Biomass Production in Minnesota and Potential Demand

- Potential demand for liquid fuels
- Existing and potential supply
  - Natural stand resources
  - Agricultural Residues
  - Dedicated crops
- Production economics
- Ethanol fuel price

Demand for Liquid Fuels

~ 3 million passenger vehicles in Minnesota

- If 25% replacement with ethanol and 20% reduction in mpg
- 840 million gallons/year
- if 100 gallons/ton yield
- 8.4 million dry tons

Billion Ton Update

U.S. DOE recently updated the "Billion Ton Study" with estimates of U.S. biomass supply.

Conclusions:

- 1.3 billion tons could be potentially available
- Energy Crops will play a major role in producing this biomass
- High-Yield Scenario – 500 million to 800 million dry tons/year by 2030 with high value scenario (4% annual growth increase)

Minnesota Potential Biomass Sources

- Agricultural Residues
- Forest Resources
- Dedicated Energy Crops

Agricultural Residues

- Soybean – very little residue available
- Corn – up to 4 tons produced but …
  - Long-term sustainability issues
  - Karlen, Johnson – REAP program
  - National program to evaluate long-term impacts of residue removal

Agricultural Residues

"Take home message" – although production is high, an average of about 1 to 1.5 dry tons/acre/year could be removed

- If moldboard plow and corn/soybean rotation – very limited opportunity for additional removal
- Continuous corn and reduced tillage – highest availability
- However … nutrient replacement, yield impacts
- Corn cobs – high potential, collection/handling economics

Estimation of Forest Biomass Availability

- Minnesota estimates - ~ 6.0 million dry tons available sustainable production (Governor's Task Force)
- Currently – about 3.2 million tons used in papermaking, forest products and harvest residues
- Harvest residues – about 25% of total stand
- Consideration for long-term productivity, more realistic is probably about 2 million additional dry tons

Variety of Energy Crop Options

12 Year Poplar in Central Minnesota

Switchgrass in NW Minnesota

Miscanthus, Switchgrass, Energy Cane, Virginia Wild Rye, Prairie Cordgrass

- Poplar – long rotation or coppice, Willow – coppice
- Energy crops generally lower input than other crops
- High Energy Out:Energy In Ratio

Dedicated Energy Woody Crops

- Poplar and Willow dominant species
- Cottonwood - widespread adaptability across U.S.
- Species that cross with cottonwood
- Characteristics that lend themselves to agricultural management

Verso Paper
Central Minnesota

25,000 acres

3.5 to 4.5 t ac^{-1} yr^{-1}

12 year pulpwood rotation

One primary clone NM6

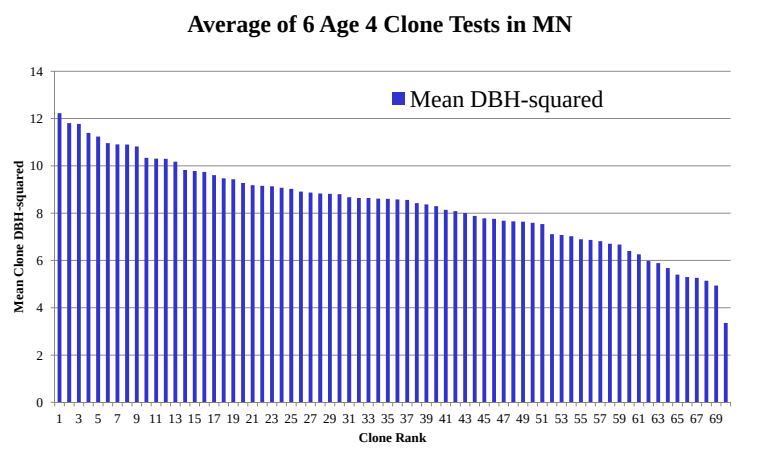
New DXN clones developed at NRRI are being propagated for commercial production

Harvesting Equipment Test
Poplar in PNW

Long Term
Breeding and Genetic Improvement

- Capitalize on existing breeding programs in MN and OR (poplar) and NY (willow) to expand focus and deployment of new clones to entire U.S.
- Test second-generation clones in national test network to improve yield over time

Composite Results of Six Clone Trials in Central MN: Age 4 All MN-bred clones



- Note: commercial control NM6 is average rank of 66th
- Average of top 20 clones is 1.98 that of NM6
- Dodged a bullet through genetic development program
- Marsonnina leaf disease reducing yield over time

AURI-NRRI Herbaceous Biomass Project Switchgrass/Cordgrass/Virginia Wild Rye

AURI-NRRI Herbaceous Biomass Project
Switchgrass/Cordgrass/Virginia Wild Rye

- Evaluating Production and Fertilizer Response
- Swithgrass – 4 to 5 tons/acre/yr ovendry
- Prairie Cordgrass – 5 to 6 tons
- Virginia Wild Rye – 3.8 – quickly established

Economics of Production

(based on UM-FINBIN production cost data)

Cost Component	Corn	Wheat
direct expenses ($/acre)	$348.01	$178.01
overhead expenses ($/acre)	$174.07	$88.41
Total ($/acre)	$522.08	$266.42
Commodity Price	$6.49	$6.28
Assumed Yield (bushels/ac)	182	58
Gross Revenue ($/acre)	$1,181.76	$361.35
Return over Expenses (acre)	$659.68	$94.93
Poplar Coppice Annual Cost ($/ac/year)	$58	$58
Biomass Cost (pre harvest) @ 4 tons/ac/yr	$179.42	$38.23
Biomass Cost (pre harvest) @ 5 tons/ac/yr	$143.54	$30.59
Harvest Cost/dry ton (coppice harvester)	$20.00	$20.00
Assumed Delivery (50 mile haul)	$18.00	$18.00
Total Delivered (@ 5 tons annual yield)	**$181.54**	**$68.59**
Feedstock $/gallon etoh @100 gallons/ton	**$1.82**	**$0.69**

Note: biomass cost is that price that will produce the equivalent revenue to the farmer

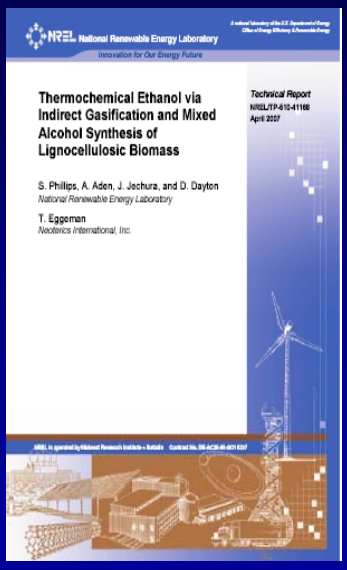
Liquid Fuels Production

- ZeaChem – biochemical/thermochemical
  - pilot plant running at Boardman, OR
  - poplar trees primary feedstock
- POET Project Liberty
  - broke ground for plant in Iowa very recently
- Mascoma – biochemical – engineered yeast
  - development of pilot plant in Michigan
- Dupont/Danisco – pilot plant in Vonore, TN
  - Breaking ground for plant near Nevada, IA

Cellulosic Ethanol Economics

- Phillips, et.al. - NREL Study
- Process flow diagrams
- Economic analysis
- $0.57/gallon capital and operating
- assumed very inexpensive feedstock

- "nth" plant – not immediate
- $3.00 capital/gallon



Potential Economics

- $3.85 pump price = roughly $3.40/gallon MN rack price
- reduce value of etoh by 20% so equivalent to $2.72

- if 100 gallons/ton and biomass is grown at $100/ton = $1.00/gallon in feedstock ($0.57 + $1.00 = $1.57/gal)
- if the first generation of plants run as expected
- if markets for fuel don't fluctuate too much to disrupt the momentum

Then new industry born with large impact

Conclusions

Biomass production for liquid fuels economically realistic under current markets

A tidal wave of impact if economically feasible

Technology will be proven soon

Relevant Questions

Jobs created per ton and economic impact?

How to reduce/avoid the food versus fuel debate?

What to grow, how to grow it, on what soils?