Agenda

Biopolymers

Brazilian Scenario
Product Sustainability
  Renewable feedstock
  LCA
  WFT and LUC
  Recyclability
Responsible sourcing
Communication and education
Key learning
Conclusion
Biopolymers

I´m Green Polyethylene
- biobased
- recyclable
“IB is key to creating a low-carbon economy and it provides a sustainable, commercially viable route out of over-dependence on fossil fuels and on financial services for economic growth.”

Jonathon Porrit

“The US Biobased Products Preferred Procurement Program is to increase the development, purchase and use of biobased products through government procurement programmes and voluntary product certification and labeling for consumers.”

A dynamic industry growing at a rate of roughly 20 percent per year

“Biopolymers is the evolution of plastics that will contribute significantly to a sustainable society.”

Market drivers

Bioplastics
Technology: The production route for green polyethylene and the fossil polyethylene are exactly the same, therefore the green polymer has got the same characteristics, quality and properties than the fossil equivalent.
How do we define product sustainability?

If the green Economy is to bring the necessary changes to guarantee a future for Life on Earth, decision making on sustainable products, investments, and policies must be made using Life Cycle Thinking and operationalized through life cycle management, approaches and tools.

Building the Single Market for Green Products

Eco-design, design for recycling, RecyClass, circular economy, new business models ...

Vision 2050: LCA will become the main tool to define product sustainability
Agenda

- **Brazilian Scenario**
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  - Key learning
  - Conclusion
Brazilian Scenario
Favorable aspects for the development of biopolymers

Continental dimension
Brazilian Scenario
Favorable aspects for the development of biopolymers

The largest watershed in the world
Brazilian Scenario
Favorable aspects for the development of biopolymers

Intense solar radiation and climate diversification
Brazilian Scenario
Favorable aspects for the development of biopolymers

Pioneer in research and development of biofuels
The product sustainability journey

July 2007
Preliminary investigation
environmental assessment based on secondary data

PHASE 0

September 2010
Plant start up
Code of conduct established
Biobased carbon verification

PHASE 1

October 2013
Environmental Assessment
LCA, WFT, LUC
Primary data
Key suppliers
Critically reviewed
ISO 14040

PHASE 3

April 2011
Product validation
Product certified by Vinçotte

PHASE 2

99% biobased content verified by ASTM D6866

PHASE 2

I'm green

PHASE 0
Agenda

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Sugarcane Ethanol

Efficient use of resources

- SUGAR CANE
- SUGAR CANE CRUSHING
- SUGAR SYRUP
- ETHEROL PRODUCTION
- BAGASSE
- ENERGY
- FILTER CAKE
- VINNASSE
- SUGAR
- ETHANOL FUEL
- INDUSTRIAL ETHANOL
- GREEN ETHYLNE
- GREEN POLYETHYLENE

Efficient use of resources

- Ethanol only: 35%
- Ethanol and Sugar: 61%
- Total: 441
Brazilian Electricity Matrix

- Hydropower: 83.1%
- Hard coal: 1.7%
- Oil, Petroleum based: 2.8%
- Natural gas: 4.6%
- Wind: 2.7%
- Nuclear: 0.5%
- Bagasse: the same contribution as natural gas

I'm green
Brazilian Electricity Matrix

83.1%

- Bio-electricity from bagasse is essential for the Brazilian Energy Matrix
- Energy Credits: replacement for natural gas
- Economic factor: export additional electricity to the grid generate additional revenue

The sugarcane harvesting happens during the dry season when water reservoirs for hidropower electricity is low.
Sugarcane Ethanol
Production & Productivity

Production MM ton¹
- BRASIL: 671
- INDIA: 285
- MEXICO: 70
- COLOMBIA: 101
- AUSTRALIA: 80
- INDIA: 64

Productivity ton/ha
- BRASIL: 79
- INDIA: 64
- AUSTRALIA: 31
- COLOMBIA: 101
- MEXICO: 49

Reference: FAO STAT, Crystalsev; Sindpeças; Global Insight; Bear Stearns; McKinsey analysis, UNICA, Raizen
Land Usage
Significant potential for sustainable growth

Total Area
851.48
Millions of hectares

Protected/Native
495.6 (58%)

Arable Land
329.94 (39%)

Sugar Cane
8.14 (2.4%)
50% Sugar
50% Ethanol

Pasture
158.75 (48%)

Agriculture
51.7 (16%)

Available
111.34 (33%)

Other
25.92 (3%)

Braskem’s capacity of I’m green™ polyethylene production: 200 kton/year

460 millions liters of Ethanol = approx. 68 thousand hectares
Sugarcane Ethanol
Brazilian Agroecological Zoning Programme

Areas for sugarcane expansion:
- Areas with proper conditions for mechanical harvesting
- Degraded pasture land
- Regions with lower need for water usage in production

No sugarcane expansion:
- Areas with sensitive ecosystems
- Amazon Forest
- Pantanal Wetlands
- Upper Paraguay river basin
- Cerrado areas

Soil and weather condition = productivity
(no expansion to Amazon and Pantanal)

Respect for food security

87% DA PRODUÇÃO NACIONAL
Sugarcane Ethanol

Vinçotte - French certification

- The renewable content is validated through the C-14 test – Beta analytics.
- Star system based on % of renewable content
- Green polyethylene got a 4 start rating indicating more than 80% renewable content

<table>
<thead>
<tr>
<th>Biobased</th>
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<td>between 20 and 40 %</td>
<td>between 40 and 60 %</td>
<td>between 60 and 80 %</td>
<td>more than 80 %</td>
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Life Cycle Analysis

Study Premisses

- **Functional Unit:** 1 kg of resin
- **Boundary:** cradle to gate
- **Data coverage – Brazilian Scenario**
  - 3 ethanol suppliers + Centre-South Average (Jan a March 2012)
  - Green PE Plant (Feb, March and April 2012)
- **Software:** SimaPro
- **Method**
  - CML 2001
  - Substitution credit methodology – system expansion
- 6 Impact categories: GWP, Fossil energy demand, Ozone layer depletion, Eutrophication, Acidification, Photochemical Ozone Potential + Water Footprint and LUC

*Brazil Centre South dataset*
Life Cycle Analysis

The Base Case

“1 kg of Green HDPE (slurry process, average ethanol supply) following a system expansion approach to account for the electricity co-generated during the process. dLUC is also considered to account for the soil carbon stocks and also the biogenic carbon due to the CO2 removal during sugarcane growth”
Study prepared by:

- E4tech
- LCAworks

Brazilian experts:

- Andreas Detzel (Chair - IFEU)
- Martina Krueger (IFEU)
- Ramani Narayan (Michigan State University)

Critical Review Panel

- Andreas Detzel (Chair - IFEU)
- Martina Krueger (IFEU)
- Ramani Narayan (Michigan State University)
LCA
Main Impact Categories
Impact by process stage

Global Warming Potential
Fossil Energy Consumption
Ozone Layer Depletion Potential
Eutrophication Potential
Acidification Potential
Photochemical Ozone Creation Potential

Sugarcane  Ethanol  Green Ethylene  HDPE
Global Warming Potential

LCA Results

Harvesting 1,11

GWP 100 Balance
Positive and negative emissions

SUGAR CANE

ETHANOL

GREEN ETHYLENE

GREEN POLYETHYLENE

Biogenetic carbon -3,14

dLUC -1,10

Braskem av. LCA
Kg CO₂ eq / kg bio-based PE
-3,13

Industrial process 0,23

Green electricity -0,71

Industrial process 1,22

Industrial process 0,24

Total -2,15

Kg CO₂ eq / kg bio-based PE
Global Warming Potential

Comparative view: Biobased x Fossil based

-2.15 kg CO₂eq/kg of green PE

1.83 kg CO₂eq/kg fossil PE

Delta 3.98

Braskem bio-based HDPE (slurry)

Braskem fossil HDPE

GREEN POLYETHYLENE
Kg CO₂eq/kg bio-based PE

BRASKEM FOSSIL POLYETHYLENE
Kg CO₂eq/kg fossil PE

I'm green
The impact of international transport to markets

USA
-2.10
+2%

Europe
-2.10
+2%

Japan
-2.05
+4%

The transport impact throughout the life cycle accounts to 9%

Brazil -2.15
Kg CO₂ eq/kg bio-based PE

The impact of international transport.
Sugarcane ethanol generates bioelectricity contributing to reduce fossil energy demand

More than 80% of energy used for green PE production is renewable energy
Semi perennial characteristics of sugarcane and crop rotation = peanuts production

Process waste: filter cake and vinasse

Avoids the use of 1,449,010 metric tons of chemical fertilizers (Datagro 2008)
**Water Footprint Accounting**

*Plantation & Mill*

**Green WFP**
- **Rain water, plant intake**
- **Direct**
  - Main component: evapotranspiration of sugarcane
  - Vinasse and filter cake “recycling” relatively minor impact
  - Note data gaps and non-linear relationship
- **Indirect**
  - Bio-diesel blend for field operations

**Blue WFP**
- **Production water, from rivers**
- **Direct**
  - Processing of sugarcane in the mill (e.g. washing of cane, steam generation for processing)
- **Indirect**
  - Inputs such as biodiesel & grid electricity

**Grey WFP**
- **Water needed to dilute effluent**
- **Direct**
  - Phosphorus, nitrogen, potassium from fertilisers
- **Indirect**
  - Only data for biodiesel available

**Allocation**
- Ethanol & electricity exported to the grid by the mills

*Data provided by:* ETH Bioenergia, Tarumã and GASA operated by Raízen (Cosan) located in the west of São Paulo State, within the catchment area of the **Paraná Basin**.
Water Footprint

Braskem Supplier
E4tech WFP calculations

Brazil average
Mekonnen & Hoekstra (2010b)

Water for industrial use ⬇️ Blue

1992
5 m³/ ton. cane crushed

2007/2008
1,89 m³/ ton. cane crushed

2009/2010
1,49 m³/ ton. cane crushed

2012
Our study = 1,10 m³/ ton. cane crushed

Green (data from Cabral et al., 2012)

Blue

Grey

Water (data from Cabral et al., 2012)
Water Sustainability

Annual precipitation data

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Harvesting occurs during the dry season.

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Annual Precipitation Data

(Average 1993 – 2009)
Water Sustainability

Water Scarcity

Average water scarcity does not exceed 14%.
- Crop growing season during months with high precipitation – so WFP not an issue
- Monitor agricultural activities’ impact closely
Direct and Indirect LUC

- New sugarcane
- Crop- or pastureland
- Land available for cultivation
- New crop-or pasture land

DIRECT LUC

INDIRECT LUC
Land use change

dLUC

-1.1 Kg CO₂ eq/kg bio-based PE

Degraded soil → CO₂ → New sugarcane → Recovered soil

VINNASSE → FILTER CAKE → CHEMICAL FERTILISER
Product Recyclability
End of life – Closed Loop

- I’m green™ polyethylene is 100% recyclable. It can be disposed on the existing recycling schemes for traditional PE.

- I’m green™ polyethylene can generate bio-electricity if send to EfW plants.
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Responsible Sourcing
Code of conduct for ethanol suppliers

The 5 pillars

1. Reduction of Cane Burning
2. Conserving biodiversity
3. Good Environmental Practices
4. Respect for Human Rights
5. Life Cycle Assessment (LCA)

Guaranteed by a 3rd party auditing programme

In line with Brazilian Legislation

Federal Policy to reduce trash burning by 2017
Responsible Sourcing

Plant start up
- Development of the 3rd party auditing programme – partners selection –
  - 90% of mills audited*

Internal auditing programme
- Implementation of the 3rd party auditing programme
  - 94.7% of mills audited*

*corresponding of 80% of the volume of ethanol supplied
3rd Party Auditing Programme
Methodology

1ª stage: Mill selection
- Mills that contribute to 80% of the volume supplied
- Validity of auditing: 2 years

2ª stage: Site visit
- 3rd party auditor to follow the assessment checklist
- Critical ranking system
- Produce the auditing report with or without points for improvement

3ª stage: Continuous Improvement
- Suppliers’ meeting: audit feedback
- Actions discussed
- Re-validation of commitment from the supplier
- Action plan for improvement (if applicable)
3rd Party Auditing Programme

Results

- All mills committed to the code of conduct
- To date 87% of the mills have been audited
- No mills have shown “high critical” results
- Action Plan is being received by all audited mills.
- The non-delivery of the action plan will get the mill to be audited again.
Responsible Sourcing

WWF USA

- BFA – Biobased Feedstock Alliance
  “helping to build a more sustainable future for the bioplastics industry”
- Brand Owners led initiative
- Feedstock scorecard for risk management
- Tailored pilot with Braskem supplier

Solidaridad

- Solidaridad Global Farmer Support Programme (FSP) - emerging countries focus
- Sugarcane supply chain engagement: farmers, ethanol mills, Braskem and its clients
- Increase awareness about sustainability and promote transparency in the sector
- Development of tools to promote sustainable practices in the farms, to support the improvement in the field and to monitor progress
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I’m green™: applied to indicate % of renewable content
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• Key learnings
  Conclusion
Key Learnings

- LCA is an essential tool to measure product sustainability
- Data gaps still exist - the best available information has been used.
- Identification of hot spots for continuous improvement
- The full picture: Understanding the value chain
- Study transparency: Methodologies and premises must be clearly stated
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Key learnings

» Conclusion
Conclusion

- Life cycle thinking and the circular economy
- Responsible claims – LCA based communication
- Sustainable sourcing – co-responsibility avoiding burden shift. Add value.
- Continuous improvement at the Green Ethylene plant
- Working with clients for product development and understanding the value proposition
Thank you!

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