

Engineering Woody Feedstocks for Biofuels

Overview of Federal R&D Efforts

Presented by

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SunGrants Programs

Overview

- Department of Agriculture -U.S. Forest Service
- Department of Energy- Office of Science
- Department of Energy- Office of Biomass Program
- Joint USDA/DOE Solicitation
- SunGrants Institutions- Forestry

U.S. Forest Service

Genetics and Tree
Breeding Research for
Energy and Biobased
Products



U.S. Forest Service R&D

- Developing science and technology to sustainably produce, manage, harvest and convert forest biomass.
- Wood to energy (heat-power-biofuels), chemicals and other wood products
- Dimensions include improved planting stock genetics and biotechnology, harvesting and transportation, processing and storage, conversion, economics, and sustainability.



Forest Service R&D: Feedstock Management Systems

- Regeneration options
- Density relationships
- Nutrient and water use efficiency
- Product optimization
- Functional optimization





Forest Service- Genetics R&D

- **Traditional tree breeding**
 - Poplar
 - Willow
 - Loblolly pine
 - Eucalypts
- **Genome sequencing and mapping**
- **Screening**
 - Wood formation
 - Crown architecture
- **Potential**
 - Enhanced breeding, testing and selection
 - Infrastructure for breeding traits and adaptability
 - Enhanced yield, specific stress tolerance, fertility control, eliminating undesirable crop characteristics

Forest Service R&D: Sustainability

- **Productivity**
- **Soil and water quality**
- **Habitat**
- **Landscape function**
- **Land use change**
- **Net energy and net GHG emissions**



U.S. Department of Energy

The DOE Bioenergy Research Centers

*Adapted from
Patrick Glynn, Ph.D.*

**Program Manager
DOE Bioenergy Research Centers
U.S. Department of Energy
Office of Science**

<http://genomicsgtl.energy.gov/centers/>

Bioenergy Research Centers Solicitation Package

DOE/SC-0097

U.S. Department of Energy's
**Genomics:GTL
Bioenergy Research Centers**



 Office of
Science

 GTL
Bioenergy
Research
Centers

White Paper



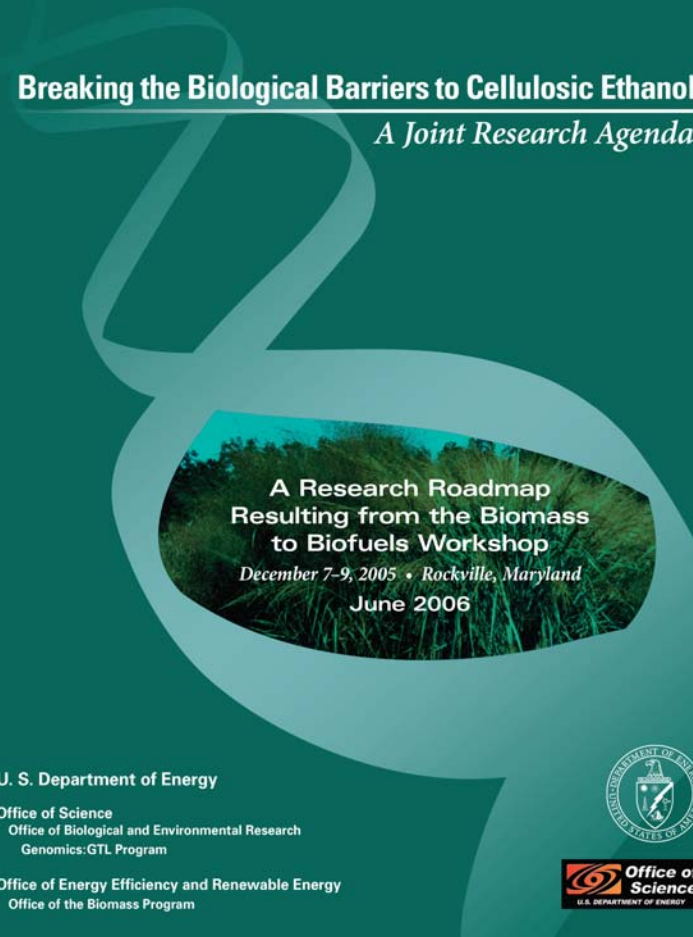
DOE GENOMICS:GTL
SYSTEMS BIOLOGY
FOR ENERGY AND
ENVIRONMENT

OFFICE OF SCIENCE
U.S. DEPARTMENT OF ENERGY


August 2006

DOE/SC-0095

Breaking the Biological Barriers to Cellulosic Ethanol
A Joint Research Agenda




**A Research Roadmap
Resulting from the Biomass
to Biofuels Workshop**
December 7-9, 2005 • Rockville, Maryland
June 2006



U. S. Department of Energy
Office of Science
Office of Biological and Environmental Research
Genomics:GTL Program

Office of Energy Efficiency and Renewable Energy
Office of the Biomass Program

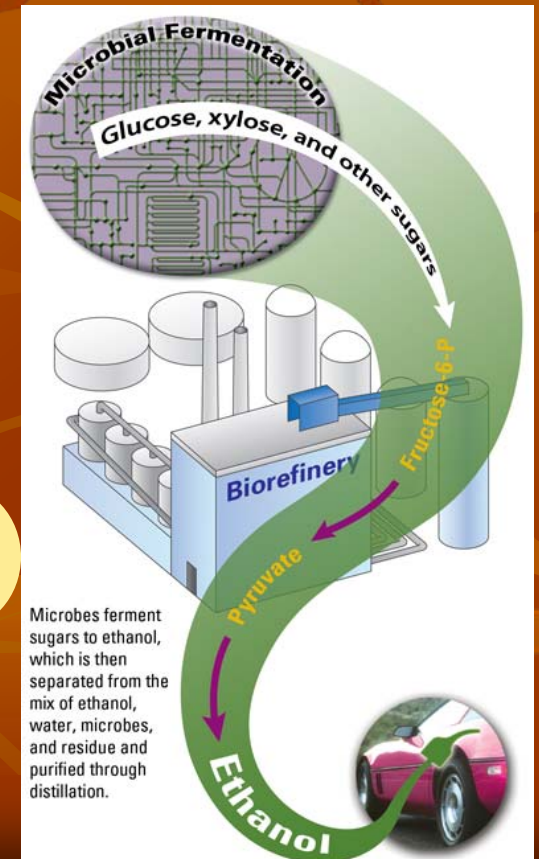
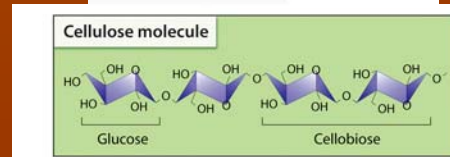
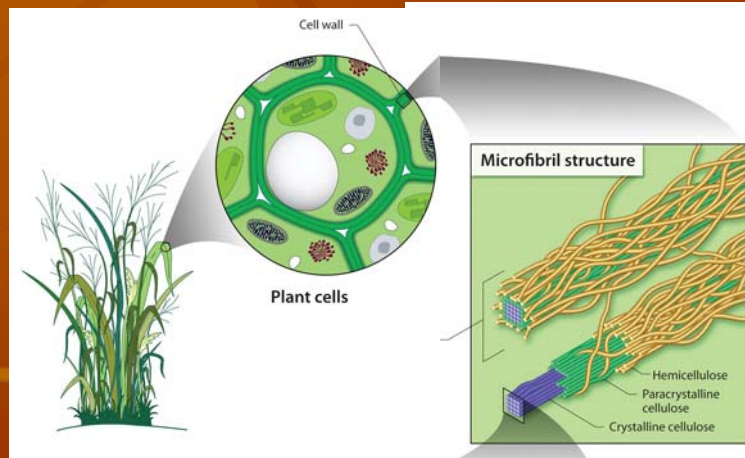


**Office of
Science**
U.S. DEPARTMENT OF ENERGY

Making Cellulosic Ethanol

Basic Transformation

Lignocellulose → Sugars → Ethanol





DOE- Bioenergy Research Centers Basic Rationale

- Cost-effective production of cellulosic biofuels will require transformational breakthroughs in *basic* science
- The scientific problem is highly challenging, but very well defined
- Systems biology and biotechnology revolution provide powerful new tools for addressing this challenge

Partnerships and Funding

- To be funded at up to \$25 million per Center per year for five years (\$375 million total DOE investment planned)
- All are partnerships: total of 18 major universities, 7 national labs, several private firms, and a nonprofit

Complementary, Synergistic Research Agendas

- **DOE BioEnergy Science Center (BESC)** led by DOE's Oak Ridge National Laboratory (ORNL) in Oak Ridge, Tennessee.
 - Emphasis on overcoming “recalcitrance” and improving deconstruction
 - Focusing on switchgrass and poplar (building on ORNL work)
- **DOE Great Lakes Bioenergy Research Center (GLBRC)** led by the University of Wisconsin in Madison, Wisconsin, in close collaboration with Michigan State University in East Lansing, Michigan.
 - Focusing on a variety of different plants; agronomic orientation
 - Will also study economic and environmental sustainability
- **DOE Joint BioEnergy Institute (JBEI)** led by DOE's Lawrence Berkeley National Laboratory.
 - Focusing on “model crops” of *Arabidopsis* and rice, with expectation of transferring knowledge to bioenergy crops
 - Strong focus on microbial processes and fuel synthesis
- All 3 centers will make use of DOE Joint Genome Institute, light sources, and other facilities in the Office of Science complex

DOE- Biomass Program- Feedstocks

Office of Energy Efficiency and
Renewable Energy

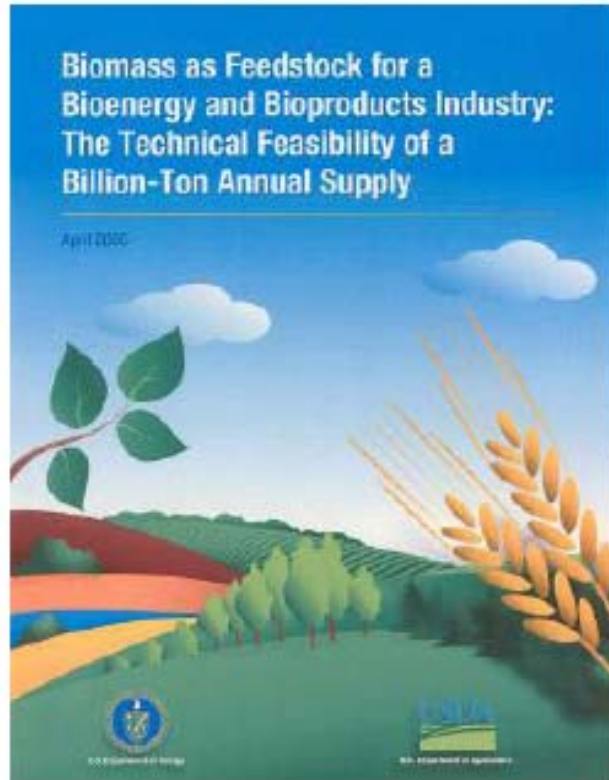
Judy K. Partin

Pacific Northwest Laboratory



DOE Biorefining Industry 2030 Goals

biomass program



Biomass as Feedstock for a
Bioenergy and Bioproducts Industry:
The Technical Feasibility of a
Billion-Ton Annual Supply

April 2000

<http://bioenergy.ornl.gov>

Displace a significant fraction of gasoline demand
~ 60 billion gallons/year by 2030



~1.3 Billion tons/yr
Biomass Potential
in the U.S.

Sugar Platform

Syngas Platform



*Including Corn Grain, an Estimated 600 – 700 Million Tons
of Biomass per Year is Needed for 60 B gal of ethanol*



biomass program

- **Agricultural resources (998 MDT)**

- **Crop residues (428 MDT)**
 - corn stover, wheat straw
 - barley straw, soybean forage
- **Grains to biofuels (87 MDT)**
 - corn, wheat, milo
 - soybeans, other oil seeds
- **Perennial crops (377 MDT)**
 - grasses- switchgrass, prairie grass, miscanthus
 - woody – willow, poplar
- **Other residues (106 MDT)**
 - animal manure
 - food/feed processing residues
 - MSW and landfill gases





biomass program

- **Forest resources (368 MDT)**

- Forest thinnings (60 MDT)
- Fuelwood (52 DMT)
- Industrial wastes (145 MDT)
 - Wood processing mill residues
 - Pulping (black) liquors
- Logging residues (64 MDT)
- Urban wood residues (47 MDT)
 - Construction and demolition debris
 - Packing wastes

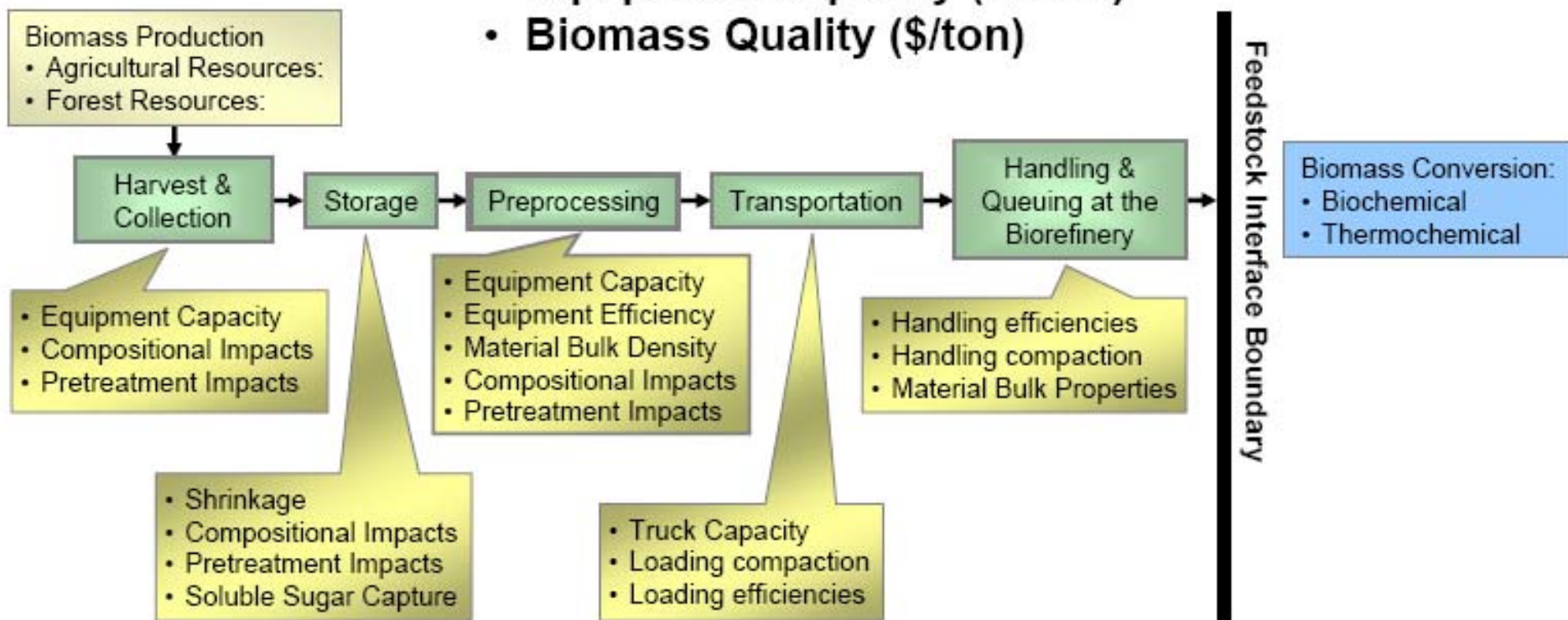




biomass program

Performance Metrics:

- **Efficiency (\$/hr)**
- **Equipment Capacity (ton/hr)**
- **Biomass Quality (\$/ton)**

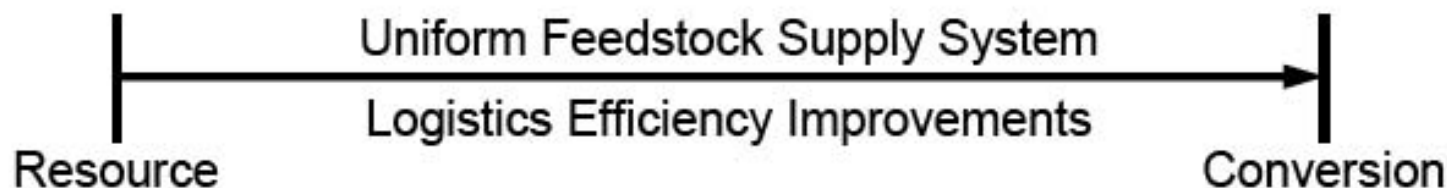




Feedstock Supply Logistics

biomass program

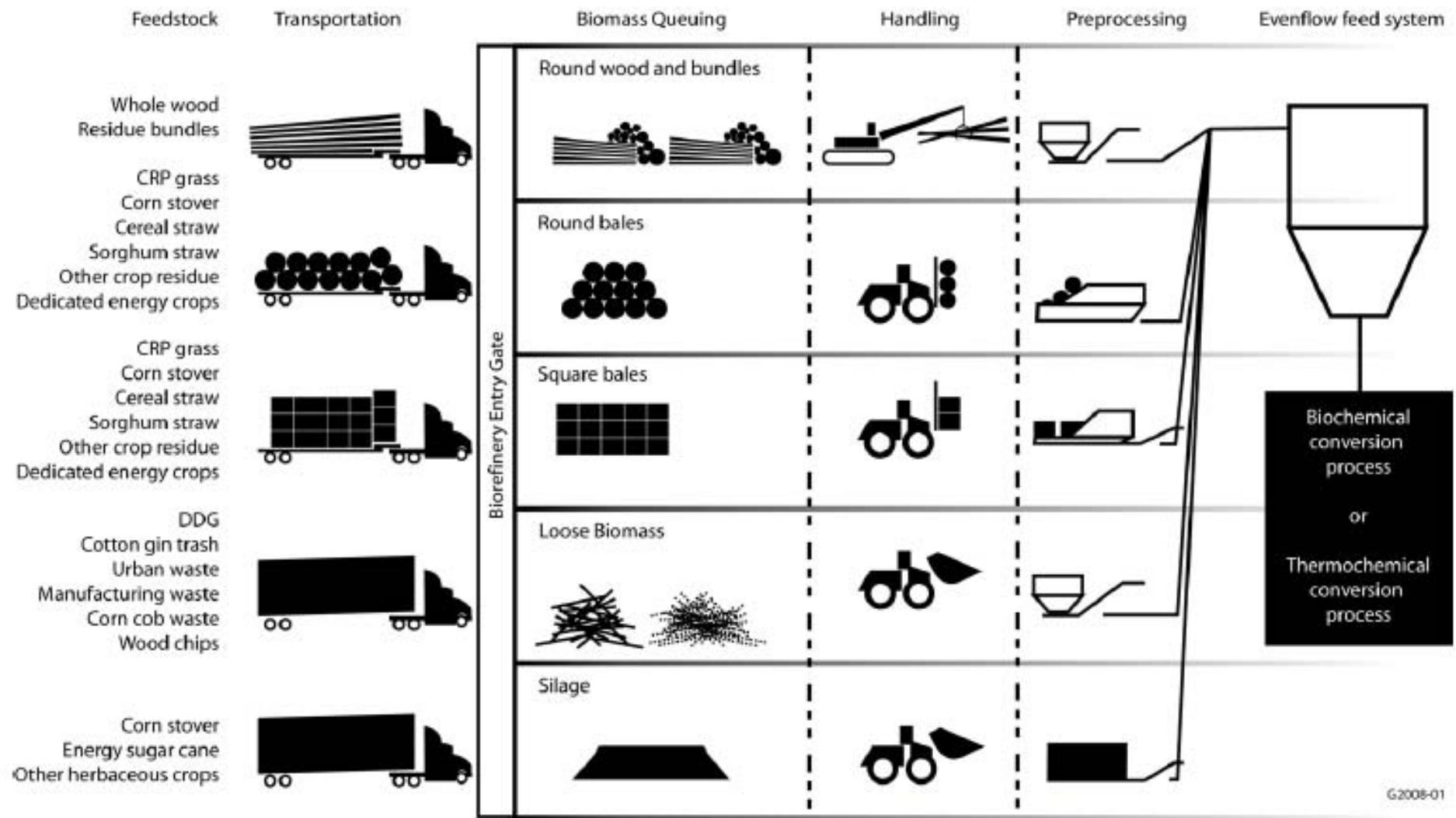
- Connect the Diversity of Feedstock Resources to Standardized Biorefinery Conversion Facilities (Biochemical and Thermochemical)
 - Standardize biomass material attributes (physical properties) and quality specifications
 - Commodity Scale Lignocellulosic Supply System
- Improve Feedstock Supply System Logistics
 - Engineer (preprocess) biomass materials for more efficient handling/storage
 - Moisture management for stable storage
 - Utilize existing high efficiency solid/liquid handling infrastructure
- Feedstock Crop Development and Sustainable Production





Pioneer Feedstock Supply System

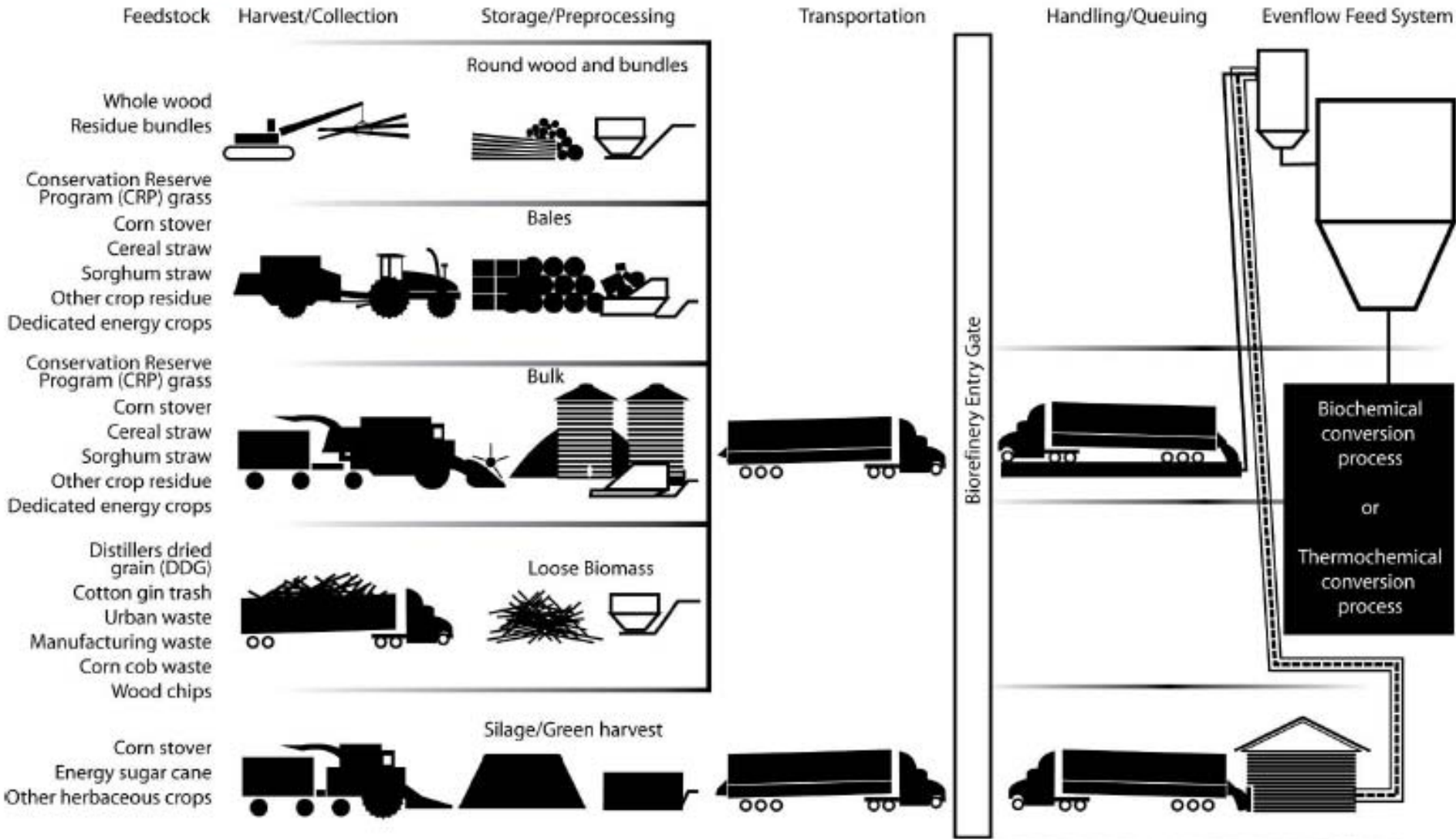
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Uniform Feedstock Supply System Design

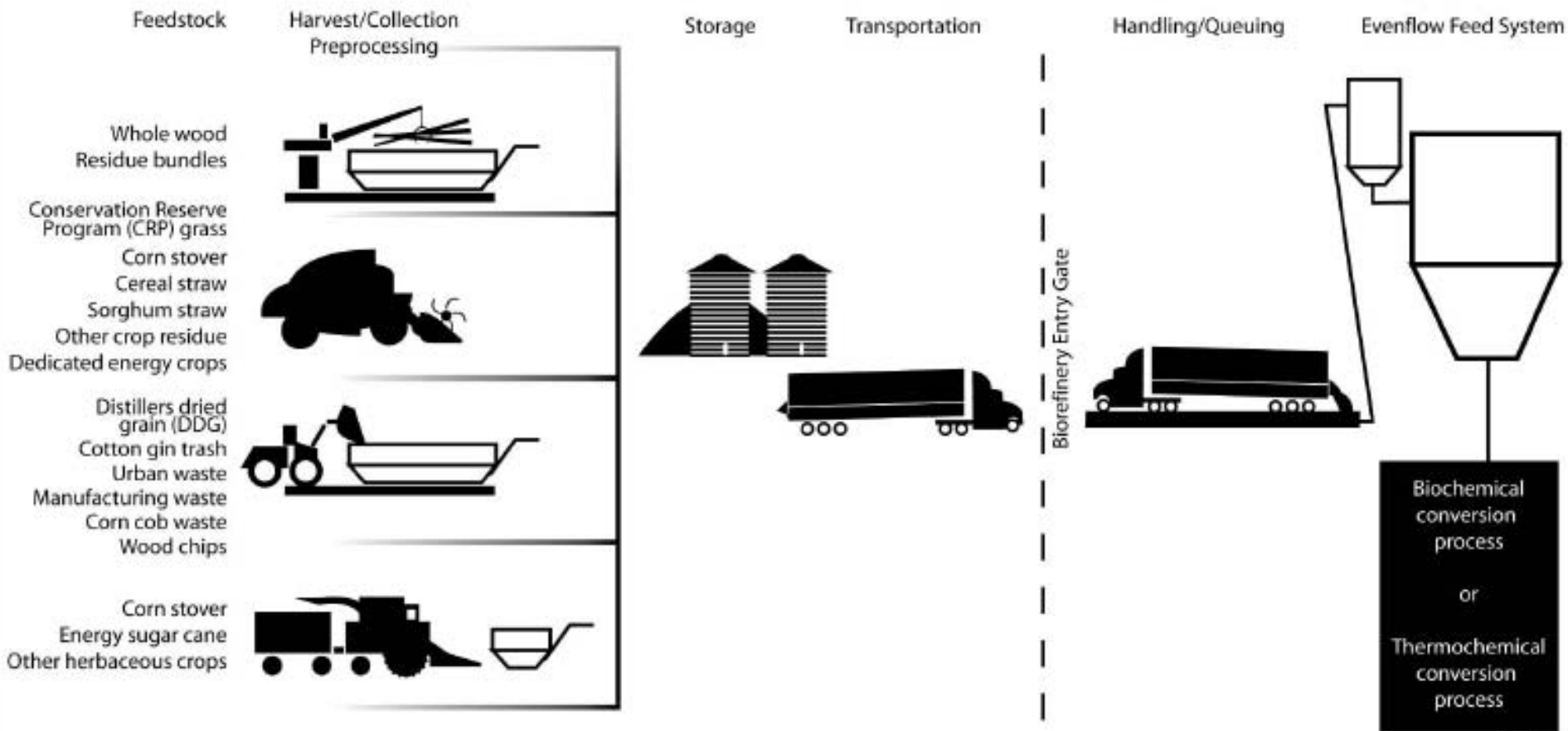
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Advanced Feedstock Supply System Design

biomass program

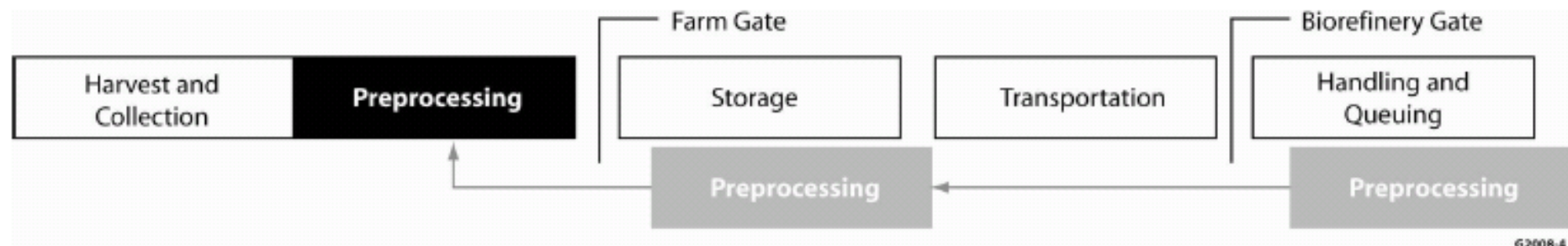
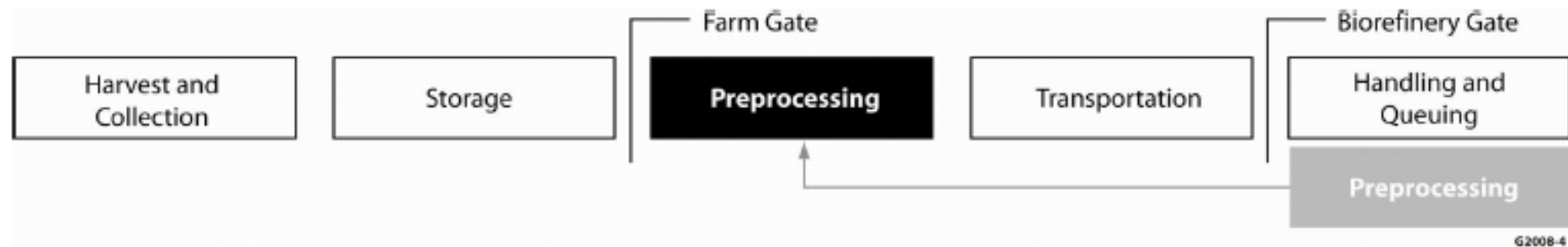




R&D Path to the Uniform Feedstock Supply System Design

biomass program

- Harvesting/Collection and Preprocessing are Key Unit Processes
- Harvesting addresses feedstock diversity
- Moving preprocessing forward in the supply system creates down-stream uniformity and increases system efficiencies





Application to Woody Biomass

biomass program

• Conduct State of Technology Assessments

– Identify underutilized resources

- Forest harvest residues
- Forest thinnings
- Short-rotation woody crops
- Urban wood waste

– Model unit operation costs

- Harvest and Collection
- Preprocessing and Storage
- Transportation and Handling

– Determine opportunities for optimization

- Efficient harvesters for small-diameter trees
- Flexible on-site grinding operations for material formatting
- In-expensive material quality screening techniques



**Joint USDA/DOE
Biomass Research and
Development Initiative**

BR&Di
BIOMASS RESEARCH & DEVELOPMENT INITIATIVE

The Energy Policy Act of 2005 amended Section 307(d)(1) – (4) of the Biomass R&D Act of 2000 and set forth the technical areas for the joint solicitation.

The Technical Areas are:

- 1) Feedstock Production through the development of crops and cropping systems relevant to production of raw materials for conversion to biobased fuels and biobased products.
- 2) Overcoming Recalcitrance of cellulosic biomass through developing technologies for converting cellulosic biomass into intermediates that can subsequently be converted into biobased fuels and biobased products.
- 3) Product Diversification through technologies relevant to production of a range of biobased products (including chemicals, animal feeds, and cogenerated power) that eventually can increase the feasibility of fuel production in a biorefinery.
- 4) Analysis that provides strategic guidance for the application of biomass technologies in accordance with realization of improved sustainability and environmental quality, cost effectiveness, security, and rural economic development, usually featuring system-wide approaches. Joint Solicitation Awards

Sun Grant Centers



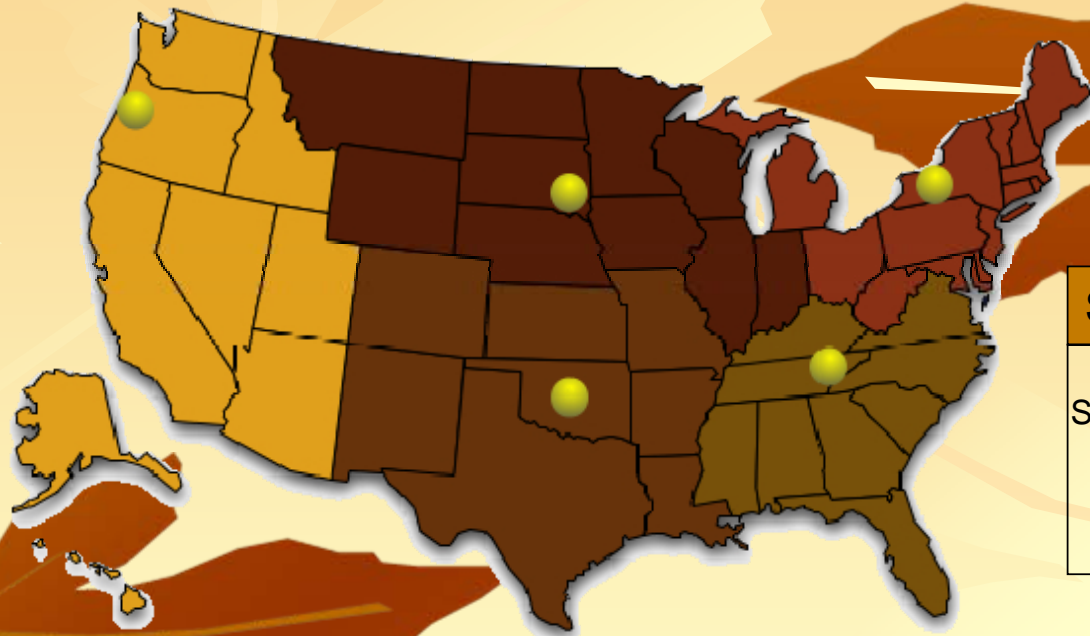


The Sun Grant Mission

Through development, distribution and implementation of biobased energy technologies, the Sun Grant Initiative holds these aims:

- Enhance America's national energy security
- Promote diversification and environmental sustainability of America's agriculture
- Promote opportunities for economic diversification in America's rural communities

The Sun Grant Initiative



SGI Regional Centers

Oregon State University
South Dakota State University
Oklahoma State University
Cornell University
University of Tennessee

*A concept to solve America's energy needs and
revitalize rural communities with Land Grant University Research,
Education, and Extension programs
on renewable energy and biobased, non-food industries*

Feedstock Workshops

- ❑ Partnership with DOE Office of Biomass Programs
- ❑ Feedstock development workshops held in each region (2006-2007)
- ❑ Collected input from stakeholders on biomass availability and sustainable supply

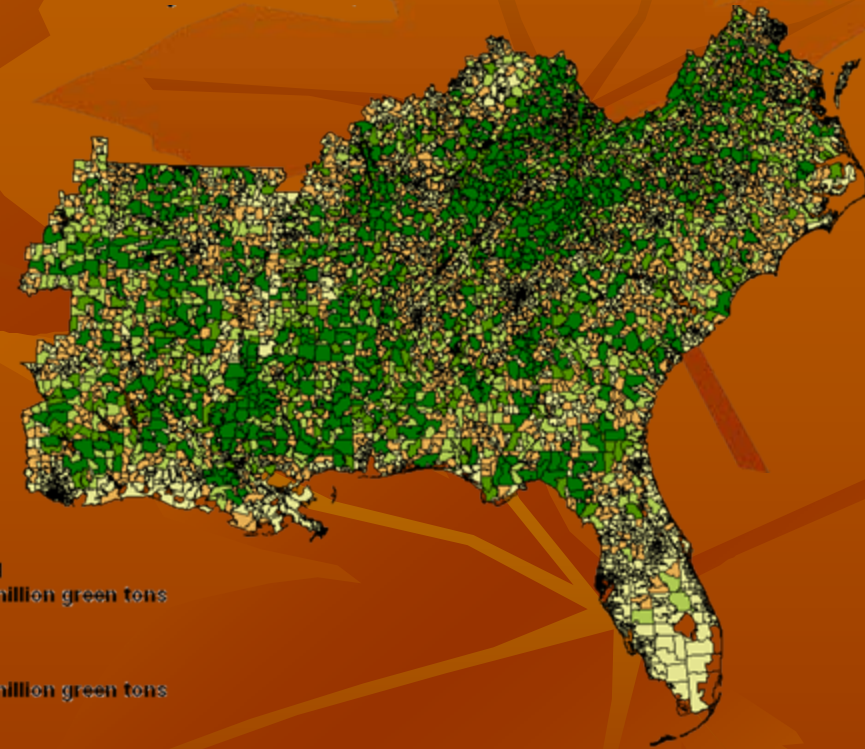


Regional Partnership Program

- Biomass resource assessment
 - Issues related to biomass supply, costs, food vs. fuel, water availability
 - Spatially explicit data
- Biomass resource development
 - Optimize residue removal systems for wood, herbaceous, and grain crops
 - Wide-scale field trials to fill information gaps
 - Woody crops national lead housed in SE (Univ. of TN)
- Biomass crop development
 - Increase biomass production through breeding and new plant development
- Education and outreach
 - Expand BioWeb content and other information delivery options

Bioenergy Feedstock Atlas

- National estimate of feedstock potential (supply curves) based on regional input
- Identification of sustainability limits
- Nationally coordinated, Regionally managed
- Standardized data
 - Field data
 - Spatial data layers
- Integration of literature and field data to develop relationships between yield and environmental factors
- Economic analysis of production to delivery using regional data.



OUR COMMON FUTURE

THE WORLD COMMISSION
ON ENVIRONMENT
AND DEVELOPMENT



Sustainability

“...the capacity to meet the needs of the present without compromising the ability of future generations to meet their own needs”

(Brundtland Commission, 1987)

Economy

Society

Environment

Managing our lands for energy, food and fiber



Thank you!



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For more information, please visit:
<http://www.fs.fed.us/woodybiomass>