Sustainable polymer from sugar cane

- BIOCYCLE® -

2012

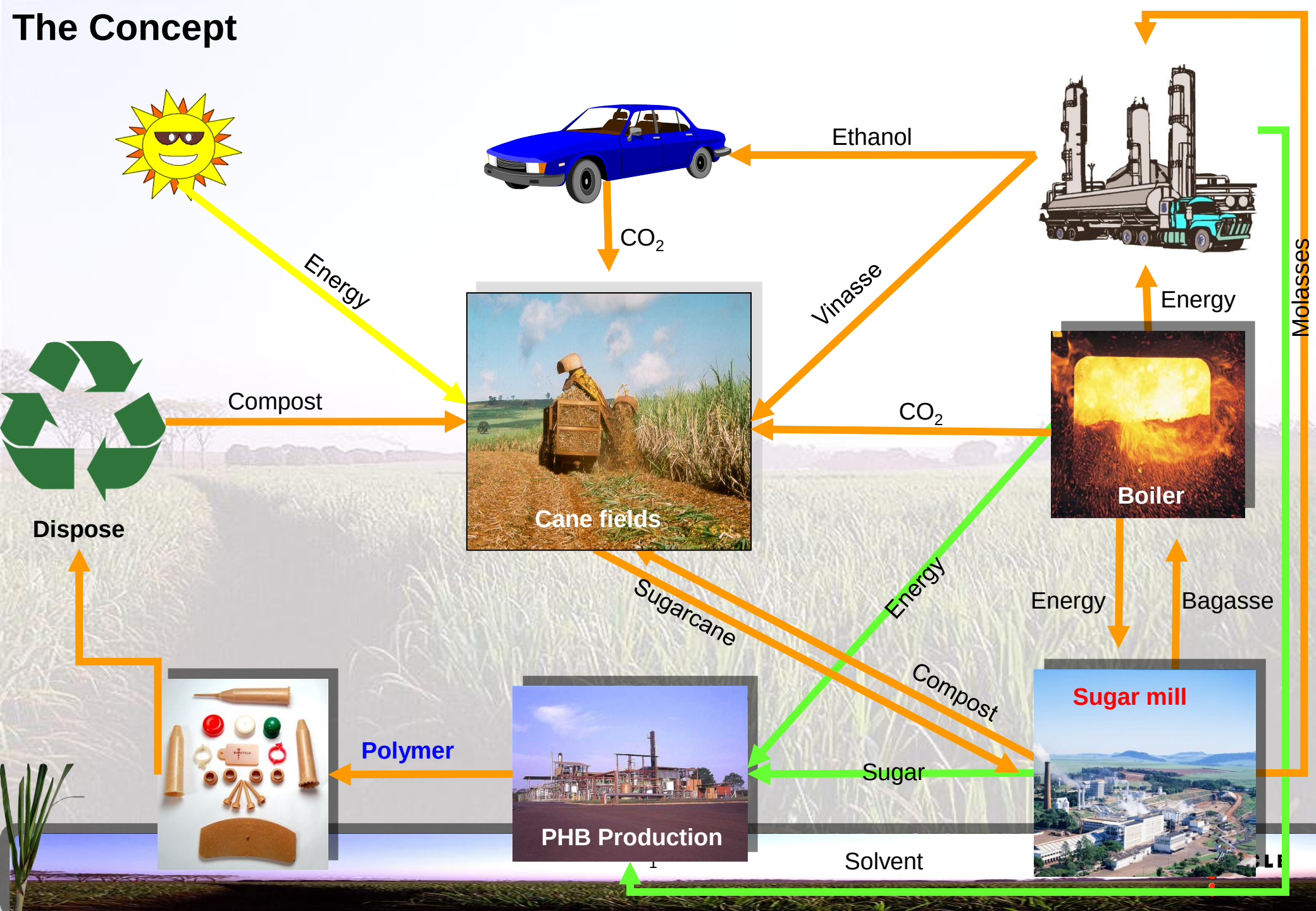
BIOCYCLE

FAPESP

Workshop for Sustainable Production of Biopolymers and other Bio-based Products

July 25th - FAPESP - São Paulo

The Concept


Energy
Ethanol
CO_2
Vinasse
Energy
Molasses
Compost
CO_2
Dispose
Cane fields
Boiler
Sugarcane
Energy
Energy
Bagasse
Compost
Sugar mill
Polymer
Sugar
PHB Production
Solvent

Company Overview

- The development of PHB in Brazil

1991

Research grant establishes the "Production of Biodegradable Plastics from Sugar via Bio technological Route"

COPERSUCAR - IPT

1994

Implementation of the Pilot Plant to produce PHB / PHB-HV at Usina da Pedra, Serrana -SP

2000

PHB Industrial S/A was created along with the BIOCYCLE® brand.

2004

PHB production process proves to be economically viable

Focus on Material Engineering – Market Applications – "1st generation"

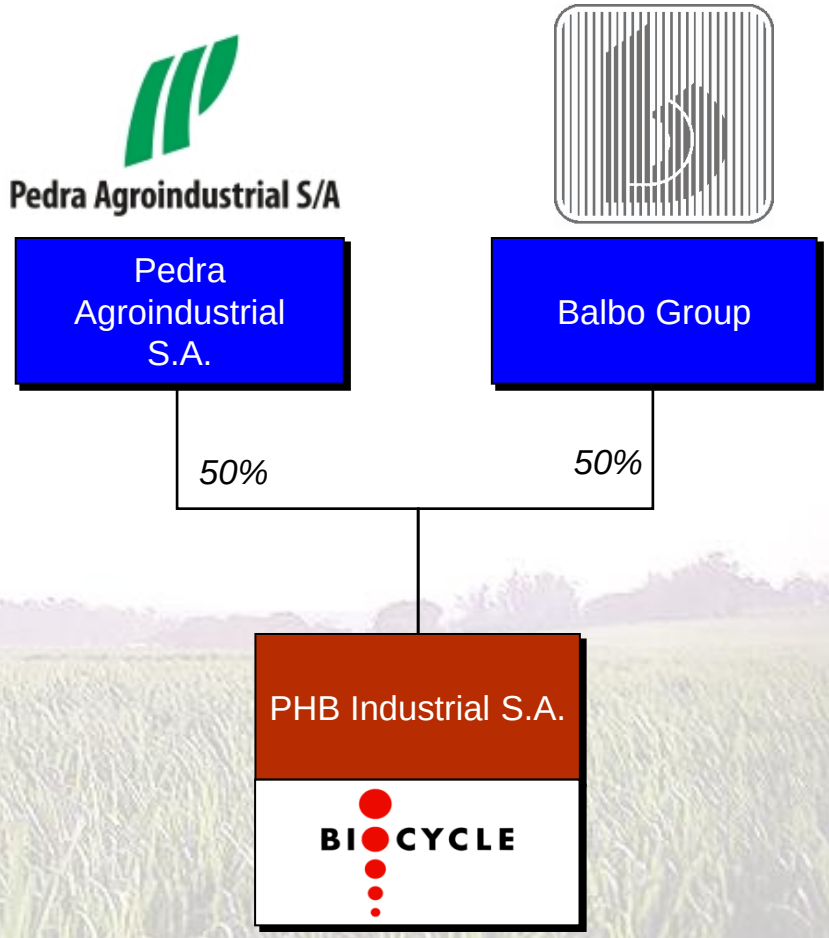
2008

Consolidation of productive process

Applications, New Solvent, New Patents– "2nd generation"

ORGANIZATIONAL STRUCTURE

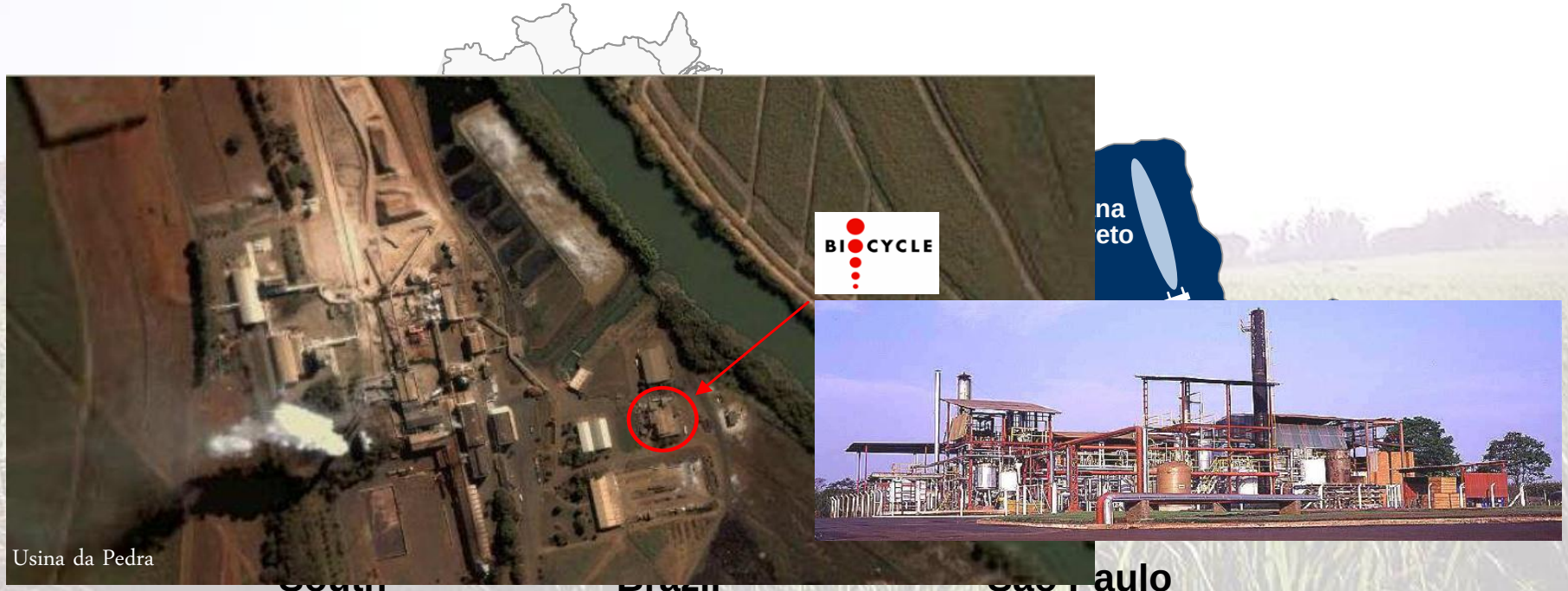
- Pedra Agroindustiral S.A. / The Balbo Group
  - More than 80 years of experience in the sugar and alcohol industry
  - Industrial assets comprised of six mills in the state of São Paulo and one in the state of Minas Gerais
  - Total annual production [1]:
    - 20 Million tons of crushed Sugar Cane
    - 650 Million kilograms of sugar
    - 900 million liters of alcohol
    - More than 10,000 employees
  - Culture area of more than 180,000 hectares of sugarcane [1]
  - Energy generation capacity of approximately 800,000 MWh [1]
  - Commercialization of CERs through Kyoto Protocol
  - Major worldwide organic sugar producer Native
- PHB Industrial S.A.
  - Leverages the collective experience and relationships of Pedra Agroindustrial S.A. and the Balbo Group



(1) 2010 / 2011 crop

Company Overview

- PHBISA's technology has been developing and refining over 16 years of research



America

PHB INDUSTRIAL S.A. – Overview

- PHBISA utilizes a **completely renewable concept** to produce PHB, its blends and composites (brand - Biocycle®)

- 100% Brazilian Technology to produce biopolymer based in vegetable glucose supported by know-how and **patents** (17), embodying from the bacteria selection to the applications;

- Production process filled **without GMO**.

- Biopolymer completely **biodegradable, compostable and sustainable** – PP contra type.

- Product with **high performance** and functionality

- ***"New technology frontier"***

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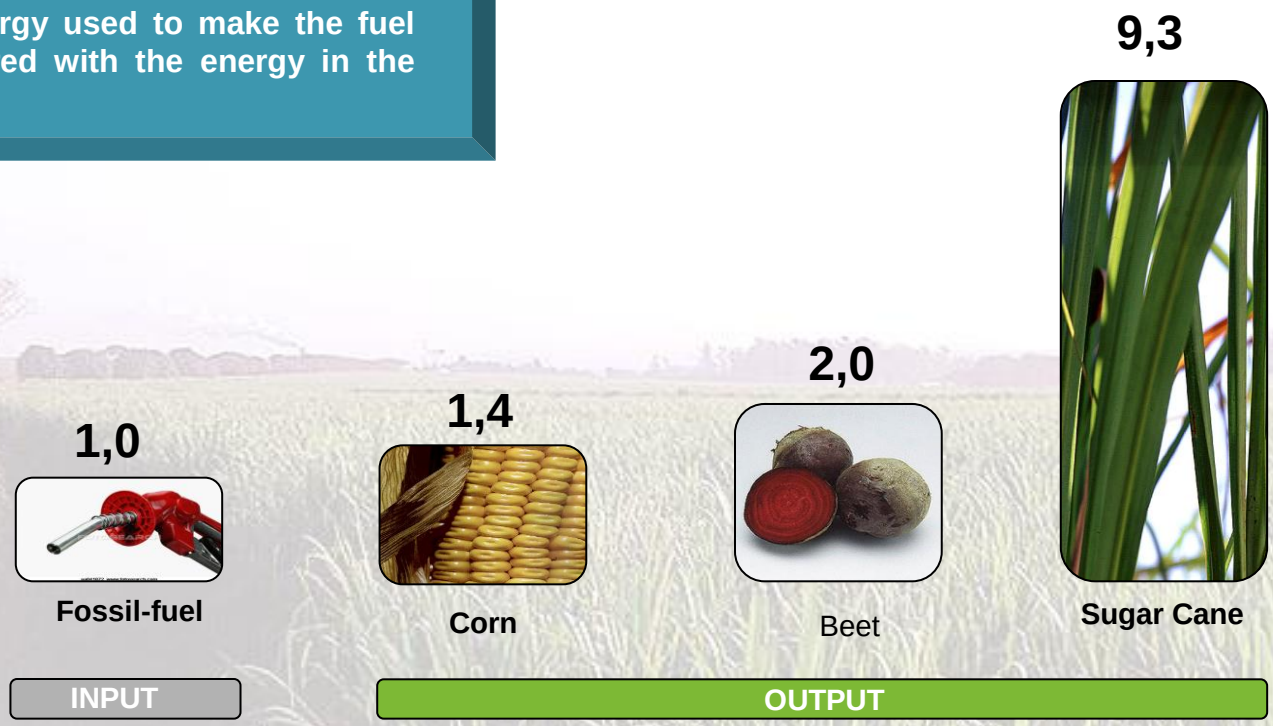
Sugar Cane

Competitive advantage over other biomass

Fossil-fuel energy used to make the fuel (input) compared with the energy in the fuel (output)



Sugar Cane presents the **highest energetic productivity** compared to other biomass.

Fonte: Unica

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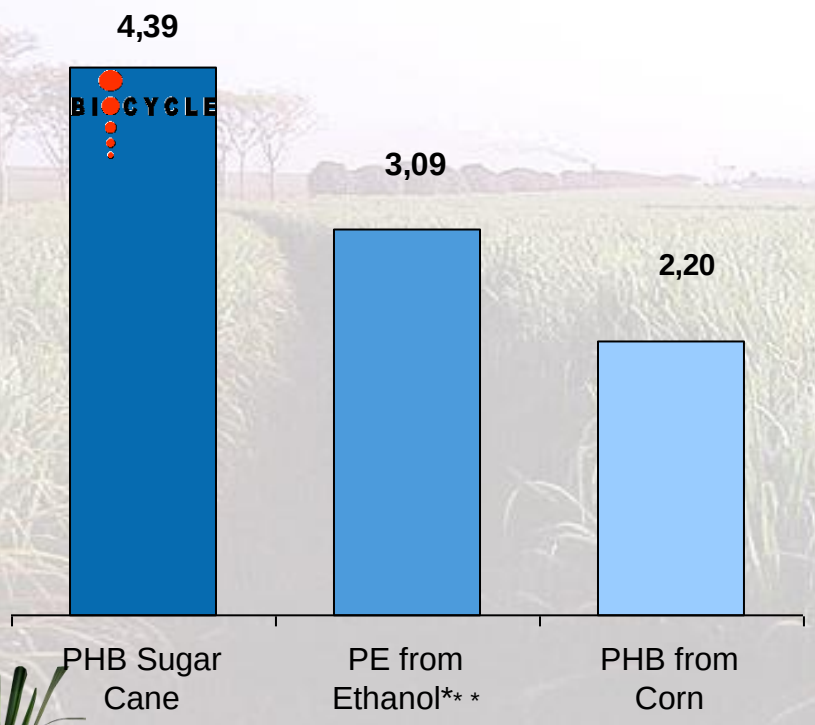
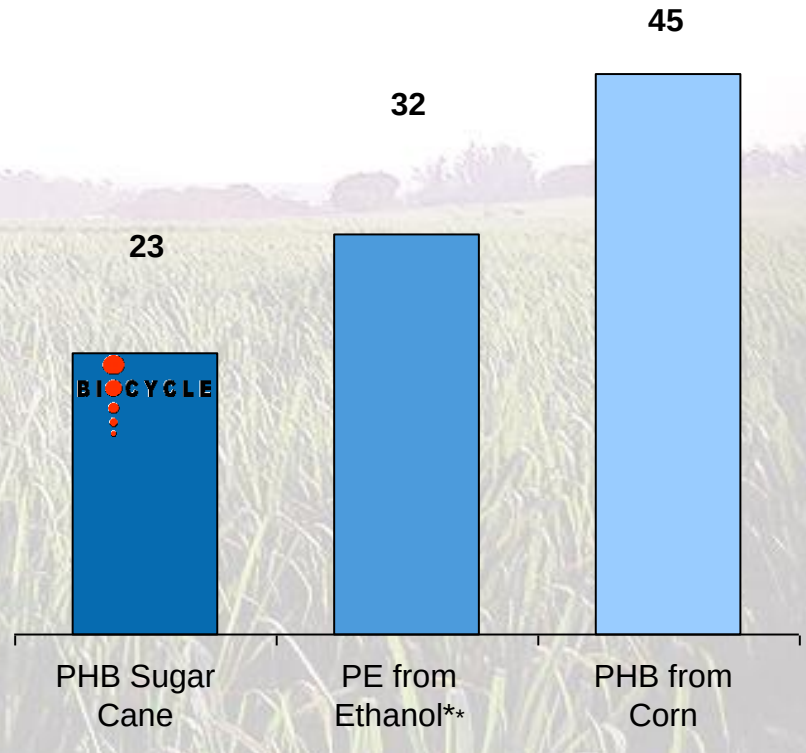
Biopolymers - Productivity comparison & Demanded Area

Biopolymer Production
(ton/hectare)



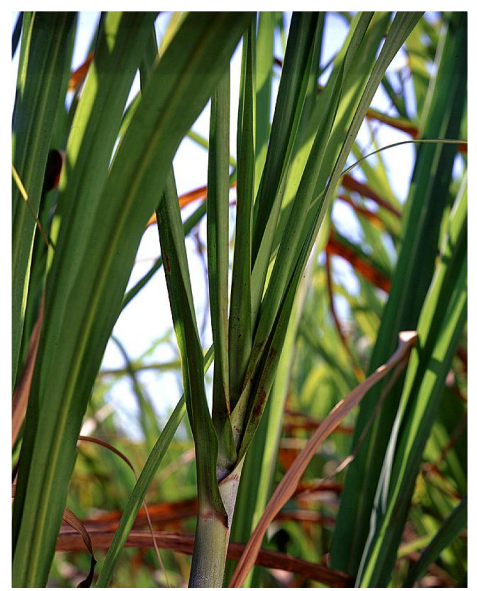
Necessary area to produce 100.000 tpy of PHB
(thousand hectares)



Source: PHBISA's Analysis /
* "Braskem's Green Polymers: A Partnership Beyond Renewable Raw Materials" – European Bioplastics Conference – Nov09

Biocycle is a net CO_2 consumer / cleaner, when considered the entire lifecycle

1 kg of PHB rescue around **~4,4 kg CO_2**



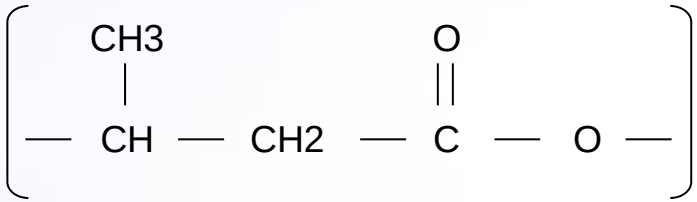
Lifecycle CO_2 - Rescue Comparison	
Product	**CO_2 (kg) / Ton of Product**
PHB – Biocycle (Sugar Cane)	**4.400**
PE Green	2.500
PHB (corn)	2.200
PLA (corn)	1.700
PP	(1.900)
PET	(3.200)

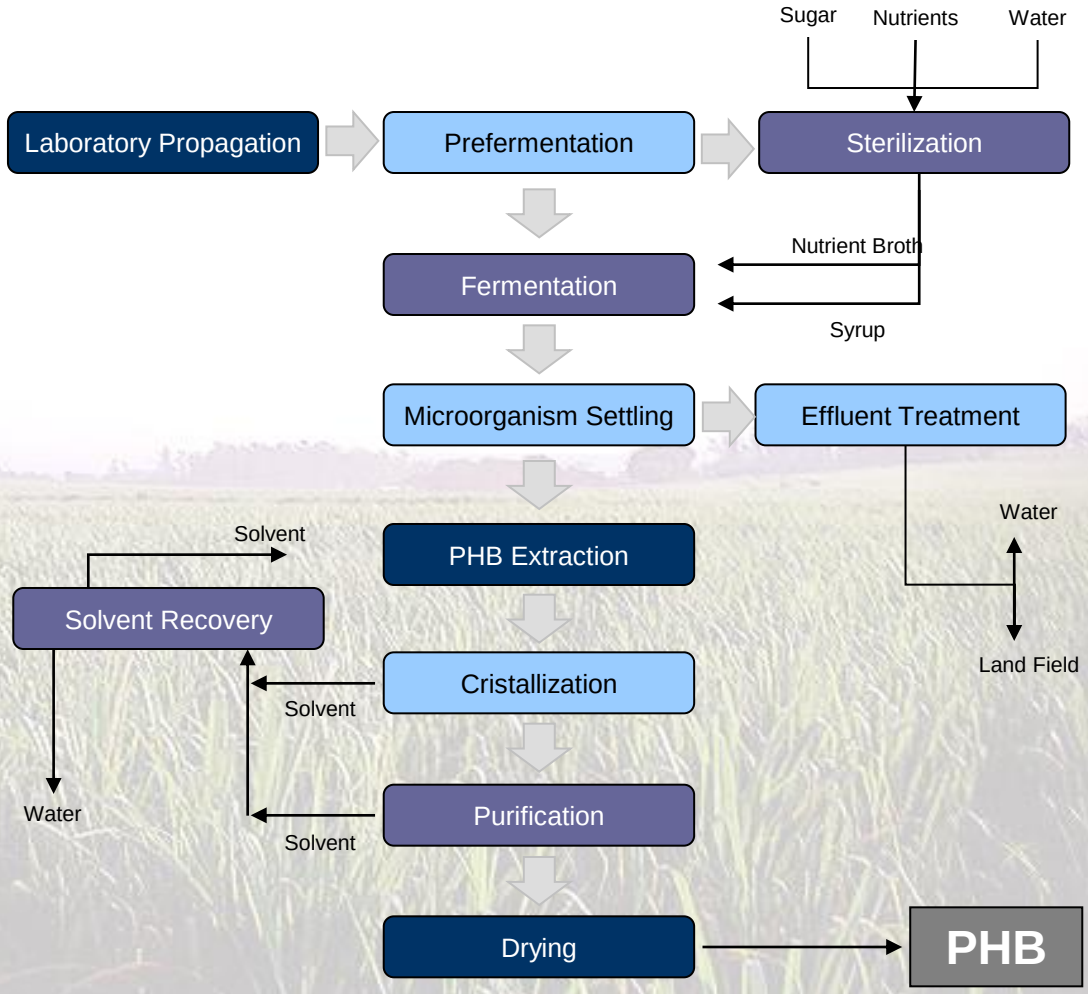
Source: Rescue CO^2
1. PHBISA: "Estudo LCA" CETEA/ITAL & Estudos CTC / Unicamp
2. PE Braskem: "Braskem's Green Polymers: A Partnership Beyond Renewable Raw Materials" – 4º European Bioplastics Conference
3. PHB Milho:Metabolix
4. PE / PET / PLA: Cargill Dow LLC

Production Technology

Chemical Formula

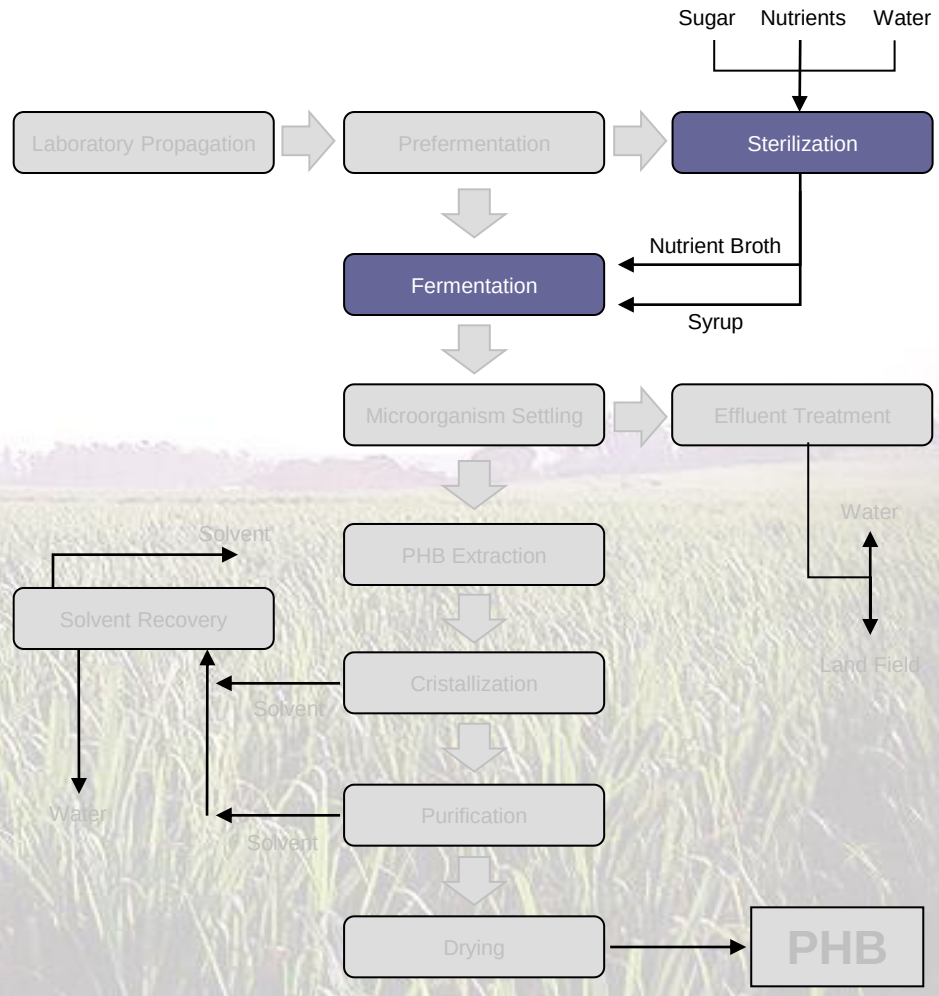
Linear chain of poly (3-hydroxybutyric) acid (PHB)





Production Technology

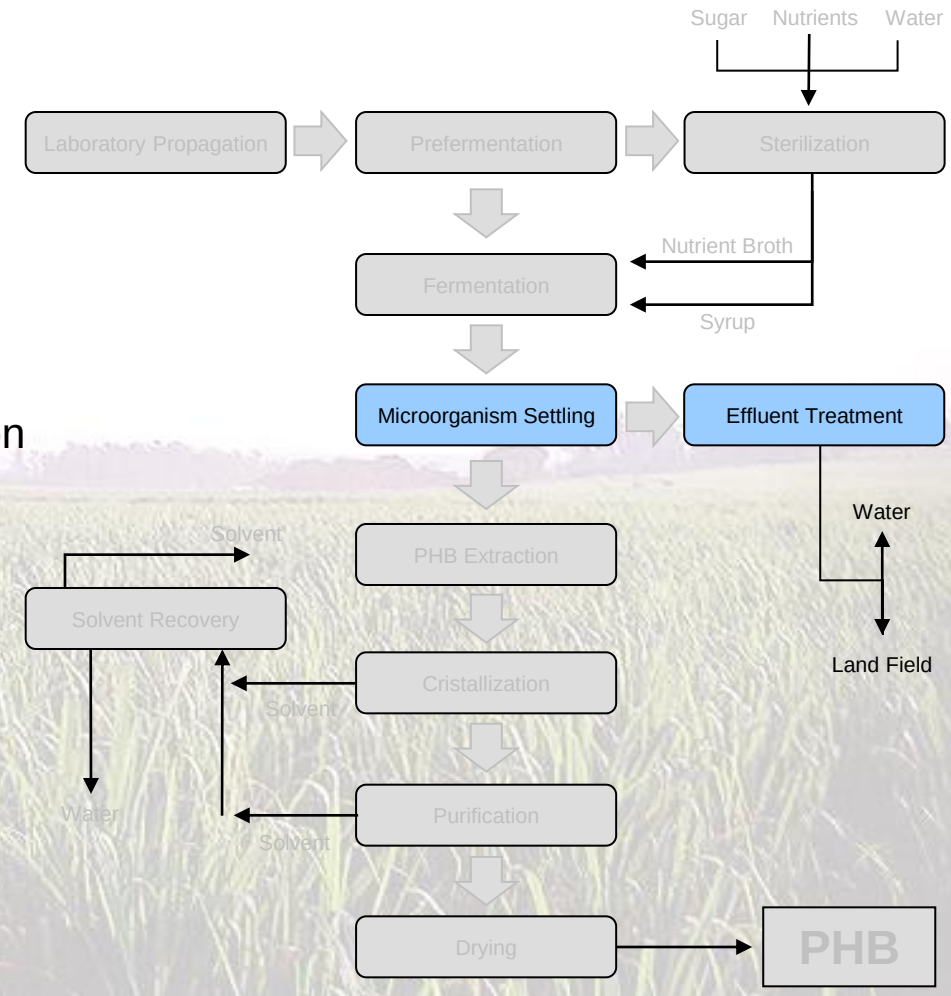
- Sterilization
  - At this point, inputs are introduced into a fermenter:
  - The streams are mixed in the fermenter, along with the bacteria, to begin the process of converting the feedstock to PHBs



- Fermentation Process
  - Bacteria act as biofactories with the ability to turn a feedstock into PHB in an aerobic environment
  - PHBISA has achieved up to 90% content in the biomass in this process

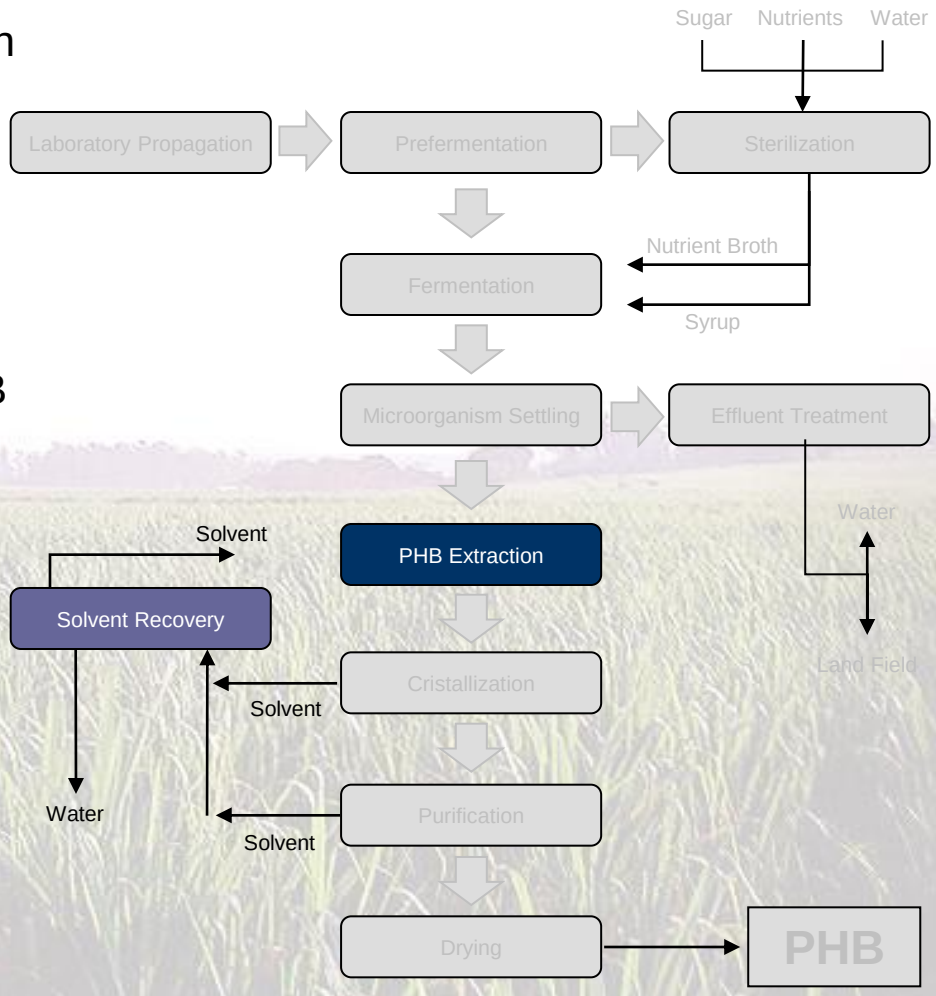
Production Technology

- Microorganism Settling
  - Material is in liquid form with bacteria fully suspended
  - The cells are separated from the solution
  - Cells are then separated and passed on to the PHB extraction phase



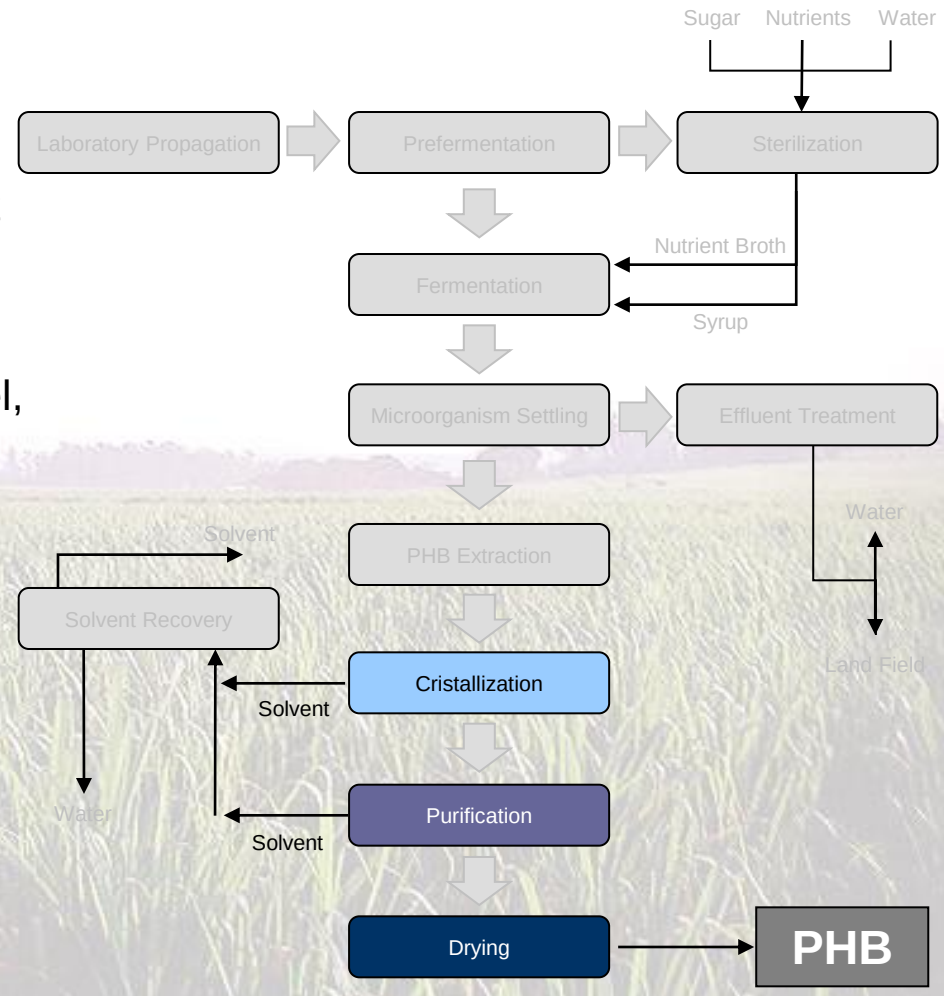
Production Technology

- PHB Extraction
  - The solvent, a non-toxic ethanol production by-product, is mixed
  - The cells react to the solvent by bursting, leaving the PHB absorbed in the solvent
  - The rest of the cell particles remain undissolved, suspended in the solvent
  - The bulk of the solvent plus dissolved PHB is then filtered from the cell debris
  - At this point, the mixture of solvent and dissolved PHB moves on to the crystallization / purification steps while the debris by-product is removed from the batch

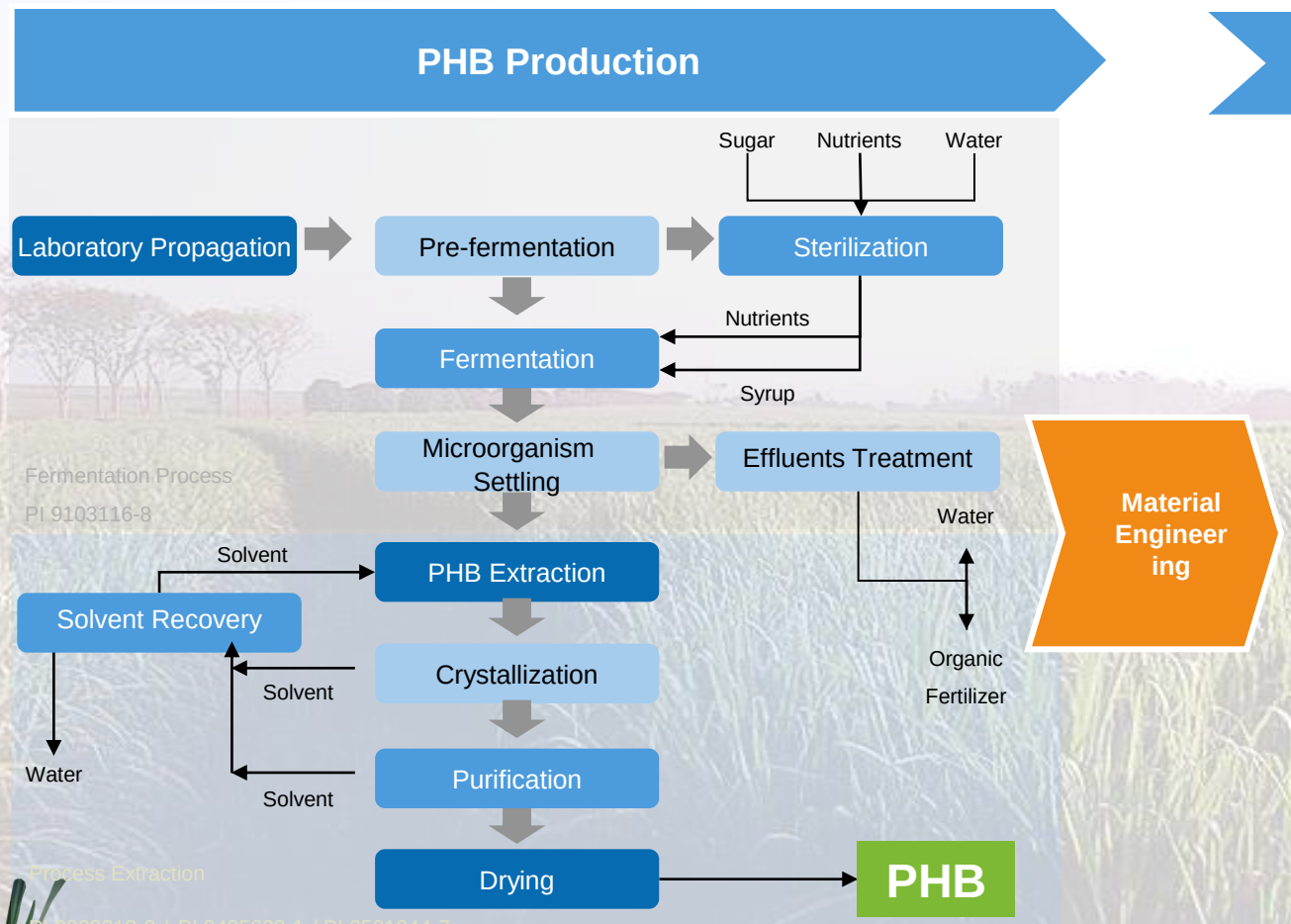


Production Technology

- Crystallization / Purification
  - After the filter stage, the PHB and separated it from the remaining solvent
  - In the purification stage, the separated solvent is removed and recycled
  - Once the PHB is at this high purity level, it is steam dried and packaged for delivery to converters and other end customers



Production – *"New Technology Frontier"*



Material Engineering

Compound with…

- Copolyester
- PCL
- PLA
- Wood Powder
- Starch
- Bagasse
- Sisal Fiber
- Other

BIODEGRADABILITY

COMPOSTABILITY

Technical characteristics of the base polymer that can be improved through polymer blends and alloys with PHB

- Processing Technology – viscosity, crystallization and reactive extrusion
- Mechanical Properties – tensile strength and impact resistance
- Thermal Properties – heat deflection, melting point, glass transition and decomposition
- Biodegradability – velocity and rate
- Cost

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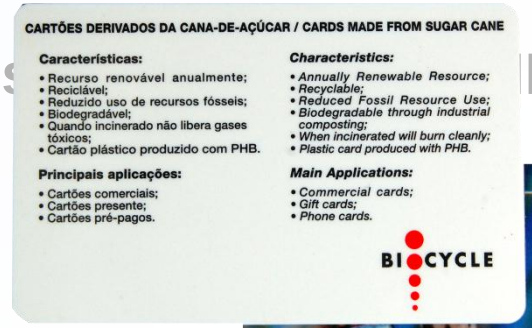

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Such product rou al clients

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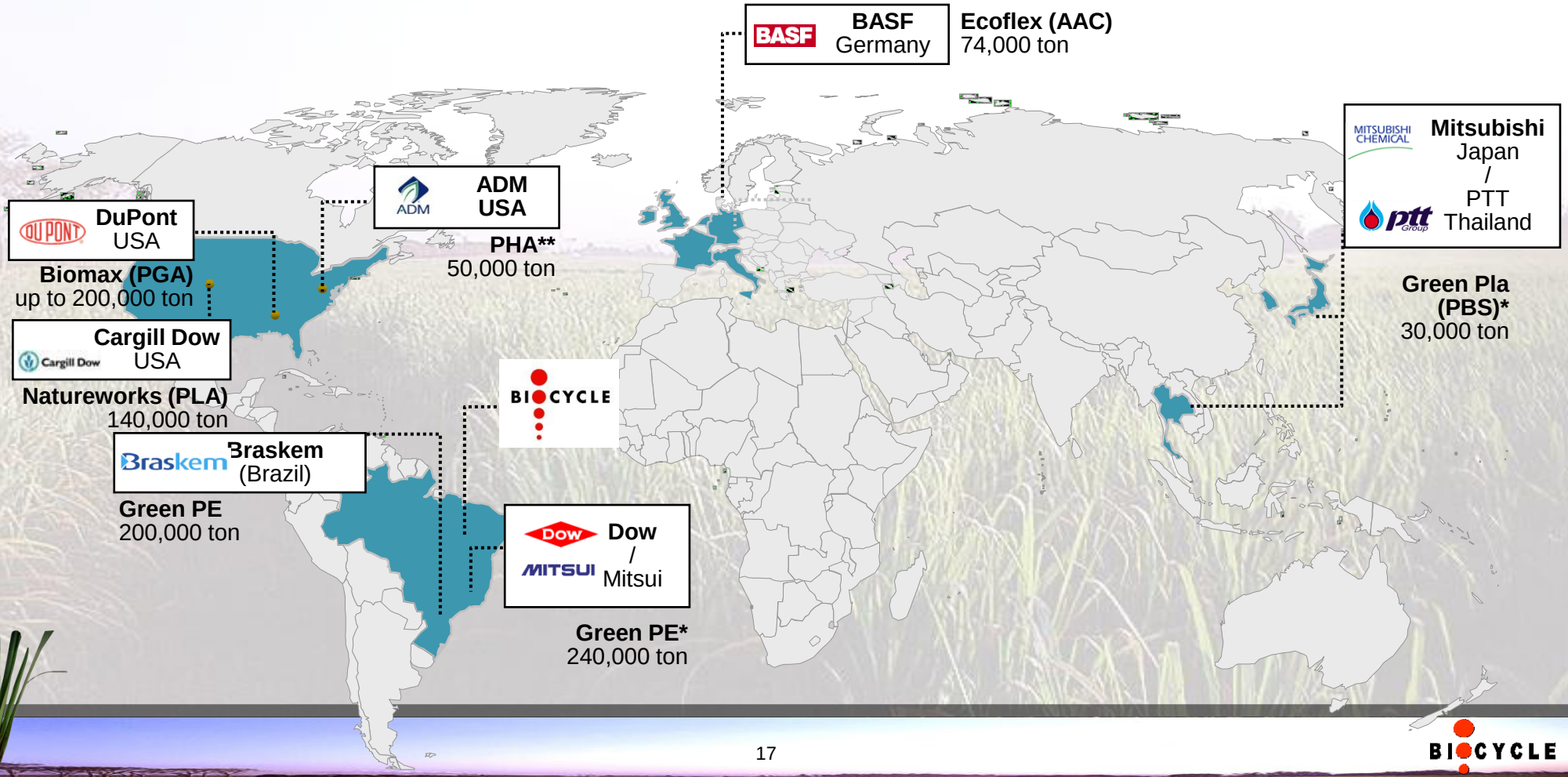
Major Players from Europe, America and Asia are investing in different biobased technology streams, showing the market trends…



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