Introduction

Chairman Cochran and members of the committee, thank you for convening this panel, and for the opportunity to share some of the exciting possibilities for expanding biomass energy production in the coming years.

With the encouragement of this committee=s hard work over many years, and particularly the Biomass Research and Development Act of 2000, and the landmark Energy Title of the Farm Security and Reinvestment Act of 2002 (FSRIA), the promise of biomass energy is beginning to be realized. Evidence of these first steps toward a bio-based economy includes rapidly increasing numbers of ethanol and biodiesel plants converting corn and soybeans to transportation fuels, anaerobic digesters producing electricity from manure, and the development of a host of innovative technologies to produce biomass energy and complementary products from lignocellulosic feedstocks. This evidence underscores the fact that biomass energy is a real alternative, and that agriculture can play a significant role in America=s energy future.

Although these current activities are important, they are not enough to achieve the full potential that exists. Efficient and competitive biomass energy requires new agricultural production strategies, to provide cost-effective biomass feedstock while protecting and enhancing the natural resource base. Conversion technologies must be developed that can transform these feedstocks into diverse product streams, and these technologies must be scaled so they can be implemented on farms and in local communities. And these feedstock production and conversion technologies need to be integrated in value-chains that reward all participants, from farmer to processor to consumer, across the United States.

Biobased production has the potential to provide secure domestic energy, invigorate agricultural enterprises, and catalyze robust rural development. But it will take strong partnerships and serious investments by industry, government, and academia to achieve that vision. Today I would like to discuss some of these emerging partnerships, and identify some of the areas where greater investments in fundamental knowledge and technical innovation are critical to making these opportunities real.

Strategic Partnerships

The opportunities to convert agricultural crops and residues into biobased products and bioenergy present entirely new value-added pathways for agriculture and industry. Coordinated business, government, and university partnerships can greatly accelerate the emergence of these new pathways and facilitate their success. Many of the opportunities for Iowa have been detailed in the October 2002 report titled ABiobased Products and Bioenergy Vision and Roadmap for Iowa. This report is the result of the Iowa Industries of the Future project, involving over 500 Iowa stakeholders in discussing the opportunities and challenges for a bio-based economy in Iowa. This report outlines potential markets for Iowa=s biomass resources and sets realistic goals for progress. The report also outlines the science and technology focus areas that need to be addressed to assure advancement of the bioeconomy and Iowa=s position within it.

The BIOWATM Development Association, an association composed of representatives from production agriculture, industry, environmental interests and academia, has been formed to support and promote the growth and development of Iowa=s bioeconomy. BIOWA is working closely with the Iowa Department of Economic Development to structure Iowa=s economic development portfolio so that it focuses on the opportunities and challenges provided by biobased businesses.

While state-level initiatives can leverage local enterprise and resources, the federal government can also play a catalytic role. By establishing standards and stimulating market demand, the federal Biobased Product Preferred Procurement Program will help biobased businesses achieve the economies of scale needed to compete. This program, initiated by Section 9002 of FSRIA and managed by the USDA Office of Energy Policy and New Uses, is modeled after a similar program the EPA developed to encourage procurement of recycled materials. By defining a suite of designated biobased products, this program will provide not just improved access to federal procurement processes, but also a benchmark for state and local procurement policies, as well as encourage private sector demand.

While near-term biobased agricultural and economic development opportunities are being nurtured by business and government, research investments will drive the next generation of innovation needed for the bioeconomy to flourish. The joint USDA-DOE Biomass Research and Development Initiative, which previous panelists Mark Rey and David Garman co-chair, illustrates the groundswell of interest in this area. I know many members of this committee are working hard to secure funds for the Sun Grant Initiative, which will provide another major boost to university research. These research efforts need to span both basic and applied sciences, and also be widespread and diverse. One of the distinguishing features of successful biomass energy strategies is a close coupling with local agricultural production systems, which vary greatly across this nation.

Iowa State University provides an example of active university engagement with these challenges. In 2002 our University President, Gregory Geoffroy, approved a Bioeconomy Initiative to provide a central focus for biomass research and education on campus. An interdisciplinary graduate program has been established in Biorenewable Resources and Technology, including advanced training in the plant science, production, processing, and utilization areas identified as critical barriers to biobased production by the U.S. Dept. of Energy.

Coordinated teams of faculty and students are focused on six research platforms: biobased products from vegetable lipids, expression and purification of recombinant proteins, metabolic engineering of new fermentation products, natural fiber utilization, syngas fermentation, and lignocellulosic feedstock development. This research is supported by a range of university, industry, state and federal funds, including competitive grants from the USDA, DOE, and NSF. Platform teams have strong linkages with industry, including such companies as Cargill, Genencor, West Central Cooperative, John Deere, and Alliant Energy. The BIOWA effort already mentioned provides a mechanism for these partnerships to flourish and develop critical mass. Similar combinations of university research expertise, industry innovation, and governmental support are proving powerful and effective engines for bioenergy development throughout the U.S.

Near-term Opportunities

Even with effective partnerships and significant investments, the development of a biobased economy will not happen overnight. Extensive analysis of a range of feedstocks has identified several opportunities for near-term progress. Two of the feedstocks of particular interest are livestock manure and crop residues. These materials are attractive because they are byproducts of existing agricultural production systems, are potentially available in very large quantities, and, in the case of manure, can benefit from certain types of bioenergy use. Other organic residues and byproducts, including wood and paper wastes, agroprocessing wastes, and biotechnology byproducts, also represent immediate opportunities to pursue.

Manure

Although often viewed as a problematic waste, livestock manure also represents a considerable resource. Much of the energy and nutrients fed to the animals is not absorbed, and passes out with the manure. This residual value has long been recognized by farmers, particularly in the use of manure for crop production and soil tilth. Unfortunately, these nutrients may also contaminate surface or groundwater, while some of the energy is lost as methane. Methane is a potent greenhouse gas if lost into the atmosphere, but is also the principal component of natural gas, with obvious renewable energy ramifications.

Although anaerobic digestion has been used to capture and use manure generated methane for decades, the number of operating facilities on farms has until recently remained quite low. Most of the farm-scale anaerobic digestion plants that were installed during the 1970=s and 1980=s failed, due to a combination of technical, managerial, and economic weaknesses. However, advances in anaerobic digestion technology, and increased environmental awareness to reduce greenhouse gas emissions, have improved the outlook for the installation of farm-scale systems.

Processing manure through an anaerobic digester extracts much of the available energy, while preserving the nutrients for subsequent crop utilization. Side benefits of digestion include increased availability of nitrogen for crop utilization, and significant reductions in odor released.

Despite these benefits, anaerobic digestion is not for every livestock operation. Manure must be easily collected, and of intermediate consistency so that it will readily flow. Excess moisture increases processing costs, both by increasing the size of digester vessels, and by increasing heating requirements during winter operation. But the primary limitation to anaerobic digestion today is economic. Unless farms have significant on-farm demand for heat and electricity, excess power production will be sold to the grid. And while some utilities have implemented green power procurement programs that pay a premium for renewable energy, many in rural areas have not. The outlook for dairies is most promising, as many have compatible manure handling systems and significant on-farm demand for heat and power. In regions where green power premiums are available, anaerobic digestion can break even for farms of only a few hundred cows . For swine operations, with limited on-farm energy demand, favorable conditions are rare.

For beef and poultry operations with drier manure, there has been increasing interest in combustion, gasification and other thermochemical conversion processes. These technologies are also being applied to plant biomass, and can play a very promising role. Depending on the configuration, thermochemical systems can convert biomass energy to many useful forms, including heat, power and even hydrogen fuel, while retaining P, K, and mineral elements in the ash. But nitrogen, the most valuable nutrient in manure, is typically not conserved, and instead is lost as NOx and other gaseous emissions. In agricultural systems we presume this lost manure nitrogen is compensated for by increased nitrogen fertilizer demand, which requires significant amounts of energy to produce. Nitrogen fertilizer production requires one of the major energy inputs to agriculture, accounting for about one third the energy required to produce our crops. If we consider N losses from manure in the context of the entire crop production B livestock B manure B energy cycle, the net energy benefits of manure combustion will be considerably reduced. This example points up the need for comprehensive life cycle analysis of biomass production, processing, and utilization, to insure that the complete systems achieve the intended goals.

Corn Stover

Crop residues are an agricultural byproduct with even greater energy potential than manure. Among the many straws and crop residues produced at present, corn stover is widely recognized as the most promising high volume, low cost lignocellulosic feedstock on which to base a range of biobased energy, chemical, and material industries for the next several decades4, 5, 10. With a sustainable harvest estimated at 100 million dry metric tons per year4, this resource contains over 1.7 x 109 GJ of energy annually. Because stover is a crop residue, the incremental energy, nutrient and cost inputs for collection are relatively small, offering corn producers the potential for a valuable new co-product from existing acreage. Since corn is widely grown across the United States, biorefineries based on corn stover can provide an important new economic engine for rural development in many regions of the country.

However, several significant challenges must be addressed before this vision can be achieved. First, stover biomass must be supplied at a price that is competitive with petroleum, profitable for producers, and favorable for the growth of the rural agroindustrial economy. To achieve these economic objectives new technologies must be developed and optimized for stover harvest and storage. As stover becomes a significant feedstock commodity, the genetic potential of corn must be exploited to increase both stover yield and biomass conversion rates. And as these new technologies and varieties are developed and optimized, they must be implemented in ways that are sustainable with respect to soil, the environment, and rural communities.

Current stover harvest systems rely on multiple passes across each field (for grain harvest, stover windrowing, baling, and bale collection) followed by dry storage of stover bales. This system has been used for decades for livestock bedding and hay production, but for the biomass industry is problematic with respect to soil contamination, space requirements, and transportation costs, not to mention occasional catastrophic losses due to fire. Overall biomass harvest and delivery costs of this multi-pass, dry storage system have been estimated at $43 to $60/dry ton, including a $10 to $11/dry ton return to the farmers that are involved. The price target for corn stover biomass is $30/dry ton, as estimated in the DOE=s Roadmap for Agricultural Biomass Feedstock Supply in the United States . This target is considered competitive with petrochemical feedstocks for many commodity chemicals and transportation fuels, and is thus essential for widespread biobased industrial development in rural America.

An alternative system, coupling single-pass, simultaneous harvest of grain and stover with ensiled stover storage, has recently been shown to reduce centralized delivery costs by 26%

relative to the multi-pass, dry storage approach . These savings are possible with first generation prototype equipment, and further breakthroughs are expected as equipment manufacturers invest and optimize next-generation designs. Single-pass harvest has been estimated to reduce harvest energy requirements by 33%, while reducing harvest related soil compaction and erosion by 50%5. Coupling these harvest strategies with ensiled storage can provide a safe, scalable, and cost-effective year round stover supply. Ensiled storage can also function as low-cost pretreatment for cellulose and hemicellulose hydrolysis , increasing biomass value at the farm or co-op storage site. Additional economic gains can be achieved using selected corn varieties with improved genetics for specific stover feedstock applications. With targeted research and demonstration of these new strategies, as well as effective implementation, corn stover biomass appears poised to become the high volume, price-competitive biorefinery feedstock many had hoped.

Integrating the entire feedstock supply system and taking advantage of the complementarities and interoperability between the unit processes can maximize overall system performance. Due to trade-offs among feedstock supply processes, it is important to consider the full feedstock supply system so that opportunities for economic and environmental improvements can be identified and exploited. As with manure, iterative life-cycle assessment and economic analysis of the resulting integrated corn stover feedstock systems will ensure that the strategies developed are both economically rewarding and environmentally sustainable.

Achieving Long Term Sustainability

While manure, corn stover, and other agricultural residues represent immediate opportunities for biomass energy, long term growth of the bioeconomy will require additional feedstocks as well. A number of strategies have been proposed to increase biomass production in both productive and marginal lands, including cover crops, switchgrass and other native warm season grasses, and grass-legume mixes. With new conversion technologies for lignocellulosic biomass, one can even imagine plantings mimicking native prairie being harvested for biomass use. Such dedicated biomass crops offer intriguing opportunities to both increase agricultural productivity while addressing critical sustainability concerns.

Increased use of perennials and cover crops in agricultural systems has a number of environmental advantages. By increasing vegetative cover and root biomass, soil erosion is reduced and soil quality enhanced. Even with removal of most of the surface vegetation for biomass feedstock, the root biomass sequesters carbon to address global warming concerns. Extending the growing season through the use of perennial species also allows plant uptake of nutrients during spring and fall rain events when nutrients would otherwise leach or erode, providing one of the most effective strategies for alleviating water quality concerns.

The Conservation Title of FSRIA 2002 provides a mechanism for encouraging greater use of cover crops and perennial species to conserve our working lands. While this mechanism exists on paper, implementation of the Conservation Security Program has not proceeded as quickly as hoped. The potential synergies with biomass feedstock production provide additional motivation for making sure that this conservation program gets stronger support.

Decentralized Value Chains

Much has been made of the need for biobased production to mimic some of the efficiencies of the well established petrochemical industry in order to compete. The biorefinery concept is certainly part of this, with multiple processes and products taking advantage of every feedstock component and byproduct stream. But biomass production, especially from agriculture, must recognize some unique attributes which argue for a somewhat different strategy than the centralized and concentrated petrochemical approach.

One of the distinct characteristics of biomass as an industrial feedstock is its low energy density relative to fossil fuels, and this is especially true of non-woody plants. As a result, transportation costs to large centralized conversion facilities generate significant diseconomies of scale. Optimum sizing of bio-based facilities thus requires a decentralized infrastructure, with many loci of bioindustrial development.

While a decentralized mode of development has obvious advantages for rural development, it faces particular challenges as well. One of these is the need to generate and tap different types of investment capital than is normally the case. Many of the initial business successes have found new markets for products with unique value and high enough margins to justify capital investment. But as we move toward high volume, relatively low value commodities like energy and transportation fuels, the requirements for capital will increase. Venture capital is scarce in rural communities, and debt markets view unproven business enterprises with understandable concern. As a result, state and federal programs need to help generate the considerable investment capital needed to nurture and grow the bioeconomy and its infrastructure.

Perhaps one of the most critical issues that needs to be addressed as we ramp up the development of biobased businesses is the business models for the supply chains. It is critical that the business models be sustainable (economically, socially, and environmentally) over the long term. The economic criteria of sustainability require that the every link of the supply chain (including the producer link) receive enough return to pay their fixed and variable costs and some reasonable profit.

The current paradigm for agricultural-based supply chains is for contract production. These contract arrangements typically do not meet the definition of sustainability. In general, the contracts are designed to cover the producer=s fixed costs (i.e. , the mortgage payment to the lender), and some part of the variable costs, but provides no level of profit. For producers, this type of Avalue chain@ results in the producer using the equity built in other parts of the business, sometimes over generations, to sustain the viability of the value chain. In essence, the value chain is mining the equity of the producer.

We need to find ways to recognize and reward the farmers that are the foundation of bioeconomy value-chains. One proposed solution is for producers to use their equity to vertically integrate up the value chain, as has been done with many of the ethanol plants in the Midwest. However, given the size of the capital investments that will be required for establishing integrated biorefineries, and because of intellectual property protections, it is likely that the Aethanol@ model will be rare. So, new types of business relationships need to be evaluated so that the new systems do develop to meet the definition of sustainability.

Some biobased enterprises are finding creative solutions for including farmers in a central role. Partnerships between utilities and farmers are addressing capital and management barriers to expand distributed energy generation from anaerobic digestion. In Oregon, a cluster of dairies now supplies manure to a centralized digester, gaining economies of scale that many individual farmers could not achieve. In Iowa, an industrial lubricants company engages farmers in the initial processing steps, reducing the biomass transportation requirements and shifting processing income to the farm. This partnership is off to an excellent start, already capturing 20% of product market share.

The United States is not alone in considering ways to encourage and reward farmer-based value chains. The European Community is moving ahead aggressively in this area. Denmark alone has over 10,000 straw-fired boilers producing energy on farms, and almost 60 straw-fired district heating plants. These systems are producing local energy from local biomass, and reinvesting in their own communities for local economic development.

A decentralized biobased industry can take advantage of these innovative strategies, and others yet to unfold. But the effort to organize and reward farmer involvement in these value chains is not a trivial task. Management support, technology assistance, and access to capital are all necessary to ensure that the farmer foundation of biomass value chains is durable and strong.

Closing Remarks

I hope these remarks have provided both some insights into present opportunities, as well as the future potential that biomass energy and agriculture share. With strategic partnerships fostering both innovation and implementation, increasingly competitive conversion technologies, and efficient, sustainable feedstock strategies, the emerging bioeconomy has tremendous potential. Nonetheless, there are still many challenges to overcome, and the federal government and this committee will need to play a key role in making that vision real.

As integrated biobased production systems develop, with value chains from farm to biorefinery to consumer, it will be crucial to ensure we achieve both productivity and sustainability. The Energy Title of FSRIA provides several important mechanisms to help us on that path. Synergies with the Conservation Title of FSRIA are particularly important, with the potential to simultaneously address biomass feedstock, carbon sequestration, and water quality concerns. Full funding of the Biomass Research and Development Act of 2000 will help accelerate the trajectory of discovery and innovation that still needs to occur. These and other complementary federal policies can provide the necessary framework for what may be the most important industrial transformation of the century.

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Footnotes have links which will EXIT the Senate website:

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