West Central Renewable Ammonia Development LLC

Distributed Ammonia Production from Biomass

Minnesota Renewable Energy Roundtable

July 24, 2012

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- Public/private collaboration to develop biomass to anhydrous ammonia project in west central Minnesota
- Project milestones and objectives:
  - Develop biomass supply of 100,000 tons per year
  - Engineer unified conversion process using commercially available technologies
  - Estimate capital & operating costs of proposed plant
  - Prepare financing plan for construction & operations

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Project History

- 2009 - Ag sub-committee of the Kandiyohi County/Willmar Economic Development Commission identified ammonia opportunity
- 2010 preliminary feasibility study conducted
  - Wind to ammonia not economic
  - Biomass to ammonia has potential
- 2011 Next Gen grant opened and WCRAD was formed to pool public/private resources
- 2012 WCRAD awarded grant

Acknowledgements

- The effort for local ammonia production has benefited from the efforts of a number of people among them:
  - West Central Research & Outreach Center
    - Mike Reese
  - S.L. Simon Engineering PA
    - Stan Simon
  - Swift County EDC
    - Jennifer Gruis
  - Kandiyohi County/Willmar EDC
    - Steve Renquist and Cathy Keuseman

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Strategic Issue

- Achieving Minnesota's goal of 25 x 25 depends heavily on crop and crop residue for biomass supply.
- Crop productivity depends on a reliable source of nitrogen fertilizer
- Dependency transfers from foreign oil to foreign ammonia

Economic Significance

- All nitrogen fertilizers used in Minnesota are produced out of state and most are out of country.
- Fertilizer producers have changed their pricing strategy to “value added” basis as opposed to “cost to produce” based
- The result is a significant burden on MN agriculture – about $500 million for corn alone

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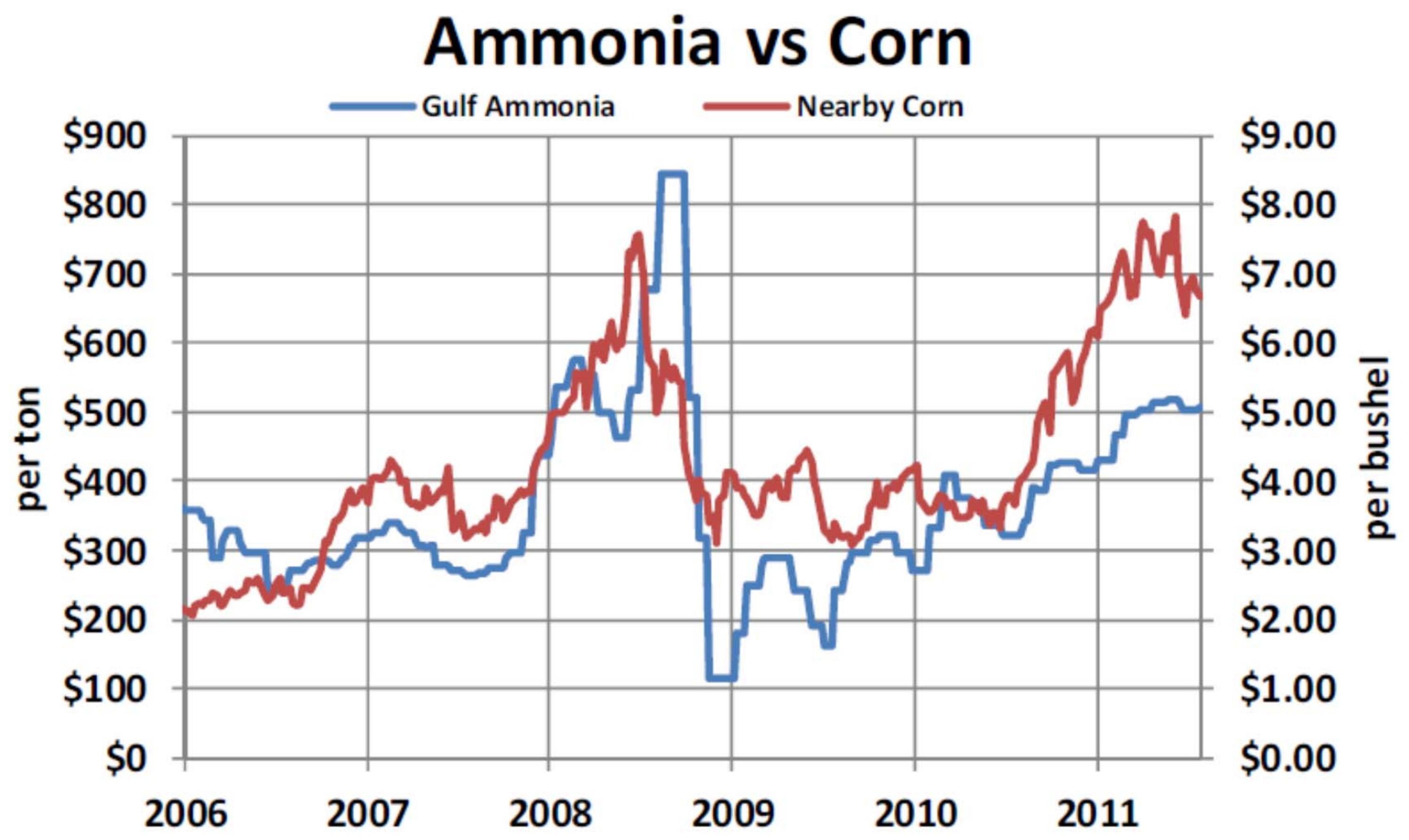
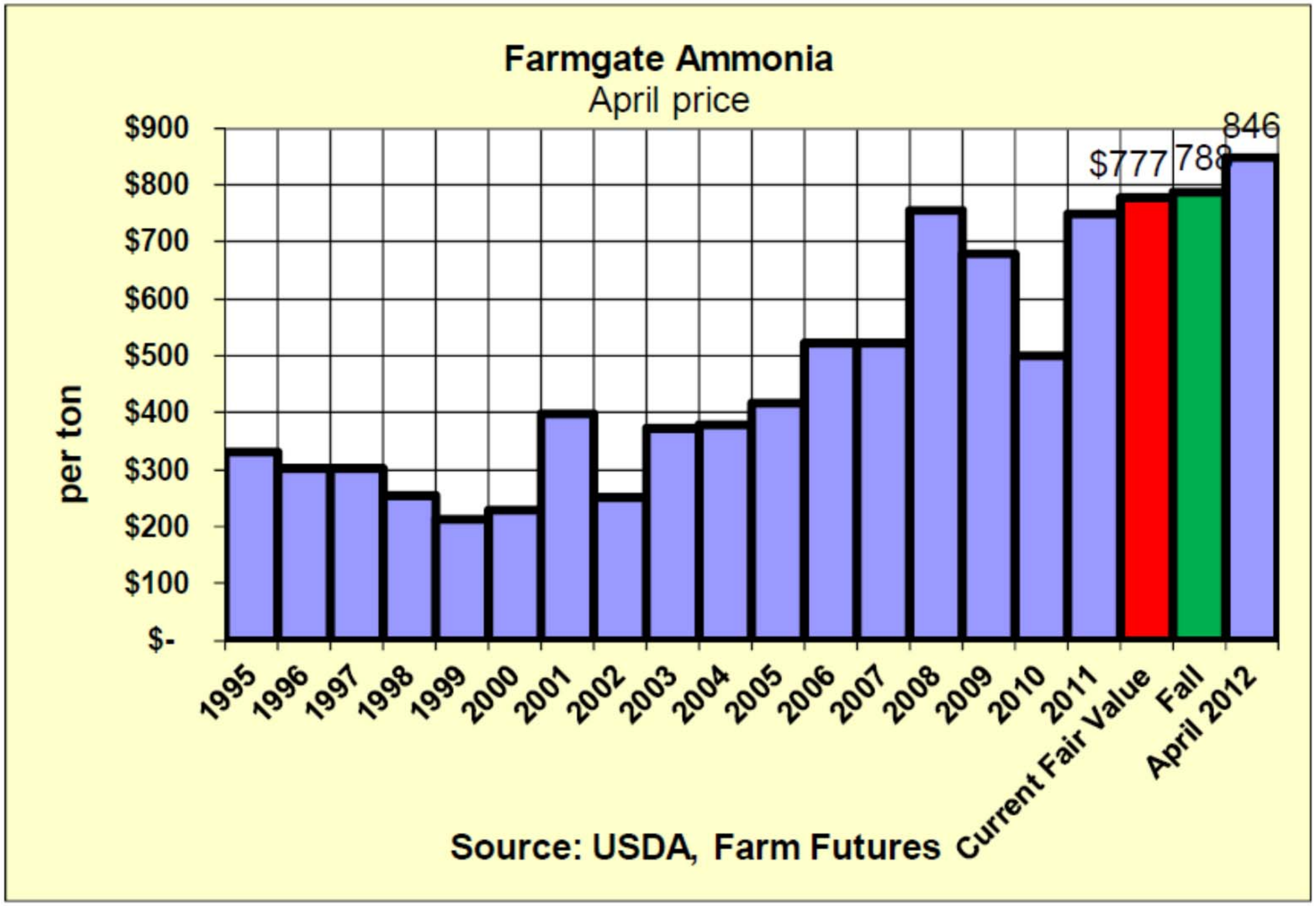
The Price of Ammonia is Tied to Corn



Farmgate Prices at Record Highs



Sources & Uses of Funds

Debt Financing	$29,000,000
Seed Equity	1,500,000
Member Equity	27,500,000
Total Sources of Funds	$58,000,000

Buildings & Equipment	$52,000,000
Soft Costs	2,800,000
Pre-Production Expenses	1,000,000
Working Capital	2,200,000
Total Uses of Funds	$58,000,000

Breakeven Prices

Net Income Analysis

Biomass $/Ton	NH_3 $/Ton
$ 0.00	$252.45
$ 25.00	$299.20
$ 50.00	$352.95
$ 75.00	$406.70
$100.00	$460.45

EBITDA Analysis

Biomass $/Ton	NH_3 $/Ton
$ 0.00	$109.82
$ 25.00	$163.57
$ 50.00	$217.32
$ 75.00	$271.07
$100.00	$324.82

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Project Questions

- Establish biomass supply chain
  - Is pelleting a cost savings?
  - What role for natural gas?
- Process design
  - Is the gasification technology ready?
  - Can we produce 99.999% hydrogen?
  - What ammonia reactor design will we use?
- What form of nitrogen fertilizer will we produce?

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Biomass Supply

Biomass Source	Annual Acres	Available biomass tons per year
CRP lands – 1/3 per year	1/3 of 185,299	123,486
Spoiled hay – 3% of acres	3% of 139,500	15,000
Wheat straw	73,100	73,100
Corn for Grain	1,086,300	2,172,600
Corn to Sugar Beets	94,800	189,600
Sweet Corn Stover	100,000	200,000
7 County totals		2,773,786
We need		95,000 tons per year
		3% of the available

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Biomass Supply Second Phase

- Sort the biomass supply by harvest window
  - Maximize utilization of the harvest equipment
  - Widen the harvest window to protect against weather
  - Corn stover is not expected to be the largest contributor
- Identify specific farmers and land for contracting
  - Moving from aggregate to specific for biomass sources

Local Feedstock Options

Wood Chips or Pellets

Sources of Woody Biomass:

- Logging residue
- "Primary" mill residue
- "Secondary" mill residue
- Dedicated energy crops
- Land clearing projects
- Brush from brush lands
- Pre-commercial thinning

The project's prime back-up
&
6-month reserve supply

***Assumption:* 30,000 tons *or* 4% of available tons**

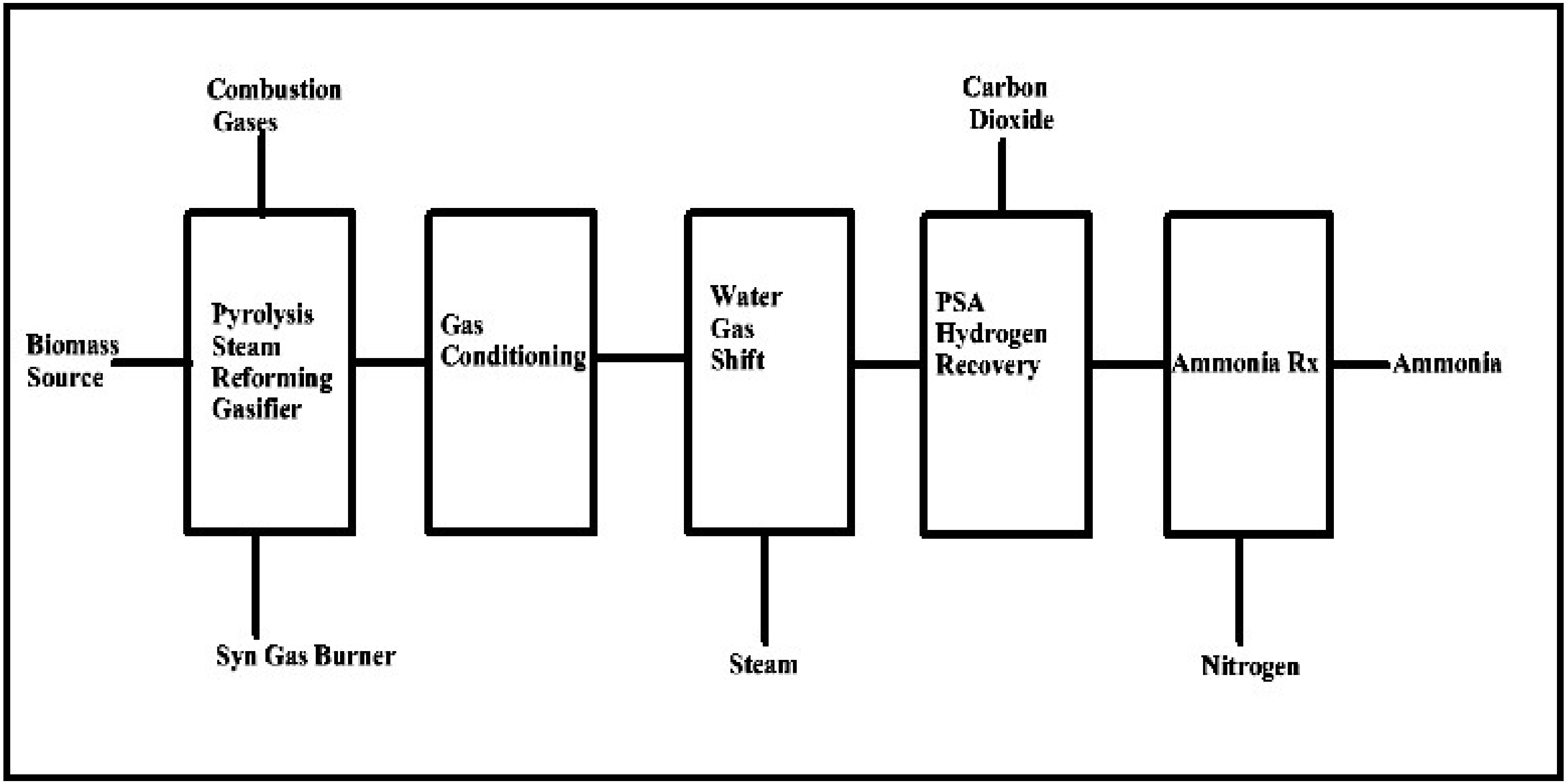
Minnesota's Forest Biomass Value Chain
Page 24…
…."There are 800,000 green tons available the next four years"….

***Source:* BioBusiness Alliance of Minnesota**

Natural Gas

- Natural gas prices are low - $4 per million Btu or less
- Up to 1/3 of biomass can be replaced with natural gas with <u>no</u> process change.
- What role should natural gas play in the process design?
  - As start up fuel?
  - As operating fuel?
  - As feedstock?

Biomass to Ammonia Process



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Process Issues

- Gasification
  - Feedstock flexibility
  - Yield
  - Syn gas quality
- Hydrogen production
  - Water gas shift performance
  - Hydrogen separation
- Ammonia Reactor
  - Conventional Haber Bosch
  - Urea reactor

Nitrogen Forms

- Nitrogen fertilizer can be applied in several forms
  - Anhydrous ammonia
  - Urea
  - Aqueous Ammonia
  - UAN solution
- It is dangerous to assume you can change customer preference but the cost effects are substantial

In Summary

- There is strong incentive for Minnesota to become its own nitrogen fertilizer supplier.
- The current pricing strategy is creating a price umbrella which invites competition.
- At issue:
  - Is the technology available to execute the process?
  - Will the business withstand predatory response?