Design for Recyclability
Dow: 2025 Sustainability Goals

- **Leading the Blueprint**
- **Delivering Breakthrough Innovations**

- **Advancing a Circular Economy**
- **Increasing Confidence in Chemical Technology**

- **Engaging Employees for Impact**
- **Valuing Nature**

- **World-Leading Operations Performance**
2018 has been a ‘A tale of two worlds….’

- Investing to Support Customer Growth

**Gulfstream**
1535 kta

**Sadara**
1300 kta

**Global Consumption on the Rise**

- Market Trends: Drive Packaging Consumption
  - 30.1 kg per person
  - US & Western Europe

- Bar chart showing consumption by region and population

- Diagram highlights: Demographic Change, Waste/ Food Loss, Functionality/ Brand Appeal, Efficiency/ Transportation
What our value chain partners want to know about Dow & Sustainability

Circular Economy
• Recyclable and recycled content
• Bio-based, compostable and biodegradable

Marine Debris
What is the market saying?

11 companies made sustainable packaging commitments... ...they currently account for ~13.2B lbs* of plastic pkg usage/yr

The CEO of Unilever called on the consumer goods industry to abandon the linear "take-make-dispose" model of consumption and turn to a truly circular model that emits no waste.

<table>
<thead>
<tr>
<th>8 Brand Owners</th>
<th>2 Retailers</th>
<th>1 Pkg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coca-Cola</td>
<td>PepsiCo</td>
<td>Danone</td>
</tr>
<tr>
<td><strong>100% Recyclable etc.</strong></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><strong>Increase PCR Use</strong></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><strong>Inc. Recycle Rates</strong></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><strong>Downgauge/Lightwt</strong></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><strong>Bio-source/based etc.</strong></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><strong>Bio-degradable</strong></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><strong>Most Notable Claim</strong></td>
<td>100% Collection</td>
<td>Biodegrad. Research</td>
</tr>
</tbody>
</table>
Flexible Plastic Packaging – A Smart, Sustainable Choice

Lightweight and durable, yet challenging end-of-life options

U.S. Packaging Recovery Rates for Selected Materials

- Paper and Paperboard Products: 76.1%
- Steel Packaging: 72.2%
- Aluminum Packaging: 38%
- Glass Packaging: 34.1%
- Plastics Packaging: 13.8%

Note that while paper and paperboard packaging recovery rates are high, this is primarily due to high recycling rates for corrugated cardboard; only 25 percent of all other types of paper packaging is recycled.

The Challenge Behind Designing For Recyclability

High Barrier Multi-material (eg, Nylon/Foil/Retort) 36%
No Barrier Monomaterial (All PE) 3%
Low Barrier Multi-material (eg, EVOH/PE) 20%
Barrier Multi-material (EVOH/PE/PE T) 41%

Barriers to recyclability:
1) Infrastructure to handle films
2) Multi-material compatibility
3) End markets

Extended shelf-life of food, its protection and the associated reduction in food waste and the resource efficiency cannot be ignored in this equation!

* Source: Pouch & Film Study, Dow Market Intelligence
How to Start?

There’s no “one size fits all” solution

*But there are many solutions to handle different needs*

- Resource Efficiency
- Reduce GHGs
- Enhance Recyclability
- Influence Consumer Behavior
- Improve Infrastructure
- Create New End Markets
### Resource Efficiency: down-gauging and material substitution

#### Raising the bar!

<table>
<thead>
<tr>
<th>Property</th>
<th>INNATE™ Precision Packaging Resins</th>
<th>ELITE™ EPE Resins</th>
<th>DOWLEX™ C₈ LLDPE Resins</th>
<th>C₄ LLDPE Resins</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impact Strength</td>
<td>✓✓✓✓✓</td>
<td>✓✓✓ ✓</td>
<td>✓ ✓</td>
<td>✓</td>
</tr>
<tr>
<td>Tear Resistance</td>
<td>✓✓✓✓</td>
<td>✓✓✓✓</td>
<td>✓✓✓ ✓</td>
<td>✓</td>
</tr>
<tr>
<td>Puncture Resistance</td>
<td>✓✓✓✓✓</td>
<td>✓✓✓✓</td>
<td>✓✓✓ ✓</td>
<td>✓</td>
</tr>
<tr>
<td>Tensile Strength</td>
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<td>✓✓✓✓</td>
<td>✓✓✓✓ ✓</td>
<td>✓✓✓ ✓</td>
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<tr>
<td>Modulus</td>
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<td>✓✓✓✓</td>
<td>✓✓✓✓ ✓</td>
<td>✓✓✓ ✓</td>
</tr>
<tr>
<td>Pinhole Resistance</td>
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<td>✓</td>
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<tr>
<td>Extrusion</td>
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<td>✓✓✓✓</td>
<td>✓✓✓✓ ✓</td>
<td>✓✓✓ ✓</td>
</tr>
</tbody>
</table>

**Drop Dart Impact Strength**
Resource Efficiency

Reduced Material Usage

- Application: Large format bags
- Structure: 3-layer PE 140um
- 20% down-gauging achieved
- Superior mechanical properties
- 100% pass rate on drop test

Material Elimination

- Application: Pet Food
- 3 mil film with PA in Core layer
- Elimination of 6um PA layer
- Higher Dart
- Higher Modulus
Enhance Performance: BOPE

Diagram showing performance metrics for different materials:
- Ecomonics
- Recyclability
- Heat Seal
- Stiffness
- Clarity
- Toughness

Materials compared:
- BOPE (25μm)
- BOPET (12μm)
- BOPP (18μm)
- BOPA (15μm)
Enhance Recyclability

RecycleReady Technology

for store drop-off recycling by Dow

PET Laminate

PE Laminate

Must Have A Market For the Recycled Material

Material Must Be Capable Of Being Recycled

Collection & Processing

Stand Up Pouch

Form Fill Seal

Thermoformed

Spouted Pouches

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Enhance Recyclability: Higher Barrier Systems

Frozen Food
Dry Goods (salt, sugar)
Detergent (PODs)
+Other low barrier

Low Barrier (MVTR)

Dry Pet Food
Granola
Nuts
Wet wipes

Moderate Barrier (EVOH/PE)

Coffee
Microwaveable Meals
Meat & Cheese
Snacks

Multi-material barrier (metallized films, foil, PA/EVOH/PE)
Enhance Recyclability: Higher Barrier Systems

Compatibilize EVOH with PE for Recycle Stream

Transmission Electron Microscopy

- No Compatibilizer
  - Large EVOH domains
  - Point defects

- Conventional Compatibilizer
  - Bimodal EVOH domains

- Small, uniform EVOH domains

SIGNIFICANT IMPROVEMENTS IN GELS AND OPTICS!
Enhanced Recyclability via Compatabilization

Mixed Streams

- Flexibles
  - Coming from separate collection
- Rigid
  - Coming from mix collection
  - PE & PP
  - PE & PET
End markets for Polyethylene Film

Polyethylene containing film is the largest global volume product

The primary points where prime PE film is lost in its life cycle

1. **Film Extrusion** – off specification, scrap, and trim
2. **Post Consumers** – after the package contents are removed

Innovation needed to enable select films to re-enter the prime product stream
End Market Development Opportunity

What are the gaps in terms of performance?
- Could include degradation mechanism of PE in presence of shear, heat
- Generation of color caused by degradation and presence of inks
Develop end use market – Plastic waste road in India

- Two Dow press release
- >14 external media reports
- Two documentary videos
- ~3 million impressions
- Strong municipality supports
- 8% bitumen replacement
- 4 partners and 3 municipalities
- 40+ volunteers and pickers
Infrastructure on the way to Circularity

RESEARCH PROGRAM ANNOUNCES PARTNERSHIP WITH MRF TO PILOT CURBSIDE RECYCLING OF FLEXIBLE PLASTIC PACKAGING

WASHINGTON (June 20, 2018) — The Materials Recovery for the Future (MRFF) research program today announced a new partnership with J.P. Mascaro & Sons Inc. to pilot single-stream curbside recycling of flexible plastic packaging (FPP) at its TotalRecycle materials recovery facility (MRF) in Berks County, Pennsylvania. This will be the first pilot to demonstrate the technical and economic feasibility of recycling household FPP from municipal residential singlestream recycling programs.
In Summary

There’s no “one size fits all” solution
But there are many solutions to handle different needs

- Resource Efficiency
- Reduce GHGs
- Enhance Recyclability
- Influence Consumer Behavior
- Improve Infrastructure
- Create New End Markets
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