the U.S. Senate Committee on Agriculture

Prepared Statement of
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Mr. Chairman, thank you for this opportunity to discuss how agriculture and forestry resources can help reduce our nation's reliance on petroleum, and our dependence on foreign sources of oil in particular. I am the director of the National Bioenergy Center at the National Renewable Energy Laboratory, in Golden, Colorado. NREL is the U.S. Department of Energy's primary laboratory for research and development of renewable energy and energy efficiency technologies. I am honored to be here, and to speak with you today.

The committee is to be commended for its hearing on the role agriculture can play in reducing our nation's dependence on petroleum. NREL is dedicated to helping our nation develop a full portfolio of renewable energy technologies that can meet our energy needs. There is, of course, a lengthy list of renewable and conventional energy options that we as a nation must pursue. If we consider solely those things we can do to create a viable alternative to oil, then maximizing our biofuels industry must become a priority. That is because biomass is the only renewable option for liquid transportation fuels.

Agriculture and its biofuels future

Biomass is plant material, such as grasses, trees or agricultural wastes that can be turned into energy. Biomass can yield energy in a number of ways, though it is only recently that we have come to fully understand just how valuable a contribution biofuels can make.

The Department of Agriculture and the Department of Energy have looked at the question of whether the nation's biomass resource - including its existing and potential agricultural base - could foster a biofuels industry large enough to meet a significant portion of our nation's future fuel needs. The report, now commonly referred to as "The Billion Ton Study," for the first time confirmed that the U.S. could yield more than a billion tons of biomass annually for energy needs. Moreover, this could be done without negatively affecting the nation's ongoing needs for food or fiber.

These conclusions are significant because the 1.3 billion tons of biomass that was forecasted contains as much energy as 3.5 billion barrels of oil. Accordingly, a supply of 3.5 billion barrels is about 60% of the 6 billion-plus barrels of oil the U.S. consumes each year.

The United States, including Alaska, currently produces about 2 billion barrels of oil per year. That amounts to 67 percent of the resource potential from agriculture and forestry biomass. U.S. oil production peaked in the early 1970s at the same level of production, about 3.5 billion barrels per year. To put this in perspective, the U.S. has never produced more than 3.5 billion barrels a year of oil.

While it will take a significant and sustained national effort to get us to this level of biofuels production, The Billion Ton Study does reveal that the biomass resource is large enough to ultimately replace a major portion of the petroleum-derived fuels on which we depend. The fact that the biomass resource is regionally distributed has benefits of its own. It is anticipated that every state in the nation could produce biomass and enjoy economic stimulus as the result of biofuels expansion.

The Billion Ton Study showed that U.S. agriculture and forestry industries have the potential to produce enough biomass resources to supply 30-40% current U.S. petroleum products. How quickly biofuels can penetrate the U.S. transportation energy market is a difficult question to answer. DOE is studying this question, and will publish a "30 by 30" study that examines market, policy, and technology changes required for the U.S. ethanol market to reach 60 billion gallons per year by the year 2030. (60 billion gallons/year of ethanol is roughly 30% of today's U.S. gasoline market; hence the phrase "30 by 30".) This is an aggressive but achievable goal that will require policy drivers together with technology advances.

It should be emphasized that the nation already has seen benefits from a strong and growing ethanol fuels industry. The U.S. currently produces more than 5 billion gallons a year of ethanol, almost exclusively from corn grain, and the industry is growing 30 percent annually.

To move the ethanol industry to where we need it to be, we have to move beyond corn grain as the primary biomass resource. One of the most abundant potential resources we have is corn stover, the non-food parts of the corn plant, including the stalks, leaves and husks. Other resources are forest thinnings, hardy grasses, like switch grass, and fast growing trees.

To use these and other resources we need to perfect new technologies that convert the cellulosic materials of the plants into fuel. That is the focus of the research being conducted by NREL and DOE. The goal of the DOE Biomass Program and the National Bioenergy Center is to make cellulosic ethanol as cheap as corn ethanol, and do so within the next 5 years. A facility built today for converting cellulosic biomass to ethanol would produce fuel at about twice the price of one of today's existing corn grain ethanol facilities. DOE and NREL have a long-term goal to make cellulosic ethanol cost-competitive with gasoline produced from petroleum by the year 2030. Achieving this goal will require revolutionary approaches for producing, collecting, and converting biomass.

The near-term target we have set to accomplish this goal is ambitious, but we believe it can be met with adequate research support and a focused R&D effort. Our goal is to reduce the cost of producing cellulosic ethanol from $2.25 a gallon in 2005, to $1.07 in 2012. To get there we are working to greatly increase production efficiencies, and boost the average yield from 65 gallons per ton as it is today, to 90 gallons per ton in 2012.

Ongoing research pushing down economic barriers to cellulosic ethanol

The encouraging progress we have had in ethanol to date lends credence to our longer term targets. Over the past 5 years, we've been able to drastically cut the cost of ethanol from cellulosic biomass, corn stover in particular, by reducing the cost of enzymes in partnership with two major enzyme manufacturers, and improving the biomass conversion process.

As recently as the 1990's, the high cost of cellulase enzymes was forcing the use of a less efficient process, called acid hydrolysis. We have since gained major efficiencies because of a partnership between DOE and two of the world's largest biotechnology companies - Genencor and Novozymes. The consequences of that research have been profound - with the cost of enzymes for producing cellulosic ethanol having been reduced more than tenfold. Now, all major process development work on cellulosic ethanol production is pointed to the more efficient enzymatic hydrolysis process - proving that industry is successfully taking advantage of these scientific breakthroughs. We continue to work toward further reductions in the cost of these enzymes.

Integration of biorefineries into existing industries

Also important to our work is the development of "biorefineries". Scientists at NREL, together with those at other DOE national laboratories, universities and corporations, are leading the development of fully integrated refineries that use biomass, instead of petroleum, to produce fuels, chemicals, synthetic materials - virtually all of the products we use from a conventional oil refinery today. Biorefineries utilize a complex array of processing facilities to break down, convert and recombine a wide range of biomass components into fuels and chemicals, in a manner similar to how petroleum refineries convert petroleum crude oil. We envision that future biorefineries will utilize a wealth of resources we either underutilize or don't use at all today. That includes agricultural residues, forestry residues, dedicated energy crops, municipal solid waste, algae and by-products of the food and grain industry.

A range of biorefinery R&D work is underway in partnership with industry. DOE's biomass program is partnering with a number of the major ethanol technology providers and ethanol producers, including Abengoa, ADM, Broin and Cargill, to increase the yield of ethanol from existing corn ethanol facilities and expand the slate of feedstocks. In many ways, a cellulosic biorefinery can be viewed as an expansion of a corn ethanol facility. That's why we believe tomorrow's cellulosic ethanol industry will not replace today's corn grain ethanol industry, it will evolve from it.

At the same time, DOE is partnering with chemical industry leaders, such as DuPont, to develop new opportunities for producing both fuels and chemicals from biomass. DOE is partnering with the forest products industry to explore and develop biorefinery concepts that can integrate into existing forestry operations. And, most recently, DOE is partnering with oil industry technology developers to explore novel options for introducing biomass streams into existing petroleum refineries. These and other partnerships are speeding the progress of new technologies to the marketplace, and may uncover new options for producing fuels from biomass.

DOE will continue to partner with industry on the development of biorefinery technology. The agency is currently reviewing proposals from industry to cost-share the construction of one or more biorefinery demonstration facilities. DOE has also invited proposals to partner with industry on the development of robust microorganisms needed to produce ethanol from the complex mixture of carbohydrates made by pretreatment and hydrolysis of lignocellulosic

biomass.

Integration of thermochemical technologies

Thermochemical conversion technologies such as gasification, pyrolysis and thermal depolymerization systems are all worthy of further research and development. These technologies have the potential to achieve the same biofuel cost goals as cellulosic ethanol, and can convert a broader range of biomass feedstocks. Additional research is needed to determine how these technologies and the respective biofuel products they produce can impact the cost, efficiency and integration into existing fuels infrastructure. Some of the products of thermochemical conversion technologies integrate well into an ethanol plant, while others integrate well into a petroleum refinery. For example, gasification of lignin-rich residue and making a mixture of alcohols from the SynGas is one way to increase the yield of biofuel per ton of lignocellulosic biomass in a cellulosic ethanol facility. In another example, processing biomass oils (triglycerides) in conventional petroleum hydroprocessing units can produce a high quality hydrocarbon diesel fuel from biomass that blends well with petroleum diesel. In yet another example, exploring the integration of biomass pyrolysis with petroleum refining is the subject of some of DOE's biofuel research at NREL, PNNL, and UOP (an Illinois-based process technology company); and this approach shows good promise for forestry resources. These different technologies for refining biomass may all be required to process all the different forms of biomass, achieve our biofuel cost goals, and satisfy demand for all the different petroleum-derived fuel products, including: gasoline, diesel, jet fuel, railroad fuel, LPG, and heating oils.

Our goal is to make renewable biomass-derived fuels and chemicals the solution for ending, as President Bush himself memorably put it, our nation's "addiction" to oil. And with the President's Advanced Energy Initiative, we are on course to bring the nation's first commercial cellulosic ethanol production facilities into existence by 2012. There is little doubt that ethanol will be, and should be, the first biofuel that we can use to reduce our dependence on petroleum. However, DOE and the National Bioenergy Center recognize that other biofuel options need to be developed as well.

Ethanol and biodiesel reduce the use of petroleum

You may have heard some discussion about the energy efficiency of ethanol. The first ethanol plants built in the late 1970s were costly and energy-intensive, and that did spark a debate about whether it made good "energy sense" to replace gasoline with ethanol. Today's ethanol industry is considerably more cost effective and energy efficient. Researchers at DOE, USDA and elsewhere have shown that the net energy benefits of fuel ethanol are clear and considerable.

The "Well to Wheels" study conducted by Argonne National Laboratory, General Motors, and several other partners including two major oil companies concluded that the energy contained in ethanol made from corn is about 1.4 times the fossil energy used to produce the ethanol, and 10 times the petroleum used to produce the ethanol. For cellulosic ethanol, the ratio of energy in the ethanol to the fossil energy used increases to about 10 Btu's in the ethanol for every 1 Btu of fossil fuel used. From the perspective of science, at least, this debate has been decided in

favor of continued development of ethanol. Ethanol is proving to be a very effective option for reducing our dependence on petroleum - regardless of whether it is made from corn or cellulosic materials.

Biodiesel and other derivatives of fats, oils and greases can make a significant contribution. Researchers at DOE and USDA have shown that the energy contained is biodiesel is 3.2 times the fossil energy used to produce the biodiesel. A wide variety of seed oils, animal fats, and waste oils from all parts of the country can be converted to biodiesel. Aquatic species such as algae can also play a major role in the long term, because they do not require fertile soils, can grow in brackish water, and yet, algae can produce very high yields of oil. Considerable research and development will be required to realize the potential of algae as a source of oil feedstock.

Linking biofuels research to fuel standards, engine performance, and emissions

There is a small but rapidly growing biodiesel industry in the United States. The growth of this industry is currently limited by a number of barriers to market penetration, including: the need to understand fuel quality issues and develop new fuel quality standards, uncertainty regarding impact on NOx emissions, and by lack of understanding of how this new fuel affects engine performance and durability. This is especially true for new diesel engines equipped with advanced emission control technologies that will be introduced beginning next year. NREL's Center for Transportation Technologies and Systems is working to address these issues in partnership with biodiesel producers and engine manufacturers. We, along with industry, believe additional engine testing is needed to better understand the performance of B20 (20% biodiesel) and lower blends in the advanced emission control diesel engines that will enter the market in the 2007-2010 time frame in response to EPA regulations. This engine test work would advance biodiesel technologies by ensuring compatibility with these new (and much different) engines.

NREL's Center for Transportation Technologies and Systems is working to address the biodiesel utilization issues noted above. Similar R&D is needed to more accurately quantify the air quality benefits of ethanol and develop engines that are optimized to operate on ethanol as well as on gasoline. Other promising answers to our future transportation needs are gasoline-electric - and perhaps ethanol-electric and biodiesel-electric - hybrid systems, including so-called "plug-in hybrids," which could eventually achieve fuel economy of more than 100 miles per gallon.

Continued research hastens fuels development

In conclusion, several key points warrant review. Biomass is the only renewable option for producing liquid transportation fuels. The U.S biomass resource can supply a large portion of demand for gasoline and we can greatly expand the resource base when world petroleum production begins its decline. The biofuels industry can use resources from every region of the country and could become a needed stimulus for ailing rural economies.

Accelerated development of a cellulosic ethanol industry can be accomplished - if we put

adequate resources behind the effort. Accelerating the adoption of E-85 is critical to displacing a large fraction of petroleum with ethanol.

The President's Advanced Energy Initiative holds the promise of accelerating our work so that we can help get this industry up and running, to benefit the American people, even sooner. His initiative envisions a more aggressive research effort in all key areas of cellulosic ethanol: further reductions in enzyme costs, advances in process technology to reduce capital and operating expenses and advances in feedstock R&D that will reduce the cost of production, collection and transportation of biomass to the biorefinery.

Ongoing work on other technologies, like research into biorefineries, thermochemical conversion technologies, and other biofuels will create many new products beyond the biopower, ethanol and biodiesel we are producing today. Linking biofuels research to engine design and performance will help ensure the most environmentally sound sustainable solution to our transportation needs.

As director of the nation's research center for bioenergy, I want to stress that a sustained, high-level of investment for research in bioenergy will provide our nation with many benefits, today and well into the future. Biofuels made from agriculture, forestry, and other resources are an environmentally and economically beneficial way to bridge the gap between rising energy demand and peaking oil production, while reducing U.S. dependence on imported oil.