

“OPTIMAL ETHANOL BLEND-LEVEL INVESTIGATION”

Overview & Key Findings

The University of North Dakota Energy & Environmental Research Center (EERC) and the Minnesota Center for Automotive Research (MnCAR) conducted research on one flex-fuel and three non-flex-fuel 2007 model vehicles to investigate the possible existence of a fuel-economy-based “optimal” ethanol blend level, at which the actual measured miles per gallon is greater than the miles per gallon predicted by the fuel’s per-gallon energy content. The investigation was cosponsored by the U.S. Department of Energy and the American Coalition for Ethanol (ACE).

OVERVIEW

Researchers: the University of North Dakota Energy & Environmental Research Center (EERC) & the Minnesota Center for Automotive Research (MnCAR)

Testing Method: the Highway Fuel Economy Test (HWFET), a test developed by the U.S. Environmental Protection Agency to determine fuel economy

Vehicles Tested: Toyota Camry (2.4 liter engine), Ford Fusion (2.3 liter engine), non-flex-fuel Chevrolet Impala (3.5 liter engine), flex-fuel Chevrolet Impala (3.5 liter engine)

Fuels Tested: various blends of undenatured ethanol & Tier 2 gasoline, from 0% to 85% ethanol

Primary Objective: to investigate the possible existence of a fuel-economy-based “optimal” ethanol blend level, at which the actual measured miles per gallon is greater than the miles per gallon predicted by the fuel’s per-gallon energy content

Secondary Objective: to acquire emission data for all surveyed fuels and determine whether they continued to meet EPA guidelines

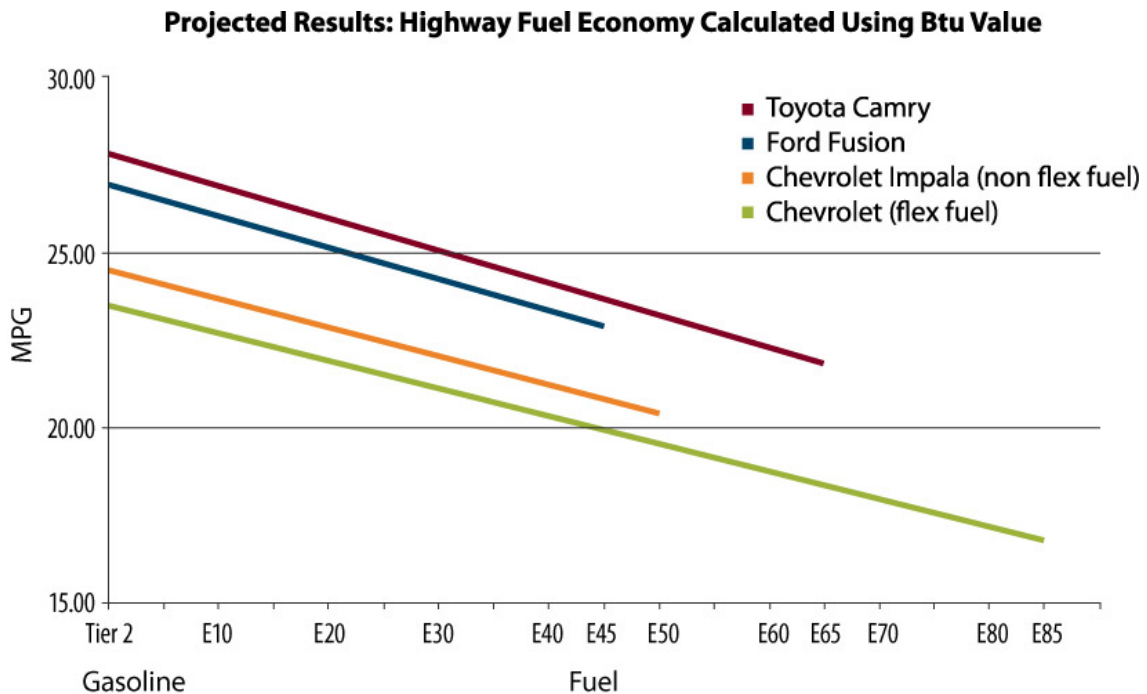
Highway Fuel Economy Testing (HWFET) was conducted on a Toyota Camry, Ford Fusion, non-flex-fuel Chevrolet Impala, and flex-fuel Chevrolet Impala using various blends of undenatured ethanol and Tier 2 gasoline, ranging from 0% to 85% ethanol. Actual fuel economy performance of certain ethanol blends was significantly better than the estimated fuel economy based on the Btu content of the fuel.

KEY FINDINGS

- 1. Ethanol’s energy content was not found to be a direct predictor of fuel economy.***
- 2. E20 and E30 ethanol blends outperformed gasoline in fuel economy tests for certain autos.***
- 3. Standard, non-flex-fuel vehicles operated well on ethanol blends beyond 10 percent.***
- 4. Vehicle emissions met EPA requirements and were improved in key areas.***

1. Ethanol’s energy content was not found to be a direct predictor of fuel economy.

A fuel’s energy content in British Thermal Units (Btu) is current standard practice for estimating fuel economy, a method that, because of ethanol’s lower Btu value, leads to estimates of decreased fuel economy in proportion to the percentage of ethanol in the fuel blend.



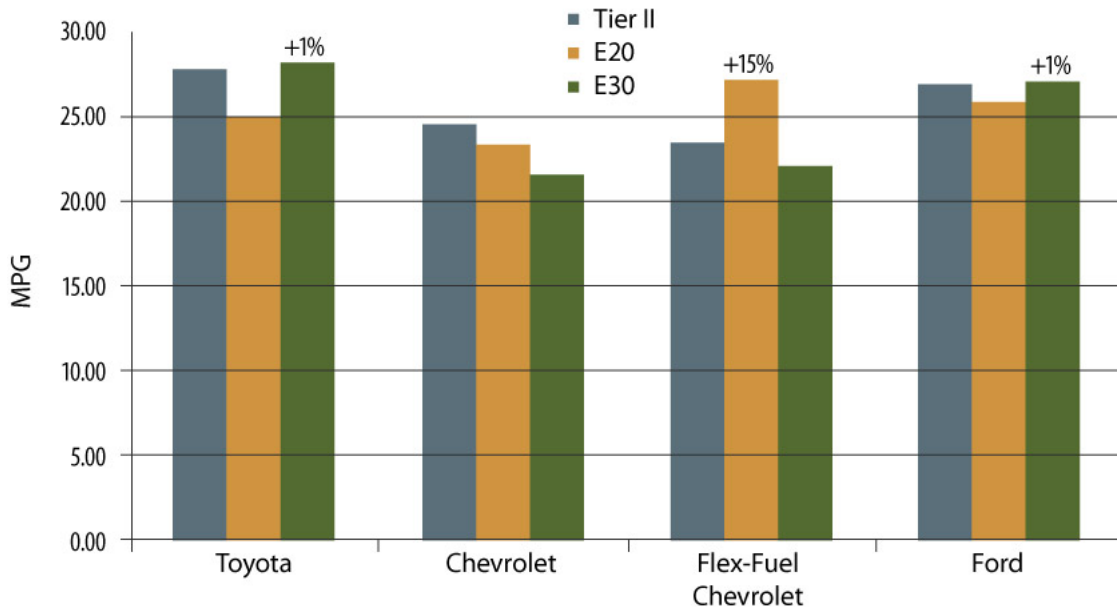
This research, however, did not find ethanol’s Btu content to be a direct predictor of fuel economy. All four vehicles tested exhibited better fuel economy with the ethanol blends than the Btu-value estimates predicted. In three of the vehicles, an ethanol blend actually offered better fuel economy than straight gasoline.

2. E20 and E30 ethanol blends outperformed unleaded gasoline in fuel economy tests for certain autos.

Contrary to Btu-based estimates of fuel economy for ethanol blends, three of the four vehicles tested achieved their highest fuel efficiency not on gasoline, but on an ethanol blend. Mid-level blends of ethanol E20 (20% ethanol, 80% gasoline) and E30 (30% ethanol, 70% gasoline) offered the best fuel economy in these tests.

- E30 offered better fuel economy than gasoline (a 1% increase) in both the Toyota and the Ford.
- E20 offered better fuel economy than gasoline (a 15% increase) in the flex-fuel Chevrolet.
- The non-flex-fuel Chevrolet more closely followed the Btu-calculated trend for fuel economy, but did experience a significant improvement over the trend line with E40 (40% ethanol, 60% gasoline), indicating that this may be the “optimal” ethanol blend level for this vehicle.

Actual Results: Highway Fuel Economy Improvement Demonstrated with E20, E30 vs. Gasoline



3. Standard, non-flex-fuel vehicles operated well on ethanol blends beyond 10 percent.

All automakers currently cover the use of up to E10 (10% ethanol, 90% gasoline) by warranty for standard, non-flex-fuel vehicles. In this preliminary research, the three non-flex-fuel vehicles tested each operated successfully on ethanol blends significantly higher than this 10% ethanol level.

- The Ford Fusion operated on E45 and did not give an engine fault code until E50.
- The Toyota Camry operated on E65 and did not give an engine fault code until E70.
- The non-flex-fuel Chevrolet Impala operated on E55 and did not give an engine fault code until E70.

4. Vehicle emissions met EPA requirements and were improved in key areas.

A secondary objective of the investigation was to acquire HWFET hot-start tailpipe emission data for all surveyed fuels; cold-start emissions were also determined on the vehicle's optimal blend level and on Tier 2 gasoline using Federal Test Procedure 75 (FTP-75). More rigorous testing will be required, but the results are well within EPA guidelines.

- Emissions of CO₂ show improvement over gasoline in most ethanol blends, with significant emission reductions shown when using the vehicle's optimal ethanol blend level.
- Exhaust emission values for nitrogen oxides (NO_x) and carbon monoxide (CO) were at or below EPA Tier 2, light-duty vehicle, Bin 5 levels for all vehicles tested.
- Exhaust emission values for nonmethane organic gases (NMOG) were at or below EPA Tier 2, light-duty vehicle, Bin 5 levels for all vehicles tested with one exception.
- The one exception (the flex-fuel Chevrolet Impala) exceeded the cold-start emissions standard for NMOG on Tier 2 gasoline and on E20, the E20 exceedence being 21% less than that of the gasoline.