Product Sustainability
I’m green™ polyethylene

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Sustainability
July 2014
Agenda

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.

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

Market drivers

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

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

Eco-design, design for recycling, RecyClass, circular economy, new business models ...
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  - Communication and education
  - Key learning
  - Conclusion

CLIENTE OK
Brazilian Scenario
Favorable aspects for the development of biopolymers
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

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

April 2011
Product validation
Product certified by Vinçotte

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

PHASE 0

PHASE 1
99% biobased content verified by ASTM D6866

PHASE 2

PHASE 3
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Efficient use of resources

Sugarcane Ethanol

- **SUGAR CANE**
- SUGAR CANE CRUSHING
- SUGAR SYRUP
- ETHANOL PRODUCTION
- INDOURAL ETHANOL
- GREEN ETHYLENE
- GREEN POLYETHYLENE
- FILTER CAKE
- VINNASSE
- BAGASSE
- ENERGY
- ETHANOL FUEL

For existing plants, more than 61% of ethanol is produced, while 35% is used for ethanol only. 0.05% is for ethanol and sugar.
Brazilian Electricity Matrix

- Hydropower: 83.1%
- Bagasse: the same contribution as natural gas
- Nuclear: 4.6%
- Natural gas: 4.6%
- Wind: 2.8%
- Oil, Petroleum based: 2.7%
- Hard coal: 1.7%
- Total: 100%
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.
<table>
<thead>
<tr>
<th>Country</th>
<th>Productivity (ton/ha)</th>
<th>Production (MM ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEXICO</td>
<td>49</td>
<td></td>
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<tr>
<td>COLOMBIA</td>
<td>70</td>
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<td>BRASIL</td>
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<td>INDIA</td>
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<td>285</td>
</tr>
<tr>
<td>AUSTRALIA</td>
<td></td>
<td>31</td>
</tr>
</tbody>
</table>

Reference: FAO STAT, Crystalsev; Sindpeças; Global Insight; Bear Stearns; McKinsey analysis, UNICA, Raizen
**Land Usage**

**Total Area**

851.48 Millions of hectares

**Protected/Native**

554 (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
Land use: from sugarcane to I’m green™ polyethylene

1 hectare of land
77 tons of Sugarcane
6700 liters of Ethanol\(^{(1)}\)
3 tons of Green Ethylene\(^{(2)}\)
3 tons of I’m Green™ Polyethylene\(^{(2)}\)

<2.0% of Brazilian ethanol production ← Braskem → 0.02% of Brazilian arable land

(1) NIPE/UNICAMP/UNICA
(2) Braskem’s project data
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
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
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 to 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) when a substitution credits methodology is applied to the surplus electricity co-product and when CO2e credits for dLUC carbon storage on land and CO2 removal into the polymer resin are accounted for in the model”.
The LCA Practitioners Team

Study prepared by:
- E4tech
- LCAworks

Brazilian experts:
- E4tech
- NIPE
- UNICAMP

Critical Review Panel
- Andreas Detzel (Chair - IFEU)
- Martina Krueger (IFEU)
- Ranami 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
LCA
Main Impact Categories
Comparative view

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

LCA Results

Harvesting
-1.11

GWP 100 Balance
Positive and negative emissions

Biogenetic Carbon
-3.14

SUGAR CANE

ETHANOL

GREEN ETHYLENE

GREEN POLYETHYLENE

Industrial process

0.23

Industrial process

1.22

Industrial process

0.24

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

-3.13

-0.48

1.22

0.24

Total

-2.15

Kg CO₂ eq/kg bio-based PE

Im green
Global Warming Potential

- **GWP100**
  - HDPE (slurry)
  - Ethylene
  - Ethanol bagasse, diesel
  - Sugarcane diesel, field emissions, trash burn

- **42%** Ethanol
- **41%** Sugarcane
- **9%** Ethylene
- **8%** HDPE (slurry)
- **3%** Unib Gás, grid elec

- **Ethylene**: Fossil fuel, heat & power, transport
Global Warming Potential

Comparative view: Biobased x Fossil based

Braskem bio-based HDPE (slurry)

Braskem fossil HDPE

kg CO$_2$eq/kg of green PE

1.83
BRASKEM FOSSIL POLYETHYLENE
Kg CO$_2$eq/kg fossil PE

Delta 3.98

-2.15
GREEN POLYETHYLENE
Kg CO$_2$eq/kg bio-based PE
The impact of international transport to markets

USA
-2,10* +2%

Europe
-2,10* +2%

Japan
-2,05 +4%

*SMEP
Kg CO₂ eq/kg bio-based PE

The transport impact throughout the life cycle accounts to 9%

Brazil -2,15
Kg CO₂ eq/kg bio-based PE

I'm green™
Sugarcane ethanol generates bioelectricity contributing to reduce fossil energy demand.

More than 80% of energy used for green PE production is renewable energy.
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.
Green (data from Cabral et al., 2012)

Blue

Grey

Water for industrial use

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

Water Footprint

Braskem Supplier
E4tech WFP calculations

Brazil average
Mekonnen & Hoekstra (2010b)
Water Sustainability

Annual precipitation data

Harvesting occurs during the dry season.
Land use change

dLUC

-1.1 Kg CO₂ eq/kg bio-based PE

CO₂

Degraded soil

New sugarcane

Recovered soil

VINNASSE
FILTER CAKE
CHEMICAL FERTILISER

CO₂
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)

In line with Brazilian Legislation

[Images and logos related to Brazilian legislation and responsible sourcing]
Responsible Sourcing

Managing the Code of Conduct

- Guaranteed by a 3rd party support
- 3rd party auditing
- Suppliers committed with a action plan for improvement


- Meta: 60% in 2010, 61% in 2011, 70% in 2012, 80% in 2013
- Realizado: 85% in 2010, 95% in 2011, 90% in 2012, 97% in 2013
Responsible Sourcing

NGO partnerships

**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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Key learnings
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Communication And Education

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 exists - 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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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
South America Applications

- **Tetra Park**: Coating/Beverages Cartons
- **Pilecco**: Technical bobin/Food Arroz Grãos Nobres
- **NobelPack**: Durable bags Retailers: Cacau Show Ofner Marisa Spicy Centauro Others
- **Estrela**: Pieces / Toy Banco Imobiliário (monopoly)
- **SURYA Brasil**: Flexible Tubes/Personal Care Sapien Women
- **BASF agrochemical**: Container/Agribusinesses Regent
- **Grande Raymundo da Fonte**: Embalixo Raymundo da Fonte/Brilux Trash Bags
- **Adimax**: Pet Food Magnus Eco Fórmula Natural
- **Tetra Pak**: Caps / Beverage Ninho (Nestlé)
South America Applications

- Walmart
  - Bom Preço
    - Trash Bags

- Panvel
  - Flexible Tubes /
    - Personal Care
    - Vert

- Kimberly-Clark
  - Packaging for toilet paper / Personal Care
    - Neve

- Ipiranga
  - Packaging for oil lubricant
    - Ipiranga F1 Master Performance

- Acinplas
  - Star Bags / Retailing
    - Bags for vegetables

- Zafari
  - T-Shirt bags
    - Bags for Zafari supermarket

- Johnson & Johnson
  - Bottles / Personal Care
    - Sundown

- Natura
  - Bottles / Personal Care
    - Ekos
    - TodoDia

- MSA
  - Helmet
    - V-Gard

- Prysmian
  - Wires and Cables
    - Afumex Green
South America Applications

- **Faber Castell**
  Case for pencils

- **FMC Agricultural Products**
  Container/Agricultural Businesses

- **FMC**
  Bottles/Personal Care
  Sunscreen as a protective equipment

- **Luvex**
  Bottles/Personal Care
  Sunscreen as a protective equipment

- **Coca Cola**
  Coating/Beverages
  Del Valle

- **Eletrolux**
  Appliance for washing machines
  Ecologic

- **The Coca-Cola Company**
  Coca Cola
  Coating/Beverages
  Del Valle

- **Zandei**
  Rigid Packaging/Personal Care
  Packaging for Personal Care products

- **La Papelera del Plata**
  Packaging for kitchen paper
  Sussex tendencia

- **Boral**
  Caps/Beverages
  Milk Piracanjuba

- **Unilever**
  Coating/Beverages
  Ades
Europe Applications

- **Tetra Pak**
  - Caps / Beverages
  - Valio and others

- **ECOVER**
  - Ecover
  - Bottle/Home Care
  - Ecover

- **Nomacorc**
  - Closures/Beverages
  - Wine Corc: Select Bio

- **Plastic Omnium**
  - Rigid Container
  - Waste Containers

- **Sphere**
  - Trash Bags
  - Alfapac Vegetal Origin

- **McCain**
  - Multi layer Packaging
  - Film/Food
  - Frozen Fresh Fries

- **L’Occitane**
  - Bottles/ Personal Care
  - Bonne Mère

- **Papier Mettler**
  - Durable Bags
  - Retailers: Kaiser’s
  - REWE
  - Rossmann
Asia and Oceania applications

Yuhan Kimberly
Packaging film/Personal Care
Huggies

Ajinomoto
Caps/Food
Ajinomoto

KAO
Stand Up Pouch/Personal Care
Asciences’s
Segreta
Merit

Morinaga
Internal straw/Beverage Energy

Aeon
Retailing
Single use bags and baskets

Takeda
Packaging/Pharmaceuticals
Takeda

Calpis
Beverage packaging
Calpis

Shiseido
Packaging/Personal Care
Super Mild
Tsubaki
Elixir
Uno Fog Bar

Mitsubishi
Fiber/Automotive Carpets
Mitsubishi
Asia and Oceania applications

Nepia
Tissue packaging/Personal Care
Nepia

Bubble Pack
Bubble Wrap Film/Consumer good
Bubble Pack

Nature Organics
Packaging for pre wash stain remover/Home Care
Earth Choice

Toyota
Fiber/Automotive Carpets
Toyota

Samsung
Packaging for cables
Samsung

Osang
Packaging to involve the fruit
Osang

Kia
Front dashboard and door trims/ Automotive
Kia Soul EV

Kosé Cosmeport
Multilayer Packaging Film/Personal Care
Kosé Cosmeport

Japan Gateway
Multilayer Film/Home Care Choice

Choose
Braskem
North America Applications

- General Mills
  - Packaging Food
  - Cascadian Farm Cereal

- Coca-Cola
  - Bottle/Beverages
  - Odwalla

- P&G
  - Packaging/Personal Care
  - Pantene Nature Fusion Shampoo

- Aveda
  - Cosmetic
  - Dry Remedy