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- CAST is a nonprofit organization composed of scientific societies and many individual, student, company, nonprofit, and associate society members.
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Primary Objective

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• The wide distribution of CAST publications to nonscientists enhances the education and understanding of the general public.
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- Published 48 times each year
- More than 60 current agricultural news items--gleaned from 100+ sources
- News articles are categorized in areas of emphasis that parallel the three CAST work groups, and the “page 1” stories often feature CAST activities
- Washington, D.C. congressional updates from Meyers and Associates
Infrastructure Considerations for Biomass Harvest, Transportation, and Storage

Convergence of Agriculture and Energy: IV.
CAST Commentary QTA2010-2
September 2010

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Background

• The U.S. is committed to using biomass to replace fossil fuels
• Biomass includes all plant and plant-derived materials
• The Energy Independence and Security Act of 2007 (EISA 2007) mandates 136 billion liters (36 bil. gal.) of renewable fuels by 2022 and 79 billion liters (21 bil. gal.) of advanced biofuels and cellulosic ethanol by 2022
U.S. Policy Objectives

• Decrease
  — Imports of petroleum
  — Trade deficit
  — National security concerns

• Decrease greenhouse gases

• Foster the growth of agriculture, forestry, and rural economies
Cellulosic Biofuels

• The first generation of biofuels has been produced primarily from starches, plant oils, and sugars historically used for food.

• We focus on the second generation, i.e. cellulosic biomass crops that are generally inedible for humans. Primary examples – crop residues, perennial grasses, perennial woody crops, and forest management residues.

• Look at two case studies – corn cobs and switchgrass.
Sustainable Collection of Biomass

• The amount of biomass that can sustainably be removed from the field is dependent upon
  — Carbon content of soil
  — Micronutrients in biomass removed
  — Mass left to protect soil from erosion
  — Terrain and climate

• More than 700 million metric tons (MT) of cellulosic biomass feedstocks can be harvested economically and sustainably for biofuels in the United States
Biomass Logistics

- A well-defined system of on-farm bins, grain elevators, transportation equipment, and commodity markets exists to supply corn grain ethanol plants.

- A similar system does not exist to supply biomass feedstocks for energy and industrial use.
Differing Cost Structures to Produce Biomass

• Residue collection has a different cost structure than dedicated crops

• Dedicated perennials – i.e. switchgrass or woody crops – have a different cost structure than annual plantings

• Large up front costs, i.e. tree plantation (How long to first harvest?)

• Opportunity costs of long term commitment – can’t change easily between cash crops
Farm Costs of Producing Biomass

- Land rent
- Management
- Seed, planting, establishment, weed control
- Collection and harvesting
- Transportation and handling
- Storage
Harvest Window

- Can be critical
- Varies by crop
- Typically harvest once a year
- Time frame frequently limited by growing cycle, weather, or other field work
Biomass Collection Methods

- Baling (Dry)
- Chopping (Wet or Dry)
- Loafing (Dry)
Baling

- Mow
- Field dry
- Windrow (Rake)
- Bale
  (Round or Square)

Size, weight, and density can vary
**Bales**

**Round Bale example**
- 1.5m diameter by 1.8m long (5 by 6 ft)
- up to 580 dry kg (1250 lb)
- 10 bales per wagon,
  17 per flat bed truck

**Square Bale example**
- 1.2m square by 2.7m long
  (4 by 9 ft)
- up to 588 dry kg (1250 lb)
- 17 bales per wagon,
- 28 per truck
Chopping of Stover and Hay

- Forage harvester or chopper
- Forage wagon
- Compressed and stored in bunkers
- Some biomass crops (switchgrass) can be direct chopped and harvested dry, reducing trips over the field
Loafing

• Pickup from windrow
• Compress and make dome-shaped stacks
• Densify with roll compaction to 240kg per cubic meter
• Transport 22.5 MT per truckload
Biomass Storage

• Storage is generally required since harvest occurs once a year but biorefinery runs year-round

• Storage losses and costs will occur whether biomass is stored at
  – Farm
  – Intermediate or aggregator site
  – Biomass processing site
Farm Level Storage

- On-farm storage is low cost and provides flexibility
- Need to remove from field to a prepared surface
- Covered or open (wrapped, tarp, or structure)
- Storage losses
- Moisture content, ventilation, combustion risk
Storage and/or Aggregation at Off-Site Locations

• Require all-weather roads with few load restrictions
• Loading equipment
• Scales
• Densification equipment
• Office
• Share crews and equipment between multiple locations
Inventory Carrying Costs - 1

- Processors generally need to own or control a year’s supply of raw material after harvest.

- Inventory Carrying Costs are real and accrue to the system (are a cost to someone) no matter whether storage occurs at the farm, processor, or an intermediate site!!
Inventory Carrying Costs - 2

• Inventory Carrying Costs include
  – taxes, depreciation, insurance, and maintenance expenses of storage sites and structures
  – weight and quality losses of stored biomass (5-18%)
  – cost of money to the owner of the inventory
Storage, Quality Tracking, and Monitoring

• It is necessary to track each lot of biomass from the farm through intermediate locations to the processing plant and finished product.

• This is necessary to monitor inputs, to pay for desired biomass quality attributes, and to optimize plant operations.

• Characteristics such as bulk density, carbohydrate levels, BTU content, moisture level, and ash content impact operating costs, product quality, and yield.
Why Cobs

- High in sugars
  - 16% more carbohydrates than corn stalks
- Twice as heavy as stalks so easy to separate
- Easy to collect
  - by the same farmers who supply corn to ethanol plants
- Little fertilizer value
- Enough cobs to produce 19 billion liters (5 billion gallons) of ethanol per year
Case Study - Corn Cobs - 2
POET Experience 2007 - 2009

• 10,000 MT of cobs from more than 10,000 hectares (24,700 acres)

• 15 manufacturers – 3 cob harvest concepts
Cob Harvest Concept - 1

CCM
(corn cob mix in one hopper - stalks left in field)

John Deere CCM System with Grain/Cob Cart
Cob Harvest Concept - 2

Towable single pass stover - cob separator with stalks left in field. (Separate corn and cob hoppers)

Case-IH Combine with the POET Cob Caddy
Cob Harvest Concept - 3

Second pass cob and stalk bales, round or square, picked up from ground after harvest
Case Study - Corn Cobs - 3

POET 2012 Plan

• Emmetsburg, Iowa plant
• Harvest cobs from
  400 farms
  121,400 hectares (300,000 acres)
  227,000 MT cobs
• Produce 95,000 million liters of ethanol
  (25,000 gallons)
Case Study - Switchgrass

- Tennessee is funding a pilot-scale cellulosic ethanol biorefinery for switchgrass
- A goal is to develop an integrated supply chain from farm to refinery
- Farmers have multiyear contracts with biorefinery to grow switchgrass
- Harvest in fall after first frost
- Staged at field’s edge and tagged
- Transported to central storage to weigh, test, and cover
Case Study - Switchgrass Insights - 1

• One-on-one extension technical expertise critical for establishing a new cropping system
• Existing equipment is not designed for high yield biomass crops like switchgrass
• Future contracts will require incentives payments for desired feedstock characteristics beyond yield and quality
• Efficient contracts will include factors like moisture content range, chemical composition, particle size, packaging, age, etc.
Case Study - Switchgrass Insights - 2

- Round bales better for on-farm storage
- Cover bales to prevent loss and degradation, and store bales off the ground - at least on gravel
- Efficiency gains in movement from storage when independent contractor used - not farmer
- Quality highest in a 3-2-1 pyramid storage stack - not in a larger footprint
Conclusions

• Extensive research has demonstrated that cellulosic biomass can replace fossil fuels and reduce petroleum imports, the trade deficit, and greenhouse gas production.

• Cellulosic feedstocks include crop residues, perennial grasses, woody crops, and forest residues. More than 700 million tons of these feedstocks can be sustainably harvested in the United States and processed and converted to biofuels.

• Productivity and economic desirability of biomass species are a function of soil, rainfall, climate, and competing crops. Research is needed to determine optimal regional patterns for biomass production, i.e., species and process methods.
Conclusions - 2

• Although much research has been devoted to specific biomass issues, the U.S. lacks the well-developed logistics, grading, and marketing systems for biomass biofuels that exist for grain-based feedstocks and fossil fuels.

• Much additional innovation and research is needed to develop new methods to routinely and reliably handle and transport large quantities of bulky materials.
Conclusions-3

Research is needed to develop and improve

• Harvest machinery
• Transport vehicles
• Biomass handling equipment
• Storage methods and storage structures
• Types of contracts, payment methods, and performance incentives
Convergence of Agriculture and Energy:
IV. Infrastructure Considerations for Biomass Harvest, Transportation, and Storage

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**Introduction**

The United States is committed to expanding the role of biomass as an energy source to decrease imports of oil and gas and the production of greenhouse gases and to foster the growth of agriculture, forestry, and rural economies. The Energy Independence and Security Act (EISA) of 2007 mandates the production of 136 billion liters of renewable fuels by 2022 including 79 billion liters of advanced biofuels and cellulosic ethanol. In addition to transportation fuels, biomass can be used to generate electricity or steam. During the past several years, research and development activities have focused on the collection and use of agricultural crop residues and the production of dedicated agricultural biomass crops for use in energy and biofuel production.

Biomass includes all plant and plant-derived materials. The first generation of biofuels has been produced primarily from starches, plant oils, and sugars that have been used historically for food. This paper focuses on agricultural cellulosic biomass crops that are generally inedible for humans. The primary agricultural cellulosic feedstocks for

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