High Octane Ethanol Blends for Improved Vehicle Efficiency

Brian West
Fuels, Engines, and Emissions Research Center

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Bioenergy Technologies Office
Vehicle Technologies Office

ORNL is managed by UT-Battelle
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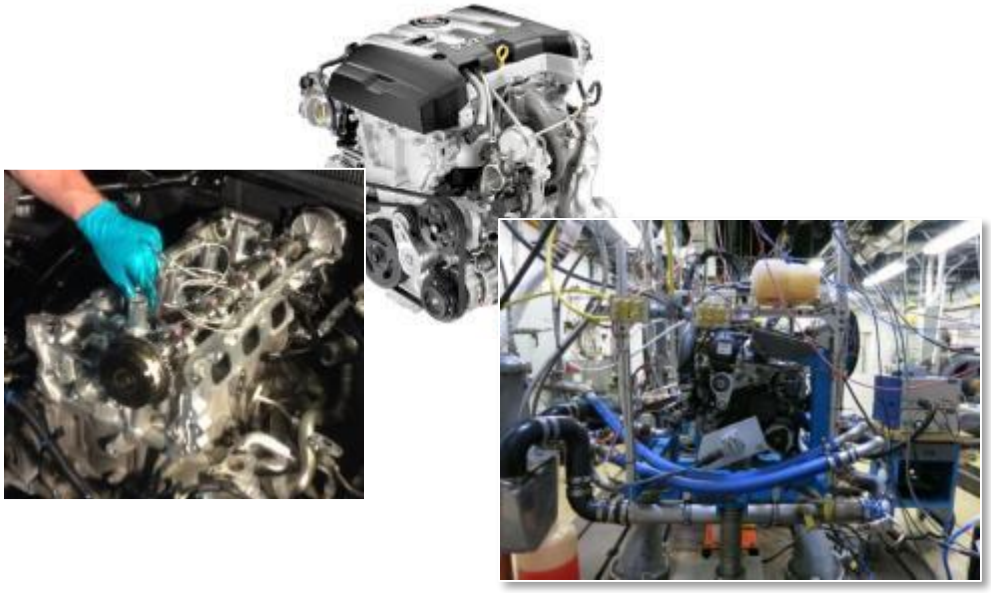
Industry and DOE Investing In Programs to Quantify Efficiency and GHG Benefits of High Octane Fuels

DOE Work supported by

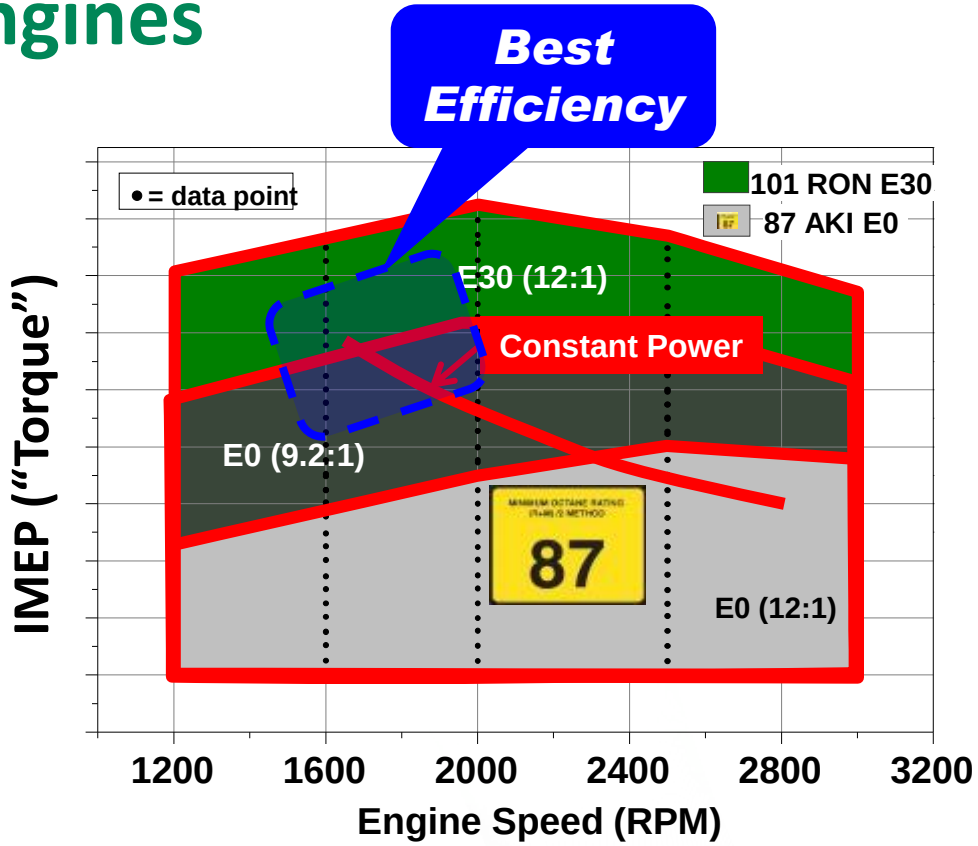
- **Vehicle Technologies Office**
- **Bioenergy Technologies Office**
- **Studies quantifying**
  - **Infrastructure compatibility**
  - **Efficiency and performance improvements in engines/vehicles with high octane fuels, various sources of octane, different engine architectures**
  - **Market analysis**
  - **GHG benefits**

Industry Cost-Share, Funds-in, and Technical Support



Recent Experiments Highlight Efficiency Benefits of High Octane Fuel for SI engines

- **Engines can make more torque and power with higher octane fuel**
- **Ethanol is very effective at boosting octane number**
  - 87 pump octane E0 + 30% Ethanol = 101 RON Fuel
- **Increased torque enables downspeeding and downsizing for improved fuel economy**
- **For future vehicles, engine and system efficiency can balance lower energy density of ethanol blends**
- ***Every gallon of ethanol could displace a full gallon of gasoline***



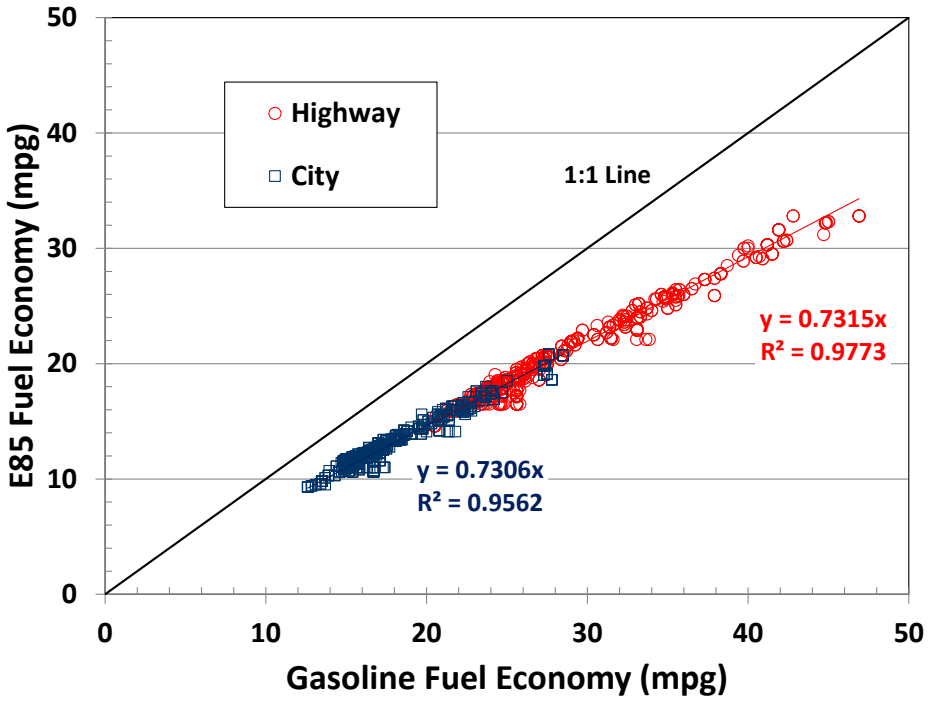
In a high compression research engine, high-octane E30 enables doubling of available torque compared to 87 AKI E0 fuel

- Splitter and Szybist, ORNL

Flex Fuel Vehicles (FFVs) Can Use Any Blend of Ethanol.

Consumers Continue to Shy Away from "E85"

- **Over 17M FFVs on road – annually consume ~13 gal E85 per vehicle**
- **Lower Energy Density and often higher $/BTU (compared to gasoline or E10)**
  - Shortened range
  - Higher cost per mile



- **How much ethanol is in my "E85?"**
  - Specification allows 51% to 83% ethanol to address quality and volatility of blends
  - Potential for significant variability in vehicle fuel economy, contributes to consumer confusion

Consumer acceptance is key to success of any new fuel

Vehicle Study to Determine Potential Performance Improvement of Legacy FFVs with High Octane Blends

Work supported by DOE Bioenergy Technologies Office

- **Motivation: Measureable performance improvement in legacy FFVs could enable early adoption of "High Octane Fuel for Your FFV"**
- **Acquired 4 "ethanol tolerant" FFVs**
  - GMC Sierra
  - Chevrolet Impala
  - Ford F150
  - Dodge Caravan
- **Prep and Baseline "wide open throttle" (WOT) test with Regular E10**
- **Prep and WOT test with ~100 RON E30**

HIGH OCTANE FUEL For your FFV

MINIMUM OCTANE RATING
RON METHOD
100

CAR AND DRIVER

C/D TEST RESULTS

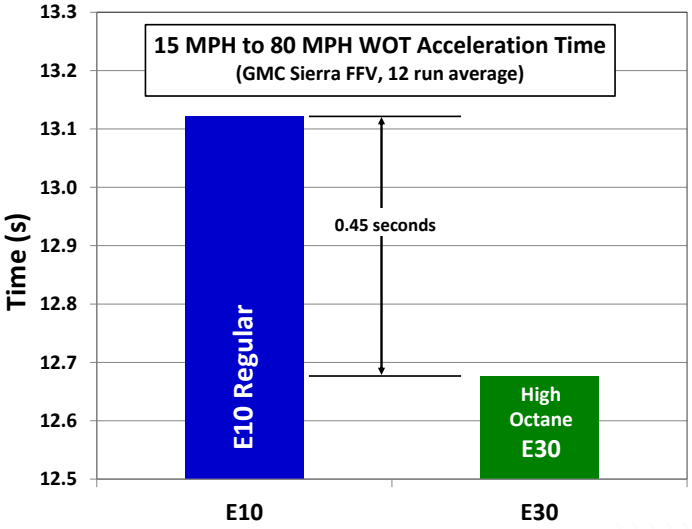
ZERO TO 60 MPH	7.7/7.3 sec
ZERO TO 100 MPH	16.6/20.7 sec
ROLLING START, 5-60 MPH	8.0/7.9 sec
1/4-MILE	16.0 sec @ 87 mph/ 15.7 sec @ 89 mph

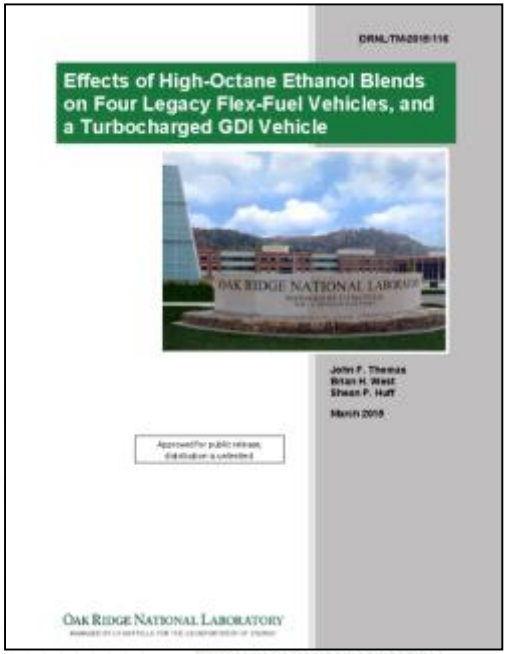
Car and Driver FFV test shows 0.4 second faster 0-60 mph time with E85

www.caranddriver.com/reviews/2014-chevrolet-silverado-v-6-instrumented-test-review

- **Report available:**
  - 3 of 4 FFVs show acceleration improvement with E30
    - ORNL's Sierra results with E30 similar to Car and Driver test with E85 ➔

If half of all FFVs on road today filled up with E30 half the time, they would consume half-billion gallons more ethanol annually





http://info.ornl.gov/sites/publications/Files/Pub54888.pdf

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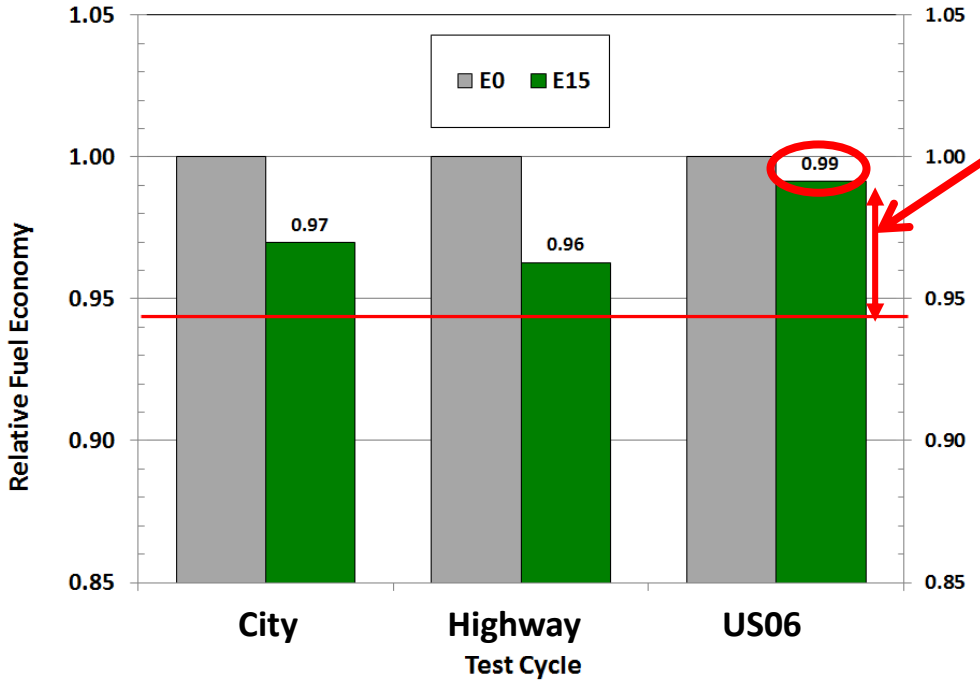
Benefits of Engine Downsizing with High Octane E-Blend Demonstrated on Late-Model Turbo Direct Injection Vehicle

- **E15-Compatible Ford EcoBoost Fiesta**
  - **1.0 liter, 3-cylinder turbo Direct Injection engine**
- **Owner's Manual:** **"Regular unleaded gasoline…is recommended….premium fuel will provide improved performance and is recommended for severe duty usage..."**
- **Experiment:**
  - **Blend regular 87 octane E0 with 15% Ethanol**
    - **Boosts octane, lowers energy content**
  - **Test on City, Highway, and US06 (high-load cycle)**
- **Results within 1% of *Volumetric Fuel Economy Parity* with E15 on US06**



4.6% Efficiency Improvement

Fuel:	E0	E15
RON	**90.7**	**97.8**
AKI	87.7	92.6
Btu/gal	113,100	106,700
Relative Btu/gal	**1.00**	**.943**

Addition of 15% ethanol boosts octane, improves engine performance & efficiency.

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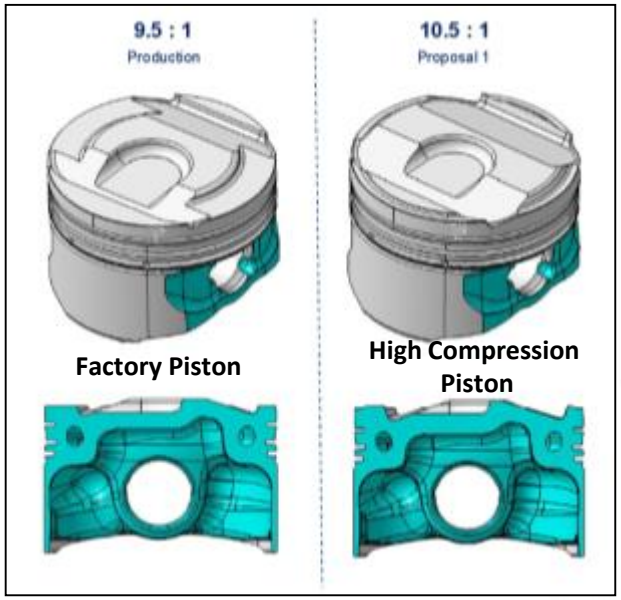
High-Octane Efficiency Benefits Demonstrated at the Vehicle Level

- **GM Cadillac ATS with 2.0 liter Turbo Direct Injection engine for dedicated vehicle study**
  - Manual Transmission and final drive gears to readily enable downspeeding
  - Currently conducting baseline tests on range of fuels with factory pistons/calibration
  - Change to high compression ratio, revise calibration
    - Pistons for high compression being designed now
  - Fuel blends will span various octane levels with different sources of octane number



- *GM Tech support*
  - *High compression pistons*
  - *Engine controls support (spark, boost, etc)*
  - *Ability to monitor cylinder pressure*
  - *Source for taller gears (final drive ratio)*