# ETHANOL
## ASSESSING ITS VALUE AS A TRANSPORTATION FUEL FOR NEW YORK STATE

### Energy Vision

**Prepared by Joanna D. Underwood & James S. Cannon, Consultant**

**November 28, 2006**

### Introduction

Spurred on by a very strong farm lobby over the last decade, the federal government and many state governments, including New York State, have embarked on programs to promote the production and use of ethanol as a transportation fuel. These programs have been based on a variety of assumptions regarding the benefits this fuel would have for our economy.

Ethanol programs have largely been viewed as a win-win situation, in which agricultural, environmental, and energy policy objectives would converge to create a single strategy that would benefit states and the country overall. Ethanol production would achieve a number of important agricultural policy objectives, such as creating jobs, increasing crop prices, and increasing tax revenues from the agricultural sector, while creating a fuel that would ostensibly help displace the use of imported oil. The fuel itself has been seen not only as generating fewer pollutants and greenhouse gases than gasoline but also as taking advantage of domestically plentiful renewable resources, since it can be made by fermenting various sugars from carbohydrates found in agricultural crops and may in the future be able to be made using cellulosic residues from crops or wood.

Viewed up close, unfortunately, ethanol made from corn emerges not as a win-win but, at best, as a win/lose strategy for New York State (and many other states). While state ethanol programs may achieve short-term gains for their agricultural (largely corn-growing) community and for ethanol producers, most will actually be producing a fuel that:

- Can play just a minor role in displacing oil in the near term while consuming corn – a food crop increasingly needed for feeding the world's hungry peoples

- Will add to inflationary pressures by driving up the cost of animal and food products dependent on corn

- Has debatable net pollution reduction benefits and that requires major use of non-renewable land and energy resources to produce, resulting in little or no net energy benefit

- In addition to playing a minor role in displacing oil in the short term, may contribute little or nothing to addressing the key challenge that this country faces in the long

term – namely, the need to shift away from oil-derived fuels altogether to the new fuels and advanced propulsion systems needed for a sustainable energy future, and finally

- Is produced and able to compete in the marketplace only with huge public subsidies, diverting billions of dollars in public funds from pursuit of potentially better alternatives.

These findings, discussed below, offer good reasons for New York State and many other states to question investments in corn ethanol and to look more broadly for their major transportation fuel solutions as they seek to chart the most effective course toward a sustainable environmental and energy future. Using ethanol in New York State that has been produced in other states should not be discouraged. But, given the need to cast a wide net in search of petroleum-free fuel options, research aimed at developing cellulosic ethanol or ethanol produced from municipal solid wastes (as well as research of bio-diesel and bio-methane) deserves to be continued, positioning New York to be a leader as it finds the most promising choices.

## Corn Ethanol: Good for Farmers and Fuel Producers but a Marginal Contributor to Oil Displacement

For corn growers and ethanol producers, public support of ethanol has been good news. Fuel ethanol production in the U.S. has grown substantially in recent years, both in volume and in number of participants.

Ethanol production in 2005 set a record -- 3.9 billion gallons, or 255,000 barrels of ethanol per day, which is more than double the industry output in 2000, according to data released by the U.S. Energy Information Administration. The Renewable Fuels Association (RFA), a Washington DC-based trade group, says there are currently 95 ethanol production plants in the U.S. owned by more than 75 different firms with a total capacity of 4.3 billion gallons of ethanol per year. There also are 34 ethanol plants under construction with a combined capacity of 2.1 billion gallons per year.

Ethanol plants currently operate in 19 states, although production remains predominantly in the Midwest. Ethanol production represents the third largest component of corn demand after feed use and exports. Farmer-owned ethanol plants account for half of U.S. fuel ethanol plants and almost 40 percent of industry capacity.

The future for ethanol and for bio-fuels generally over the next decade has been described as very bright in some quarters. A Worldwatch Institute report, *Bio-fuels for Transportation: Global Potential and Implications for Sustainable Agriculture and Energy in the 21st Century*, concluded that bio-fuels, including ethanol, could provide 37 percent of U.S. transport fuel within the next 25 years, and up to 75 percent if automobile fuel economy doubles. The US Environmental Protection Agency estimates that use of renewable fuels, mainly ethanol, in 2012 will reduce carbon dioxide emissions by 9 to 14 million tons, or about 0.4 to 0.6 percent of the anticipated greenhouse gas emissions from the U.S. transportation sector. (1) Four in five adults in the U.S. strongly or somewhat agree that national and state governments are not doing enough to promote production of bio-fuels made from agricultural crops or plant matter, according to a survey released in 2006 by the Biotechnology Industry Organization, a trade association based in Washington, DC.

Ethanol production is very likely to surpass 7.5 billion gallons by 2012, a national target set by the U.S. Congress in the Energy Policy Act of 2005. A review of public statements by ethanol industry analysts, plant developers, builders, and financiers has led the RFA to project an additional 4.1 billion gallons of new capacity between 2006 and 2015, with most of the capacity coming on line within the next three years. This investment is expected to bring total industry capacity to 10.3 billion gallons by 2015. Assuming an average capacity utilization rate of 95 percent, ethanol production is projected to top 9.8 billion gallons by 2015.

The feedstock for 97 percent of all ethanol produced in the U.S. today, according to the U.S. Department of Agriculture, is corn. And, while possible feedstocks from sugar crops or other cellulosic materials are the subject of research, corn will be the main source for the foreseeable future, making the national goals very good news for corn producers. Total corn harvested this year will be about 10.7 billion bushels. According to the Congressional Research Service, fifteen percent of this total -- 1.6 billion bushels -- will be used for ethanol production. Nearly 3 billion bushels are slated to go for ethanol production by 2015 producing more than 8 billion gallons of the fuel forecast for 2015. (One bushel of corn produces 2.7 gallons of fuel.)

Of course, as surplus corn stocks are drawn down, farm level corn prices will increase. Corn prices, in fact, already have just risen sharply, according to the Chicago Board of Trade, to a ten-year high of almost $3.90 a bushel, increasing the prices of animal products and of many foods across the country. (2)

Despite the astounding growth in U.S. ethanol production this decade, the bottom line is that the approximately 4 billion gallons of ethanol currently in use displaces just 2.5 percent of the gasoline used (140 billion gallons in 2005) by motor vehicles. According to the National Academy of Sciences, even if every bushel of corn were diverted from food to motor fuel use, it would displace just 12 percent of gasoline usage. (3) Ethanol made from corn, therefore, can be at best a marginal fuel option for displacing oil in the near term.

Furthermore, diversion of corn from use as a food is already making many foods more costly for Americans. And it will increasingly create hardships for the economically disadvantaged in a hungry world. The US accounted for 70 percent of the world's corn exports in 2005 even as countries such as China were having to begin importing corn to supplement their domestic grain production. (4) This conflict will only worsen and cross wider sections of society as fuel demand increases. The CEO of Cargill, one of the U.S.'s largest corn and ethanol producers, told a gathering of business writers in May of this year that he saw producing food as the most important task for agriculture. "We have to look at the hierarchy of value for agricultural land use" he said: "food first, then feed and last fuel." (5)

## Ethanol's Problems in Today's Fuel Markets: High Direct and Indirect Costs

Ethanol produced from corn imposes five types of significant direct and indirect costs, which undercut its value as as a short-term transportation fuel option.

First, unsubsidized ethanol is more expensive to make and sell than gasoline. This is especially true for consumers using ethanol who live outside of the five Midwestern states—Illinois, Iowa, Nebraska, Minnesota and Indiana. A recent analysis found that the average annual cost of a car fueled by a mixture of 85 percent ethanol in gasoline (E85) ranges from roughly $800 to $1,250 more than one powered by gasoline alone. (6)

Second, unlike gasoline, ethanol absorbs water and therefore cannot be shipped through conventional gasoline pipelines due to the likelihood of cracks caused by the freezing of the water component. Instead, ethanol must be transported by trucks, trains or barges, which are cumbersome and more expensive. (7). One study estimates the cost of transporting 5.1 billion gallons of ethanol within U.S. markets to be five times more expensive than gasoline shipped by pipeline.

Third, ethanol has much lower energy content than gasoline. This leads to a 2.0 percent decrease in vehicle fuel economy when burning a 10 percent ethanol blend. When using E85, it takes 1.4 gallons of ethanol fuel to equal the energy content of 1 gallon of gasoline. This causes a 5 to 15 percent reduction in fuel economy. (8)

Fourth, use of ethanol may impose a higher rather than a lower pollution cost on society than gasoline. The use of ethanol fuel can reduce carbon monoxide (CO) in vehicle emissions and may reduce greenhouse gases somewhat. However, a 2006 study by Wisconsin's Bureau of Air Management concluded that statewide use of a 10 percent ethanol blend with gasoline would increase nitrogen oxides (NOx) emissions by about 1 to 2 percent on an average summer day. This would be equivalent to the NOx emitted by a 350 megawatt coal-fired power plant. (9) More significant, on a "plant to wheels " basis, the National Academy of Sciences concluded that with E85, total-life-cycle emissions of five major air pollutants, including CO, VOC, PM10, sulfur oxides (SOx) and nitrogen oxides (NOx), are higher per unit energy than with gasoline." (10) In addition, corn is among the most intensive users of fertilizer and pesticide. A significant expansion of corn production would have severe consequences for groundwater pollution and runoff.

Fifth, perhaps the biggest shortcoming of ethanol stems from the inefficiency of its production. The biggest energy advantage for ethanol is that some of its energy is drawn from sunlight. Growing corn is the initial solar energy accumulator. The problem is that growing corn is a very inefficient solar accumulator. Less than 1 percent of the energy in sunlight falling on a corn plant is converted into energy held in corn kernels. This means that huge acreages are needed for corn crops, accompanied by massive doses of water and, increasingly, fertilizer. Heavy equipment is needed to harvest the crop and carry it to ethanol production facilities, which themselves are only about 70 percent efficient in converting corn kernels into ethanol. (11)

Overall, converting crops to modern transportation fuels is very energy intensive (only 22 percent of the energy in delivered ethanol comes from solar energy), with great demands on space and water that, like oil, are limited resources. By stimulating domestic bio-fuel production based on corn, the country is, in effect, promoting renewable fuels that require lots of nonrenewable inputs. Compared to commercial solar photovoltaic technology (now able to capture 18 percent of solar energy), or wind turbines (with efficiencies above 20 percent and no requirements for water), corn is a problematic energy choice.

A number of recent studies have sought to evaluate the total ethanol-related energy balance with differing results. Some, including those performed by the US Department of Agriculture, have concluded that there is a positive net energy benefit from ethanol. (12) By contrast, a 2006 study conducted by scientists at Cornell University and at the University of California at Berkeley concluded that alcohol production consumes 29 percent more units of fossil fuel energy than it yields when the fuel is burned. (13)

## Ethanol's Failure as a Transitional Strategy to a Sustainable Transportation Future

While ethanol's near term benefits in displacing gasoline use are limited and expensive, this fuel could still be part of a viable energy strategy were it useful as a stepping stone in a transition to a more abundant and sustainable energy source. However, there seems to be a slim chance that ethanol can play an important role as a transitional fuel in moving toward the long term goal.

First, with regard to motor vehicle technology, ethanol, like gasoline, is burned in conventional internal combustion engines, an inefficient 19th century technology that is not likely to survive in the post petroleum age.

Second, with regard to a transitional role for ethanol, beyond the possibilities of relying on feedstocks such as sugar beets, sugar cane or sorghum, the big hope for its advocates has been that new technologies will be invented to convert cellulose—the inert constituents of trees, grasses and agricultural wastes—into ethanol. If cellulose could be converted into ethanol, then vast new feedstocks could be tapped for energy production instead of, or in addition to, corn. Grasslands and planted fields of fast growing trees could be harvested and converted into energy without conflicting with food production or greatly straining land or water resources. The July 2006 U.S. DOE report, *Breaking the Biological Barriers to Cellulosic Ethanol: a Joint Research Agenda*, cites recent advances in biotechnology aimed at producing ethanol from cellulose. The DOE roadmap charts a path to meet the DOE's goal of displacing 30 percent of 2004 transportation fuel consumption, or roughly 60 billion gallons of gasoline, with bio-fuels produced from cellulose by 2030.

Research is centered on enzymatic breakdown of cellulosic biomass to five and six carbon sugars and lignin, using a combination of thermochemical and biological processes. Advocates hope that the combination of cellulosic biomass resources and advanced conversion technologies—including ethanol production using enzymes and synthetic diesel production via gasification—will compete with conventional gasoline and diesel fuel without subsidies in the medium term. Money is flowing into research to make this happen. For example, Chevron Corporation has launched three research partnerships this year. In June, Chevron committed to invest up to $12 million over five years in Georgia Tech's bio-fuels program. It also established a strategic research alliance with the National Renewable Energy Laboratory, a division of the United States Department of Energy based in Golden, Colorado, in which the two groups have signed a five-year agreement to research and develop new production technologies to convert cellulosic biomass into bio-fuels. And, most recently, Chevron formed a research collaboration with the University of California (UC), Davis campus to pursue advanced technology aimed at converting cellulosic biomass into transportation fuels. (14)

The problem is that enzymes capable of converting cellulosic materials have not yet been found in nature or invented through genetic engineering, despite decades of serious scientific inquiry. It might happen tomorrow, but it might not happen for decades. Even if found, a long process is likely before systems to convert cellulose into ethanol become commercially viable at a reasonable cost. Even then, biomass growth will remain a poor energy accumulator, meaning that vast acreages and heavy-duty machinery to move large quantities of materials to energy production facilities will always be needed. Despite these many challenges, the needs of the times suggest that R&D into cellulosic bio-fuels (including ethanol as well as bio-diesel and bio-methane) should be pursued. But prudent energy and transportation policy today should ensure continuous assessment of progress to see which merit significant sustained investment.

## The Tax Implications of Ethanol

For decades, ethanol has relied on subsidies from the federal government for financial viability. Subsidies have reached record levels in the U.S. and are a costly way of achieving public policy objectives, concludes *Biofuels—At What Cost? Government Support to Ethanol and Biodiesel in the United States*, a 2006 report from Global Subsidies Initiative (GSI), an arm of the International Institute for Sustainable Development (IISD), based in Geneva, Switzerland. Current bio-fuel subsidies in the U.S. account for between $5.5 billion and $7.3 billion per year. The bulk, up to $6.8 billion, is dedicated to supporting ethanol production and use. Between 2006 and 2012, total bio-fuel subsidies are expected to climb to between $8 billion and $11 billion annually, with up to $8.7 billion of this just for ethanol.

Ethanol subsidies are the result of many independent decisions at different levels of government, resulting in politics that are often poorly coordinated and targeted. Virtually every production input and production stage of ethanol and biodiesel is subsidized somewhere in the country. In many locations, producers can tap into multiple subsidies at once. A federal tax credit to blenders of $0.51 per gallon of ethanol (or $0.82 per gasoline gallon equivalent) is provided by the U.S. government. Moreover, the federal government protects domestic producers from international competition by levying a significant tariff on imported ethanol, which is now $0.54 per ethanol gallon, and awards tens of millions of dollars in grants to support ethanol research and development every year.

The ethanol industry is also receiving financial support at the state level. At least 15 states offer some type of incentive program to ethanol producers. Illinois, Indiana and Kansas had ethanol fleet fuel purchase requirements in place as of March 2006. Ohio joined the list when it enacted bio-fuels legislation in July. Earlier this year, Iowa enacted a law requiring that 25 percent of the state's automobile fuel come from renewable fuels by 2020. Louisiana, Missouri and Washington have all adopted similar measures this year. They joined Minnesota and Montana, who already had ethanol mandates on the books. The 10-agency Bioenergy Working Group established last year by the California Energy Commission has recently issued a report, *Recommendations for a Bioenergy Plan for California*, which proposes a set of initiatives to accelerate biomass energy production and bio-fuel use in the state. In 2006, New York State allocated $10 million for building retail ethanol and biodiesel refueling facilities in the State and another $20 million to build a demonstration cellulosic ethanol plant.

A legitimate question can be raised about whether this strong government support properly recognizes the value of ethanol or whether the growth in ethanol is simply an artifact of government financial support. The National Taxpayers Union (NTU), a nonpartisan citizen group with 350,000 members, is one proponent of the latter view. Ethanol is not a panacea to U.S. energy concerns, concludes the 2006 NTU analysis, *Ethanol: Bumper Crop for Agribusiness, Bitter Harvest for Taxpayers*. The report predicts that consumers and taxpayers will see few benefits from growing federal subsidies to a 30-year old ethanol fuel industry that has yet to become self sufficient. Despite federal and state government subsidies, a guaranteed market that is protected from international competitors, and millions of dollars from private and public investors, ethanol is not and may never be a truly competitive energy alternative, says the report.

## Conclusions

While ethanol produced from corn provides some benefits in terms of displacing petroleum and reducing greenhouse gas emissions, the gains so far are small in comparison to their subsidy cost. And by the distorting mix of agricultural and energy goals with regard to ethanol, one casualty

has been the development of coherent national energy policy that focuses on promoting the best options to displace oil in both the short and the long terms. It is surely in New York State's interest to assess each fuel for its short term oil displacement capability and for its long term role in the transition to the sustainable transportation systems that will be needed for a post-oil world.

For some fuels and technologies the roles they can play have already become quite clear. For example, fully commercial natural gas and hybrid electric technologies have already demonstrated their potential to contribute broadly to meeting our oil displacement goals and have gained strength from their added roles in facilitating a transition to a renewable hydrogen fuel cell future. Devoting just 6% of this country's abundant natural gas to transportation fuel use could power 20 million light-duty vehicles, displacing the use of 10 billion gallon of gasoline while decreasing emissions. An important plus: it appears that this additional natural gas could be produced in the near term as biomethane from landfill gas, sewage, and animal waste – all renewable sources. (15) New York State has both local natural gas deposits and many sources of potential bio-methane production.

Toward the long-term goal of relying on hydrogen, the equipment being produced to handle gaseous or cryogenic natural gas onboard vehicles will be easily adaptable to handle gaseous of cryogenic hydrogen in the future when the hydrogen economy becomes economically feasible. And the refueling stations being built to deliver compressed natural gas to vehicles today can be adapted to delivering biomethane as well as hydrogen in the future – at first hydrogen made from the natural gas using already commercial technology but, ultimately, hydrogen extracted from water using renewable energy. (16)

Since the propulsion source in future fuel cell vehicles will likely be in part or entirely electric (rather than mechanical as with current petroleum vehicles), the electric drive train in hybrid electric vehicles also contributes to the U.S.'s short as well as long term goals. In the near term it makes fuel use much more efficient. In the long term, it includes most key components that will be needed to use electricity generated by hydrogen fuel cells, when this zero emitting power generator becomes cost effective in the future. (17)

The ad hoc system that has characterized subsidies to transportation fuels as a secondary consideration to agricultural policies has resulted in skewed priorities. With reference to the case of natural gas, government support for natural gas vehicles -- whose environmental and energy advantages are undisputed -- has totaled roughly $10 million per year for the past decade – a fraction of the support provided for ethanol. New alternative fuel federal tax credits beginning in late 2006 could raise the subsidy for natural gas to between $100 and $150 million per year. But this would still be less than 10 percent of the subsidies promoting ethanol.

A new transportation fuels approach is essential that starts with a strategy to quench the nation's thirst for oil once and for all through initial, transitional and ultimately sustainable resources. Then policy tools, including select financial carrots and sticks, on the federal and state levels, can be created to ensure the most rapid progress toward the critical goal of a sustainable transportation/energy future.

FOOTNOTES:

1. Source of U.S. EPA report on Co2 reduction by ethanol use

2. Chicago Tribune, November 28, 2006

3. National Academy of Sciences, "Environmental, Economic, and Energetic Costs and Benefits of Bodies and Ethanol Befouls" Jason Hill, et al., PNAS, Vol. 103 No. 30, July 25, 2006

4. Source US export of corn and China's beginning to import corn.

5. "Cargill, ADM differ in food-fuel debate," Associated Press report, May 16, 2006

6. Source for the cost analysis that found higher cost to driving (E 85) ethanol car versus gasoline

7. Matthew L. Wald, "New Recipe for Gasoline Helped Drive Up the Price", The New York Times, May 6, 2006, A10 (also US DOE Energy Information Administration, "Eliminating MTBE in Gasoline in 2006" – Feb 22, 2006)

8. Source for facts on loss in fuel economy

9. Bureau of Air Management, "Ozone Air Quality Effects of a 10% Ethanol Blended Gasoline in Wisconsin" 2 (2006)

10. NAS op. cit.

11. Source for analysis of corn as an inefficient solar concentrator_

12. Source for USDA studies of net energy efficiency of ethanol

13. David Pimental (Cornell University) and Tadeusz W. Patzek (the Department of Civic and Environmental Engineering at the University of California at Berkeley) "Ethanol Production Using Corn, Switchgrass, and Wood: Biodiesel Production Using Soybean and Sunflower," (2005)

14. Source for Chevron partnerships cited

U.S. Department of Energy, "Biogas For Transportation Use: A 1998 Perspective," prepared by QSS Group, Inc. (July 9, 1998).

15. Interview with Rich Kolodziej, NGV America, Washington DC. November 28, 2006.

16. Discussed in two reports, Harnessing Hydrogen (1995) and Greening Garbage Trucks: New Technologies for Cleaner Air, (2002), written by James S. Cannon, published by INFORM.

17. Hybrid Vehicles Newsletter, James S. Cannon, Energy Futures, Boulder, Colorado.