Impacts of Using Corn Stover for the Cellulosic RFS on US and World Agricultural Commodity Markets, Land Use, and GHG Emissions

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Presentation Outline

- Background corn stover data for cellulosic biofuel
- Identify research priority
- Define objective and impact areas
- Describe method and model
- Present hypothesis on cellulosic biofuel RFS and GHG emission
  - Farm practice adjustment
    - Corn stover extraction and tillage
    - Corn stover extraction and fertilizer application
  - US and world area allocation
  - US and world livestock production response
- Schedule of project activities and budget
# Cellulosic feedstocks To Meet EISA In 2022

<table>
<thead>
<tr>
<th>Feedstock Source</th>
<th>Ethanol Volume (bg)</th>
<th>Share (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural Residue</td>
<td>5.7</td>
<td>35.63</td>
</tr>
<tr>
<td>of which, Corn Stover</td>
<td>4.9</td>
<td>30.63</td>
</tr>
<tr>
<td>of which, Sugar Bagasse</td>
<td>0.6</td>
<td>3.75</td>
</tr>
<tr>
<td>of which, Wheat Residue</td>
<td>0.1</td>
<td>0.63</td>
</tr>
<tr>
<td>of which, Sweet Sorghum</td>
<td>0.1</td>
<td>0.63</td>
</tr>
<tr>
<td>Forestry Biomass</td>
<td>0.1</td>
<td>0.63</td>
</tr>
<tr>
<td>Urban Waste</td>
<td>2.3</td>
<td>14.38</td>
</tr>
<tr>
<td>Dedicated Energy Crops</td>
<td>7.9</td>
<td>49.38</td>
</tr>
<tr>
<td>Total</td>
<td>16.0</td>
<td>100.00</td>
</tr>
</tbody>
</table>
Agricultural residue feedstock possible in 2022 (mwt)

<table>
<thead>
<tr>
<th>State</th>
<th>Rice</th>
<th>Corn</th>
<th>Oats</th>
<th>Rice</th>
<th>Sorg</th>
<th>Wheat</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>IL</td>
<td>0.0</td>
<td>65.3</td>
<td>0.1</td>
<td>0.0</td>
<td>0.3</td>
<td>3.6</td>
<td>69.2</td>
</tr>
<tr>
<td>IN</td>
<td>0.0</td>
<td>33.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>1.7</td>
<td>34.8</td>
</tr>
<tr>
<td>IA</td>
<td>0.0</td>
<td>79.1</td>
<td>0.3</td>
<td>0.0</td>
<td>0.2</td>
<td>0.1</td>
<td>79.7</td>
</tr>
<tr>
<td>MO</td>
<td>0.0</td>
<td>14.7</td>
<td>0.0</td>
<td>0.4</td>
<td>0.7</td>
<td>3.7</td>
<td>19.5</td>
</tr>
<tr>
<td>OH</td>
<td>0.0</td>
<td>15.1</td>
<td>1.1</td>
<td>0.0</td>
<td>0.0</td>
<td>3.9</td>
<td>20.0</td>
</tr>
<tr>
<td>Cbelt</td>
<td>0.0</td>
<td>207.2</td>
<td>1.5</td>
<td>0.4</td>
<td>1.2</td>
<td>13</td>
<td>223.2</td>
</tr>
<tr>
<td>US</td>
<td>20.0</td>
<td>406.0</td>
<td>8.0</td>
<td>15.0</td>
<td>27.0</td>
<td>166.0</td>
<td>642.0</td>
</tr>
</tbody>
</table>
Research Priority Area Addressed

- Impact of Bioenergy policy on broader agricultural markets and other biobased industries.
  - Interaction of cellulosic ethanol policy and market outcomes in ethanol, feedstocks, and commodity markets in general

- Environmental Impacts of Biobased Industries and their implications for Regulatory and Economic Incentives.
  - Land use impacts
    - As grain ethanol is impacted through the ethanol market
    - As grain commodities are impacted through the corn market
  - Fertilizer use impact
  - Agricultural production impact
    - Livestock production and manure management
General Objective

■ To assess the impacts on US and World agriculture of imposing the 16 billion gallons of cellulosic ethanol RFS by 2022.

■ Areas of Impacts
  ● Ethanol prices, RIN values, production, consumption, and trade
  ● Feedstock (corn stover, switchgrass) prices, production, and use
  ● Food and feed grain prices, production, use, and trade
  ● Livestock, poultry, and dairy prices, production, consumption, and trade
  ● Food security of developing countries
  ● Land use change by country by commodity
  ● Fertilizer use by country, commodity, and nutrient
  ● GHG emissions by country and source
## Econometric Models of Agricultural Markets

### U.S. and International Models

<table>
<thead>
<tr>
<th>Crops</th>
<th>Livestock</th>
<th>Dairy</th>
<th>Aggregate Measures</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>Cattle-Beef</td>
<td>Cheese</td>
<td>Government Costs</td>
<td>Consumer Food Exp</td>
</tr>
<tr>
<td>Corn</td>
<td>Swine-Pork</td>
<td>Butter</td>
<td>Cash Receipts</td>
<td>Value of Ag Exports</td>
</tr>
<tr>
<td>Barley</td>
<td>Poultry</td>
<td>Non-Fat Dry</td>
<td>Production Exp.</td>
<td>Federal Crop Insurance</td>
</tr>
<tr>
<td>Sorghum</td>
<td>Turkey</td>
<td>Milk</td>
<td>Farm Income</td>
<td>Biofuel</td>
</tr>
<tr>
<td>Soybeans</td>
<td>Eggs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rice</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cotton</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sugar</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biomass</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Source: Iowa State University, Food and Agricultural Policy Research Institute (FAPRI)*
Country Coverage by Commodity

Grains

- Wheat
- Corn
- Barley
- Sorghum
- Combination of Commodities
- Other Regional Aggregates/Combination
Country Coverage by Commodity

Livestock

* Countries aggregated into broad geographic areas are not highlighted.
Country Coverage by Commodity

Oilseeds

- Soybean & Products
- Rapeseed & Products
- Palm Oil & Products
- Peanut & Products
- Combination of Commodities
- Other Regional Aggregates/Combination
Country Coverage by Commodity

Biofuels
- Yellow: Ethanol
- Green: Biodiesel
- Blue: Ethanol and Biodiesel

Note: Countries aggregated into broad geographic areas are not highlighted.
Basic Crop Sector Model

International Prices

Price Transmission

Net Exports

Imports

Exports

Ending Stocks

Other Demand

Feed Demand

Food Demand

Domestic Demand

Trade Policy Content

Ending Stocks

Exports

Imports

Beginning Stocks

Yield

Area

Domestic Supply
Land Allocation Structure in Brazil

- Total Ag Area
  - Ag NR
    - Grain Area
      - Grain NR
    - Oilseed Area
      - Oilseeds NR
    - Others Area
      - Other NR
    - Pasture
      - Pasture NR
Basic Livestock Sector Model

- Beginning Inventory
- Breeding Stock
- Births
- Slaughter
- Ending Inventory

Market-Clearing Price

- International Prices
- Imports
- Exports
- Net Exports

- Domestic Supply
- Domestic Demand
- Food Demand
- Ending Stocks
- Trade Policy Content

Domestic Demand
Basic Biofuel Sector Model

- Beginning Inventory
- Capacity
- Capacity Utilization
- Production
- Domestic Supply
- International Prices
- Imports
- Exports
- Net Exports
- Market-Clearing Price
- Domestic Demand
- Voluntary E-10
- E-85
- Ending Stocks
- Additive
- Trade Policy Content

Domestic Supply

Exports

Imports

Capacity

Capacity Utilization

Production

Beginning Inventory

Market-Clearing Price

Net Exports

Additive

Voluntary E-10

E-85

Ending Stocks

Trade Policy Content

IOWA STATE UNIVERSITY
Basic Corn Stover Sector Model

Corn Yield

Corn Area

Extraction Rate

Domestic Supply

Market Price

Nutrient Demand

Cover Demand

Feed & Bedding Demand

Ethanol Feedstock Demand

Domestic Demand
FAPRI Market to GHGe Model

1. CONDITIONING VARIABLES
   - macro variables
   - policy variables
   - other exogenous variables

2. CARD-FAPRI PARTIAL EQUILIBRIUM MODEL
   Cropland* Pasture Forest
   \[ y = f(x | \beta) \]
   - exogenous variable uncertainty
   - parameter uncertainty

3. CARD-FAPRI GreenAgSIM MODEL
   supplemental land allocation rules
   \[ \sigma_x \sigma_p \sigma_\gamma \]
   Variability \((M) = f(\sigma_x, \sigma_p, \sigma_\gamma)\)

4. MARKET OUTCOMES IMPACTING GHG
   - change in crop and change in forest and pasture
   - cattle
   - other animals
   - fertilizer
   - rice area

5. CARD-FAPRI GreenAgSIM GHG MODEL
   GHG Emission Accounting
   \[ G = f(M | \beta) \]
   \[ \sigma_\theta \sigma_\lambda \]
   coefficient uncertainty
   Variability \((\text{CO}_2\text{-e}) = f(\sigma_x, \sigma_p, \sigma_\theta, \sigma_\lambda)\)

6. GHG EMISSIONS
   \[ \text{CO}_2\text{-equivalent} = f(C, \text{N}_2\text{O}, \text{CH}_4 | \lambda) \]
   \[ \sigma_\lambda \]
   coefficient uncertainty

*See Table 1 for list of crops.
**Sequential uncertainty is multiplicative.

Notes:
- \( M \): Vector of all market outcome variables affecting GHG emissions
- \( G \): Vector of GHG (\( \text{C}, \text{N}_2\text{O}, \text{CH}_4 \))
- \( \text{C} \) (carbon); \( \text{CO}_2 \) (carbon dioxide); \( \text{N}_2\text{O} \) (nitrous oxide); \( \text{CH}_4 \) (methane); \( \text{CO}_2\text{-e} \) (\( \text{CO}_2 \) equivalent)
Fertilizer from Inorganic and from Corn Stover

Stover Content
N 20 lbs/ton
P 7
K 33

Removal @ 67%
N 36%
P 26%
K 86%
Alternative Value of Corn Stover

$/dton

Fertilizer

Biofuel Feedstock

- Net Value
- Baling
- Transport
- Corn Stover Price

14.93
26.43

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Iowa State University
Tillage Practice and Corn Stover Extraction

Table with data: No Mulch Ridge Reduced Conventional

Percent

No Mulch Ridge Reduced Conventional

Tillage Extraction

Iowa State University

Food and Agricultural Policy Research Institute
Idle Cropland in 2010 and 2025

Million ha

<table>
<thead>
<tr>
<th>Country</th>
<th>2010</th>
<th>2025</th>
</tr>
</thead>
<tbody>
<tr>
<td>BR</td>
<td>20.7</td>
<td></td>
</tr>
<tr>
<td>U9</td>
<td></td>
<td>7.6</td>
</tr>
</tbody>
</table>

Notes:
- Idle cropland is defined as land that is not being used for agriculture.
- The chart shows the comparison between 2010 and 2025 for different countries.

Source: Food and Agricultural Policy Research Institute

Iowa State University
Corn Yield in 2010 and 2025

mt/ha

2010
2025

AG AR AU BR CA CN EG EU ID IN KR ML MX NI PH PK RU SF TA TH U9 UK VN

5.0
11.9
US Gains Competitive Advantage in Corn

- US corn production will expand depressing world corn prices.

- Other countries lose their competitive advantage.

- Favor production in the US with higher yield and has available idle crop land which has lower carbon stock released when converted into cropland.
Pork and Broiler Gain Over Beef Production

- US corn production will expand depressing world corn prices.
  - Larger feed cost savings in pork and broiler relative to beef.
  - Larger price declines in pork and broiler.
  - Substitution away from beef to pork and broiler.

- GHG emission through enteric fermentation will be slower.
US Beef Sector Gains Competitive Advantage

- US beef producers benefit from lower cost of feeds.

- Rest of the world beef producers face lower price of beef but do not benefit so much from lower feed cost due to their pasture based production system.

- GHG emission advantage through higher efficiency in the US beef production system.
Comparative US and Brazil Livestock Performance

- Calf Crop (calf/cow): US 0.97, Brazil 0.76, Argentina 0.65
- Slaughter Rate (%): US 0.31, Brazil 0.22, Argentina 0.27
- Weight (mt/head): US 0.34, Brazil 0.25, Argentina 0.22

*US  Brazil  Argentina*
<table>
<thead>
<tr>
<th>Activity</th>
<th>Schedule</th>
</tr>
</thead>
<tbody>
<tr>
<td>Literature Review</td>
<td>August 2011</td>
</tr>
<tr>
<td>Model Development (Fertilizer)</td>
<td>September 2011</td>
</tr>
<tr>
<td>Baseline Run (waived mandate)</td>
<td>November 2011</td>
</tr>
<tr>
<td>Scenario Run (Full RFS)</td>
<td>January 2012</td>
</tr>
<tr>
<td>Impact Analysis</td>
<td>March 2012</td>
</tr>
<tr>
<td>Report Write-up</td>
<td>June 2012</td>
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</table>
## Budget

<table>
<thead>
<tr>
<th>Category</th>
<th>Amount Requested</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salaries @ $7,791.66/month for 1.5 months for PI</td>
<td>11,687</td>
</tr>
<tr>
<td>Benefits @ 33.3% of salary</td>
<td>3,892</td>
</tr>
<tr>
<td><strong>Sub-total</strong></td>
<td><strong>15,579</strong></td>
</tr>
<tr>
<td>PhD Student @ $1,600/month half time for 12 months</td>
<td>19,200</td>
</tr>
<tr>
<td>Benefits @ 13.2% of salary</td>
<td>2,534</td>
</tr>
<tr>
<td><strong>Tuition (for Fall 2011, Spring 2012, and Summer 2012)</strong></td>
<td><strong>26,063</strong></td>
</tr>
<tr>
<td>Supplies &amp; Services (includes $2,500 for PC upgrade)</td>
<td>3,500</td>
</tr>
<tr>
<td>Travel (airfare, lodging, meals for 3 days prof meeting)</td>
<td>2,200</td>
</tr>
<tr>
<td>Publication (one article in referred journal)</td>
<td>1,500</td>
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<tr>
<td>Miscellaneous* @ $150/month/full time equivalent</td>
<td>1,125</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>49,968</strong></td>
</tr>
</tbody>
</table>
Thank You!