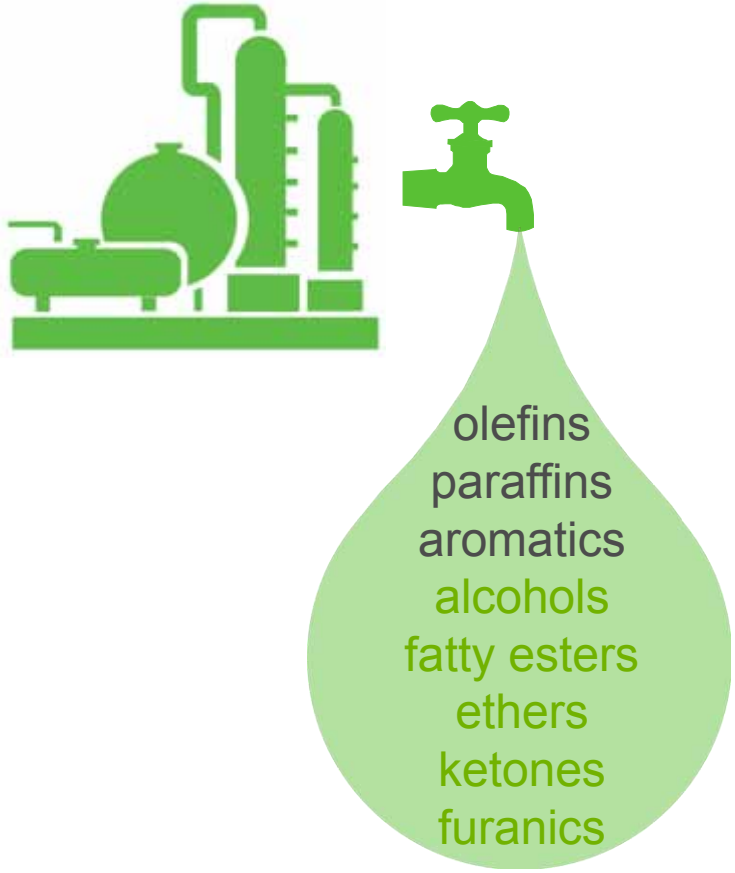
Higher efficiency engines can be enabled through fuels

Biofuel Provide Unique Fuels Options & Properties

Petroleum-derived Fuels



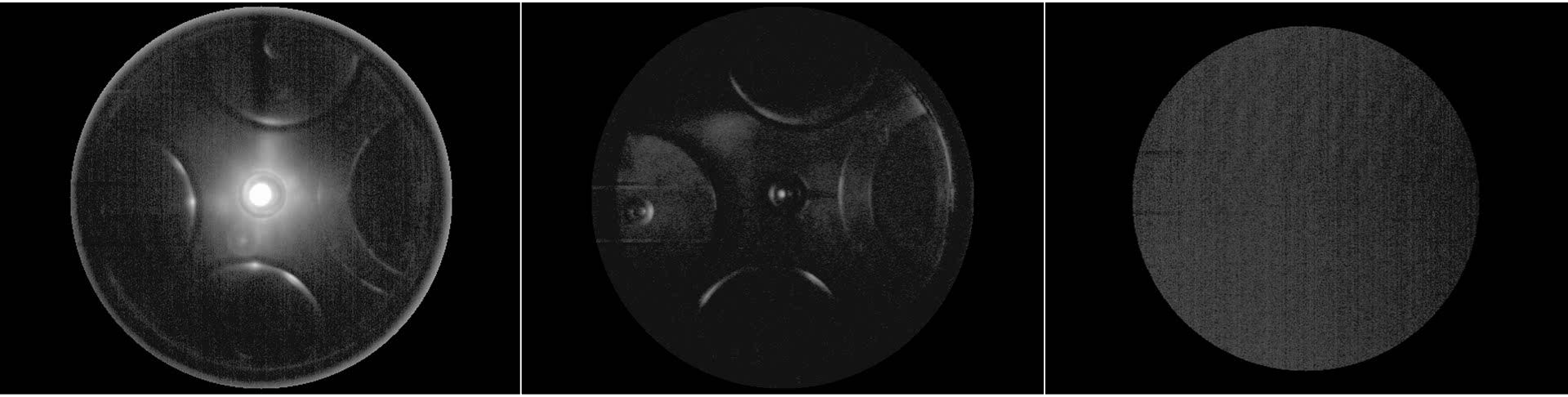
Biomass-derived Fuels



Biofuels can help enhance conventional fuel properties and performance

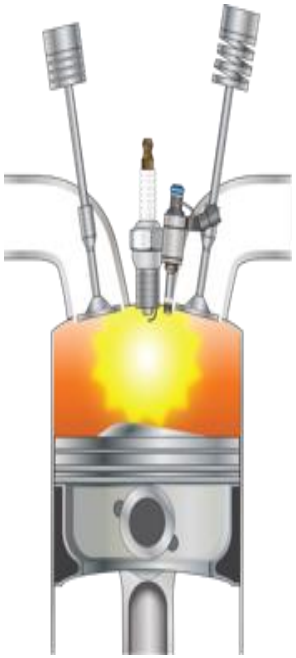
Fundamentally different **combustion dynamics** require **different fuel properties**

Spark ignition (gasoline)	Kinetically controlled combustion	Compression ignition (diesel)

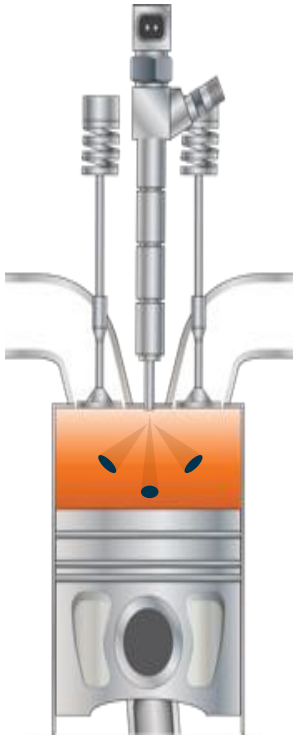


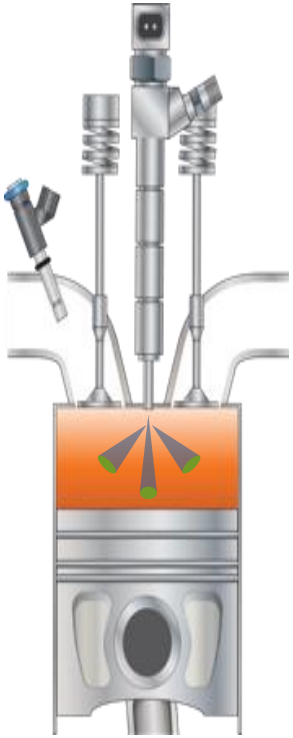
Parallel thrust efforts are underway

Thrust 1: Spark Ignition (SI)	Thrust 2: Advanced Compression Ignition (ACI) kinetically-controlled and compression-ignition combustion

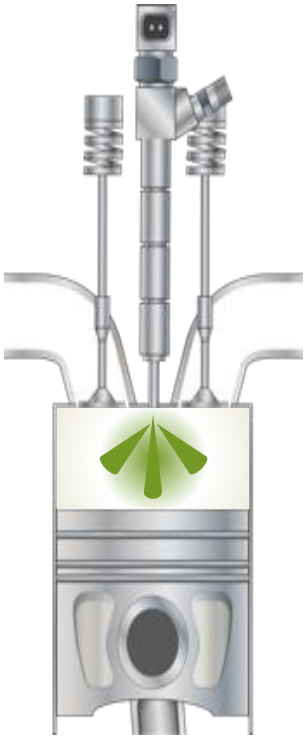


Low reactivity fuel





Range of fuel properties TBD



High reactivity fuel

9

Applicable to **light, medium, and heavy-duty** engines

Fuels-Engine Co-Optimization (Co-Optima)

- FY16 - **$22M** ($12M VTO, $10M BETO)
- FY17 Request - **$30M** ($15M VTO, $15M BETO)
- Coordinated across **9 national labs**
- Well aligned with **U.S. DRIVE FWG**

Thrust 1

spark ignition (SI)

2025 commercial entry

Low Reactivity Fuel
(gasoline)
high RON

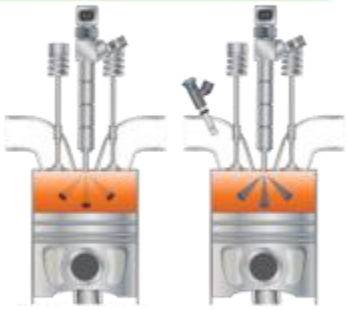
- Octane & beyond
- Downsized, boosted engines, higher CR
- FY16 Q1 -Select 20 fuels
- **FY17 Q2- Go/No Go vs. existing high octane alternatives**

Thrust 2

Advanced compression ignition (ACI)
including low temperature, kinetic regimes

2030 commercial entry

High Reactivity Fuel
(diesel)
high cetane



Range of Fuel Properties TBD
(new fuel)
undetermined fuel needs

- Kinetically controlled
- Low temperature combustion
- Maximize fuel efficiency with very low emissions
- Less known needs
- **Parallel to Thrust 1**

High performance, lower carbon fuels for high efficiency engines

Sustainable TRANSPORTATION

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

Questions

Reuben.Sarkar@ee.doe.gov