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Mr. Chairman and Members of the Subcommittee, I appreciate the opportunity to testify on the state of current knowledge and knowledge gaps affecting implementation of life cycle assessment (LCA) protocols to estimate greenhouse gas emissions (GHG) by different types of biofuels as required by the Energy Independence and Security Act of 2007 (EISA). I believe that development of these protocols will have a large impact on the economic viability of both the biofuel industry and the broader farm economy.

I am Dr. Kenneth G. Cassman, Director of the Nebraska Center for Energy Sciences Research, a position I have held since the Center was created in 2006. Previously I worked as a research agronomist in the Amazon Basin of Brazil, Egypt's Nile Valley and at the International Rice Research Institute in the Philippines. My academic appointments include seven years on the faculty at the University of California—Davis, and 13 years at the University of Nebraska where I served as Head of the Department of Agronomy from 1996-2004. My research, teaching and extension efforts have focused on ensuring local and global food security while conserving natural resources and protecting environmental quality. My current research focuses on the environmental impact of biofuel systems, including development of life-cycle assessment tools for estimating the GHG emissions of corn grain-ethanol, and cellulosic ethanol produced from corn stover or switchgrass.

I come from a state where the long-term viability of the biofuel industry is a major driver of economic development, especially in rural Nebraska. In fact it is now one of the largest industries in the state, and Nebraska ranks second nationally in ethanol production. Nebraska also has an emerging biodiesel industry, and the Abengoa company is developing a pilot plant for cellulosic ethanol production in York, NE—a project partially supported by the Department of Energy. Like many regions of the country, Nebraska's entrepreneurs are looking at advanced cellulosic biofuels and considering their potential.

My testimony will focus on three topics:

1) The importance of using the best science and most recent data for establishing the methods and standards for GHG emissions reductions of *corn-grain ethanol* systems compared to gasoline in complying with the 2007 EISA, and how the lack of scientific consensus about this issue can be addressed;

2) The need to achieve a scientific consensus on the environmental impact and GHG emissions of *second-generation biofuels*, such as cellulosic biofuels, before they are widely commercialized; and
3) The science required to ensure that such a consensus is achieved for developing the life cycle assessment methods and standards for second generation biofuels.

As you are well aware, EISA requires that:

- EPA establish methods and standards for assessing lifecycle GHG emissions for different types of biofuels with the comparable petroleum-based fuel as the basis for comparison;
- Starch-ethanol plants, such as those that use corn grain, that came into production after 2007 must reduce GHG emissions by 20% (existing plants are exempted);
- Cellulosic biofuels must reduce GHG emissions by 60%; and
- Advanced biofuels must reduce GHG emissions by 50%.

Regulations for GHG emissions reductions are also part of the California *Low Carbon Fuel Standards* (LCFS), which will play an important role in determining the value of different biofuels in marketplace. Unlike the 2007 EISA, there are no exemptions for existing biofuel plants under the California LCFS. In addition to California, a number of others states are developing or considering the development of LCFS. Because it is important that EPA biofuel emissions assessment protocols be consistent with state-level LCFS, EPA has an opportunity to play a leadership role to ensure that the best science and most recent data are incorporated into these standards.

There may also be opportunities for the biofuel industry to monetize GHG emissions reductions if they can be properly documented and certified for emissions trading markets both in the U.S. and globally. For example, several Climate Change bills under development include cap-and-trade provisions for GHG emissions. Developing scientifically robust, accurate, and user-friendly LCA assessment tools provide the foundation for inclusion of biofuels in a cap-and-trade emissions market.

As we embark on the effort to develop LCA methods for estimating GHG emissions from different biofuels, it is imperative that the regulatory process "*get corn ethanol right*" for three reasons. First, corn grain-ethanol (hereafter called corn ethanol) is the only biofuel that will be directly affected by the EPA guidelines as soon as they are developed because it is the only biofuel that is available and used on a large scale. Present annual corn ethanol production capacity is approaching 9 billion gallons per year (bgy), and it will likely reach more than 12 bgy by end of 2009. In contrast, the 2007 EISA does not mandate use of more than 1 bgy of cellulosic ethanol until after 2013. Hence, EPA's guidelines for GHG emissions from cellulosic biofuels may be developed and refined over the next four years before cellulosic ethanol is commercialized on a large scale. Second, EPA's efforts to determine the degree to which corn ethanol reduces GHG emissions compared to gasoline may have a large influence on the development and implementation of state-level LCFS. In fact, if corn-ethanol is determined by EPA and/or state regulators to emit more GHG than gasoline, then corn-ethanol would fetch a lower price in LCFS markets as blenders must buy higher-priced low carbon-intensity fuels to

offset the use of corn-ethanol. If this occurs, it would likely have a devastating impact on the US corn ethanol industry and the farm economy. Third, the values set by EPA for GHG emissions of corn ethanol compared to gasoline will influence public opinion regarding the whether corn ethanol, and perhaps renewable fuels in general, are a positive or negative factor in addressing climate change concerns. It is not enough to say "we have a process to adjust the number later," although EPA is required to do that as well. History tells us that public opinion will latch onto the first standard issued, and if the number is inaccurate, the public may lose trust in the LCA process itself and withdraw their support for further development of renewable biofuels because of concerns about environmental impact.

Given this situation, we must learn from our experience with corn ethanol, where large-scale commercial production is well ahead of the science and knowledge required to develop accurate regulations regarding impact on GHG emissions. Instead, we must develop the scientific methods and forge a scientific consensus BEFORE producers start growing "second generation" biofuel crops on a large scale. Indeed, it may be difficult to entice producers to grow a second generation biofuel crop feedstock such as switchgrass if there is a risk that life-cycle GHG emission reduction levels will be changed at a later date such that they fall below the required 2007 EISA thresholds. What investor will invest many millions of dollars in a cellulosic refinery without knowing this information with a high degree of certainty?

I believe our experience at the University of Nebraska – Lincoln to develop user-friendly life-cycle assessment software for estimating GHG emissions of corn-ethanol systems is instructive in this regard. Our goal was to bring together an interdisciplinary group of scientists to use the best available science and most recent data to ensure that the model accurately estimated the performance of corn-ethanol systems as they currently function. Our model is called the Biofuel Energy Systems Simulator (*BESS Model*), and it estimates the life-cycle net energy yield and GHG emissions of corn ethanol. It has the capability to simulate ethanol facilities at a state or regional levels, and also for an individual biorefinery, including: crop production, the ethanol biorefinery, and the cattle feedlot for feeding co-product distiller's grains. Systems that include an anaerobic digestion unit as part of a closed-loop corn-ethanol biorefinery can also be simulated. The BESS model is available to the public for download at www.bess.unl.edu.

The BESS model performs three types of life-cycle analysis:

- Energy analysis—life-cycle net energy yield & efficiency;
- GHG emissions analysis—net carbon dioxide (CO2) and trace greenhouse gases (CH4, N2O), and global warming potential (GWP); and
- Resource Requirements—crop production area and total amounts of grain, water, fossil fuels (petroleum, natural gas, and coal) used in the production life-cycle.

It is my understanding that EPA has been relying on a different model called the Greenhouse gases, Regulated Emissions and Energy use in Transportation (GREET) model from the U.S. Department of Energy's (DOE) Argonne National Laboratory. Unlike the BESS model which can only simulate corn ethanol systems, the GREET model has the capacity to evaluate and compare the environmental impacts of a wide range of renewable and conventional transportation fuels and motor vehicle fleets. While having the capacity to evaluate a wide range of different biofuels, as well as petroleum-based fuels, is critical to the EPA effort to meet the

2007 EISA requirements for establishing GHG emissions protocols, we believe the GREET estimates for corn-ethanol do not reflect the current status of the corn-ethanol industry.

In fact, there are large differences in estimates of GHG emissions from direct effects of corn-ethanol production obtained from the BESS and the GREET models. While the BESS model estimates an emissions reduction of 54% reduction compared to gasoline, the GREET model estimates a 24% reduction, and this lower value is currently being proposed as the standard for implementing the California LCFS. It is our understanding that EPA is also basing their estimates of direct-effect GHG emissions for corn ethanol on the GREET model. Because an additional amount of GHG emissions is likely to be added due to land-use change, the GREET estimate will therefore result in failure of corn ethanol to meet the statutory 20% GHG emissions reduction standard of the 2007 EISA. The primary reasons for the greater GHG emissions reduction estimated by the BESS model is because it uses more recent data for crop production, biorefinery energy efficiency, and co-product use that the GREET model. As such we believe the corn-ethanol values in BESS are more appropriate for developing the 2007 EISA GHG standards. Moreover, unlike other LCA models including GREET, the BESS model was developed by an interdisciplinary team of scientists with expertise in agronomy, soil science, ecosystem modeling, engineering, and animal science, and the development effort included input from biofuel industry professionals. We believe that an interdisciplinary effort is critical for developing LCA protocols of biofuel systems.

The "cautionary tale" to be learned from our experience with corn ethanol is that before second generation biofuels can become commercially viable, we need anticipatory research to accurately document GHG emissions and environmental impact. We at the University of Nebraska – Lincoln have a vision of how to make that happen, and it would involve a wide regional collaboration.

For each biofuel crop, research must be conducted at a production scale to determine the impact of feedstock crop production system on greenhouse gas emissions, soil carbon sequestration, and on soil and water quality and wildlife. For example, besides unused woody biomass and sawdust from forestry systems, switchgrass is the next most likely commercially viable cellulosic biofuel crop. Therefore, we must identify the key knowledge gaps about the environmental impact of switchgrass systems and invest in research to close them.

The University of Nebraska is developing research to support development of carbon intensity standards and certification protocols for switchgrass. While the environmental benefits of cellulosic ethanol production are estimated to be larger than for grain-ethanol, these benefits have not been validated in large production-scale field conditions that are representative of commercial production. Instead, to date most estimates have been produced by models and assumptions based on data from relatively small-scale research over relatively short periods. In fact, our initial investigations to date suggest that the direct-effect GHG emissions reduction potential of switchgrass is about the same as for corn ethanol unless switchgrass has a larger potential to sequester carbon in soil. Validation of benefits under production-scale conditions will help guide development of appropriate policies and markets and reduce risks to producers by helping to ensure that GHG emissions reduction estimates are based on the best available science.

Therefore, for each promising biofuel, such anticipatory research would require the following elements:

- Production-scale research on environmental impact of feedstock crop production systems, including GHG emissions, soil carbon sequestration or loss, and impacts on water and soil quality, other environmental services;
- Collaboration with industry to obtain the most recent estimates of biorefinery energy efficiency and GHG emissions from feedstock conversion to biofuel at a commercial scale;
- For indirect effects, more detailed understanding of complex interactions that govern land use change is required through development of appropriate econometric models, with strong collaborative input from biophysical scientists.
- Development of software tools that can be used to perform LCA-GHG emissions assessments, and these tools must be widely accessible, transparent, user-friendly, and based on best available science published in refereed scientific journals

In summary, I realize that EPA is on a relatively short timetable to publish the proposed rule for comment this fall and the final rule in the spring 2009 as stipulated in the 2007 EISA. But it is imperative that EPA use the best science and most recent information in developing the LCA methods and standards for establishing GHG emissions from corn-ethanol because not doing so could have significant negative impact on the biofuel industry and the farm economy in general. In contrast, the guidelines for second generation biofuels will not have immediate impact because these biofuels have not yet been commercialized on a large scale, which gives time to refine and improve the guidelines as commercialization proceeds.

Finally, Mr. Chairman and Members of the Subcommittee, I want to commend you and your colleagues on the full House Agriculture Committee for recognizing the importance of developing the scientific tools required to support accurate life cycle analysis by including it as a priority within the Biomass Research and Development Initiative of the new Farm Bill. This competitive grant program, jointly run by USDA and Department of Energy, includes a challenging set of nine objectives, including one on Energy and Environmental Impact, which specifically identifies "improvement and development of tools for life cycle analysis of current and potential biofuels." Mandatory funds were provided for this program in the amounts of $20,000,000 in fiscal year 2009, $28,000,000 in fiscal year 2010, $30,000,000 in fiscal year 2011, and $40,000,000 in fiscal year 2012. It is my hope that additional discretionary funds are appropriated as well to ensure adequate funding research on environmental impacts of biofuel systems and development of accurate life-cycle assessment tools so that regulation does not once again precede scientific understanding with potentially negative consequences for on viability of the biofuel industry.

Mr. Chairman and Members of the Subcommittee, I hope I've been able to provide some helpful information about the urgent need for the best available science and accurate data for determining the life cycle environmental impact for the next generation biofuels, and about how to help ensure that this is accomplished. As a step in the right direction, it is imperative we get the numbers "right" for both corn ethanol and the second generation biofuels to come before significant investments are made by industry or producers. I am happy to answer any questions.