MORE HYPE THAN HOPE

How conservation evaporates ethanol's benefits for cars

By Zoltan C. Mester

The recent drop in crude oil prices does not change the overall trend that in the not distant future we are running out of this natural resource and there is an urgent need to develop alternative energy sources. Ethanol emerged as the primary candidate to replace a part of the gasoline pool used for transportation. Ethanol can be produced from carbohydrates which are abundantly present in nature as key structural and functional constituents of plants. Carbohydrates come in a great variety including simple sugars, most prominently glucose, and in more complex forms such as starch and cellulose, which consist of several thousand interconnected glucose units. Ethanol production from complex carbohydrates is a two-step process: first the carbohydrate structure has to be broken down to its simple sugar units which in turn need to be converted to ethanol by fermentation. Starch can be converted to ethanol with relative ease while other carbohydrates such as cellulose are more resistant to ethanol conversion. Factors influencing commercial scale ethanol production include availability of the renewable source material in sufficient quantities, efficient means of conversions to ethanol, attractive pricing conditions, government subsidies and tax incentives.

In the USA more than 95 percent of the ethanol is produced from corn, while other sources include cheese whey, barley and shorgum. The United States Department of Agriculture (USDA) forecasted 10,550 million bushels of corn crop from 71 million acres of land for 2006. Approximately 20 percent (2,100 million bushels) of the corn crop is slated for ethanol production.

The first question we ask, "How much ethanol can be obtained from the annual corn crop dedicated to ethanol production?". The next logical question is what impact this quantity of ethanol has on the domestic gasoline consumption. Regarding the first question we need to estimate the *material yield* for ethanol defined as the quantity of ethanol that can be obtained from one mass unit of corn. On the average two-thirds of corn's dry mass is starch. Assuming that all of the starch can be broken down to glucose which in turn can be converted to ethanol without losses, the ethanol yield is estimated 0.057 gallons of ethanol per pound of dry corn corresponding to 0.125 gallons of ethanol per kilogram of dry corn or 2.71 gallons of ethanol per corn bushel (1 corn bushel equals 56lbs at 15 percent moisture). Using 149 bushels per acre average corn yield predicted for 2006 and the maximum material yield for ethanol, one acre corn crop would result in 404 gallons or 9.6 Barrels of ethanol. Since corn is harvested once a year this also represents the annual ethanol production limit from the fresh crop for this year. .

Using these estimates approximately 5.7 billion gallons or 135 million Barrels of ethanol can be obtained from the 2006 corn crop slated for ethanol. Due to incomplete material conversions, material losses, and limitations in distillation capacity the actual ethanol yields are lower. The current domestic distillation capacity is 4.3 billion gallons per year (280,000bbl per day) with an additional 1.98 billion gallons capacity under construction. Now we are in the position to estimate the impact of ethanol on gasoline consumption.

Assuming 3.4 billion Barrels (average 9.3 million Barrels per day) of gasoline consumed in 2006 the 5.7 billion gallons (372,000 Barrels per day) of maximum ethanol production represents 4 percent of the gasoline pool. The percentage of gasoline that can be replaced by ethanol drops to a modest 2.9 percent (266,000bbl per day) because it takes 1.4 unit volume of ethanol to replace 1 unit volume of gasoline to account for *equivalent heat contents* in these fuels.
The Energy Policy Act of 2005 mandated a steady growth in annual ethanol production from renewable sources reaching 7.5 billion gallons of output in 2012. Renewable sources include dedicated energy crops, trees, wood, plants, grasses, fibers, agricultural residues, and waste materials. Assuming 10 percent increase in gasoline consumption in 2012 compared to present levels, the 7.5 billion gallons of ethanol targeted by the Energy Policy Act from *any* renewable sources would still replace only 3.4 percent of the gasoline pool adjusted for equivalent heating values. To achieve this goal from *corn alone* would require 32 percent increase in the quantity of corn dedicated to ethanol production compared to the present level. This scenario would likely *upset the balance* with other important uses of corn such as food for humans and feed for livestock.

The question then arises whether improvements in fuel economy can achieve comparable gasoline savings as predicted by ethanol substitution.
Based on statistical information from the Federal Highway Administration in 2004 approximately 90 million pickups trucks, SUVs and vans were registered in the USA. Assuming 90 percent of this fleet was gasoline powered with 18mpg average fuel economy and 15,000 miles driven per vehicle annually this fleet of vehicles consumed 1.79 billion Barrels of gasoline per year (4.9 million Barrels per day). By raising the fuel economy to 20 miles per gallon corresponding to 11 percent increase would save 7.5 billion gallons of gasoline per year. This gasoline saving is equivalent to using 10.5 billion gallons of ethanol as gasoline substitute which is 40 percent more ethanol than set by the Energy Policy Act for 2012.

In sum, ethanol from corn alone is not a significant factor as gasoline substitute at the national level but it can ease the gasoline squeeze in and around areas where the corn industry thrives. The goals by the Energy Policy Act for ethanol production from ***any renewable source*** *can be met by a relatively modest increase in fuel economy for SUVs, vans and pickup trucks not even taking into account passenger cars. Success in commercial technologies for cellulose conversion holds promise of providing a year round supply of ethanol in quantities that would reduce gasoline consumption at the national level.*

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