BIOPRODUCTS FROM BIOMASS

University of Washington

Bioresource Science and Engineering

William T. McKean

Mark Lewis

BIOPRODUCTS FROM BIOMASS

OBJECTIVES:

- PRODUCE FIBER AND CHEMICAL PRODUCTS FROM BIOMASS

APPROACH:

- PULPING with MILD CONDITIONS DEVELOPED TO PARTIALLY DISSOLVE NON-WOOD HEMICELLULOSE without DECOMPOSITION

- PRODUCE THE BIOCHEMICALS FROM THE HEMICELLULOSE RICH PULPING WASTE LIQUOR

BIOREFINERY: RAW MATERIALS

RAW MATERIALS

1.Agricultural Residues
- a.**Wheat Straw**
- b.Seed Alfalfa Straw
- c.Canola Straw
- d.Bagasse
- e.Corn Stover

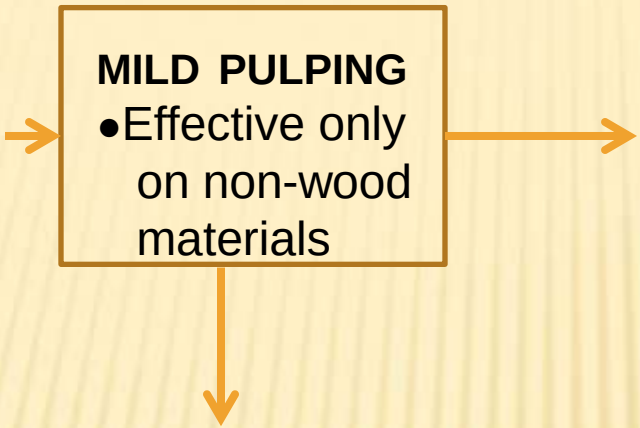
2. Energy Crops
- a.Energy Cane
- b.Switch Grass

BIOREFINERY: PULPING

RAW MATERIALS

1.Agricultural Residues
- a.**Wheat Straw**
- b.Seed Alfalfa Straw
- c.Canola Straw
- d.Bagasse
- e.Corn Stover

2. Energy Crops
- a.Energy Cane
- b.Switch Grass

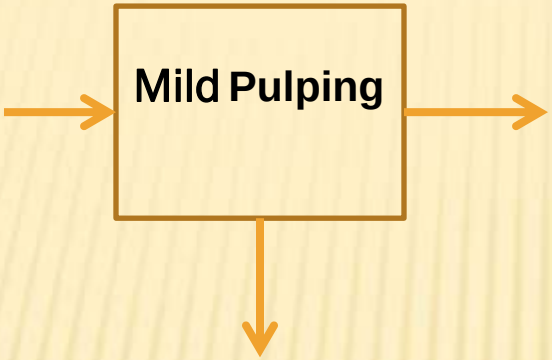


BIOREFINERY: PRODUCTS

RAW MATERIALS

1.Agricultural Residues
- a.**Wheat Straw**
- b.Seed Alfalfa Straw
- c.Canola Straw
- d.Bagasse
- e.Corn Stover

2. Energy Crops
- a.Energy Cane
- b.Switch Grass



FIBER PRODUCTS

1. Molded Products
2. Food Service
3. Packaging-Paper/Paperboard
4. Printing and Writing Grades
5. Niche Specialty

WASTE LIQUOR

1. Hemicellulose Sugars
2. Sulfur Free Lignin
3. Non Process elements(ash)

BIOREFINERY: GLYCOL PRODUCTION

SUGAR RAW MATERIALS

1.Non wood Biomass
PulpingWaste Liquors
2. Energy Sugar Beets

3. Wood Sources:
- Sulfite Pulping Waste Liquor
- Various Pulp Mill Sludges
- Acid Prehydrolysis Liquors
- Some Solvent Pulping Liquors
- Steam Explosion Liquid and Solid Products

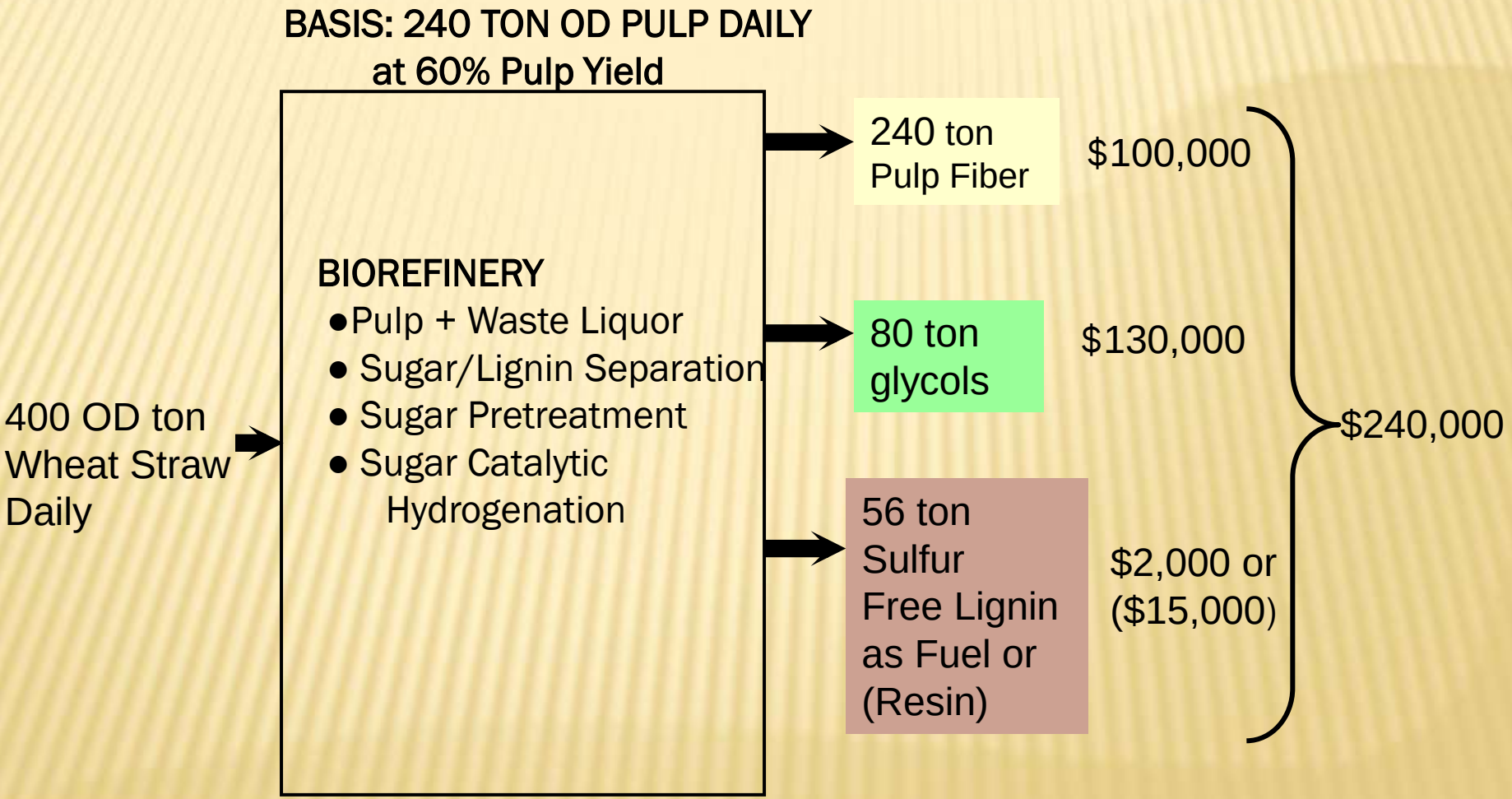
SUGAR PRETREATMENT

- Lignin, Ash and Impurity Removal

CATALYTIC HYDROGENATION

- Sugar Alditols
- Ethylene Glycol
- Propylene Glycol
- Butane Diols

BIOREFINERY MATERIAL BALANCE – WHEAT STRAW



LABORATORY CATALYTIC HYDROGENATION

PILOT PLANT HYDROGENATION REACTORS

S2G BioChem
SUSTAINABLE CHEMICAL SOLUTIONS

Sugar-to-Glycol

Manufacturing Bio-chemical Glycols From Cellulosic Sugars

Sample Pulp Mill Economics

October 2012

North Vancouver, BC
www.s2gbiochem.com

Example: Pulp Mill Economics

- Biomass to Mill "A": 1,200,000 MT/yr (dry)
- Hemicellulose in biomass ~20%: 240,000 MT/yr
- Dissolving pulp yield (primarily cellulose): 450,0000 MT/yr @ $750+/MT
- Balance burned: ~$100/MT value

- Supplement Revenue: Sugar to Glycol
  - Monomer sugar rich pre-hydrolyzate : e.g.: 200,000 MT/yr
  - Potential to offload recovery furnace – increase pulp production
  - Supply hemicellulose over-the-fence to Sugar-to-Glycol plant…

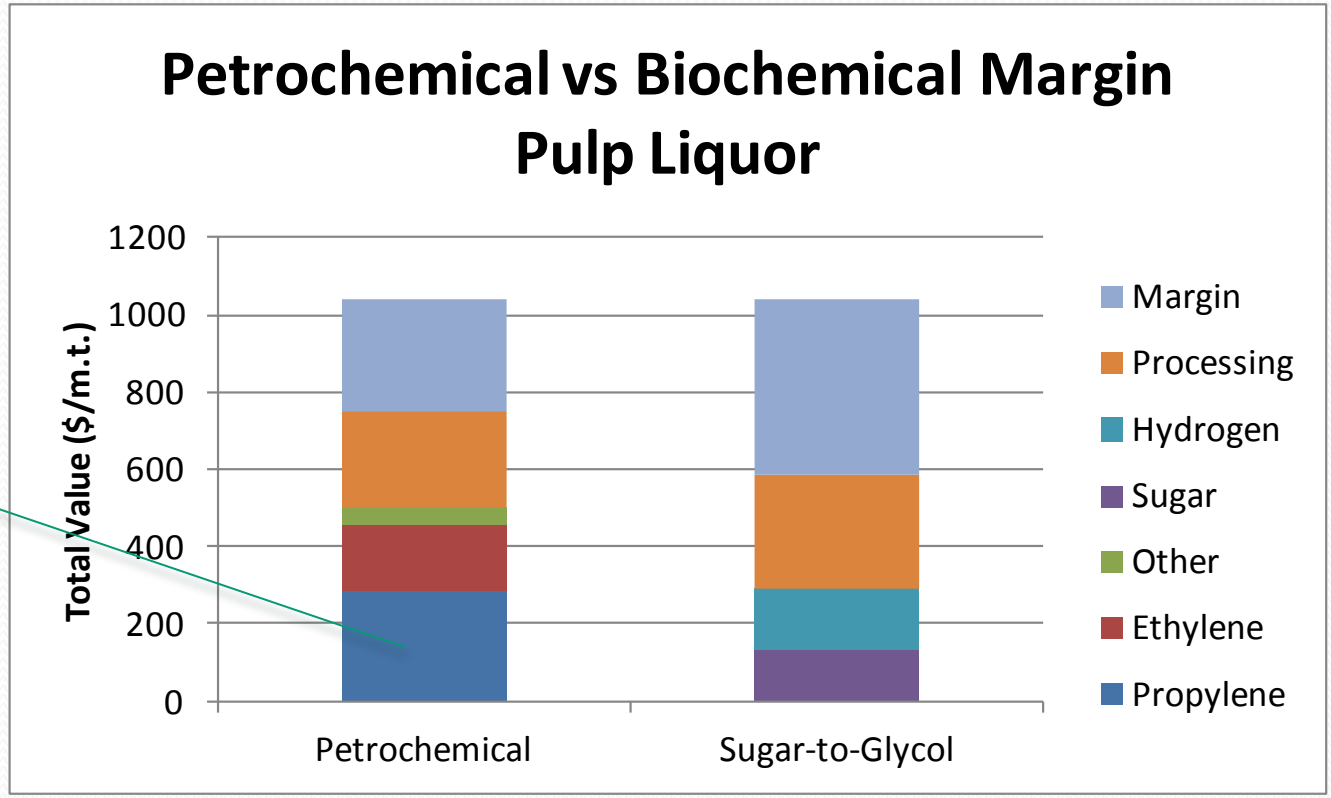
S2G Economics - Highly Simplified, Worst Case

- Feed: 200,000 MT/yr monomer sugars
- Products: 160,000 MT/yr glycols (80% yield)
  - PG: $1500/MT
  - EG $850/MT → 1500/MT
  - BD $2000+/MT

  } $1000+/MT avg
- Net Revenue ~$160,000,000 +/yr
- Opportunity cost (sugar cost): $20,000,000
  (power: ~$100/MT feed)
- Operating costs: $72,000,000
  (hydrogen, catalyst, steam, labour, etc.):~$450/MT
- Crude margin: $68,000,000/yr
- Capital: $150,000,000

Margin

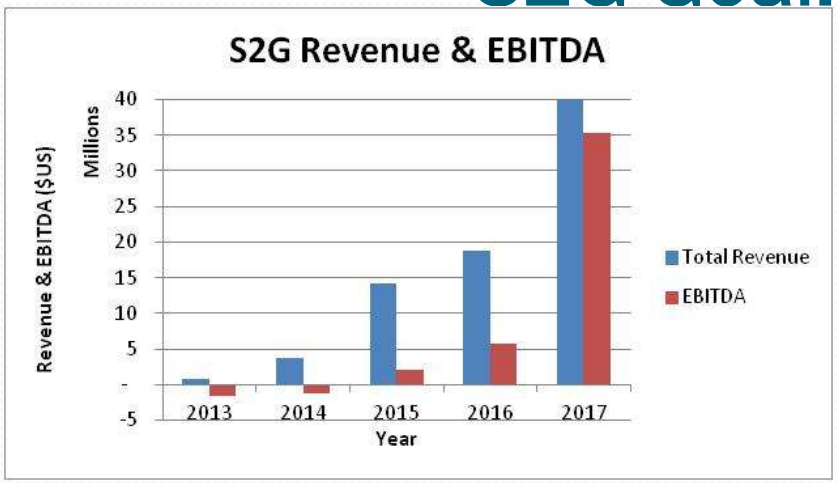
Tied to Oil Pricing



Next Steps

- Confirm process performance – pilot runs with real liquors
- Update process modelling → engineering study → economic model
- Arrange project financing, partners

S2G Goal: Value Growth



Position for IPO or liquidity event in 3 years

Gevo: $100 MM;
Elevance: $100 MM;
Solazyme: $225 MM

- Pipeline of projects
- Revenue & profit growth
- Proven biochemical market
- Operating commercial plants
- IP barriers
- Pilot plant – feedstock flexibility