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Overview: Developing New Energy Sources from Agriculture

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In the early 1900s, energy sources around the world were mostly agriculturally derived and industrial products were primarily made from plant matter. Early motor fuels also came from agriculture — Henry Ford used ethanol in his original engine and Rudolf Diesel's engine could run on peanut oil. By 1920, petroleum emerged as the dominant energy source for transportation fuels and industrial products. For over 80 years, the United States and other industrialized countries have relied on petroleum as an economical and dependable source of energy. However, this reliance on petroleum is becoming a major issue as our domestic oil supplies shrink and our dependence on oil imports grow.

Since the energy crisis in the 1970s, policymakers have been looking to agriculture as a source of energy supply and legislation has been passed to encourage renewable energy production and fund research on developing ethanol, biodiesel, solar and wind power, and bioproducts. More recently, the security risks of imported oil and environmental concerns have intensified the interest in developing renewable energy sources and replacing petroleum products with more environmentally friendly bioproducts. The U.S. Congress responded to the recent energy situation by passing two major bills providing incentives for renewable energy production; the 2002 farm bill contained the first energy title in farm bill history and the Energy Policy Act of 2005 was the first Federal energy law passed since 1992.

Projections indicate that worldwide energy use could grow by more than half in the next two decades, and U.S. energy use is expected to increase by one-third during this time. Heavy reliance on fossil fuels could continue, with related concerns about air pollution, greenhouse gases, and increasing dependence on oil from unstable countries. In his State of the Union Address, President Bush outlined

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The Advanced Energy Initiative that promises to break America's dependence on foreign energy by replacing more than 75 percent of our oil imports from the Middle East by 2025. In 2005, about 25 percent of our crude oil came from the Middle East, mostly from Saudi Arabia. Canada and Mexico are currently the leading oil importing countries, followed by Saudi Arabia.

The President's goal is ambitious, but realistically achievable through the development of biofuels, biopower, bioproducts, and other alternative energy sources. Renewable energy is abundant, diverse, and widely distributed throughout the United States. Commercial technologies are currently available that are harnessing energy from agricultural crops, animal fats, and waste materials. Moreover, research may currently be on the verge of providing a number of technological breakthroughs leading to a significant expansion in our renewable energy resource base.

The majority of U.S. oil imports are used for transportation, so achieving energy independence will require domestic energy resources to produce biofuels for motor vehicles. The most common biofuel used today is ethanol, which is made mostly from corn. Although ethanol is a gasoline substitute, it has been primarily used in the United States as a gasoline additive to reduce harmful air emissions or to boost octane. Although ethanol growth has

been impressive in recent years, it still is less than 3 percent of total annual gasoline consumption. About 14 percent of the U.S. corn crop was utilized for ethanol in 2005 and USDA predicts the annual corn production used for ethanol will rise to 23 percent by 2016. Clearly, the supply of corn is relatively small compared to gasoline demand, so other domestic sources of transportation fuel are needed to achieve our energy goals.

Biodiesel, which is just beginning to establish a market in the United States, is a biofuel substitute for petroleum diesel. Similarly to ethanol, it is rarely used in neat form and is most commonly blended with diesel fuel at levels of 20 percent or lower. The majority of the 91 million gallons of biodiesel produced in 2005 came from soybean oil, but, it can also be made from other oilseed crops, animal fats, and grease. Biodiesel can extend diesel fuel supply, but it too is limited compared to total petroleum diesel demand. A much larger quantity of energy feedstocks is needed to allow biofuels production to reach a larger scale.

The desire to replace a significant amount of imported oil beyond our current capabilities has created much interest in producing biofuels from feedstocks other than row crops. These feedstocks, called biomass, include agricultural forestry and crop residues, wood waste, municipal solid waste, trees, and grasses. There are basically two technologies for converting biomass into a biofuel. The first is a process developed in the 1940s that uses a gasification method. With the gasification process, biomass is gasified at high temperatures to produce synthetic gas called syngas. The syngas then goes through a process that synthesizes the gas into a transportation fuel (e.g., diesel fuel). The second process converts biomass into ethanol, often referred to in the literature as cellulosic ethanol. This process uses genetically engineered bacteria to break down the more complex sugars found in the woody material of biomass. The sugar extracted from the biomass can then be used to produce chemicals, ethanol, and other biofuels. However, the technology for producing cellulosic ethanol is not fully developed.

Developing domestic renewable sources of energy for generating power and producing heat is another important component of the President's plan to increase domestic energy supplies. As recently as 1999, North American natural gas reserves were considered plentiful and growth of the U.S. utility industry was dependent on natural gas. However, recent supply disruptions and major price shocks have transformed natural gas from a fuel of choice to a fuel of risk. Estimates of natural gas reserves in North America were adjusted downward during the first half of 2004 and industry analysts doubled their price projections for the next several years.

Currently, both large- and small-scale technologies are being developed to generate solar and wind power. Some small-scale solar applications are already commercially available that provide electricity for lighting, battery charging, small motors, water pumping, and electric fences. There is also an emergence of solar technology that is being used in homes and in the industrial sector to provide hot water and space heating.

Wind is another abundant renewable energy source, and windmills do not produce harmful environmental emissions. Wind power is already making a small contribution to the U.S. electricity system. Utility-scale turbines have been increasing in number, due to government support and advances in technology that have substantially reduced production costs, especially in areas with consistently high wind speeds. Small wind systems are also being developed that in the future may allow farmers to economically generate electricity in remote areas to avoid paying for expensive transmission wires.

Biomass can also be used to generate electric power by direct burning, using gasification systems, or mixing biomass with coal in coal-fired electrical generation facilities. Currently, biomass supplies over three percent of U.S. energy consumption. The primary feedstocks include wood waste used by the pulp and paper industry for industrial heat and steam production. In addition, forest residues and municipal solid waste are used to generate electricity.

Another potentially large source of renewable energy is animal waste that can be turned into methane gas through anaerobic digestion. Anaerobic digestion has been used for years by municipal wastewater treatment plants in the United States to convert waste solids to methane gas, which can be converted into heat or electricity. More recently, research and demonstration projects have focused on producing methane gas from confined livestock operations. Currently there are only about 40 anaerobic digesters located throughout the United States on swine, dairy, and poultry operations. However, anaerobic digesters are growing in popularity to help dairy farmers and other livestock producers meet new state and Federal regulations for controlling animal waste. Anaerobic digesters can help control water pollution and odor from animal waste, as well as provide electrical and thermal energy. In addition, methane, a potent greenhouse gas, is not emitted

into the atmosphere when animal wastes are converted into energy.

Obviously, it is going to take a variety of alternative energy sources to solve our energy supply problems. Biofuels can replace a significant amount of oil imports; however, increases in energy efficiency and other technological advancements will also have to play an important role in gaining our energy independence.

There is much uncertainty over the future potential of renewable energy. However, there is no doubt that the world demand for oil is increasing rapidly and competition over the world's remaining oil reserves will intensify. Thus, it seems reasonable to suggest that future generations will eventually replace petroleum with alternative sources of energy. One long-run vision is the emergence of a biorefinery industry, designed after oil refineries, with the capability of converting large quantities of biomass into a number of energy and biobased products. Biorefineries have the potential to replace nearly all petroleum-based products, including transportation fuels, electricity, natural gas, and petrochemicals.

In the shorter term, we should be able to produce enough biofuel to replace a significant portion of our oil imports. Just reducing our dependence on our most unstable trading partners could prevent future energy supply disruptions and severe price shocks. Adding biofuels and other diverse sources of energy to our Nation's energy portfolio will significantly reduce economic and national security risks.

The selection of papers for this theme will look at agriculture's current role as an energy producer and explore opportunities to enlarge its contribution to domestic energy supply. The first article, by Duffield and Collins, reviews U.S. renewable energy policy, which has been critical in advancing the development of renewable fuels.

The article by Eidman examines the economic and environmental aspects of ethanol and biodiesel. It also discusses the drivers behind the recent rapid growth of these two biofuels, evaluates current feedstock supply, and looks at the prospects for continued growth in the future.

The third article, by Gallagher, goes beyond traditional feedstocks and examines the existing supply of biomass in the United States and estimates the amount that can be economically harvested from U.S. farmland. It also provides a review of current and potential processing technologies for converting biomass to biofuels.

The fourth article, by Fischer, Finnell, and Lavoie, focuses on current and future technologies for generating renewable energy from solar, wind, and geothermal power.

In the final article, Conway and Duncan discuss the development of bioproducts made from agricultural materials, such as hydraulic fluids, lubricants, and biopharmaceuticals. They outline the necessary steps to bring these products to the marketplace through public policy, research, and market development.

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