



# Multi-layered packaging plastics: Tackling pollution through waste prevention and valorisation

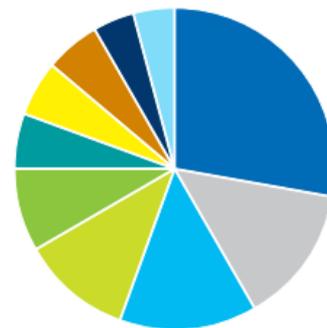
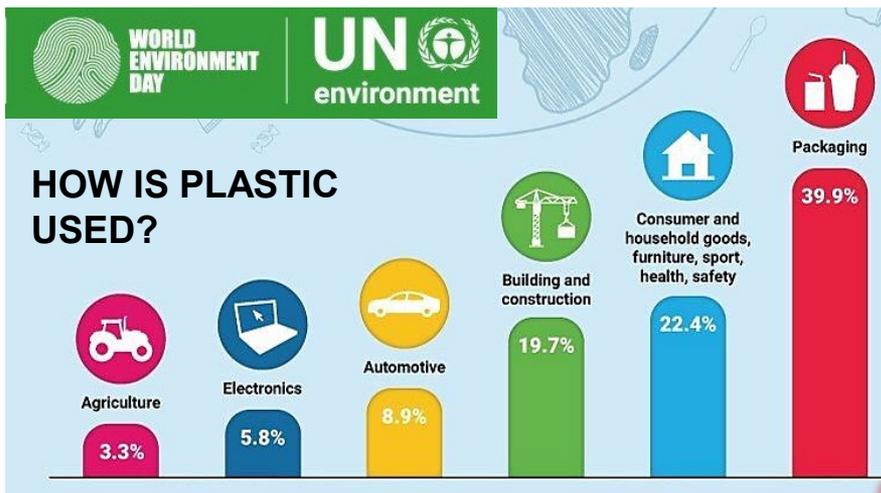
## **BIEA STEM Conference 2020**

Investigators: Daniel Balint, Bamber Blackman, Maria Charalambides, Soraia Pimenta, Ambrose Taylor

Manu Charles Mulakkal

*[Email: m.mulakkal@imperial.ac.uk](mailto:m.mulakkal@imperial.ac.uk)*

**Mechanics of Materials Division**  
**Department of Mechanical Engineering**



The top 10 types of litter quantified by Thames River Watch are:



- Food wrappers **20%**
- Cotton bud sticks **10%**
- Drink bottles & their tops **10%**
- Takeaway containers **8%**
- Unidentified plastic greater than 2.5cm **6%**
- Polystyrene cups **4%**
- Plastic cups **4%**
- Unidentified synthetic foam **4%**
- Cutlery/straws/lollipop sticks/stirrers **3%**
- Wet wipes **3%**

Imperial College  
London

# GLOBAL PACKAGING<sup>1</sup>

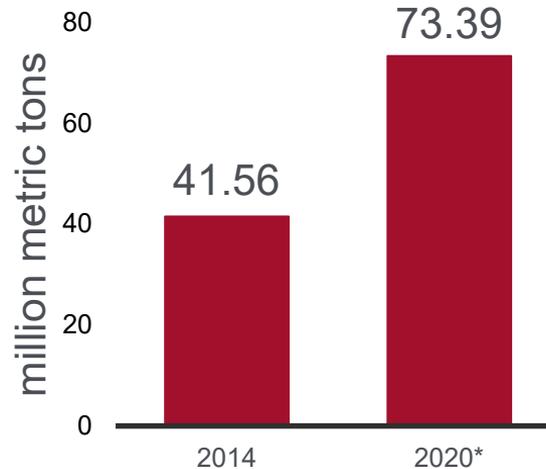
## Flexible Packaging<sup>1</sup>

Greater demand for products and Increased consumption

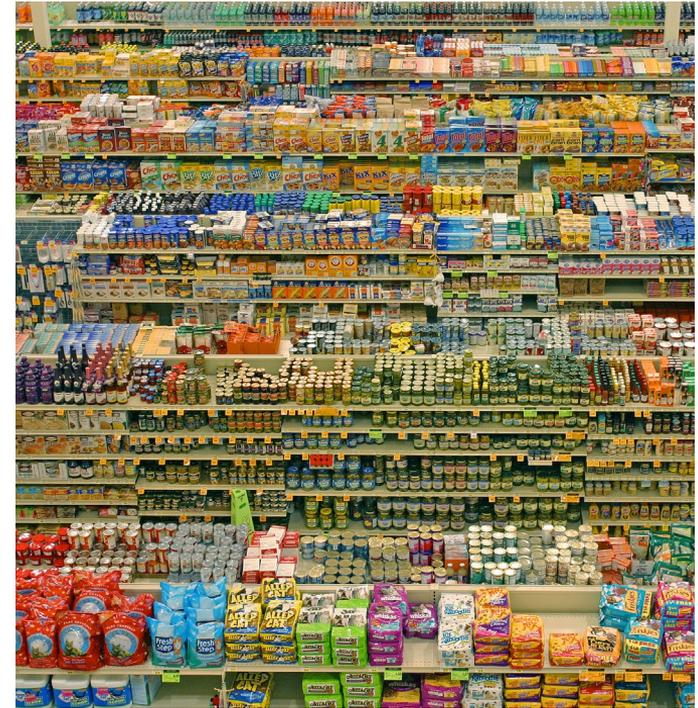


### Global PET production 2014-2020<sup>2</sup>

TYPICAL PACKAGING PLASTICS  
Polypropylene, Polyethylene,  
PET, Polyamides, EVOH



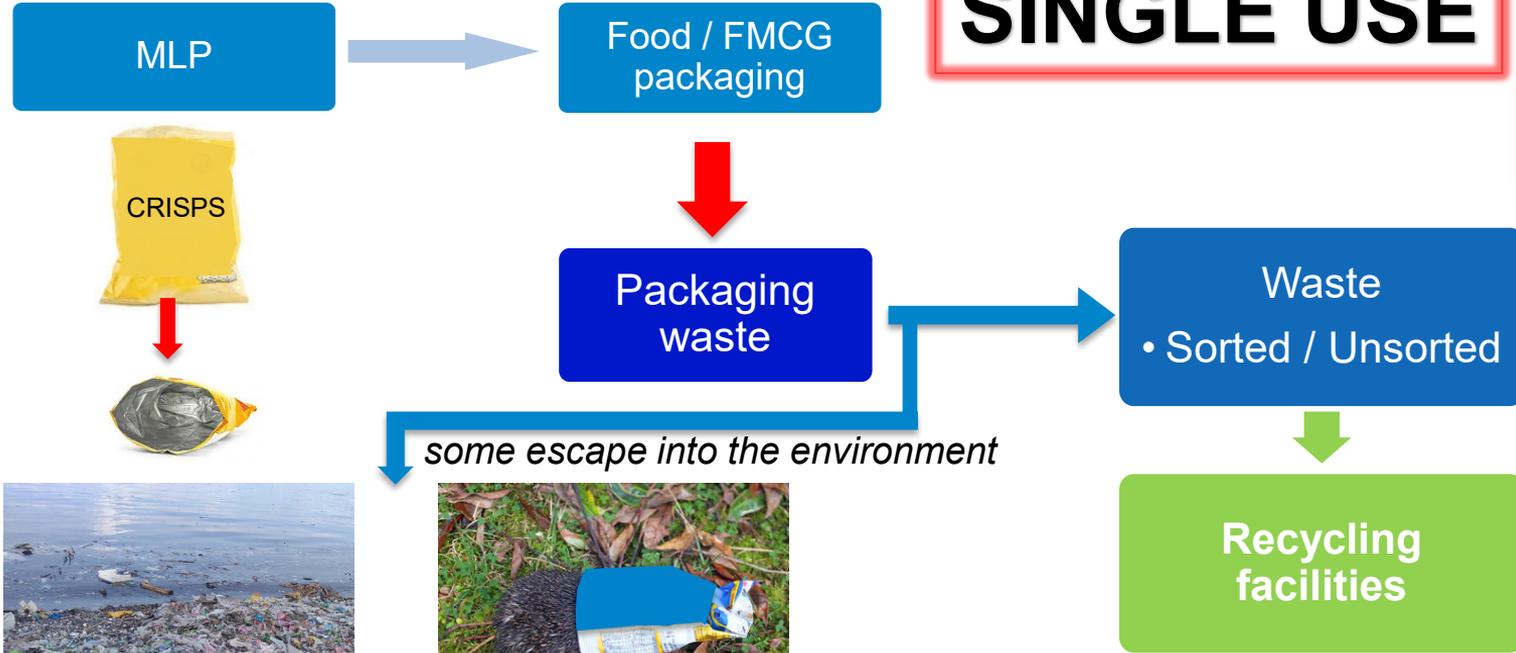
Reproduced from Wikipedia under [CC BY-SA 2.0](https://creativecommons.org/licenses/by-sa/2.0/)



<sup>1</sup> Market report by Technavio

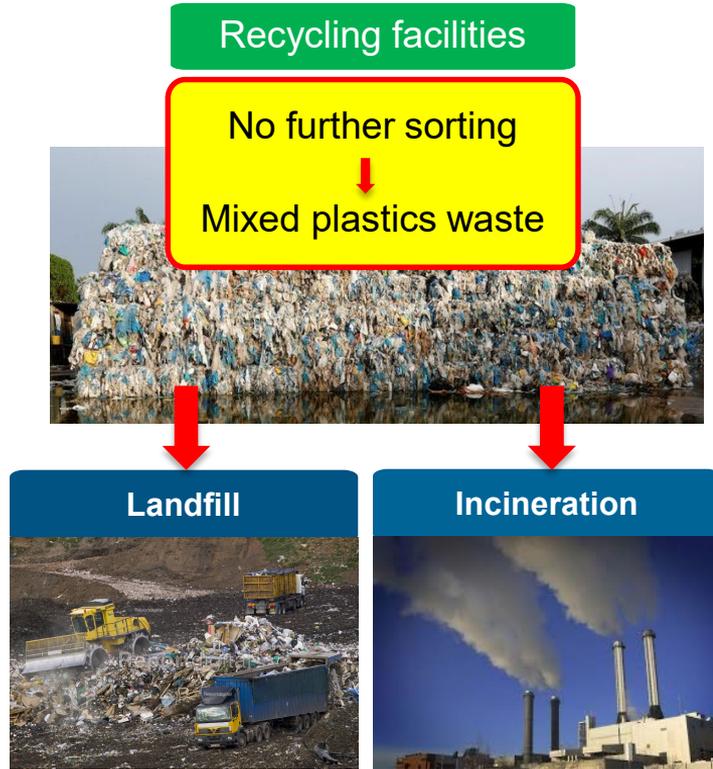
<sup>2</sup> Business Wire. "Polyethylene Terephthalate (PET) Production Worldwide in 2014 and 2020)." Statista





**SINGLE USE**





## Factors limiting effective MLP recycling

Sorting	Low value	MLP design
<ul style="list-style-type: none"><li>• Not effective enough for MLP yet</li><li>• Mixed plastics waste</li><li>• Typically smaller than A4</li></ul>	<ul style="list-style-type: none"><li>• Pigments - dark grey/ green in colour</li><li>• Low material properties</li><li>• Less desirable</li></ul>	<ul style="list-style-type: none"><li>• Strong adhesion</li><li>• Thermoset adhesives</li><li>• Unable to separate layers</li></ul>



## Recycling solutions

### Mechanical recycling

- Break down materials but retains the polymer structure
- Mechanical means - shredding and shear
- Melt processing

**Better/ easier integration with existing recycling systems**

**COMPARETIVELY COST EFFECTIVE**

### Chemical recycling

- Breakdown materials at molecular level
- Dissolution and precipitation
- Convert back to equivalent petroleum by-products for precursors/ starting material

**Novel and highly reactive reaction media**

**HIGH SET-UP COST AND EXPENSIVE**



## Mechanical recycling: Options

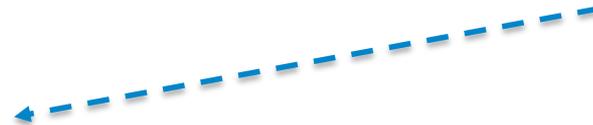
# Mechanical recycling

**Blending strategies**



Fibre reinforced blends

Compatibilisation



**Layer separation strategies**



Design for Recycle

Interlayer

Reduced adhesion

**Recycled materials**



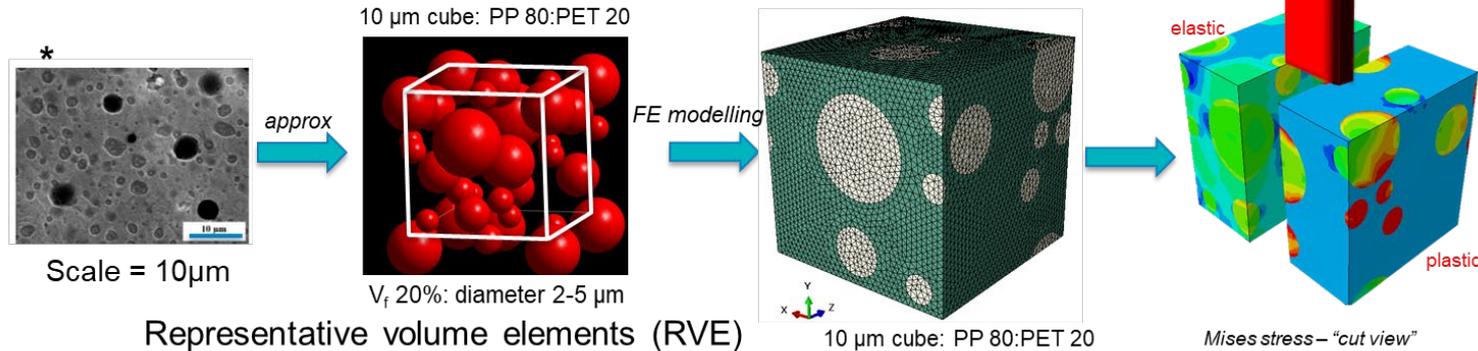
# Compatibilisation

Micro-mechanical models  
New compatibilisers

# Design for recycling

Water-soluble adhesives  
Selective surface-treatments

## 80% Polypropylene (PP) : 20% PET blend





# Mechanical recycling: Opportunities

Collection and Sorting a major limitation

**Create VALUE for recycled materials**

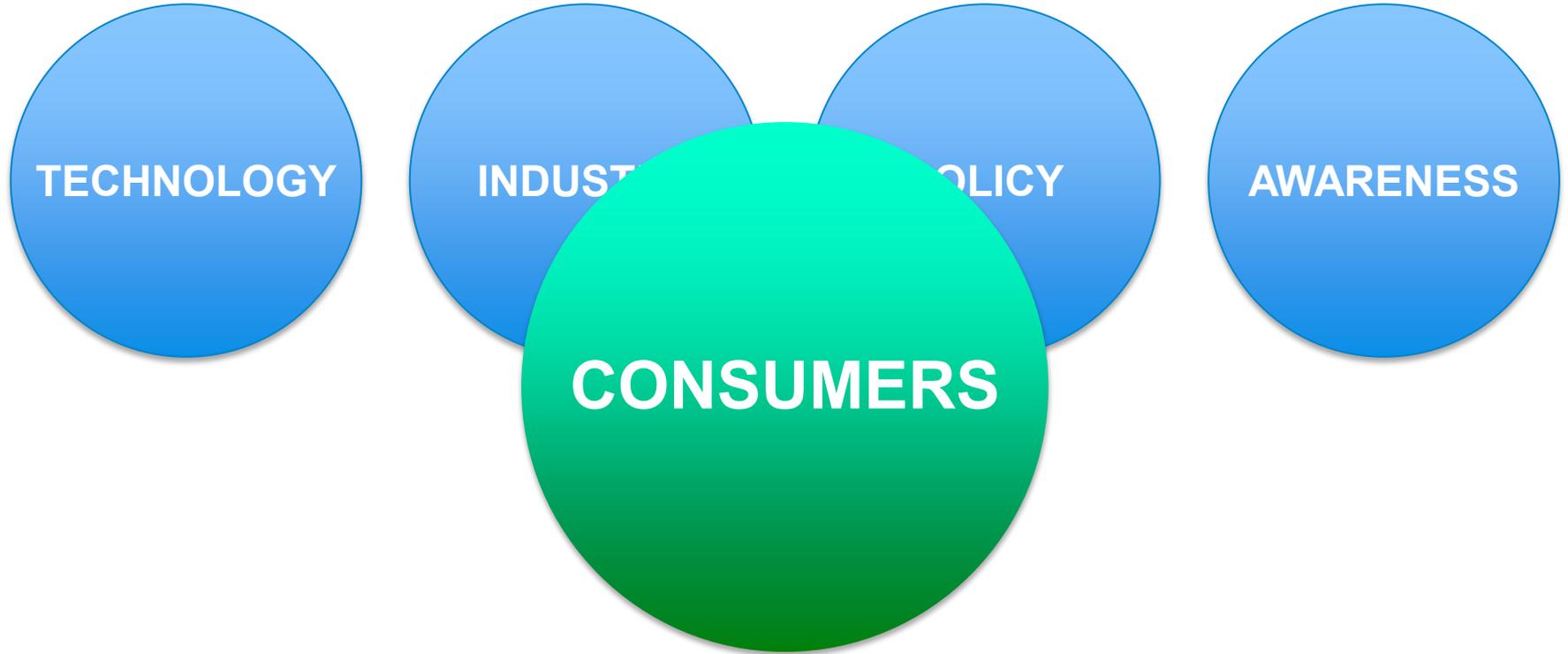


Improved mechanical properties + New functionalities + Policies



**Market for recycled materials**







# Conclusions

