Written Statement of
Dr. Thomas D. Foust
Biomass Technology Manager
National Renewable Energy Laboratory
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Food, Feed, and Fuel Production: Today and Tomorrow
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Mr. Chairman, thank you for this opportunity to discuss important issues related to the nation's energy policies as America moves aggressively to reduce our dependence on foreign oil, improve environmental sustainability and fully meet the energy demands of the future. I am honored to be here and to speak with you today. We applaud the Committee for its examination of the complex issues surrounding current and future food, feed and fuel production issues.

I am the Biomass Technology Manager at the National Renewable Energy Laboratory (NREL) 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. Researchers at NREL have been working on biofuels technologies since our laboratory was founded in 1977, with a primary focus on developing advanced, second generation biofuels technologies that do not rely on grain or other food-based feedstocks. Due to the success of these efforts at NREL, and other leading institutions, to significantly reduce the costs of advanced biofuels technology, America stands at the brink of success of greatly reducing our dependence on petroleum, both in the near- and long-term.

Several recent published studies have shown that there is sufficient biomass potential in the U.S., and worldwide, to produce significant amounts of transportation fuels without impacting food production and prices. Nonetheless, recent increases in food prices and especially corn prices have raised concerns about biofuels development. Clearly, biofuels, and specifically advanced biofuels, have great promise. However, they must be produced in a sustainable fashion in order to reap the potential benefits.

Although there is considerable debate on the impact that first generation biofuels are having on food and feed prices, the overwhelming consensus among experts is that advanced biofuels will greatly lessen any effect on food and feed prices. By using non-food resources, advanced biofuels avoid any direct competition with food and feed supplies. The only likely impact that advanced biofuels technology will have on food and feed prices will be land use competition. I will specifically address that issue in this testimony, as well as the sustainability issues associated with large volumes of biofuels production.

Advanced biofuels vary in terms of technical maturity as well as in ultimate volume production potential. I am going to discuss several advanced biofuels technologies, primarily from the point of technology maturity, but also in terms of reasonable estimates for production capacities over the next 10 – 15 years. All advanced biofuels technologies offset our petroleum consumption and at the same time reduce our carbon dioxide emissions. As I talk about advanced biofuels capacities in the following discussion, remember that today in the U.S. we burn approximately 140 billion gallons/year (bgy) of gasoline and 60 bgy of diesel, of which 40 bgy of the latter is used in on-road applications.

Biofuels Potentials

Ethanol

First, let's start with ethanol. Current production of this alcohol fuel from the starches of corn grain is a well established technology, and accounts for almost all of the current 9.4 bgy U.S. capacity. Additional plants in planning or under construction are estimated to increase our capacity to nearly 14 bgy within several years. The limiting factor is, of course, the feedstock itself – corn grain. It is an important food and feed commodity in the U.S., and studies suggest that we cannot produce more than 15 bgy of ethanol from corn grain without significant and unacceptable lasting impacts on the economics of critical food products that depend on corn.

There is currently no other readily available starch- or sugar-based crop in the U.S. from which to ferment ethanol in quantity, hence production potential is limited, unless cellulosic biomass feedstocks can be utilized.

Cellulosic ethanol offers a path over these ethanol capacity hurdles by utilizing cellulosic feedstocks which are abundant and do not directly compete with food and feed needs. Significant technical progress has been made on increasing the economic viability of cellulosic ethanol, chiefly by reducing the costs of production. DOE performs a rigorous state of technology (SOT) assessment every year to estimate production costs for a commercial-scale plant based on emerging technologies being demonstrated at the national laboratories and in the industry. The 2007 SOT results estimate a production cost for both biochemical and thermochemical pathways in the $2.20-$2.50/gallon range. This compares very favorably with gasoline and corn ethanol at current crude oil and corn prices. However, given that cellulosic ethanol technology is still in a pre-commercial state, substantially more can be done to reduce costs. The current DOE and NREL goal is to demonstrate within four years, the technology that when commercialized will produce ethanol at $1.33/gallon (2007$). Achieving this goal will secure the competitive position of cellulosic ethanol with gasoline and corn ethanol over the long term. To drive the initial deployment of cellulosic ethanol, numerous cellulosic commercial-scale plants and near commercial-scale plants (Figure 1), are planned or currently under construction, many with DOE support. These initial plants will rapidly begin the cellulosic ethanol deployment process.

The volume production potential of cellulosic ethanol is very large. By developing both biochemical and thermochemical conversion routes, cellulosic ethanol production can utilize essentially the entire biomass resource base available. The heralded "Billion Ton Study"[1] estimated this potential to be 1.3 billion tons/year by mid century. If this resource base was converted to ethanol, the potential exists to displace over 50% of current gasoline.

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[1]R.D. Perlack et al. Biomass ad Feedstock for a Bioenergy and Bioproducts Industry: the Technical Feasibility of a Billion-Ton Annual Supply, April 2005, DOE/GO-102005-2135

Based on this potential, ethanol's partial compatibility with the existing transportation fuel infrastructure and significant achievements in both R&D and deployment, cellulosic ethanol should remain the cornerstone of near term U.S. biofuels development. With a continued focus on cellulosic ethanol and continued progress on cost-centered research and deployment, our nation can soon realize the benefits of advanced biofuels technology.

Other "non-ethanol" advanced biofuels

As promising as cellulosic ethanol may be for addressing our nation's transportation needs, it does have some limitations. Limitations commonly cited are: a reduced energy content when compared to gasoline, so consumers will experience a mileage penalty in today's vehicles when compared to gasoline; it is not fully compatible with the existing transportation fuel infrastructure; and, ethanol is only suitable as a gasoline replacement, it does nothing to address the need for diesel and jet fuels. Therefore, advanced biofuels development should be expanded into additional technologies and fuel options.

History has shown us that by embarking on and adhering to the broadest research portfolio, we will create the best set of technology options from which industry and the marketplace can choose. This will ensure that U.S. industry maintains its leadership role amid global competition. To accomplish this objective, we must embark on a robust advanced biofuels development effort that builds upon, and does not pull precious resources from, existing cellulosic ethanol efforts. This strategy needs to include these key elements:

Economic Analysis

A robust effort in advanced biofuels development needs to be built on sound and unbiased analysis of the technical performance and real-world cost of biofuels production both at the current state of the technology and the potential that could be achieved with an aggressive R&D effort. DOE is currently sponsoring NREL to work with ConocoPhillips and Iowa State University to perform this assessment.

Advanced Biochemical Conversion beyond Ethanol

Butanol, a member of the alcohol family, can be produced by a fermentation process similar to ethanol, and has certain advantages over ethanol. In particular, its energy content is significantly higher than ethanol (but still not that of gasoline) and it is more compatible with the existing fuel infrastructure, a result of its reduced tendency to absorb water and corrode pipes. However, butanol is more difficult to ferment, and the economics and technology remain well behind that of ethanol. BP and Dupont are actively engaged in a bio-butanol development program in the United Kingdom. Although, in the U.S., butanol is not yet out of the starting gate and will most likely be a minor contributor compared to ethanol in the near future, it does have long-term advantages over ethanol and should be pursued as part of a robust advanced fuel strategy. Since butanol production can potentially use the exact same resource base as ethanol production, its volume production potential is also quite large.

Thermochemical conversion

Thermochemical conversion of biomass to ethanol is a key component of the current cellulosic ethanol effort. Thermochemical conversion technologies also show considerable promise beyond ethanol and need to be equally supported and pursued. If biochemical conversion is the “elegant” method of producing alcohols from certain biomass feedstocks, then thermochemical conversion is the “Swiss army knife” method of attacking a wider range of feedstocks and producing a broader spectrum of fuels. At high temperatures and pressures, this method converts biomass to intermediate liquids or gases, which can then be synthesized into fuels by numerous proven and emerging technologies. Since some of the thermochemical conversion approaches show considerable promise for producing hydrocarbon fuels similar to gasoline and diesel and more infrastructure-compatible fuels, they are a means to lowering the barriers to commercialization. Since thermochemical conversion technologies can essentially capture the entire feedstock resource base, their volume production potential is also quite large.

Aquatic Biofuels

Aquatic species such as microalgae are capable of producing remarkable levels of lipids, sometimes referred to as bio-oils, without impacting the food, fiber, and chemical infrastructures of our nation. Aquatic species do not require arable land or fresh water and could potentially eliminate any food, feed versus fuel competition. Lipids (triglycerides) by their inherent chemical structure lend themselves well to conversion to higher energy density fuels like diesel and jet fuel. Hence, they could fill an important need in a long-term advanced biofuels strategy. Because of the potential high lipid yields of algae, studies[2] suggest that aquatic species have the potential for supplying all of the nations’ fuels needs on a relatively modest amount of land.

However, for all of the significant potential of aquatic species, research challenges such as the growing of the algae to the harvesting of oil need to be overcome to make this promising area of advanced biofuels development technically and economically viable. This area should be pursued as a longer-term option.

Advanced Biofuels Sustainability

Finally, but perhaps most importantly, let me address the issue of sustainability of advanced biofuels. Advanced biofuels have clear environmental benefits when compared to first generation biofuels technologies and conventional petroleum fuels. For example, cellulosic ethanol is expected to improve upon the positive energy balance of today’s corn ethanol by delivering four to six times as much energy as needed for production[3]. Additionally, DOE research has shown

[2] M.E. Huntley and D.G. Redalje, “CO_2 Mitigation and Renewable Oil From Photosynthetic Microbes: A New Appraisal”, Mitigation and Adaption Strategies for Global Change (2006), Springer 2006

[3] M. Wang et al, “Life-cycle energy and greenhouse gas emission impacts of different corn ethanol plant types,” *Environmental Research Letters*, May 2007.

that cellulosic feedstocks can reduce life-cycle greenhouse gas emissions by over 85 percent, compared to gasoline[4].

Although these benefits, in and of themselves, are significant, sustainability needs to be addressed through comprehensive "cradle to grave" research. More understanding is needed about the overall life cycle impacts of biofuels pathways on our environment – our land, water and air. DOE has begun several activities in this area. In FY 08 DOE commissioned NREL in partnership with other leading national laboratories and universities to initiate an effort to collect and analyze data to assess the direct and indirect impacts of biofuels production. This work will be used to develop sustainability assessments of biofuels deployment scenarios such as those specified in the recently enacted Energy Independence of Security Act (EISA) of 2007 which calls for 36 billion gallons of biofuels production by 2022, of which 21 billion gallons have to be advanced biofuels.

One sustainability issue particularly relevant to this hearing is land use competition, both direct and indirect, for biofuels feedstock production and the role this will play in tomorrow's food, feed and fuel marketplace. One recent study[5] specifically looked at the indirect land use issue for biofuels production and concluded that the impacts can be significant. Although the methodology and hence the results reported in this research paper have been broadly rebutted by several segments of the biofuels research community, the paper does raise an important point that competition for direct and indirect land use needs to be considered when the sustainability and food price impacts of advanced biofuels are assessed.

The degree to which a relationship exists between land use change and large-scale biofuels production has begun to be addressed extensively in the research community. The hypothesis is that direct land use changes are caused by feedstock production for biofuels in a given biofuels-producing country, while indirect land use changes occur in other countries through price signals of agricultural commodities because of the increased commodity demand induced by biofuels production.

Argonne National Laboratory and Purdue University, supported by DOE, is addressing some of these issues with Purdue University by expanding Purdue's Global Trade Analysis Project GTAP model (a general equilibrium model), so that reliable results of biofuels-induced land use changes can be generated.

While the recently completed and current on-going efforts on land use changes have been focusing on corn ethanol in the U.S., sugarcane ethanol in Brazil, and biodiesel production from oil seeds in Europe, no efforts have yet been undertaken on second-generation biofuels production. DOE will be addressing this with Purdue's GTAP model in the near future. In general, it is anticipated that land use changes for second-generation biofuels production will be less extensive than those for first-generation biofuels production.

[4] Ibid.

[5] Searchinger, T., et al, "Use of U.S. Croplands for Biofuels Increases Greenhouse Gases Through Emissions from Land-Use Change." Science; Vol. 29, 2008; p.1238-1240.

Summary

Advanced biofuels are a significant step in the right direction to addressing tomorrow's food, feed and fuel potential. The current successful, goal-focused effort on cellulosic ethanol is on target towards achieving our nation's immediate objective, to displace imported oil, reduce greenhouse gases, and minimize food and feed price impacts. However, we need to accelerate and expand our existing advanced biofuels effort to include other conversion options and fuels, beyond ethanol, to truly achieve the benefits that advanced biofuels offer. On this path, we will need to more accurately study and monitor the potential food versus fuel controversy and set proper policies and incentives in that area to minimize conflicts, meet economical food and feed requirements and launch an important industry in a sustainable manner.

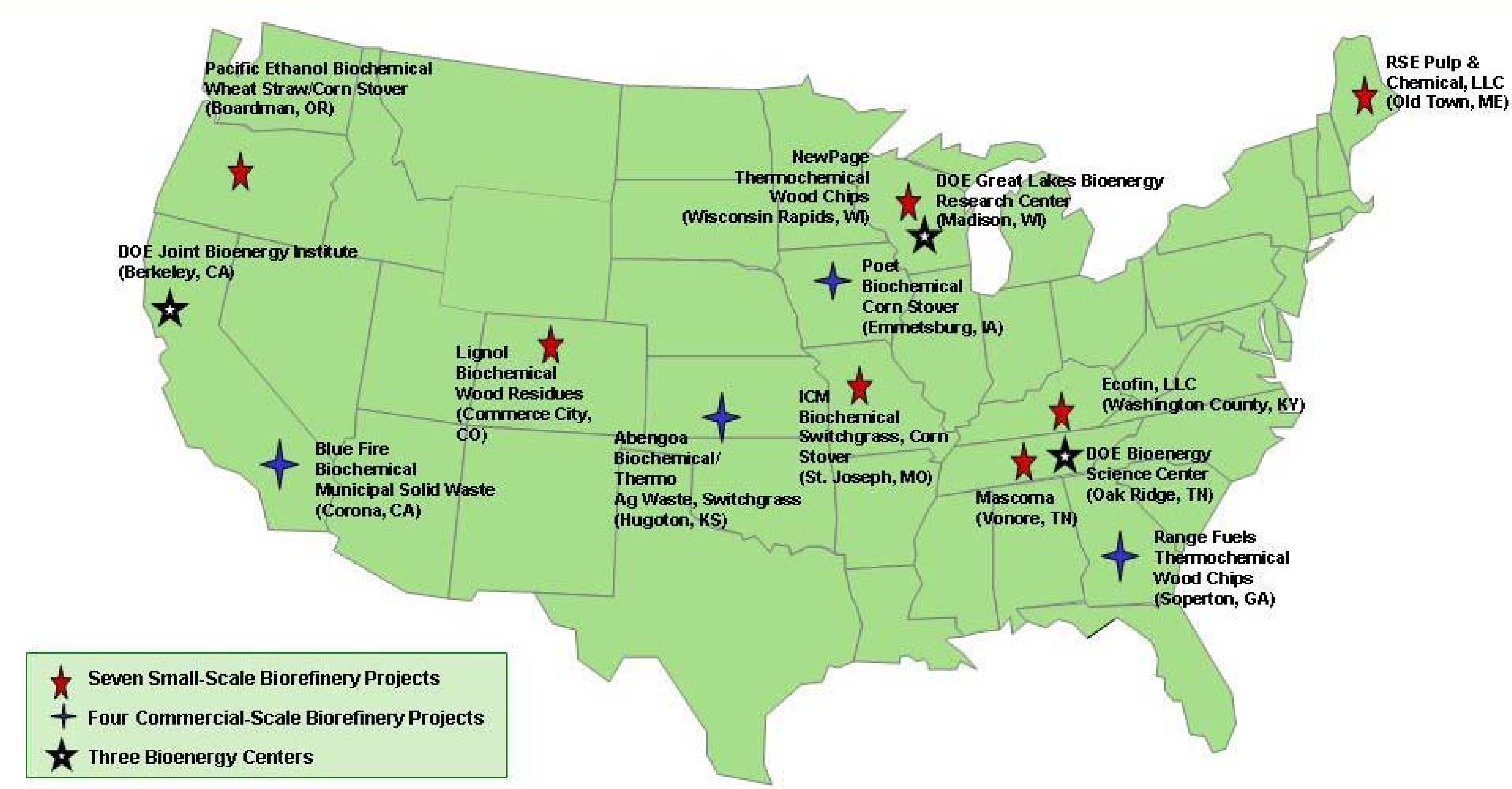

Figure 1: Current cellulosic ethanol deployments in the U.S.