

UNIVERSITY	RESEARCH TYPE (S)	PROGRAM	DESCRIPTION
Cornell University	Member	Sun Grant Center of Excellence	See appendix
Iowa State University	Chemical catalysts	Boost ethanol production by increasing yield of fermentable sugars from corn	Allows ethanol producers to use all the sugars in corn. Boosts ethanol production by 10 to 15%
	Distillers grain	Reduce Energy Costs in Ethanol Production Through Improved On-Farm Storage Methods	Demonstrate the feasibility, animal productivity, cost and economics of long term storage and feeding of wet distillers grains in a cow calf operation.
	Anaerobic digestors	Production of Ethanol and Other Chemicals from Corn Stover and Sorghum	<p>First goal to use acid bacteria of anaerobic digestion to produce glycerol and acetic acid in high enough concentrations to make their isolation economical.</p> <p>Second objective to demonstrate distillation of ethanol from fermented sweet sorghum silage.</p>

	Cellulosic ethanol	<p>Hybrid Thermal Biological Conversion to Industrial Chemicals</p> <p>Thermal depolymerization of corn stover into complex sugars and their subsequent hydrolysis and fermentation to ethanol.</p>	<p>Project has five major elements: 1) evaluate depolymerization potential of corn stover & switchgrass as lignocellulosic feedstock; 2) determine fermentation potential of pyrolysis sugars using conventional microorganisms; 3) screen & select extremophilic microorganisms suitable for direct fermentation of pyrolysis sugars; 4) perform laboratory tests on hydrogenolysis of pyrolysis liquids; and 5) estimate cost of integrated pyrolysis / fermentation / distillation process for corn stover-to-ethanol plant.</p> <p>Delignify biomass & yield levoglucosan, an anhydrosugar, that can be hydrolyzed to fermentable sugars. Convert low-value lignocellulose into high-value chemical products like ethanol.</p>
	Distillers Grains	Mold to convert corn fiber typically used for animal feed into ethanol.	Demonstrated-process to convert corn fiber -- a byproduct of wet milling process that produces corn syrup -- into fuel-grade ethanol on very small scale. With additional research, would like to at least double amount of ethanol their process produces. Large-scale pilot desired. Test on other byproducts of corn processing also desired.

	Ultrasonics	Ultrasonic pretreatment of corn to increase release rates of sugars by nearly 30%	Demonstrated pre-treating milled corn with ultrasonics can break the corn pieces into finer particles, exposing more of the corn's starch to the enzymes that convert starch to simple sugars. Research team also plans to see if ultrasonics releases some sugars from the fibrous, cellulosic material in corn. Next step to quantify amount of ethanol produced when corn slurry is treated with ultrasonics. Larger, pilot scale desired.
	Member	Midwest Consortium for Biobased Products and Bioenergy	See appendix
Kansas State University	Sorghum	K-State Department of Agronomy established the Center of Excellence for Sorghum Improvement	Research aimed at developing new, improved varieties will also be conducted at the school's various research fields around Kansas. Sorghum is often used as animal feed, raw material for ethanol, and food.

	Economic impacts	Renewable Energy website	http://www.agecon.ksu.edu/renewableenergy/
Michigan State University	Cellulosic ethanol	Utilization of Renewable Resources Focus on pretreatments to increase conversion of lignocellulose to fermentable sugars	MSU's Biomass Conversion Research Laboratory is collaborating with other universities on new projects to genetically engineer plants to express the cellulase (cellulose-hydrolyzing) enzymes in plant tissue and then develop processing strategies so enzymes can retain their activity until released in the biorefinery. Working to develop optimal mixtures of hydrolytic enzymes to convert complex carbohydrates in biomass to fermentable sugars.
	Cellulosic ethanol	Life Cycle Models of Biobased Product Systems Realize full economic & environmental benefits of biobased products.	Currently collaborating with other universities involved in life cycle studies involving "refining" of corn, soybeans and forage crops (alfalfa and switchgrass) to fuel ethanol and other products. Goal is to identify portions of overall agricultural production, biorefining and product use systems that have the greatest impact on environmental & economic performance so these areas are targeted for additional research & improvement.

	Private-sector collaboration	Industrial Biotechnology Park	Along with Wayne State University and Diversified Natural Products, Inc. (DNP), a business center will be created to focus on use & manufacturing of alternative fuels.
	Economic impacts	MSU Ethanol Energy Balance Study	Independent study funded by MSU shows that there is 56% more energy in a gallon of ethanol than it takes to produce it.
	Member	Midwest Consortium for Biobased Products and Bioenergy	See appendix
Michigan Technological University	Vehicle technology	Ethanol combustion systems	MTU's Alternative Fuels Group Enterprise worked with Chrysler Global Electric Motor vehicle and John Deere to power vehicles through hydrogen & fuel cells. Currently working on designing a military vehicle that runs on fuel cell technology for The United States Army Tank Automotive and Armaments Command.
	Vehicle technology	Challenge X	See appendix
	Vehicle technology	GATE Center	See appendix
Mississippi State University	Vehicle technology	Challenge X	See appendix

North Carolina State University	Cellulosic	Conversion of paper residues into ethanol	Convert lignocellulosic biomass to energy. Current ongoing research involves conversion of starch & hemicelluloses into advanced particles and gels, fractionation of recycled papermaking fibers, separation of pressurized screening of deformable tacky contaminants in paper recycling, the characterization of different types of waters and their interactions with cellulose fibers, extraction of chemicals from biomass, conversion of paper residues into ethanol & strength properties of recycled fibers.
	Ag Waste	Ethanol from Swine Waste Project	Evaluated feasibility of converting swine waste to ethanol or an ethanol based liquid fuel. Project has focused on both technical issues & economic implications of various swine waste gasification options. Evaluations of swine waste energy content, wastehandling logistics, gasification parameters, fuel grade gases and liquid fuels produced as a result of gasification, and ash product have been completed.
Ohio State University	Hydrogen	Ohio State University Research Foundation	In 2004: research began to develop low cost catalyst to help convert ethanol into hydrogen when using reforming (i.e. chemical conversion) processes.
	Vehicle technology	Challenge X	See appendix
	Vehicle technology	GATE Center	See appendix

Oklahoma State University	Cellulosic	Bioprocess, biosystems & metabolic engineering & applications of enzymes in conversion process of xylose to ethanol.	Develop bioconversion process of agricultural feedstock (lignocellulose) into biofuel (ethanol) efficiently. Facilitate commercialization with higher profit margin. Application of biotechnological methods for bioconverting agricultural residues into bio-fuels (ethanol) requires new technologies with improved efficiencies. Partnering with Mississippi State University.
	Sorghum	Explore sweet sorghum to be used as a renewable energy crop and has become a viable candidate for ethanol production	Develop Sorganol.
	Member	Sun Grant Center of Excellence	See appendix
Oregon State University	Member	Sun Grant Center of Excellence	See appendix
Pennsylvania State University	Vehicle technology	Challenge X	See appendix
	Vehicle technology	GATE Center	See appendix

Purdue University	Cellulosic ethanol	Laboratory of Renewable Resources Engineering (LORRE) developed strain of yeast that effectively makes ethanol from agricultural residues that would otherwise be discarded or used as animal feed.	Purdue's genetically altered yeast allows about 40% more ethanol to be made from sugars derived from agricultural residues, such as corn stalks and wheat straw, compared with "wild-type" yeasts that occur in nature. Ability to ferment xylose increases the yield of ethanol from straw by about 40%. Technology is licensed to Iogen, Inc. A major component of LORRE's research is bioenergy, and in particular, corn stover.
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	Fuel cell technology	Ethanol potential in fuel cells	Considered filing for a patent and is attempting to procure funds from federally funded laboratories to continue research on the project.

Rose-Hulman Institute of Technology	Vehicle technology	Challenge X	See appendix
San Diego State University	Vehicle technology	Challenge X	See appendix
South Dakota State University	Member	Sun Grant Center of Excellence	See appendix
Southern Illinois University	Distillers grains	National Corn-to-Ethanol Research Center Future research: Optimization of biofuel production Biorefineries (use of plants to produce chemically useful products).	Research is done on behalf of or alongside paying clients, through collaboration or research partnerships and by the NCERC itself in areas of unmet needs. NCERC-led DDGs research includes: 1) Identifying Plant Parameters that Influence the Composition of Distillers' Dried Grain with Solubles (DDGS); 2) Determining the Feasibility of Improving the Flowability Consistency of DDGS; & 3) Adapting NCERC for Commercial Demonstration of Corn Kernel Fiber Ethanol Production at a Dry Grind Fuel Ethanol Plant.
Texas A & M	Biomass to fuel	Artie McFerrin Department of Chemical Engineering	Developed MixAlco process, which converts biomass into alcohols for use as fuels. A pilot plant operated on campus. MixAlco process treats biomass feedstock with lime and then fermented to form organic salts. Water is removed and mixture is heated to form ketones, such as acetone, which is an ingredient in nail polish remover. Adding hydrogen to the ketones forms alcohols that can be used as biofuels.

	Vehicle technology	StarRotor engine project	Goal: 90 miles per gallon in a conventional car equipped with a hybridized StarRotor engine
Texas Tech University	Unspecified	Estimates Texas High Plains could produce 400 million gallons annually. It could supply 200 million gallons of biodiesel in less than five years, 600 million gallons of lignocellulosic biomass within the next ten.	Working to increase production of renewable biofuels including ethanol, biodiesel and lignocellulosic biomass – or fuel developed from grasses and other plant matter.
	Vehicle technology	Challenge X	See appendix
University of Akron	Vehicle technology	Challenge X	See appendix
University of California - Davis and Berkeley	Cellulosic	Joint Genome Institute, charged by UC-Lawrence Berkeley scientists for DOE, has banks of DNA sequencers ready to search for switchgrass genes.	Sequencing all DNA in Brachypodium, a kind of prairie grass that federal researchers in a report on biofuels last week recommended be sequenced as soon as possible. Future research: Genome institute will be sequencing the cassava and the oyster mushroom, which is white-rot fungus that eats lignin, part of the woody tissue of the plant, and so holds some keys to freeing cellulose for conversion to biofuels.
	Vehicle technology	Challenge X	See appendix

	Vehicle technology	GATE Center	See appendix
University of Idaho	Fermentation	Developed at the Environmental Research Institute of the University of Idaho	Concept of creating microbial consortia designed to optimally perform specific tasks continues to be developed for other applications. Applications include consortia optimized to maximize biomass production, minimize biomass production, bioremediation, or biosphere creation.
University of Illinois – Urbana-Champaign	Distillers grain	College of Agricultural, Consumer, and Environmental Sciences (ACES).	Developed process that reduces volume of DDGS produced and improves its nutritional characteristics. Called “enzymatic dry grind,” process soaks corn in water for a short period of time, then grinds it coarsely and incubates it with enzymes—breaking down the corn kernel. Leader of “quick germ” and “quick fiber.” Goal is to make dry grind look like wet milling, but at a much lower capital cost. Studying how livestock producers can best incorporate wet and dry distillers grains into their feeding programs.
	Distillers grain	DDG website support	http://ilift.traill.uiuc.edu/distillers/

	Member	Midwest Consortium for Biobased Products and Bioenergy	See appendix
University of Iowa	Fuel cells	Patent pending	Developed two methods to use the ethanol in the fuel cell. The "direct" method feeds the ethanol directly into the fuel cell, while the "indirect" procedure sends the fuels through a reformer, which produced hydrogen.
University of Maryland	Vehicle technology	GATE Center	See appendix
University of Michigan	Vehicle technology	Challenge X	See appendix
University of Michigan – Dearborn	Vehicle technology	GATE Center	See appendix
University of Minnesota	Cogeneration		Evaluating alternatives for using biomass fuels (DDGS or other ethanol coproducts and/or corn stover) to generate electricity and process heat at ethanol plants.
	Distillers grains	University of Minnesota West Central Research and Outreach Center in Morris.	Research to help hog producers incorporate more DDGs in the rations of grow-finish pigs and sows.

University of Nebraska	Economics	Conclusion: Ethanol has positive energy balance. Provides more energy than is used to produce it. Calculated the energy output to energy input ratio for converting irrigated corn to ethanol is 1.3-to-1 and 1.4-to-1 for dryland corn.	To calculate a modern energy balance for ethanol, they gathered & assessed current information on all fossil fuel needed to grow and transport corn & convert it to ethanol, blend it with gasoline & get it to the pump.
	Distillers Grains	Storage of wet-milled DDGs	UNL animal scientists completed research that devised formulas for mixing several widely available dry forages with wet DDGs. Findings could help feedlot managers and cow-calf producers purchase wet distillers grains during the summer when their plentiful supply can mean lower prices and safely store them for use later in the season, or for winter feeding.
University of Oklahoma	Cellulosic	Assembled an integrated gasification and biology program	Syngas rates remain slow and are limited by the fundamental biology and mass transfer.
University of Tennessee	Vehicle technology	Challenge X	See appendix
	Vehicle technology	GATE Center	See appendix
University of Tennessee – Knoxville	Member	Sun Grant Center of Excellence	See appendix
University of Texas at Austin	Vehicle technology	Challenge X	See appendix
University of Tulsa	Vehicle technology	Challenge X	See appendix
University of Waterloo	Vehicle technology	Challenge X	See appendix
University of Wisconsin-	Vehicle technology	Challenge X	See appendix

Madison			
Virginia Tech	Crop science	Energy cropping, 'closed loop' agricultural systems and/or sustainable agriculture, use of biosolids and other wastes in crop production, etc.	Switchgrass as a Biofuels Crop for Upper Southeast, USDOE through Lockheed Martin Energy Systems, \$300,001, 05/01/1992 to 04/01/1997
	Cellulosic ethanol	Goal: Foster research on improvements in cellulase activity & biomass pretreatment to make bioethanol processes more efficient and economical.	In collaboration with National Renewable Energy Laboratory & ORNL, VTU researchers will develop new nano-scale tool to determine cellulose accessibility to the digesting enzymes & measure fraction & concentration of enzymes on cellulose surface. Research will also quantitatively determine substrate characteristics & their impacts on activities of enzymes.
	Vehicle technology	Challenge X	See appendix
	Vehicle technology	GATE Center	See appendix
Washington State University	Cellulosic	WSU Extension Energy Program, Agri-environmental and Bioproducts Engineering Research Group - AEBE	Co-fermentation of C5, ligno-cellulosic sugars (wheat straw, paper pulp, etc.) for ethanol production. Technical, economic and policy analysis. Assist both public and private sector groups interested in using/marketing ethanol as a fuel.
West Virginia University	Vehicle technology	Challenge X	See appendix
	Vehicle technology	GATE Center	See appendix

21st Century Truck Partnership: Industry-government collaboration among heavy-duty engine manufacturers, heavy-duty truck and bus manufacturers, heavy hybrid power train manufacturers, and four federal government agencies. Partners work cooperatively to develop a balanced portfolio of research aimed at achieving their research goals, coordinating their research activities as appropriate, and making effective use of the nation's research universities and national laboratories. Proprietary research agreements between individual companies and federal agencies, which cannot be shared with industrial competitors, will continue to be funded appropriately.

Industrial Partners: Allison Transmission, BAE Systems, Caterpillar, Cummins Engine, DaimlerChrysler, Detroit Diesel Corporation, Eaton, Freightliner, Honeywell International, International Truck and Engine, Mack Trucks, NovaBUS, Oshkosh Trucks, PACCAR, Volvo Trucks North America, Federal Government Partners, U.S. Department of Energy (DOE), U.S. Department of Defense (DOD), U.S. Department of Transportation (DOT), U.S. Environmental Protection Agency (EPA).

National laboratory partner: Argonne National Laboratory, Brookhaven National Laboratory, Idaho National Laboratory, Lawrence Berkeley National Laboratory, Lawrence Livermore National Laboratory, Los Alamos National Laboratory, NASA Ames Research Center, National Institute of Standards and Technology, National Renewable Energy Laboratory, Oak Ridge National Laboratory, Pacific Northwest National Laboratory, Sandia National Laboratories.

Challenge X: Crossover to Sustainable Mobility is a three-year collegiate engineering competition sponsored by the U.S. Department Energy's (DOE's) FreedomCAR and Vehicle Technologies Program and General Motors (GM) Corporation. The competition, which runs from 2004 through 2007, offers college engineering students the opportunity to conduct hands-on research and development with leading-edge automotive propulsion, fuels, materials, and emissions control technologies. Teams: Michigan Tech, Mississippi State University, Ohio State University, Pennsylvania State University, Rose-Hulman Institute of Technology, San Diego State University, Texas Tech University, University of Akron, University of California-Davis, University of Michigan, University of Tennessee, University of Texas-Austin, University of Tulsa, University of Waterloo, University of Wisconsin-Madison, Virginia Tech, West Virginia University.

FreedomCAR and Vehicle Technologies (FCVT) Program: Development of more energy efficient and environmentally friendly highway transportation technologies that will enable America to use less petroleum. The long-term aim is to develop "leap frog" technologies that will provide Americans with greater freedom of mobility and energy security, while lowering costs and reducing impacts on the environment.

Collaborative among DOE, energy companies: BP America, Chevron Corporation, ConocoPhillips, Exxon Mobil Corporation, and Shell Hydrogen (US), and the U.S. Council for Automotive Research (USCAR) partners (DaimlerChrysler Corporation, Ford Motor Company, and General Motors Corporation). All the partners independently undertake their own research activities on advanced light-duty vehicle and/or fuel technologies relevant

to achievement of the vision or through separate legal arrangements. USCAR partners jointly conduct related collaborative precompetitive R&D. Companies will make independent decisions on commercialization depending upon establishment of viable business cases.

GATE Centers: DOE established Graduate Automotive Technology Education (GATE) to provide a new generation of engineers and scientists with knowledge and skills in advanced automotive technologies. Ten GATE centers were established at nine universities to address the following key technology areas: Fuel cells, Hybrid electric vehicle drivetrains and control systems, Lightweight materials, Direct-injection engines, and Advanced energy storage. Nine universities: Michigan Tech, Ohio State University, Pennsylvania State University, University of California-Davis, University of Maryland, University of Michigan-Dearborn, University of Tennessee, Virginia Polytechnic Institute, West Virginia University.

Midest Consortium for Biobased Products and Bioenergy: Group of four universities and three federal laboratories working together since 1999 to expand and improve technologies for conversion of plant material to industrial products: chemicals, plastics, fuels, power and other products. Participating universities: Purdue, Illinois, Iowa State, and Michigan State. Government laboratories: USDA National Center of Agricultural Research Utilization, Ames Laboratory, and Argonne Laboratory.

Sun Grant Initiative: Authorized in Energy Title of 2002 Farm Bill. Funding from the Departments of Agriculture, Energy, and Transportation. Funding totals over \$40 million over four years. Five land grant universities serve as regional Sun Grant Centers of Excellence: South Dakota State University, Oklahoma State University, the University of Tennessee – Knoxville, Cornell University, and Oregon State University. Federal funds will be shared among each region. As the Sun Grant Initiative develops its programs, it will integrate the national bioenergy research and education priorities identified by the federal agencies with the state and local priorities identified in its regional workshops and listening sessions.

The Sun Grant Initiative programs aims to revitalize rural communities, enhance the nation's energy security and improve our soil, water, and air. The primary challenges that must be faced include:

- The emergence of agriculturally based bio-industries that can coexist with and complement petroleum based industries.
- Developing biobased industries that improve the environment and protect air, water, soil, and other natural resources.
- Developing biobased industries that diversify American agriculture and complement food production.
- Developing industries that provide opportunities for the growth and prosperity of rural America .