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Sustainable products from plant biomass

Glycell™ - Leaf Resources' pretreatment process for the conversion of lignocellulosic biomass

Alex Baker Bio PacRim Conference

December, 2014

Forward Looking Statements

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Leaf Resources

Active participants in the advanced bio-economy

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- Leaf Resources Limited (ASX:LER) is focused on making sustainable products from plant biomass.
- We offer an advanced technology package for breaking down plant derived biomass to useful, sustainable, renewable and biodegradable products.
- Leaf Resources' innovative Glycell™ is a disruptive process technology that can reshape the economics of using large scale biomass resources as a replacement for petroleum derived products.

The carbon evolution

The future of materials

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Coal was the industrial material of the 19th century

Oil was the industrial material of the 20th century

Cellulose will be the industrial material of the 21st century*

** Lüder Gerking, CEO, Nonoval GmbH & Co.KG*

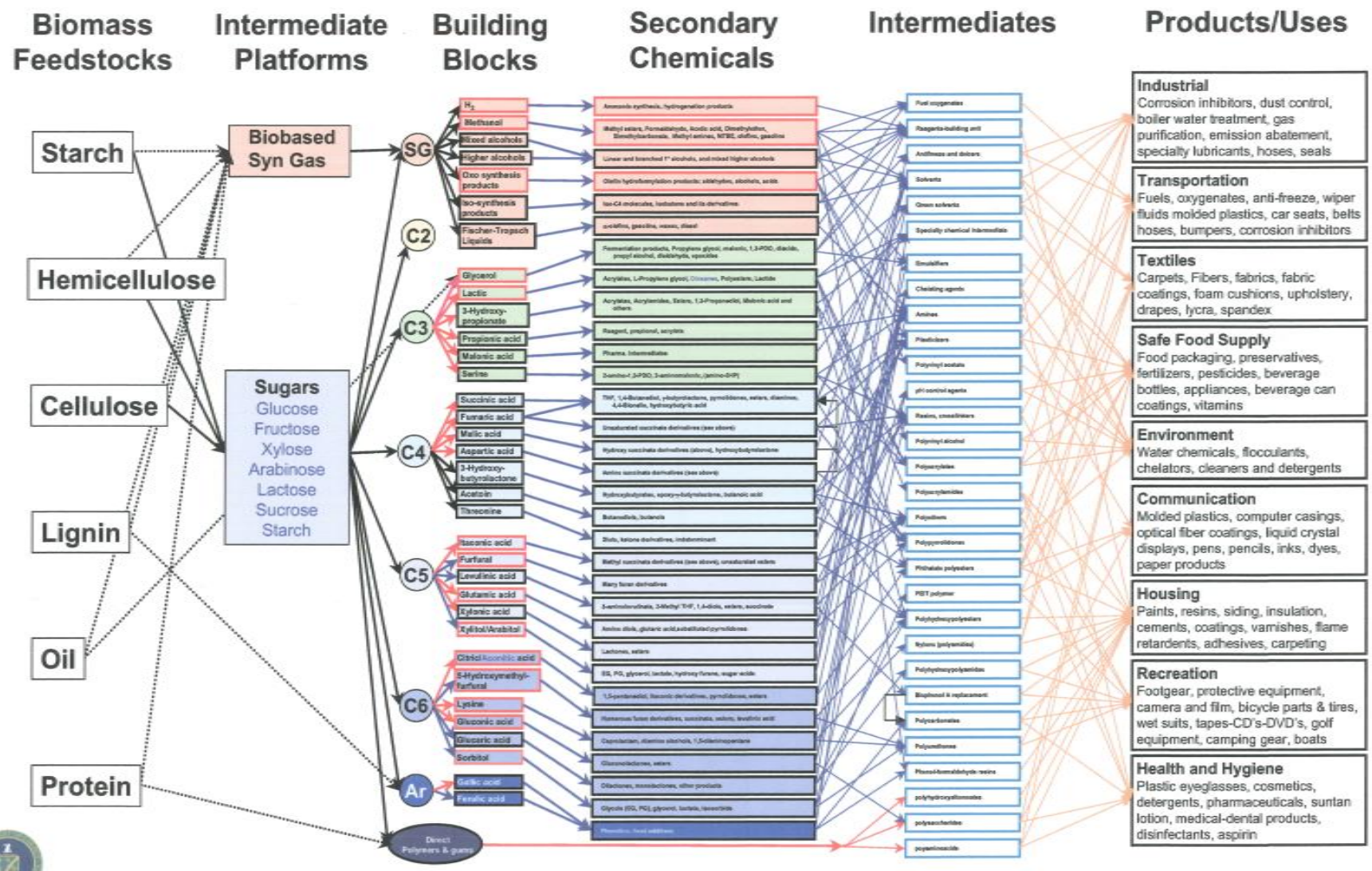

Figure 3 – Analogous Model of a Biobased Product Flow-chart for Biomass Feedstocks

U.S. Department of Energy
Energy Efficiency and Renewable Energy

Clean sugars feed bio-based chemicals market

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Bio-based chemicals: growing 20%pa, exceeding $500b by 2017

Glycell™ process
Low cost clean sugars… faster

Proprietary technology owned by others converts the sugars to

Renewable chemicals and green sustainable products.

Bio-based chemical examples

- Zeachem - Acetic Acid, Ethyl Acetate
- Bioamber - Succinic Acid
- Myriant - Succinic Acid
- Avantium - PET replacement
- Baskem - Polyethylene
- Renovia - Adipic and Lactic acid
- Multiple - Ethanol
- Others - Many uses

Used by companies such as:

- Toyota
- Dow
- Dupont
- Mitsui
- Johnson and Johnson
- Proctor and Gamble
- Coca-Cola
- Plus many others

* See announcement 14th July 2014

Development pipeline

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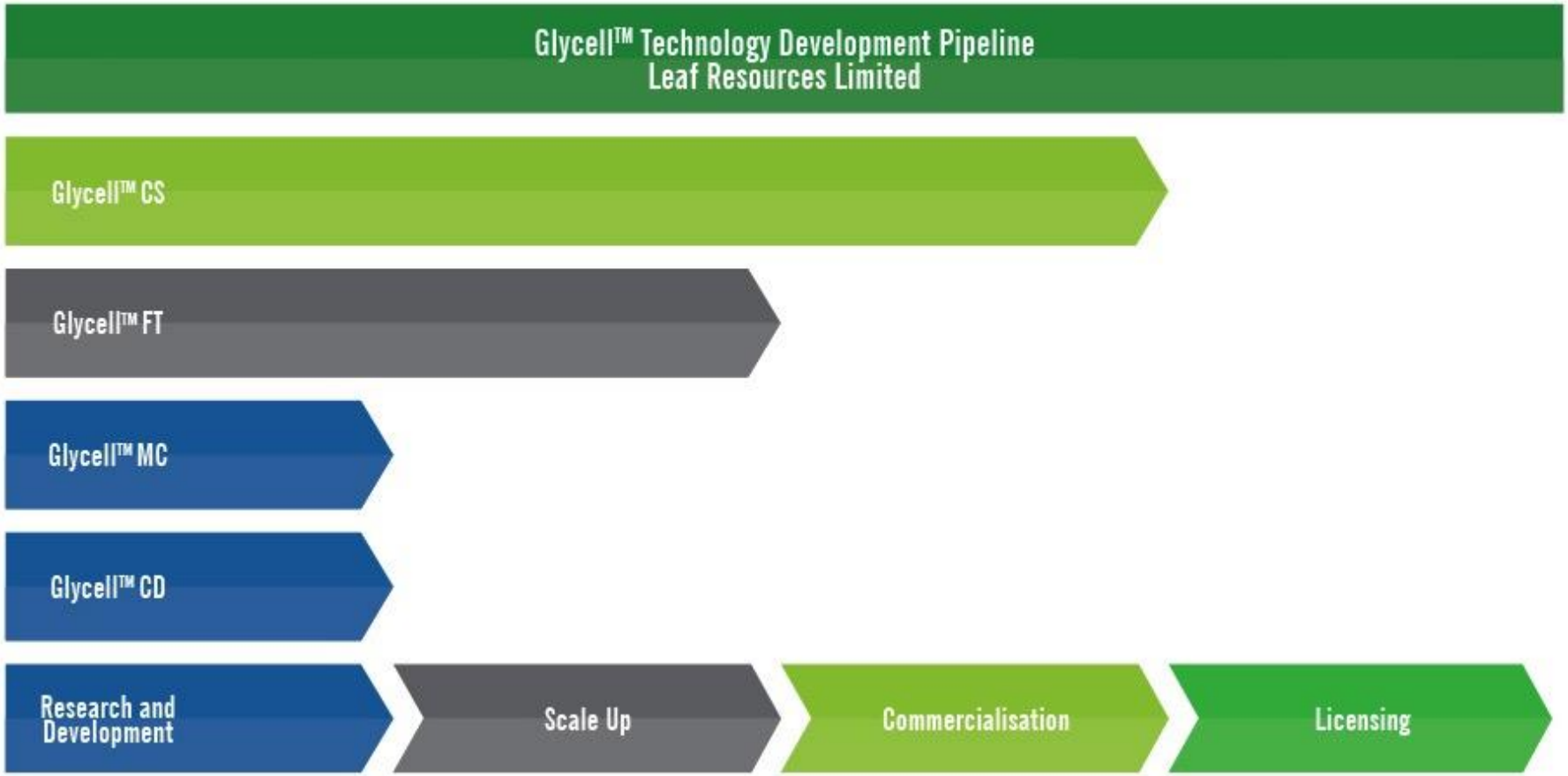

Glycell™ CS Key objectives

Process focus

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Key proposition and competitive advantage	**"Produce low cost cellulose at any scale"**
Cellulosic sugars	Maximise cellulose conversion to cellulosic sugars
Clean enriched streams	Separate pentose rich and hexose rich liquid products
Funding Model	Partnerships for a capital light approach
Glycerol recovery	Profound effect on cost of sugars

The Glycell™ Process

Proprietary technology for cellulose production

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The Glycell ™ process has compelling advantages over traditional methods of cellulose extraction

Product benefits:

- Innovative process
- Uses a renewable biodegradable reagent
- Mild temperature and low pressure
- Continuous Process design
- Short processing time

Economic benefits:

- Significantly lower capital costs[1]
- Significantly lower operating costs
- Industrially available equipment
- Operates at a range of scales
- High Cellulose recovery
- High conversion of Cellulose to Sugars[2]

[1] see announcement lodged ASX 7th July 2014
[2] See announcement lodges ASX 14th July 2014

Leaf Resources Glycell™ CS Process

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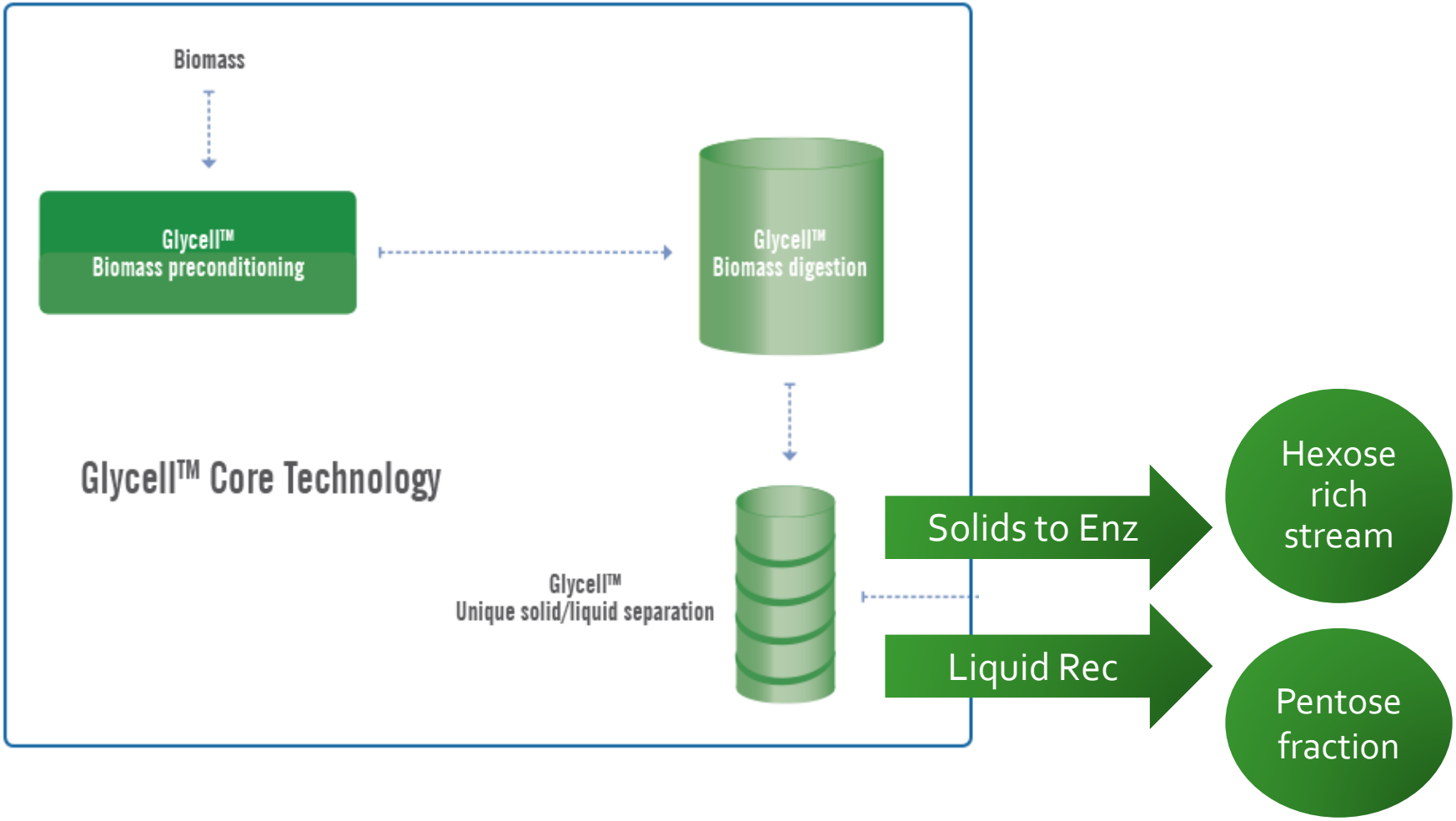

Biomass flexibility

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Poplar

Oil Palm fibre (EFB)

Bagasse

Eucalyptus

Eucalyptus

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C6 sugar yield

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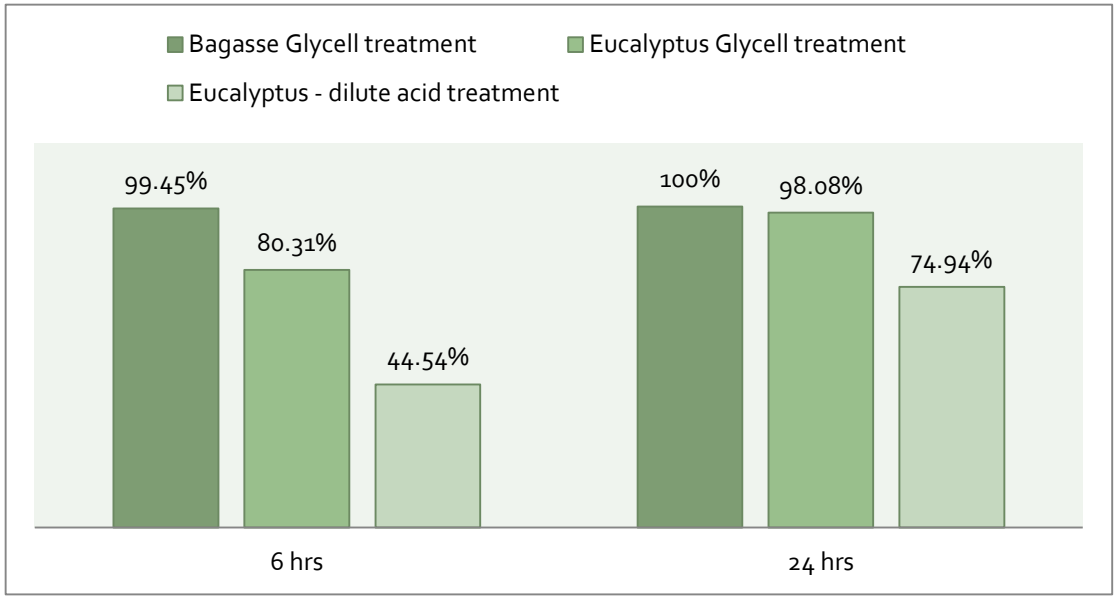

Cellulose saccharification after enzymatic hydrolysis using the Glycell™ process - C6 Sugar yield as % of theoretical maximum

- High cellulose recovery (94%) High sugar conversion
- 30% more sugars – boost economics
- Minimal degradation products detected
- This is commercially significant as many products need "clean sugars"

The saccarification (digestibility) procedure measures the efficacy of a given pretreatment based on a maximum enzyme loading and is reported as a percentage of the theoretical mass yield. Cellulase enzyme cocktail used was Cellic ® CTec3 (Cellic ® CTec3 is a registered trademark of Novozymes) at 20 FPU/g cellulose at 2% cellulose weight loading applied to all samples.

Improved saccharification kinetics

Significant opportunity to reduce enzyme load and size of reactors

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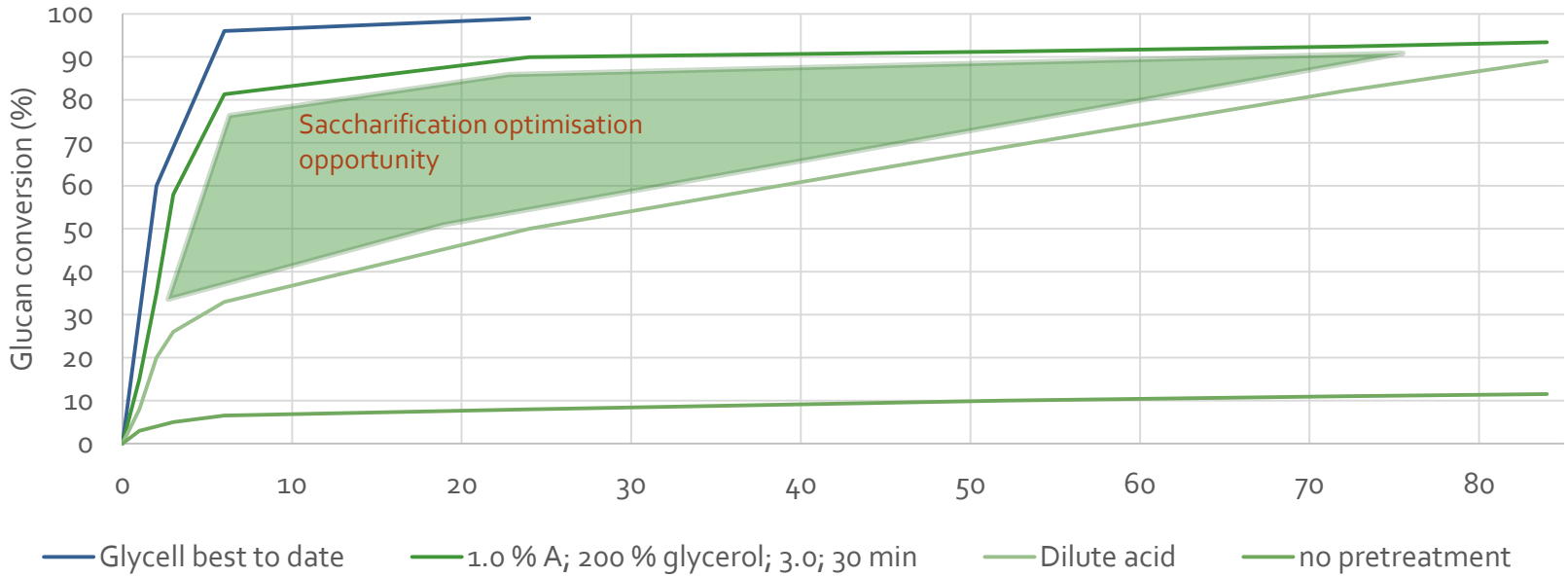

- Dilute acid – NREL design target (2013) – 0.9 % acid; 2.3 liquid:solid; 5 min – 90 % hydrolysis of cellulose after 84 hours with enzyme load of 10 mg/g cellulose
  - ca. 5 % conversion of xylan to furfural
- Glycell best to date – Hardwood – 0.8 % acid; 0.8:1 glycerol:solid; 30 min
  - No measurable furfural formation

Degradation products

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Description	Cellobiose (g/L)	Xylitol (g/L)	Formic Acid (g/L)	Acetic Acid (g/L)	Levulinic Acid (g/L)	Ethanol (g/L)	HMF (g/L)	Furfural (g/L)
Bagasse	ND	ND	ND	ND	ND	ND	ND	ND
Eucalyptus	ND	ND	ND	1.85	ND	ND	ND	ND

- Other than Acetic acid, all typical degradation products were not detected for both bagasse and Eucalypt conditions

Cost of Sugars

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Inputs and effect on cost of sugars	
Feedstock Input Price ($/as is tonne at 50% moisture)	Sugar cost (¢/lb)
85% glycerol recovery	
100	12
75	8
55	5

- Class 5 conceptual design & costing
- Sugars Cost – Marginal cost of combined C5 & C6 sugars production net of lignin revenue less capital cost of production over 20 year plant life
- Estimates give ~4c/lb cost of capital (40 tph as is brown field plant)

Zeachem Collaboration

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- Collaboration Agreement with ZeaChem Inc.
- The evaluation by ZeaChem and Leaf Resources of the Leaf Glycell™ process for the production of fermentable sugars at ZeaChem's demonstration plant at Boardman, Oregon.
- The trials will use Poplar as a feedstock
- Pretrial work at Andritz Springfield - 17 conditions evaluated on poplar furishes
- Glycell CS on poplar chip effective
- Saw dust and planar dust 50:50 blend also tested

Key competitive advantages

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Based on current data, Leaf Energy's Glycell™ process when compared to other pretreatment processes, such as acid hydrolysis and/or steam explosion:

- Produces high yield cellulose with less degradation products;
- Excellent enzymatic conversion of cellulose to sugars;
- Enzyme kinetics improved on the Glycell™ pretreated biomass allowing quick sugar production, and;
- produces clean sugars due to milder conditions.

Thank You

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Looking forward to Partnering

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