



Roundtable on Ethanol Fuel: Automaker View

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Alliance Members

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Ethanol as Transportation Fuel

- ✦ Alliance supports increased fuel ethanol use for light duty vehicles with spark ignition engines
- ✦ Real and potential benefits
 - Renewable; variety of feedstocks
 - Offsets gasoline use
 - New market for agricultural products
 - GHG
 - Other

First Things First

✦ First: which fuel?

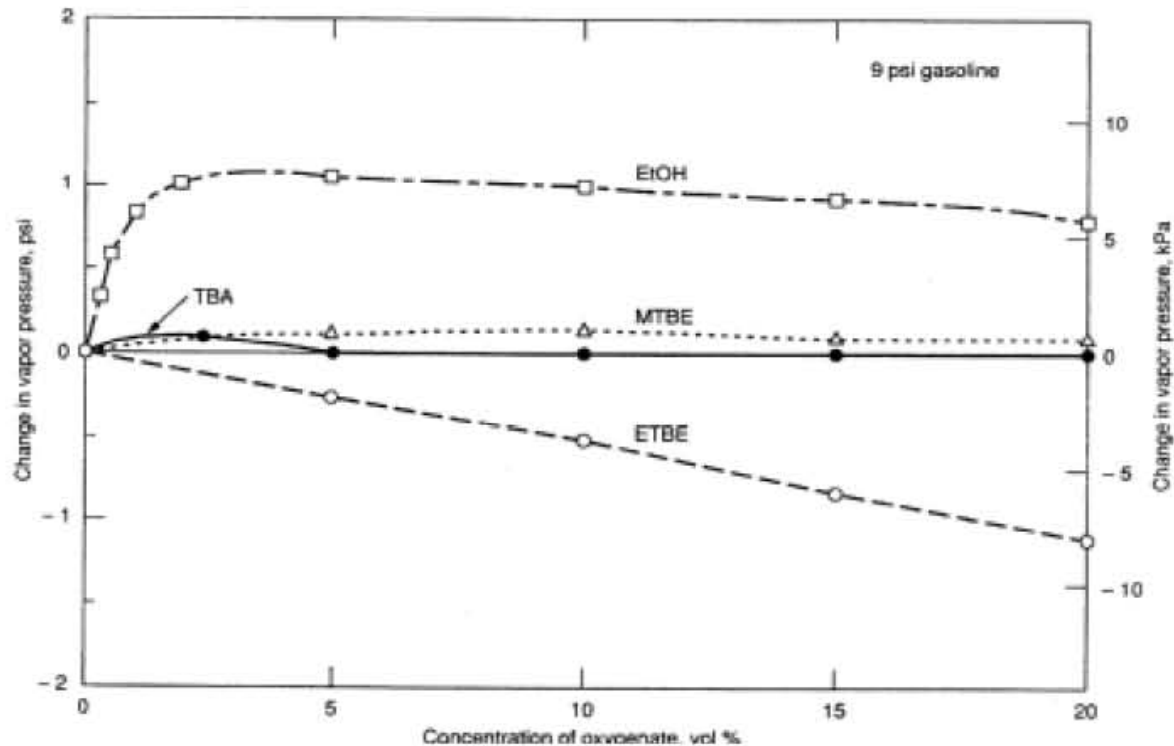
- High level blends (E85)
- Low level blends (E6, E10)
- Other concentrations (e.g., E20, E30)
- Each has own impacts, issues

✦ Alliance recommends against blending ethanol (ETOH) with diesel fuel

Simple Chemical, Complex Behavior

- ✚ Small polar organic molecule ($\text{CH}_3\text{—CH}_2\text{OH}$)
- ✚ High water solubility—requires careful handling
- ✚ Non-additive impact on gasoline mixture RVP
 - low RVP when neat, higher when blended
- ✚ Affects combustion process
- ✚ Adds octane, dilutes unfavorable gasoline molecules
- ✚ Affects older and newer technologies differently
- ✚ Has lower energy content than gasoline, so it lowers vehicle fuel economy
 - Effect increases with concentration

RVP of Gasoline-ETOH Blends



American Petroleum Institute (June, 2001). *Alcohol and Ethers: A Technical Assessment of Their Application as Fuels and Fuel Components*. API Publication 4261. Third Edition.

High Level: E85

- ✦ Requires special vehicle design
 - Technology (software, optical sensors, other) needed to detect ethanol & adjust air-fuel
 - Special materials needed for fuel pumps, lines, tanks and injectors to avoid corrosion, limit evap
 - E70 used in winter to ensure ignitability
- ✦ Lower RVP than most low-level blends
- ✦ Design helps vehicle avoid some emission issues of low level blends
- ✦ E85 fuel quality requires attention like any other transportation fuel (e.g., detergency)

E85, cont.

- ✦ Requires own fuel infrastructure to avoid water pick-up
- ✦ To overcome chicken-egg problem (lack of infrastructure), automakers developed Flexible-Fueled Vehicles (FFVs)
 - FFVs can use E0, E85 or any blend in-between
- ✦ Today, 5 million FFVs are on the road, ready for fuel infrastructure to grow

Low Levels: E6, E10

- ✦ Today, virtually all U.S. vehicles are designed to handle up to E10
 - Adaptations include fuel system materials, engine calibrations
- ✦ Sources of emission impacts
 - Evaporative
 - Tailpipe
 - Permeation

Emissions: Evap

- ✦ Modern vehicles use technology to control evaporative emissions
 - Carbon canisters
 - Fuel system materials
 - Tight seals (e.g., at fuel intake)
- ✦ Tier 2 and LEV2 control evap emissions very well, including for gasoline-ethanol blends under 10%

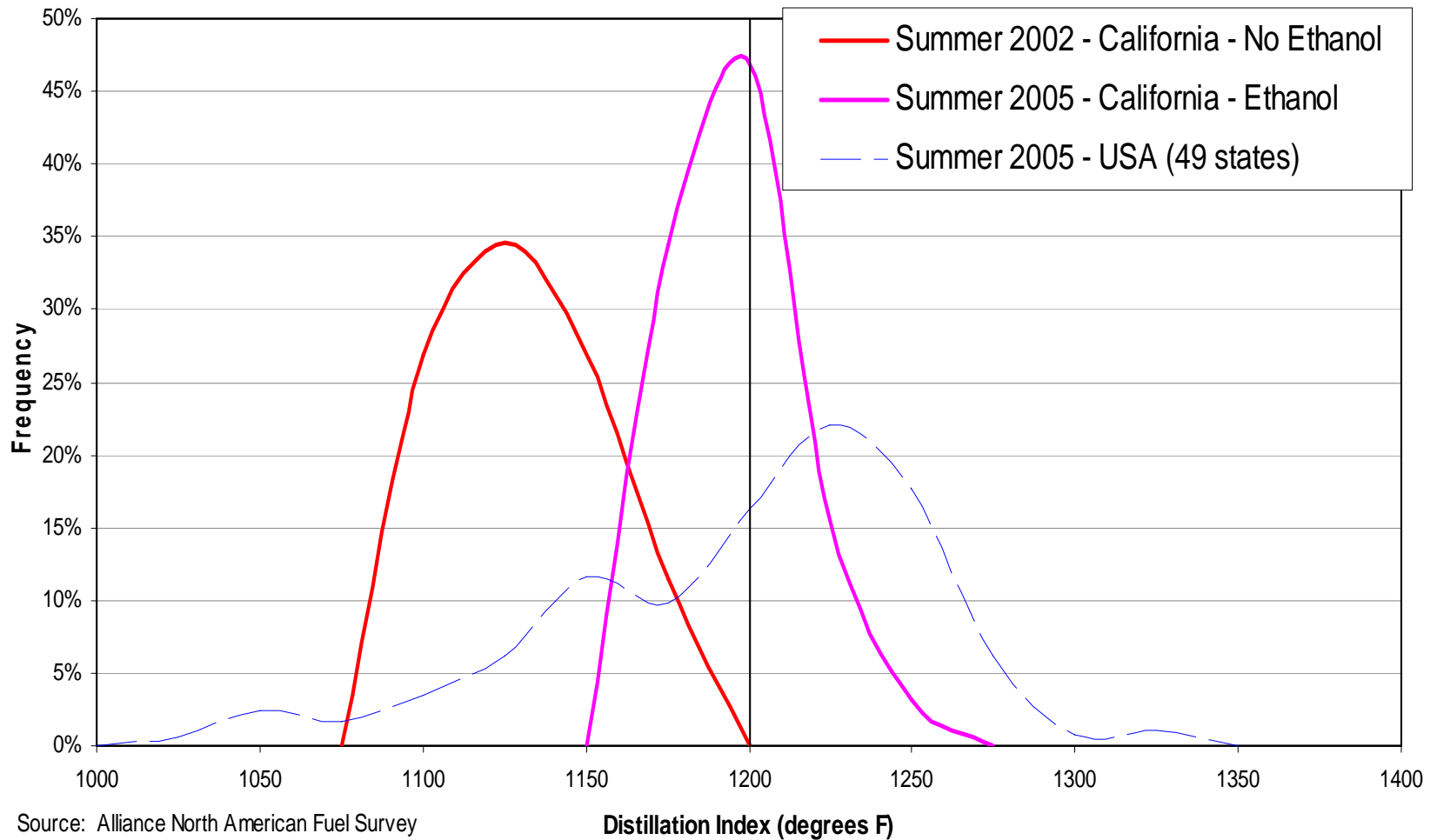
Emissions: Tailpipe

- ✦ Impact depends on technology, base fuel
 - ETOH helped older engines burn cleaner
 - Newer vehicles don't benefit from added oxygen due to almost universal use of closed loop air-fuel ratio control
- ✦ How ETOH affects exhaust emissions:
 - Changes fuel properties: Distillation Index, T50, $T_{V/L=20}$
 - Higher heat of vaporization can affect combustion temperature and catalyst light-off time
 - Can make combustion gases too lean
- ✦ Can mitigate undesirable effects by properly balancing the final gasoline-ethanol blend

Potential Performance Impacts

- ✦ Volatility too high (T50 too low):
 - hot driveability problems, lower fuel economy
- ✦ Volatility too low (high DI/T50):
 - poor cold start, poor warm-up performance, poor cool weather driveability, increased deposits, unequal fuel distribution in carbureted vehicles
- ✦ Volatility just right: $DI \text{ (adj for ETOH)} = 1200 \text{ max}$
 - Alliance/WWFC offset = $20 * Oxy$
 - ASTM considering an offset
- ✦ Performance problems indicate higher emissions

California DI, Pre- & Post-ETOH



Source: Alliance North American Fuel Survey

Permeation Emissions

- ✦ Differs from evaporation
 - Emissions depend on ETOH concentration and materials used in fuel handling system
 - Phenomenon not fully understood
- ✦ Significant emissions problem for older vehicles (pre-LEV2/Tier 2)
 - New vehicles use less permeable materials

Mid-level Blends

- ✦ Vehicles (non-FFV) are designed to handle blends only up to 10%
 - Concerns: emissions (exhaust, evap, permeation); performance; durability (corrosion, elastomers, plastics)
- ✦ Blends above 10% volume are illegal in mass market because EPA deems not “substantially similar” under the Clean Air Act
 - EPA waiver required
 - Research underway (MN, CRC, auto companies)
- ✦ May be bigger issue for small engines (lawnmowers, motorcycles, etc.)

Conclusions, Recommendations

- ✦ Adding ethanol to gasoline has complex effects, depending on finished fuel and vehicle design
- ✦ Can mitigate emission impacts
 - Proper fuel blending
 - Fleet turnover
- ✦ E85 avoids many of the emission & performance issues associated with uncontrolled E6/E10 blending
- ✦ Bottom Line: Take close look at options, use an integrated approach