RENEWABLE ENERGY SOURCES AND AGRICULTURE

Society's push for sustainable energy from renewable sources has led to heightened interest in plant and non-plant materials to replace fossil fuels for energy creation. A summary of some of the sources of this renewable energy follow, along with issues to consider when any of them are used to produce energy.

GROWING CROPS FOR BIOFUEL FEEDSTOCK PRODUCTION

Growing crops and non-crop commodities such as algae that can be used to produce biofuels presents a promising energy source to replace fossil fuels. Much of the interest in the soybean world has been "fueled" by soybean's position as the preeminent feedstock for the production of renewable diesel [RD]. In fact, soybeans are considered the "go to" feedstock for RD biofuel production. This is because, of all the crops that provide oilseeds for RD production, soybeans occupy by far the largest acreage in the U.S.

Renewable Diesel [also known as hydro-treated vegetable oil] is a plant-based energy source that is capable of replacing petroleum-based diesel fuel. This biofuel is quite different from biodiesel because it is produced by a different process that yields a hydrocarbon product that is molecularly identical to standard fossil fuel diesel. Thus, RD can be used in any diesel engine with no required modifications to that engine–i.e., it can be used as a "drop-in" fuel. Also, it does not have to be blended with petroleum-based diesel to maintain performance in standard diesel engines. RD 1) emits significantly less emissions than standard fossil fuel diesel and gasoline, 2) is easier to refine than gasoline, 3) has the potential to power myriad commercial vehicles, and 4) can replace coal and other fossil fuels for generating electrical power. Current biofuel producers are planning expansion principally using soybean oil as a feedstock.

A Sept. 2022 report titled "Renewable Diesel Projected to Turbo Charge Biofuel Growth" by K. S. Zuckerberg, Lead Economist with CoBank, provided positive news for U.S. soybean producers as they looked for new markets for their soybeans. Key points from that report follow.

- Biofuels such as RD are liquid fuels that are produced from plant feedstocks, and are being promoted to reduce the use of fossil fuels.
- Consumption of energy from renewable sources has increased across the globe, and this will likely continue as more governments mandate a shift to less carbon-intensive energy sources.
- All current and proposed RD projects will require the U.S. to vastly increase production of the feedstocks used for RD production, and the most available and important feedstock source will be soybean oil.
- A key element of the 2022 Inflation Reduction Act that was enacted by the U.S. Congress is the subsidizing of private sector investment in domestic production of clean energy.
- Ethanol [alcohol fuel produced from corn feedstock] and biodiesel [diesel fuel made by processing vegetable oils and other fats] are biofuels that have to be blended with petroleum gasoline and petroleum diesel, respectively. Since RD is chemically similar to petroleum diesel, it does not have to be blended with traditional petroleum diesel. It can be used in any diesel engine with no required modifications to that engine–i.e., it can be used as a "drop-in" fuel.
- Electric vehicle sales are increasing; however, production of batteries needed to power these vehicles is being hampered by high elemental lithium prices and supply chain issues.
- RD is a "greener" fuel [carbon intensity (CI) score of 41] than petroleum diesel (CI score of 90), and thus produces lower greenhouse gas [GHG] emissions.
- Of all the crops that can provide oilseeds for RD production, soybeans occupy by far the largest acreage in the U.S. Thus, it is the crop that is presently considered the primary source of feedstock for U.S. RD production.
- Growth in U.S. RD production is expected to rise from today's production of approximately 1 billion

gallons to 6.5 billion gallons by 2030, and this will require 3.4 billion new bushels of soybeans. Using a projected U.S. soybean yield estimate of 51.9 bu/acre, and assuming the stoppage of all soybean exports [projected to be 2.5 billion bushels in 2030], this would require an additional 17.9 million U.S. soybean acres to produce the 927 million bushel shortfall needed to meet the projected RD demand.

- Acres that would have been devoted to corn will likely be the primary source of new soybean acres needed to meet projected RD demand. This may not be an issue if electric vehicle adoption reduces the need for corn-based ethanol [historically, ~35% of U.S. corn production has been used for ethanol production], which in effect would lower the needed U.S. corn acres.

According to information in a Nov. 2022 article titled "Economist's Angle: Soybean Processing Growth is Crushing It" by Scott Gerlt, ASA Chief Economist, the soybean processing industry plans to grow significantly in future years. Much of this planned expansion is in response to the anticipated growth in demand for RD. Announced plans for new or expanded crushing plants in the U.S. would increase crush by 34%, and would add about 750 million bushels per year in crush capacity. Of course, this planned expansion of U.S. crush capacity that is based on growing RD production will only come about as the RD industry grows. The locations, capacities, and timelines of these planned U.S. plant expansions are presented graphically in the article.

A Jan. 2023 article titled "Soybean crush is expanding" by Ed Usset provides further commentary on what the use of soybean oil as a feedstock for RD production may mean for soybean and grain markets in coming years. Key points from that article follow.

- New construction or expansion for the soybean crushing industry is estimated at 4 billion dollars to produce an additional 600 million bushels of crushing capacity.
- Assuming a national average soybean yield of 53 bu/acre means that an additional 11.3 million acres of soybeans will be needed to satisfy this increased demand.
- There is much conjecture about what crop acres will be displaced by the additional soybean acres that will be needed to meet the demand for soybean feedstock for RD production. In addition to current corn acres that may be impacted as stated above, it is likely that current acres devoted to wheat and other small grains, plus acres currently devoted to cotton, will be impacted as well.
- In the coming years, RD likely will influence every grain market in the U.S.

Since soybean oil is now and is projected to continue to be the primary feedstock for RD production, U.S. soybean producers are in a position to play a major role in reducing GHG emissions by providing the raw material for producing RD fuel that has a lower carbon footprint than petroleum diesel. This will result in an increased demand for soybeans, and will likely cause a shift to more soybean acres in this country in order to meet this increased demand for RD feedstock. All of this should be great news for all U.S. soybean producers. However, as indicated in the following paragraph, this can change with events that alter feedstock availability.

In an Aug. 2024 article titled "Increased Feedstock Imports Push Soy from Biofuels", author Scott Gerlt provides information about how the importation of competing feedstocks such as foreign fats, oils, and greases has resulted in the displacement of soybeans as a feedstock for biofuel production. This will 1) reduce the profitability for crushing plants that are unable to make the feedstock switch, and 2) result in a significant amount of U.S. soybean oil production that was intended for use in biofuel production being left out of programs intended to support that production. According to information in the article, this can be changed by 1) increasing renewable volume obligations [RVO's] enough to allow room for all feedstocks in the RFS, and 2) updating soybean CI scores using current science and data.

The growing of crops solely for biofuel production faces criticism because it could result in the use of arable land that is essential for and now used for food production. Thus, there is growing interest in and

consideration for identifying bioenergy cropping systems that are suitable for use on marginal land sites, or sites that are less suited for food crop production.

A July 2024 article titled "Which Biofuels Crops Work Best and Where?" provides insight into just what crops producers should consider for biofuel production based on their U.S. location. This article cites research conducted using biomass from four non-leguminous, high-cellulose plant species [corn (stover), energy sorghum, miscanthus, and switchgrass] that can be used to create biofuels. The following are major points from the article.

- Univ. of Illinois scientists assessed the financial and environmental impacts of growing the above four crops [all C_4 species] in rainfed environments to provide feedstock that can be used to create sustainable aviation fuel [SAF] in the U.S.
- The study aimed to identify the feedstock with the lowest breakeven price and CI score for growers switching from another crop. They also considered the cost of C abatement and the amount of biomass produced per unit of land.
- The average yield of the 3 energy crops was greater than 4X that of corn stover. Also, the choice of feedstock crop based on yield varied among regions of the country.
- The analysis used in the study quantified the significant potential for SAF production from energy crops to reduce GHG intensity of aviation fuels.
- Corn stover-based SAF had the lowest breakeven price per gallon of fuel produced, but it had the highest cost of GHG abatement.
- In the final analysis, identifying and quantifying factors that are important in the production of SAF from bio-feedstocks, while also identifying specific regions of the country where a particular feedstock species performs best, will be necessary for the development of policies and incentives that will be needed to encourage use of bio-feedstocks for SAF production.
- The researchers concluded that either carbon prices will need to increase or the cost of producing SAF's will need to decrease to make SAF's an economically viable alternative to current jet fuel.

An article titled "ISU studies explore win-win potential of grass-powered energy production" cites results from research reported in articles titled "Optimal production and dispatch of renewable natural gas, electricity, and fertilizer in municipal-scale anaerobic digestion supply chains"and "Techno-economic and life cycle analysis of renewable natural gas derived from anaerobic digestion of grassy biomass: A U.S. Corn Belt watershed case study". The research was conducted by scientists at Iowa State Univ. and used various organic residues as feedstock to produce renewable natural gas [RNG]. A brief summary of results from that research follow.

- Global energy consumption is increasing. Thus, there is an increasing demand for renewable energy sources to replace fossil fuels.
- The analyses reported in the above articles indicates that RNG production by anaerobic digesters [AD] that use organic materials is a viable alternative to renewable electricity.
- Using grassy biomass from restored native grasslands to produce RNG through AD provides opportunity for sustainable biofuel production from marginal or low-productivity farmland, and could promote ecosystem services and markets for C credits.
- The economics for grass-to-gas production of biofuel depends on biomass yield and existing environmental credits or credits that may become available.
- Land use scenarios with the greatest biomass yield represent the most attractive economic outcomes because of more feedstock available to produce more RNG.
- Robust policies that support environmental credits are needed to realize the most economical and environmental value from RNG production from grassy biomass that can be produced on marginal cropland.

While none of the above-cited research projects involves using soybeans to make biofuel, they do involve instances where the production of fuel from plant materials is being researched. And since the development of renewable energy sources to replace fossil fuels is needed, soybean producers should consider how results from the above research projects

might fit into their current production systems. After all, it could be that a diversified program other than the oft-used corn-soybean rotation might be more profitable in the long term if markets for biofuel feedstocks are in place and/or continue to develop. Thus, consideration of such added diversity might enhance the profit potential for soybean producers.

Of course, use of a more diversified production system to produce biofuel feedstocks will need to ensure the marketability of products from that system. Marketing opportunities for biofuel feedstocks are just now being realized in the southern U.S., so soybean producers need to ensure there is a viable and sustainable market for alternative crops they may be considering to grow for biofuel feedstock material.

Are Soy-Based Biofuels a Threat to Food Production

In Nov. 2022, a report titled "Food and Fuel: Modeling Food System-Wide Impacts of Increase in Demand for Soybean Oil" by Jayson Lusk was prepared for the United Soybean Board [USB]. Dr. Lusk used economic models to develop projections/estimations of just how the increased demand for soybean oil to be used for processing biofuels will affect the food processing sector that uses soybean oil. A summary of the study results can be accessed here. Pertinent points from the report follow.

- The share of soybean oil going into biofuel production in the U.S. has quadrupled over the past decade. The price for crude soybean oil has approximately doubled since the fall of 2020.
- The overall objective of the research that resulted in this analysis was to evaluate whether or not the increased use of/demand for soybean oil needed for the production of biofuels has contributed to the rising retail prices for food products that are purchased by consumers.
- The following points were determined from this research. 1) The cost of wholesale soybean oil is only a small part of the overall cost of producing retail food items. 2) The increased amount of soybean oil used for biofuel production has not necessarily come at the expense of soybean oil used for food. 3) Soybean oil is jointly produced with soybean meal during processing, and this results in an increased quantity of soybean meal that far exceeds the quantity of oil produced from the processing.
- Equations used in the economic model indicate a 20% increase in the quantity of soybean oil that will be demanded for use in biofuel production.
- The expanded crush [i.e. processing] of soybeans for oil creates an increased availability of soybean meal used in animal diets, and this results in a lower price for soybean protein used in animal feed. This decrease in animal protein price resulted in 0.16%, 0.13%, 0.06%, 0.02%, and 0.01% decreases in retail prices for eggs, chicken, pork, dairy products, and beef, respectively.
- The projected retail price increases for food items as a result of the increased demand for soybean oil needed to produce biofuels are 4.41%, 0.82%, and 0.16% for salad and cooking oil, margarine, and baking and frying oil plus other foods containing oil, respectively. These price increases are much smaller than the estimated 8.17% price increase for crude soybean oil.
- While the increased demand for soybean oil for uses other than food processing may contribute to the rising price of soybean oil-based food products, the increased availability of soybean meal resulting from the increased soybean crush drives down the cost of soybean protein used in animal diets. This will offset the effect of this increased demand for soybean oil on the consumer price index [CPI], which is estimated to be only +0.05%.
- Overall, the conclusions drawn from this research are that 1) the rise in demand for soybean oil has had little effect on the CPI, and 2) the increased demand for soybean oil to meet the demands of the biofuel industry has had limited impact on the rise in retail food prices at the grocery store. Non-farm factors such as transportation, processing, packaging, and retail costs associated with food processing in the U.S. far outweigh the costs of raw farm commodities such as soybean oil that are used in the production of the food purchased by consumers.

Will Other Oilseed Crops Such as Canola Compete with Soybeans for Acreage?

Canola refers to a group of rapeseed cultivars that were genetically modified through traditional, non-GMO breeding methods to have low levels of glucosinolates [<30 micromoles] and erucic acid [<2%]. The term canola is a combination of "Canadian" and "oil" [or ola] to distinguish it from rapeseed. Go to Growing canola for oilseed or cover crop use, Canola Production, and Great Plans Canola Production Handbook to access guidelines for producing the crop as both a cover crop and a cash crop.

According to NASS, harvested acres and yields of canola averaged 2.09 million and 1,700 lb./acre from 2020 through 2023 in the U.S. During this same 4-year period, soybean harvested acres averaged 84.36 million and yielded an average 50.7 bu/acre. Thus, U.S. average canola acreage was only 2.5% as much as average soybean acreage during this 4-year period.

North Dakota had an estimated 1.915 million acres of canola in 2023, the most of any U.S. state. Montana and Washington had an estimated 160 and 163 thousand acres, respectively. Together these three northern U.S. states had over 96% of the nation's total harvested canola acres in 2023.

Unlike soybeans, canola has no national checkoff. The U.S. Canola Association thus does not fund research directly, but does advocate for a National Canola Research Program that provides grants from the NIFA/USDA. The recipients of these grants have been North Dakota State Univ., Kansas State Univ., and the Univ. of Idaho [shared with other universities in the Pacific Northwest region of the U.S.].

The below links are to articles that provide insight into why U.S. canola acres may increase, and where such increases are likely to occur if that happens.

American Farmer's Next Hot Commodity is Canola for Biofuels.

- Oil from canola seeds produces a shelf-stable cooking fat, but may soon be considered a desirable feedstock for the growing production of biofuel that is produced for the heavy transportation sector that includes trucking, rail, and marine conveyances.
- Canola seeds contain over twice as much oil as soybean seeds. Thus, they could be an excellent feedstock for biofuel production.
- The vast majority of canola that is presently grown is spring canola in the northern U.S. and Canada. This crop is planted in the spring and harvested around September.
- Chevron Corp., Bunge Global SA, and Corteva Inc. have established a joint pilot program that encourages farmers in several states to plant winter canola. Plantings in the fall of 2024 are expected to increase dramatically [but still occupy a very small acreage].
- Producers who have grown canola tout its side benefits of improving soil health, suppressing weeds, and boosting yields of following crops.
- Canola grown as a winter crop in the southern U.S. may work best on land that is to be fallowed during the summer months since its harvest will necessarily dictate ultra-late planting of corn, cotton, and soybeans on canola acres in the region.

Why farmers are swapping some soybeans for canola.

- Growers in the upper Midwestern U.S. have found that canola as an alternative crop to some soybean acres makes sense because of 1) a September vs. October harvest, and 2) its need for minimal inputs.
- Canola can use the same planting and harvesting machinery as that used for soybeans.

Growers see new life for canola in U.S. South.

- Winter canola is viewed by some southern farmers as an alternative crop to wheat in the southern U.S. since it can be used as a feedstock for RD production
- Corteva's role in the partnership mentioned above is to produce winter canola hybrids that are suited for the southern U.S.
- Present canola acreage in the southern U.S. is so small that USDA does not collect or publish acreage statistics for states in that region.
- The limitation to canola production in the south has generally been market-related and not production-related.

- Winter canola in a doublecrop [DC] production system with soybeans as the summer crop provides two crops that can be used as feedstock for RD production.
- Winter canola is a non-host for some major soybean pests such as SCN.

The above narrative indicates that spring canola is well-adapted to being grown in the upper midwestern U.S., and may replace some soybean acres in that region. Current information also indicates that winter canola may replace some wheat acres in the southern U.S. where DC is a major production system. However, this will not likely impact Midsouth soybean acreage since there is little DC in the region.

Only an economic analysis of a DC system that uses canola as the winter crop compared to soybeans grown as a monocrop in the ESPS will determine if replacing wheat with canola in a DC system will improve overall economic returns and be more profitable than growing soybeans as a monocrop in the ESPS. Also, any increase in U.S. canola acreage will likely depend on whether or not RD continues to be considered a significant source of biofuel in future years.

SOLAR ENERGY

Capturing the sun's energy to generate electricity for human use is not a simple undertaking. In fact, current technology for this capture involves the installation of an array of solar panels, and such installations will necessarily involve converting land from other uses such as crop production. How this will affect the capacity to produce food in an amount needed to feed the world's increasing population is a subject for debate.

Articles titled "Loss of Productive U.S. Farmland to Energy Production", "Solar Lease Contracts", and "Solar Farms and Contracts" are posted on this website. Information in these articles provides details about what is involved in solar energy production, and how this might affect the ability to produce crops that would provide an end product that can be consumed or used by humans and food animals. Following are links to additional articles that provide points to consider when 1) deciding whether or not to install renewable energy power sources [solar panels or wind turbines] on all or part of a farm, and 2) negotiating contracts to cover such installations.

In a May 2024 article titled "Do solar panels add value to your farmstead" by Michael Lauher, the author makes the following points.

- A residential solar system [vs. a community-scale solar farm] powers one home or business.
- The value that a residential solar system adds to a property depends on whether or not the panel array was purchased or leased by the property owner. If the panel array was purchased then it is owned by the person selling the property. If the array was leased, then its addition to the value of the property being sold will depend on 1) whether or not the lease goes with the property that is sold or stays with the person who signed the lease, and 2) who is responsible for maintaining the panels and who owns the panels at the end of the lease.
- Timing of the purchase of solar panels could have an impact on their value in relation to the change in state and federal government programs that are evolving.
- Whether or not a supplier of electricity is regulated by a government agency may also determine the value of a solar array since this will likely result in different compensation schedules for the purchase of excess electricity produced by the solar panel array.
- Any government action that makes compensation schedules and requirements regarding residential solar arrays more uniform among the myriad electricity suppliers will create more certainty in the market which will subsequently contribute to more value.
- In the end, the value of a residential solar array to a farm property being sold will largely depend on the individual installation details.

An April 2024 article titled "Agrivoltaics: Weighing solar growth and farmland loss" by Andrew Branan offers the following points.

- Agrivoltaics is a new word that means the dual use of land for solar energy production and agriculture.

The practices used in this system and relevant laws governing them vary by country.

- An increase in utility-scale solar development on land previously used for agriculture has generated interest in the effect of solar development on farmland loss. Also, this loss of farmland has generated concern over the loss of agricultural output from such land.
- The immediate impact to individual agricultural producers losing their access to leased fields is easily measured in lost production acres. Research on how this affects individual farming communities is in its infancy.
- Since most solar projects are long-term, the promise that one day this converted farmland will again be farmed does not address the short-term effect of such land conversion.
- Once land is converted to solar energy production [i.e. installation of solar panels], options for a continuation of agricultural production on this land are limited to mostly pollinator habitat production [limited economic impact to landowner] and sheep grazing [limited U.S. markets for sheep meat and wool].
- Research to overcome the limitations to agricultural production on solar panel sites should focus on 1) how livestock grazing on these sites affects soil health, carbon sequestration, and water quality, 2) site design requirement [e.g. panel spacing and height] that will allow more diversified agricultural application on these sites, and 3) the socioeconomic impacts to the affected local communities.

A March 2024 article titled "Wind, solar contracts: Beware the fine print" by Ben Potter offers the following points that landowners should consider when negotiating a contract that will allow renewable energy production [i.e. power generation from wind and solar] on their property.

- Pay attention to contract components such as payment plan for electricity produced, term of the contract, who pays for insurance and taxes, compensation for crop damage during installation, land use allowed once the project is completed, decommissioning terms, and compensation for residual fertility and compaction issues once a project is decommissioned.
- Make sure developers do not leave odd-shaped areas outside the project boundaries.
- Who holds the natural resource rights to the land encompassed by an energy project?
- Ask for references and prior experience with such projects.

In a January 2024 article titled "Crop and Energy Production Merge in Iowa Project", author Terri Queck-Matzie provides the following points.

- Solar power may enhance production of the increased amount of energy needed by the world, but its benefit will be limited if it curtails the ability to produce enough food to feed an increasing world population.
- Solar panels do not necessarily disrupt farmland use, but they certainly may affect just what the converted farmland can be used for.
- The above-cited research project seeks to determine just how solar panels may affect growth and development of fruits and vegetables that are planted beneath and among the panels, and conversely, how different types of vegetation may affect the energy production of the panels.
- One of the results of the project may be the determination that varieties specific to the project environment will need to be developed.
- The project will involve specialists from multiple disciplines–e.g. horticulturists, entomologists, economists, environmentalists, sociologists, engineers–that will study the myriad effects from the solar farm installation.

All of the above narrative indicates the following. 1) Myriad bioenergy crops can and will be grown in the U.S., and they will displace some acreage that is currently devoted to presently-grown commodity crops. 2) Some bioenergy crops may be better suited for growing on marginal acres than are presently-grown commodity crops. 3) Growing of bioenergy crops will likely depend on U.S. region, and the soil properties and weather patterns common in those regions. 4) Solar energy farms are likely to displace current acreage devoted to the growing of present commodity crops, and this displacement will be for the long-term.

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