THE ECONOMICS OF BIOMASS COLLECTION AND TRANSPORTATION AND ITS SUPPLY TO INDIANA CELLULOSIC AND ELECTRIC UTILITY FACILITIES

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Introduction

- Interest in cellulosic energy
  - National energy security
  - Policy mandating its use (Renewable Fuel Standard)
- ½ of US agricultural cropland is capable of producing some biomass (USDA/DOE Billion Ton Study, 2005)
- Use of biomass
  - Cellulosic liquid fuels (ex. Iogen Corporation in Canada)
  - Electric power in traditional coal-fired plants
- How much will biomass cost to produce, collect, harvest, and transport to the plant gate?

Literature Review

- Numerous existing studies have estimated biomass costs
  - Assumptions, time of study, and market input prices vary
- Used to generate parameters and assumptions for this analysis
- General guide for accuracy of total costs – in some cases, used as a benchmark

Corn Stover Assumptions

- Yield Assumptions
  - Corn yield = 160 bushels per acre (USDA, IN average, 2007)
  - Total stover yield = 4.25 dry tons per acre
- Removal Rates: one rate is not appropriate for all areas
  - Scenario 1: Windrow behind combine, bale
    - 38 percent of available stover is removed
  - Scenario 2: Rake into windrow, bale
    - 52.5 percent of available stover is removed
  - Scenario 3: Shred stalks, rake into windrow, bale
    - 70 percent of available stover is removed
  - Decision will depend on soil characteristics and operational resources available

Corn Stover Assumptions, Cont.

- Nutrient Replacement
  - Additional fertilizer added when the next year's crop is planted to account for removed stover
  - N: Anhydrous ammonia (82-0-0) or liquid nitrogen (28-0-0)
    - 15.9 pounds per ton of stover removed
  - P_2O_5: Monoammonium phosphates (MAP) (11-52-0)
    - 5.9 pounds per ton of stover removed
  - K_2O: Potash (0-0-61)
    - 30 pounds per ton of stover removed

Switchgrass Assumptions

- Yield Assumptions
  - 5 dry tons per acre
  - Life of the stand: 10 years
- Land Rent
  - $70 per acre or $14 per dry ton
- Field Preparation and Seeding
  - Mow and spray with 2 quarts of glyphosate per acre
  - Cave-In-Rock seed, 7 pounds of pure live seed per acre

Switchgrass Assumptions, Cont.

- Fertilizer
  - P_2O_5: Monoammonium phosphates (MAP) (11-52-0)
    - 30 pounds per acre in establishment year
    - 3.15 pounds per ton of switchgrass removed in production year
  - K_2O: Potash (0-0-61)
    - 37 pounds per acre in establishment year
    - 13.25 pounds per ton of switchgrass removed in production year
  - Lime
    - 2 tons per acre in establishment year
  - N: Urea (45-0-0)
    - 80 pounds per acre in production year
- Herbicide
  - 1.25 quarts of Atrazine in both establishment and production years
  - 1.25 pints of 2,4 D in both establishment and production years

Harvesting Assumptions

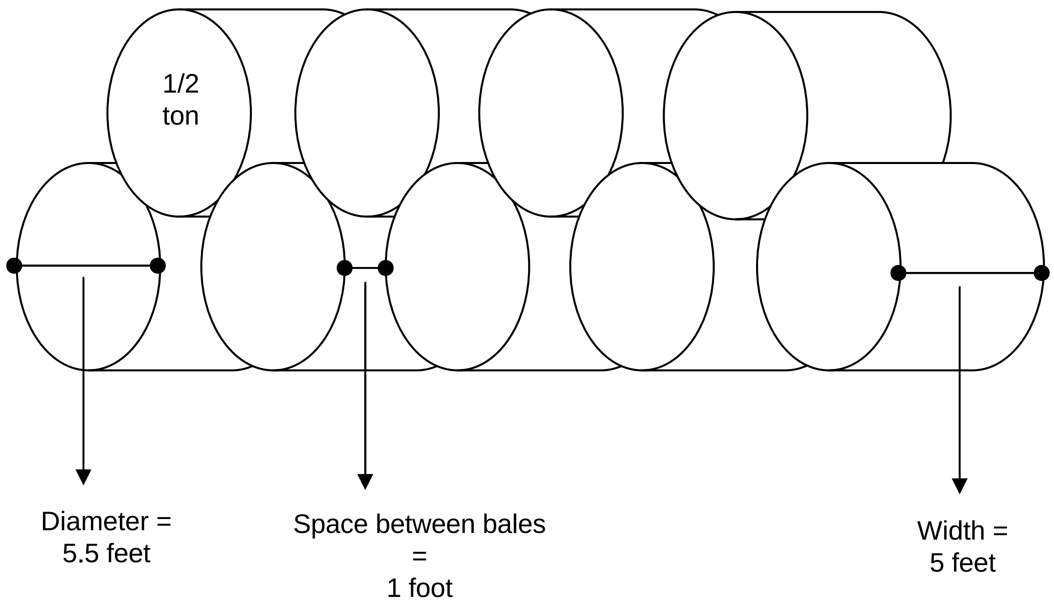
- 1000 pound round bales
  - 5 feet wide and 5.5 feet diameter
- Custom equipment
- Owned equipment
  - Annual per ton payments for each piece of equipment with 8 percent interest rate
  - Farms with more acres will have a lower annual per ton payment
  - Fuel and labor requirement from MS State Budget Generator
- On-farm diesel: $3.53 per gallon (EIA, 3/31/2008)
- IN Field work wage rate: $9.46 per hour (NASS, 2006)

Bale Packaging Assumptions

- Twine
  - 15 revolutions
  - 18.8 percent dry matter loss in 6 months
- Net Wrap
  - 2 revolutions
  - 8.4 percent dry matter loss in 6 months
- Plastic Wrap
  - 15 revolutions of twine, 2 revolutions of plastic wrap
  - 6.15 percent dry matter loss in 6 months

Storage Assumptions

- Stacked and stored along the edge of the field
- Premium for extended storage based on lost revenue of land on which bales are stored
- Profit premium: 15% of the per ton product cost



Transportation Assumptions

- Distances from 5 to 50 miles in intervals of 5 miles
- Custom equipment
- Owned equipment
  - Highway diesel: $3.93 per gallon (EIA, 3/31/2008)
  - Truck driver wage rate: $14.37 per hour (BLS, 2006)
- Semi-tractor and flatbed trailer
  - Gas mileage: 6.73 miles per gallon
  - Driving speed: 50 miles per hour
- 26 bales per load
- Loading/unloading time: 20 minutes

Per Ton Costs and Distance

- Averaged over removal rate, farm size, equipment choice, and bale packaging
- Marginal transportation cost
  - Custom: $0.28 per mile
  - Owned: $0.12 per mile
  - Average: $0.20 per mile

Corn Stover

	Custom	500 acres	1000 acres	1500 acres	2000 acres
5 miles	$36.49	$42.80	$38.48	$37.04	$36.32
10 miles	$37.87	$43.47	$39.15	$37.71	$36.99
15 miles	$39.26	$44.14	$39.82	$38.38	$37.66
20 miles	$40.64	$44.81	$40.49	$39.05	$38.33
25 miles	$42.03	$45.48	$41.16	$39.72	$39.00
30 miles	$43.41	$46.15	$41.83	$40.39	$39.67
35 miles	$44.80	$46.82	$42.50	$41.06	$40.34
40 miles	$46.18	$47.49	$43.17	$41.73	$41.01
45 miles	$47.57	$48.16	$43.84	$42.40	$41.68
50 miles	$48.95	$48.83	$44.51	$43.07	$42.35

Switchgrass

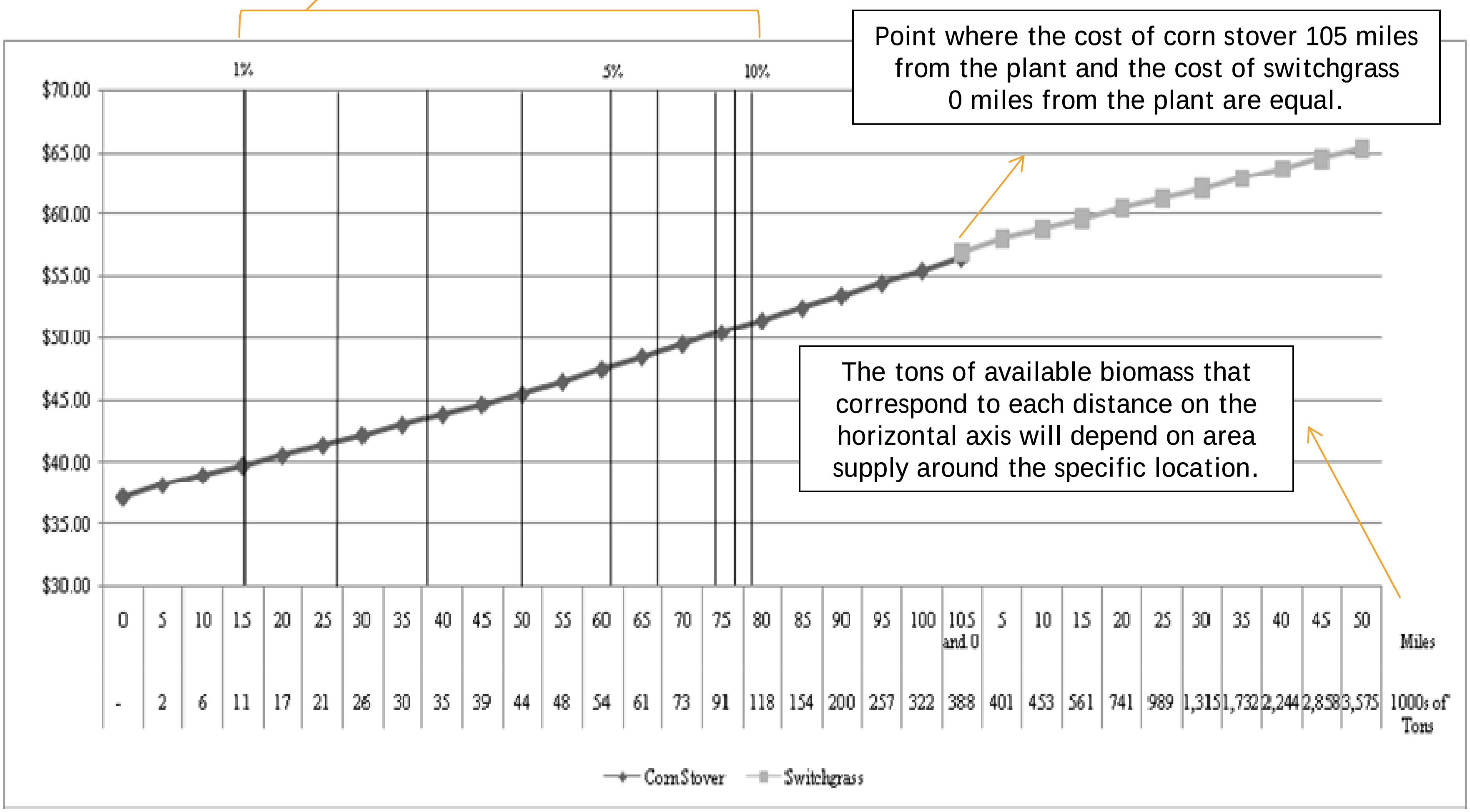
	Custom	500 acres	1000 acres	1500 acres	2000 acres
5 miles	$58.45	$60.52	$57.84	$56.94	$56.50
10 miles	$59.84	$61.19	$58.51	$57.61	$57.17
15 miles	$61.22	$61.86	$59.18	$58.28	$57.84
20 miles	$62.61	$62.53	$59.85	$58.95	$58.51
25 miles	$63.99	$63.20	$60.52	$59.62	$59.18
30 miles	$65.38	$63.87	$61.19	$60.29	$59.85
35 miles	$66.76	$64.54	$61.86	$60.96	$60.52
40 miles	$68.15	$65.21	$62.53	$61.63	$61.19
45 miles	$69.53	$65.88	$63.20	$62.31	$61.86
50 miles	$70.92	$66.55	$63.87	$62.98	$62.53

Plant Demand Assumptions

- Plants operate 350 days per year, 24 hours per day
- Heat content of biomass (Domalski, et al. – 1987)
  - Corn Stover: 7,593 BTU/lb
  - Switchgrass: 7,267 BTU/lb
- Heat content of coal (NTEL)
  - Between 10,010 and 11,729 BTU/lb
- Coal demand used to calculate total heat production (NTEL)
  - Knox Co. Plant (144 MW/year): 90 tons/hour
  - Marion Co. Plant (1189 MW/year): 270 tons/hour
  - Tippecanoe Co. Plant (43 MW/year): 19 tons/hour
- Percentage of heat from biomass between 1% and 10%

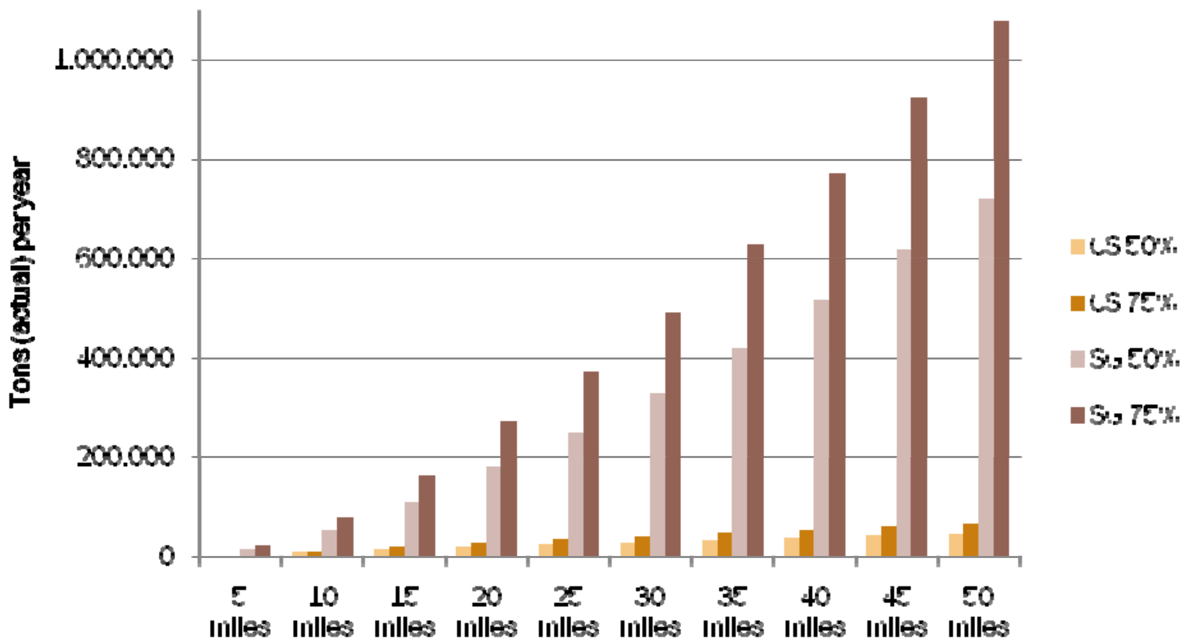
Example of a Supply Curve Knox Co. Plant

Vertical lines represent the percentage of heat production coming from biomass. Placement of these lines will depend on the relationship between plant size and area supply.



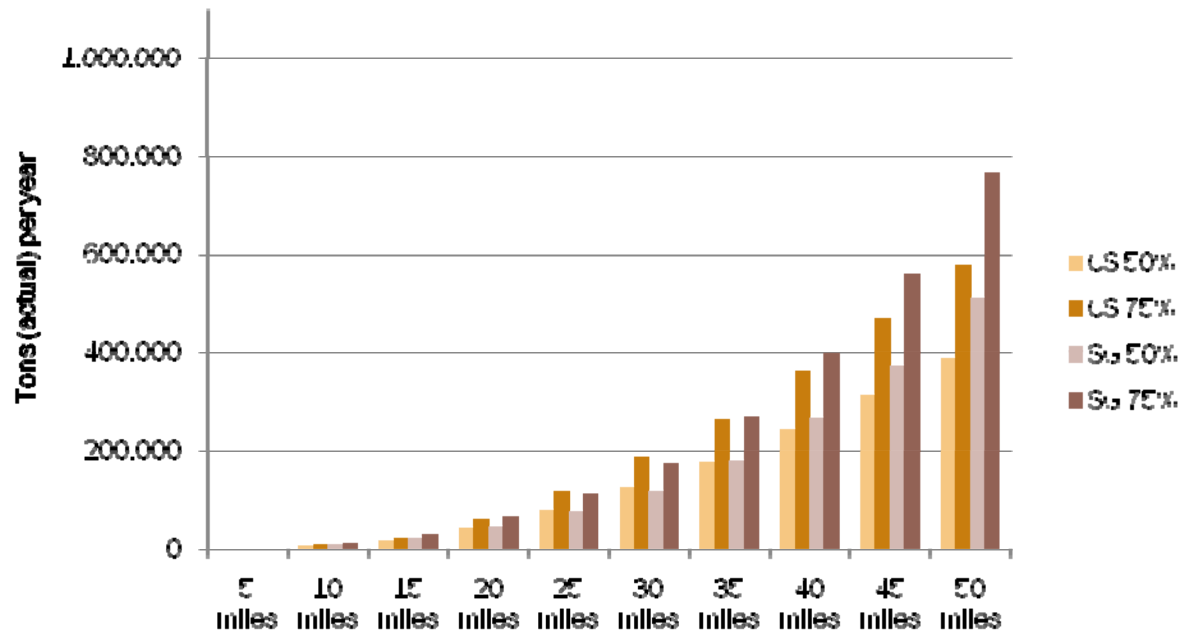
Knox Co. Plant

- Large switchgrass supplies with little corn stover
- Feedstock for 10 percent of heat production by acquiring corn stover up to 80 miles from the plant

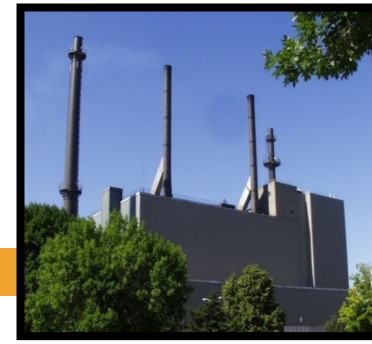


Marion Co. Plant

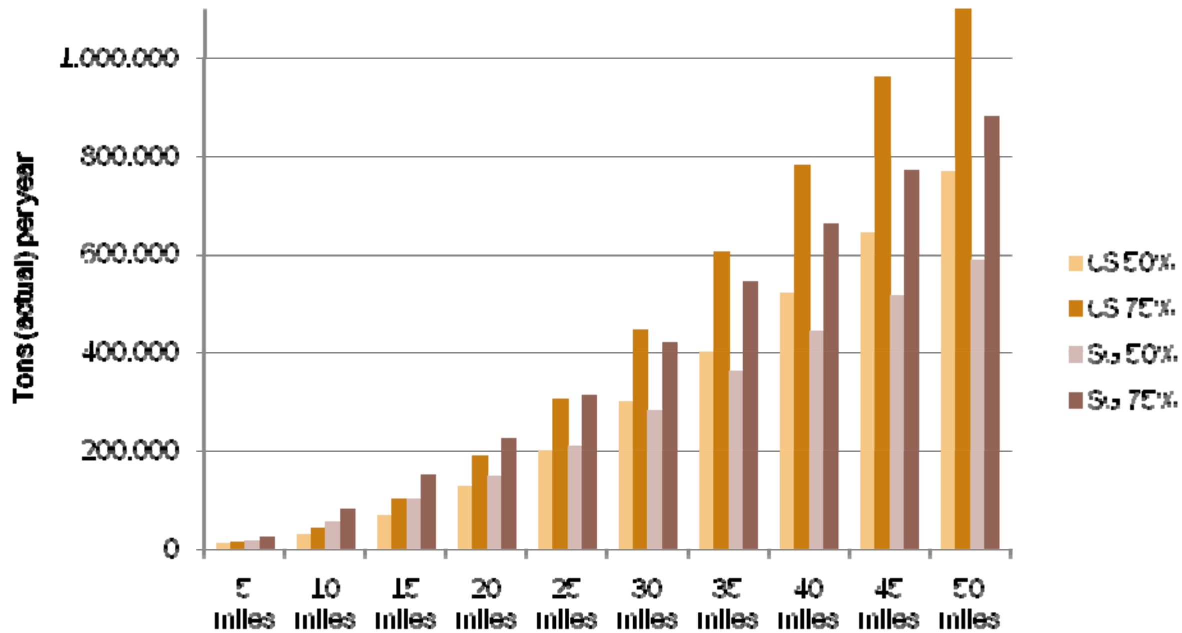
- Metropolitan location with close proximity to surrounding rural counties
- Feedstock for 10 percent of heat production by acquiring corn stover up to 40 miles from the plant



Tippecanoe Co. Plant



- Abundant supplies of both corn stover and switchgrass
- Feedstock for 10 percent of heat production by acquiring corn stover up to 8 miles from the plant



CO_2 Emission Reductions

- Net emission reductions from using biomass rather than coal
  - Calculated based on Chariton Valley report (2002) and Spatari, et al (2005)
  - Corn Stover: 2.88 tons of CO_2 equivalent per ton of CS
  - Switchgrass: 2.60 tons of CO_2 equivalent per ton of SG
- Coal combustion: 2.86 tons of CO_2 equivalent per ton of coal (Hong & Slatick, 1994)
- Carbon credit = $5.22 per ton
  - Carbon Financial Instruments on the Chicago Climate Exchange
- Delivered price of coal = $34.31 per ton (EIA, 1/2008)

Change in Input Fuel Cost Due to Biomass Use

- Savings from less coal, savings from less emissions, and average cost of purchasing biomass

	Knox		Marion		Tippecanoe	
Fraction of Heat from Biomass	Corn Stover	Switchgrass	Corn Stover	Switchgrass	Corn Stover	Switchgrass
0.05	1.67%	5.30%	0.32%	4.83%	0.41%	5.46%
0.10	5.98%	10.97%	1.26%	10.47%	0.81%	11.31%

  - Always a price increase when using biomass relative to coal only case

- CO_2 breakeven per ton prices or the per ton carbon tax necessary to have the 10 percent of heat from biomass case cost the same as the coal only case

	Corn Stover	Switchgrass
Knox	$10.03	$14.57
Marion	$6.35	$15.24
Tippecanoe	$5.79	$14.46

Conclusions

- Corn Stover
  - Costs are lower because it is a secondary crop
  - Management decisions will change costs
- Switchgrass
  - As a primary crop, there are higher costs compared to corn stover due to more required inputs and activities
- Supply
  - Location! Location! Location!
  - Corn stover will be more sought after due to lower cost
- Individual producer characteristics and resources will drive decision to produce biomass
  - Uncertainty in production will lead to plants contracting supply
- Ways to reduce costs include equipment innovation, yield increases, and more efficient management

Thank you! Questions?

TRANSITION TO A BIO ECONOMY

Risk, Infrastructure and Industry Evolution

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