NP307
Significant Accomplishments for FY 2006

Our Nation's need for biofuels to help meet our growing demand for domestically-sourced, renewable transportation fuels is the major driver behind ARS' research in bioenergy. Consequently, supporting research that enables the continued growth in the two commercial biofuels – ethanol and biodiesel – is a priority for the ARS National Program in Bioenergy and Energy Alternative. In addition, special cellulosic energy crops, such as switchgrass, that can be cultivated on lands unsuitable for corn or soybeans could significantly increase the amount of ethanol that could be domestically produced without disrupting traditional markets for food or feed. Therefore, another major component of NP307 focuses on energy crops. Finally, in order to provide farmers and ranchers with power that is affordable and has relatively fixed costs, NP307 also funds research that brings alternative sources of energy, such as wind and solar, to rural America.

Component I: **Ethanol**

Enzyme process that enables the commercial production of ethanol from barley. Barley could be converted into ethanol if problems with its high viscosity and low ethanol yields were overcome. Researchers at Wynmoor, Pennsylvania, found that adding beta-glucosidase enzymes to the starch hydrolysis step solves both problems of viscosity and yield. This discovery should enable the building of ethanol plants outside the corn belt and in barley growing regions such as the East Coast, Northwest, and Upper Midwest. Having barley as a viable feedstock could provide an additional one to two billion gallons of fuel ethanol in the United States. (NP 307, Performance Measure 2.1.1)

Producing valuable co-products for corn-based ethanol. Researchers at Wyndmoor, Pennsylvania, determined that treating corn germ with certain protease enzymes such as thermolysin or flavourzyme produces peptides that could act as physiological modulators in the human body. One such effect might lower blood pressure since these peptides inhibit Angiotensin I Converting Enzyme. The ability to produce valuable nutraceuticals from the proteins in corn would improve the long-term business stability of corn-ethanol producers. (NP 307, Performance Measure 2.1.1)

Complete saccharification and fermentation of wheat straw to fuel ethanol. Wheat straw contains 70 percent complex carbohydrate, which can serve as a low cost feedstock for production of fuel ethanol. Batch alkaline peroxide pretreatment, separate enzymatic hydrolysis and fermentation (SHF), and simultaneous enzymatic saccharification and fermentation (SSF) systems have been developed for production of ethanol from alkaline peroxide pretreated wheat straw. Researchers at Peoria, Illinois, have demonstrated that wheat straw pretreated with alkaline peroxide can be completely enzymatically saccharified into fermentable sugars. No common fermentation inhibitors were produced. Both SHF and SSF approaches worked equally well for production of ethanol from the pretreated wheat straw, both systems capitalizing on an ethanologenic recombinant bacterium capable of utilizing multiple sugars (glucose, xylose, arabinose). The research will greatly contribute to the development of an integrated bioprocess technology for fuel ethanol production from lignocellulose.
(NP 307, Performance Measure 2.1.1)

Construction of a proteomic workcell. An automated method to screen large numbers of samples is needed to help identify new microbial strains and enzymes that can be used for efficient production of ethanol and other value-added products from agricultural feedstocks. In cooperation with Hudson Control Group, Inc., Springfield, New Jersey, scientists at Peoria, Illinois, have constructed a plasmid-based functional proteomic workcell for high-throughput assembly, optimization, and modification of gene libraries and microbial strains. Mechanical hardware has been integrated and controlling software developed to provide a robotic platform that picks colonies, cultures bacteria, prepares plasmid DNA, performs in vitro transcription/translation, and assays enzyme activity. This workcell and high-throughput strategy will ultimately be used for identifying strains of ethanologenic yeast capable of fermenting xylose. (NP 307, Performance Measure 2.1.1)

Evolutionary enzyme design for improved biorefining of crops and residues. The current ethanol industry uses a process requiring gelatinization of corn starch at high temperature before the addition of amylases enzymes for starch hydrolysis. Researchers at Albany, California, conducted research under a CRADA with a private sector partner to increase the hydrolysis rate of amylase family enzymes. The result will benefit American farmers, make the fuel ethanol price more competitive, and ultimately alleviate the dependency on imported petroleum. (NP 307, Performance Measure 2.1.1)

Component II: **Biodiesel**

Predicting cold flow behavior for biodiesel. Poor cold flow behavior relative to petroleum-derived diesel is a major quality issue in biodiesel fuels. Researchers at Peoria, Illinois, developed a thermodynamic model to predict the cold flow properties of biodiesel fuels. Results show that the model will be useful for screening additives and determining the effects of contaminants on cold flow properties. (NP 307, Performance Measure 2.1.1)

Polymers from glycerol co-product. Given the forecasted increase in biodiesel volume, there will also be increasing quantities of glycerol, the major co-product of biodiesel production. Therefore, finding new, value-added uses for glycerol will help ensure favorable production economics for biodiesel manufacturers. Scientists at Wyndmoor, Pennsylvania, were able to synthesize linear and hyperbranched polymers from glycerol. Glycerol-based hyperbranched polymers represent a new class of water-soluble polymers that could open up new markets for glycerol. (NP 307, Performance Measure 2.1.1)

Component III: **Energy Alternatives for Rural Practices**

Pumping from deep wells using renewable energy. Using a traditional centrifugal pump powered by photovoltaic or wind energy, the maximum water well depth is limited to about 165 feet. This limitation precludes the use of renewable energy in many rangelands. Researchers at Bushland, Texas, found that use of helical pumps instead allowed wind power based well systems to pump from depths as much as 490 feet. These systems should provide a means for farmers and ranchers to obtain water using renewable energy in areas where ground water is quite deep. (NP 307, Performance Measure 2.1.1)

Component IV: **Energy Crops**

Large scale sequencing of switchgrass and brachypodium for molecular breeding of energy crops. Scientists at Albany, California, were the first to publish gene sequences for Brachypodium, a model grass plant, and switchgrass. These same scientists are also leading national efforts to sequence the entire genome for Brachypodium as well as most of the genes in switchgrass. These latter efforts are funded by DOE's community sequencing program at the Joint Genome Institute. The sequence data generated will accelerate efforts to breed better varieties of perennial, herbaceous energy crops such as switchgrass. (NP 307, Performance Measure 2.1.1)

Developing agromonic practices for switchgrass production in Northern Plains. Researchers in Lincoln, NE, completed a five year field study for switchgrass production at the farm scale. Results indicated that switchgrass could be grown in the Northern Plains with an average yield of 3-4 dry tons/acre and at an average cost of $45/ton. Practices for stand establishment and fertilization/harvesting management significantly impacted costs. (NP 307, Performance Measure 2.1.1)