

Sun Grant Initiative

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Biomass Research and Development
Technical Advisory Committee
February 27-28, 2013

- A consortium of the nation's land-grant universities addressing national bioenergy and bioproduct challenges at the local level and on a regional scale
- Supporting research and educational activities in the development of:
 - Biobased transportation fuels
 - Biobased products

- Five Regional University Centers
- Engaging agricultural and natural resource colleges in every state and territory
- Including
 - State Agricultural Experiment Stations
 - Cooperative Extension Service



 **North Central Regional Center**
South Dakota State University
<http://ncsungrant.sdstate.edu>
(605) 696-7860

 **South Central Regional Center**
Oklahoma State University
<http://sungrant.okstate.edu>
(405) 744-3255

 **Northeast Regional Center**
Cornell University
<http://www.ncsungrant.cornell.edu>
(607) 255-5544

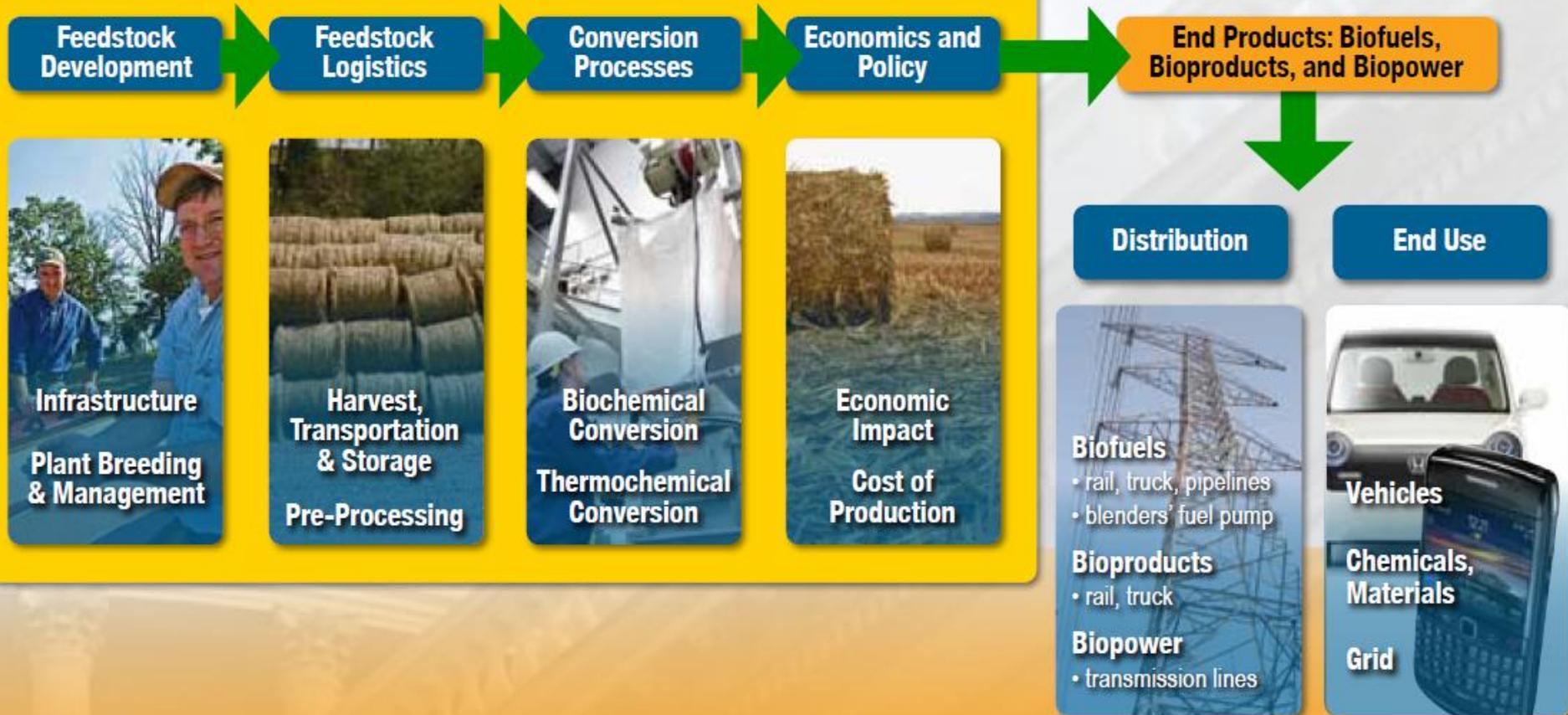
 **Western Regional Center**
Oregon State University
<http://sungrant.oregonstate.edu>
(541) 737-9353

 **Southeast Regional Center**
The University of Tennessee
<http://sungrant.tennessee.edu>
(865) 946-1109

 **Western Insular Pacific Subcenter**
University of Hawaii – Mānoa
(808) 956-8858



Sun Grant Initiative



SUSTAINABILITY



U.S. Department of Agriculture

- Sustainable Feedstock Production
- Regional Competitive Grants



Feedstock Development

- Plant Breeding
- Agronomic Management
- Sustainable Production
- Equipment Technology



Logistics

- Feedstock Production
- Harvest, Delivery, and Storage
- Transportation
- Pre-Processing



Conversion Processes

- Conversion Technologies
- Cost of Production
- Biological Conversion
- Thermochemical Conversion



System Analysis

- Industrial Ecology
- Feedstock Transport
- Biofuels Transport
- Delivery Infrastructure



Economics, Marketing, and Policy

- Economics and Policy
- Impact on Food, Feed, and Fiber Markets
- Economic Return
- Production Economics



Environmental Impacts

- Life Cycle Analysis
- Greenhouse Gas Emissions
- Carbon and Energy Balance
- NOX Emissions



U.S. Department of Energy

- Regional Biomass Feedstock Partnership
- Regional Competitive Grants



U.S. Department of Transportation

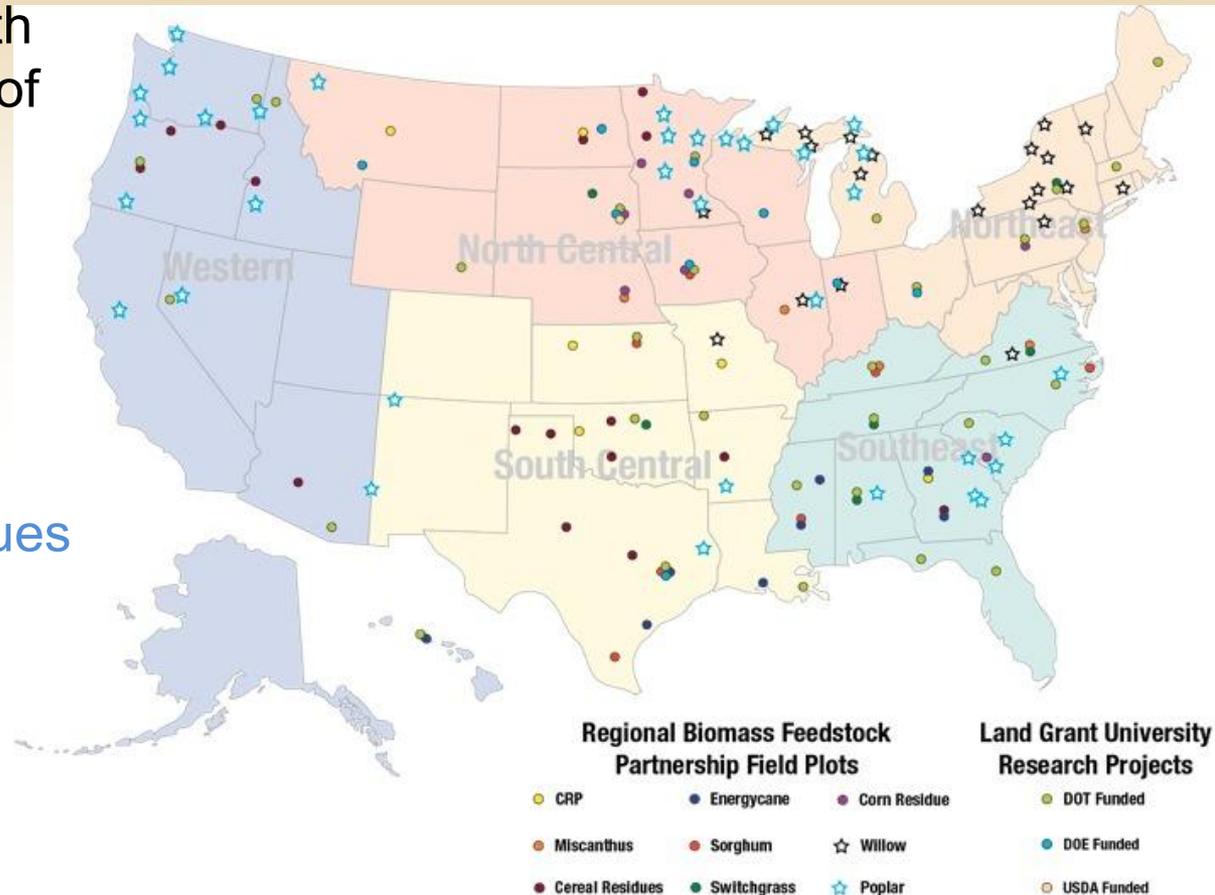
- Renewable Transportation Fuels
- Regional Competitive Grants

- More than 200 projects with collaborators in over 90% of states

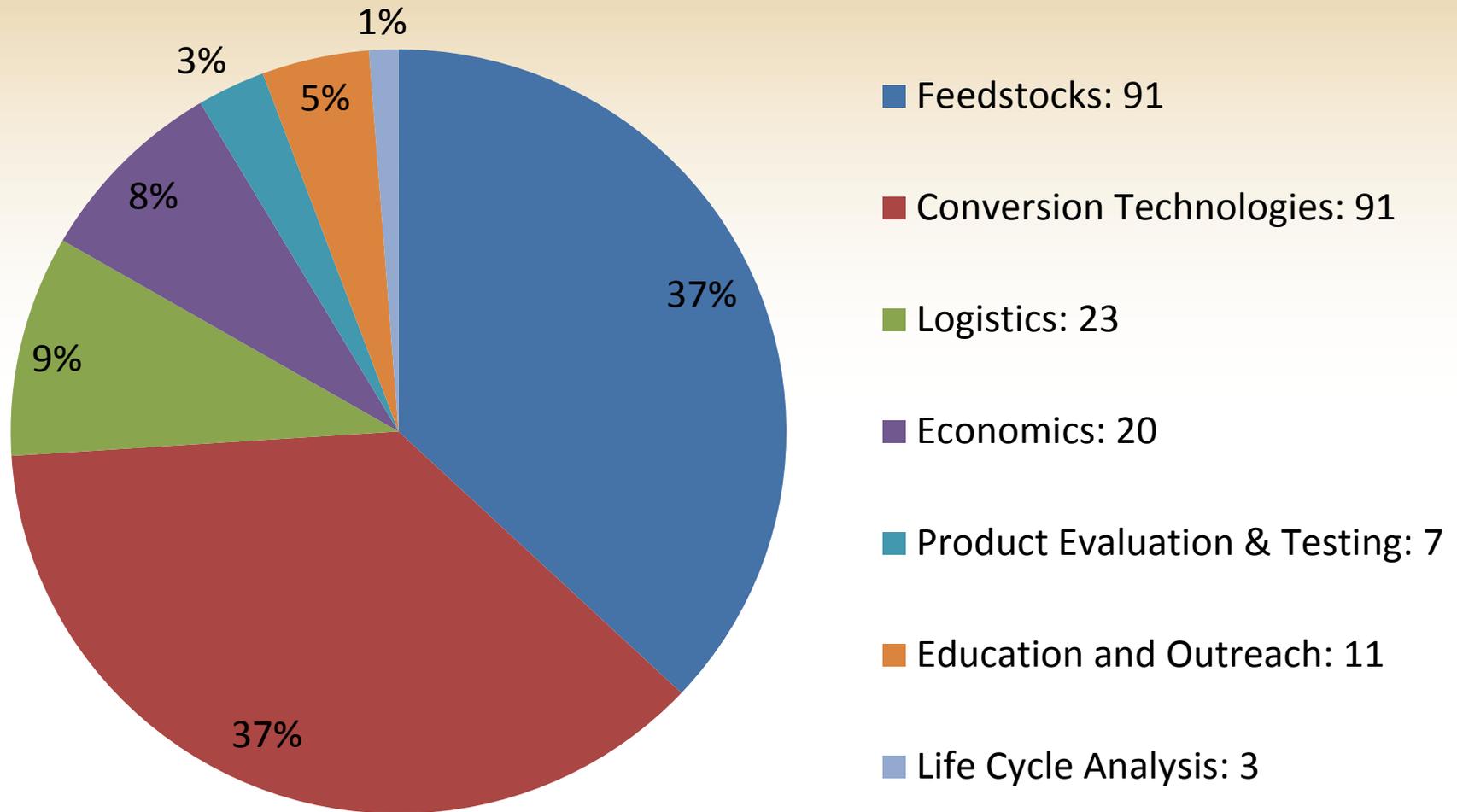
- Feedstocks include:

- Switchgrass
- Miscanthus
- Energycane
- Corn and cereal residues
- CRP
- Willow
- Poplar
- Prairie cordgrass
- Others

- Sustainability measurements

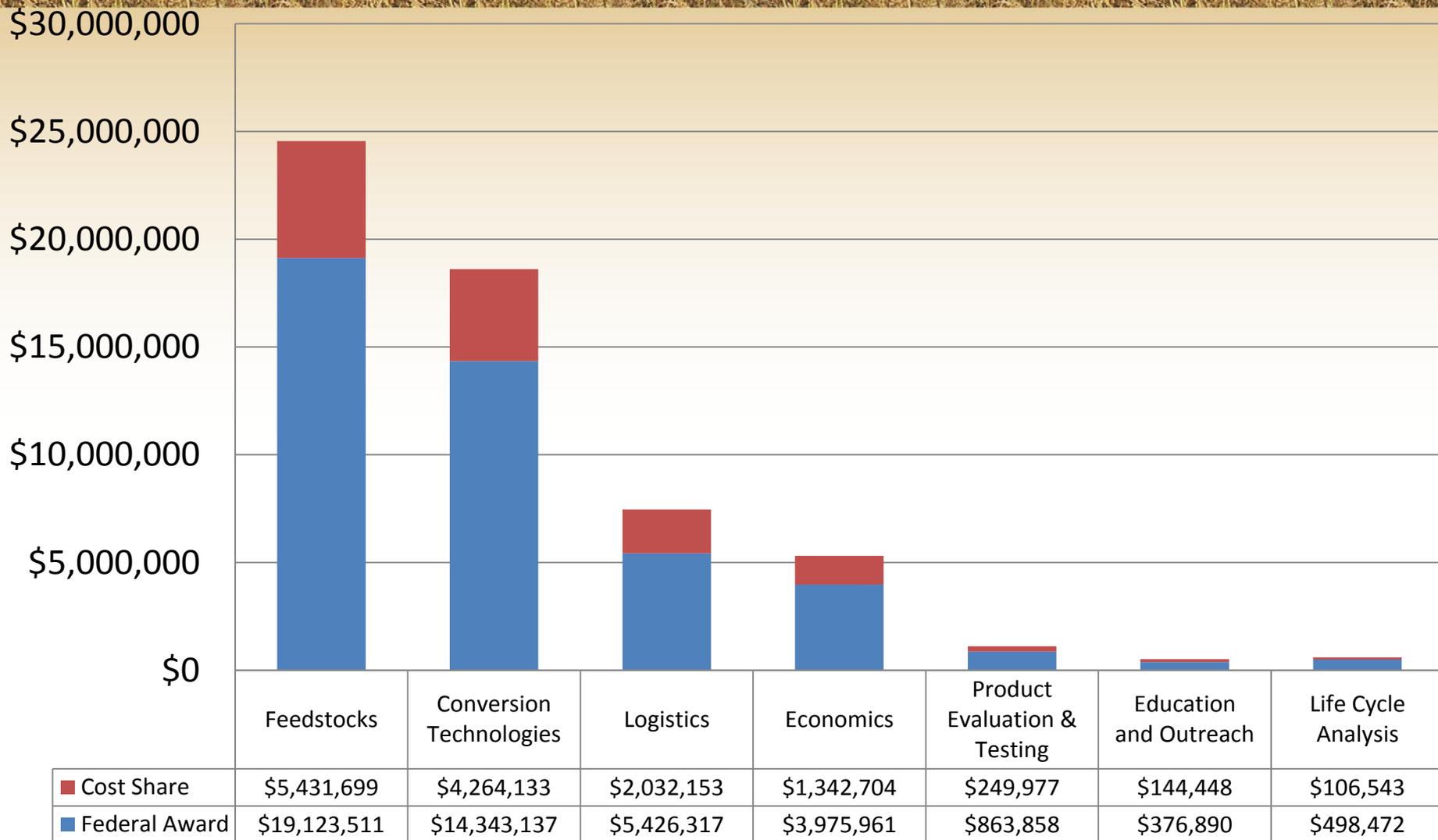


- Projects are typically multidisciplinary; however they are categorized based on one of the primary objectives
- During the last year several projects have been completed; most are still in-progress
- Estimated budget numbers in Fig. 2 are based on funding awarded and do not include administrative costs
- Budget figures do not include funds for the DOE-funded Regional Feedstock Partnership



*Most projects are multidisciplinary and thus include more than one type of activity. This figure simply indicates one of the predominant activities.

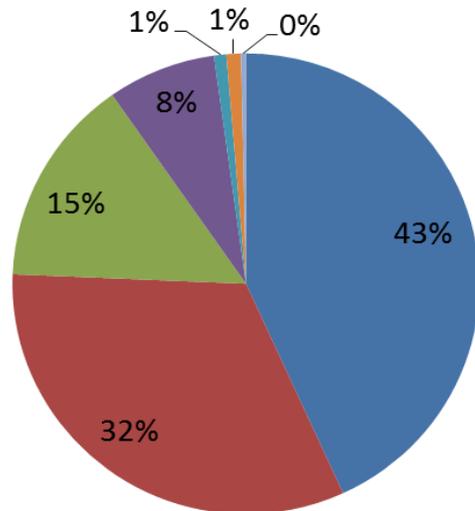
Fig. 2. Estimated Project Costs—All Agencies*



*Most projects are multidisciplinary and thus include more than one type of activity. This figure simply indicates one of the predominant activities.

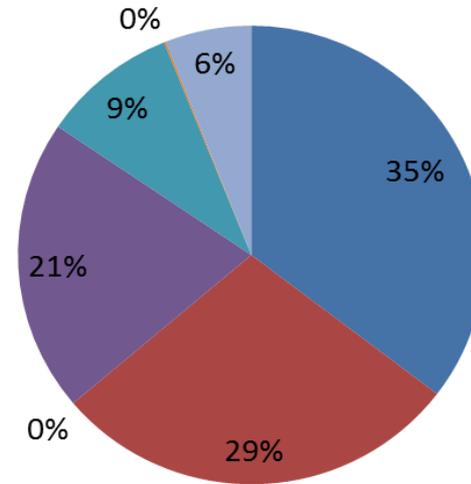
Competitive

- Feedstocks: \$22,005,487
- Conversion Technologies: \$16,555,348
- Logistics: \$7,458,470
- Economics: \$3,830,134
- Product Evaluation & Testing: \$433,810
- Education and Outreach: \$511,081
- Life Cycle Analysis: \$174,926



NON-Competitive

- Feedstocks: \$2,549,723
- Conversion Technologies: \$2,051,922
- Logistics: \$0
- Economics: \$4,488,531
- Product Evaluation & Testing: \$680,025
- Education and Outreach: \$10,257
- Life Cycle Analysis: \$430,089



*Most projects are multidisciplinary and thus include more than one type of activity. This figure simply indicates one of the predominant activities.

- Jobs
- Economy
- Partnerships (industry, state, federal)
- Catalyst—smaller projects



Western Region

- Western Sun Grant Center work with ZeaChem
- Feedstock supply assessment—poplar, cereal straw, grass straw
- Demonstration facility → commercial expansion in 2014

Lab/Bench
Menlo Park, CA



2006

Pilot
50,000 gallons/year (GPY)
Golden, CO



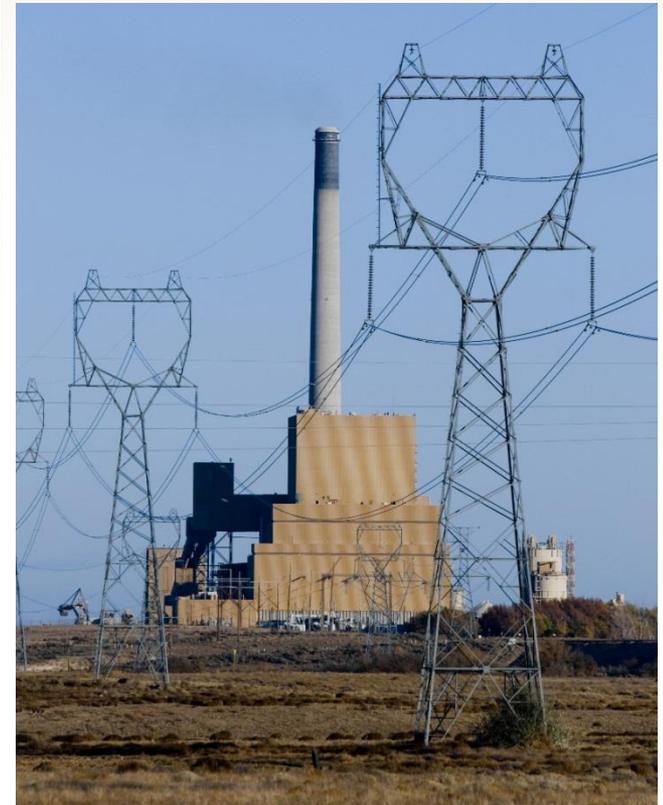
2009

Integrated Biorefining
Facility (IBR)
250,000 GPY
Boardman, OR
\$25M US DOE Grant



2011

- Seeking alternatives to coal to power the Boardman, OR Power Station by 2020
- Giant reed (*Arundo donax*)
- Jobs
- Producers
- Rotations





South Central Region

- Brings the gasifier to the biomass & converts it to combustible gas (wood chips, rice straw, cattle manure, etc.)
- SDL Citadel Global (Dallas, TX) has licensed the TAMU gasifier technology utilizing municipal solid wastes (MSW) for power generation
- Project associated with 4 MS and 1 Ph.D. student, 11 new associated grants, 5 peer reviewed articles, 11 presentations, 2 books and 3 outreach publications, 4 disclosed patents, 2 patents and 1 license issued, and 1 start-up job

Sergio Capareda—Texas A&M
\$279,380—South Central SG



Yangi Wu—Oklahoma State Univ.
\$200,000—South Central SG

- Created & licensed 'Cimarron', a new switchgrass cultivar
- Cimarron produces 10% more biomass than the best commercial variety
- Licensed Cimarron to Johnston Seed Company
- Project associated with 1 MS and 1 Ph.D. degree, 3 new associated grants, 8 peer reviewed articles, 10 presentations, 1 book and 1 outreach publication, 1 patent, 1 license, and 2 start-up jobs





North Central Region

Matthew Darr—Iowa State Univ.
\$699,557—North Central SG

- Experimental models for rapid in-field densification of CS
- CS harvest scenarios and economics
- Storage effects on CS quality
- Industry partners included DuPont and AGCO
- Project associated with 4 MS and 2 Ph.D. students, 10 undergraduates, 10 peer reviewed articles, 5 presentations





Associated project led by Ken Moore at ISU completed later evaluating potential ground cover crops in association with corn—sustainability

- Purpose is to advance commercialization of inventions developed through SDSU research
- Recent awards made to three PIs at SDSU
- Six month projects—total DOE funds of about \$107,000
- Required 20% cash cost share from industry partner(s)

Catalytic Fast Pyrolysis Conversion of Corn Stover to Transportation Fuels



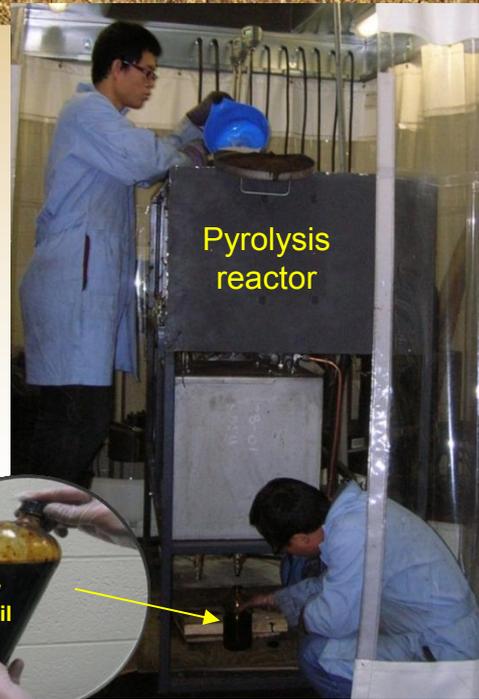
Forest residues



Corn stover

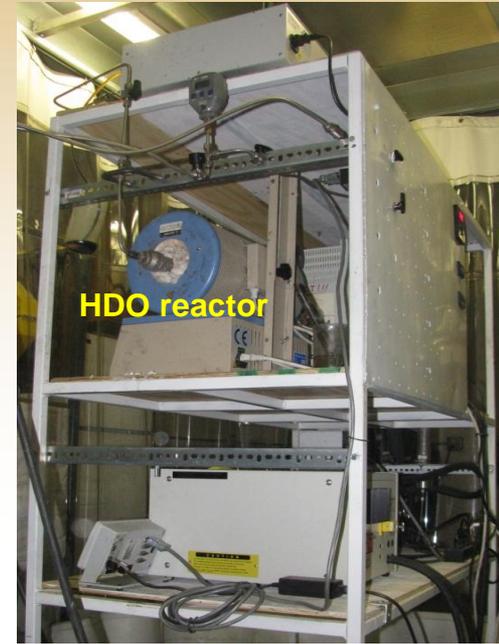


Switchgrass



Pyrolysis reactor

Raw bio-oil

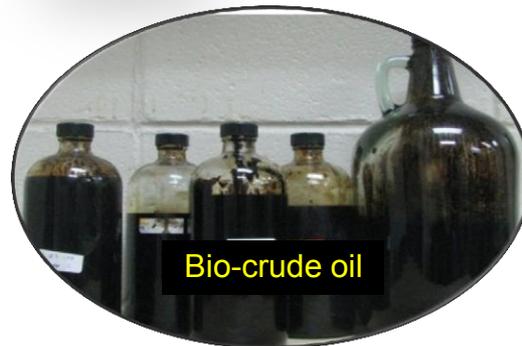


HDO reactor



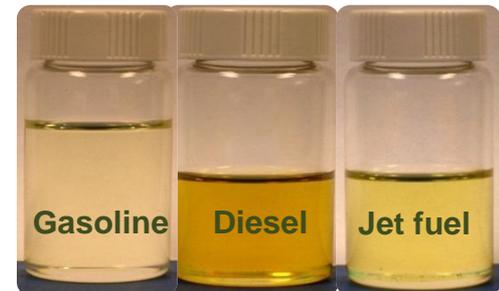
Corn stover

Pyrolysis



Bio-crude oil

HDO upgrading



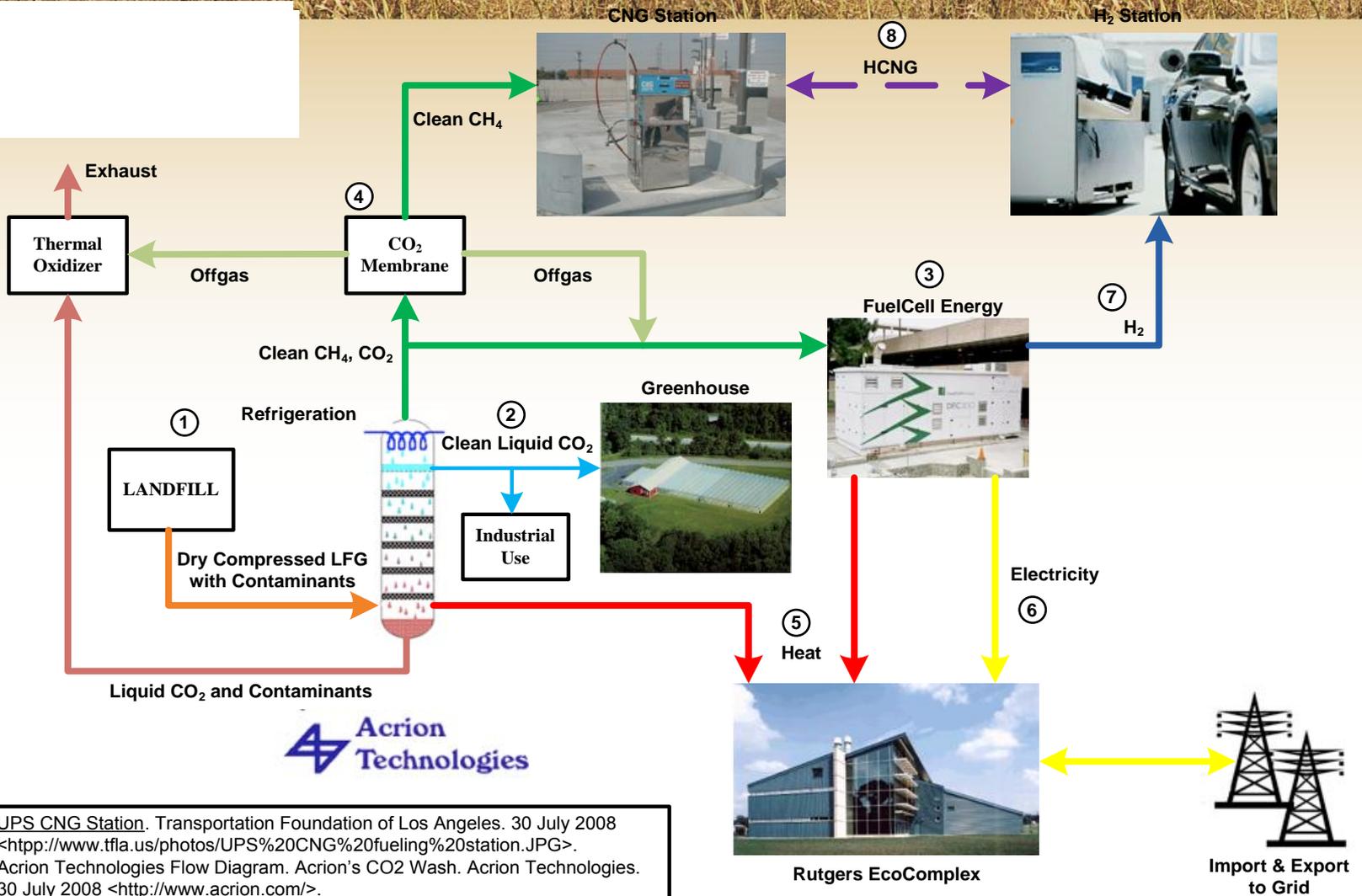
Gasoline

Diesel

Jet fuel



Northeast Region



UPS CNG Station. Transportation Foundation of Los Angeles. 30 July 2008
<http://www.tfla.us/photos/UPS%20CNG%20fueling%20station.JPG>.
 Acron Technologies Flow Diagram. Acron's CO2 Wash. Acron Technologies.
 30 July 2008 <http://www.acron.com/>.
 FuelCell Energy DFC 300. [Carlist.com](http://www.carlist.com). 30 July 2008
<http://www.carlist.com/autonews/image/fedcdcf300.jpg>
 Linde H2 Fueling station. The Linde Group. 30 January 2008
<http://financialreports.linde.com/2007/ar/pics/img/a45a.jpg>.

<p>CO₂ Wash® landfill gas cleaning system</p> 	 <p>Burlington County, New Jersey Resource Recovery Complex</p>
<p>Direct FuelCell® and Hydrogen co-production technologies</p> 	<p>CNG/H₂/HCNG compression and refuelling stations</p> 
 	



Southeast Region

1

Energy Crop Production

- 5,000 acres of switchgrass
- Contract with private farmers
- Refined management practices



2

Preprocessing Technology

- Biomass storage and handling logistics
- Enhanced feedstock quality



3

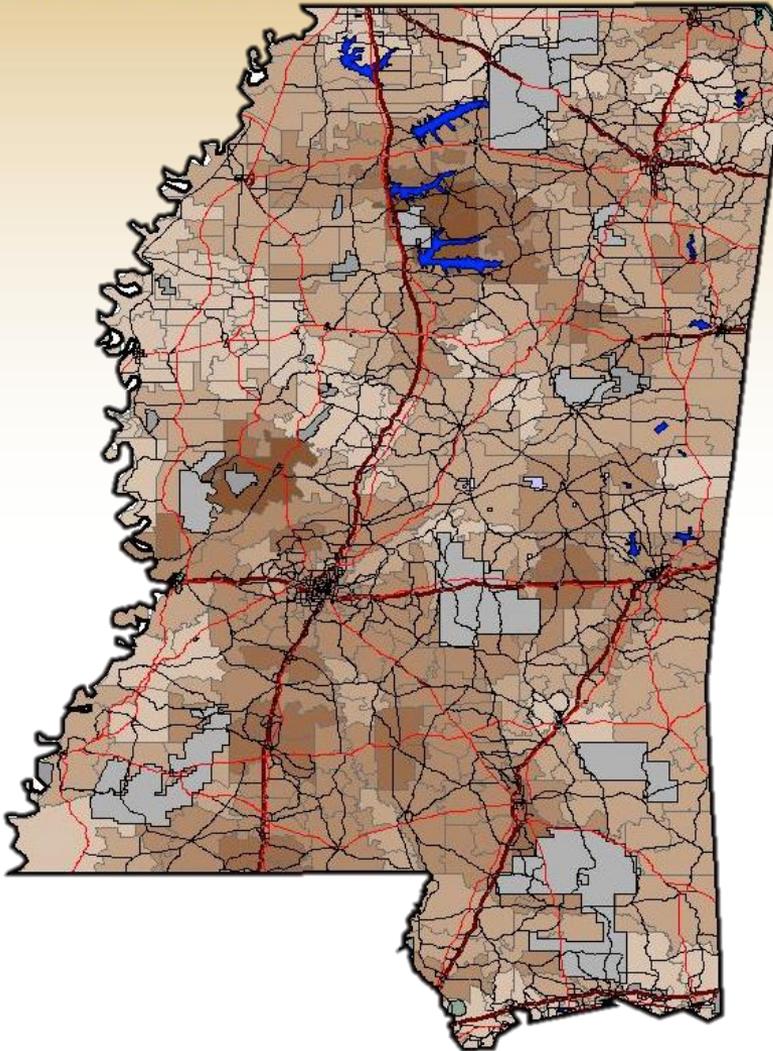
Biorefining

- Cellulosic ethanol
- 250,000 gpy capacity
- 1/100-scale PDU available



- Transportation and storage directly impacts feedstock quality and costs
- Partnership with BaleTech to evaluate optional technologies
- Preliminary results indicate stretch-wrapped outperforms conventional in terms of delivered cost





- BioSAT – quickly screen & identify least cost biomass collection or processing demand centers (33 Eastern states)
 - *Web-based for easy access*
 - *Assess economic availability of biomass*
 - *Broad collaboration with USFS-SRS, private industry, ENGO's, other universities*
- BioFLAME – GIS-based logistics tool
- POLYSYS-FOR – incorporating woody crops into land-use model
- Biomass Transport Emissions (w/ DOT-UTC)

- What is BioWeb?
- An online encyclopedia of everything biomass
- Feedstocks, biofuels, biopower, bioproducts, biorefineries
- Comprehensive and consistent content
- Tailored to various audiences
- Using best available technology to develop, deliver, and maintain
- Easy to use and navigate



SunGrant BioWeb
...an on-line resource for bioenergy and bioproducts

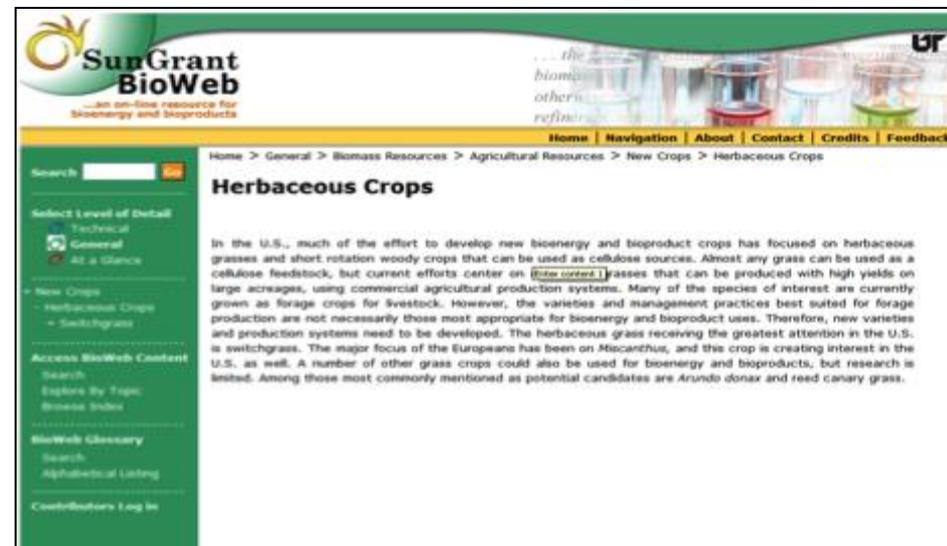
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Switchgrass

Switchgrass (*Panicum virgatum*) is a warm season perennial whose native range includes all of the U.S. east of the Rocky Mountains, extending into Canada and Mexico. It is a major species of the prairies that covered much of the American heartland prior to the introduction of agriculture. Switchgrass is a C4 species (i.e., the first product of photosynthesis is a four carbon compound), consists of numerous upland and lowland varieties, and displays substantial genetic diversity. Switchgrass has been produced as a forage crop and used for conservation purposes for many years. Its development as a potential energy crop began in 1991 as part of the U.S. Department of Energy's Biomass Feedstock Development Program at Oak Ridge National Laboratory. Field trials were established at 18 sites (13 states including VA, WV, TN, KY, NC, GA, AL, TX, AR, LA, ND, SD, and IA). Nine cultivars were evaluated to identify best regional varieties, establish appropriate management practices, and conduct genetic research to improve yield and performance characteristics. The Alamo variety was determined to be the best cultivar tested for production in the South, Alamo and Karlow best for mid-latitude production, and Cave-in-Rock, Trailblazer, and Sunburst varieties best suited for northern latitudes.

Under research conditions (5-10 years data; one cut production system, multiple sites and states), yields of genetically unimproved Alamo and Karlow averaged 12 to 19 Mg/ha/year (5.35 to 8.45 dry ton/ac/year) and 11.6 to 15.5 Mg/ha/yr (5.2 to 6.9 dry tons/ac/year) respectively. The best one year yield attained under a two cut system was for Alamo in Alabama (34.6 Mg/ha; 15.4 dry tons/ac). Both Alamo and Karlow varieties produce high yields in the South (except for arid conditions in TX) under a one and two cut system, maintaining high yields for a number of years. However, two cut systems are more intense and require greater energy and nutrient inputs than single cut systems. The oldest continuous research plot for Alamo was established at Auburn University in 1988 and has averaged 23 Mg/ha (about 10 dry tons/ac) over a 13 year time period. First generation synthetic cultivars



SunGrant BioWeb
...an on-line resource for bioenergy and bioproducts

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Herbaceous Crops

In the U.S., much of the effort to develop new bioenergy and bioproduct crops has focused on herbaceous grasses and short rotation woody crops that can be used as cellulose sources. Almost any grass can be used as a cellulose feedstock, but current efforts center on late harvest grasses that can be produced with high yields on large acreages, using commercial agricultural production systems. Many of the species of interest are currently grown as forage crops for livestock. However, the varieties and management practices best suited for forage production are not necessarily those most appropriate for bioenergy and bioproduct uses. Therefore, new varieties and production systems need to be developed. The herbaceous grass receiving the greatest attention in the U.S. is switchgrass. The major focus of the Europeans has been on Miscanthus, and this crop is creating interest in the U.S. as well. A number of other grass crops could also be used for bioenergy and bioproducts, but research is limited. Among those most commonly mentioned as potential candidates are *Arundo donax* and reed canary grass.



Regional Feedstock Partnership

- Sun Grant/Land Grant/DOE/USDA-ARS partnership
- Funding
 - DOE—\$18,919,986
 - Cost Share—\$4,729,997
- Feedstock field trials
 - Woody species
 - Poplar, willow
 - Corn stover
 - Small grain residue
 - Herbaceous crops
 - Energycane, Sorghum, CRP
 - Miscanthus, Switchgrass



- Large field trial data set
- Resource Assessment
 - Regional and national maps
- Sustainability
 - GHG, soil quality, water quality
 - Corn, sorghum, switchgrass, miscanthus



- Broad scope of projects—cover entire bioenergy value chain
- Primarily early stage projects that may not have been funded in other programs
- Projects have often been catalyst for further research activity
- Strong linkage to industry