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E-85 and Flex-Fuel Technology

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What is an Alternative Fuel?

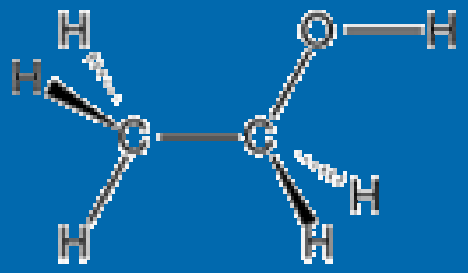
- As defined by Energy Policy Act of 1992 (EPAct)
  - Substantially non-petroleum
  - Substantial energy security benefits
  - Substantial environmental benefits
- Methanol/ethanol/alcohol blends (85%)
- Natural gas/Propane
- Coal derived liquid fuels
- Hydrogen
- Electricity
- Biodiesel
- Biological source fuels
- P-series fuels

Why do we need them?

- Reduce our nation's dependence on imported petroleum
- Reduce exhaust emissions and environmental pollutants
- Controlling costs in certain applications
- Expand fuel technology to find the perfect fuel

Ethanol

- Ethyl alcohol, grain alcohol
- liquid product produced from the fermentation of plant sugars/starches
- can be produced from almost any organic feedstock
- Flammable/colorless/strong odor



Ethanol Properties

- Heavier than gasoline
- Less dense than water
- Mixes with water
- Has less heat energy than gasoline
- Less volatile than gasoline
- Corrosive

Ethanol Production

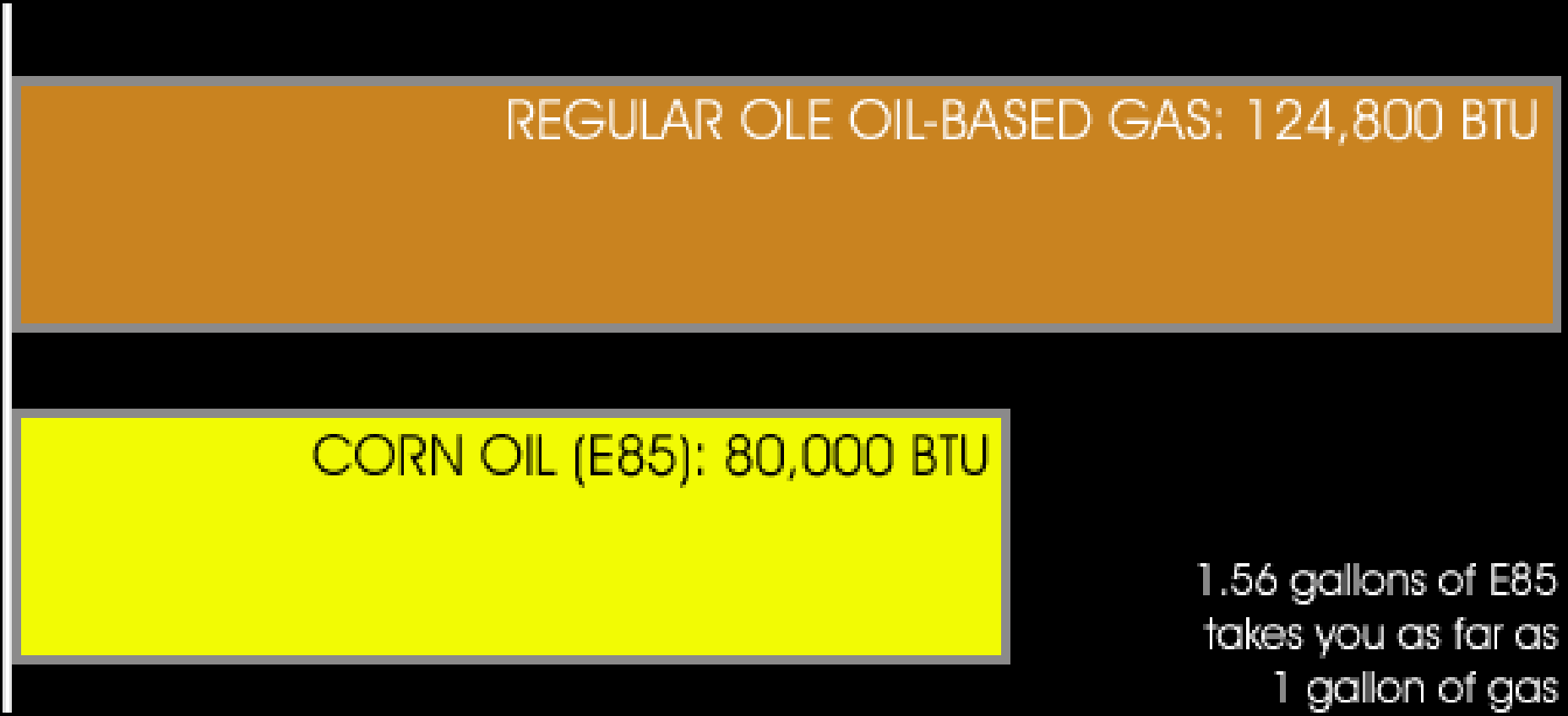
- Glucose
  - Expensive due to food value
  - Sugar rich=sugar beets/sugar cane
  - Starches=corn/potatoes
- Cellulose
  - Cheap feedstock due to no/little food value
  - Extract cellulose from plant material
  - Convert cellulose to glucose
    - Acids or enzymes
  - More expensive due to extra processes
- Energy returned on energy invested
  - Corn=1.34/1
  - Sugar Cane=8/1

Ethanol in Fuel

- Largest use is in fuels
- Must be void of water (anhydrous)
- High octane
- Lower emissions
  - 40% less CO
  - 10% less NOx
  - 20% less PM
  - No net CO2

- Mixture of 85% ethanol/15% gasoline
- Designed for Flex-Fuel vehicles
- 105 octane rating
- Well suited for racing applications
- Possible cold-start concerns

one gallon: A COMPARISON



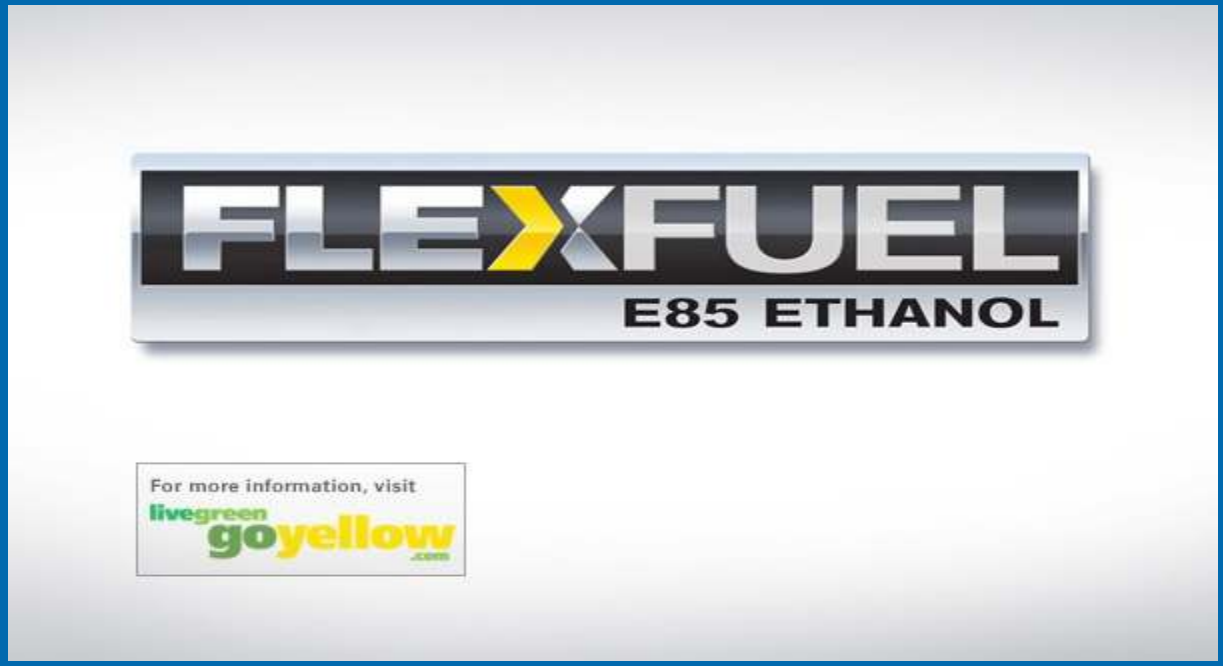
1.56 gallons of E85
takes you as far as
1 gallon of gas

Other Ethanol Blends

- E10
  - 10% ethanol/90% gasoline
  - Very common in US
  - 1990-newer vehicles are compatible
- E70=winter blend E85
- E95=Diesel engines

Ethanol Argument

- Benefits
  - Domestically produced
  - Renewable
  - Biodegradable
  - Lower emissions
- Detriments
  - Less heat energy
  - More expensive to produce
  - Limited availability



Flex-Fuel Technology

Flex-Fuel Technology Basics

- What does “Flex-Fuel” mean?
- Are Flex-Fuel vehicles available?
- How flexible are FF vehicles?
- What is different about FF vehicles?

Flex-Fuel Vehicle Modifications

- anti-corrosion protection
- increase fuel system capacity
- fuel conductivity consideration
- verify alcohol percentage

Anti-Corrosion Protection

- alcohol's corrosive nature
  - methanol worse than ethanol
- aluminum & magnesium lines/tanks
  - stainless steel not affected
- deteriorates rubber components
  - use of Teflon seals, o-rings, etc…
- formic acid production
  - nitride coatings/FFV oils

Fuel System Capacity

- alcohol's lower heat energy per unit
- larger fuel tank capacity
  - sender modifications
- larger fuel line diameters
- increased flow fuel injectors
  - higher fuel pressures?

Conductivity Concerns

- alcohol is electrically conductive
- gasoline is “dielectric”
- fuel pump design is considered
- fuel sender design is considered

Alcohol % Identification

- Flex-Fuel vehicle need to verify %
  - designed to operate 0%-85%
- two main methods of verifying %
  - Flex-Fuel sensors
  - inference strategy

Flex-Fuel Sensors

- first method of learning alcohol %
- mounted in the fuel line
- can measure fuel conductivity, fuel temperature, dielectric constant
- direct input to the PCM
- sends signal continuously

Flex-Fuel Sensors

- normally use power, ground, and signal output circuits
- typically output a square wave signal in hertz (cycles per second)
- PCM uses tables stored in memory to adjust fuel control and ignition timing
- phased out by fuel inference type strategies

Flex-Fuel Sensor

- 0% ethanol=51 hz
- 25% ethanol=67 hz
- 50% ethanol=89 hz
- 85% ethanol=115 hz
- Shorted sensor= 170 hz

FF Sensor Pros/Cons

- Pros
  - proven technology
  - read continuously
  - fuel system faults do not affect
- Cons
  - water read as alcohol
  - extra cost
  - extra parts to fail

Inference Strategy

- currently preferred method for alcohol %
- use oxygen sensor information to “infer” the alcohol concentration of the fuel
- Ford= “deductive refueling logic”
  GM= “Virtual Flex-Fuel Sensor”
- learns only after KAM reset or fuel level change
- FLI increase by at least 10% or KAM reset

PCM Inference Mode

- disables canister purge/normal fuel adaptive learning
- meters fuel based upon previous %
- monitors ECT, MAF, BOO, Gear, HEGOs
- alters injector on-time to obtain 0% fuel error

PCM Inference Mode

- delays locking in value
  - fuel in tank has reached engine
- locks in FF% once HEGOs switch normally
- canister purge/normal fuel adaptive learning are reinitialized after inference
- typically complete within 7 miles

Inference Strategy Pros/Cons

- Pros
  - uses existing components
    - less cost
    - less parts to fail
- Cons
  - infers alcohol % only after refuel
  - fuel system faults can alter inferred value
  - calibration revisions to fine tune strategy

Flex-Fuel Specific Faults

- PCM sees higher than correct alcohol %
  - PCM commands higher injector on-time
  - A/F ratio richer than optimal
  - HEGOs read a rich mixture
  - PCM will decrease injector on-time
  - fuel trims will show -% (rich condition)
  - may set rich codes (P0172/P0175)

Flex-Fuel Specific Faults

- PCM sees lower than correct alcohol %
  - PCM commands lower injector on-time
  - A/F ratio leaner than optimal
  - HEGOs read a lean mixture
  - PCM will increase injector on-time
  - fuel trims will show +% (lean condition)
  - may set lean codes (P0171/P0174)

Flex-Fuel Fault Diagnosis

- problem could be Flex-Fuel related
  - check FF PID first
  - compare PID reading to fuel sample
  - clear KAM and relearn alcohol %
  - substitute/change to known value fuel
- problem could be unrelated
  - fuel pressure
  - vacuum leaks
  - MAF voltage

Alcohol in Non-Flex Fuel Vehicles

E85 Fuel

- Designed for Flex-Fuel vehicles
- Lower heat energy than gasoline
- Corrosive to certain materials
- Can void manufacturer warranties of non Flex-Fuel vehicles

Manufacturer Statements (General Motors)

- Only vehicles designated for use with E85 should use E85 blended fuel.
- Use of fuel containing greater than 10% ethanol in non-E85 designated vehicles can cause driveability issues, service engine soon indicators as well as increased fuel system corrosion.
- Repairs that result from the use of improper fuel, such as the use of gasoline containing more than 10% Ethanol in a non-FlexFuel certified vehicle, are not covered under the terms of the New Vehicle Warranty.

Straight E85 or ethanol is not smart

- Fuel injected vehicles
  - May run properly due to adaptive learning
  - Will set MIL and set lean codes
  - May lean out dangerously at WOT
- Carbureted vehicles
  - Will not run properly
  - Will be lean at all times

Blending Ethanol

- Blending ethanol can obtain ethanol benefits without undesirable effects
- Vehicles built after 1990 were designed for E10
- Ethanol can increase octane and lower emissions
- Maximum ethanol % can be tested on various vehicle designs

Blending for Fuel Injection

- Start with low ethanol % and increase until undesirable traits are present
- Check HEGOs at WOT
- Calculate % by volume
- Sample fuel at rail to verify %

Alcohol Conversions

- Corrosion protection
  - Teflon, polyethylene, stainless steel
- Fuel system
  - Sufficient fuel flow
  - Initial filter replacements
  - Enrichment method
- Engine modifications
  - Ignition timing, compression
- Cold start enrichment

Aftermarket Conversions

- Aftermarket alcohol conversion kits are widely available online
  - Reprograms (E85 Solutions)
  - Standalone CPUs (FLEXTEK)
- Conversions do not void warranty
  - Magnuson-Moss Act
- May require recertification to be resold

Blending for Carburetors

- Much less ethanol can be used in unmodified carbureted vehicle
- Older vehicle designs not set up for alcohols
- If ethanol use is desired for carbureted vehicle, rejetting should be performed.

Carburetor Conversions

- Larger power valve if available
- Increase accelerator pump flow
  - Drill orifice 10%-25%
  - Adjust arm travel or pump cams
- Use alcohol rated seals, gaskets, float
- Manual chokes are desired

Optimizing for Alcohol

- increased ignition timing
- higher compression ratio
- superchargers/turbochargers
- electric fuel pump
- tune, tune, tune