The Evolving Role of Flexible Packaging in the Circular Economy

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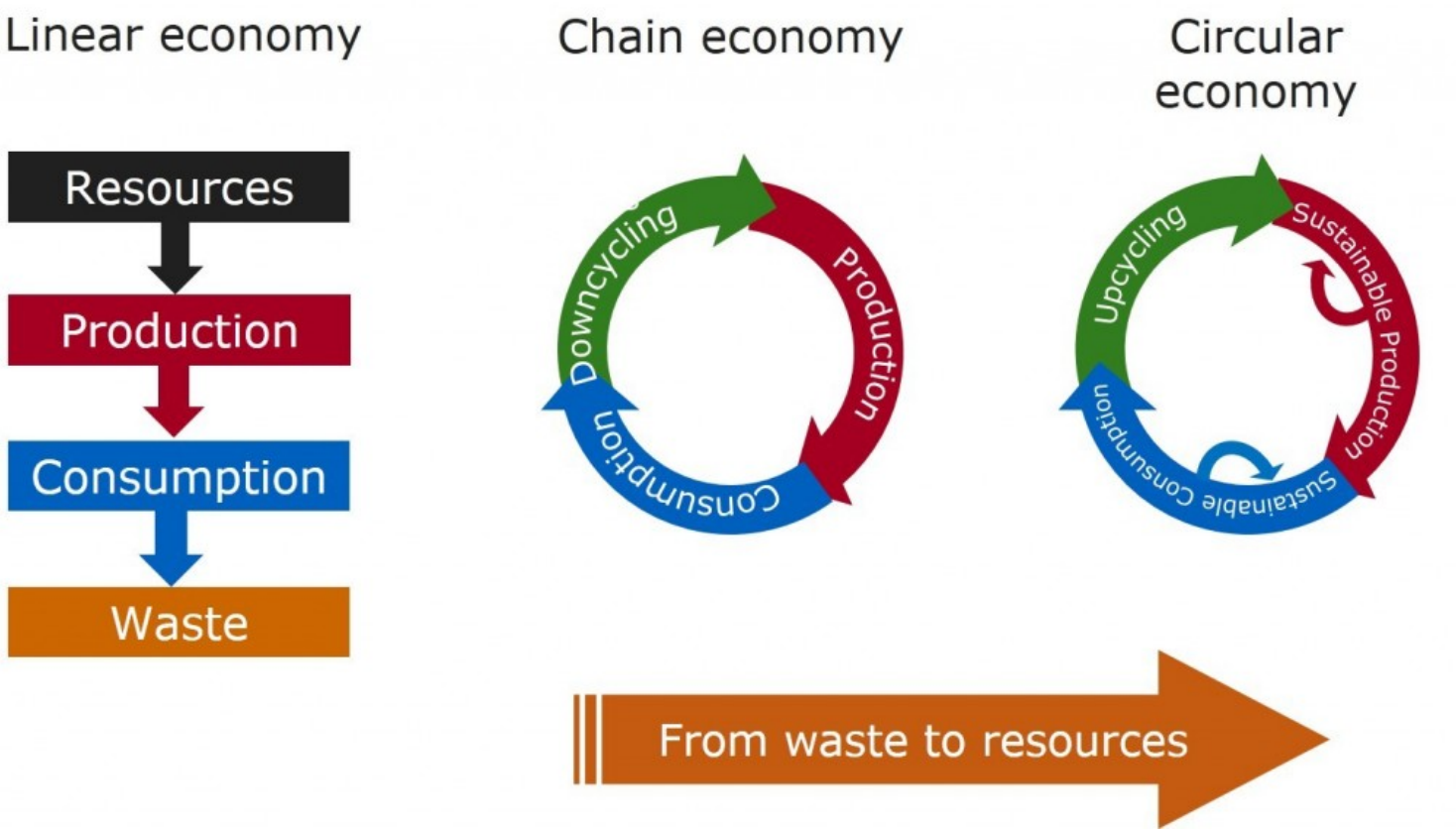
Background: Economic Models



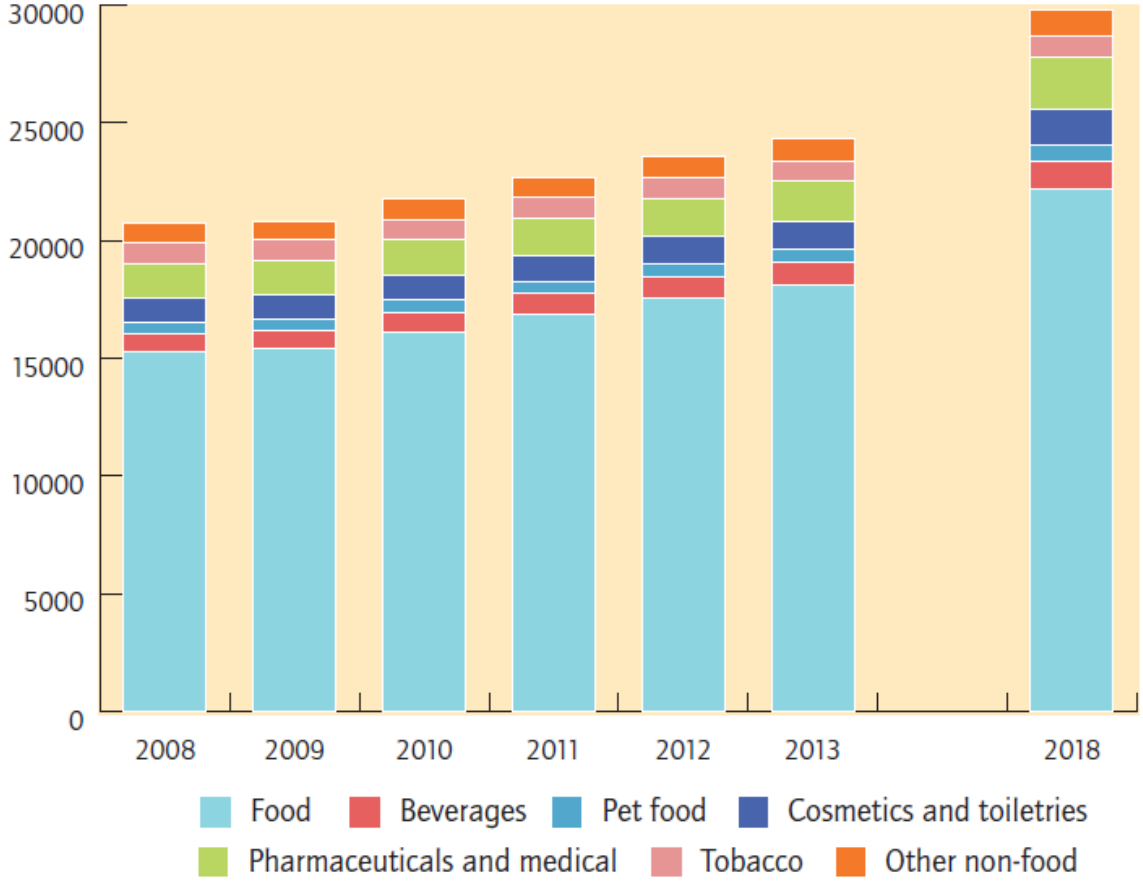
Linear economic model is unsupportable:

- Generalizing the life cycles of developed countries would require resources of 2 or 3 planet Earths
  - In 35 years, volume of resources extracted has increased by 65%
- Strategic commodities (Au, Ag, In, Ir, W, etc.) are becoming scarcer
- Growth of harmful emissions (including CO2)

Ref: http://www.circular-europe-network.eu/wp-content/uploads/2015/07/Linear_Eco-1024x588.jpg

Background: the Flexible Packaging Market

Global forecast: consumer flexible packaging consumption by end use 2008 – 2018 ('000 tons)



Environmental Advantages of Flexible Packaging

Environmental advantages of flexible packaging

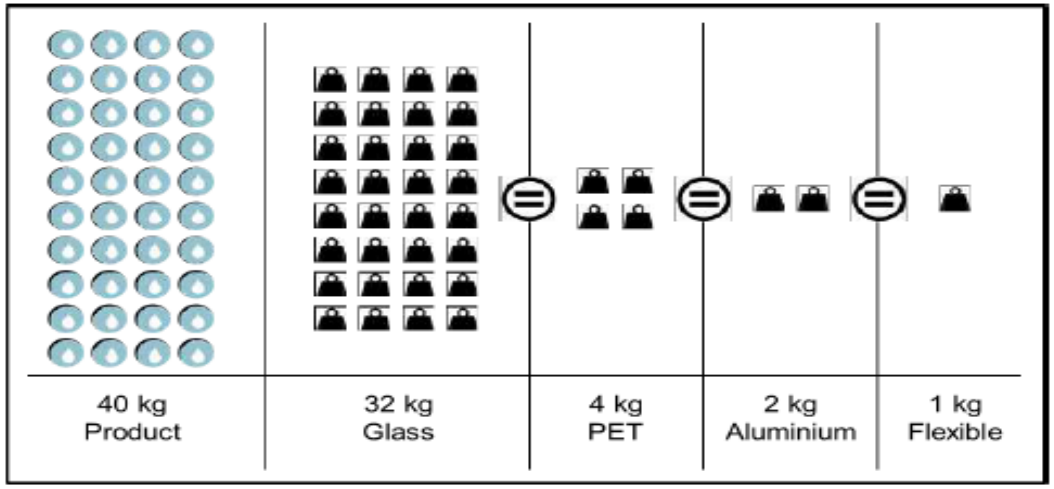
- Shelf life extension, product protection, food waste reduction
- Raw material utilization (light weighting)
  - High packaging to product ratio

	Packaging	Packaging to Product Ratio
Butter (Büsser, 2009) Block of 250 grams	Wrapper: Aluminium foil/ synthetic wax/ paper	1:17
Coffee (FPA, 2013)	Flexible "brick pack"	1:29
Beverage (FPA, 2013)	Aluminium foil laminated plastic pouch	1:35
Rotisserie Chicken(FPA, 2013)	Plastic pouch	1:76
Soup (FPA, 2013)	Plastic pouch, large size for food service	1:108

Packaging type	Folding carton with inner plastic bag	Round paperboard canister with Plastic Lid	Stand-up flexible pouch
Packaging Weight (g)	22.68	39.69	11.34
Product Weight (g)	340	680	680
Packaging to Product Ratio	1:15	1:17	1:60

Environmental Advantages of Flexible Packaging

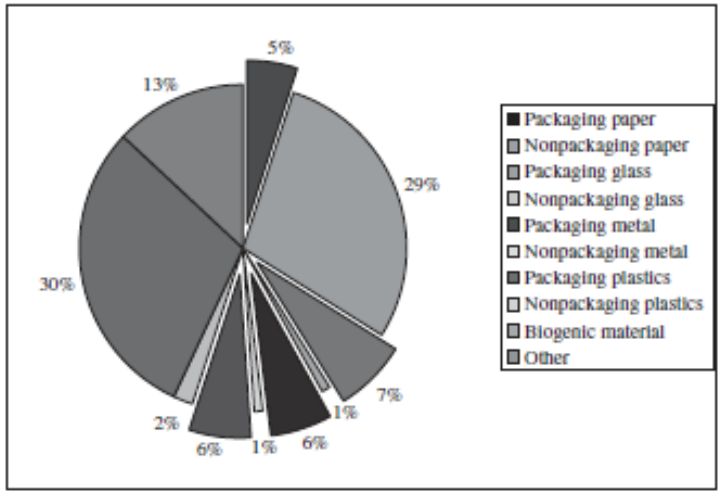
- Transportation savings (reduced transport weight)



Perceived Environmental Impact of Packaging Waste

Municipal solid waste (MSW) consists of items commonly discarded, including:

- food scraps
- yard trimmings
- durable items such as refrigerators and computers
- Packages
  - Legislative and regulatory efforts to control packaging are based on the mistaken perception that packaging is the largest component of MSW.
  - Environmental Protection Agency (EPA, 2006) found that only approximately 31% of the MSW generated in 2005 was from packaging-related materials; this percentage has remained relatively constant since the 1990s despite an increase in the total amount of MSW.
    - Non-packaging sources such as newsprint, telephone books, and office communications generate more than twice as much MSW
- Contribution of packaging to household waste



Reducing Packaging Waste is a Global Issue

More than 70% of the total plastic ever produced is now in waste streams, sent largely to landfill - although much of it just litters the wider environment, including the ocean

Increasingly, environmental consciousness related to packaging is increasing:

litter, water pollution, air pollution, solid waste

Leads to packaging restrictions (bag bans or bag fees)

examples:

- North America:
  - US: California, Hawaii, North Carolina, Michigan
    - >200 counties and municipalities
  - Canada: Alberta, Manitoba, Quebec
  - Mexico
- Europe:
  - Denmark, UK, Switzerland
  - EU (more restrictions in France, Germany, Italy, Netherlands, Romania)
- South America: Argentina, Colombia, Brazil, Chile
- Africa: Botswana, Eritrea, Ethiopia, Kenya, Mauritania, Morocco, Nigeria, Rwanda, South Africa, Tanzania, Tunisia, Uganda
- Asia: Bangladesh, China, Hong Kong, India, Indonesia, Israel, Malaysia, Myanmar, Taiwan
- Oceania: Australia, New Zealand

Bag bans/fees lead to other packaging restrictions.

examples:

- India has banned all forms of disposable plastic in its capita
- Styrofoam Bans are Sweeping Across the US
- France becomes first country to ban plastic cups and plates

Packaging and the Circular Economy

- Reduced Food Waste
- Enhanced Recyclability

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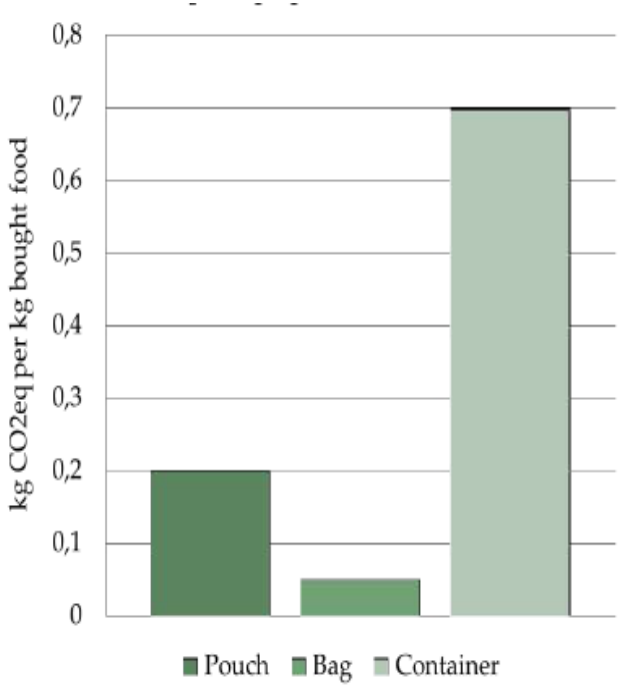
Environmental Impact of Flexible Plastic Packaging and Food Waste

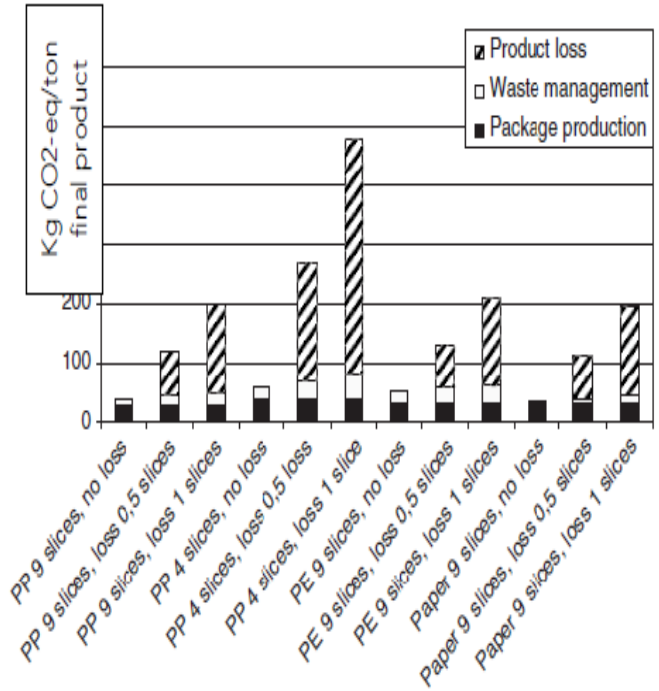
Environmental impact of flexible packaging is less than that of food waste

Global Warming Potential of Three Packaging Solutions for Rice



Rice packaging, incineration, no food

Carbon Footprint of Bread Waste versus its Packaging, and Contributions of their Waste Management (Recovery)



Waste Reduction

The Meat Example

Functional Unit:
1kg of Meat

Ex-PS tray & cling film
17g packaging
4 days shelf life

x5 shelf life

MAP
30-40g packaging
6 days shelf life

x10 lighter
x6 shelf life

VSP
13-19g packaging
21 days shelf life

x2-3~ lighter
x3 shelf life

BSB
3g packaging
35 days shelf life

denkstatt

Packaging Footprint vs. Meat Loss Footprint

What **PACKAGING** costs in
Green House Emission
*GHG emitted for packaging production to protect 1kg of meat

with MAP (0.06 CO_2eq/kg)

with VSP (0.04 CO_2eq/kg)

with BSB (0.02 CO_2eq/kg)

It can take 1000x more CO_2 eq* to produce meat than to protect it

What it takes to produce **FOOD (MEAT)** in
kg CO_2 eq/kg
*emitted for meat production to produce 100g of meat

6-35 kg CO_2 eq per kg of meat depending on region of production

100g of meat

* Between 100x and 2000x more CO_2 eq., depending on the region of production of the meat, and the packaging used.
** LCA – IPCC GSP 100 a kg CO2 eqv functional unit: 1kg of red meat

Environmental Advantages of Flexible Packaging

- Food waste prevention

From 5% waste to 0.14%

From 11% waste to 0.8%

From 42% waste to 3.4%

From 9.4% waste to 4.6%

(*Denkstatt study 2015, data collection within Austrian retailers)

Package Life Cycle Analysis – Cradle to Gate

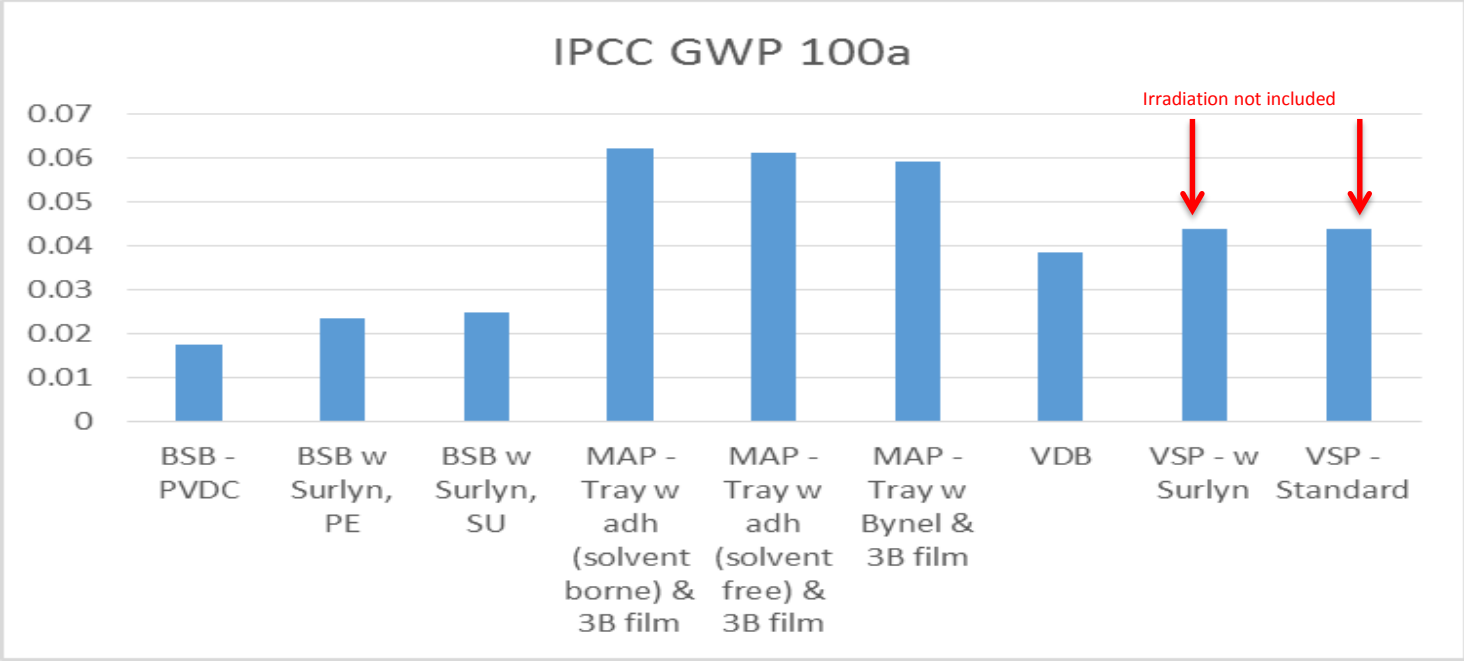
Packaging alone

Impact category (IPCC*) Global Warming Potential (GW)

100 year time horizon (100a)

kg CO_2 equivalent

Functional Unit: 1 package

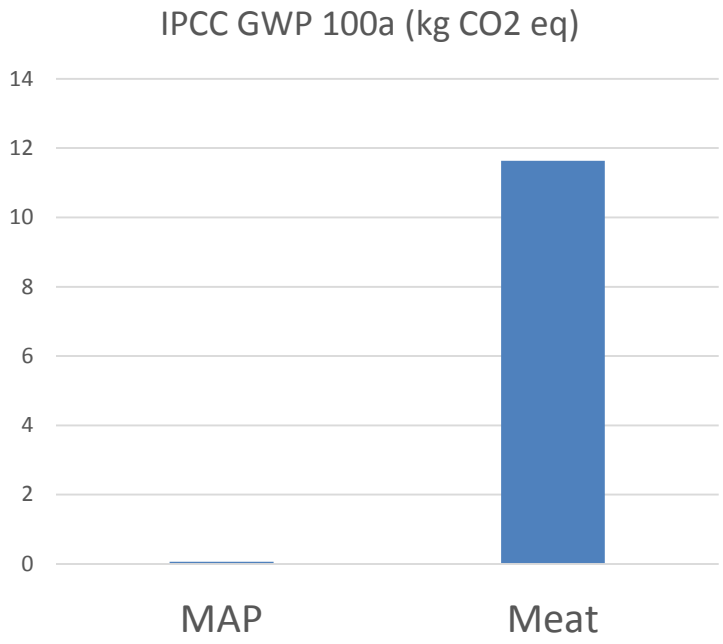


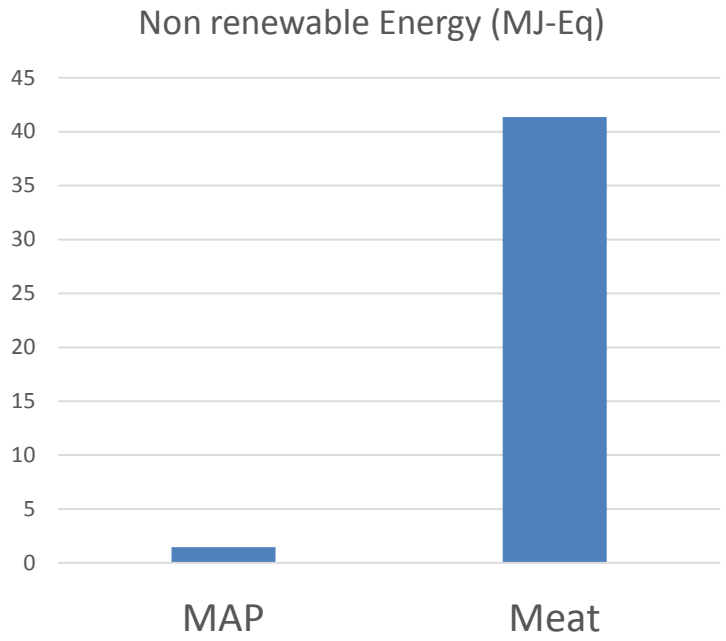
IPCC: Intergovernmental panel on climate change

Package Life cycle Analysis – Cradle to Gate

Packaging plus Food

Beef produced in US and packaged in MAP





*Meat Data Reference: Red meat, live weight
Incudes cattle and sheep, prior slaughter

Packaging and the Circular Economy

- Reduced Food Waste
- Enhanced Recyclability

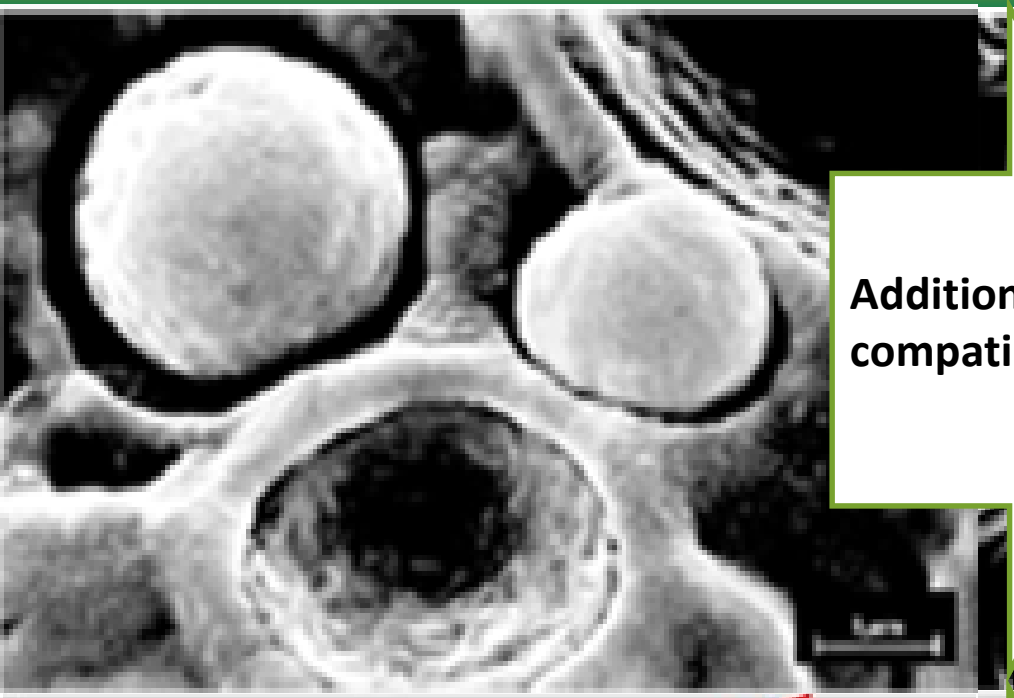
Approaches to Improving plastic packaging recycling

Successful plastic recycling depends on

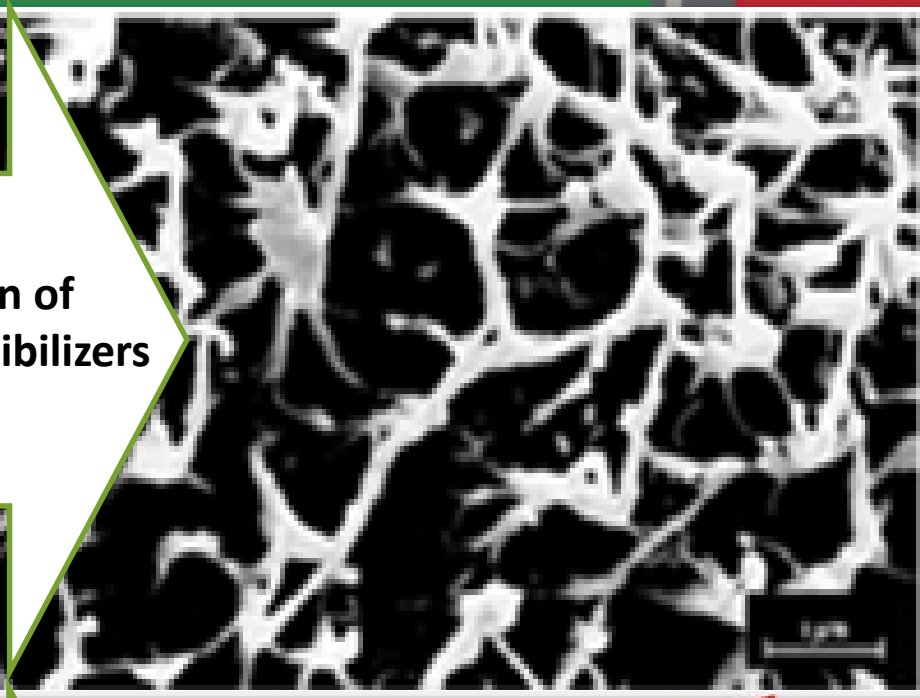
- Disposal and collection of the plastic waste
- Chemistry and consistency of the mixed polymer stream chemistry

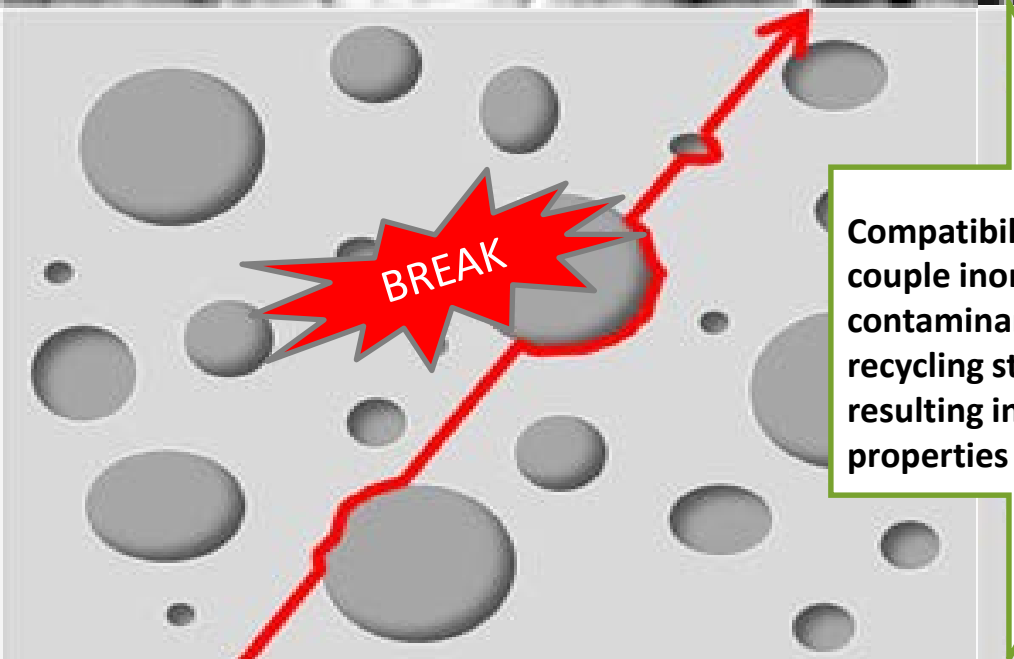
Properties of polymers from mixed-stream recycle can be enhanced by using impact modifiers

Enhancing properties of recycling stream through impact modifiers

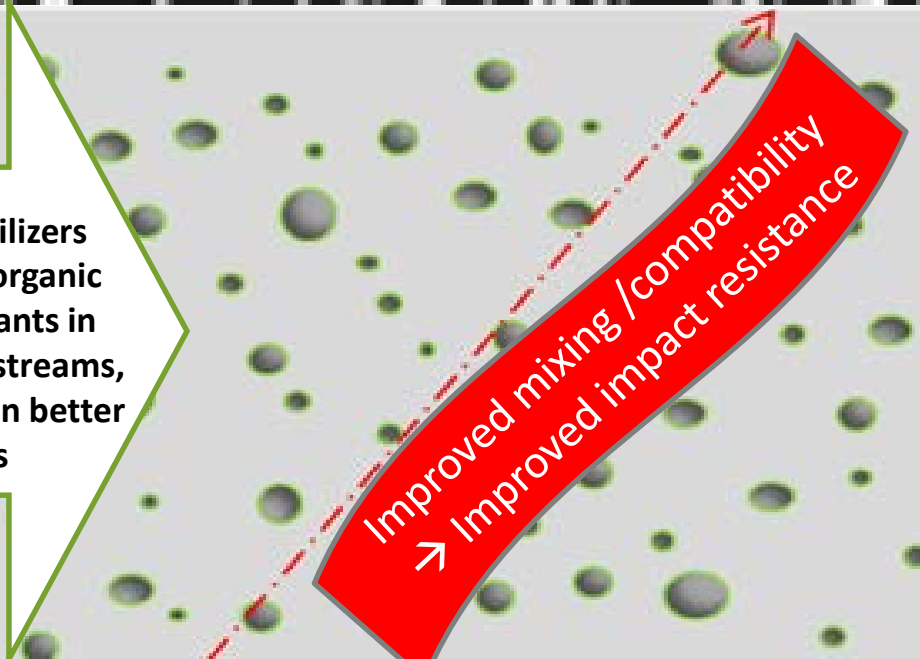


Addition of compatibilizers





Compatibilizers couple inorganic contaminants in recycling streams, resulting in better properties



Recycled Plastics Enhancers

Compatibilizers

Major Fraction \ Minor Fraction	PET	H/LDPE	PP	PVC	PS	ABS	PA	EVOH
PET		■ ■	■ ■				■	
H/LDPE	■ ■		■	■ ■	■		■	■
PP	■ ■	■			■		■	■
PVC		■ ■	■ ■					
PS		■	■			■		■
ABS		■	■		■			

■ Elvaloy® AC — Acrylic copolymer
■ Elvaloy® — Functional terpolymer
■ Fusabond® — Grafted copolymer
■ Surlyn® — Ionomer
■ Entira™ EP — Modified copolymer

Impact Modifiers

Matrix	Toughening	Examples
PET	■ ■	Elvaloy® PTW Elvaloy® AC
PP	■ ■	Elvaloy® AC Entira™ EP
PVC	■	Elvaloy® 4924
ABS	■ ■	Elvaloy® PTW Elvaloy® AC
PA	■ ■	Fusabond® N493 Surlyn® 9320
PC	■ ■	Elvaloy® PTW Elvaloy® AC

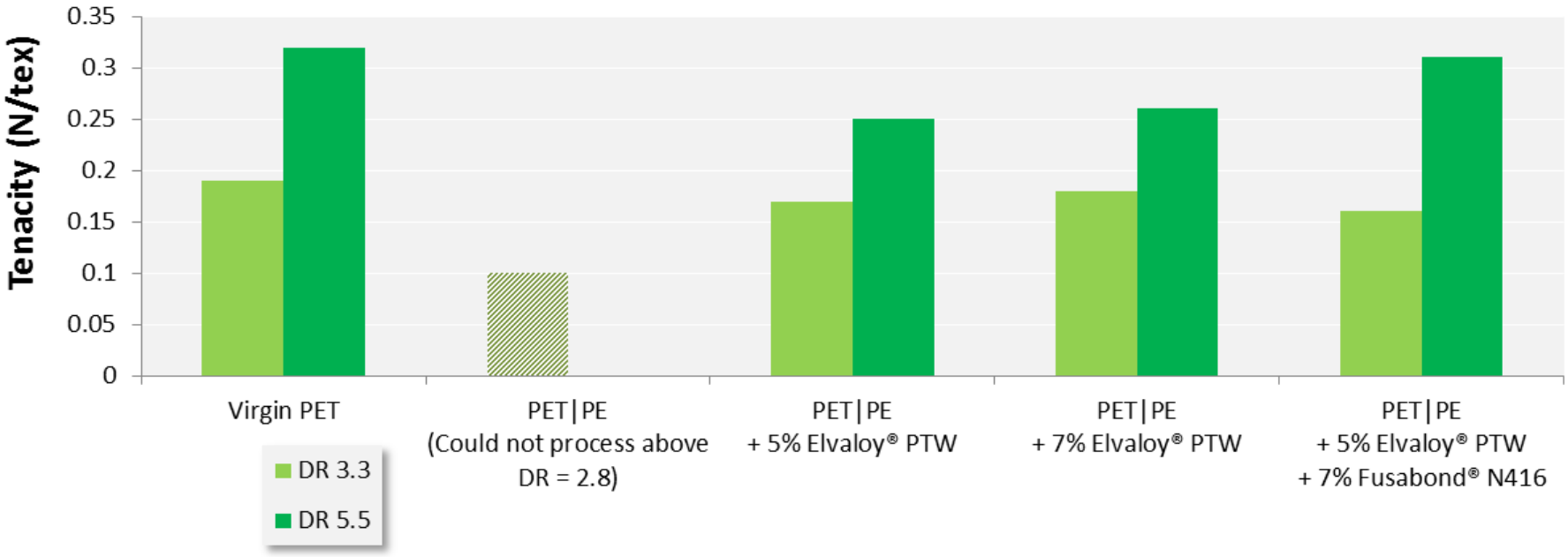
Coupling Agents

Matrix \ Filler / Filled Compound	Glass Fiber	HFFR*	WPC**
PET	■ ■		
H/LDPE	■	■	■
PP	■	■	■
PA	■		

* Halogen-Free Flame Retardant | ** Wood Plastic Composite

Example: Compatibilization of Mixed Plastics

- **PE-contaminated PET Fibers**
  - Model blend PET:PE = 92.5:7.5 wt./wt.
  - Blend compatibilized with terpolymer Elvaloy® PTW
  - Evaluation of Tenacity = f(Draw Ratio)
    - Draw ratio 3.3, 5.5



- **Without compatibilizer: no stable extrusion process**
- **With compatibilizer: increase in tenacity, in par with virgin PET**

Encouraging consumer participation

How2Recycle

began in 2008, as a project of GreenBlue's Sustainable Packaging Coalition soft launch in early 2012, now has over 50 participating companies and brands.

The How2Recycle label aims to clarify actual recyclability of packaging components to consumers

voluntary, standardized labeling system that clearly communicates recycling instructions to the public

For flexible packaging in North America, brand owners and retailers using RecycleReady Technology from Dow® from their converters can submit final package structure to the Sustainable Packaging Coalition (SPC) to qualify for the "How2Recycle" label so that the empty package can be included in grocery store dropoff programs

The Environmental Impact of Packaging Waste

Unique problems related to recycling flexible packaging:

- Low bulk density
  - reduces incentive for collectors
  - Financing for Extended Producer Responsibility targets (EPR) is based on weight
- Handling in materials recovery facilities (MRFs)
  - Sorting
  - Food contamination
- Multilayer construction

The Environmental Impact of Packaging Waste

In the US, currently:
- 34% of plastics are recycled or composted
- 11% used for energy recovery
- Remaining 55% goes to landfill

- Multiple End of Life Strategies
  - Adding Value to Recycled Plastics
    - Circular Economy
      - Resources in use for as long as possible
        - extract the maximum value from them while in use, then recover and regenerate products and materials at the end of each service life.
        - keeps materials in play through multiple cycling or by lengthening cycling duration to save on virgin material inputs
    - Cascading Value
      - "The Cascading Materials Vision is a common framework of guiding principles for industry and other stakeholders that will help businesses source secondary materials that protect their profits, the environment and future wealth of our natural resources"
      - Power of Cascaded Use transforms materials across product categories to offset the need for virgin material inputs
  - Energy Recovery
    - Plastics to oil
      - Catalytic cracking to recover hydrocarbon content of the plastic
    - Engineered fuel
      - Densified Plastics and paper, maybe with a binding agent
    - Gasification
      - Waste is pyrolyzed to produce char which reacts with steam to produce carbon monoxide and hydrogen that can be converted into methanol/alcohol and potentially into olefins and plastic
  - Design for Recyclability

DESIGNING TO RECYCLE - IMPLICATIONS

MONOMATERIAL FILMS

Specialty polymer sealant + PE or copolyester sealant + OPET

- ✓ Easy to collect within current recycling stream
- ✓ From 

  To 

- ❖ Thick film
- ❖ Low barrier
- ❖ Compromise on shelf life

SIMPLIFIED MULTILAYER FILMS

No paper
No metalization
No solution-based adhesives
No carbon black

- ✓ Replacement of solution-based adhesives with coextrudable thermoplastic tie layer materials
- ✓ Downgauging possible
- ✓ Allowing lightweighting and barriers

MULTILAYER FILMS WITH INTEGRATED COMPATIBILIZERS

Integration of compatibilizers in the multilayer structure... extra compatibilizer in order to facilitate recycling

- ✓ Optimized shelf life impact
- ✓ Optimum food waste reduction
- ✓ Optimum downgauging

Circular Economy in Practice

Example of Circular Economy – Adding Value to Recycled Material

Accomplishments and Benefits for Brazil in collaboration with Cimflex

- ✓95% recycle rate
- ✓Cut unsafe reuse
- ✓Recycled 150,000 tons of containers, 2002-2010
- ✓Make high-value products from recycled waste - pipe, conduit, containers
- ✓Saved 374,000 tons of crude
- ✓Reduced emissions - >160,000 tons of CO_2 equivalents
- ✓2,500 new jobs

A Value Chain Collaboration and Product Success

Virtuous Cycle

DuPont™ Bynel®

DuPont™ Fusabond®

DuPont™ Bynel® – Coextrusion adhesive resin to provide the best adhesion between layer

DuPont™ Fusabond® – Coupling agent that allows better homogenization of the different polymers, allowing the possibility of recycling the processing scrap

Lubricant oil

Multilayer bottles and drums

Agricultural producers

After using the agrochemical, the farmer triple washes the package and delivers it to packaging receiving centers.

Receiving center

Collection center collects the packages and delivers them to recycling companies.

Construction

DuPont™ Fusabond® – The resin that allowed the recycling of post consumption packages, using the material to create flexible and rigid tubes. Also, part of the material is used to produce monolayer ctrs for lubricant oil.

The Virtuous Circle: Food Security, Packaging and Sustainable Development

Supporting partners:

The Virtuous Circle: Food Security, Packaging and Sustainable Development

Key Learnings

Some important factors affecting use of compatibilizers to produce high quality (high value) mixed stream recycled packaging:

- The compatibilization process is simplified and most effective if the recycle stream does not contain:
  - aluminum bound to film
  - paper combined with plastic
  - carbon black inks
- Replacing cross-linked adhesives with tie layers made from coextrudable thermoplastics can make a difference in quality of the recycled polymer stream

Conclusions

- Although flexible plastic packaging has been in use for less than a century, it has had an enormous impact on packaged goods as well as on waste proliferation.
- The advantages of plastic packaging in reducing both food waste and package weight, combined with robust end of life strategies for the package, are valuable contributors to the packaging market.
- Managing packaging materials as valuable resources will enable meeting consumer desires and environmental standards and managing public perception of their benefits.
- In terms of how best to collect waste and ensure sustainability, the Virtuous Circle projects demonstrate the importance of appropriate collection schemes: unless these are in place, whether or not the material is recyclable or not is a moot point.
- Collaboration throughout in the framework of the circular economy in a format like the Virtuous Circle benefits all players in the value chain.

Going Forward

What were they thinking?

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