PLASTIC PACKAGING IN THE CIRCULAR ECONOMY

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DOW PACKAGING AND SPECIALTY PLASTICS

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PLASTICS HAVE A GREAT SUSTAINABILITY STORY
The journey continues…
2018 was a ‘A tale of two worlds’ for the Plastics Industry

China: Scrap imports down 12 percent due to ban

Maharashtra: Ban comes into force, dispose of all plastic materials in a month

India: 1/3 of all food is wasted

180,000 new mouths to feed every day
### Global Brands Driving Need for Sustainable Solutions

**Spring ‘19: 350+ Signatories to the Ellen MacCarthur Foundation’s New Plastics Economy**

All CPG’s, retail and packaging producing signatories (107) have committed to making 100% of their plastic packaging reusable, recyclable or compostable by 2025. And CPG’s and retailers have committed to an average of **25% recycled content by 2025**

<table>
<thead>
<tr>
<th>Brand Owners</th>
<th>Retailers</th>
<th>Converters</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Single-Use to Reusable</strong></td>
<td>✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔</td>
</tr>
<tr>
<td><strong>Eliminate Unnecessary Plastic Packaging</strong></td>
<td>✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔</td>
</tr>
<tr>
<td><strong>100% Recyclable, Reusable, Compostable</strong></td>
<td>✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔</td>
</tr>
<tr>
<td><strong>PCR Content</strong></td>
<td>✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔</td>
</tr>
<tr>
<td><strong>Increase Recycle Rates</strong></td>
<td>✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔</td>
</tr>
<tr>
<td><strong>Downgauging</strong></td>
<td>✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔</td>
</tr>
<tr>
<td><strong>Bio-source/ based</strong></td>
<td>✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔</td>
</tr>
<tr>
<td><strong>% PCR Committed</strong></td>
<td>25 25 40 TBD</td>
<td>30 TBD 15 25 25 15 50 25 TBD</td>
</tr>
<tr>
<td><strong>Plastic Pkg Volume Metric tonnes</strong></td>
<td>287 K 750 K 40 K ND ND ND 129 K 1.7 MM ND 90 K ND 3.0 MM 610 K ND ND ND ND ND ND</td>
<td></td>
</tr>
</tbody>
</table>

*All CPG’s, retail and packaging producing signatories (107) have committed to making 100% of their plastic packaging reusable, recyclable or compostable by 2025. And CPG’s and retailers have committed to an average of 25% recycled content by 2025.*
• Sustainability drivers and market demands for recycled materials slow growth of virgin

• Virgin growth is reduced by recycled materials – a participation strategy shift for PE manufacturers

• Large scale and positive economics should accelerate feedstock recycling

By 2050, nearly 60 percent of plastics production could be based on plastics reuse and recycling.

Global polymer demand 2016–50 and how it could be covered, millions of metric tons¹

<table>
<thead>
<tr>
<th>Year</th>
<th>Virgin feedstock</th>
<th>Recovered feedstock (plastic equivalent)</th>
<th>Recovered monomer</th>
<th>Mechanical recycling</th>
<th>Projected demand growth²</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
<td>1,200</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>2020</td>
<td>1,000</td>
<td>200</td>
<td>0</td>
<td>0</td>
<td>7</td>
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<tr>
<td>2025</td>
<td>800</td>
<td>200</td>
<td>0</td>
<td>0</td>
<td>18</td>
</tr>
<tr>
<td>2030</td>
<td>600</td>
<td>200</td>
<td>0</td>
<td>0</td>
<td>17</td>
</tr>
<tr>
<td>2035</td>
<td>400</td>
<td>200</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>2040</td>
<td>200</td>
<td>200</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>2045</td>
<td>100</td>
<td>200</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>2050</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Source: McKinsey&Company

¹Scenario based on a multi-stakeholder push to boost recycling, regulatory measures to encourage recycling, consistent progress on technologies, and $75-per-barrel oil price.
²Compound annual growth rate. Mechanical recycling limited by downcycling and applicable materials, monomerization limited by applicability to condensation polymers only, pyrolysis limited by likely rise in input costs.
³After demand reduction, assuming annual global GDP growth of 3.1%.

BALANCE IN MATERIALS MOVING FORWARD CREATES OPPORTUNITY
A PLASTICS CIRCULAR ECONOMY: SCOPE AND CHALLENGES

Assets → Market → Consumer → Waste Management

Gas/Oil → Feedstocks → Polymers → Pouch, Bumper, Bottle, Tray → Used Product

Chemical Recycling (Large and Consolidated) → Mechanical Recycling (Small and Distributed)

Chemical Facilities

Dow Restricted 7/10/2019
Plastics Industry Response to the Challenge

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

- Material Reduction
- Reduce GHGs
- Enhance Recyclability
- Influence Consumer Behavior
- Innovate
- Improve Infrastructure
Partnerships are key and creating opportunities across the value chain, including the waste management infrastructure.

- Converting packages from hard-to-recycle to recyclable.
- Adoption / piloting of technologies for chemical recycling / feedstock recovery.
- Acquisition of recycling companies to increase both the quality as well as availability of materials to meet CPG company goals.


- 100% of ACC’s Plastics Division’s U.S. manufacturing sites participating in Operation Clean Sweep Blue by 2020, with all North American sites by 2022.
- 100% of plastics packaging is recyclable or recoverable by 2030.
- 100% of plastics packaging is re-used, recycled, or recovered by 2040.
KEEPING PLASTIC VALUABLE

- Designed for lowest environmental impact
- Develop and support reuse formats
- Invest & collaborate on global waste management infrastructure to improve recovery
- Continue to increase recyclability and stimulate recycling markets

Practical and social benefits of plastic are matched by environmental performance
HIERARCHY OF PACKAGING RECYCLING

- Designed for lowest environmental impact
- Develop and support reuse formats
- Invest & collaborate on global waste management infrastructure to improve recovery
- Continue to increase recyclability and stimulate recycling markets

End Use Market Value

1. All Flexible Films Recovered and Recycled (includes chemical and mechanical)
2. Industrial Flexible Films in Closed Loop
3. Industrial Flexible Films Recycled to Durables
4. Rigid Packaging Recycled to Durables
Members of The Materials Recovery for the Future Collaborative share a simple vision:

“Flexible packaging is recovered, and the recovery community captures value from it.”

We are leading research to advance understanding of how flexible plastic packaging can be effectively sorted for recovery.
**Material Science of Recycled Materials**

- **Mechanical recycling**: method by which waste material is recycled into “new” raw material without changing the basic structure of the material
- **Waste materials**: Post Industrial Resin (PIR) and Post Consumer Resin (PCR)

**PCR State**
- Material inhomogeneity
- Contamination
- Broad product spec
- Limited supply
- Very few food contact grades (LNO)
- Recyclers lack polymer expertise
- Market use infancy

**Material Properties**
- Viscosity mismatch
- Thermo-oxidative degradation
- Organoleptics ↓
- Color ↓
- Gels ↑
- Mechanicals ↓
Improving roads with recycled plastic

Paving a new way

Building and improving roads and infrastructure is critical in both emerging and developing regions. Dow is working with partners around the globe to construct polymer-modified asphalt roads with post-consumer recycled plastic.

Benefits:
1. Longer term performance in asphalt roads
2. Reduction in GHG emissions associated with traditional processes.
3. Broad applicability across states, cities, and counties.

2019 GOALS

Expansion to U.S. and Africa
77 tons of plastic waste diverted for roads
12 new road projects
2 parking lots
Designing recyclable structures
- Converts non-recyclable to recyclable
- Challenge – maintain product integrity

Mechanically recycling materials
- Transforms materials back to pellets
- Challenge – not all materials, not highest quality

Solvent-based systems
- Process innovation to improve quality
- Challenge – energy intensity, recovery of solvents

Feedstock Recovery
- Highest quality
- Challenge – distributed versus consolidated model, energy intensity
NEEDS FOR A PLASTICS CIRCULAR ECONOMY

- Funding is needed for fundamental Process R&D to facilitate scale-up of chemical transformation technologies such as pyrolysis and gasification, which can be used to convert used, otherwise non-recycled plastics into feedstocks for the manufacture of new basic materials. Improvements in reactor design and process control for improved heat transfer and reduced reactor fouling can allow larger conversion units to operate more reliably and economically.
- Regulatory support must be provided for these technologies to be classified as “recycling” so that facilities can be permitted and operated as manufacturing plants rather than as waste treatment facilities.
- Definitions for recycling and recycled content must include all types of recycling processes: traditional mechanical recycling (making pellets by chopping, washing, and pelletizing), chemical recycling (depolymerization to make polymers into feedstocks for re-polymerization), advanced cleaning (solvent dissolution, separation of polymers, removal of contaminations), and other future technologies.
- Goals and commitments should include the use of recycled content in products in addition to materials being designed as “recyclable” in order to assure that recyclable products actually get recycled after their initial use.