Fuels Technologies

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Energy Efficiency and Renewable Energy
U.S. Department of Energy

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Program Mission

To develop more energy efficient and environmentally friendly highway transportation technologies that enable America to use less petroleum.
--EERE Strategic Plan, October 2002--

Presentation Outline

- Fuel Technologies Research Goals
  - Fuels as enablers for advanced engine combustion
  - Fuel and lubricant impacts on emission controls
  - Displacement of petroleum
- Approach
- Example Project Accomplishments
- Research Directions

Fuels Technologies R&D Budget by Activities

Major Activities	FY 2007 Appropriation	FY 2008 Request	FY 2008 Appropriation	FY 2009 Request
Fuels Technologies	**18,413**	**13,845**	**17,836**	**16,122**
Advanced Petroleum Based Fuels	6,511	6,512	6,451	5,808
Non-Petroleum Based Fuels	11,902	6,948	10,885	9,863
SBIR/STTR		385	500	451

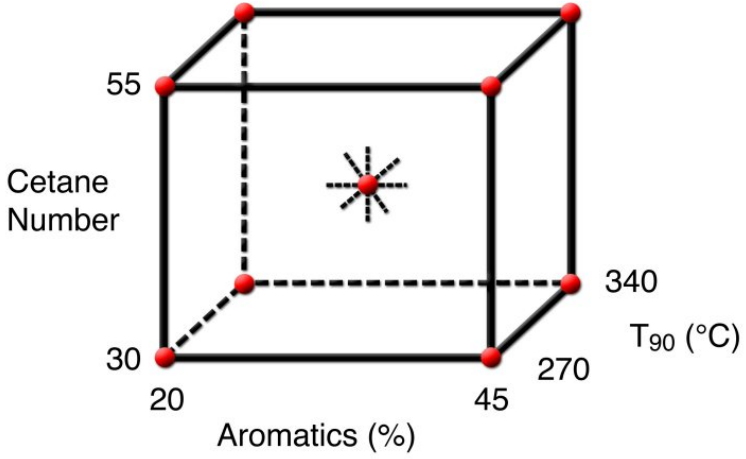
- Advanced Petroleum Based Fuels: improve fundamental understanding of fuel effects on advanced combustion and to enable the development and deployment of advanced engine systems

- Non-Petroleum Based Fuels: evaluate alternative fuels and fuel-blending components that are suitable for advanced combustion engines and can directly displace petroleum.

Vehicle Technologies Budget

	FY 2008 Current Appropriation	FY 2009 Request
Hybrid Electric Systems	94,135	103,361
Advanced Combustion Engine	44,591	33,600
Materials Technology	39,636	36,903
Fuels Technology	17,836	16,122
Technology Integration	16,845	31,100
Total, Vehicle Technologies	213,043	221,086

Characterizing Fuel Property Effects on High-Efficiency Clean Combustion…
FACE: Fuels for Advanced Combustion Engines

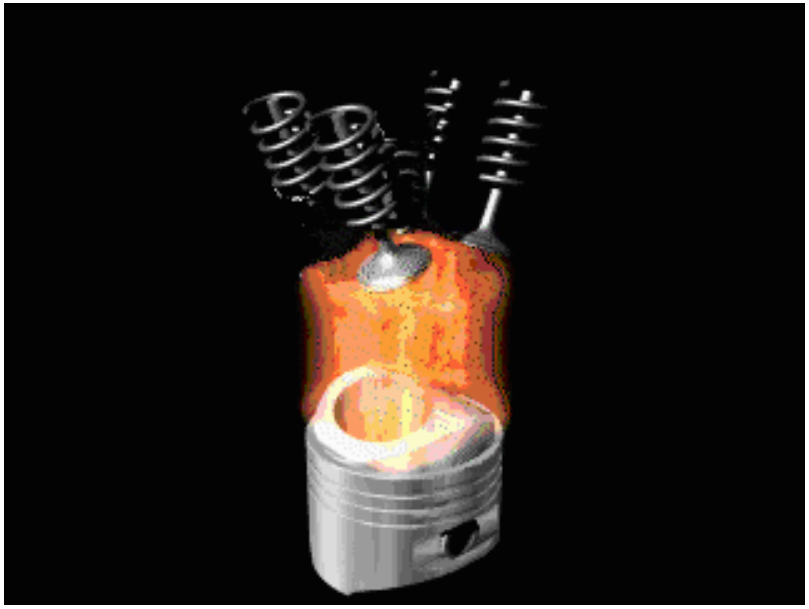


Being managed through Coordinating Research Council

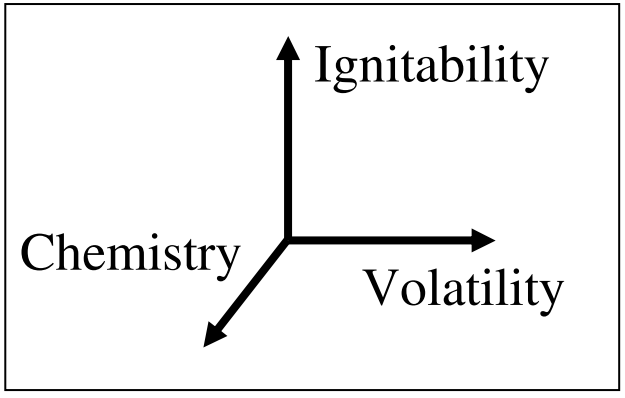
FACE Objective

Improve understanding of fuel property effects on emerging combustion processes

- Many emerging advanced combustion technologies
  - Combustion labels
    - PCCI, HCCI, CAI, etc.
  - Injection strategies
    - Early, late, split, premixed
  - Ignition control
    - Intake temperature, EGR, spark assist, variable compression ratio, etc.



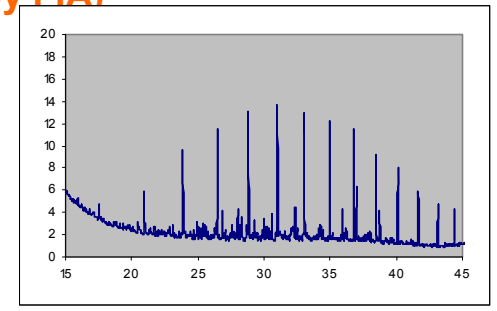
- Difficult to compare fuel effects between different engines
- As combustion systems advance, and emissions standards continue to tighten, engines are likely to become *more* sensitive to these effects.



- **Approach:** Design, blend and test a standard set of research fuels that allow investigators to quantify fuel effects
  - Effort intended to illuminate fuel effects on combustion
    - Goal is *not* to design an optimal fuel for advanced combustion

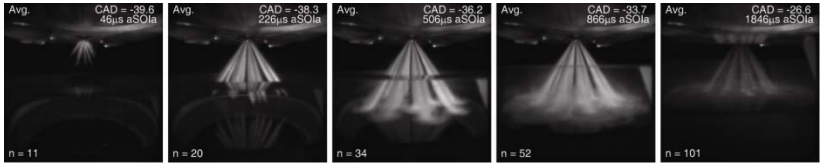
Characterization of fuels is highly detailed

- Octane Number (RON & MON for gasoline range)
- Cetane Number and IQT Derived Cetane Number (for distillates)
- API Gravity
- RVP
- Sulfur
- Distillation (D86 – IBP, T5, T10,…T90, T95, EP)
- Oxygen
- H/C ratio
- Benzene
- Heat of Combustion (gross & net)
- Other D4814 properties for gasoline
- Other D975 properties for distillates
- PIANO (n-paraffins, iso-paraffins, aromatics, naphthenes, olefins) (by FIA)
- Detailed Hydrocarbon Analyses (Possible techniques):
  - GC and GC/MS
  - 2 Dimensional GC and 2D GC/MS
  - GC-FIMS
  - NMR

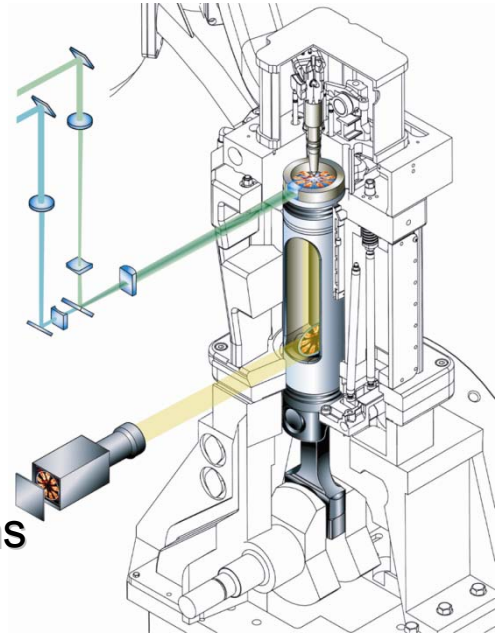


Fuel Effects Research at Sandia Nat'l Labs

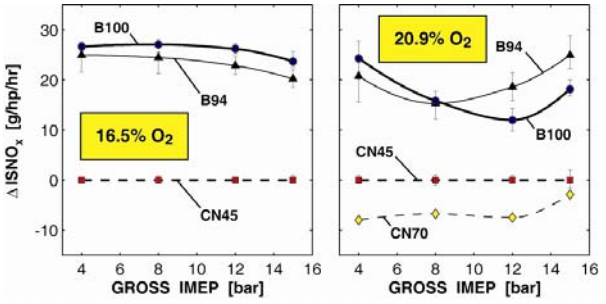
- **Using optical engine to answer fuel-effects questions**
  - Provides in-cylinder insight



1. **Is fuel volatility important for early direct-injection HECC strategies?**
   - Yes. Liquid fuel impingement on in-cylinder surfaces affects efficiency
   - Subsequent pool fires affect emissions



2. **How much and why do NO_x emissions increase when fueling with biodiesel?**
   - NO_x increase is larger at higher-EGR conditions
   - Many coupled factors involved
     - Radiative heat transfer
     - Reaction rates
     - Actual combustion temperatures



Sandia National Laboratories

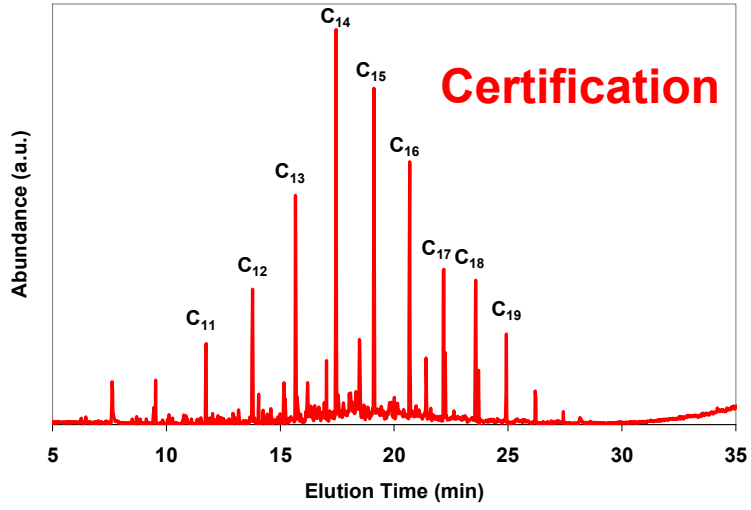
CRF

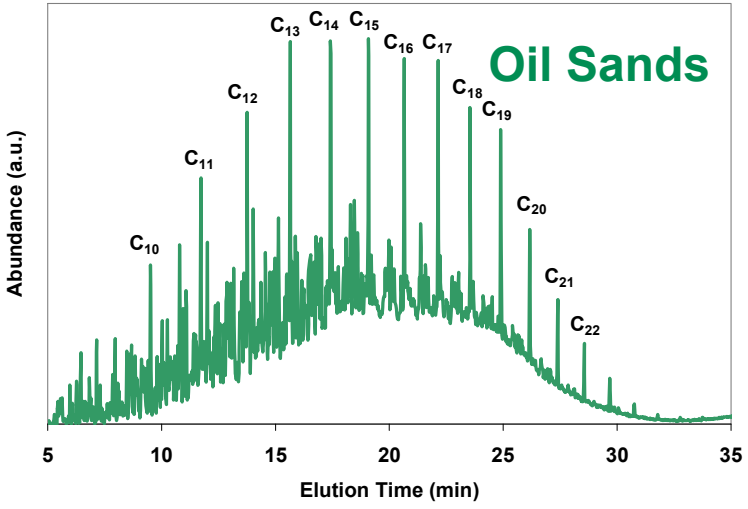
Biodiesel Deployment

- B100 and B20 Quality Surveys
  - Nationwide sampling
  - Relative to ASTM specifications
- Oxidation Stability Project
  - Determine acceptable stability test method: B100, B20, and B5
- Test Method Development
  - Biodiesel quality evaluation, including field tests
- Quantitative Fleet Evaluations
  - 2 in-use fleet evaluations with control vehicles ongoing
  - B20 FET in collaboration with NBB
- Biodiesel Vehicle Emission Measurement
  - Addresses NO_x reduction
  - Testing: NREL truck / bus chassis dyno

Unconventional Hydrocarbons: Oil-Sands Derived Fuels

- Chemical and physical properties of future fuels
- Canadian National Centre for Upgrading Tech (NCUT), ORNL, PNNL
  - NCUT – Product & blend stream samples and conventional analysis
  - ORNL – HCCI combustion performance evaluations and GC/MS for identification of cycloparaffins
  - PNNL – Lubricity evaluations and NMR analysis for molecular structural grouping





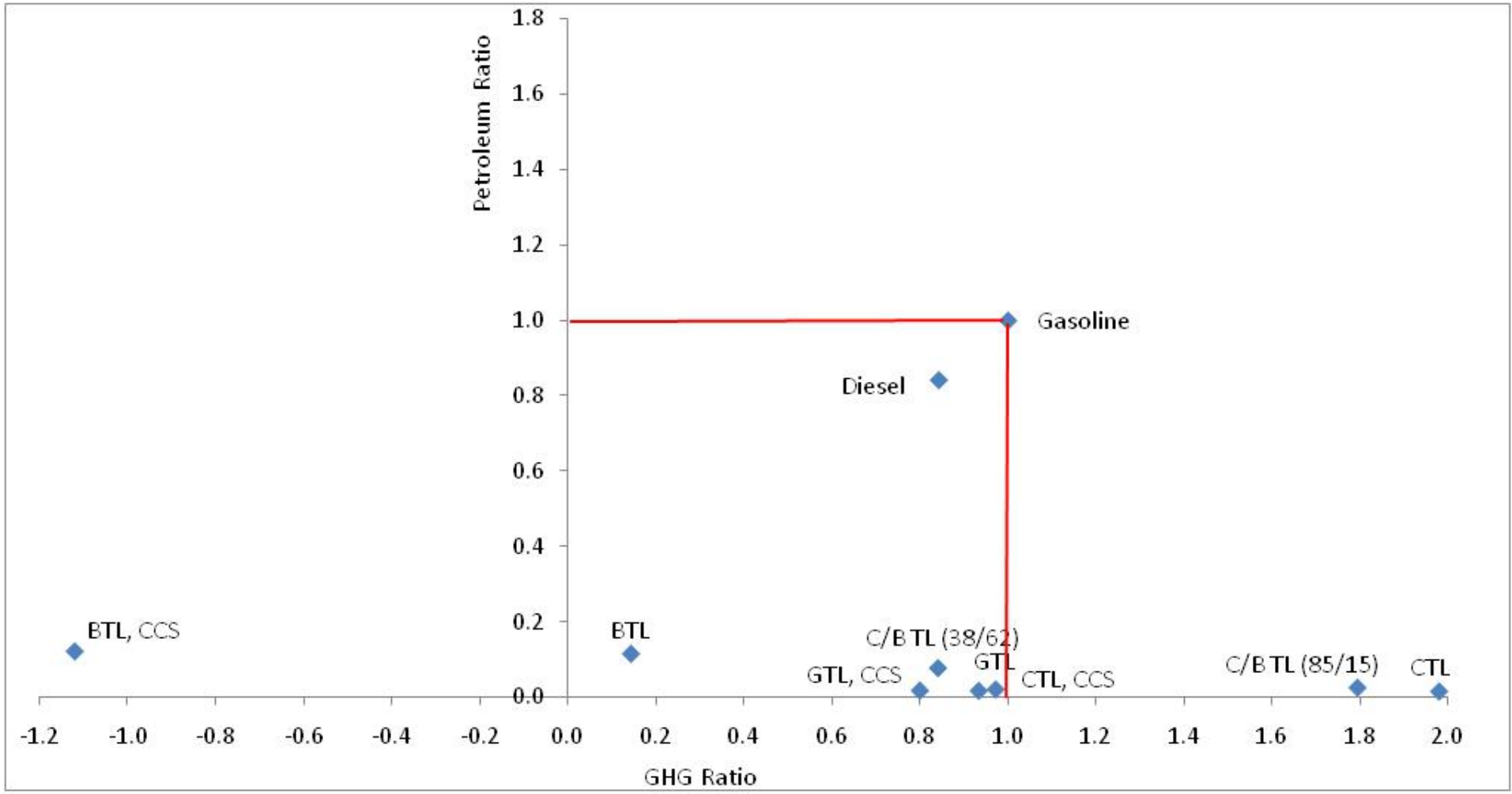
Fischer-Tropsch Diesel: xTL Fuels Compared

- Well-to-Wheels and Vehicle Performance Evaluation by Argonne
  - Natural gas to liquids (GTL)
  - Coal to liquids (CTL)
  - Biomass to liquids (BTL)
  - Co-firing of coal and biomass to liquids (C/BTL)
    - 85/15 C/B co-feeding
    - 38/62 C/B co-feeding: GHG breakeven with petroleum diesel
- All options were evaluated with and without carbon capture and storage (CCS) in FTD plants

F-T Diesel Testing Results

- CO_2 emissions on a per-mile basis were reduced for all GTL-containing fuels and vehicles, which implied that less fuel energy was consumed for the drive cycles
- NO_x emissions were mostly reduced in tested vehicles, but there was no clear trend showing a consistent decrease with an increase in GTL content
- PM data showed a decrease in PM emissions with the increase of GTL (vehicle equipped with DPF)

GHG Trade-Offs



Intermediate Blends of Ethanol and Gasoline

Motivation: 20-in-10 / EISA

- Current ethanol markets are not able to absorb volumes specified by the Energy Independence & Security Act (36B gallons)
  - Today, blended gasoline used in standard vehicles (non-FFVs) is limited to 10 percent ethanol (E10).
  - More than 99 percent of the ethanol produced today is used in E10 blends; a tiny fraction is used to produce E85 for FFVs.
  - E10 markets are likely to saturate by 2013, possibly sooner, as production capacity approaches 15B gallons (~10% of all gasoline sold).
- Two paths to increase ethanol markets beyond 15B gallons:
  - Path A: Saturate E10 markets – and significantly expand E85 markets at a greatly-accelerated pace relative to today
  - Path B: Certify “intermediate blends” of gasoline to use up to 15 or 20% ethanol (E15, E20) and let market forces drive ethanol supply distribution
- DOE is investigating the impact of Path B on the existing legacy fleet of vehicles and non-road equipment

Overview of iBlends Studies

- All testing at neutral sites
- E15/E20 impact on legacy fleet – pilot study underway (16 vehicles)
  - **Interim report to be published shortly**
- Leveraging several CRC and EPA projects
  - CRC E-77 evaporative emissions program
  - CRC CM-133 driveability program
  - EPA EPAct program (emissions)
  - CRC E-87 catalyst durability
- Materials compatibility reviews and studies
  - CRC AVFL-15, E20 fuel
  - Monitoring Minnesota E20 program; RIT fleet study
  - UL dispenser materials study underway
- Small, non-road engines: done (accelerated at EPA request)
- Additional specialty engine studies in planning stages
  - Marine engines, ATVs, snowmobiles, motorcycles
  - Heavy-duty gasoline engines

June 2007 Literature Review

- Very little data on E20
- Almost no data on E15
- Credible studies reported NO_x emission increases and long-term catalyst degradation with E20
- Prior studies found materials compatibility issues with E20, and evidence of fuel filter plugging even with E10
- Average driver might not initially detect driveability problems (stumble, hesitation, etc) in late-model vehicles using E20
  - No long-term information available on driveability
- Drivers of older vehicles could notice driveability problems (potential tampering concern)

Preliminary Results

- Consistent with prior studies
- Fuel economy decreased on volumetric basis for E10, E15, E20 (and E30) – closely tracks fuel energy content
- Cars that ran less rich at full-throttle (open-loop conditions) exhibited higher exhaust temperature (LFT)
- In post-2002 cars, casual (untrained) observations do not suggest an impact on driveability
- Older car driveability data being processed
- No MILs or filter plugging so far

Future Emphasis

- Proceed with fundamental research, FACE, and industry teams on discerning fuel effects on advanced combustion
- Work with industry to resolve deployment issues with biodiesel
- Continue studies of properties of emerging fuels effects on engines and emission control systems