DSynergy - AGENCE Michelle Wander, Madhu Khanna, Steve Long.

*Miscanthus production* - Emily Heaton, Frank Dohleman, Steve Long
Elean Power Station was the UK’s first biomass power plant. With an electricity output of 36MW, it is the world’s largest such facility. The power station generates 271.5GWh/year, sufficient for 80,000 homes.
<table>
<thead>
<tr>
<th>The “Ideal” Biomass Crop?</th>
<th>Maize</th>
<th>SRC</th>
<th>PRG</th>
</tr>
</thead>
<tbody>
<tr>
<td>C4 photosynthesis</td>
<td>★</td>
<td>★</td>
<td>★</td>
</tr>
<tr>
<td>Long canopy duration</td>
<td></td>
<td>★</td>
<td>★</td>
</tr>
<tr>
<td>Recycles nutrients to roots</td>
<td></td>
<td>★</td>
<td></td>
</tr>
<tr>
<td>Clean burning</td>
<td></td>
<td>★</td>
<td></td>
</tr>
<tr>
<td>Low input</td>
<td></td>
<td>★</td>
<td>★</td>
</tr>
<tr>
<td>Sterile – non-invasive</td>
<td>N/A</td>
<td>★</td>
<td></td>
</tr>
<tr>
<td>Winter standing</td>
<td></td>
<td>★</td>
<td>★</td>
</tr>
<tr>
<td>Easily removed</td>
<td>★</td>
<td>★</td>
<td></td>
</tr>
<tr>
<td>High water use efficiency</td>
<td></td>
<td>★</td>
<td></td>
</tr>
<tr>
<td>No known pests/diseases</td>
<td></td>
<td>★</td>
<td></td>
</tr>
</tbody>
</table>
Nitrogen use efficiency - theory

<table>
<thead>
<tr>
<th>SPRING/SUMMER</th>
<th>FALL</th>
<th>WINTER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Translocation from rhizomes to growing shoot</td>
<td>Translocation to rhizome as shoot senesces</td>
<td>Lignocellulose dry shoots harvested, nutrients stay in rhizomes</td>
</tr>
</tbody>
</table>

Mineral nutrients

SPRING/SUMMER

FALL

WINTER

Translocation to rhizome as shoot senesces

Lignocellulose dry shoots harvested, nutrients stay in rhizomes
Efficient Radiation Capture
Miscanthus

(*Miscanthus x giganteus*)
Demonstration plot of *Miscanthus x giganteus* just before harvest, winter 2003. Winter harvest has the advantage of a very low moisture content in the biomass and allows for employment of farm equipment that would otherwise be idle at this time of year.
Harvesting Equipment

Winter cutting (followed by baling) of demonstration plot of Miscanthus x giganteus at the South Farms, University of Illinois, Urbana, early 2004.
Switchgrass and Miscanthus Dry Matter Yields in Central IL

3.7% Solar Energy Conversion

Switchgrass
Miscanthus

2003
2004

June
August
June
August
TOM'S SHELL

Self Serve  Cash or Credit

Regular

ARM 9

Plus

LEG 9

Premium

First 9

Born
Cellulosic Ethanol

- Midwest = 2 million km²; if 10% was Miscanthus it would provide 760Mt dry mass per year (35 t/ha).
- 340Mt Cellulose (45% content)
- Assuming 50% efficiency of digestion to ethanol = 79 Mt Ethanol = 100 Billion liters/year
- 684 Billion all US transportation/year
Where does DS AGENCE come in?

• Small scale plots often misleading and provide insufficient material for developing harvesting and utilization technologies, or gaining agronomic experience.

DS AGENCE has allowed us to establish:

• 12 acres of trials.

• Continued support will allow us to determine yields, expand trial in Christian County and establish propagation resource.
<table>
<thead>
<tr>
<th>Establishment 2005</th>
<th>Proposed Establishment 2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5 acres Miscanthus</td>
<td>0.5 acres Miscanthus</td>
</tr>
<tr>
<td>Grass path sufficient for farm machinery</td>
<td>Grass path sufficient for farm machinery</td>
</tr>
<tr>
<td>0.5 acres Switchgrass</td>
<td>0.5 acres Corn/Soybean</td>
</tr>
<tr>
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<td>Grass path sufficient for farm machinery</td>
<td>Grass path sufficient for farm machinery</td>
</tr>
<tr>
<td>0.5 acres Corn/Soybean</td>
<td>0.5 acres Miscanthus</td>
</tr>
</tbody>
</table>
Miscanthus: Economic Potential and Environmental Impact for Illinois

Madhu Khanna, Hayri Onal, Basanta Dhungana
Dept. of Agricultural and Consumer Economics

Michelle Wander
Dept. of Natural Resources and Environmental Sciences
Research Objectives

• Examine the profitability of Miscanthus as compared to conventional crops in Illinois
  • Corn, soybeans, wheat, sorghum, oats, pasture
  • Alternative rotations
  • Alternative tillage practices
  – Under alternative market demand scenarios
  – Under alternative policy scenarios

• Evaluate the potential for Miscanthus to reduce emissions from coal based electricity generation and to sequester soil carbon in Illinois

• Identify policies for encouraging use of Miscanthus for
  – Electricity Generation (Subsidies for biomass production)
  – Mitigating Greenhouse Gases (Credits for carbon sequestered)
Yield Maps

Soybeans
Yields 25-54 bushels/acre
5 year NASS averages

Corn
Yields 89-163 bushels/acre

Miscanthus
Yields 12-17 MT/acre
MISCANMOD simulation model
Electricity Generation From Miscanthus

At $20/metric ton price for Miscanthus:
Cost of a BTU from miscanthus is equivalent to that from coal ($1.21/MMBTU)

- Land profitably allocated to miscanthus: 0.6 million acres (2.5% of cropland)
  - 9 million tons of Miscanthus

- Can generate 13% of electricity generated and 30% of electricity consumed in Illinois.

- 15-year average annual increase in profits/acre in counties producing miscanthus: $5 per acre per year (6% increase over baseline profits)

- Reduce carbon emissions from coal-based electricity generation by 41 MM tons (18% of CO₂ emissions in Illinois in 2000)
  - Carbon emissions worth $250 million at $6/ton of CO₂

- Additional soil carbon sequestration in 15 years: 5% over the baseline levels in the absence of miscanthus (2% of CO₂ emissions in Illinois in 2000)
  - Carbon credits worth $4 per acre per year for 15 years.
Sustainable Energy Plan for Illinois (July 2005) calls for
2% of electricity from renewables in 2007
1% annual increase to 8% by 2013

Simulation:
Each power plant required to produce 15% of its electricity using Miscanthus in 2017
Profits could increase by $22 per acre per year for land switching to Miscanthus.
## Producing Miscanthus for Electricity Generation in Christian County

<table>
<thead>
<tr>
<th>Variable Inputs</th>
<th>Corn-soybeans with till ($/acre)</th>
<th>Corn-soybeans with no-till ($/acre)</th>
<th>Hay (alfalfa) ($/acre)</th>
<th>Switchgrass ($/acre)</th>
<th>Miscanthus ($/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fertilizer</td>
<td>45.01</td>
<td>53.50</td>
<td>37.92</td>
<td>42.31</td>
<td>32.06</td>
</tr>
<tr>
<td>Chemicals</td>
<td>38.50</td>
<td>46.20</td>
<td>43.40</td>
<td>25.62</td>
<td>25.62</td>
</tr>
<tr>
<td>Seed</td>
<td>28.82</td>
<td>37.30</td>
<td>9.60</td>
<td>2.40</td>
<td>6.40</td>
</tr>
<tr>
<td>Interest</td>
<td>5.24</td>
<td>5.52</td>
<td>3.04</td>
<td>5.13</td>
<td>4.49</td>
</tr>
<tr>
<td>Mach. Rep. &amp; Hire</td>
<td>33.00</td>
<td>21.75</td>
<td>39.40</td>
<td>06.47</td>
<td>111.24</td>
</tr>
<tr>
<td>Drying &amp; Storage</td>
<td>13.26</td>
<td>13.26</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Crop Insurance</td>
<td>5.00</td>
<td>5.00</td>
<td>6.00</td>
<td>6.00</td>
<td>6.00</td>
</tr>
<tr>
<td>Trans. &amp; Storage</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>29.68</td>
<td>70.66</td>
</tr>
<tr>
<td>Total Cost</td>
<td>168.82</td>
<td>173.82</td>
<td>133.36</td>
<td>217.58</td>
<td>256.47</td>
</tr>
<tr>
<td>Revenue</td>
<td>306.55</td>
<td>306.55</td>
<td>333.48</td>
<td>355.31</td>
<td>394.20</td>
</tr>
<tr>
<td>Revenue-Cost</td>
<td>137.73</td>
<td>132.73</td>
<td>200.11</td>
<td>137.73</td>
<td>137.73</td>
</tr>
</tbody>
</table>
On-Farm Heat from Miscanthus in Christian County

- **On-Farm Drying Shelled Corn from 25.5% to 15.5% moisture:**

<table>
<thead>
<tr>
<th>Drying Method</th>
<th>Fuel Requirement Per 100 bushel shelled corn</th>
<th>Heating Cost: Electric Furnace (Per 100 bushel shelled corn)</th>
<th>Heating Cost: Miscanthus-Burner (Per 100 bushel shelled corn)</th>
<th>Total savings for 100 acres of corn with Miscanthus burning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Air or Low Temp Drying</td>
<td>140 KWH</td>
<td>$13</td>
<td>$2</td>
<td>$1700 per year</td>
</tr>
<tr>
<td>High Temp Dryer with in-dryer cooling</td>
<td>20 Gal propane and 10 KWH</td>
<td>$23</td>
<td>$4.5</td>
<td>$2886 per year</td>
</tr>
</tbody>
</table>

Heating a 1800 square foot house (annual heating costs):

- Electric Furnace: $1,257
- Natural Gas Furnace: $596
- Miscanthus Burner: $173
Potential Future Research Issues

• Economics of end-uses for Miscanthus
  – Electricity Generation
    • Large scale: Competition from coal and from wind power
    • Small-scale on-farm power/heat generation
  – Ethanol Production

• Indepth study of one or two counties
  – What types of
    • lands (marginal/pasture/CRP)
    • locations (next to waterbodies/sloping/floodplain)
  – are more likely to find it profitable to switch to Miscanthus?
Alternative Sources of Renewable Resources for Electricity Generation in Illinois

- **Comparison of Wind Power and Bio-Energy**
  - Cost per KWH and Potential for Storage
    - Variability in this across regions in Illinois
  - Economic Benefits for Landowners
  - Environmental Benefits
    - Carbon sequestration, soil erosion, aesthetics
How do we get from small scale trials to large scale utilization of farm biomass in Illinois?
What are the barriers?

- Experience of larger scale trials
- Propagation
- Pump-priming Markets
- Economics
Markets?

Power >10 MW

Farm and neighbor heat and power <1MW

Liquid fuels?

Horse bedding

Molded products

Paper

Construction boarding
An idea to throw at the wall.
Demonstrate a neighbor heat and power plant.

Benefits:

Farm Economy
Market created
Demonstration
Laboratory - from Agronomy and Engineering to Economics and Environmental impacts.
**Neighbor heating.** A biomass boiler is used to heat the farmhouse, large livestock housing system, 6 municipal buildings and 2 neighbor houses. 

Where: Krengerup Estate, Funen, Denmark  
Fuel - grass biomass, straw, miscanthus, switchgrass  
Manufacturer - LINKA Maskinfabrik, Denmark  
Output - 0.7 MW; Cost - US$130,000; piping & distribution US$140,000  
Ash - mixed with animal facility liquid manure and spread on land.

Uses 500 tons per year.  
Miscanthus = 35 acres in Central Illinois.