The Environmental Opportunities and Challenges of Emerging Biofuels Production

April 9, 2007

Internal Combustion Engines and Alternative Fuels Sub-Committee
United States Department of Agriculture (USDA)
Agricultural Air Quality Task Force

The Environmental Opportunities and Challenges of Emerging Biofuels Production

Introduction

Alternative energy and energy conservation is receiving increased priority because of world instability and supply and demand. Increased demand of oil by developing countries such as China and India has essentially set a floor on the price of crude oil around $60 per barrel. Economists believe that ethanol and biodiesel can be competitive at crude oil prices above $45 per barrel. As the price of natural gas and crude oil increase and emissions from fossil fuels is curtailed, the viability of alternative energy is enhanced. Biofuels production such as ethanol, higher molecular weight alcohols, chemical feedstocks, and biodiesel will be a significant part of our energy portfolio as we replace foreign oil and move toward a different energy economy. This has significant benefits for national security, trade, agriculture, and green house gas emissions, but there are countervailing air quality and water quality and supply issues that must be addressed and managed.

Currently, the United States consumes nearly 140 billion gallons of gasoline and 40 billion gallons of diesel per year. The U.S. Department of Energy (DOE) has proposed a goal of producing 30% of the country's petroleum fuels from 1.3 billion tons of biomass from agricultural and forest resources[1]. About 800 million tons per year from dedicated energy crops will be required from the agricultural sector to meet this goal. It should be acknowledged that our energy consumption will not remain static if our economy continues to grow. To substantially reduce consumption of imported oil over current levels the following are candidate options:

- Energy conservation and efficiency improvements
- Carbon Alternative Fuel Equivalent (CAFE) standards improvement
- New coal conversion technologies
- New generation nuclear plants
- Alternative energy applications such as wind and solar

[1] Biomass as Feedstock for a Bioenergy and Bioproducts Industry: The Technical Feasibility of a Billion-Ton Annual Supply, US Department of Energy and US Department of Agriculture, 2005.

- Biofuels programs (ethanol and biodiesel)

Ethanol

According to the Renewable Fuels Association, 114 ethanol plants are producing about 5.6 billion gallons per year and 80 more plants are under construction that will increase production to about 12 billion gallons per year by 2009. Most of this production will come from corn *(Zea mays)* in the United States. President George Bush, in his 2007 State of the Union Message set a goal of 35 billion gallons by 2015. This would be approximately 20% of our gasoline use and implies that a significant part of the fleet will be using E85. In order to meet this goal, a mix of short and long-term strategies must be developed. In the short term, production cannot ramp up to produce 35 billion gallons per year in eight years unless all grain stocks are diverted into ethanol production. To realistically meet the short-term goal, importation of ethanol from Brazil and other countries will be needed. To achieve sustainable domestic production to and beyond 35 billion gallons per year (DOE envisions about 60 billion gallons per year by 2030.) several critical things must happen. First, cellulosic conversion technologies must rapidly advance to commercial scale. Second, cellulosic feedstocks crops must be available on an economic and sustainable basis. Third, logistics must be developed to produce, harvest, transport, and store over one billion tons of biomass per year. All of these are daunting but achievable challenges.

Producing the estimated 380 million tons per year from dedicated energy crops is a significant challenge but also an opportunity to develop sustainable production systems. The challenge will be to adopt feedstocks and production systems that are sustainable and efficient using existing systems where appropriate. Issues such as cropping systems, land availability, suitable equipment technologies, seed stock availability, efficient and effective logistics, producer acceptance, progress on cellulosic conversion technologies, and environmental technologies will determine if the goal can be met. Dedicated energy crops and crop residues will require a completely new paradigm to produce about 800 million tons of crop-based biomass in order to meet DOE goals for 2030. Both perennial and annual energy crops such as switchgrass (*Panicum virgatum)*, miscanthus (*Miscanthus giganteus)*, mixed grasses, and sorghums can provide large, sustainable volumes of biomass for bioenergy production. To meet energy, soil quality, and environmental criteria these crops must utilize no-till/limited-till production systems, which will be necessary for reduced energy inputs and the maintenance of soil quality.

Regardless of the crop type, fertilizer will be required to meet high-tonnage production requirements. Given the anticipated increased application of fertilizer for biofuel crop production nationwide, it is essential that fertilizer uptake by crops be maximized to the greatest extent possible to minimize emissions to air and water. Also, drought tolerant crops will be critical to reduce water demand. To meet production goals, additional land will need to be made available potentially from other crops, USDA's Conservation Reserve Program (CRP) land and/or marginal lands.

Biodiesel

Approximately 40 billion gallons of diesel are consumed in the United States each year. In 2005, the Biodiesel Board reported that about 75 million gallons were produced. Total US production capacity is about 500 million gallons. Biodiesel can be used in diesel engines up to 100%, but most manufacturers warrant their engines at 20% (B20). If a 20% blend were used in the entire fleet, about 8 billion gallons per year would be required. This implies that although there may be some niche uses for 100% biodiesel, a blend of less than 20% is more practical. Because of lubricity issues related to ultra low sulfur diesel, biodiesel at low blends (2-5%) can provide lubricity benefits. There are air quality benefits for using biodiesel such as lower unburned hydrocarbons, carbon monoxide (CO), particulate matter (PM), and odor, but emissions of nitrogen oxides (NOx) emissions are either improved or slightly increased depending on engine loading.

Soybeans (*Glycine max)*, canola (*Brassica napus)*, sunflower (*Helianthus annuus)*, and cottonseed (*Gossypium)* seeds, are the primary crop feedstocks, waste oils and grease, animal fat, and imported palm oil are the current sources for biodiesel. The high cost of vegetable oils, competition with food markets, and limited availability is placing stress on the evolving biodiesel industry. Current oilseed crops (soybean oil, canola oil, sunflower oil and cottonseed oil) cannot produce the quantity of bio-oil needed for the growing biodiesel industry. This is exacerbated by the fact that utilizing soybeans for biodiesel production is being scrutinized increasingly for displacing the food uses of soy oil. Yellow grease is used as a feedstock, but its supply is limited to local areas. Palm oil (from *Elaeis guineensis*) is imported as a feedstock, but its source and long-term potential are also limited. One solution may be developing dedicated oilseed crops which may include castor (*Ricinus communis)*, sesame (*Sesamum indicum*), canola, camelina

(*Camelina sativa)*, crambe (*Crambe abyssinica)*, cuphea *(Cuphea sp.)*, sunflower, and flax *(Linum)*. Perennial oilseed feedstocks such as jatropha *(Jatropha curcas)* and Chinese tallow (*Triadica sebifera or Sapium sebiferum)* may also have a potential. Current oil yields range from about 35 gallons/acre for cottonseed to more than 100 for castor. Yields well over 100 gallons per acre (or with major co-product value) will be required for a biodiesel feedstock to be competitively viable.

Environmental Regulatory Agency Issues

Of the 194 ethanol biorefinery locations (existing or under construction) in the country according to the Renewal Fuels Association website, 111 of those are located in the Central States Air Resource Agencies Association's (CenSARA) member states of AR, IA, KS, LA, MN, MO, NE, OK, and TX.

At its Fall 2006 Meeting, the CenSARA Membership charged the staff with the task of identifying the air quality issues surrounding ethanol and/or biofuels production which are rapidly impacting air quality permitting, compliance and enforcement measures carried out by state environmental regulatory agencies. The first CenSARA workgroup meeting called to address these issues was held December 13-14, 2006 in Des Moines, Iowa. The second was completed April 17-18, 2007 in Lincoln, Nebraska with a third workgroup meeting scheduled for the first week of November 2007.

Specific environmental and natural resource conservation issues include, but are not limited to, the following:

- Siting of Facilities
- Resource Demands
  - Crops
  - Natural Gas
  - Electricity
  - Water Treatment Technologies
  - Brine Management Strategies
  - Potable Water
  - On-Site Constraints
- Source Water Quality
- Regulatory and Logistical Issues

- Reliable and Reputable Construction Companies
- Private profit dominates decision-making

Site Evaluation Criteria – Many facilities are examining one or two features in siting a biofuels plan. Feedstock supply (what is available in a 50- to a 60-mile radius from a facility) is the largest determining factor in siting a facility. Consequently, the majority of plant construction, and expansion takes place largely in the states of Iowa, Kansas, Minnesota, Missouri, and Nebraska. Other siting criteria which should be considered are transportation elements (rail and highway), power to the facility (either natural gas or electricity) and production water supply (quantity/quality; water appropriate issues; and, delivery pressure). Other siting criteria of concern include required air quality permits (particularly in non-attainment areas); brine disposal (estimate of quantity and quality, nearness to perennial stream, estimates of chronic and acute low flows of perennial streams, difficulty in meeting water quality standards, and any federal, state, or local anti-degradation policies); potable water supply and sanitary waste options; and on-site constraints such as soils, drainage, floodplain, wetlands, historical/cultural/public acceptance/zoning issues; Phase I Environmental analysis; and Federal Aviation Administration (FAA) clearances.

Resource Demands – In a typical 120 million gallons a year (MGY) ethanol production facility, the plant operating 353 days a year could expect to use 43 million bushels of corn, 4.02 million Dekatherm (Dth) where 1 Dekatherm equals approximately 970 cubic feet, 78 million Kilowatt hours (Kwh), 494 to 565 million gallons per year (mgy) of raw production water, and 460,000 gallons per year (pgy) of Potable Water. According to HDR, the current cost of these resources is $3.20 per bushel of corn, $8 per DTH, $0.07 per Kwh, and $2.50 to $4.00 per 1,000 gallons of production water. These costs are highly variable and the trend is that the more demand there is for these resources, the more the prices will increase.

Production Water Supply – The quantity and quality of water impacts not only costs but the methodologies and chemicals needed to treat the water prior to use in the production process. The least amount of treatment is when the there is low total dissolved solids (TDS) and low mineral concentrations of iron and manganese. Water quality with high levels of TSC and minerals requires chemical treatment that results in brine wastewater. With the formation of brine, the facility must then meet additional water quality standards and the least expensive option is to dilute and release to a nearby stream. However, stream flow year round is not constant which must be a factor when considering the level of treatment for the discharge.

Regulatory and Logistical Issues – The typical ethanol facility schedule often does not allow the necessary time to secure air quality permits, which could lead to investors or consultants for investors to attempt to secure a minor source permit. However, these facilities permitted as a minor source may have difficulty meeting requirements related to Hazardous Air Pollutants (HAPs) levels, stack tests provisions, leak detection provisions, and making changes to equipment at the facility without a permit modification. The availability of reliable and reputable plant construction firms is limited due to the specialty nature. Several existing plants have reported that construction of a specific part of the plant took 3 different contractors due to the inability of some contractors to fulfill the requirements in the bids. These types of facilities will also run parallel decision paths in which one or more of the decisions should be in a sequence to limit "at risk" construction. For instance, getting natural gas, electricity, a corn supply, and transportation are run in parallel instead of investigating the availability of these items, the dates of initiating resources and costs of these resources.

States do not have identical permitting programs. Obtaining a biofuels product permit in one state is not the same process as securing a biofuels product permit in another state. Facilities are required to meet Maximum Achievable Control Technology (MACT) and New Source Performance Standards (NSPS). A typical ethanol production facility must meet NSPS subparts Db, Dc, Kb, Y, DD, VV, IIII, and NESHAP Regulations subparts Q, FFFF, ZZZZ, and DDDDD. The levels of acetaldehyde emissions may trigger major source thresholds as well.

(Other issues: Transportation to and from the site is a significant factor in dust generation unless the entire facility has paved roads. In order to secure delivery of the quantity of corn needed in a 125 mgy facility, over 40,000 semi truck runs are required. This is a safety as well as public health issue (diesel engines).

Issues for Consideration

Biofuels production has a significant potential to help reduce dependence on foreign oil, provide improved economies for rural America, reduce emissions, and sequester carbon. It is important to identify and address biofuels production environmental issues so that a sustainable industry can be maintained. Although the USDA Agricultural Air Quality Task Force Committee on Internal Combustion Engines and Alternative Fuels is tasked with air quality issues, we included water issues in the interest of completeness and the relationship to air quality. The evaluation of the environmental benefits and disbenefits of biofuels production must be analyzed in a holistic manner. These are not prioritized.

- Air and water emissions from increased use of fertilizer in biofuel crop production
- Emissions from ethanol plant boilers
- VOC emissions from ethanol plants
- PM emissions from ethanol plants
- Consumptive water use of ethanol plants
- Scrubber discharges from ethanol plants
- Odors from ethanol plants
- Rural truck and rail traffic issues related to air emissions
- Diversion of CRP and marginal lands into bioenergy crop production
- Quantification of carbon credits for bioenergy production
- Quantification/credit of engine emissions for biodiesel
- Quantification/credit of engine emissions for ethanol
- Fire hazards from biomass storage
- Odors from biomass storage
- Disposal of by-products