



# Circular Economy Workshop

Towards Mitigating Climate Change

Guelph · Canada  
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# Circular Economy: A Path Towards Innovating Plastics & Biobased Materials – Need for Disruptive R&D!

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CHANGING LIVES  
IMPROVING LIFE

Plant  Agriculture

University of Guelph  
 **BDDC**  
Bioproducts Discovery  
& Development Centre



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ENGINEERING

Bioproducts Discovery & Development Centre, University of Guelph, Canada

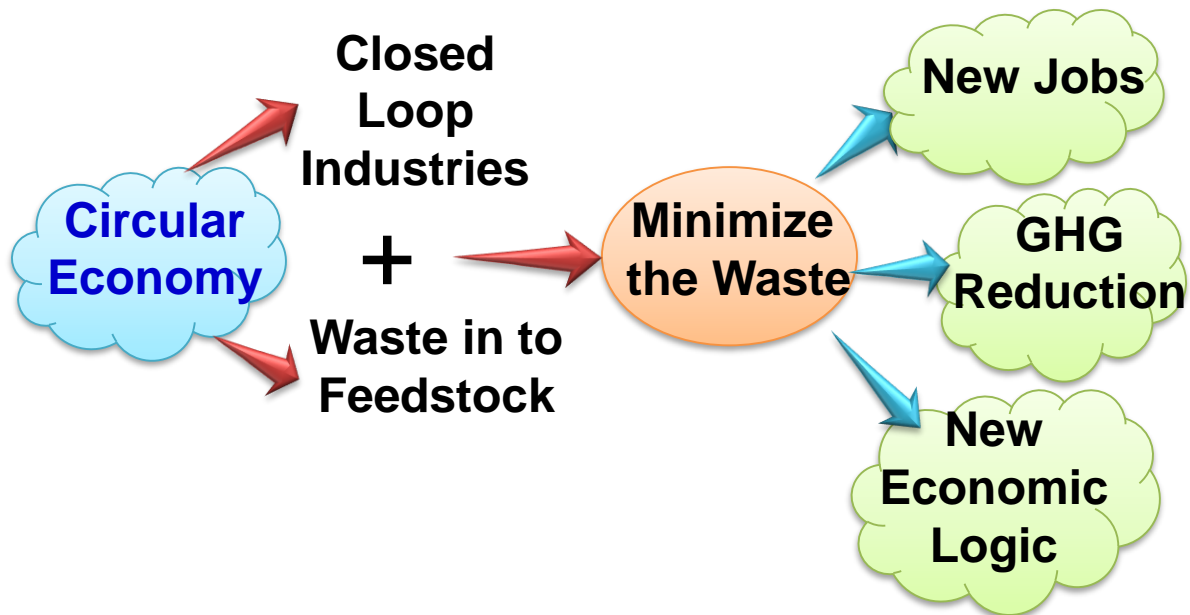
# Key points: What I will be presenting?

- **Circular Economy? “Waste-free” World – Linear model vs. Closed-loop System**
- **Research & Innovation to supplement “Circular Economy” – Focus on Bioproducts**
  - (I) **Compostable Packaging**
  - (II) **Durable Auto-parts**
  - (III) **Consumer Products**
- **Innovation? Taking Discovery Research for real world uses**
- **International move? Where we stand?**
- **Concluding thoughts**

# The Circular Economy ? – “A New Relationship with our goods and materials”



Key principles of a ‘waste-free’ world: **reuse, repair, remanufacture and upgrading.**



Walter R. Stahel, *Nature* 531, 443–446 (24 March 2016)

# The Circular Economy vs. Linear Economy

- Flow of Linear vs. Circular economy
- **Linear model**- “produce-use-and dispose”: not profitable, harmful to environment & unsustainable
- “Close loop system” money return back: innovation driven
- Collides – Solo structures of Industries, Academics & Govt.
- Knowledge Dispersion: Big Industry & SMEs

*A shift to a circular economy – A low carbon Economy*

Results ↓ Each Nation's

- ❖ GHG emission reduction: By up to 70%
- ❖ Workforce growth: ~4%

*(Study of Seven European Nations)*

[go.nature.com/biecsc](http://go.nature.com/biecsc) & Walter R. Stahel, *Nature* **531**, 443–446 (24 March 2016)

# Specific Waste Treatment – Current Scenario

Global Plastics Production in 2014: 311 million metric tons



Landfill

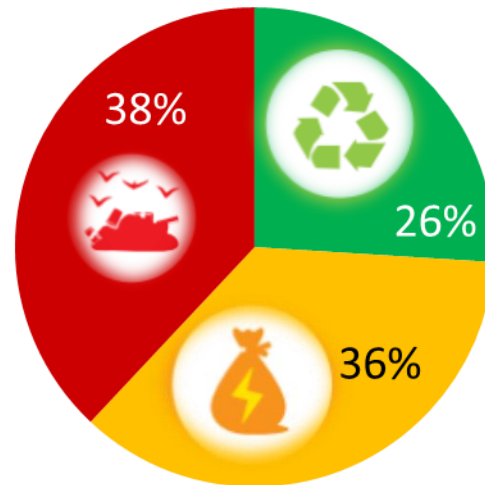


Recycling

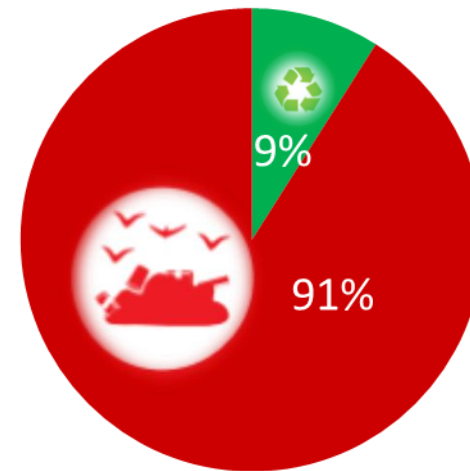


Energy Recovery

Europe



United States



Total Plastic in Waste Stream



27.7 million tons  
(2012 Stats)

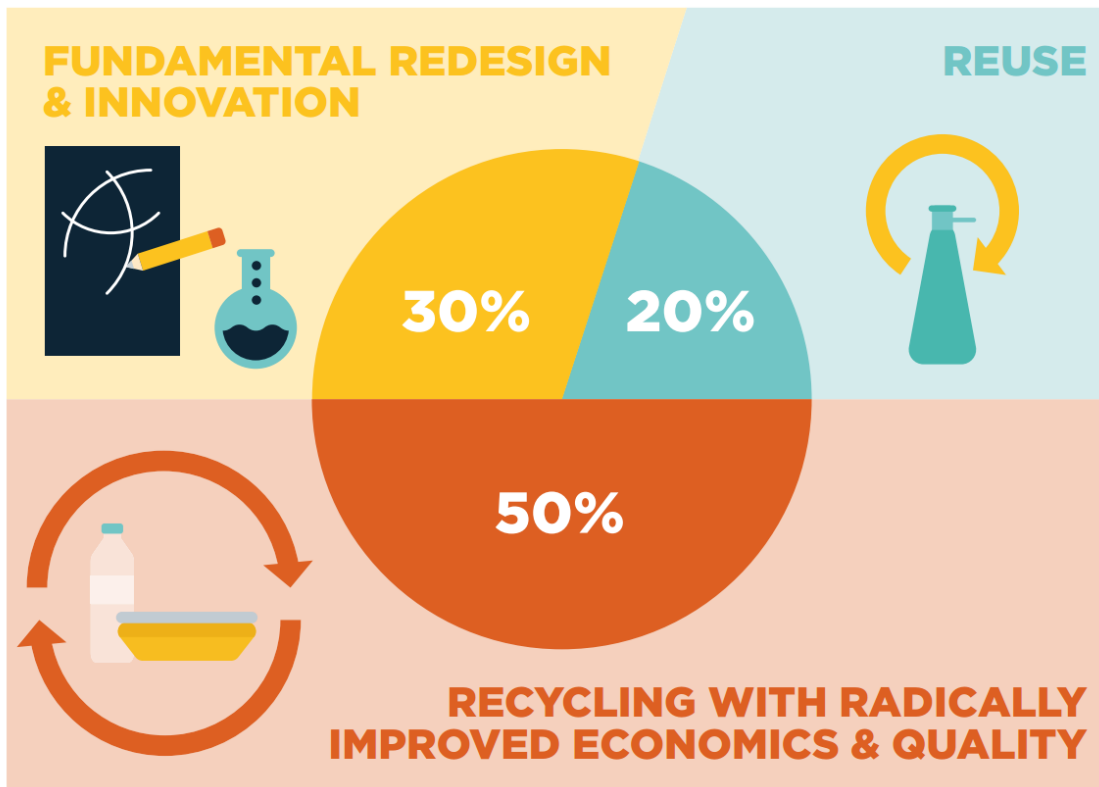
33 million tons  
(2013 stats)

In 2013, US disposed more than **35 million tons of FOOD WASTE in LANDFILL**  
Once in landfills, food breaks down to produce methane, a potent GHG contributing to climate change

1. <http://www.statista.com/statistics/282732/global-production-of-plastics-since-1950/>
2. [http://www.plasticseurope.org/documents/document/20150227150049-final\\_plastics\\_the\\_facts\\_2014\\_2015\\_260215.pdf](http://www.plasticseurope.org/documents/document/20150227150049-final_plastics_the_facts_2014_2015_260215.pdf)
3. [http://www3.epa.gov/epawaste/wastes\\_archive/plastics.htm](http://www3.epa.gov/epawaste/wastes_archive/plastics.htm)
4. <http://www.epa.gov/recycle/reducing-wasted-food-home>

# New Plastic Economy: Innovation through Circular Economy Principles: Focus on Packaging

- ❑ Packaging sector we lose/year: \$80-120 billion to economy
- ❑ By 2050: Oceans would have more plastic than fish (by weight)
- ❑ Since > 40 years – 1st Recycling Symbol in market place
- ❑ Now: ~14% packaging plastics: Collected for recycling



## A three-step fundamental approach:

- ❖ Redesign & Innovation
- ❖ Reuse
- ❖ Recycling: Improved Economics & Quality

Ref.: World Economic Forum and Ellen MacArthur Foundation, *The New Plastics Economy – Catalysing action* (2017, <http://www.ellenmacarthurfoundation.org/publications>).

# Plastic Packaging- Needs major R&D – Fundamental Redesign & Innovation

EXAMPLES	SHARE OF PLASTIC PACKAGING MARKET % BY WEIGHT	PRIORITY SOLUTIONS
<b>SMALL-FORMAT</b> Lids, tear-offs, caps, sachets and generally all items smaller than 40 - 70mm	~10%	<b>REDESIGN</b> packaging formats and/or delivery models (and after-use systems)
<b>MULTI-MATERIAL</b> Packaging with inseparable layers of different materials	~13%	<b>INNOVATE</b> in materials and reprocessing technologies
<b>UNCOMMON MATERIALS</b> Uncommon plastic packaging materials like PVC, EPS, PS	~10%	Actively explore to <b>REPLACE</b> as a priority PVC, EPS, PS by known alternatives
<b>NUTRIENT-CONTAMINATED</b> Coffee capsules, organic waste bags, takeaway food packaging	NOT QUANTIFIED	<b>SCALE UP</b> compostable plastics for targeted applications to help recover nutrients of packaging contents

- ❑ **Multimaterial: O<sub>2</sub> & H<sub>2</sub>O Barrier:** Many of such-  
**Economically / Even Technically: Non-recyclable: Compostable alternative!**
- ❑ **Scale-up: Compostable packaging & associated infrastructure: Nutrient contaminated uses**

~330 billion single-use plastic carrier bags/year – In each second; over 10,000 bags – Mostly leaks into the eco-system

**FUNDAMENTAL REDESIGN AND INNOVATION is needed for >50% of plastic packaging (by no. of items), or >30% of plastic packaging (by weight)\***

**With-out which: Will never be recycled nor reused**

**Leakage to eco-system: negative externalities, GHG emissions etc. – loss of ~\$40 billion (Ref. UNEP)**

Ref.: World Economic Forum and Ellen MacArthur Foundation, *The New Plastics Economy – Catalysing action* (2017, <http://www.ellenmacarthurfoundation.org/publications>).

# Undervalued Co-products To Value-addition



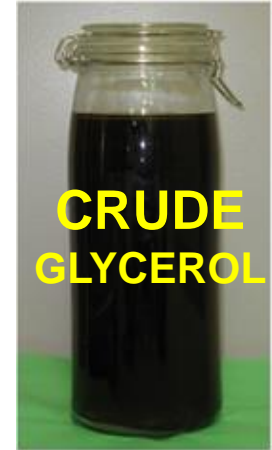
**Cellulosic Ethanol  
Industries**



**Pulp and Paper  
Industries**



**Corn Ethanol  
Industries**



**Biodiesel  
Industries**



**Coffee  
Industries**



**Tomato Sauce  
Industries**



**Wineries**

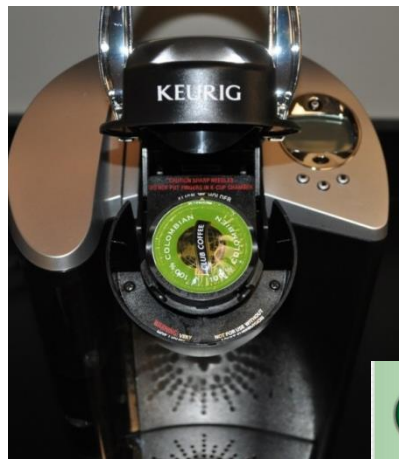
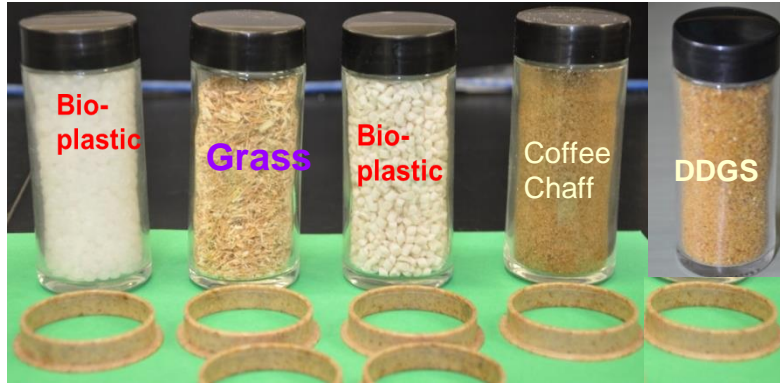


**Pyrolysis  
Industries**



# Circular Bioeconomy – Closing the Loop

► Single-serve coffee : Continues to Grow!  
\$5 billion US & Canada - 2014 sales



## COLLABORATION

BDDC, U of G; Club Coffee LP;  
CGTech; Fourmark Manufacturing

# Value-added uses: food and food production wastes: In new compostable Products

## Spent coffee grounds



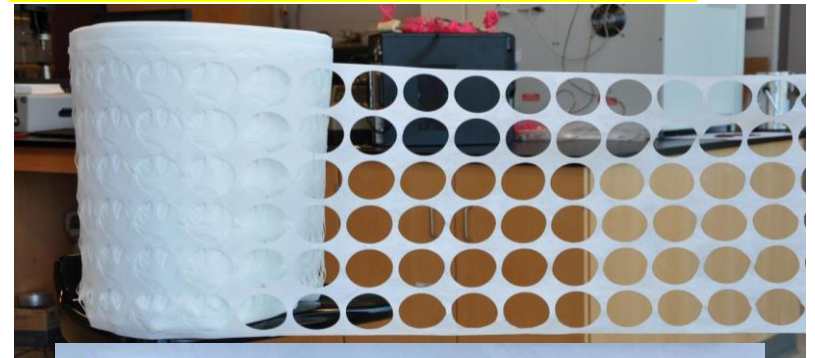
## Spent tea powder



## Waste tomato skin

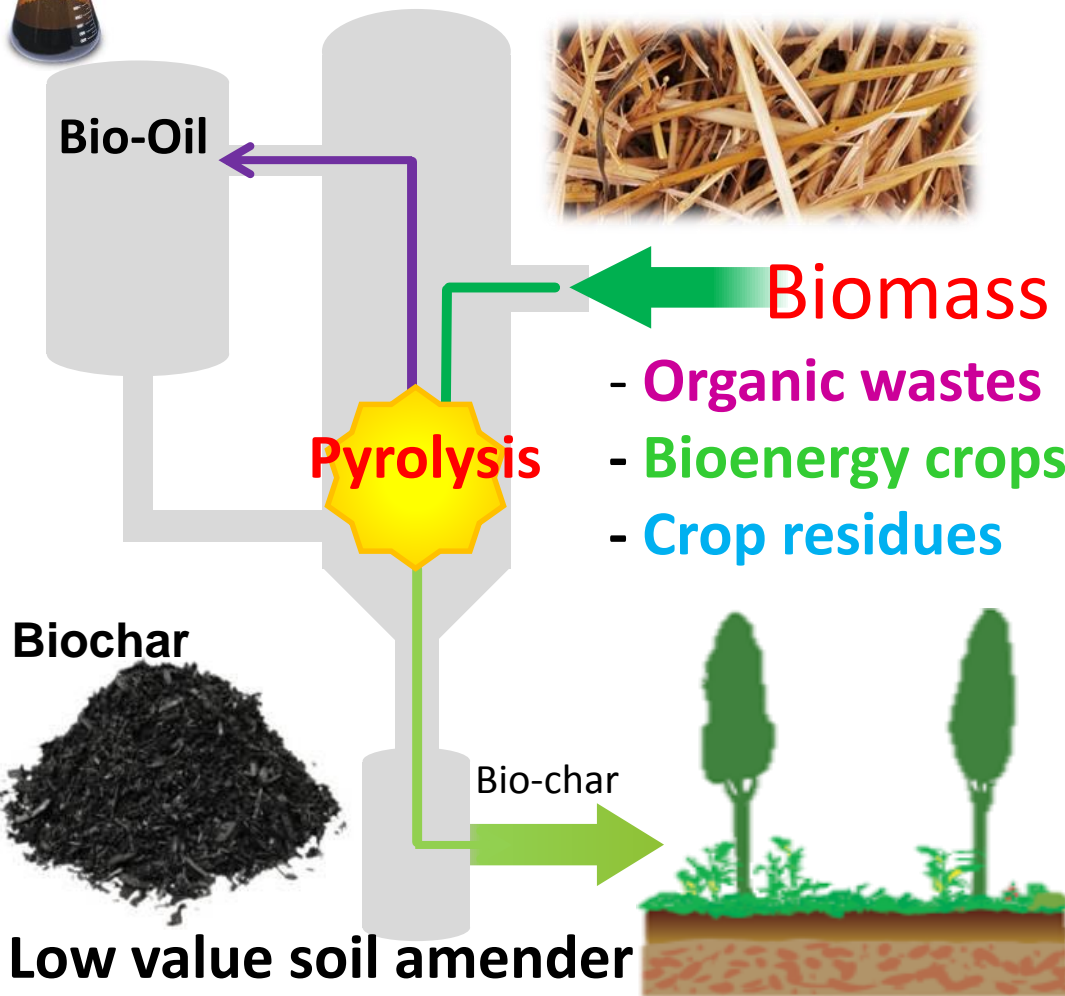


## Post-Industrial PLA cloth



Heinz Company alone: 2 million tons tomato yr.: 200,000 ton pomace = 200 million kilogram

# Pyrolyzed Biomass: Biochar Thermo-chemical Conversion



**Biochar?** “A solid material obtained from thermochemical conversion of biomass in an oxygen-limited environment” [IBI]

Bio-char Price: ~ 30 ¢/lb.

Bio-char Yield		
	Slow	Fast
Bio-char	35%	12%
Bio-oil	30%	75%

Bio-energy in the black, Johannes Lehmann

<http://www.biobasedeconomy.nl/wp-content/uploads/2012/07/Bio-Based-Industries-PPP-Vision-doc.pdf> <http://www.clariant.com> <http://www.dynamotive.com/fuels/>

# Application Areas: Biocarbon (also from food wastes): Products in the Marketplace or Under development

Automotive interior parts, Compostable Mulch Films, [Consumer products](#)



Headlamp Liner

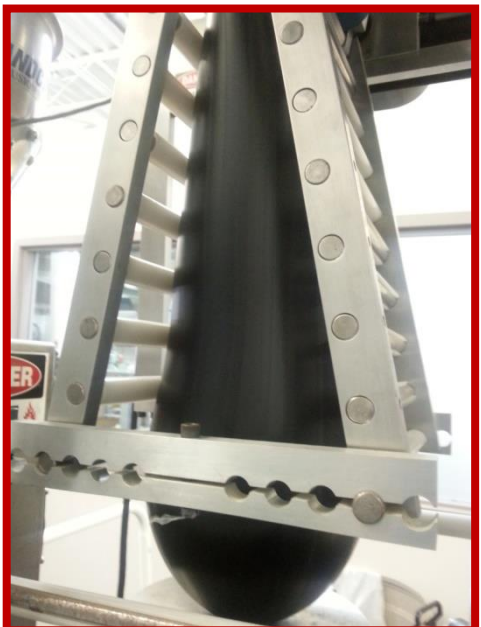


Console box

GM / Protoplast - Oil collection tray – Corvette



**USDA Certification for Bio-carbon:**  
99% new carbon – world's first substitute for carbon black – lighter and price-performance-process competitive



Compostable Mulch Film



Spare tire cover

BIOLBLACKR™



Air duct controller



Coca Cola bottle packaging tray



Fender cover

# Diverting “Tire waste” in Ontario = More Products = More Research & Innovation



Playgrounds



Mulch for gardens



Sidewalks



Running paths



Rooftops



Fine chemicals

Ontario: 12 million of tires sold each year

Ontario: 10 mil. scrap tyres each year. - “waste”

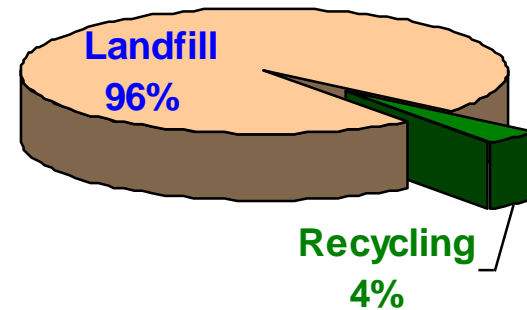
Source: <http://www.catraonline.ca/national-data>



Photo Courtesy: <http://rethinktires.ca/wp-content/uploads/Collector-Poster-Colour.pdf>

Ontario needs  
Research & Innovation-  
New Value-added  
Materials for Industrial Uses

# Carpet Wastes are Huge: Ontario Needs Research & Innovation



- **Carpet wastes-6.5 billion lbs. in landfills: North America**
- **230 to 260 million kg carpet wastes: landfills in Canada**
- **Canada: Govt. needs strategies in diverting “Waste Carpet” from landfills**
- **Ontario Needs: Research & Innovation – Using this valuable resource – New Materials**

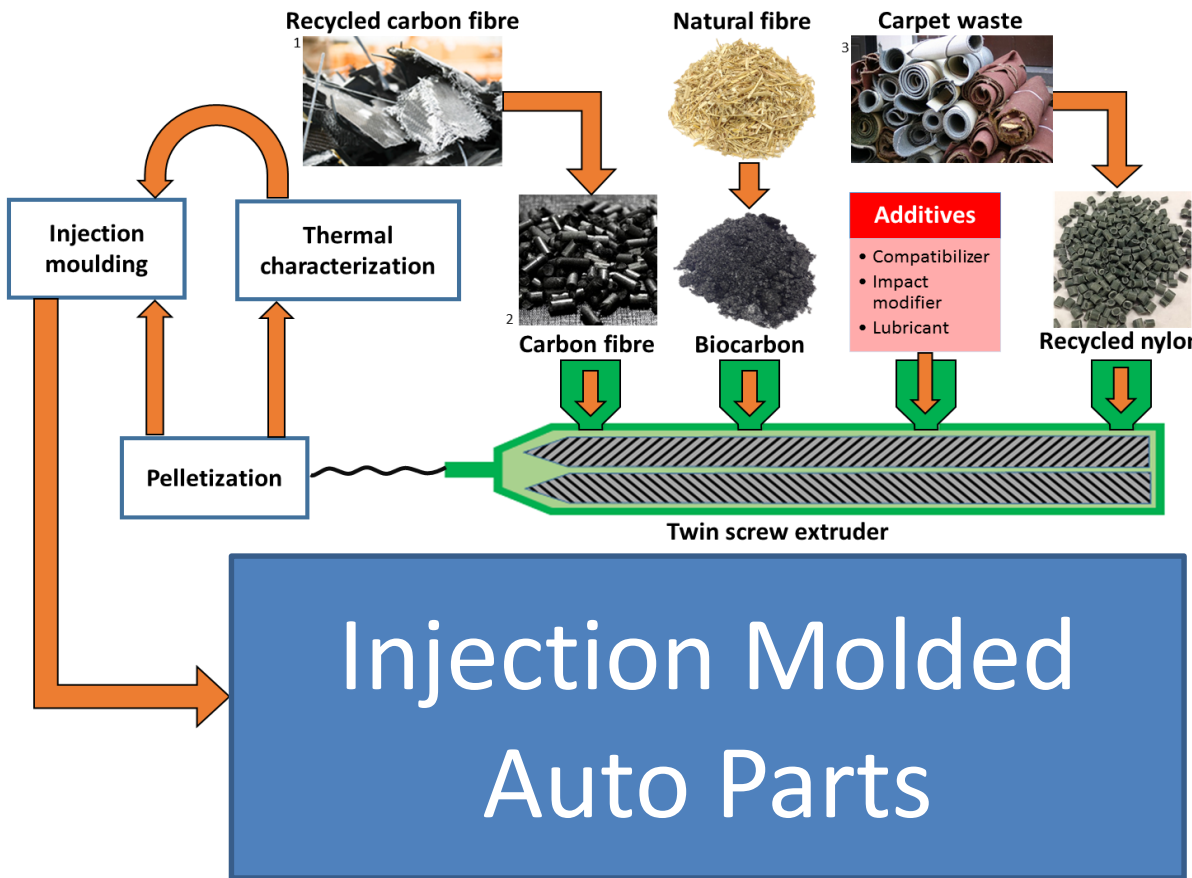
# Circular Economy: New Materials from Wastes

**Value-added Uses of “Waste Carpet”:** Engineering  
Plastics **Source:** Auto-parts Uses

On going Project – U of G/OMAFRA – Bioeconomy  
for Industrial Uses

## COLLABORATION

Ford Motor Company  
Viking Recycling  
CGTech, ON  
Ontario Inc.



## Impact on Climate Change (Preliminary Study)\*:

- Sustainable fillers + Engineering plastic based **biocomposites** to replace synthetic glass fiber-reinforced composites
- significantly lighter (~15%) : GHG reduction emissions
- The reduction of GHG emission is estimated at ~3.952 kg of CO2 per kg of virgin material counterpart.

# “Circular Economy” – International Scenario

- **China, South Korea, USA – Research Programmes: Boost of Reuse & Remanufacturing**
- **Swedish Foundation for Strategic Environmental Research & EU Horizon 2020 Programme: 1<sup>st</sup> Call on “Circular Economy” proposal in 2014**
- **2015 December: “Circular Economy” package submission by European Commission to the Parliament**
- ***Ellen MacArthur Foundation* (Founded by : Round-the world Yachtswoman) Boosting Awareness**

*Walter R. Stahel, Nature* **531**, 443–446 (24 March 2016)



# Few Key Messages: Concluding Thoughts

- Nothing is called “waste”
- “Circular Economy”: Trillion dollar opportunities
- Need: Resource productivity: Factor of five
- Govt. Call for Projects - Focus: “Circular Economy”
- **Collaboration**: Academia, Industries & Govt. –  
**Disruptive technology & business models**
- Regional “Circular Economy” – Translate to Global
- **SMEs** would play vital role in “**Circular Economy**”
- **Circular Economy**: GHG emission reduction –  
Inevitable, achievable & profitable



**Bioproducts Discovery &  
Development Centre (BDDC)**

**Many Thanks for Listening!**

**Bioproducts Discovery & Development Centre, University of Guelph, Canada**