



## Key technical factors enabling today's biochemical biorefineries

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## I. Biorefining & Biorefineries

## II. Introduction to Lignol

## III. Key Enabling Technical Factors

## IV. Conclusions



## I. Biorefining & Biorefineries - Definition



*A biorefinery is a facility that integrates biomass conversion processes and equipment to produce fuel, power, and chemicals from biomass.*

Source: National Renewable Energy Laboratory (NREL), [www.nrel.gov/biomass/biorefinery](http://www.nrel.gov/biomass/biorefinery)

*...and/or feed, food, materials from biomass*

*...useful products manufactured in a sustainable manner from biomass.*



# I. Biorefining & Biorefineries – Classes



Biochemical Biorefineries are those biorefineries which convert biomass polysaccharides and other constituents into useful products produced in a sustainable manner via biochemical deconstruction (enzymatic depolymerization) followed by biological conversion (fermentation).

Thermochemical Biorefineries are those biorefineries which convert biomass into useful products produced in a sustainable manner via thermochemical processing (syngas platform) without using biochemical or biological means.

Hybrid Biorefineries combine both Biochemical & Thermochemical Biorefining Technologies.



## II. Introduction to Lignol



- Emerging biorefinery company – Biochemical Biorefining of Lignocellulosic Biomass from Non-Food/Feed Sources
- **Corporate Goal:** low cost producer of Cellulosic Ethanol and High Purity Lignin with major GHG emission reductions
- BC based public company (LEC:TSX-V)
- Grown from 4 to 50+ employees in 3 years





# Conventional Oil Refinery

Gasoline

Petrochemicals



# **Lignol** Biorefinery



Cellulosic Ethanol

Renewable chemicals

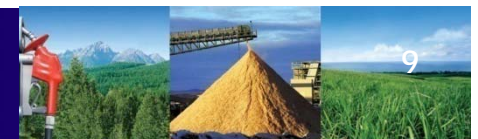
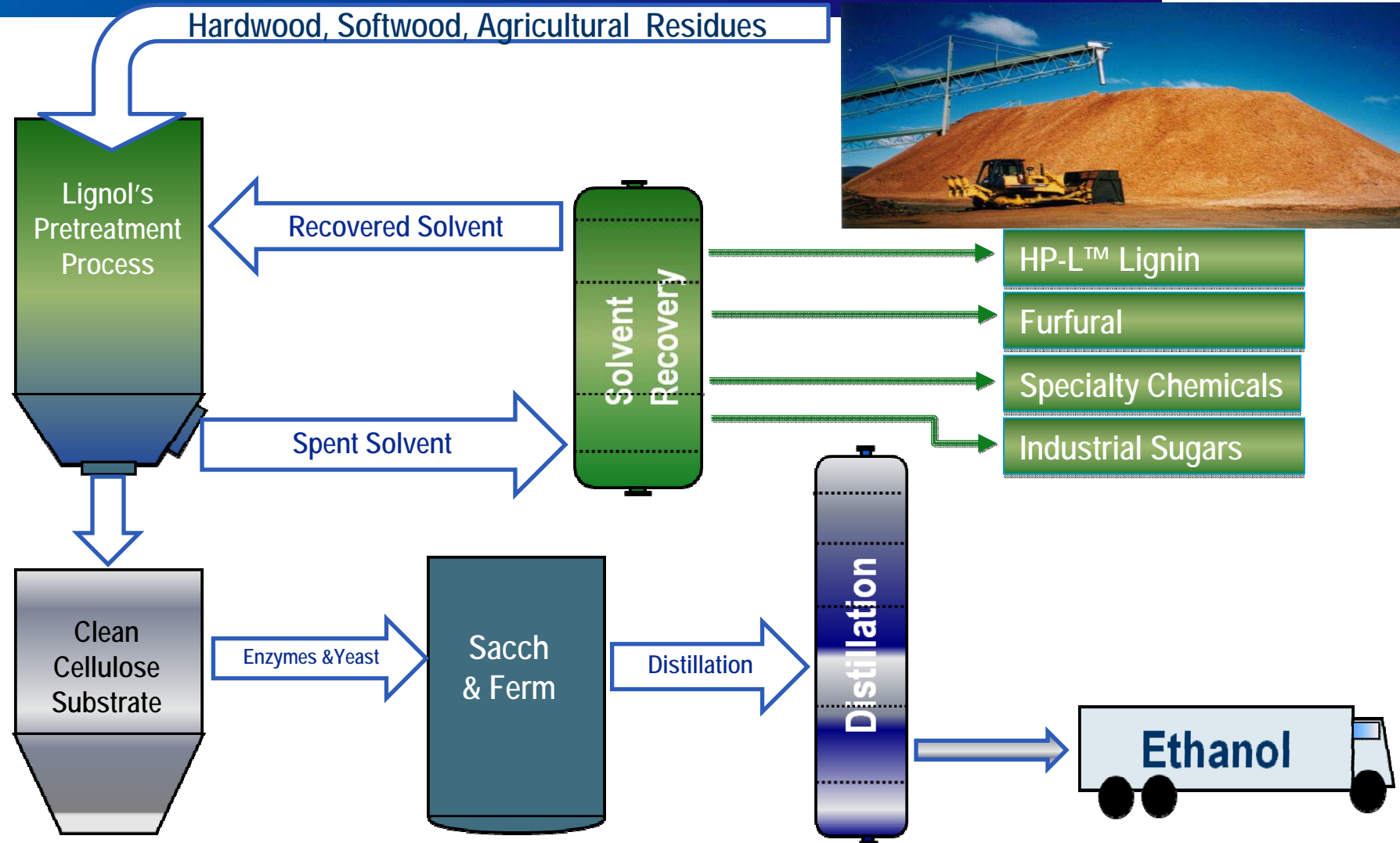


80% of our pine forests will die by 2015





## II. Introduction to Lignol



# "Clean" Cellulose Substrate



Lignol's  
Pretreated Wood



~95%  
Fermentable  
Components

## Other leading pretreatment technologies:

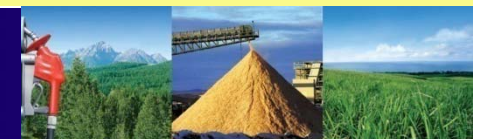
Dilute-Acid-Pretreated Corn  
Stover



Steam-Exploded Wood



Only ~60%  
Fermentable Components



## Process Features and Benefits



- Pretreatment proven on wood-based feeds and agricultural materials
  - Versatile process with few feed-related limitations
- Co-products displace petrochemicals
  - Major GHG emissions reductions beyond just transportation fuel benefits
- Versatile biorefinery with multiple products such as CE, HP-L<sup>TM</sup> lignin and furfural
  - Process economics enhanced by multiple revenue streams – process can be economic at smaller scale
- Extensive demonstration and piloting facilities provide design data
  - Technology is “demo-ready”





# Lignol's Pilot Biorefinery

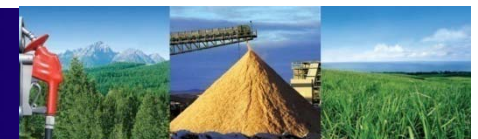


- Capacity: 1 tonne per day (dry basis)
  - Fully integrated mini-biorefinery
  - Fully instrumented
  - Industrial equipment
  - Rated at 100,000 l/yr ethanol
- Feedstocks: Hardwood & softwood, agricultural residues, energy crops
- Products: Ethanol, HP-L™ lignin, furfural, other chemicals
- Operation: 24/7 in campaigns



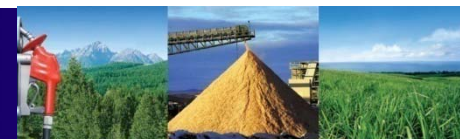
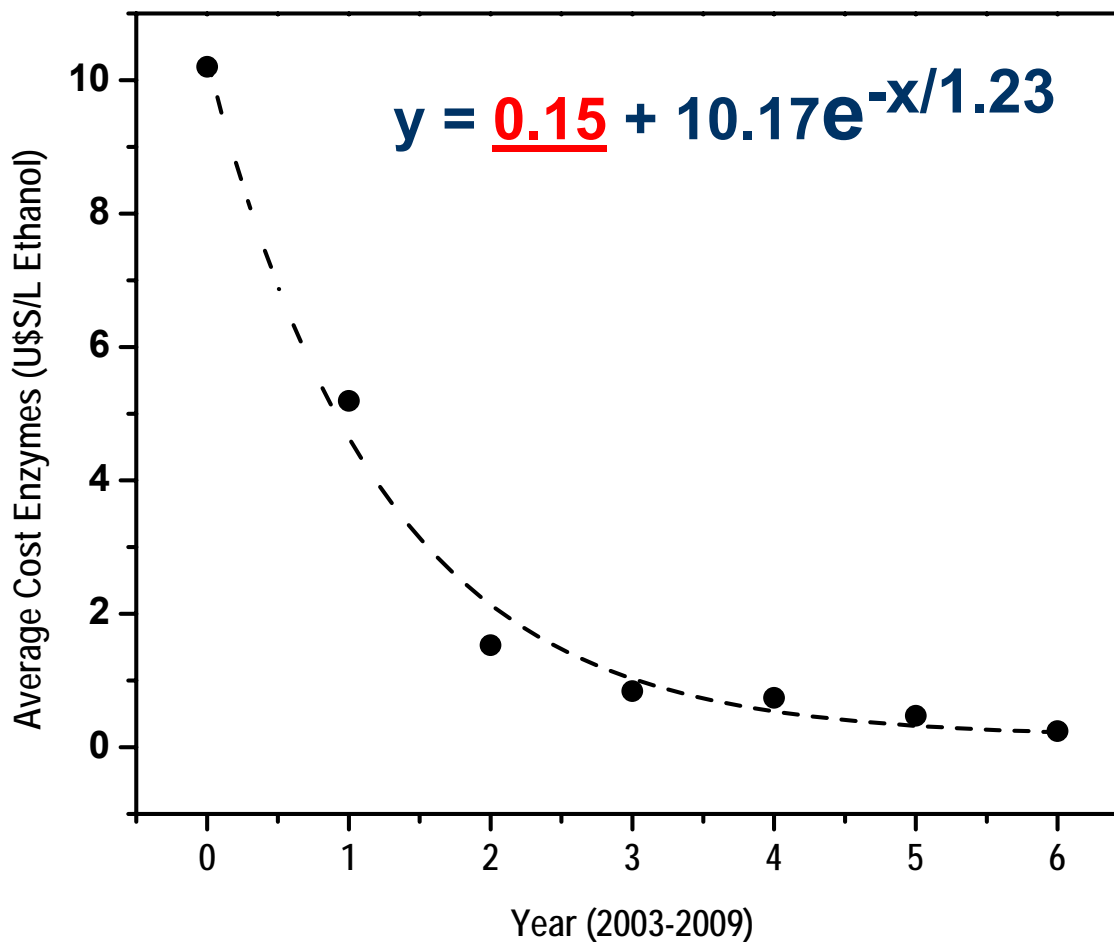


# Lignol's Pilot Biorefinery



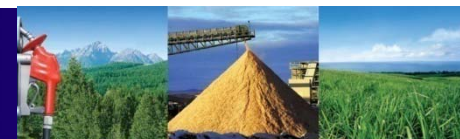
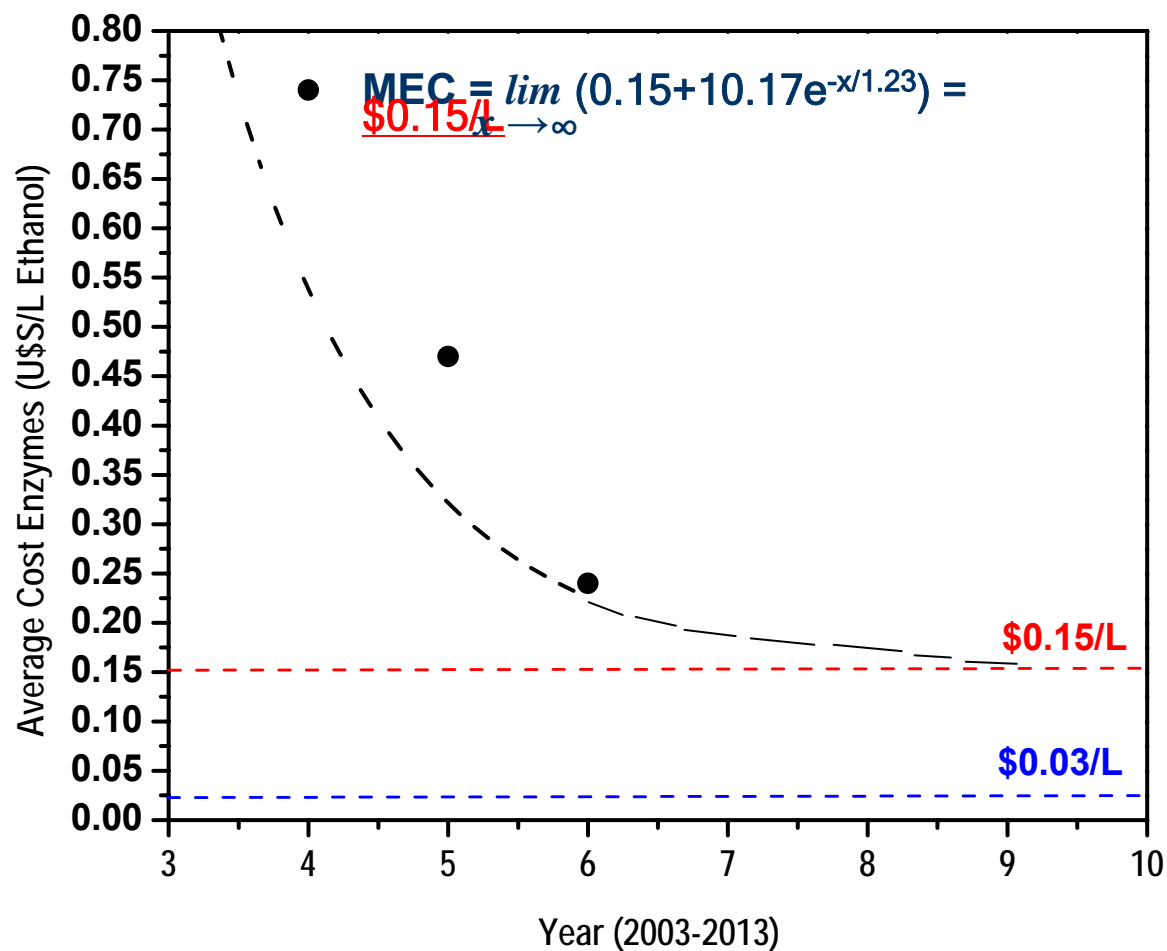
### III. Key Enabling Technical Factors

#### Key Factor I – Enzymes Cost



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### III. Key Enabling Technical Factors



#### Key Factor II – Xylose Fermentation Technologies

Biomass Species	Xylose (%)	Ethanol from Xylose (L/ton biomass)	Ethanol from Xylose (% total ethanol)
Wheat Straw (Agricultural Residue)	~20%	~127	~33%
BC Aspen (Hardwood)	~18%	~114	~25%
BC Lodgepole Pine (Softwood)	~8%	~50	~11%





### III. Key Enabling Technical Factors



#### Key Factor II – Xylose Fermentation Technologies

- Increased tolerance to inhibitors (>5% wt. mixed inhibitors)
- Increased tolerance to high ethanol concentrations (>12% wt.)
- Effective simultaneous conversion of hexoses & xylose (<24 h)
- Higher overall yields (>70% theoretical)
- Higher conversion rates (>1.0 g xylose/L/h) approaching industrial glucose conversion rates (~3.0 g/L/h)



### III. Key Enabling Technical Factors



#### Key Factor III – Substrate Pretreatment Technologies

##### Robustness

- Applicable to a wide range of biomass species
- Increased overall recovery yields (carbohydrates & lignins)
- Continuous & batch processes



### III. Key Enabling Technical Factors

#### Key Factor IV “The Buffer Factor” –Development of Co-Products



# Conclusions



- Commercialization of biochemical biorefineries is becoming a reality (<5 years) as a result of the adoption of advanced enabling technologies:
  - Enzyme cost reduction
  - Advanced xylose fermentation technologies
  - Robustness of advanced pretreatment technologies
  - Intensive co-products development
- Lignol's technology is an example of a risk-balanced biochemical biorefinery with significant environmental benefits:
  - Significant greenhouse gas reductions
  - Positive energy balance
  - Dramatically less water consumption than corn ethanol
  - Significant oil displacement potential (about double that of other bioethanol technologies)





Thank you for your attention.

Further general information at  
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