Biofuel Feedstock Supply Coordination in the North: Options and Obstacles

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USDA United States Department of Agriculture National Institute of Food and Agriculture

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TYPES OF DECISIONS

- Where should the biorefinery be located?
- What is the optimal spatial and temporal mix of feedstocks?
- What is the optimal configuration of the biomass supply chain?
- How to structure biomass supply contracts?
- How to ensure participation of small/minority/tribal farmers?
- How would the land use in the region evolve over time due to presence of the biorefinery and what are the implications for the biorefinery?

DECISION SUPPORT SYSTEMS FOR REGIONAL PLANNING AND IMPACT ASSESSMENT OF BIOREFINERIES*

A. Survey research aimed at assessing the acceptability of biorefineries to communities
B. A biomass harvest-shed design tool to help determine the optimal mix
C. A logistics decision support tool to help evaluate alternative feedstock supply chain configurations.
D. Feasibility of RBPC in Eastern Upper Pennisula of Michigan
E. Contract design research
F. Dynamic agent based simulation modeling tool tohelp predict the evolution of the harvest shed over time, under alternative market development scenarios

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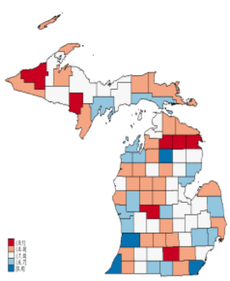
BIOREFINERY ACCEPTABILITY

- Survey of 1,000 Michigan Households
- Explored:
  - Willingness to accept biorefinery
  - Reasons to accept/reject biorefinery

- 65% supported having a new biorefinery in their community; 27% were opposed and 8% were undecided

Predicted Probability of Support

Dark Red: >90%, Dark Blue: <60%

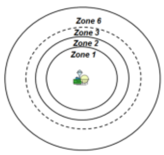


Key Reasons to Support / Oppose Biorefinery

Support (N=660)	Biggest Advantage (%)	Smallest Advantage (%)
Job Creation	45.15	8.3
Increased Sales for Area Farmers	11.06	18.7
Environmental Benefits	10.30	17.3
The Plant Would Pay Local Taxes	8.64	27.1
Reducing Dependence on Foreign Oil	22.27	28.8
Oppose (N=353)	**Biggest Drawback (%)**	**Smallest Drawback (%)**
Daily Smells or Noises	7.37	15.01
Long-term Environmental Effects	26.35	6.23
More Trucks on the Road	5.1	28.9
Risk of Industrial Accidents	2.83	11.05
Biofuels not Economically Viable	33.14	9.92
Biofuels Increase Food Prices	13.31	12.46

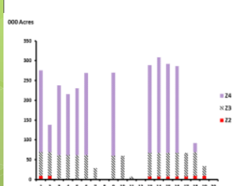
HARVEST-SHED DESIGN TOOL

- Math Programming model to determine the optimal mix of annual crops and perennial grasses for a generic biorefinery, taking into account the necessary contract terms, feedstock costs, transport costs, GHG emissions, and other environmental impacts.

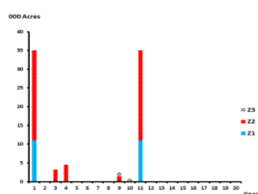


RESULTS

- Objective: minimize the discounted total biomass procurement costs (material, harvesting, transport, storage, external costs)

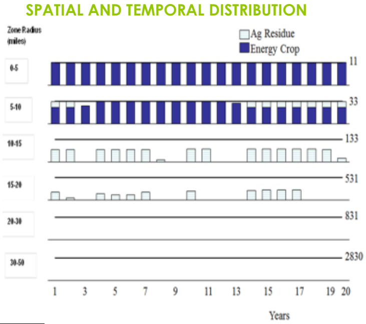


Agricultural residue acreage (000 acres) contracted by year



Perennial Energy Crop Acreage (000 acres) Contracted by year

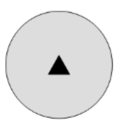
SPATIAL AND TEMPORAL DISTRIBUTION



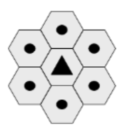
Key Insights

- Energy crops will likely account for a significant proportion of the optimal feedstock mix, despite higher establishment costs and the need for long-term contracts.
- Higher yields/acre and associated lower transport costs offset the higher costs of feedstock production.
- Agricultural residues are likely to be used primarily to cover shortfalls in energy crops.
- Spatially, energy crops will be contracted closer to the biorefinery, while agricultural residues will likely be collected from the fringe areas.

ALTERNATIVE SUPPLY CHAIN CONFIGURATIONS



Single Integrated Biorefinery



Distributed Configuration with RBPCs

- Intermediate processing with alternative product (animal feed) can address market power, 'chicken and egg', food v/s fuel issues
- Distributed system will have longer average transportdistance and double handling costs, but Intermediate densification can offset costs

Feasibility of Regional Preprocessing

- Assessing land availability, potential biomass supply and cost
- Estimating capital and operating costs of RBPD, appropriate scale of operations and production costs
- Local demand for animal feed and feed cost competitiveness
- Overall financial feasibility

RBPC COST ESTIMATES

RBPC Capacity Tons/Day	25	50	100	200
Total Capital costs 000	$3,685	$5,756	$9,344	$15,677
Total Operating costs /ton	$77.20	$56.75	$43.08	$34.30

CASE-STUDY: Feasibility in Michigan's Eastern Upper Peninsula

- Total cropland ~ 50-70K acres
- AFEX plant size = 140-200 tpd
- Capital cost = $15.7 M
- Operating cost =$35/ton
- Capital & depreciation costs= $25/ton
- Switchgrass production cost = $70/t
- MSP of animal feed= $155/t
- Not enough animal feed demand

Not a financially attractive project.

Contract Design for Biofeedstock Procurement

- OBJECTIVE(S):
  - Access willingness of ag. producers to grow energy crops
  - Estimate preferences for potential contract attributes
- METHODS:
  - Conducted focus groups and follow-up questionnaire of 26 producers in April 2013

Contract Design for Biofeedstock Procurement

- FINDINGS:
  - Producers were somewhat familiar with energy crops
  - 87% of producers would commit at least 21% of ag. land to energy crops if offered favorable contract
  - 86% of producers would commit at least 21% of their time to energy crops if offered favorable contract
  - Little correlation between demographic characteristics and commitment

Contract Design for Biofeedstock Procurement

- FINDINGS:
  - Primary factors influencing producers' decision include:
    - Agronomic attributes (e.g. affect on other crops),
    - Production practices (e.g. need to invest in specific equipment), and
    - Prior existence of supply chain (EX.: Mascoma)
    - Adoption by other community members

Contract Design for Biofeedstock Procurement

- FINDINGS:
  - Preferences for contract terms:
    - Long-term contract to match longevity of crop
    - Upfront payment; quantity and quality should have moderate impact on returns
    - Producers conduct field work
    - Weather risk should be borne by processor or shared (with other producers and/or processor)
    - Willing to store biomass if processor is responsible for transportation

Evolution Model of the Harvest Shed for Michigan Biofeedstock

- OBJECTIVE:
  - Model availability of biofeedstock harvest shed over time and space and under alternative market development scenarios
- METHOD:
  - Use simulation techniques to model the decision-making process of multiple stakeholders
  - Evaluate farmer adoption of energy crops under various market development scenarios

Evolution Model of the Harvest Shed for Michigan Biofeedstock

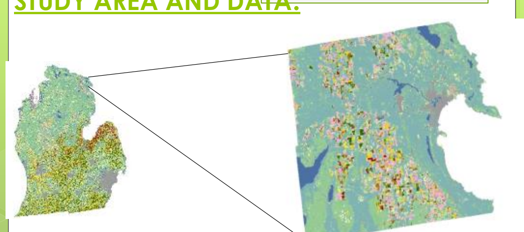
ALTERNATIVE MARKET SCENARIOS:

1. **A biorefinery procures from Individual farmers – no farmer protection**
2. **A biorefinery procures from farmer cooperative**

Introducing competition for biorefinery, reducing monopsony power

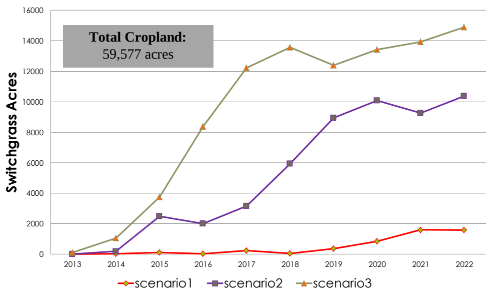
3. **Multiple easily accessible market outlets**

STUDY AREA AND DATA:

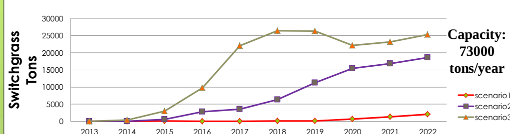


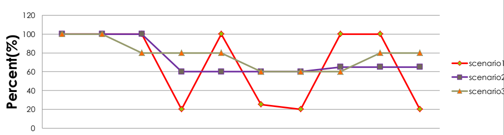
- 573 Farmers in total, populated by CLU land ownership data and census data
- Alfalfa, Corn, Soybeans, Wheat
- Real and projected crop yield, crop price and crop input cost data (2008 to 2022)
- Crop Budget from MSU Extension and Kell & Swinton (2014)

RESULTS:



RESULTS:





KEY FINDINGS:

- Farmers are quite unwilling to convert land into switchgrass use as the contract hold up risk is quite high
- Cooperative procurement is a quite efficient and realistic way to procure switchgrass. When working with cooperative, biorefinery might be willing to coordinate with geographically separated industries to foster alternative outlets with transaction cost
- Switchgrass yield under 3 scenarios might not be enough to meet commercial-scale biorefineries' procurement capacity: need technologies that increases yield, or procure in Southern states

PROJECT OUTPUTS

Publications:

- Kumarappan S. and S. Joshi (2014). "Spatially and temporally optimal biomass procurement contracting for biorefineries", BioResources. 9(2), May 2014, 2069-89.
- Joshi S., R. B. Ross, S. Loveridge, S. Yanni, H. Li, G. Signorini. G. Lee, L. Jacques,(2014) "Decision support tools for future biorefineries", Proceedings of the Association for the Advancement of Industrial Crops(AAIC) Annual Conference, Oct 12-16, Washington DC.

PROJECT OUTPUTS

THESES

- Haoyang Li: "Farmers' switchgrass adoption decision under different market scenarios-- an agent based modeling approach" M.S. Thesis 2014
- Gi-Eu Lee: "Three essays on Climate Change Policy" (Essay 1: Assessing the Acceptability of Biorefineries: Michigan Public Willingness to Pay to Attract or Keep out Local Biorefineries" based on this project) Ph.D. Thesis, In progress. Expected completion 2015
- Guilherme Signorini: "Early Contractual Relationships in the American Renewable Energy Industry: Assessing Parties Preferences for Timely Sustainable Growth"(Essay 1: Assessing Transaction Efficiency for Biomass: A Case Study of the Upper Peninsula of Michigan; based on this project) Ph.D. 2015.
- Alex Smith: "Feasibility Analysis of an AFEX Biomass Pre-Processing Depot in the Bay Mills Area of Michigan" MS Plan B paper. In progress, expected completion Dec 2015