BioEnergy and the Texas South Plains

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Objective: 1) Report basic information about current and prospective bioenergy issues in West Texas. This is by no means a complete document, but it provides numerous basic facts and figures. 2) Highlights some questions or concerns about the pros and cons of numerous bioenergy issues in West Texas (last two paragraphs).

Ethanol

Ethanol is driving grain prices to high levels—as high as ~$8/bu for corn and $13/cwt. for grain sorghum in 2012 cash prices. In 2006 these prices were about $4.00/cwt and $4.40/cwt, respectively.

Ethanol plants currently operating or resuming operation in 2012: A total of about 370 million gallons/year (Mgy)—~110 Mgy, Hereford, Hereford Renewable Energy (subsidiary of Murphy Oil); 110 Mgy, Hereford, White Energy; 110 Mgy, Plainview, White Energy; 40 Mgy, Levelland, Conestoga Energy (scheduled resumption of operations, fall 2012). Some plants may not be operating at capacity due to current high grain prices. Recent indications are that all plants are using at least some grain sorghum in lieu of corn. The Levelland plant originally sought to use 100% grain sorghum, and grain sorghum use remains a priority if it can be procured.

The total Texas High Plains annual ethanol production capacity if operating at capacity would require about 125 million bushels of grain annually.

As a rule of thumb, for each one million gallon unit capacity of annual ethanol production, about 1,000 bushels of grain is required per day for 1 year.

One bushel of corn or grain sorghum—there is no major advantage to either—produces about 2.9-3.0 gallons of ethanol per bushel (56 lbs.) at current conversion technology.

The remaining cake, or distillers grains (DG), is valuable feed; if it can be fed within a couple of days then it does not need to be dried, otherwise natural gas is used to dry it. If large feedlots and dairies can use it quickly enough it will save a lot of cost at the ethanol plant. The fat content of the material can be high (not preferred in some animal feed rations, esp. dairies). Improvement in the consistency of DGs is desired.

What is the largest input cost at an ethanol plant? Historically it has not been the grain but fuel, usually natural gas. The run up in grain prices may now make the grain the largest input expense.

Some plants may be able to obtain some of their energy from biogas off of manure or other sources.

At the ethanol plant, depending on how much water is recycled, it requires about 4 to 5 gallons of water to produce 1 gallon of ethanol. An ethanol plant can make good use of gray water from municipal sources if it is available.

One of the large ethanol plants has asked the local municipality for 1.5 million gallons of water a day. The response of many is "This is an excessive amount of water." Enough to irrigate 55 acre inches per day. Two 500 gpm wells running 24/7/365. When compared to the water used for crop irrigation this amount of irrigation is surpassed by many individual farmers in a single day.

From the above example, however, here is what is overlooked (using Texas A&M results from the Texas High Plains): <u>the amount of water to produce the grain</u>.

First grain sorghum takes less water than corn to reach <u>the point of initial grain production</u>, hence sorghum in fact can be more water use efficient in dryer environments. Grain sorghum is more heat tolerant than corn.

For corn, depending on irrigation efficiency and the efficiency of the growing environment, it takes about 1,000-1,200 gallons of water in normal, non-stressed conditions to produce the 19 lbs. of grain to produce 1 gallon of ethanol.

For grain sorghum, depending on irrigation efficiency and the efficiency of the growing environment, it takes about 1,200-1,400 gallons of water in normal, non-stressed conditions to produce the 19 lbs. of grain to produce 1 gallon of ethanol. If droughty or hot conditions are stressing the plant then sorghum will maintain its water use efficiency hence relative grain production better than corn.

Initially, the intent of the above ethanol plants was to buy some grain locally but haul most or nearly all of the grain in from the Midwest. This is possible in part because historically corn is cheaper to purchase in the Midwest vs. corn grown in the Texas High Plains, and transportation charges are modest enough to make this feasible. The Levelland plant, however, to seeks in particular to procure most or all of their grain from the region and use all grain sorghum if possible.

Iowa and eastern Nebraska, the grain source that ethanol plants in West Texas look to for their corn to run ethanol plants, are essentially grain deficit regions.

Will the Texas High Plains region be able to haul the grain in to keep ethanol plants operating at full capacity?

If one assumes that the current ethanol plants can't haul all their grain in, then how much farmland in the region would be needed to produce needed grain? For the existing ethanol plants now operating if these companies had to procure from the region 20% of their grain from corn and another 20% of their grain from grain sorghum, then this would be the annual grain production requirement:

Corn @ 200 bushels/acre, 128,000 acres

Grain sorghum @ 3,600 lbs./acre (averaged between dryland and limited irrigation), >400,000 harvested acres

Ethanol and Net Energy Balance

Ethanol has much less energy than gasoline, about 85,000 BTUs/gallon vs. ~130,000 BTUs/gal for regular gasoline

A Consumer Reports article in 2006 reported mileage on a Chevy Tahoe with regular gas at 14 mpg vs. 10 mpg on E85 (ethanol 85%, gas 15%) on this flex fuel vehicle. Some recent research suggests that the mileage of ethanol blends might be improved slightly.

Ethanol is commonly blended at 10%, E10, and this blend's ethanol acts as the oxygenate to replace the additive methyl tertiary butyl ether, MTBE, which at least 22 states (but not Texas) have banned due to carcinogenicity as well as environmental groundwater issues.

Ethanol E85 burns much hotter, octane about 105 vs. 86 for regular gas.

The net energy balance—all the work and energy that goes into producing 1 gallon of ethanol including growing the feedstock, the fuel, the fertilizer, hauling, fermenting, distribution—for ethanol is about +25% (approximated in 2008). {I don't know if this figures in the potential energy, captured in animal growth, by using the distillers grains as animal feed.} Some more recent numbers suggest the net energy balance may have improved to 30-35% due to better conversion technology and reduction in energy to produce the feedstock.

Net energy balance of various fuels:

- Petroleum based fuels—the net energy balance is not readily reported, and there is a lot of argument about this, but some suggest it is only a few %, others much more
- Ethanol, +25%
- Soybean biodiesel, 93%
- Lignin-cellulose conversion (from corn stalks, forage sorghum, range grasses), +300-500% (this includes several different conversions including ethanol, other alcohols, syngas, or electricity from combustion)

Ethanol and ethanol/gas blends are cleaner burning than regular gas, particularly for reduced nitrous oxides. This may be of particular value in large metropolitan areas.

Lignin-cellulose conversion

Source materials include a wide variety of material ranging from leftover crop residues such as wheat straw, corn or grain sorghum stalks, cotton gin trash, rangeland harvest from grasses, forages grown for biomass such as forage sorghum, sweet sorghum or switchgrass, and even mesquite off the range.

Other areas of Texas and the U.S. will consider other locally available feedstocks. These might include sugarcane, Chinese tallow, forest byproducts, and regionally adapted or introduced grasses.

Ligno-cellulosic conversion is generally estimated at 70-90 gallons of ethanol per ton of feedstock with current technologies. At these conversion rates lingo-cellulosic conversion could be much more efficient than converting starch-based grains to ethanol. The conversion process, however, requires greater capital investment per unit of ethanol production. Also, the process itself may take weeks vs. days for grain-based ethanol production.

Plans for a lignin-cellulose plant in Hugoton, Kansas began in 2007, and it now under construction. The plant's projected ethanol capacity will require ~700 tons of feedstock per day. The plant's stated ethanol production capacity of ethanol from cellulosic conversion suggests that operators hope to achieve ~115 gallons of ethanol per ton of feedstock, but other sources suggest that a more realistic conversion efficiency is 45 to 93 gallons of ethanol per ton of cellulosic material.

For a 30 million gallon ethanol plant using lignin-cellulosic feedstock using a higher conversion rate of 80 gallons ethanol/ton, 1,000-1,050 tons of forage sorghum would be required per day, or 375,000 dry tons per year. At an irrigated forage sorghum yield of 20 wet tons/A (e.g., 6.4 dry tons/A), it would require nearly 60,000 acres to produce the forage, or almost 5% of all land within 25 miles of the plant.

The logistics of bringing an average of 500-2,000 tons of biomass per day to a site for lignin-cellulose fermentation is taxing. Many trucks would be needed to haul this amount of feedstock (40+ semi loads a day in the above example). And how far away could you profitably haul the feedstock?

Texas A&M dept. of chemical engineering research (Dr. Holtzapple) is pursing ligno-cellulosic conversion technologies that should produce 4-carbon alcohols (butanol, *iso*-propyl alcohol) that have much more energy than ethanol and are much more valuable industrially as well. Four-carbon alcohols have almost as much energy as gasoline per gallon. {Also, butanol could be piped through existing pipelines whereas ethanol, which is corrosive, must be trucked or hauled by rail.}

The capital investment on a lignin-cellulose conversion plant is estimated to be 4-5X that for grain ethanol fermentation

Ligno-cellulosic conversion is estimated at 23-30 days (compared to 1-2 days for grain ethanol). A reaction facility would have collection equipment imbedded in the soil under a large stack of feedstock (imagine an above ground silage pile like you see at a dairy or beef cattle feedlot), which has been treated with water containing microbes specially selected to hasten the conversion.

Removal of large amounts of crop residues for feedstock could return much land to a high degree of soil, wind, and water erosion potential. Soil quality and soil productivity could be decreased in such a way that adding fertilizer (a high energy requiring material) would not recapture lost yield potential.

Lignin-cellulose materials could be produced on marginal land using range grasses or a mixture of grasses and adapted legumes. This could entail a one-time annual harvest of biomass. If a legume could be placed in the mixture some nitrogen (N) could be added to the system (due to nitrogen fixation from atmospheric N_2). Eventually, however phosphorus (P) fertilizer would probably be needed to sustain productivity.

Alamo switchgrass is widely cited as a likely range grass for use in ligno-cellulosic production of ethanol. The U.S. Department of Energy has researched this widely adapted variety of switchgrass extensively. Many forage experts and agronomists concur that in many areas of the U.S., other grasses might be a better choice.

Ligno-cellulosic plants, in order to be profitable, must procure their feedstocks at the lowest possible price. Past suggestions have targeted <$40/ton to be profitable. That is a price that is less, even much less, than the value of mediocre feed quality hay, forage, range grasses, and even sometimes corn and grain sorghum stalks when sold as cattle feed.

Ligno-cellulosic feedstock research takes some unusual twists. All kinds of potential feedstocks are fair game. For example, the NMSU-Clovis station received a research grant to look at biomass production of pigweed (careless weed) in a crop rotation. Texas A&M AgriLife at Lubbock has discussed how kochia, which used to be known as "poor man's alfalfa", might deliver high amounts of biomass per acre, but we don't know how it would perform in conversion to ethanol.

The current forage/biomass crop in Texas receiving a lot of interest for ligno-cellulosic conversion is sweet sorghum, which already produces the sugars needed to ferment to ethanol. {Traditional grain ethanol must convert starchy materials to sugars then to ethanol.}

<u>Biodiesel</u>

As noted above the net energy conversion (+90-100%) is much higher than for ethanol.

There are currently ~15 biodiesel plants in Texas with an annual capacity of 120 million gallons of biodiesel (B100 which is usually blended to 20% biodiesel/80% gasoline, e.g. B20), but most of these are running at limited capacity if at all. Several of these plants have stopped operation over the past several years because the cost of oils used (e.g., soybean oil) has risen too much to be profitable. Through mid-2007 it was estimated that once the source oil reached ~$0.35/lb. then it was no longer profitable to convert many of the vegetable oils to biodiesel.

One biodiesel plant, Brownfield Biodiesel, is located at Ralls, TX. They use a variety of source materials but primarily cottonseed oil, and they have a capacity of 2 million gallons per year.

Ocho Gin, Gaines Co., completed a 1.5 Mgy plant in about 2008 that would have required about 50,000 tons of cotton seed annually, but little crushing was done, and the facility has been dismantled. A plant in Spearman, TX was planned for construction for 6 million gallons per year. A Clovis, NM biodiesel plant with 15 Mgy planned to use all canola oil, and if a crushing unit is installed, then the plant would require ~250,000 acres of canola production in eastern NM and West TX. But there is essentially no current canola production in the region and canola seed prices are high enough to make biodiesel production unfeasible.

Many commodity organizations such as National Sunflower Association have not actively promoted their commodity in the biodiesel arena as they assert that <u>high quality oils will always be worth more in the food and industrial markets than for energy</u>.

Canola oil, due to its low saturated fatty acid (6%) is the current preferred oil for biodiesel. High oleic sunflower oil is a strong second choice (9% saturated fatty acid). Cotton oil by contrast is about 27% saturated. High oleic oils—sunflower, safflower, peanut—would be preferred oils for biodiesel.

The equipment now exists whereby farmers or other small operators can have a small screw press, crush oilseed stocks, and then by a fairly simple filtering process produce their own on-farm biodiesel. A few farms in West Texas have tried this, but none that I know of have stayed with it.

Current oil contents of major oilseed crops or crops with high industrial oil value and/or biodiesel potential (I will add approx. yield ranges later so approximate per acre oil yields can be determined)

*^Cotton, 16-18%
^Peanut, ~50% (breeding efforts underway at Texas A&M—Lubbock/Stephenville using exotic germplasm to increase oil content towards 60%)
Soybean, 18-20%
*^Sunflower, 39-45%
^Canola, 37%
*^Safflower, 40%
*^Castor, 50%
*^Lesquerella, 37% (long-term research conducted by Dr. Mike Foster, Pecos station, with seedings now also in the High Plains)
*^Sesame, 50%

*Crops with potential to grow well either under dryland or minimal irrigation in West Texas
^Crops with Texas A&M testing/research in West Texas during 2008-2012.

Motor fuel prices would have to rise dramatically for many of the above crops to be competitive as biodiesel. For example, peanuts at 3 tons/acre yield in Gaines Co. would currently be worth several hundred dollars more per acre (gross ~$1,950/A) at the 2012 contract price for peanuts than the oil plus meal byproduct would be valued for biodiesel and animal feed.

Algae for biodiesel—certain types of algae can produce high oil yields per acre (initial projections 1,000-3,000 gallons per acre; potential for 5,000-10,000 gal/A according to some sources). Texas A&M is working on this at the Pecos Research Station.

<u>If All Current U.S. Corn & Soybeans Were Used for Ethanol & Biodiesel</u>

All 2012 corn grain production in the U.S., if converted to ethanol, would replace about 14% of our national gasoline consumption.

All 2012 soybean production in the U.S., if converted to biodiesel, would replace about 7% of our national diesel fuel consumption.

Ethanol vs. Biodiesel—Ethanol production for 200 bu/A corn would be about 580 gallons/A; ~500 gallons ethanol/A for a 20 ton/A forage sorghum (6.4 tons/A dry matter); 400 gallons/A oil for biodiesel for 6,000 lbs./A peanuts; about 100 gallons oil for biodiesel for a 2,000 lbs./A sunflower crop; many oilseeds might produce only 40-60 gallons of oil per acre.

Wind Energy

Wind energy is receiving growing interest in West Texas, especially as the price of wind turbines becomes more competitive. Some land owners are now questioning if their land might be more profitable if they lease the land out for wind generation, stop use of irrigation water, and seed farmland into a permanent pasture grass.

What other bioenergy fuel options are viable in West Texas?

BioEnergy and West Texas Water Resources

These following comments are less about facts and figures rather I seek to raise questions awareness about what fit might be best for the Texas High Plains and our Ogallala and limited surface water resources.

First, and quite simply, what is the value of water?

What does an acre-inch (one acre of water 1" deep, about 27,200 gallons) return in economic and social value when used for the following?:

- home use
- business use
- watering lawns
- industry and manufacturing
- growing crops such as cotton, corn, peanuts, sunflower, grain sorghum, vegetables, or minor oilseed crops such as castor, canola, safflower
- producing cattle feed (alfalfa, bermudagrass, silage, or hay)
- dairy milk production and cattle feeding operations
- ethanol and other bioenergy production

Is it the best long-term practice to use irrigation for many of the above uses?

Should we be pumping irrigation water to grow fuel? Due to high grain prices, growing crops is currently the best economic option for most farmers. Many of the possible options in the Texas High Plains pale in comparison to producing the same feedstocks for fuel production in Central Texas and the Texas Gulf Coast where rainfall ranges from 35-50" per year and irrigation would not be needed.

The drive behind bioenergy resources has been to reduce dependence on foreign oil, create energy from renewable resources, etc. Ethanol surely has a role to play. However, for West Texas if that ethanol or other energy resource is dependent on Ogallala irrigation water, which is only slowly recharged at best, then is the energy truly renewable?