2008 Northeast Sun Grant Competitive Grant Awards

The Northeast Sun Grant Region has completed reviewing the 62 proposals that were submitted for the Year 2 funding under the contract entitled, "Biobased Transportation Research Program." Each proposal was reviewed by a primary and a secondary reviewer, and when required, Ad Hoc reviews were sought from qualified scientists. The Technical Review Panel was convened in Washington, DC April 9-11, 2008, to review and rank the proposals. Proposals were discussed and evaluated in order of submission and were initially placed in 3 categories, 'Fund', 'Revisit' or 'Do Not Fund'. At the completion of the initial review, the review panel was given the opportunity to re-evaluate all proposals in the 'Revisit' and 'Do Not Fund' categories to see if any re-evaluation was necessary. Approximately forty (40) proposals were placed in the 'Do Not Fund' category. Of these applications the majority did not meet the requirements of the competition, were poorly written, had little foreseeable impact or were judged of poor scientific merit. Many did, however, have one or more objectives that had merit. Recommendations where appropriate will be communicated to the PI's for the improvement of their grant applications for future competitions. The remaining fundable proposals were re-evaluated and ranked for scientific merit, appropriateness, and potential impact. Eleven (11) proposals were recommended for funding and all were SEED proposals. No LEAD proposals were recommended for funding this year. The Northeast Sun Grant Steering Committee and DOT approved the selections of the Technical Review Panel. The following is a list of the projects selected for funding:

Contrasting Soil Carbon Sequestration by Soybean and Canola PI: Roger Koide, Penn State University $99,950

Breeding Switchgrass with Improved Biomass Productivity on Marginal Land for the Northeastern U.S.. PI: Dr. Stacy Bonos, Rutgers University $79,261

Camelina: A new Oilseed Crop for Permanent No-Till Systems in the Northeast PI: Mr. David Dowler, Pennsylvania State Extension, Meadville, PA $99,998

Exploiting Diversity in Cellulosic Sorghums for Northern Latitudes. PI: Stephen Kresovich, Cornell University $100,000

Prospecting for High Temperature Biocatalysts Using a Novel Strategy PI: Dr. Patrick Schloss, University of Massachusetts - Amherst. $90,553

Developing a Biological Process to Treat Feedstock for Cellulosic Ethanol Biorefining PI: Dr. Wei Liao, Michigan State University $99,971

A Biofuel Screening Program for Grass Feedstocks: Diversity, Physiological Traits and Compositional Characteristics for Optimal Yield. PI: Dr. Gary Bergstrom , Cornell University.$100,000

Development of Biocatalyst for Biobutanol Production and Recovery by Gas Stripping. PI: Dr. Thaddeus Exeji, The Ohio State University $99,997

Marketing New England biofuels to Ensure Energy Security. PI: Dr. Mario Teisl, University of Maine $100,000

Determining Costs, Product Recovery Factors, and Environmental Impacts for Biomass Harvest Treatments in Northeastern Forests. PI: Dr. Marc McDill, Pennsylvania State University $99,825

Determination of the Underlying Cause of the Biodiesel NOx Effect in Common Rail Diesel PI: Dr. Andre Boehman, Pennsylvania State University $80,000

Feedstock Development:

NE08-001 (Seed Proposal - $99,950) – Contrasting Soil Carbon Sequestration by Soybean and Canola PI: Roger Koide, Penn State University Life cycle analyses have shown that using biodiesel in place of petroleum diesel reduces net CO2 emissions by approximately 78%. This is because CO2 from the combustion of biodiesel from plant sources (vegetable oil) is recycled back into vegetation by photosynthesis, and because 3.2 times less fossil fuel is used in the production of biodiesel than in the production of petroleum diesel of equivalent energy content (Sheehan et al. 1998). Therefore, replacing even a small fraction of petroleum diesel with biodiesel can have a significant effect on net CO2 emissions. However, it is very probable that the choice of crops to produce biodiesel feedstock will have large but as yet unknown effects on net CO2 emissions because of large differences in their ability to sequester carbon in the soil. In the U.S. the most important biodiesel feedstock crop is currently soybean. In Canada and Europe the most important crop is canola. Canola has vast potential in many parts of the U.S., including much of the NE Sun Grant region, because of its much greater per acre oil yield compared to soybean. Because soybean forms a symbiotic relationship with mycorrhizal fungi that live at the interface of between the root and the soil, we hypothesize that it will sequester significantly more soil carbon than canola, which is not mycorrhizal. Therefore, we hypothesize that soybean will result in significantly lower net CO2 emissions than canola when used to produce biodiesel. The overall objective of this research, therefore, is to compare canola and soybean as biodiesel feedstocks in terms of net CO2 emission savings with respect to petroleum diesel. No other studies have accounted for soil carbon sequestration in assessing life cycle CO2 emission reductions with biodiesel, and a direct comparison of competing biodiesel feedstock crops has not been made with respect to net carbon emissions. Reducing CO2 emissions will allow growers to both ameliorate the effects of atmospheric CO2 on climate change, and participate in the trading of future carbon credits. It will thereby increase a grower’s willingness to grow biodiesel feedstock crops and thus help to ensure the supply and low cost of biodiesel feedstock. Moreover, increased soil carbon sequestration is an important method for improving soil quality and thus agricultural environmental and economic sustainability (Drinkwater et al. 1998; Knudsen et al. 2006;

NE08-026 (Seed Proposal $79,261) – Breeding Switchgrass with Improved Biomass Productivity on Marginal Land for the Northeastern U.S.. PI: Dr. Stacy Bonos, Rutgers University The national strategy is to produce bioenergy crops on marginal cropland where there will be no competition with food production. Although perennial grasses such as switchgrasses are expected to be used as a biofuel crop on marginal land there has been little to no extensive research to evaluate their performance on marginal land. Initial studies comparing switchgrass yields on marginal land vs. prime farmland found that performance across environments was not consistent and that the top performing entry is not the same on both soil types. These results indicate that breeding for biomass on marginal lands will require evaluation of breeding materials in those environments in order to successfully develop productive cultivars for marginal land use. This knowledge is critical to the Northeast and nationally for the successful development and use of biofuels nationwide to offset foreign oil dependency. Objectives 1) Identify optimum breeding and selection techniques to identify the best performing switchgrass plants on marginal land (with low N) in Northeastern US and identify germplasm with improved performance on marginal land to use in a breeding program. 2) Identify cultivars of switchgrass with high biomass potential on marginal land (with low N) in the Northeastern US. 3) Develop new cultivars with improved biomass production on marginal land in order to optimize land use and provide a profitable biofuel crop for the North Eastern US. 4) Disseminate information to stakeholders in the industry through various outreach methods (e.g., fact sheets, presentations, internet postings, articles in trade magazines, and a workshop.

NE08-033 (Seed Proposal $99,998) – Camelina: A new Oilseed Crop for Permanent No-Till Systems in the Northeast PI: Mr. David Dowler, Pennsylvania State Extension, Meadville, PA Meeting renewable energy production goal for transportation fuels will require many different types of solutions. Different opportunities and solutions will exist for the Northeast than other regions of the U.S. due to unique geography, climate, agriculture infrastructure and proximity to markets. This project takes advantage of local infrastructure and traditional animal agriculture to establish a sustainable, renewable feedstock for biodiesel. Camelina (Camelina sativa) is a widely adaptable oilseed crop native to Eastern Europe, but can also be grown in the U.S. This oilseed contains 30 to 40% oil that is high in Omega-3 fatty acids. It can be grown as an early direct-seeded spring crop and tolerates a wide range of soil types, making it a low input crop adaptable to some of the poorer soils of NW Pennsylvania. Camelina contains 35 to 40% linolenic acid (Omega-3), compared to 8% in canola and 1% or less in soybean and corn oils. Mechanically extruded camelina produces a meal with 40% - 45% protein and high levels of Omega-3. Feeding trials have shown high levels of Omega-3 fatty acids in meat, milk and eggs when the meal is included in animal diets. This creates potential for value added products when the meal is fed to livestock, or companion animals. Camelina has tremendous potential as an alternative crop on the soils in NW PA and surrounding regions.

Yields of 1800 to 2200 pounds per acre appear possible, resulting in oil yields equal to or greater than soybeans. Glucosinolates in camelina have the potential to act as a biofumigant when incorporated in a continuous no-till crop rotation reducing the need for chemical control of weeds and pests. Local infrastructure includes; an idled oil seed crushing facility, Lake Erie Biofuels biodiesel refinery, Ernst Conservation Seeds certified seed growers, local poultry, dairy and pet food industries and production agriculture. We have assembled a team of research and outreach specialists and developed initial partnerships with a local seed company, an oil seed crushing facility, and a large biodiesel processing facility who are interested in the development of a camelina based biofuels feedstock production system that relies not only on the value of the biofuel, but also on the potential of the meal. In summary, camelina is a new experimental crop that: Adds diversity to the current supply of feedstocks for producing biodiesel Is highly productive and takes advantage of local infrastructure Is low input and high oil yield offering significant carbon offsets Can be incorporated into continuous no-till adding crop diversity Has potential to provide economic returns to compete with corn and soybeans The meal has excellent nutritional properties for added value products Integrates local growing, processing, feeding and biodiesel production into high economic value for the local economy If we succeed, camelina will add hometown security to the struggling rural community of Northwest Pennsylvania. This in turn will set a new standard of fuel production sustainability.

NE08-002 (Seed Proposal $100,000) Exploiting Diversity in Cellulosic Sorghums for Northern Latitudes. PI: Stephen Kresovich, Cornell University In northern latitudes of the U.S., a key component of any biomass-to-energy system involves the development and production of high yielding, low input (fertilizer, pesticides, water, etc.), environmentally friendly, dependable feedstocks that can be grown, transported, stored, and processed in an efficient and timely manner. We propose to implement a breeding effort for sorghum [Sorghum bicolor (L.) Moench] specifically fine-tuned for production needs in northern latitude states in the northeastern and midwestern U.S. Our overall goal is simple, to develop parental lines and hybrids of sorghum that lead to the production of at least 10-15 tons per acre of dry matter per crop with minimal inputs of fertilizer, pesticides, and water. Historical records from research in the 1980s indicate this goal can readily be achieved and much unexploited potential exists in the more than 40,000 sorghum accessions held in the U.S. National Plant Germplasm System. A preliminary study of 130 inbred lines grown in Aurora, New York in 2007 suggested that many cellulosic and sweet sorghums can currently produce high tonnage in northern latitudes (Figure 1). The sorghum breeding genepools developed will include both cellulosic and sweet types. The cellulosic types are targeted for production systems that may include other feedstocks like perennial grasses or forestry species while the sweet types may be used for fermentation of sugars to ethanol (enhancing production in areas where sugar beet processing facilities currently exist). While agronomic, harvesting, and post-harvest practices are not specifically referenced in this proposal, these will be addressed by necessity. These practices are extremely important for further research but are likely to be severely altered with genetic improvements in sorghum phenotypes and remain outside the scope of this proposal. Specific objectives and deliverables of the planned research include: Objective 1. Screen and characterize germplasm for yield, photoperiod sensitivity, cold tolerance, and perenniality (ratooning ability). Objective 2. Screen and characterize germplasm pools for composition and quality traits. Objective 3. Based on goals 1 and 2, identify and begin developing useful genepools of cellulosic and sweet sorghums for production in northern latitudes. The proposed effort builds on a current collaboration between Cornell University and Texas A&M University. At present, joint breeding and genetics efforts at the two institutions have been supported through the Department of Energy’s Genomes to Life Program (GTL). That effort focuses on elucidating the underlying genetic basis for primary carbon accumulation in sorghum and breeding varieties and hybrids for production in the southern U.S. In general, though we now are able to better understand and affect the genetics of primary carbon production by sorghum and breed lines for the southern U.S., none of these lines or hybrids has been selected for production in the northern latitudes. Much of the diversity and potential to exploit sorghum in northern latitudes remain untapped. In this proposed research, we use our extensive knowledge of sorghum diversity, genetics, and genomics to tailor elite germplasm for biomass-toenergy systems in northern latitudes.

Conversion Processes

NE08-011 (Seed Proposal $90,553) Prospecting for High Temperature Biocatalysts Using a Novel Strategy PI: Dr. Patrick Schloss, University of Massachusetts - Amherst. Prospecting for high temperature biocatalysts using a novel strategy. Technologies derived from bacteria and their enzymes are candidates to replace petroleum usage in transportation and chemical processing. Surprisingly, the biocatalysts employed in biobased technologies were obtained from screening the less than 0.1% of bacteria that can be cultured. This research trajectory has tacitly made the questionable assumption that this pool of biodiversity the best starting point for optimization. We propose an entirely different research strategy to discover novel biocatalysts – functional metagenomics. Functional metagenomics involves cloning and expressing genes obtained from uncultured organisms in a culturable host. This method has been successfully used to identify novel biocatalysts and, most importantly, provides the ability to access the 99.9% of bacterial biodiversity that cannot be cultured. As one of a handful of research laboratories in the United States that has published on the use functional metagenomics for biotechnology applications, we are uniquely qualified to apply this method. The long-term goal of our laboratory is to understand the ecological processes that affect the structure and function of microbial communities. Consistent with this, the proposed research will initiate investigations into the effect that high temperatures have on the structure of soil communities. For the past 45 years, a coalmine has been burning beneath the town of Centralia, PA heating the surrounding soils. Thus, the site is ideal for the identification of novel biocatalysts that are adapted to high temperatures. This is advantageous because industrial applications typically require thermal tolerance. Furthermore, characterizations of the soil community have already shown that it is enriched for microbial populations that are rare in most soils. It is noteworthy that we have already successfully used functional metagenomics to identify a large number of hydrolases from the Centralia soils. The goal of this project is to utilize functional metagenomics to identify novel and commercially valuable high temperature biocatalysts: Specific Aim 1. Identify biocatalysts from uncultured bacteria. We will use a panel of genetic screens to identify genes that are responsible for cellulase, xylanase, and amylase activity. The target activities for this panel will be prioritized from a range of specificities important in the conversion of plant biomass to fermentable sugars. Specific Aim 2. Identify biocatalysts with robust thermal kinetics. As we identify biocatalysts, we will characterize their thermal kinetics. Specifically, we will screen for biocatalysts that are more active and stable at high temperatures than those that are currently in use. Completion of these specific aims will identify commercially viable biocatalysts as well as demonstrate the utility of functional metagenomics. We will license all biological resources that result from the proposed research. We have a track record of licensing products to industrial collaborators through university-based commercial ventures and intellectual property programs. Our research will also have a strong educational impact on the students at the University of Massachusetts and Susquehanna University in Selinsgrove, PA, which has been characterizing the site over the past ten years. Specifically, undergraduate and graduate students will be trained in the use of functional metagenomics for use in biotechnology development. Finally, this seed grant will enable us to successfully compete for future funding opportunities focused on: (1) the thermal adaptation of specific enzymatic families; (2) developing better expression and screening methods; and (3) initiating similar surveys in other sites.

NE08-013 (Seed Proposal $99,971) Developing a Biological Process to Treat Feedstock for Cellulosic Ethanol Biorefining PI: Dr. Wei Liao, Michigan State University Environmentally friendly biobased fuels can make important contributions to the U.S. energy security, rural economic development, and environmental quality. As outlined by the federal government in the Advanced Energy Initiative (AEI), our nation's dependence on imported oil can be reduced by accelerating the development of domestic, renewable alternatives to liquid transportation fuel such as gasoline and diesel fuels (The White House National Economic Council, 2006). The national goal is to displace up to 30% of the nation's gasoline consumption by 2030. Bio-ethanol fuel presents the best opportunity for replacing a significant amount of gasoline consumption. Accelerating lignocellulosic ethanol research is key to achieving the goal. However, one of the major technical barriers to commercial lignocellulosic ethanol production is conversion technology. Addressing this barrier creates a good opportunity for the scientific community to make significant technological contributions to lignocellulosic ethanol production. The proposed project will develop an environmental benign approach to convert lignocellulosic materials to fermentable sugars for fuel ethanol production. The hypotheses are that the production of ligninolytic enzymes could be significantly enhanced by pelletized P. chrysosporium, and a pretreatment process using mixture of ligninases and cellulases can be further developed for industrial applications in a way close to the natural decomposition process of lignocellulosic materials. Specific objectives include: (1) Enhancing ligninase production on lignocellulosic materials using a pelletized fungal fermentation; (2) Developing an enzyme mixture with enhanced performance for integrated biological pretreatment and hydrolysis of the feedstock. The project will provide an integrated biological pretreatment process, which improves cellulosic conversion and reduces the environmental impacts that traditional conversion processes with thermal/chemical pretreatments encounter. The proposed topic fits well with the Sungrant's priorities to enhance national energy security through the development, distribution, and implementation of biobased energy technologies. By focusing on two major enabling activities of feedstock development and conversion processes i n Sungrant's Northeast Region Priorities Matrix, this project will contribute to: (1) increasing the use of biomass via environmentally benign processes and technologies; (2) providing new economic development opportunities to agriculture as the biomass residues are used as raw material in supporting a bio-economy.

NE08-22 (Seed Proposal $100,000) A Biofuel Screening Program for Grass Feedstocks: Diversity, Physiological Traits and Compositional Characteristics for Optimal Yield. PI: Dr. Gary Bergstrom , Cornell University. Lignocellulosic biomass could be a source for generating ethanol if cost-effective strategies to utilize this renewable resource can be generated. In order to form fermentable sugars for ethanol production, the carbohydrate polymers making up lignocellulose must undergo hydrolysis, typically using a mixture of enzymes. The current enzyme complexes from Trichoderma species, used in large quantities for hydrolysis, are a major production cost, but conversion of lignocellulose is still suboptimal. A critical need is to identify novel cellulases, hemicellulases, and other cell wall degrading enzymes that can ultimately be incorporated into enzyme cocktails for more efficient and low-cost conversion of lignocellulosic material into fermentable sugars. Plant pathogens represent an underdeveloped novel source for plant cell wall degrading enzymes (CWDEs) for lignocellulosic digestion. These pathogens have evolved to utilize lignocellulose as a food source, and they physically attack plant tissues by producing an arsenal of CWDEs that contribute to their aggressiveness. Plant pathogens rely on rapid entry of cell walls to subvert plant defenses and display a highly regulated and copious production of enzymes during infection and growth. The broad objective of this two-year project is to identify and characterize CWDEs from plant pathogenic fungi. This work will entail collecting, isolating, identifying, and archiving a large collection of virulent plant pathogenic fungi from switchgrass and other lignocellullosic feedstock crops and high-throughput screening of plant pathogens for activity of CWDEs, especially cellulases and xylanases. We will screen at least 400 isolates of plant pathogenic fungi and anticipate that we will identify 10 or more promising microbial sources of superior enzymes for further characterization and potential use in commercial feedstock conversion. Our goal is to discover new cellulases and xylanases that exhibit high affinity and high specific activity toward lignocellulosic biomass for maximal efficiency of conversion to sugars for bioethanol production.

NE08-034 (Seed Proposal $99,997) Development of Biocatalyst for Biobutanol Production and Recovery by Gas Stripping. PI: Dr. Thaddeus Exeji, The Ohio State University The world today is confronted with dwindling nonrenewable resources which serve as feedstocks for the production of fuels and chemicals. In particular, there is a growing perception by the United States government of the risks of dependence on foreign oil and global warming. In President Bush's Advanced Energy Initiative, he challenged the nation to new and productive efforts to develop alternative energy sources to replace imported foreign oil. The strategy for a future energy supply must also take the reduction of the greenhouse gas emissions into consideration. Developing cost effective and energy-efficient methods of producing biofuels such as butanol will require research that tend to draw strengths from both science and technology knowledge base. Major limitations of the biomass conversion to butanol are butanol toxicity to the microbial cells and spore formation by butanologenic microorganisms. Both result in lesser butanol titer, fermentation time, productivity, and yield. However, developments of butanol tolerant asporogenous solventogenic clostridia or in situ recovery process have been suggested by many investigators. We propose to perform research on biocatalyst development using bidisciplinary Objective 1. Science - Development of asporogenous (sporulation-deficient) and a butanol tolerant hyper-butanol producing Clostridium beijerinckii strain. We will focus on use of traditional chemical mutagenesis processes and adaptation techniques which are effective in generating solventogenic clostridia mutants to generate hyper butanol producing and butanol-tolerant asporogenous C. beijerinckii strain. We will generate and isolate mutants with phenotypes of interest. Independent mutants with same phenotypes of interest will be investigated to determine the effect mutation(s) on the critical genes for butanol formation. The generated asporogenous and butanol tolerant hyper-butanol producing C. beijerinckii strain and the wild-type will be employed in an integrated process that facilitates simultaneous biobutanol production and recovery. Continuous production of biobutanol from carbohydrate-rich food wastes using C. beijerinckii mutants and optimization of the dilution rate will be investigated. Objective 2. Technology - Development of an improved gas stripping based technology for efficient simultaneous butanol fermentation and recovery. The total concentration of butanol or acetone-butanol (AB) in the fermentation beer is typically less than 1.3% (w/v) or 2% (w/v), respectively. Because the low AB concentration in the fermentation broth has been attributed to butanol toxicity effect on the fermenting microorganisms, we will selectively remove butanol during fermentation by exploiting the volatile property of butanol and gas-liquid equilibrium to achieve maximum mass transfer. This process will keep the concentration of butanol below the threshold of toxicity to the biocatalyst while allowing the fermentation to proceed in an unimpeded fashion. Objectives 1 and 2 will focus on the development of scientific and technological aspects of butanol production that will ultimately lead to technologies deployable in Ohio and across the United States.

Economics

NE08-070 (Seed Proposal $101,219) Marketing New England biofuels to Ensure Energy Security. PI: Dr. Mario Teisl, University of Maine This Seed Proposal focuses on the areas of Marketing, Economics and Policy and Systems Integration as it applies to designing and testing information strategies to promote biofuels use and production in the Northeast. The Energy Independence and Security Act requires the sale of specified quantities of renewable and advanced biofuels. These fuels will cost more to produce but will provide enhanced reductions in GHG emissions. Our research will provide crucial knowledge about how consumers understand and evaluate biofuels in a competitive marketplace taking into consideration their environmental impacts. We will provide important information on how to best market and label advanced biofuels to insure that largest contribution to local economies and diversify regional energy supplies. This will provide valuable information about ways to promote purchases of biofuels, and provide information to policy makers on potential standards for certification and labeling of biofuel products. Perhaps more critically, developing a cellulosic biofuels market provides a potential opportunity to revitalize the forest industrial sector, thereby enhancing employment opportunities and incomes in areas of the rural Northeast that typically has few other economic opportunities. We will research, design, and test the effectiveness of various consumer information strategies to promote cellulosic ethanol in particular, and evaluate consumer's acceptance and understanding of biofuels generally. The research will also derive estimates of the market penetration of biofuels in the Northeast. These estimates of market penetration, combined with estimates of market share changes for alternatively fueled vehicles, will allow us to make petroleum displacement forecasts and evaluate the possible impact of biofuels on the Northeast's energy security. By focusing our efforts on the Northeast region we are uniquely able to bring together economists and market researchers with bioproducts researchers at the University of Maine's Forest Bioproducts Research Initiative.

NE08-055 (Seed Proposal $99,825) Determining Costs, Product Recovery Factors, and Environmental Impacts for Biomass Harvest Treatments in Northeastern Forests. PI: Dr. Marc McDill, Pennsylvania State University 1. Establish the initial study sites as part of a future network of similar sites on which biomass harvesting treatments are implemented and pre- and post-harvest ecological variables are measured. The sites will be selected to represent conditions where the five harvesting treatments are likely to be applied in Pennsylvania forests: 1) a clearcut regeneration harvest in a mature sawtimber stand; 2) a first-cut shelterwood harvest in a mature sawtimber stand; 3) a clearcut regeneration harvest in a degraded stand;4) an intermediate tending operation to remove competing understory wood vegetation from a mature hardwood stand, to allow tree regeneration to occur; and, 5) a clearcut in a softwood plantation. 2. Establish sample plots within each site on which pre- and post-harvest yield and ecological variables will be measured and compared both within and among the different treatments. Variables measured and analyzed will include: 1) soil compaction effects; 2) removal and retention of macronutrients (N, P, K, Ca, Mg); 3) damage to residual trees and advanced regeneration; 4) overstory species composition and volumes; and, 5) understory species composition, density, and stem quality. 3. Measure harvest and transportation costs associated with biomass removal on each site. Observations will be made on: 1) mechanized felling; 2) skidding; 3) chipping; 4) loading for off-site transportation; and, 5) transportation from the harvest site to the mill. 4. Analyze data and publish findings in peer reviewed journals and other media. Analyses will specifically investigate treatment costs, yields, observed differences between the pre and post-harvest stand conditions, as well as any differences occurring among the treatments. The pilot sites will be established on or near the Penn State School of Forest Resources' Stone Valley Experimental Forest (SVEF). While uncertain, timber sale revenue is expected to offset some costs associated with installing and administering establishment of the study sites; however, they will not offset costs for measuring, monitoring, and collecting data required to address the research objectives.

Fuels

NE08-024(Seed Proposal $100,000) Determination of the Underlying Cause of the Biodiesel NOx Effect in Common Rail Diesel PI: Dr. Andre Boehman, Pennsylvania State University Biodiesel fueling of DI diesel engines has repeatedly been shown to cause an increase in NOx emissions, which is an impediment to the use of biodiesel in areas that are ozone non-attainment zones, such as in some urban corridors of the Northeastern US. Roughly a 1% increase in NOx is seen for each 10% biodiesel addition to the base diesel fuel. The effect is most pronounced under high engine loads. It is fairly well understood in engines that use pump-line-nozzle type fuel injection systems, where the higher bulk modulus of compressibility (or equivalently the speed of sound) in the biodiesel fuel leads to an advanced injection timing which in turn leads to an earlier maximum cylinder temperature and thereby higher levels of formation of thermal NOx. However, in common rail diesel engines, which represent the state-of-the-art in fuel injection technology, shifts in fuel compressibility do not directly lead to shifts in fuel injection timing, so there is an insufficient understanding of the source of the effect in common rail engines. Recent work in optical engine and high pressure shock tube studies have highlighted four potential sources of the NOx effect in common rail engines. 1. Reduced radiative heat transfer from the diesel spray flame due to lower soot volume fraction with biodiesel, thereby increasing flame temperature relative to diesel fuel and causing an increase in thermal NOx. 2. Changes in fuel air mixing due to the higher density, viscosity and latent heat of vaporization of the biodiesel fuel, thereby changing flame stoichiometry. 3. Biodiesel fuels may increase adiabatic flame temperatures and thereby lead to higher thermal NOx formation. 4. The increased concentration of carbon-carbon double bonds (i.e., more olefinic or unsaturated character in the fuel) may lead to increased prompt NOx (also known as Fenimore NOx) formation in the pyrolytic zones within the spray flame. In this project we will examine the underlying mechanisms of the biodiesel NOx effect to enable more effective corrective actions to be taken in current and future diesel engine platforms. Ford Motor Company will provide a test engine and technical support for the experimental studies which will constitute the cost share for the proposed project. Objectives: 1. Extend an existing CFD model for diesel engine combustion to include more sophisticated treatment of the fuel property effects in the fuel spray model. 2. Use the CFD model to test the sensitivity of predicted NOx emissions to variations in the physical properties of the fuel (viscosity, density and latent heat of vaporization). Perform companion experiments for validation of the simulations by attempting to vary individual properties of the biodiesel fuel, such as viscosity, via treatment with additives that enhance viscosity.