Created By: Alyssa Hughes

The Implementation of Organosolv Pretreatment

Team Members:

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Project Proposal

* Our goal is to implement an Organosolv process into an existing cellulosic ethanol plant that can produce 20,000 lb/hr of fuel grade ethanol.

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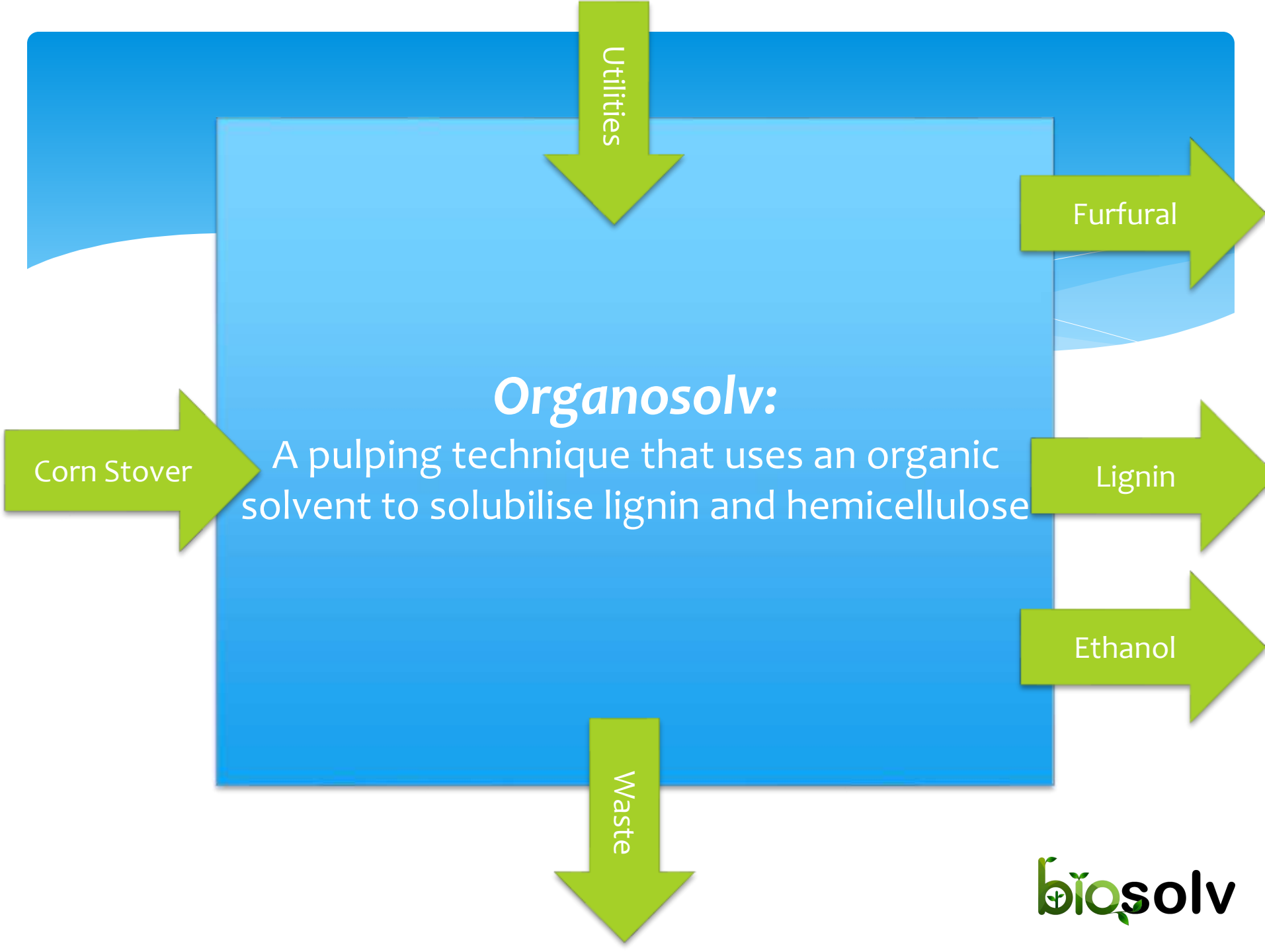
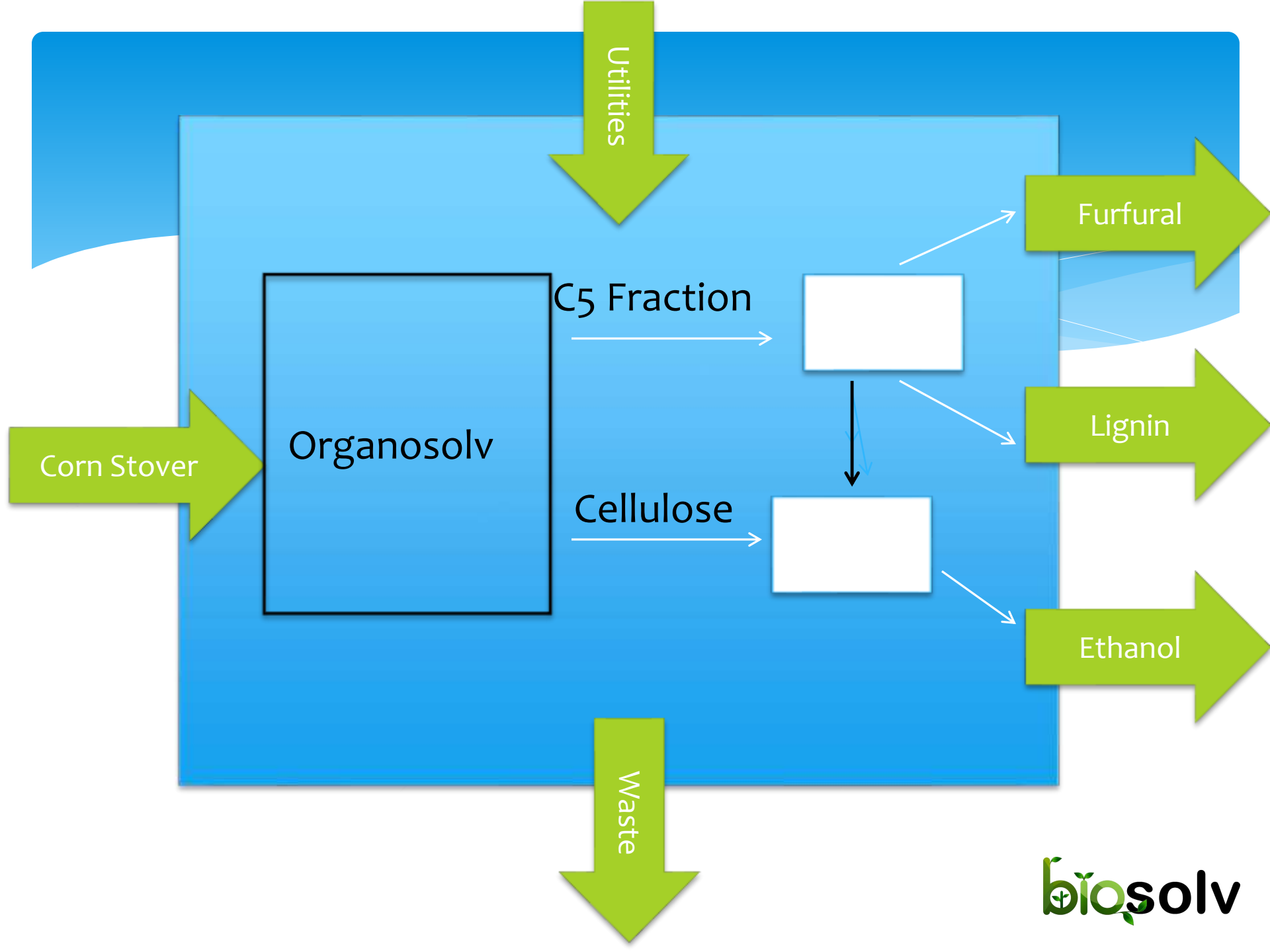

Utilities
Furfural
Organosolv:
A pulping technique that uses an organic solvent to solubilise lignin and hemicellulose
Corn Stover
Lignin
Ethanol
Waste


Utilities
Furfural
C5 Fraction
Corn Stover
Organosolv
Lignin
Cellulose
Ethanol
Waste
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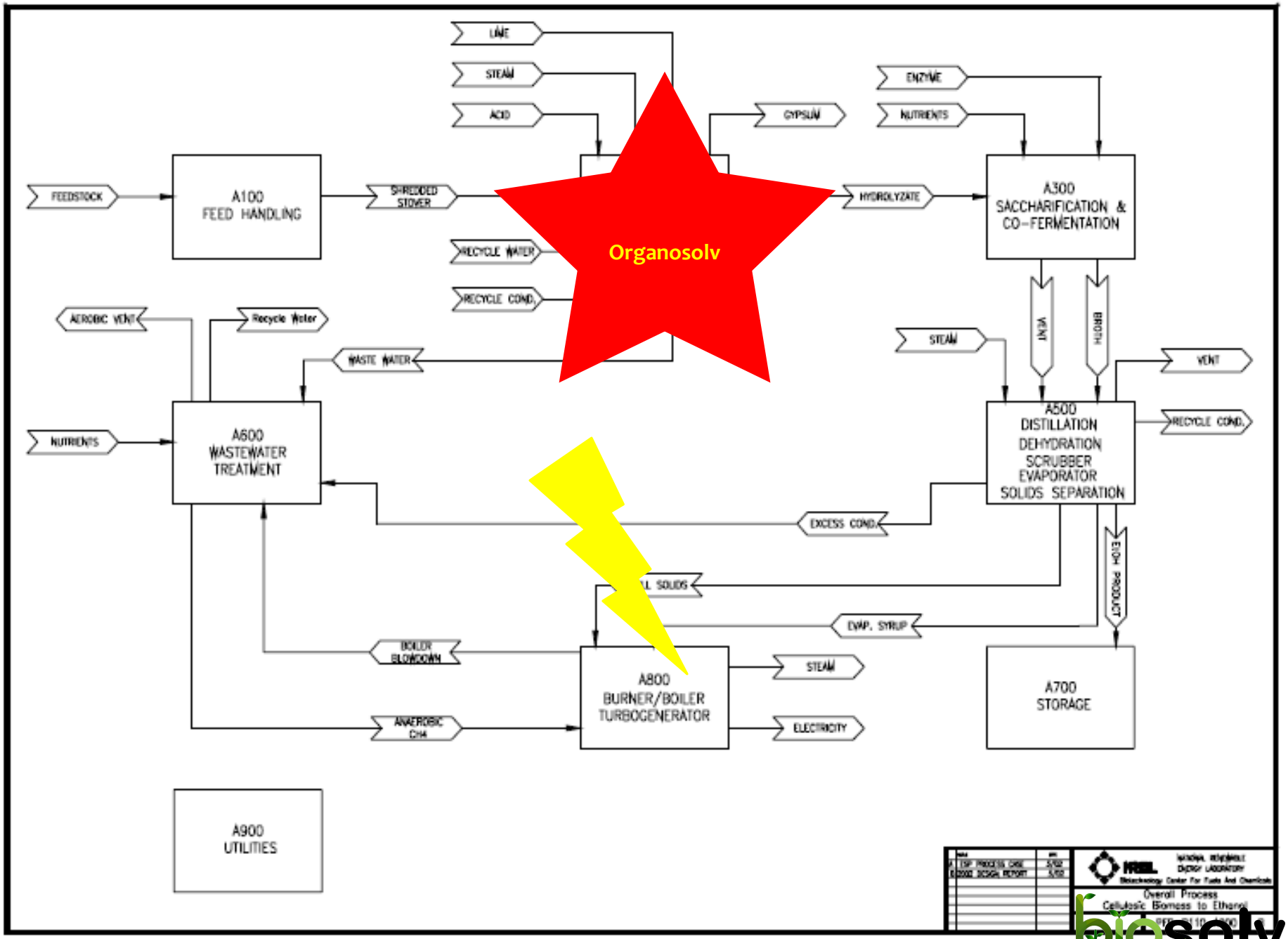
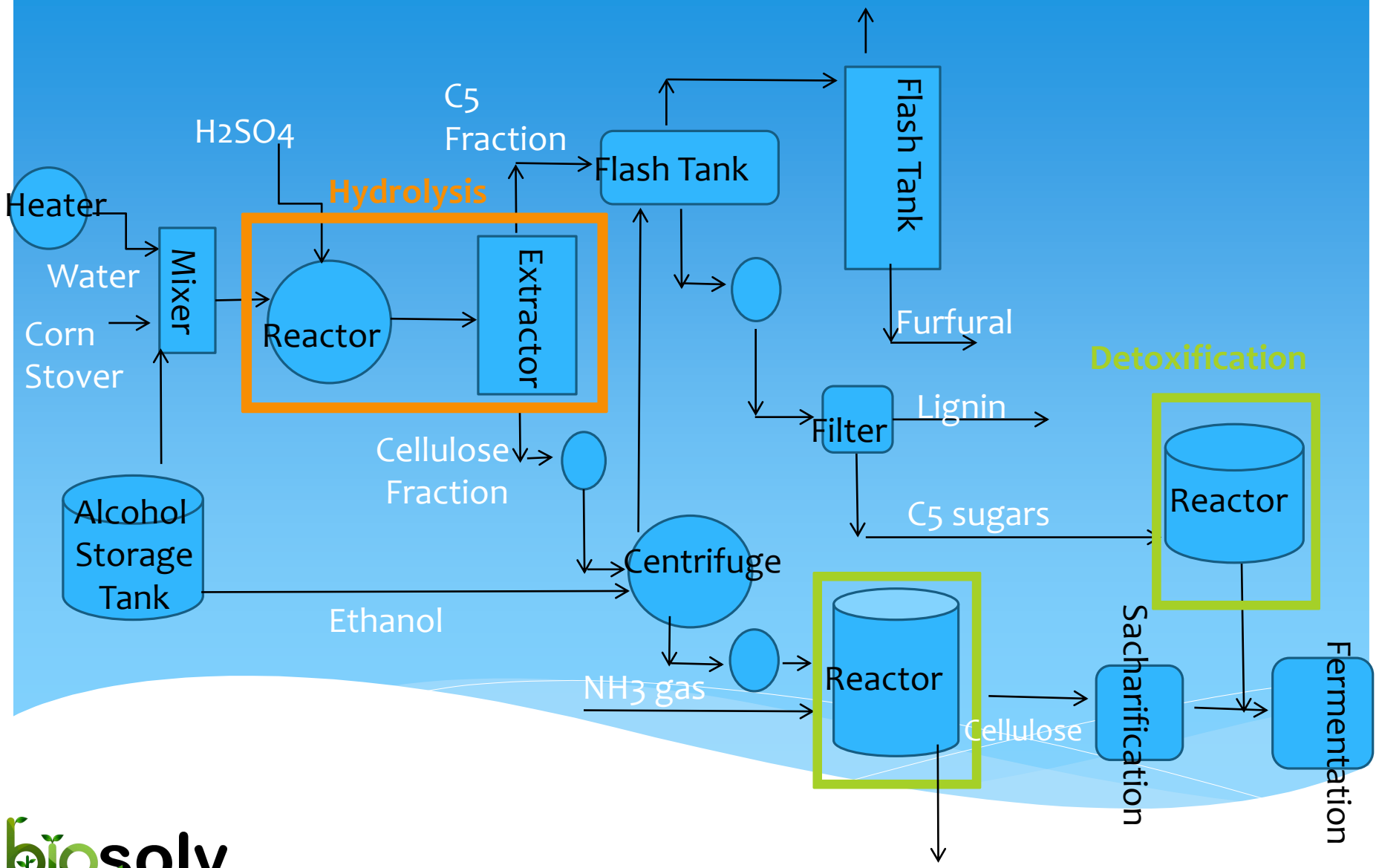

LIME
STEAM
ACID
GYPSUM
ENZYME
NUTRIENTS
FEEDSTOCK
A100
FEED HANDLING
SHREDDED STOVER
HYDROLYZATE
A300
SACCHARIFICATION &
CO-FERMENTATION
Organosolv
RECYCLE WATER
RECYCLE COND.
AEROBIC VENT
Recycle Water
WASTE WATER
STEAM
VENT
BROTH
VENT
NUTRIENTS
A600
WASTEWATER
TREATMENT
A500
DISTILLATION
DEHYDRATION
SCRUBBER
EVAPORATOR
SOLIDS SEPARATION
RECYCLE COND.
EXCESS COND.
L SOLIDS
ETOH PRODUCT
EVAP. SYRUP
BOILER
BLOWDOWN
A800
BURNER/BOILER
TURBOGENERATOR
STEAM
A700
STORAGE
ANAEROBIC
CH4
ELECTRICITY
A900
UTILITIES
NREL
Overall Process
Cellulosic Biomass to Ethanol

Process Overview



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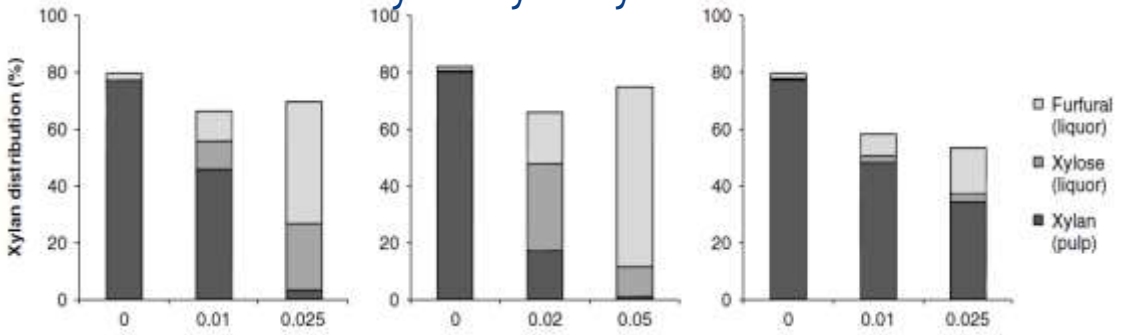
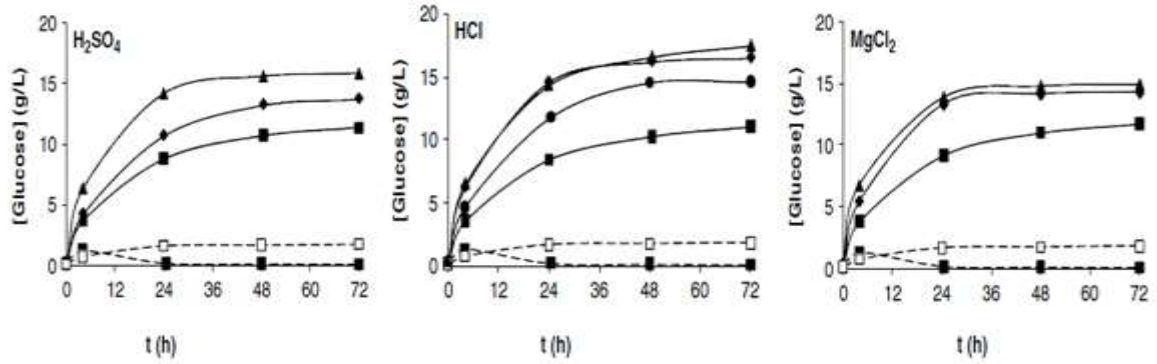
Optimization

Catalysts: H_2SO_4, HCl, $MgCl_2$

Xylan hydrolysis



Glucose yield



- *H_2SO4*
  - Weaker acid than HCl, but also less expensive and corrosive
  - $MgCl_2$ gives a lower enzymatic glucose yield then the two acids.

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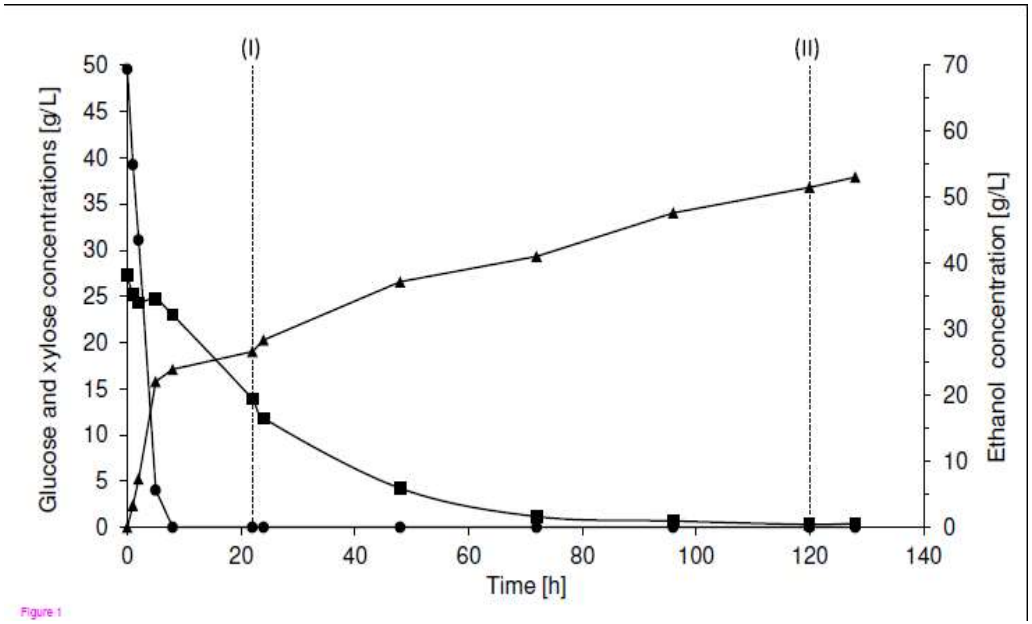
Optimization

Ethanol vs. Methanol

* *Ethanol*
  * Easy recovery
  * Low cost



Separate vs. Co-fermentation

* *Co-fermentation*
  * Reduce vessel down time for cleaning – smaller plant is at an equal annual capacity
* Higher productivities then separate processes

Organosolv Flow Diagrams

Pretreatment

Hydrolysis

C5 sugars

Fermentation of C6 Sugars

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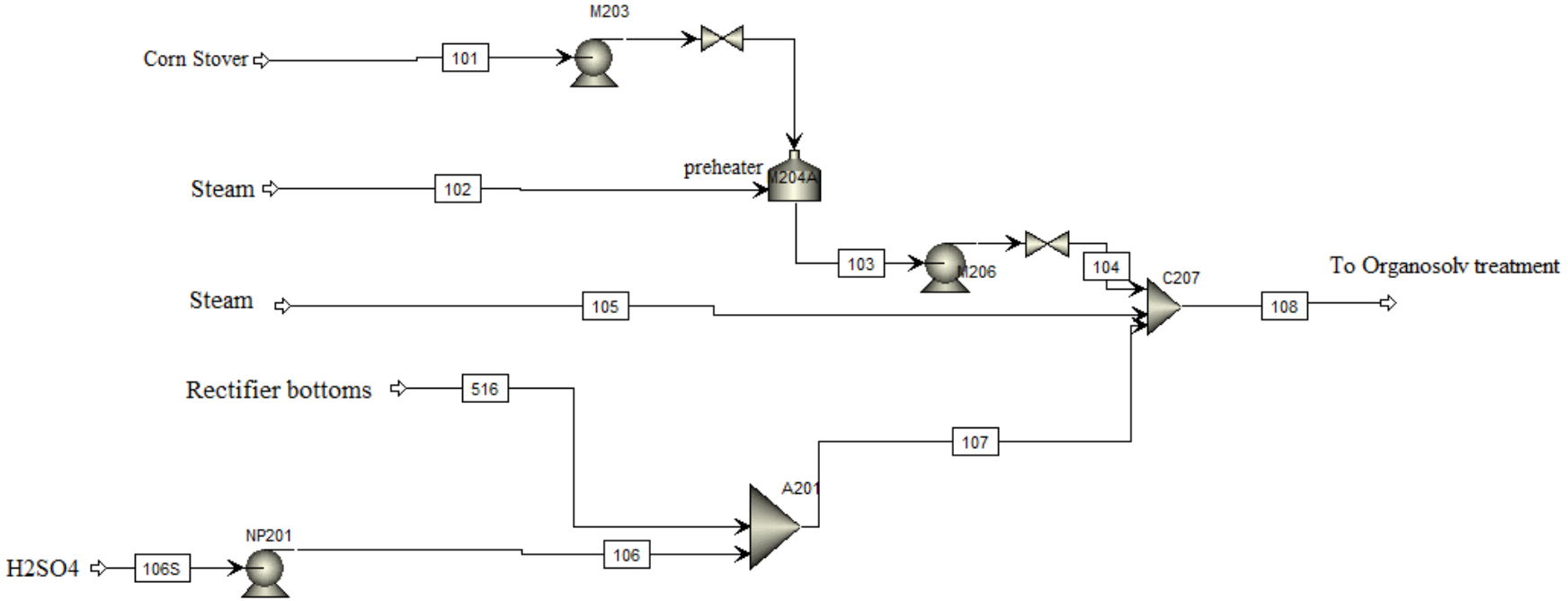
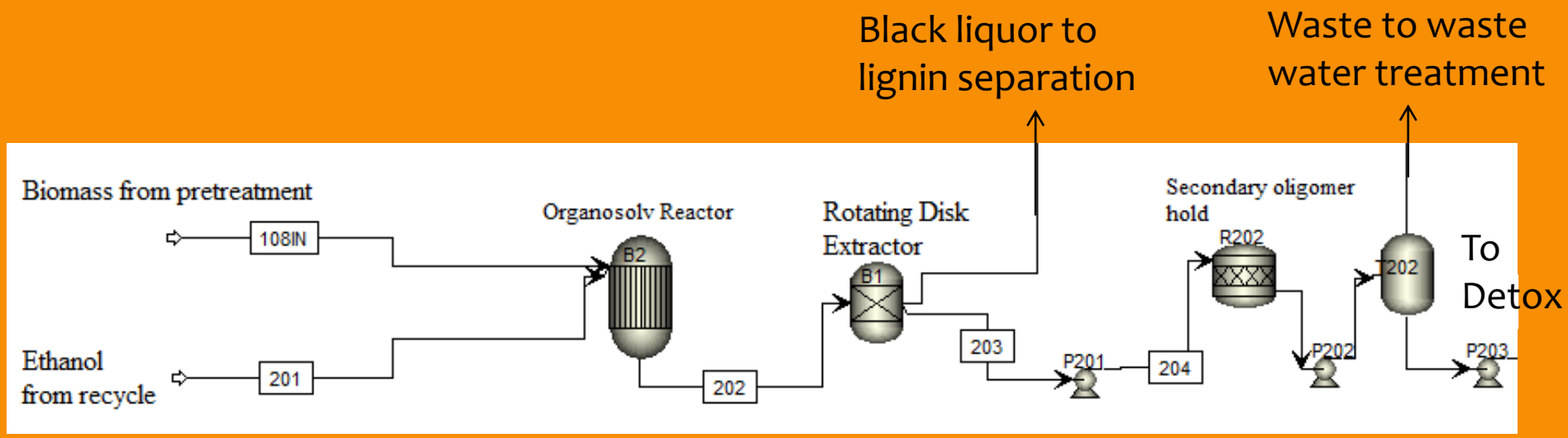
Pretreatment



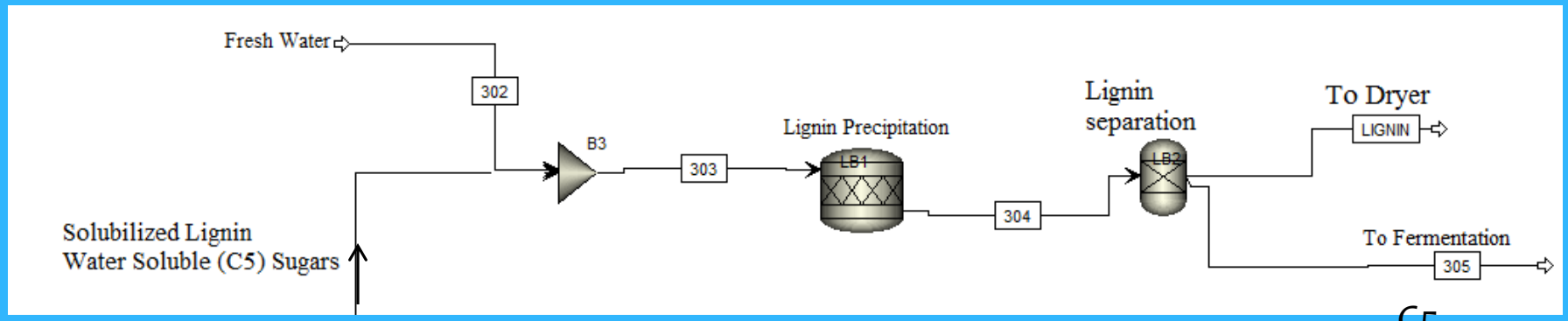
- Cornstover pulping
- Addition of steam and heat to break up lignin structure
- Initial addition of H_2SO_4 for hydrolysis

Hydrolysis



- Ethanol added for pulping, 50% (V/V)
- Pulped ~ 1 hour at 100°C, lignin solubilized
- Rotating Disk extractor removes liquor (C5 sugars, lignisol, and other by-products)
- Liquor sent to lignin separation unit, cellulose sent for further hydrolysis and saccharification and detox before fermentation

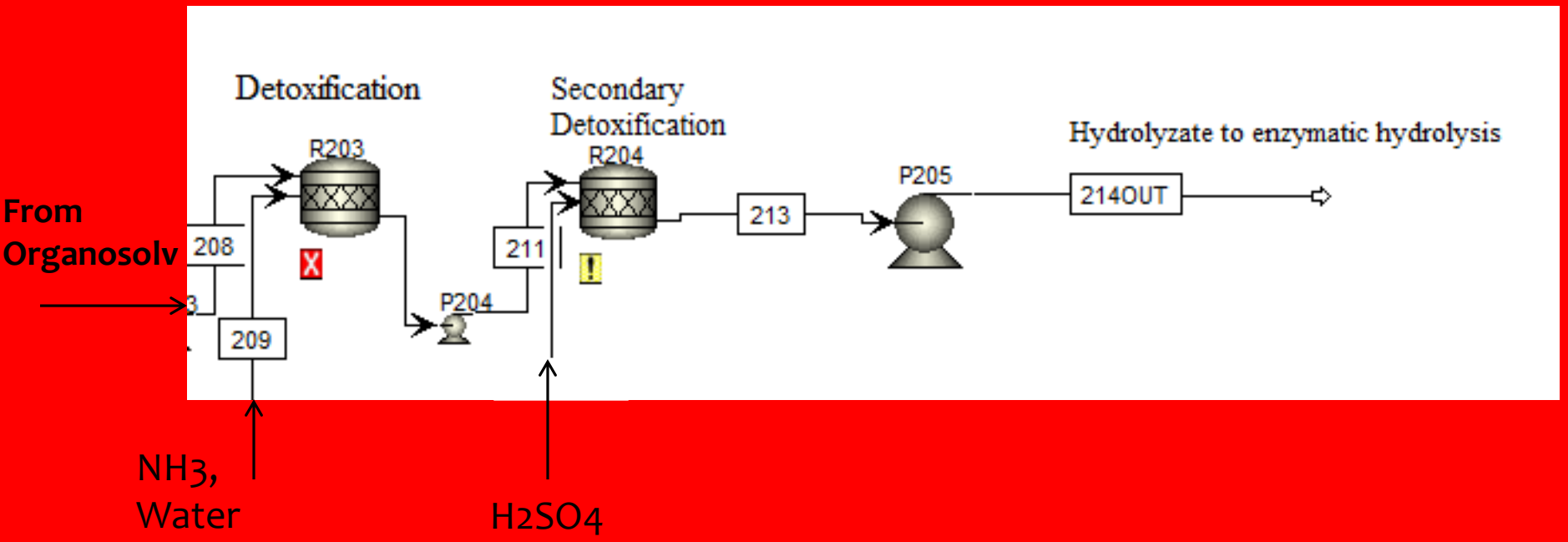
C5 Sugars



C5 Sugars

- Liquor from organosolv extractor washed with water, lignin precipitates
- Precipitate collected in filter and sent to dryer
- Filtered liquid with soluble sugars sent to fractional distillation for ethanol removal and then to fermentation

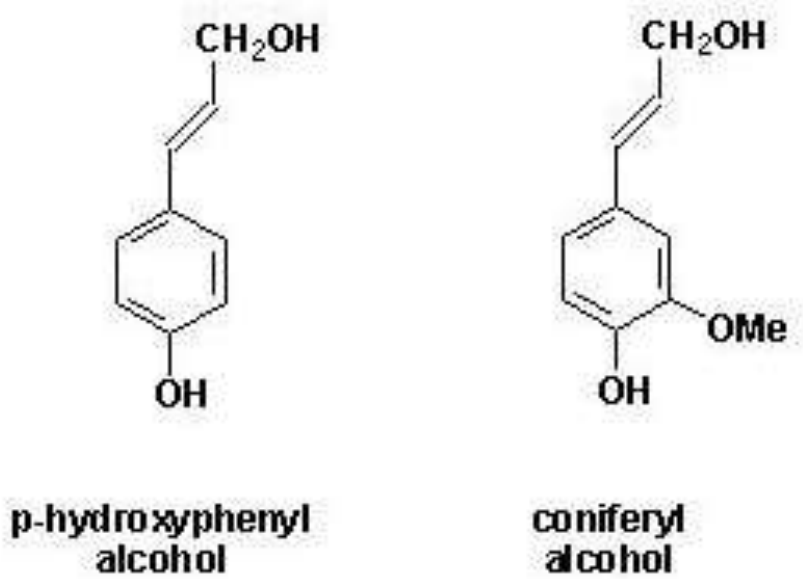
C6 Sugars



- Hydrolyzate from Organosolv detoxified with NH3
- Secondary detoxification to bring hydrolyzate to ~pH 6.8-7.2

Byproducts: Lignin

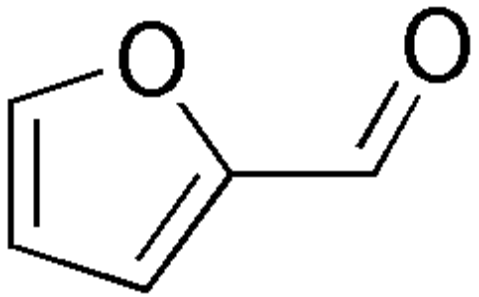
* Complex polymer with many forms and uses
* Low grade: cattle feed additive, aspalt conditioner, binders in wood and other materials
* High grade: specialty chemicals, pharmaceutical precursors, rubber additives
* Growing global market and research area
* $0.20-3.50 per kg
* Does not require very much extra equipment



Precursors for lignin

Byproducts: Furfural

* Organic compound used for chemical processes
* Solvent or lubricator
* Precursor starting material for other chemicals
* Low demand; China produces most of world supply
* $1 per kg
* Not enough produced to justify market risk or extra equipment



Business Opportunity

* Demand for alternative energy; government requirements
* More efficient process
* Less pollutant

* Midwest → Illinois
  * Heavy farming
  * Available feedstock
  * Proximity to large cities

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Economic Overview

- Based on the NREL study
  - Equipment Sizing
  - Operating Costs (Feed, Operating Conditions, etc.)
  - IRR, NPV, PBP
- Organosolv vs. NREL Pretreatment Analysis
- State & Federal Incentives
- Byproduct usability

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Organosolv Economics

- Total installed cost of Organosolv pretreatment = $21.5 million
- Total Capital Investment = $368 million
- IRR (30 year base) = 15%
- Pay back period = 4.25 years

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Organosolv Economic Issues

* Not profitable as a standalone process
* Highly dependent on incentives
* Questionable byproduct market

OSHA & EPA

OSHA

* Ventilation of CO_2
  * Control the rate and order of chemical addition
  * provide robust cooling
  * segregate incompatible materials to prevent mixing
* Large of amounts of water waste
  * Bio electricchemical system for treatment
    * Reduces green house gases
* Burning furfural
  * PEL: 5ppm 8 hr TWA

EPA

* Positive affects of Ethanol on environment:
  * Reduce carbon monoxide and nitrogen oxide outputs
  * In surface water evaporates quickly
  * Reduce green house gas emissions

Conclusion/Recommendations

- Organosolv is a better pretreatment option than current process
- Sellable lignin reduces boiler block and is profitable

- Lignin processing and stable market
- Continue project development

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QUESTIONS