

# Biomass is more than energy

14-MAR-2018

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# Avantium

Innovative Technologies for Today's Bioeconomy



Amsterdam & Brussels  
Ticker: AVTX



€109M

Raised from IPO  
15 March 2017

## Renewable Chemistries

2-Gen Sugars, Renewable Technologies,  
Electrocatalysis of CO<sub>2</sub>

YXY® Technology: FDCA to PEF  
Novel Bio-Based Plastic  
JV BASF / Avantium



## Catalysis

Foundational Technology and Expertise

Leading Systems and Services Provider for  
Catalyst R&D



Founded in 2000  
Amsterdam

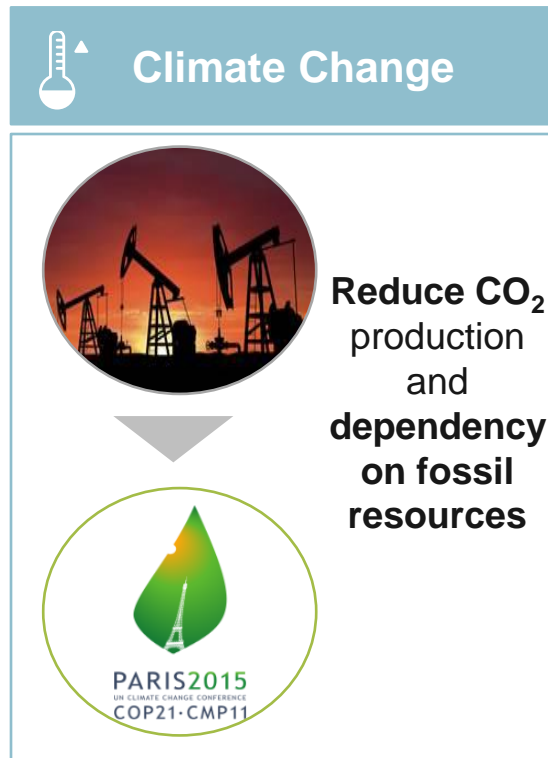
60+  
patent families



Hall of Fame  
CleanTech

160 employees  
>75% scientists  
20+ nationalities

# Global Trends Drive Transition Towards a Bio-Based Economy



# Brands desire bio-based solutions

Brand-owners realize a system-wide approach is required to solve today's toughest sustainability challenges



... to build a standardized supply chain measurement tool for all industry participants to understand the environmental, social and labor impacts of making and selling their products and services.



Encouraging the development of plant-based plastics



## Plant PET Technology Collaborative (PTC)

Strategic working group focused on accelerating the development and use of 100% plant-based PET materials and fiber in their products



## PEference

Replace a significant share of fossil-based polyesters, such as PET and packaging materials like glass and metal with 100% bio-based furanics polyesters (such as PEF)



Brands want to become sustainability champions

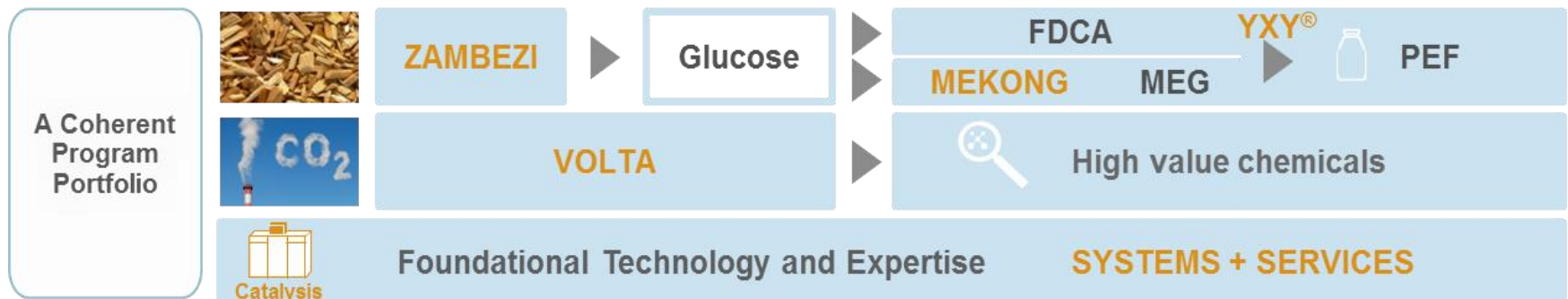
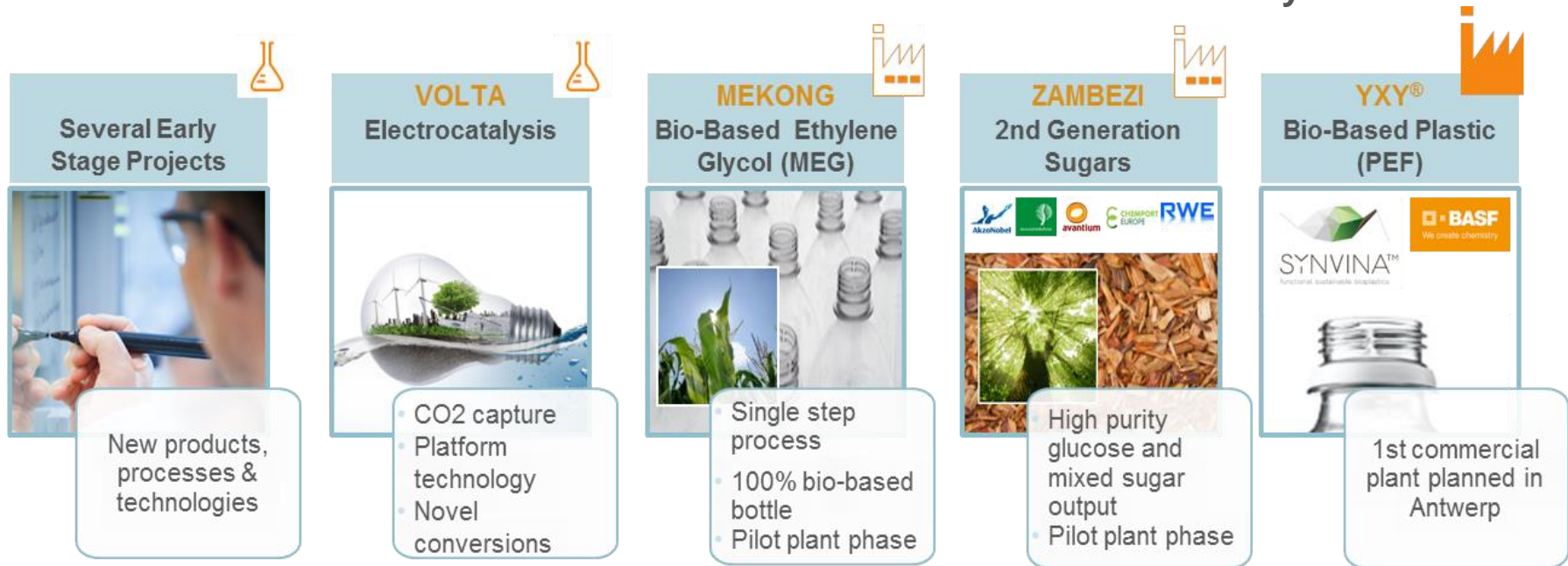


# Avantium's Renewable Chemistries

Leadership in innovative renewable technology



Commercialization enables the transition to a sustainable bioeconomy



# ZAMBEZI Second Generation Biorefinery





# First and second generation biomass (glucose)

First generation (1G) – Sugar cane, corn, sugar beet, wheat

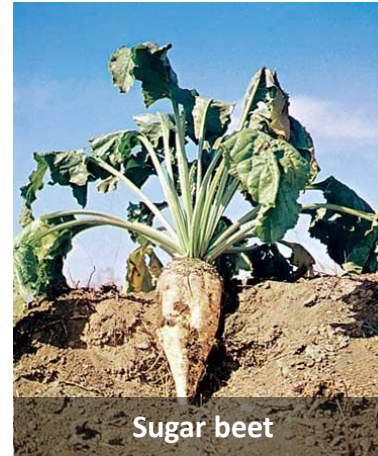
**Now**



Corn



Sugar cane



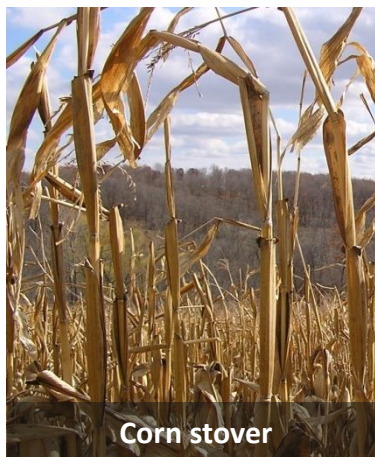
Sugar beet

Second generation (2G) - Wood, agricultural residue, recycled paper, energy crops

**Future**



Wood



Corn stover



Recycled paper

# 2G Sugar Technologies Evaluated by Avantium

Key technology identified : fit-for-purpose in biobased chemicals



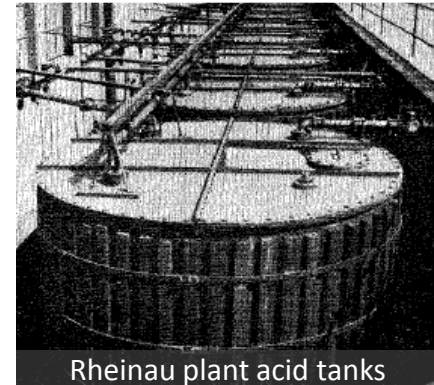
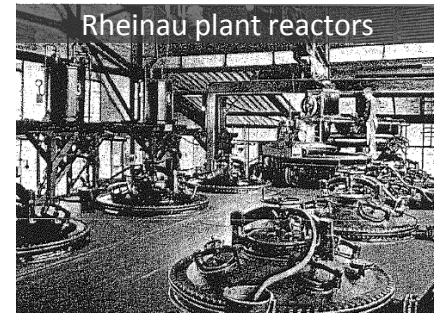
Technology	Example Companies	Advantages	Disadvantages	Application Area
Pre-treatment + enzymatic hydrolysis	M&G Chemtex /Beta Renewables Sweetwater Comet	+ High yield + Mild conditions	- Mixed products - enzyme cost	- Biofuel
Dilute acid / high temperature		+ Cheap process	- Low yield - Impure product - Dilute stream	
Organosolv + enzymatic hydrolysis	Lignol CIMV	+ High grade lignin	- High solvent & enzyme costs - Dilute product stream	- Biofuel
Hot Compressed Water	Renmatix	+ Low cost reagents	- Low yield - High pressure/temp	- Biofuel - Biochemical
Concentrated acid / low temperature hydrolysis ('Bergius process')	Avantium Virdia (Stora Enso) Green Sugar	+ High stream yield + High purity	- Acid / sugar separation - Corrosion	- Biofuel - Biochemical

Avantium selected technology



# Bergius HCl Hydrolysis technology

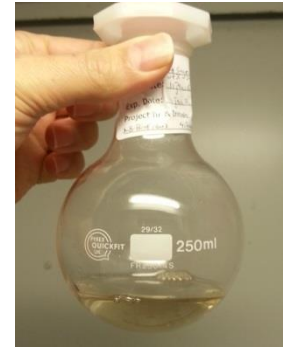
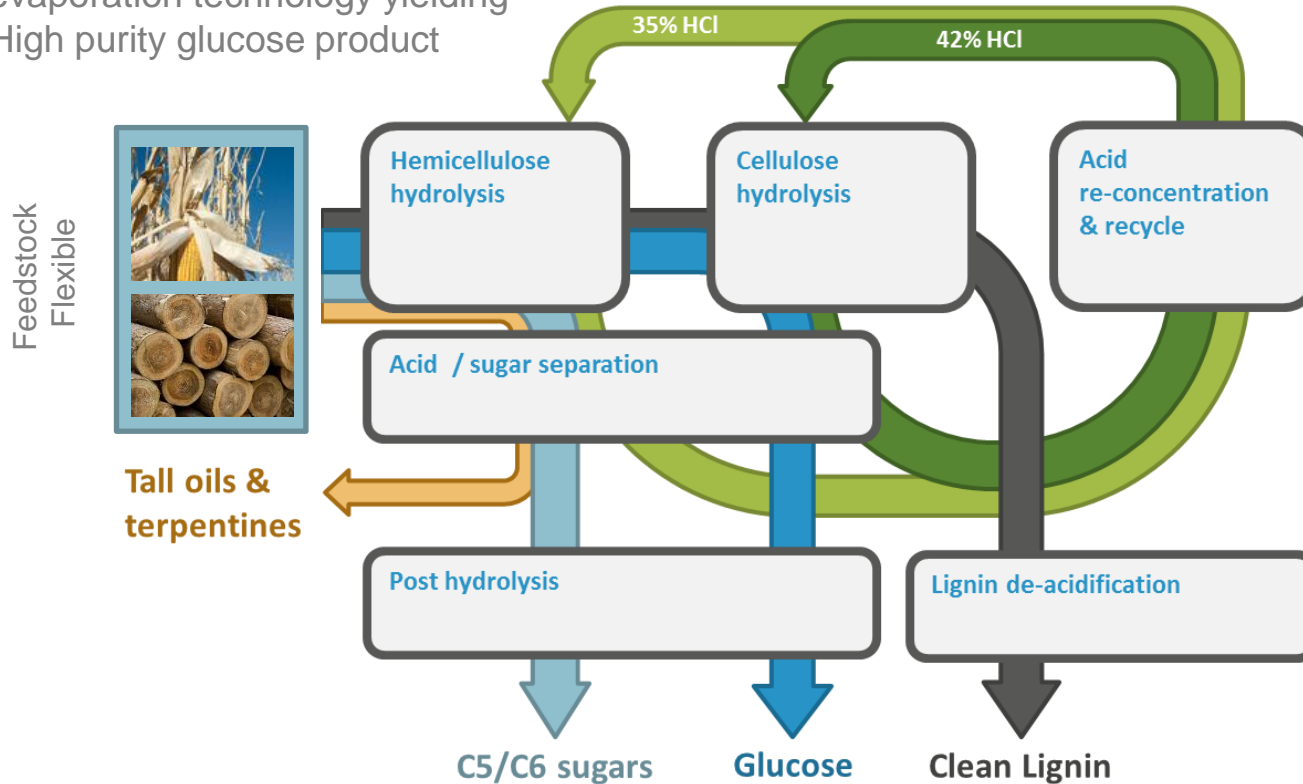
- 1916 Bergius began development of industrial process of saccharification
- 1933 Mannheim-Rheinau plant completed (single step hydrolysis) 6-8 kt/a mixed sugars
- 1939 Regensburg plant completed (destroyed 1945) 20 kt/a sugars
- 1948-59 Modified- Rheinau process (with sugar fractionation) 12 kt/a glucose
- 1953-55 Japan pilot plant
- 1957–87 Russia pilot plants (10 m<sup>3</sup> scale hydrolysis reactors)
- 1980's Dow USA: Pilot Plant - HCl recovery by solvent extraction
- 2007 HCl CleanTech (Israel) → → Stora Enso (2014) (HCl recovery via amine complexation)
- 2013-2015 Avantium studies all available know-how on Bergius process and developed proprietary improvements leading to glucose production competitive to 1G glucose



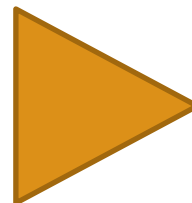
# Zambezi Process in a Nutshell

## Improved Bergius-Rheinau process:

Two-stage, concentrated HCl hydrolysis  
Acid / sugar separation by proprietary  
evaporation technology yielding  
High purity glucose product

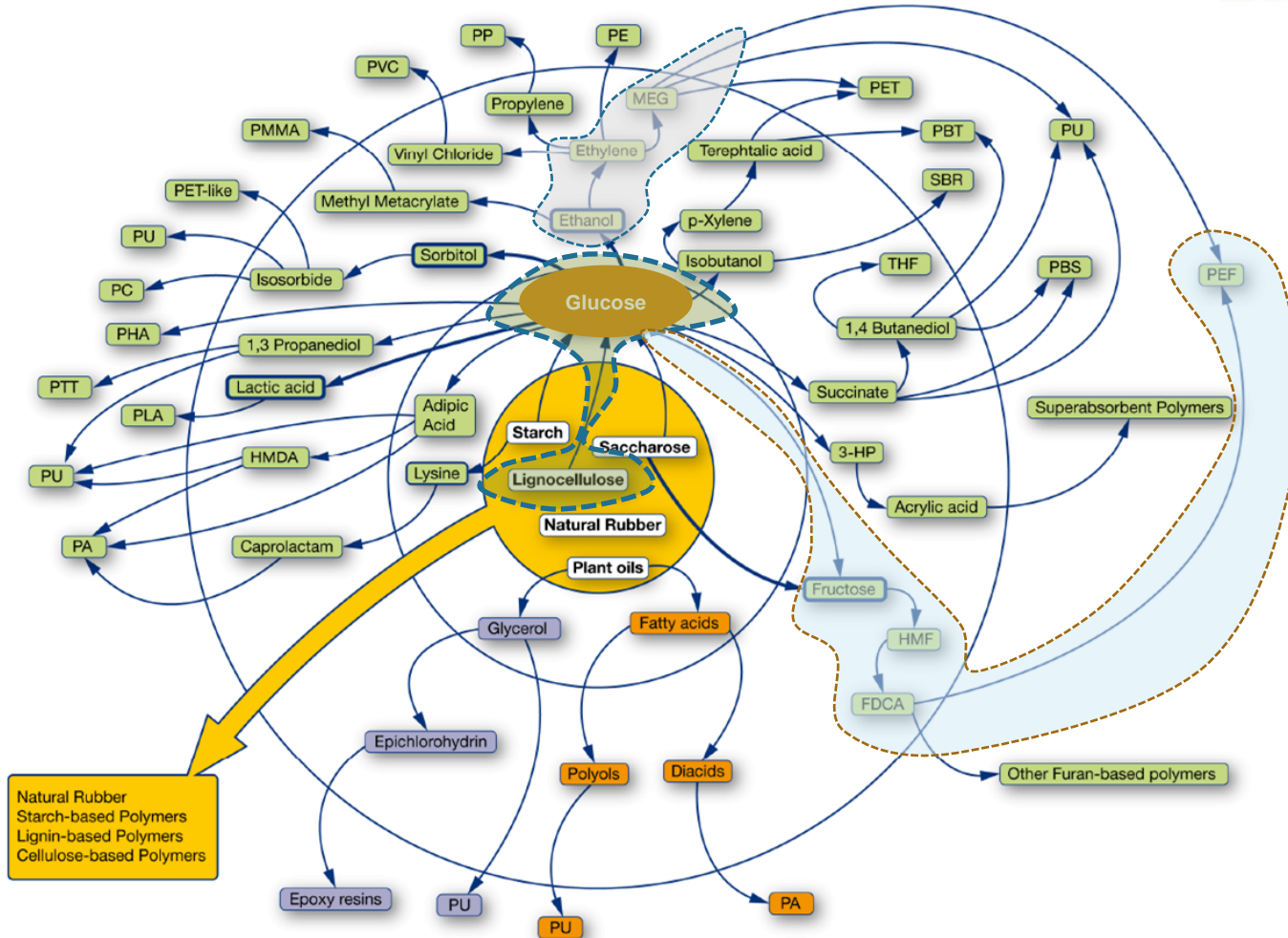


- Technical Breakthroughs
  - Acid sugar separation
  - Material construction
  - Lignin deacidification



Intellectual Property  
captured through patent filings

Glucose is a central building block for many bio-based polymers



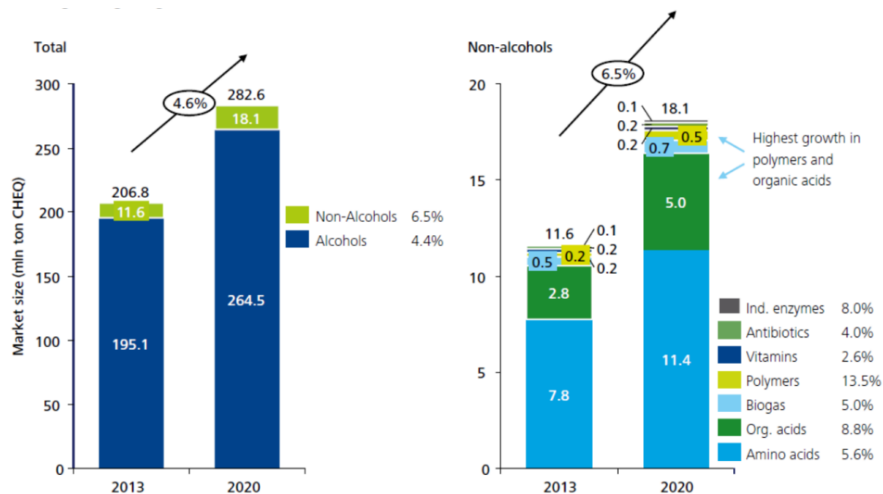
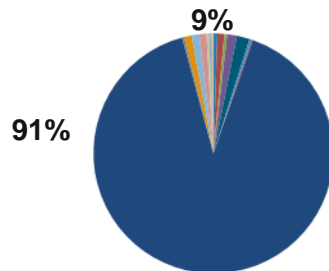
# Market Potential for Glucose

Bio vs fossil market size – Growth potential



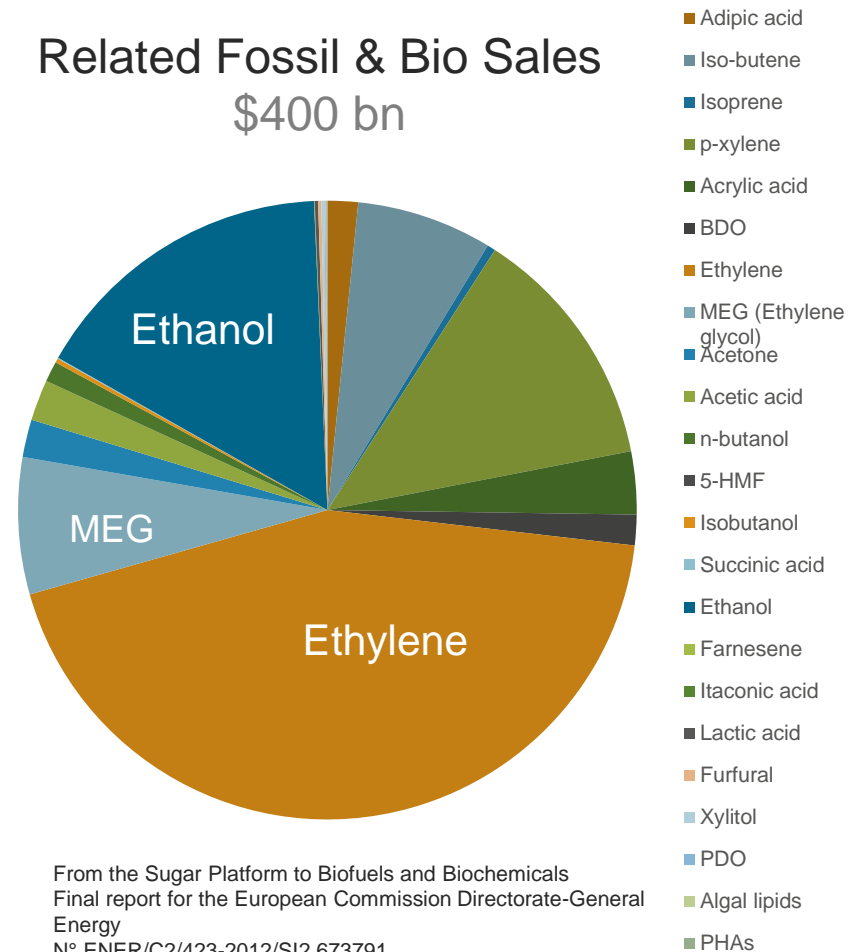
## Bio-Market Sales

\$ 65 bn



## Related Fossil & Bio Sales

\$400 bn



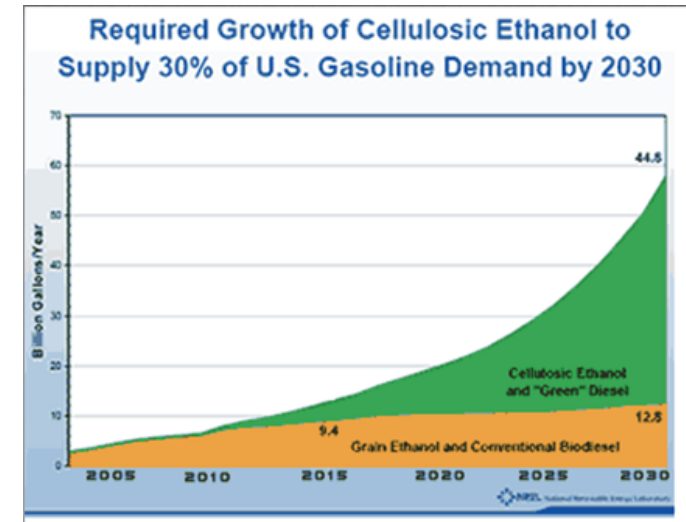
From the Sugar Platform to Biofuels and Biochemicals  
Final report for the European Commission Directorate-General  
Energy  
N° ENER/C2/423-2012/SI2.673791  
April 2015

# Market potential for C5/6 Sugars



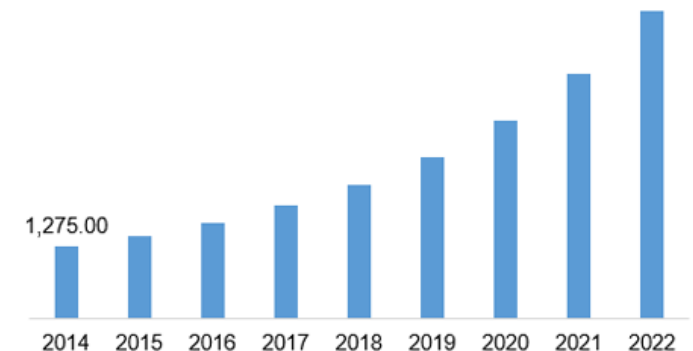
## Properties of Mixed sugar stream

- Feedstock dependent
  - Hardwood/softwood/grasses
- C6: Mannose/glucose/galactose
- C5: Xylose/arabinose



Global Lactic Acid Market Revenue, 2014 – 2022, (USD Million)

- Biofuels: bio-ethanol
- Bio-Jet Fuels
- Biogas
- Lactic Acid



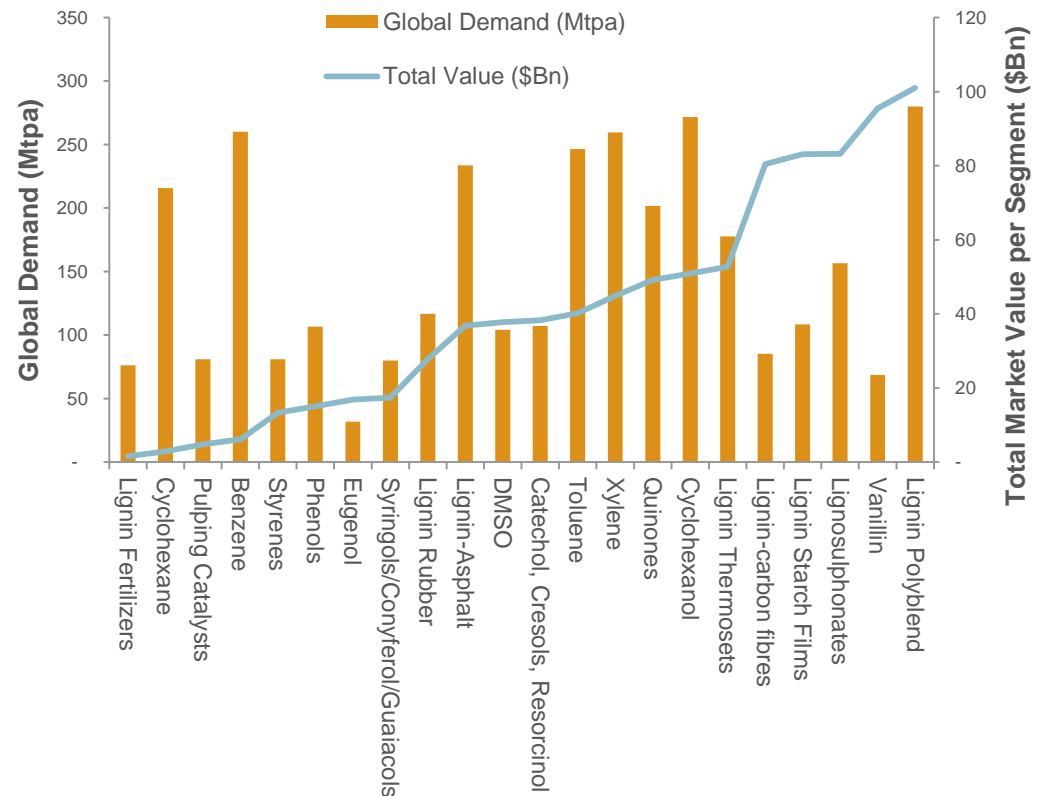
Sources: <http://peakoil.com/alternative-energy/tech-talk-without-cellulosic-ethanol-where-will-transportation-fuel-come-from> ; <http://www.credenceresearch.com/report/lactic-acid-market>



# Market potential for Lignin



- Base case:
  - Use lignin for energy production (steam)
- Potential higher value applications such as activated carbon or asphalt
  - Asphalt
  - Activated Carbon
    - E.g. for water purification
    - Global activated carbon market was 1.37 MMtpa in 2013 and grow 2.96 MMtpa by 2020 (CAGR of 11.7%)
  - 'Bergius Lignin' has been proven in activated carbon applications<sup>1</sup>



<sup>1</sup> Carbon adsorbents from industrial hydrolysis lignin: The USSR/Eastern European experience and its importance for modern biorefineries; Mikhail L. Rabinovich, Olesya Fedoryak, Galina Dobelev, Anna Anderson, Barbara Gawdzik, Mikael E. Lindström and Olena Sevastyanova, Renewable and Sustainable Energy Reviews, 2016, vol. 57, issue C, pages 1008-1024

# Opportunity by Localized Economics



Avantium is engaged globally to evaluate the economics of local scenarios

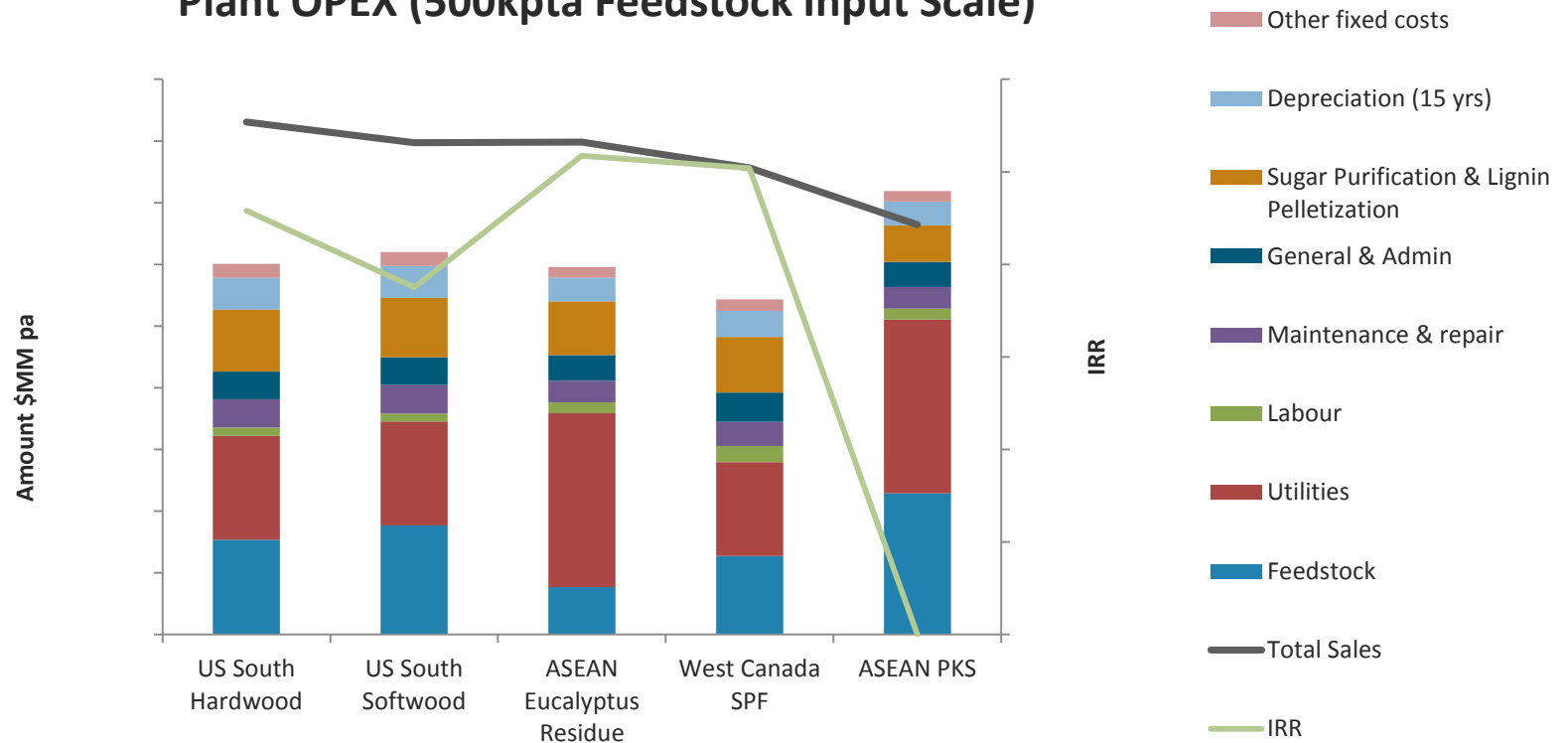


# Examples Business Cases

Case by case number crunch



## Plant OPEX (500kpta Feedstock Input Scale)



# Partnering Universe



## Feedstock



- Pulp & paper
- Forestry
- Agricultural

## Conversion



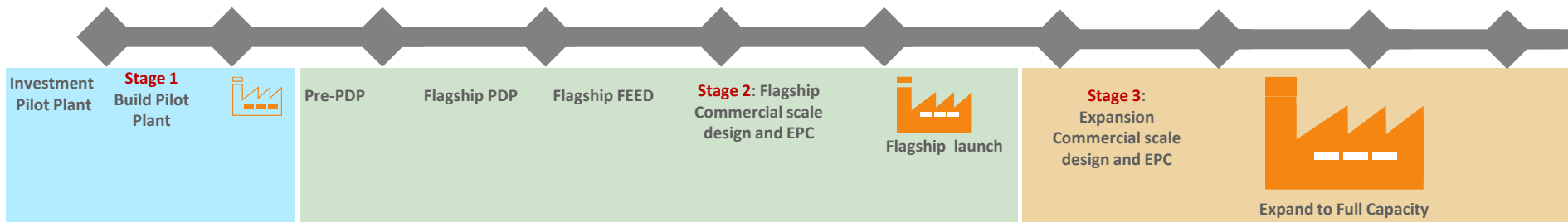
- Chemical
- Engineering
- Site / Services

## Off-takers



- 2G Glucose
- Mixed Sugars
- Lignin (specialty or energy)
- Tall oils

# Zambezi Deployment Strategy



**Phase I**  
Flagship Consortium  
Agreement Level

**Phase II**  
Ownership Vehicle &  
Operational Level for Flagship

**Phase III**  
Full Commercial Scale  
Operation

Collaborations & JDA's

Business Cases for Global Deployment

An icon consisting of several orange factory silhouettes of varying heights, arranged in a row.

Licence multiple  
plants in multiple  
locations



# Summary Zambezi



- Avantium has radically improved the Bergius bio-refining process to achieve cost competitiveness and high purity 2G glucose output
  - Technology:
    - Avantium innovations in hydrolysis, acid-sugar separation, lignin-deacidification drive process economics and product quality
    - Ability to use diverse range of 2G feedstock; initial focus on woody biomass
    - Pilot plant design completed; technology is ready for scale-up to demonstrate Zambezi technology at pilot scale
  - Market:
    - Large market for glucose and a growing need for high purity 2G glucose
    - Growing interest from energy industry for biomass cascading (for lignin)
    - Potential for higher value lignin applications
    - Strong interest for mixed sugars e.g. For biofuel and biogas
  - Partnering:
    - Feedstock
    - Conversion
    - Off-takers

Thank you for your  
attention.

Questions??

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