Plant Based Composite Materials for Automotive

They Exist and Are Ready for Prime Time

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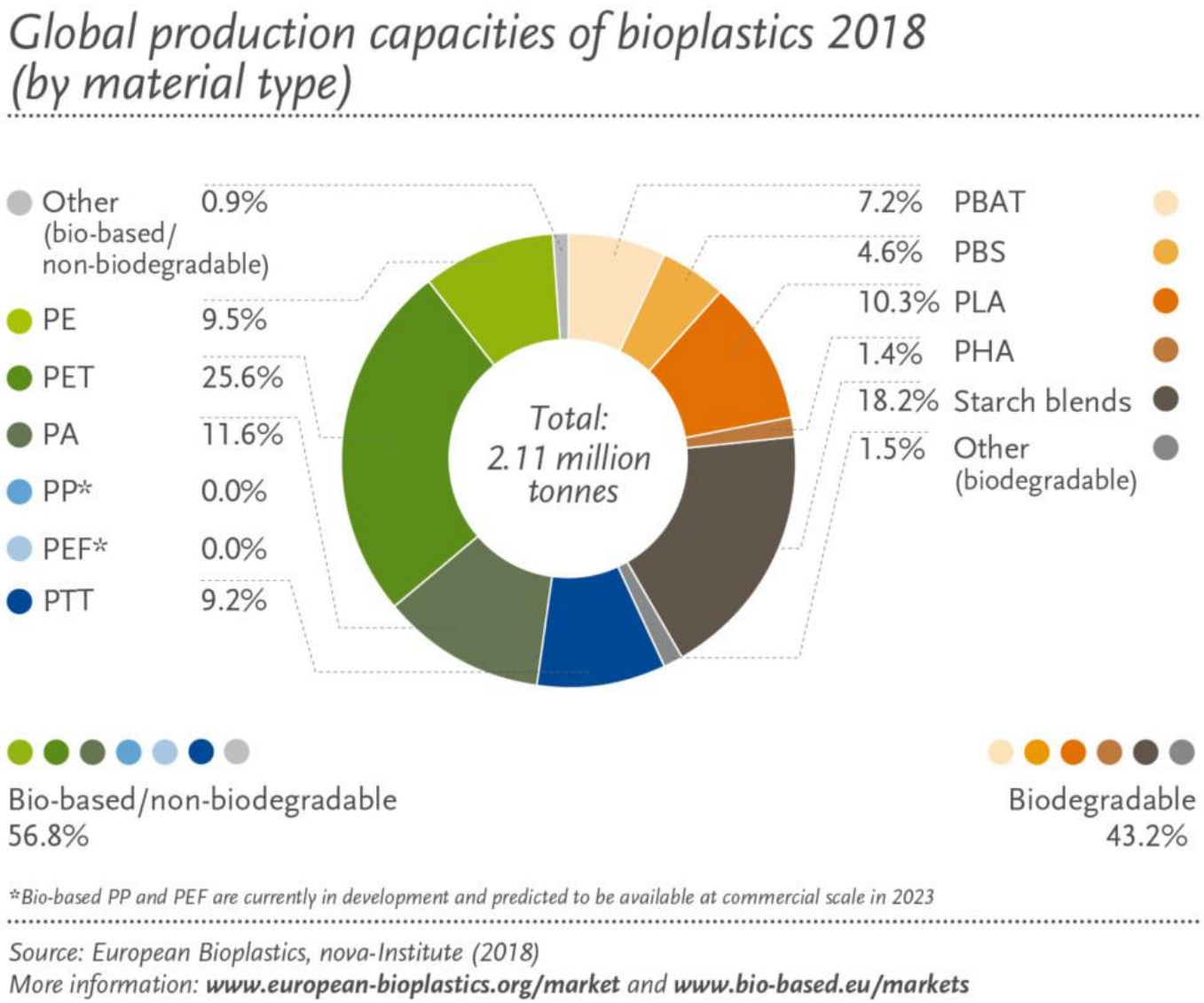
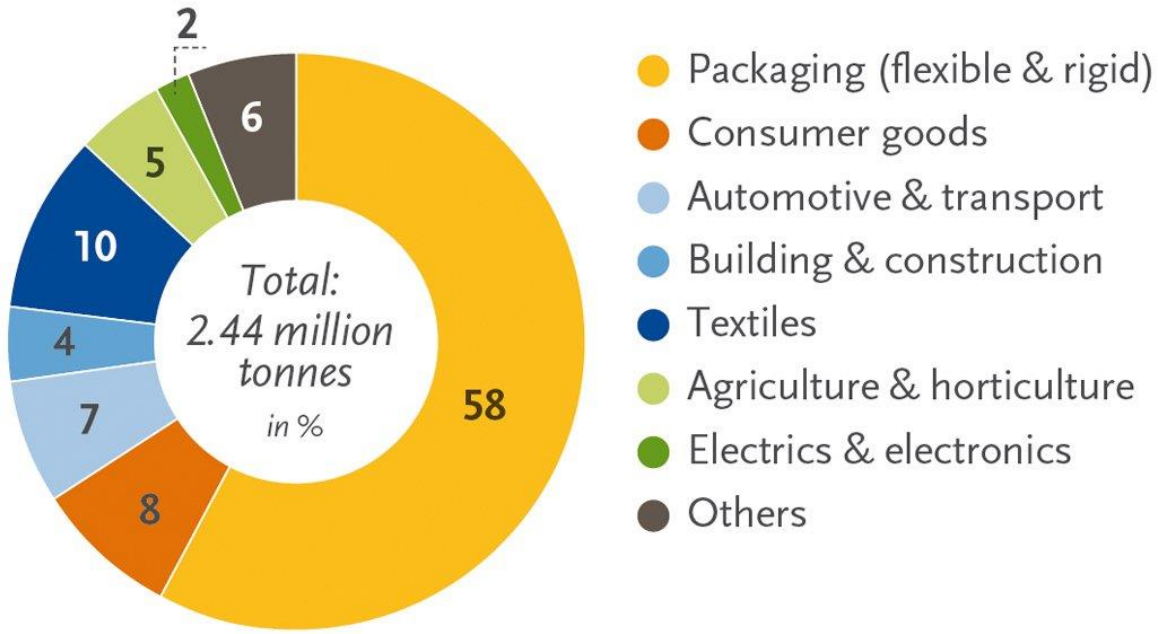
Green Dot Bioplastics

green dot®
BIOPLASTICS

Bioplastic by Type



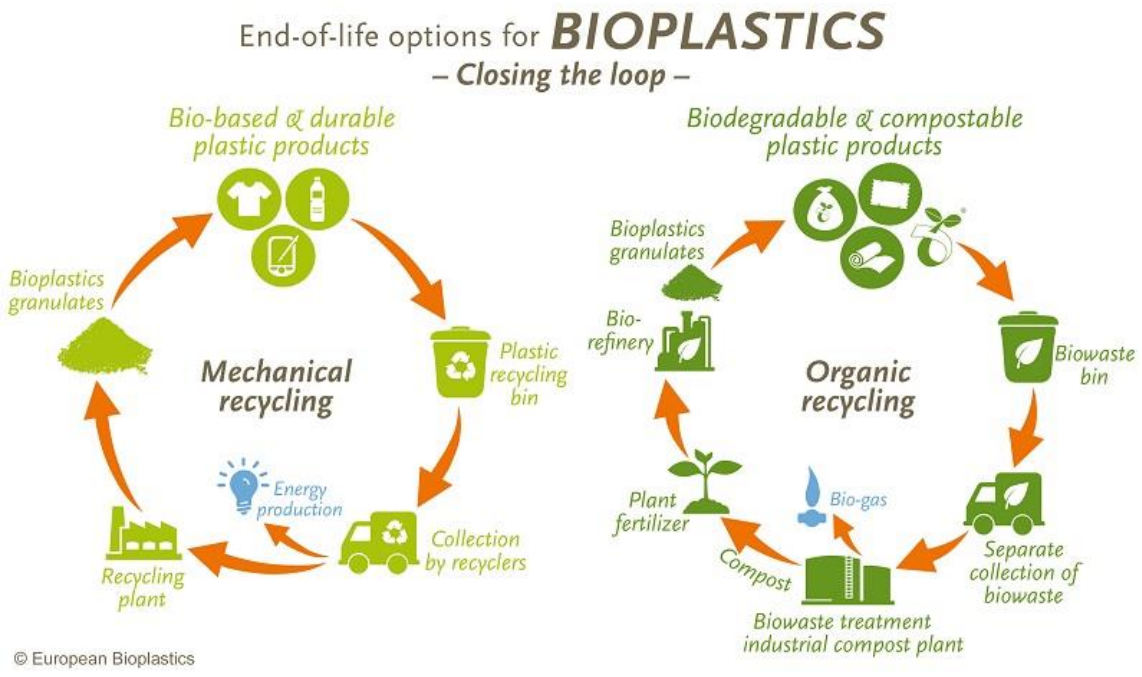
Bioplastic by Market



Source: European Bioplastics, nova Institute 2018

What is a bioplastic?

1. Biobased: comes from a renewable resource; plants
2. Compostable/biodegradable: can break down into organic matter that nourishes the planet, not destroying it.



Biocomposites are bioplastics + natural fiber reinforcements (NFRP)

Types of reinforced composites

<u>Matrix</u>

Traditional

- Polypropylene
- Epoxy resins
- Nylon

Plant-based

- Polylactic Acid – 100%
- Green PE – 100%

Biodegradable

- Starch-based hybrids
- Biodegradable polyesters
- Microbe derived –PHA
- PLA

Inorganic

- E-glass
- Carbon

Organic

- Flax
- Sisal
- Jute
- Hemp
- Coir

Use of Natural Fiber Reinforced Plastic Composites (NFRPs) Increasing in Automotive

Value Propositions for NFRPs

1. **Sustainable** – increased use of renewable resources and/or biodegradable at end of life

2. **Light-weighting** – lower specific gravity compared to glass or carbon reinforced plastics

Advantages to Natural Fiber Composites

- Low Density- May lead to weight reductions of 10-30%
- Low GHG Emissions- in two ways: plants convert $C0_2$ to O_2 & less energy in production
- Safer- reduced wear of tooling, healthier working conditions, and no skin irritation, no off gassing, reduced fogging behavior
- Sustainable- from renewable sources
- Quieter- Good thermal and acoustic insulating properties

International journal of Scientific Research & Development Vol. 3, Issue 04, 2015 - Abhishek Dwivedi, Prem Kumar Bharti

Criteria for Selection of NFRPs

Physical

- density, texture, sound absorption, fiber characteristics – length/ diameter ratio, thermo conductivity

Mechanical

- elastic modulus, shear modulus, tensile strength, elongation at break

Technical

- processing time/cost, energy input cost, processability

Environmental

- eco-friendly, government support, biodegradability, social positive view

Sisal fiber dispersion in PP; x, y, z axis, area ≈ 1 inch, fibers ≈ 2mm

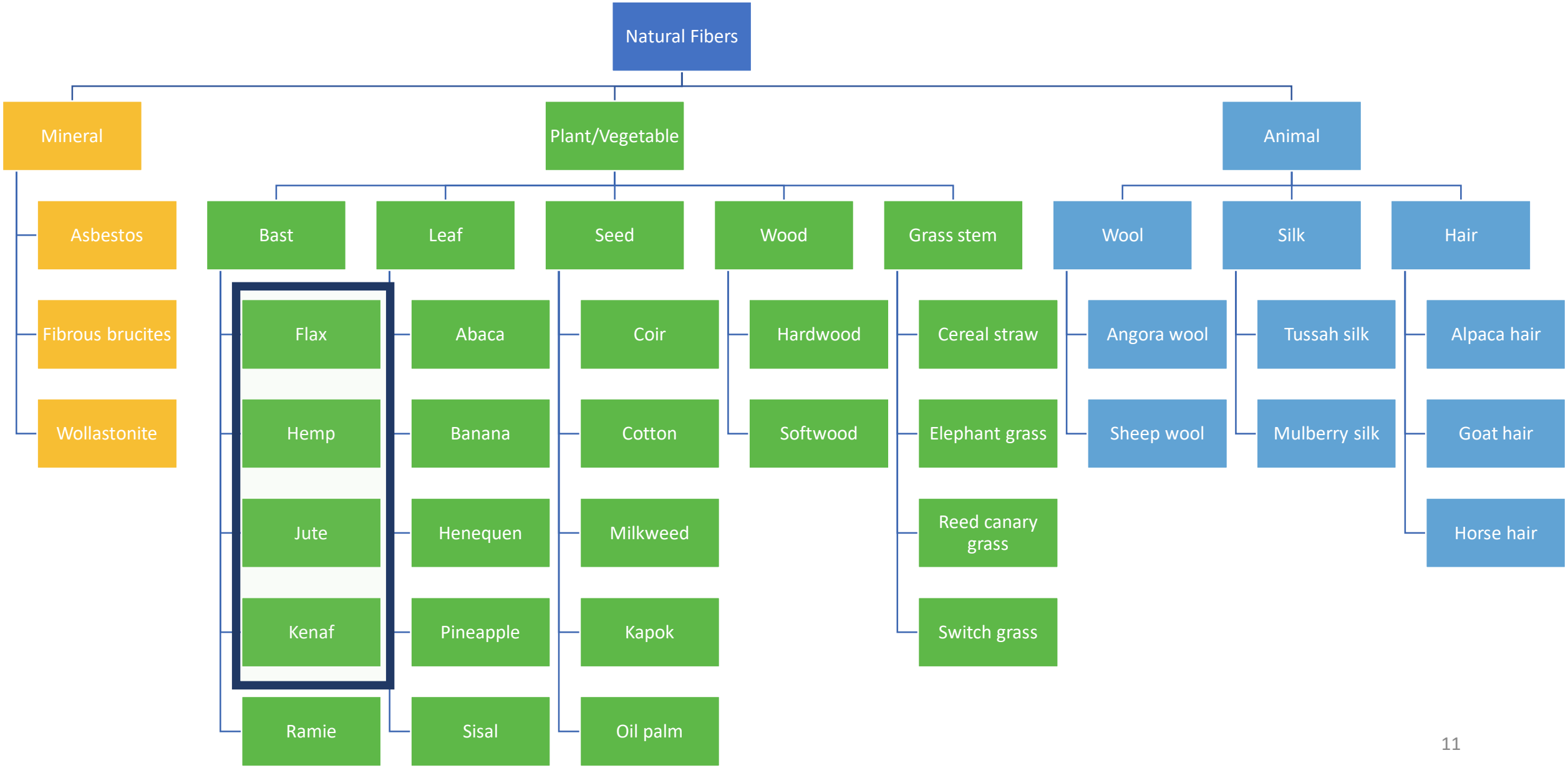
Manufacturing of NFRPs is Specific

- Glass and carbon have known health and safety issues
- Natural fibers have known moisture and handling concerns
- Processing of NFRPs is both an art and a science
  - Degradation of fiber through processing must be avoided
    - Processing temperatures
    - Fiber breakage
  - Dispersion and bonding must overcome hydrophilic fiber properties
    - Adhesion incompatibility
    - Hydrolysis can occur if H_2O is absorbed

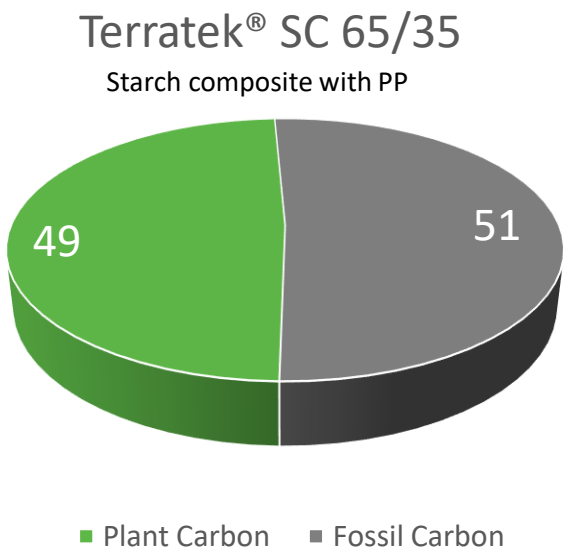
Sustainability

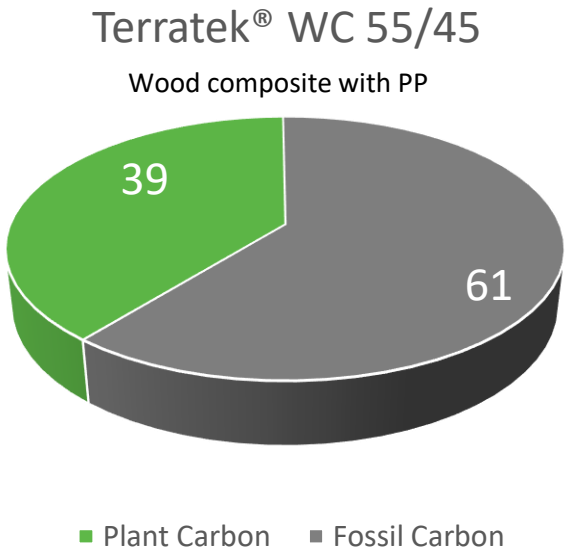
- Renewable content
- Energy consumption
- Life Cycle Analysis

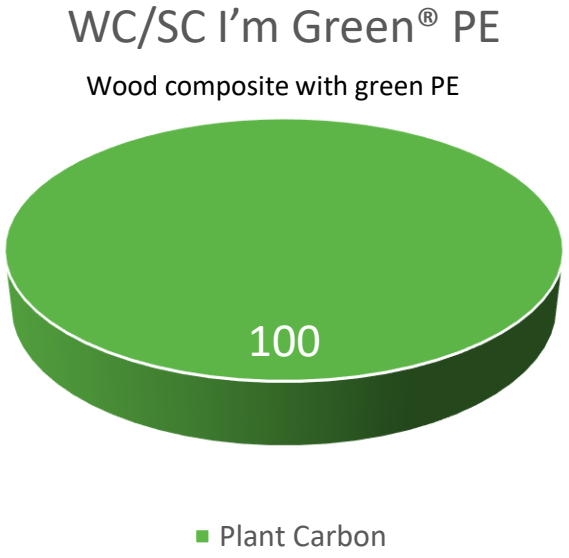
Natural Fiber Are Inherently Sustainable



Theoretical Biobased/Plant-based (New) Carbon Content of example Green Dot biocomposites

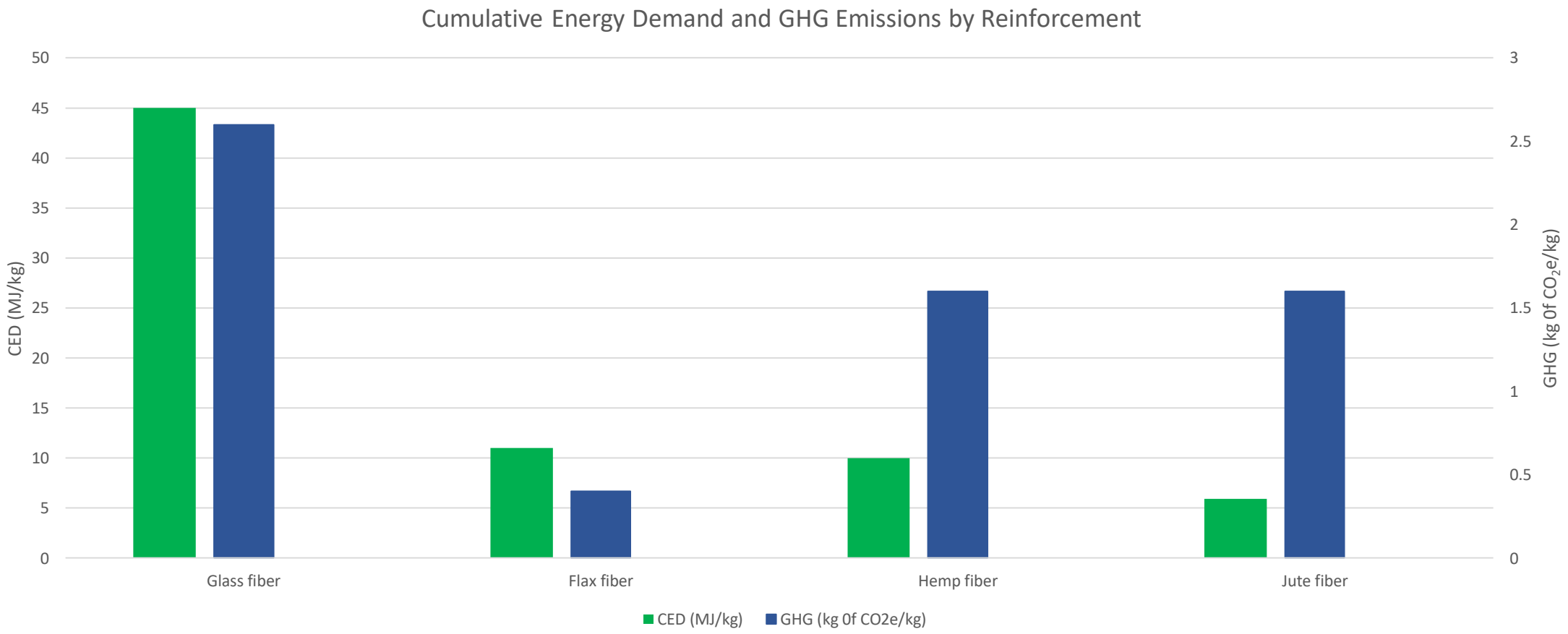






The biobased content of a product is the carbon molecular weight % from renewable resources used in the formula.

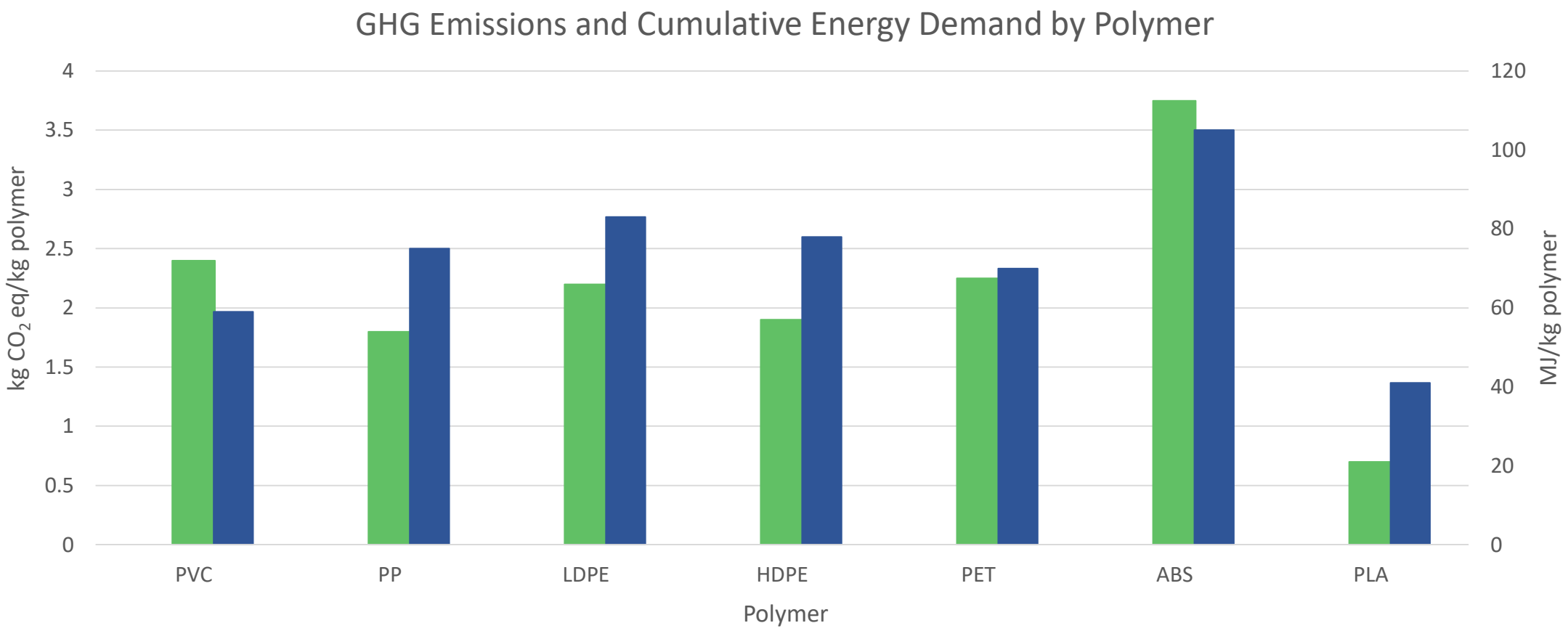
Energy Consumed in Fiber Production
plant fibers are inherently lower energy



MRS Bulletin, Vo. 37, Issue 4 (Materials for sustainable development – April 2012, pp. 374-382, Joost R. Duflou, Yelin Deng, Karel Van Acker, Wim Dewulf

GHG Emissions & Energy Consumed In Polymer Production

biopolymers are typically lower energy



Data on EU production from Plastics Europe. Data on US production from American Chemistry Council.

Life Cycle Analysis for NFRPs in Production

Product	Composite material	Replaced traditional material	Change in weight	Change in cumulative energy demand	Change in greenhouse gas emissions
Car side door	Hemp/EP	ABS	-27%	-45%	-15%
Under-floor pan	Flax/PP	GF/PP	0	-14%	NA
Rotor blade	Flax/EP	CF/EP	0	-50%	-45%
Car interior	Bagasse/PP	Talc/PP	-20%	-22%	-21%

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Lightweighting

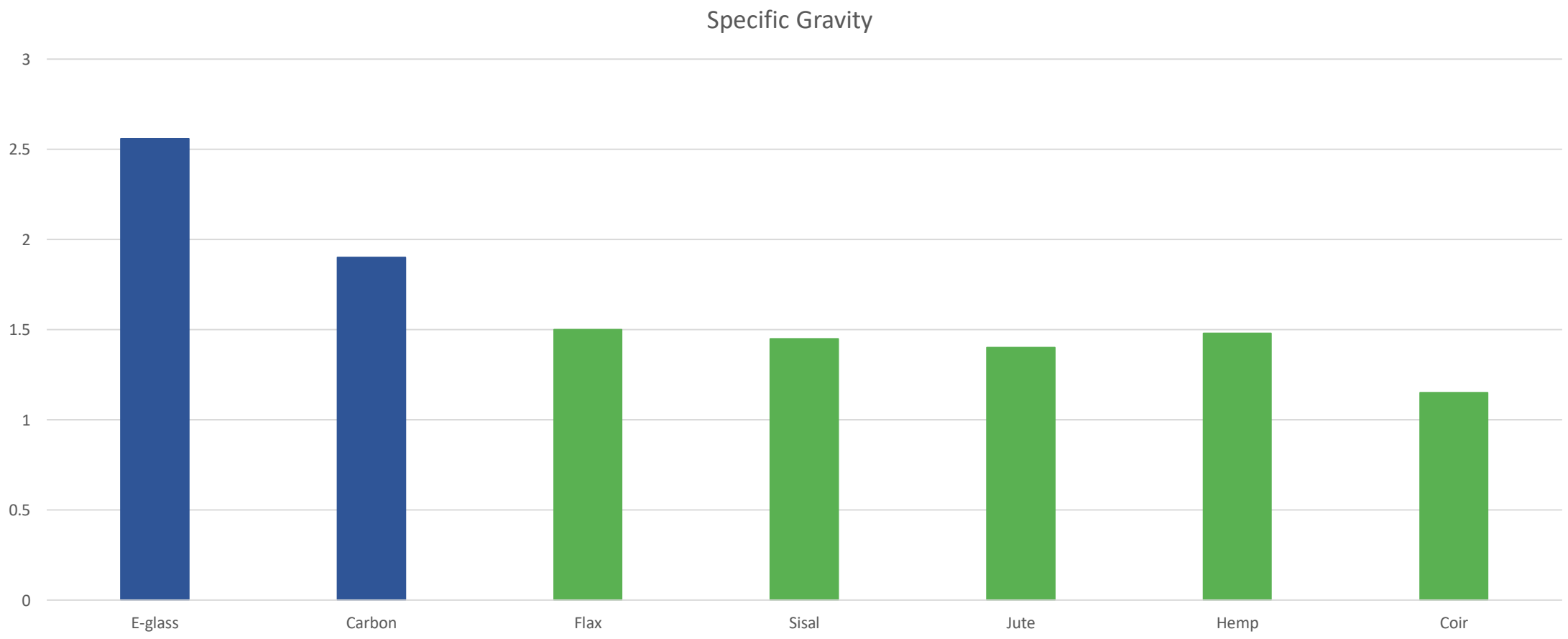
Natural fibers vs E-glass

- Can increase fuel economy

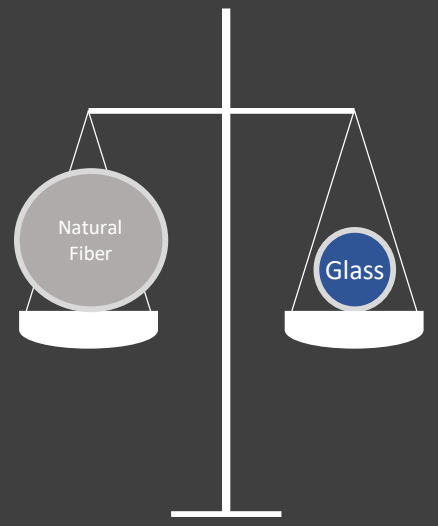
Lightweighting Examples

Images from:
Bcomp and UFP Technologies

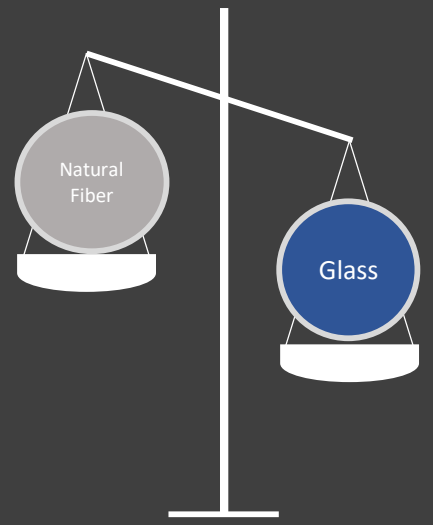
Natural Fibers Are Inherently Lighter Weight



Lighter Fibers=More Fibers By Weight



Equal weight of fibers

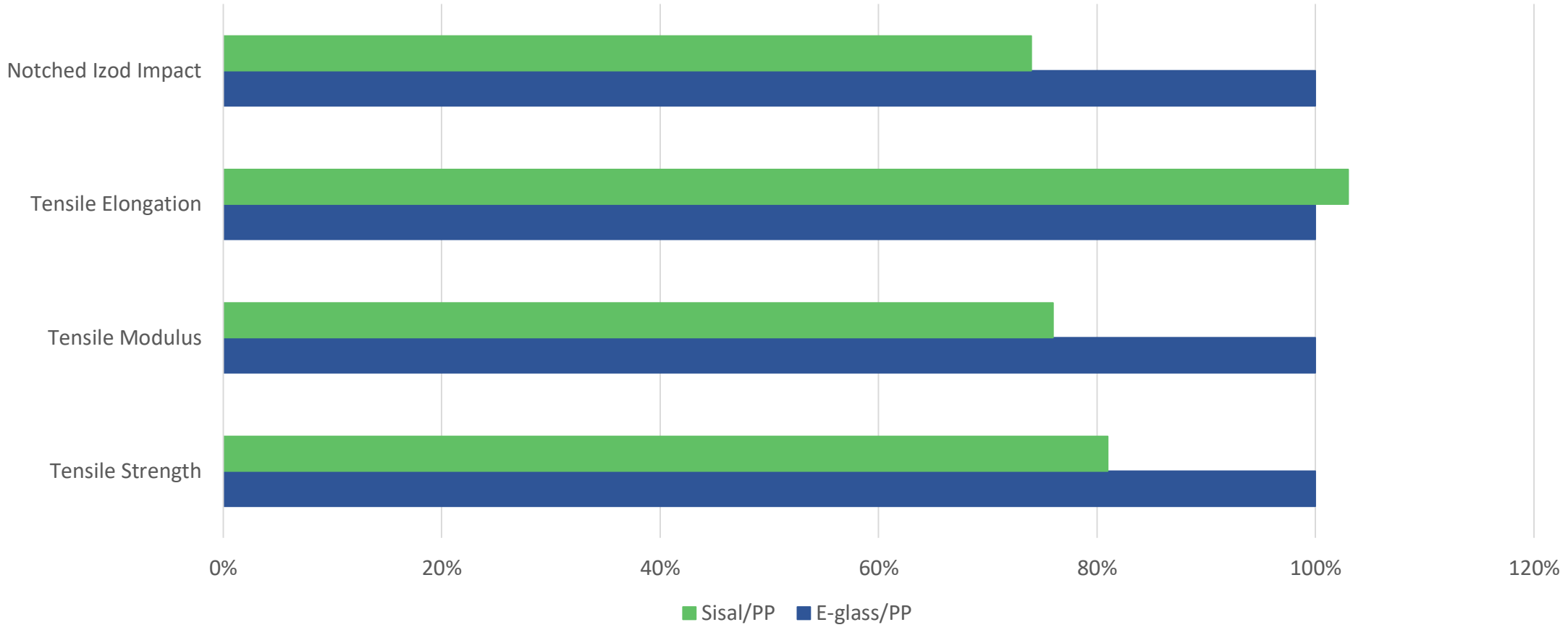


Equal number of fibers

- Glass fiber 2.6 SG
- Jute fiber 1.4 SG

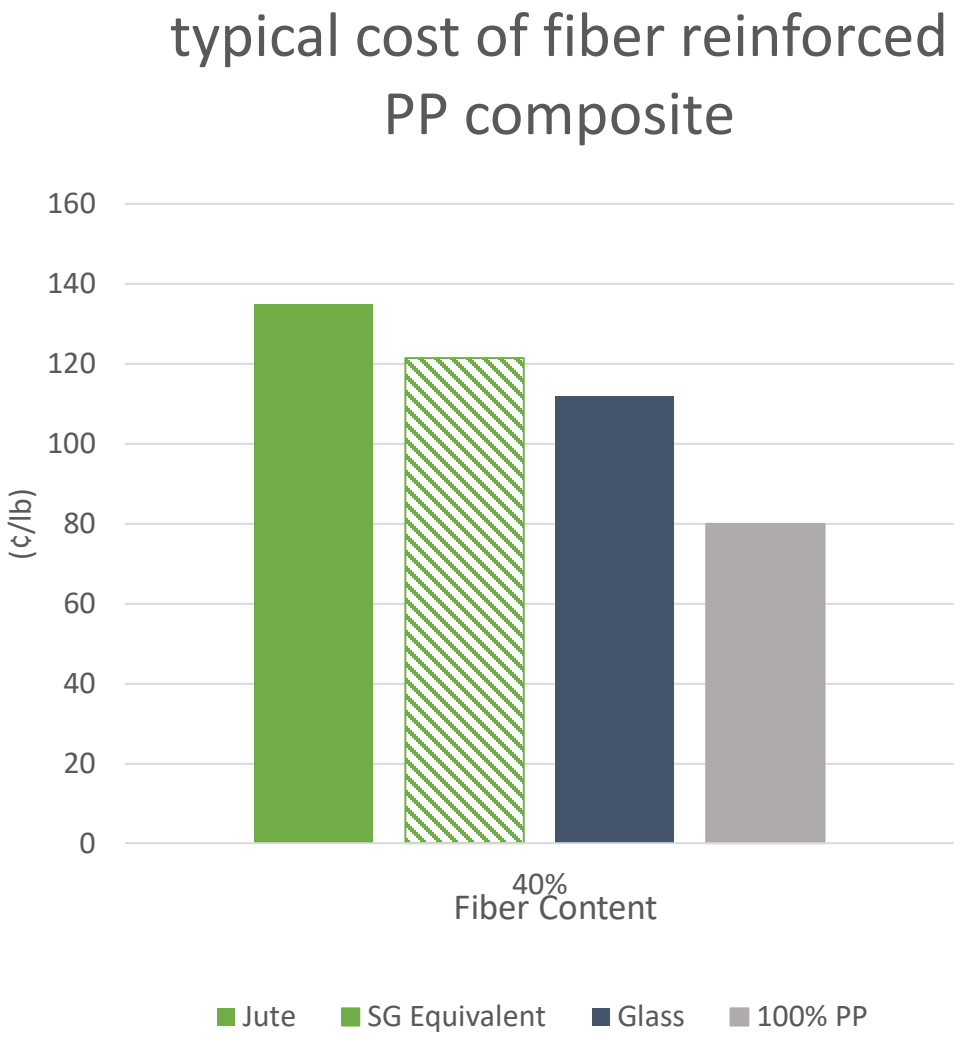
Advantage of Lighter Fibers: Less is More

Property Comparison of 20% Glass Filled PP vs. 20% Sisal Filled PP



Data collected from tests performed in Green Dot Laboratory

Comparative Cost



Product Examples

Biocomposite Product Examples

Green Dot Bioplastic NFRP biocomposites

Terratek® CC200500

Corn Cob Composite using Braskem Green PE

Product Description

Terratek® CC200500 is a proprietary blend of corn cob and biobased polyethylene for injection molding applications. CC200500 contains 15% corn cob fiber and with Braskem GreenPE this formulation is fully biobased.

Property	Test Methold	Value
Specific Gravity	ASTM D792	1.04 g/cm3
Shrinkage		0.013 mm/mm
Melt Index(190C 2.16kg)	ASTM D1238	6.7 g/10 min
Tensile Strength	ASTM D638	21 MPa
Tensile Modulus	ASTM D638	1.7 MPa
Flex Strength	ASTM D790	40 MPa
Flex Modulus	ASTM D790	1540 MPa
Elongation		5.23 %
Notched Izod	ASTM D256	28.4 J/m

100% plant base

John Deere EcoRigs® made with corncob fiber & I'm Green® PE

Biocomposite Product Examples

Green Dot Bioplastic NFRP biocomposites

Terratek® **SC200500**

Product Description

Terratek® SC200500

Terratek® SC200500 is a proprietary blend of biofillers and polypropylene for injection molding applications.

Property	Test Methold	Value
Specific Gravity	ASTM D792	1.05 g/cm3
Shrinkage		0.014 mm/mm
Melt Index (190C 2.16kg)	ASTM D1238	17.5 g/10 min
Tensile Strength	ASTM D638	22.256 MPa
Tensile Modulus	ASTM D638	1940 MPa
Flex Strength	ASTM D790	47.629 MPa
Flex Modulus	ASTM D790	1760 MPa
Elongation		4.07 %
Notched Izod	ASTM D256	19.6 J/m

lightweight natural (animal based) fiber with agricultural waste filler in PP for strength and toughness

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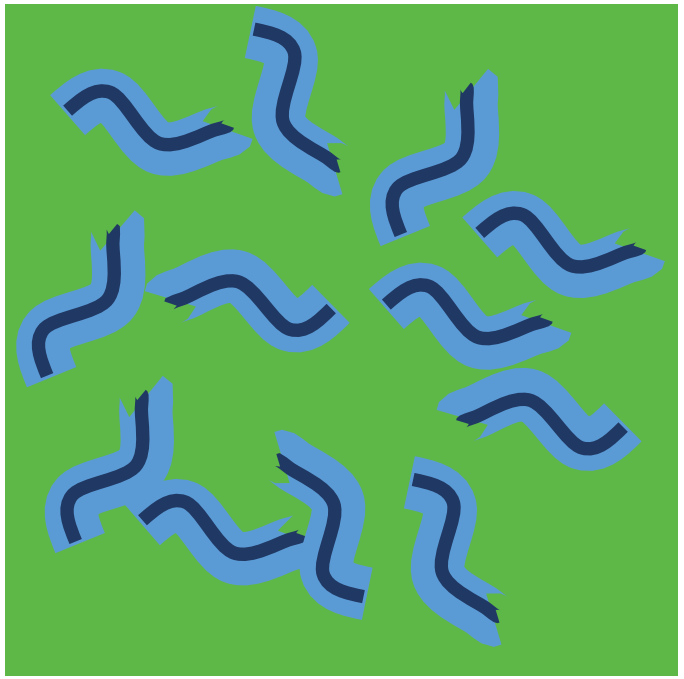
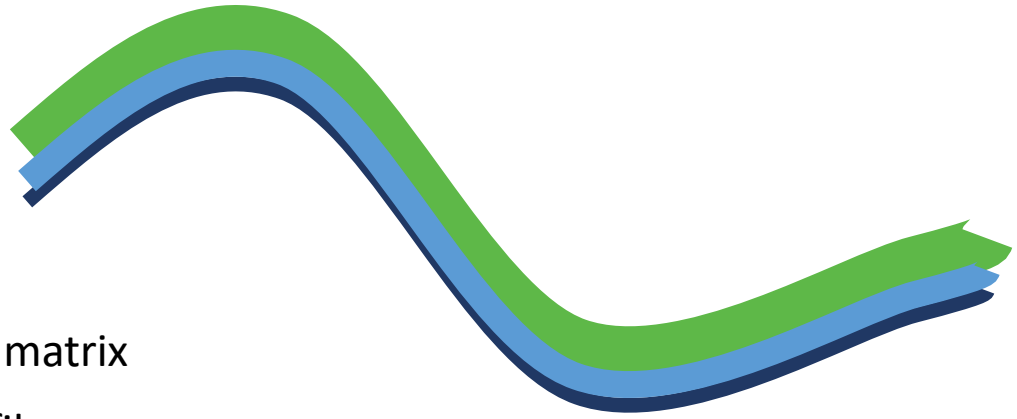
Biocomposite Textiles

3D Composite Shape
(injection molded or extruded part)



2D Composite Shape
(textile-like structure)



Polymer matrix

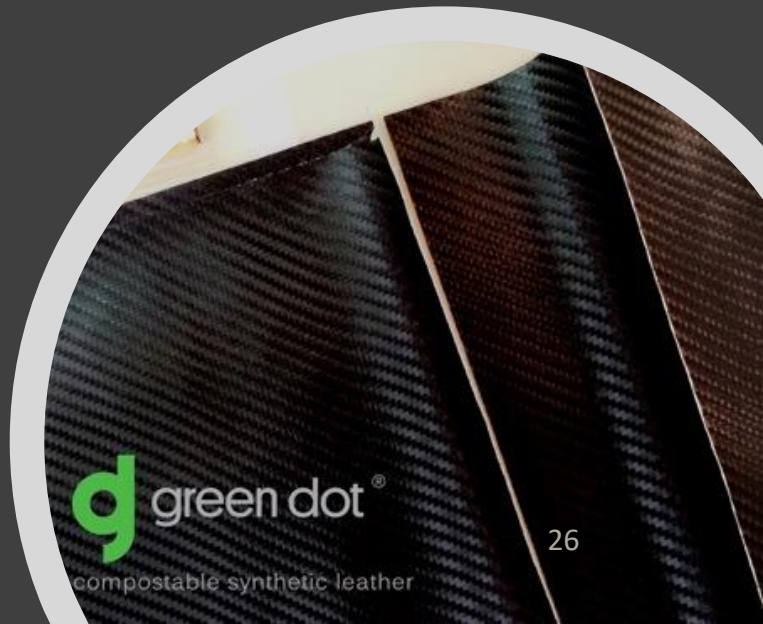
Natural fiber

Surface treatment or
Bonding agent

Plant based composites can be either monolithic structures or laminates. Both can consist of plant based and/or biodegradable components

Plant Based Synthetic Leather

- Cleaner manufacturing process. No solvents. No air or water discharge.
- High renewable content
- Can be 100% biodegradable



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