Methanol and ethanol

Replacement of all or part of the gasoline presently being used by methanol or ethanol is easily possible, as will be discussed in Chapter 23. Mixtures of up to 15% ethanol (or methanol) can be used as fuel in current engines with no modification. The 15% blends are known as M85 and E85 for methanol and ethanol, respectively. Methanol and ethanol deliver, liter for liter, somewhat over half as much energy as gasoline (24 and 18 compared to 35 MJ/L). Both ethanol and methanol can be stored easily and transported conventionally. Ethanol is not toxic (unless drunk to excess), but methanol (also known as wood alcohol) is poisonous.

An ethanol/methanol car and engine could be lighter than a gasoline engine, and a car designed as a methanol car could be more efficient. The fuel could be delivered as in a diesel engine, but in a simpler way. The engine can be supercharged as in racers; the fuel used in the Indy 500 is methanol. The engine cooling system could be designed to eliminate the radiator and fan. Compared to gasoline, the 10% to 15% methanol (or ethanol) mix results in improved economy and performance, lower exhaust temperature, and lower emissions (since the engine can be tuned much leaner, there can be a 50% reduction of CO and NOx accompanied by about a 9% increase in mileage). There is essentially no soot, because there are no carbon-carbon bonds. Methanol and ethanol are better antiknock compounds than tetraethyl lead. Ethanol has an octane rating of 113, so mixing it in gasoline increases the octane level of gasoline mix. This saves energy at the refinery, because the refinery doesn’t have to crack the hydrocarbons quite so much.

Cars can have their engines converted to use pure alcohol for several hundred dollars. Parts of the fuel injection system must be changed if the engine is to run on pure ethanol.
that do not need to be made if the car is run on the gasoline mix. Since alcohol vapors are less dense than gasoline vapor, there is an added risk of sparking and the gas filler needs to have spark arresters installed. The converted car running on alcohol has about a twentieth the unburned fuel, a tenth the CO, and similar NO\textsubscript{x} in comparison to the car running on gasoline.\textsuperscript{(184)} Chrysler Brazil claims that its engines, which run on alcohol with no pollution controls, could pass California pollution specifications.\textsuperscript{(182)} Emissions of a 1972 Gremlin burning gas and methanol and gas are compared in Table E15.5.1.\textsuperscript{(181)} A few researchers have found problems with methane emissions,\textsuperscript{(185)} but most agree that methanol and ethanol reduce emissions. Some found indications of emission problems in very cold weather,\textsuperscript{(144)} but others have reported no such problems.\textsuperscript{(186)} There is some evidence that methanol damages engine parts and the fuel delivery system (because methanol, but not ethanol, is quite corrosive). This can be overcome through use of stainless steel construction.

\begin{center}
\textbf{TABLE E15.5.1}
\end{center}

Pollutants, Measured in Grams per Kilometer, Emitted by 1973 Cars

<table>
<thead>
<tr>
<th></th>
<th>Gasoline</th>
<th>Methanol Blend</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO</td>
<td>20.3</td>
<td>2.4</td>
</tr>
<tr>
<td>NO\textsubscript{x}</td>
<td>2.0</td>
<td>0.22</td>
</tr>
<tr>
<td>Unburned hydrocarbons</td>
<td>1.38</td>
<td>0.20</td>
</tr>
</tbody>
</table>

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\end{flushleft}

Some investigators claim that methanol and ethanol are energy gainers (or at least not losers).\textsuperscript{(187)} Others think ethanol production is energy inefficient as currently practiced in the United States (this is not true in Brazil, as discussed in Chapter 22). One bushel of corn gives 2.5 gallons of ethanol, and 110 bushels of corn per acre is produced at a cost of
$280 and 137 gallons of gasoline (assuming no irrigation). Pimentel\textsuperscript{(188)} found an input of 138 MJ of energy to produce 1 gallon, or 80 MJ, of energy using current techniques. Even with credits for cattle feed in Ref. 188, the energy balance was found to remain negative. Others disagree. While details of Pimentel’s analysis are a source of some controversy, it is clear that ethanol production in the U.S. is less energy efficient than in Brazil because of the much greater substitution of fuel for human labor in the U.S.

A cassava-based ethanol blend (E85) car was tested in Guangxi, China. The Chinese import almost all their petroleum and the sustained economic boom led to the number of cars increasing greatly, so there is interest. The overall cost of running with E85 is greater than with gasoline (but the additional cost comes within the Chinese economy). As expected, emissions of CO\textsubscript{2}, CO, HC, and particulates are lower for the E85 car, while NO\textsubscript{x} is higher. Overall, energy consumption is greater for the E85 car than the conventional car, but gasoline consumption is lower.\textsuperscript{(189)}

Further, environmental costs are estimated at $0.36/gal. The true cost of a gallon of ethanol is $2.55/gal, including environmental costs.\textsuperscript{(188)} Ethanol is currently being sold for $1.22/gal as a chemical (it costs considerably more as liquor).\textsuperscript{(190)} Progress continues to lower the price, but there is still some way to go to reduce it below the cost of gasoline. (The production of gasoline also has environmental costs that are not accounted for in the price.)

Methanol promises to be more economic. Several processes may produce substantial amounts of methanol efficiently.\textsuperscript{(191)} The processes could avert flaring of natural gas from remote oil wells (the CH\textsubscript{4} would have a hydroxyl, OH, added in place of one hydrogen to make CH\textsubscript{3}OH), and make a valuable product out of something now wasted. The result is
a liquid easy to store and ship. When no natural gas pipeline is nearby, methanol production would be a good alternative to flaring.

There is an active lobby of farmers who have gotten their legislators to subsidize ethanol from corn as an additive to gasoline. Many Midwestern states (including my home state of Ohio) routinely sell gasoline mixed with 10% to 15% ethanol.

**MBTE and ethanol**

Several decades ago, methyl tertiary butyl ether (MBTE) was added to gasoline sold in California to reduce pollution. Especially after the passage of the Clean Air Act, its use increased greatly. MBTE is suspected of being a carcinogen, and its presence (even in low concentrations, around 5 nmol/mol) can cause water to have a taste reminiscent of turpentine.(192,193) Over 45,000 wells are contaminated from leakage, primarily from around 140,000 underground gasoline storage tanks in the states that have used the additive.(192) The total cleanup cost could reach $29 billion.(192)

Rules written by the Clinton administration to ban the substance before the Bush inauguration were withdrawn as the Bush administration took office.(194) The Bush administration, bolstered by over $1 million in campaign contributions from MBTE producers, has refused to authorize its cleanup or to ban the additive from gasoline,(194) despite pressure from California’s senators and a Senate vote to authorize $400 million for the cleanup.(193)

The ongoing research on MBTE’s effect on health and the indications of carcinogenity convinced many epidemiologists and ordinary people in California and other states that MBTE should be banned as an additive to fuels. As a result, seventeen states have banned
MBTE use as a gasoline antipollution additive.\textsuperscript{(194)} This will cause the states to turn to alternatives, specifically, to ethanol, to retard smog formation. The problem is that increased demand could raise prices for ethanol, but no one knows for certain by how much.\textsuperscript{(195)}