KEY CHALLENGES IN THE PLASTIC PACKAGING INDUSTRY

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CHEMISTRY THAT MATTERS™

CONTENT

SABIC TODAY

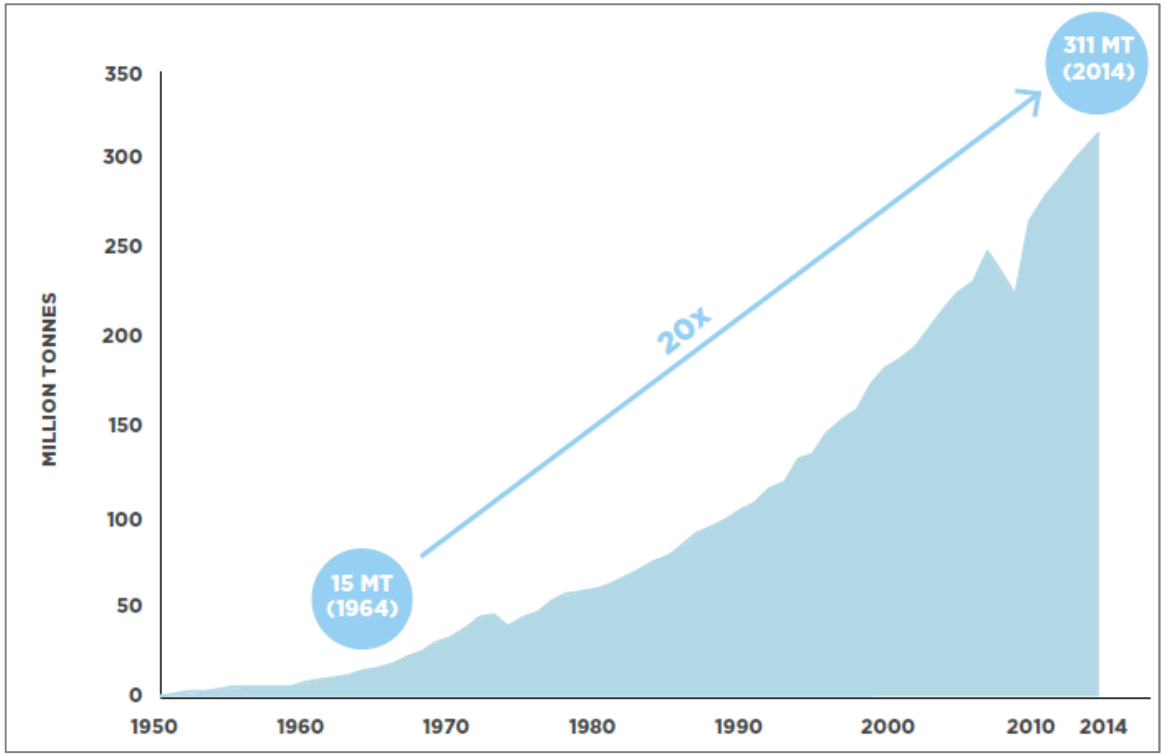
SABIC IN 2015

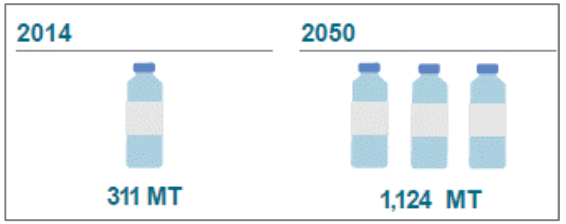
* Forbes 2015

PRESENTATION RUNNING HEAD

THE PLASTICS SUCCESS STORY

A SUCCESS STORY

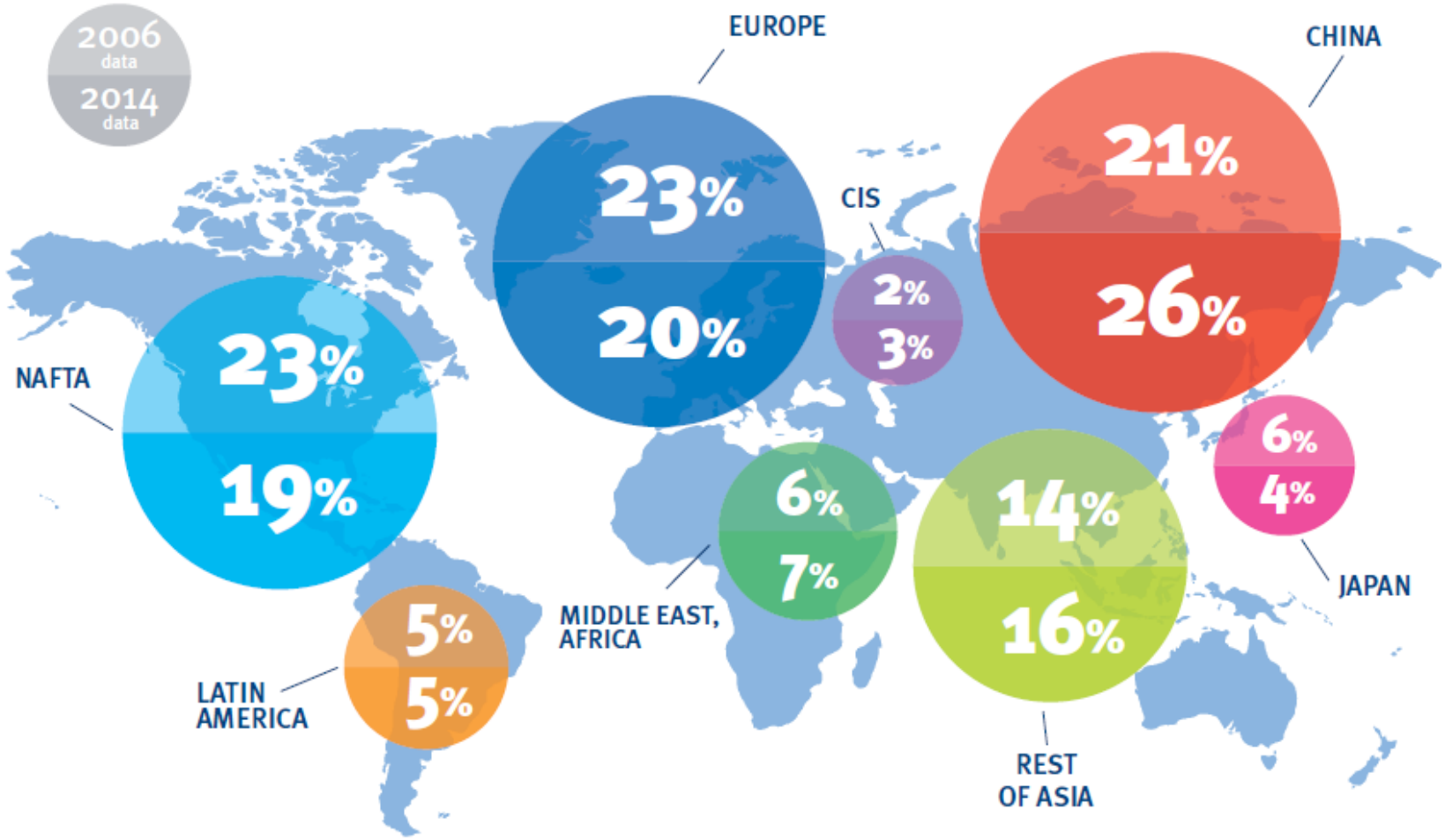




- 20 times growth of plastic production during the last 50 years
- Plastic production is expected to triple in coming 40 years

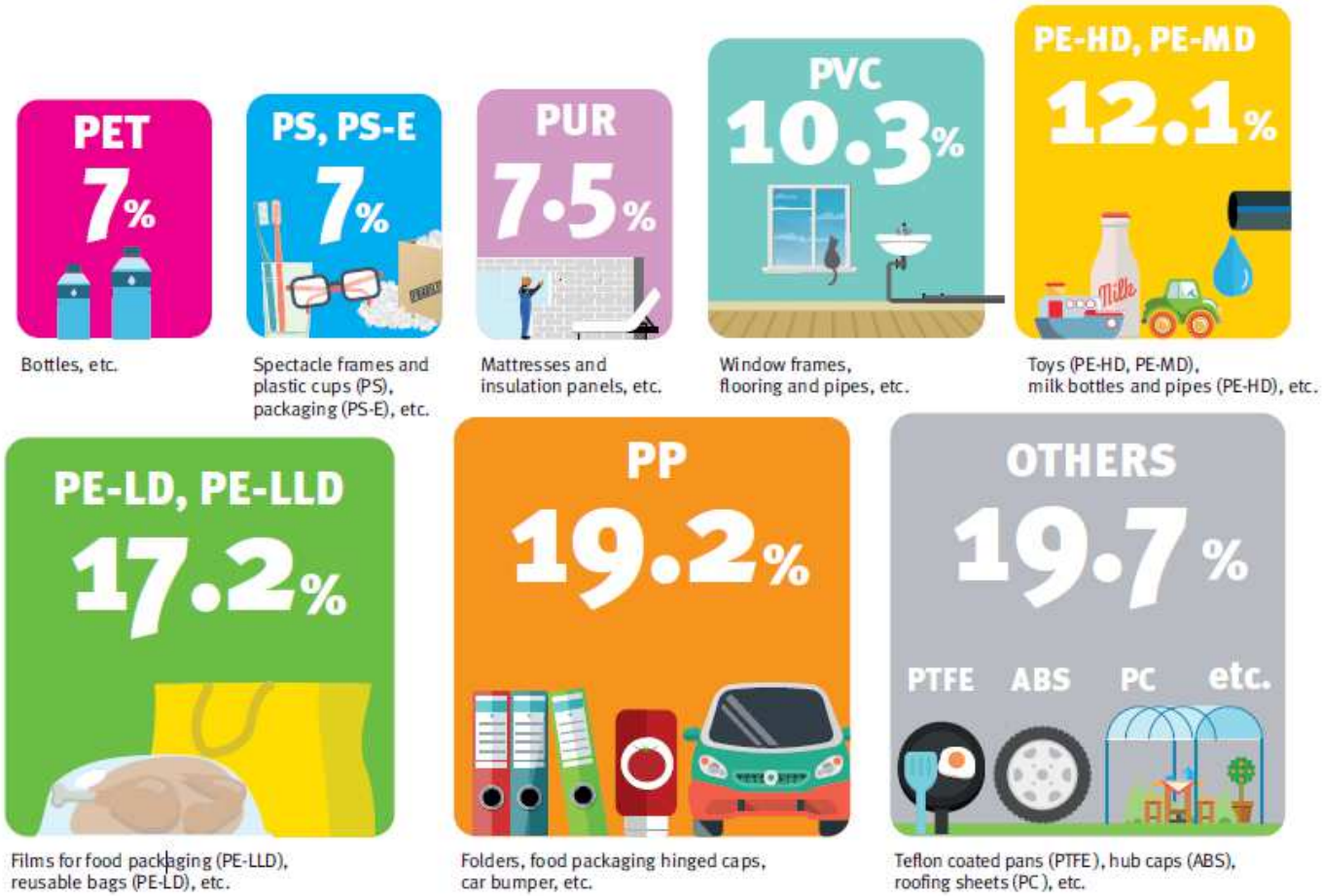
Source: PlasticsEurope & Ellen McArthur Foundation

APAC WILL DRIVE GROWTH



Source: PlasticsEurope ; Plastics – The Facts 2015

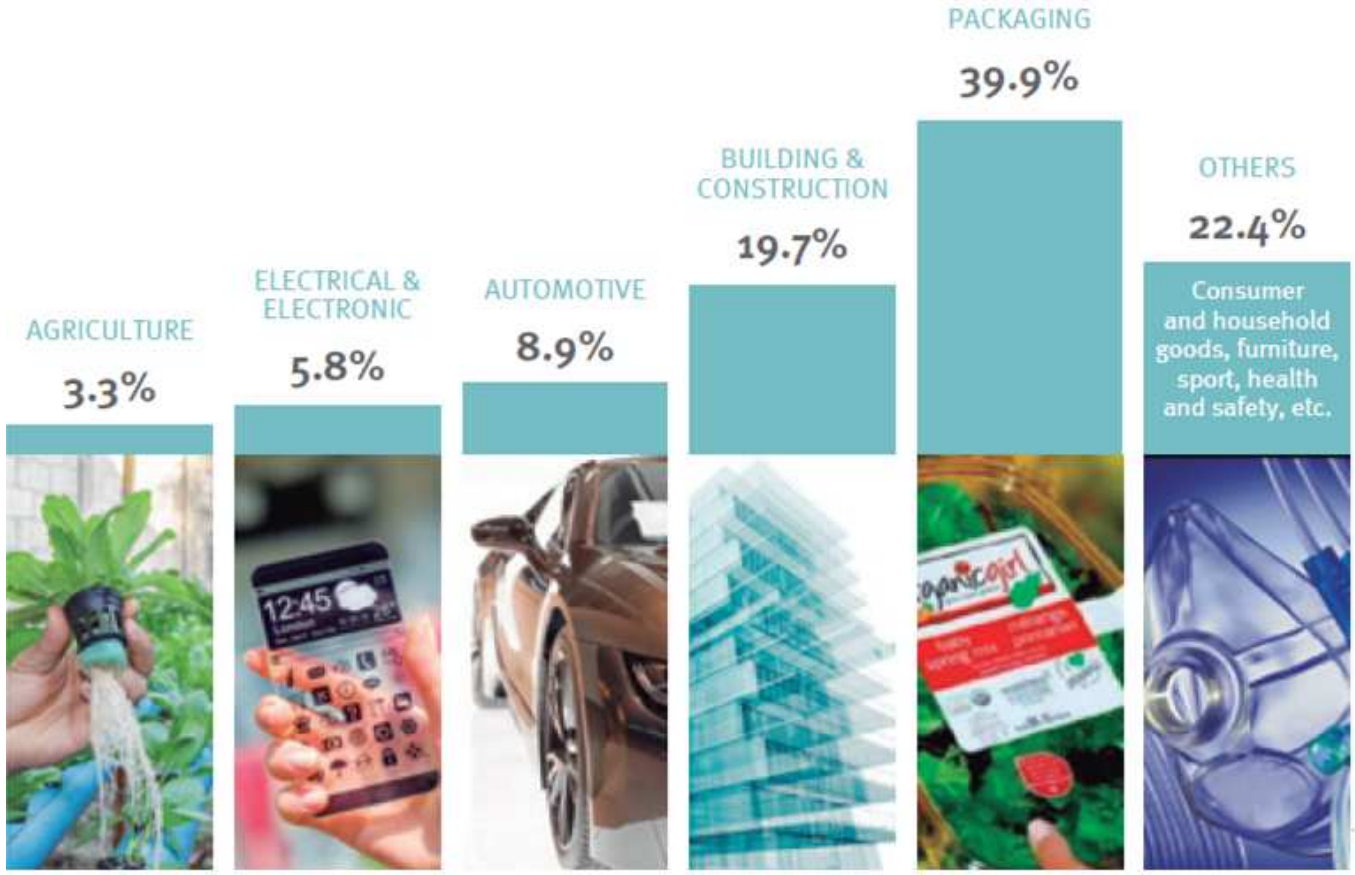
A VARIETY OF PLASTICS FOR DIFFERENT NEEDS



- Polyolefins accounts for almost 50% of total market with growing share
- Biodegradable and renewable plastics represent <1% of total market

Source: PlasticsEurope ; Plastics – The Facts 2015

PLASTIC USE PER INDUSTRY



- Packaging represents 40% of plastics market

Source: PlasticsEurope ; Plastics – The Facts 2016

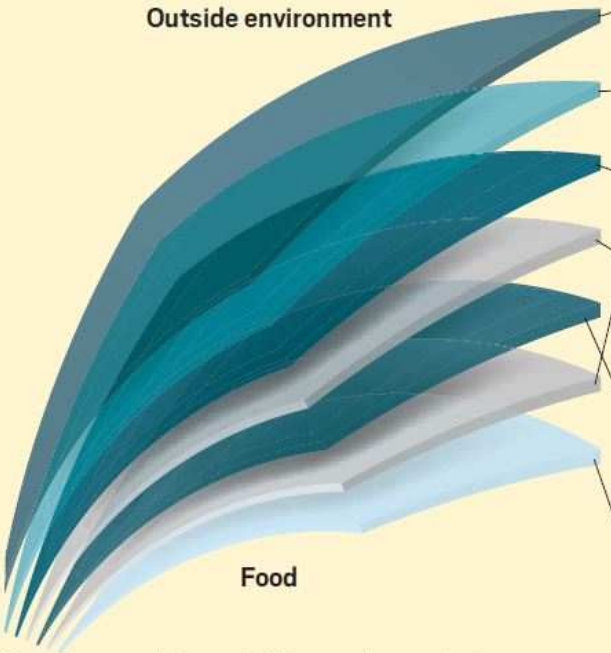
PRESENTATION RUNNING HEAD

PACKAGING FUNCTIONALITY AND INNOVATION

PACKAGING IS HIGH TECH

Highly engineered

Each component of a flexible multilayered package imparts important functions to the overall architecture.



Coating: This optional thin film protects the printed material. It can be any of a number of specialty polymers.

Outer layer: This layer provides a printing surface and is usually polyethylene or polyethylene terephthalate (PET).

Structural layer: This layer gives the package its shape and prevents tearing and puncturing. Polyethylene is the workhorse. PET might be used for greater toughness.

Tie: A tie layer combines two chemically dissimilar polymers, such as nylon and polyethylene, that tend to separate. Functionalized polyolefins are common tie-layer resins.

Barrier: This layer primarily keeps oxygen from infiltrating the package. Ethylene-vinyl alcohol offers high performance and is considered the industry standard. Nylon and PET can be used when less oxygen blocking is needed. Aluminum, deposited on a polymer or used as foil, offers the highest level of performance.

Seal: The polymer in this layer usually has a low melting point so it can be heat-sealed. It also must not interact chemically with the food it contacts. Polyethylene is often used. Companies look to ethylene-vinyl acetate or ionomer when they need higher performance.

Note: The example is generic. Various products and environments require different arrangements of layers.

CREDIT: YANG H. KU/C&EN/SHUTTERSTOCK (ALL)

Source: A.H. Tullo, Chemical & Engineering News, Volume 94 Issue 41 | pp. 32-37, 2016

CONTINUOUS PACKAGING INNOVATION

	Original packaging	New packaging	Result
 Bananas	Sold loose	Perforated polyethylene bags	Lasted 15 days unpackaged versus 36 days in bags
 Beef	Polystyrene foam tray with cling wrap	Vacuum packing in oxygen barrier film	Shelf life extended from four days to up to 30 days
 Bell peppers	Sold loose	Modified atmosphere packaging with perforated polypropylene film	Lasted four days sold loose versus 20 days in packaging
 Bread	Paper bag	Biaxially oriented polypropylene film	Food waste reduced from 11.0% to 0.8%
 Cheese	Sliced at counter and wrapped in paper	Polyester tray with a polyethylene and polyester lid	Food waste reduced from 5.00% to 0.14%
 Cucumbers	Sold loose	Polyethylene shrink wrap	Shelf life extended from three days to 14 days
 Grapes	Sold loose	Perforated bags	Bagging leads to a 20% reduction in in-store waste

Source: A.H. Tullo, Chemical & Engineering News, Volume 94 Issue 41 | pp. 32-37, 2016

THE FOOD WASTE PROBLEM (IN NUMBERS)

Scale

- ✓ Edible food wastage worldwide = **1.3 billion tonnes**
- ✓ Land use: ~ 30% of the world's agricultural land (**1.4 billion hectares**)

Environment

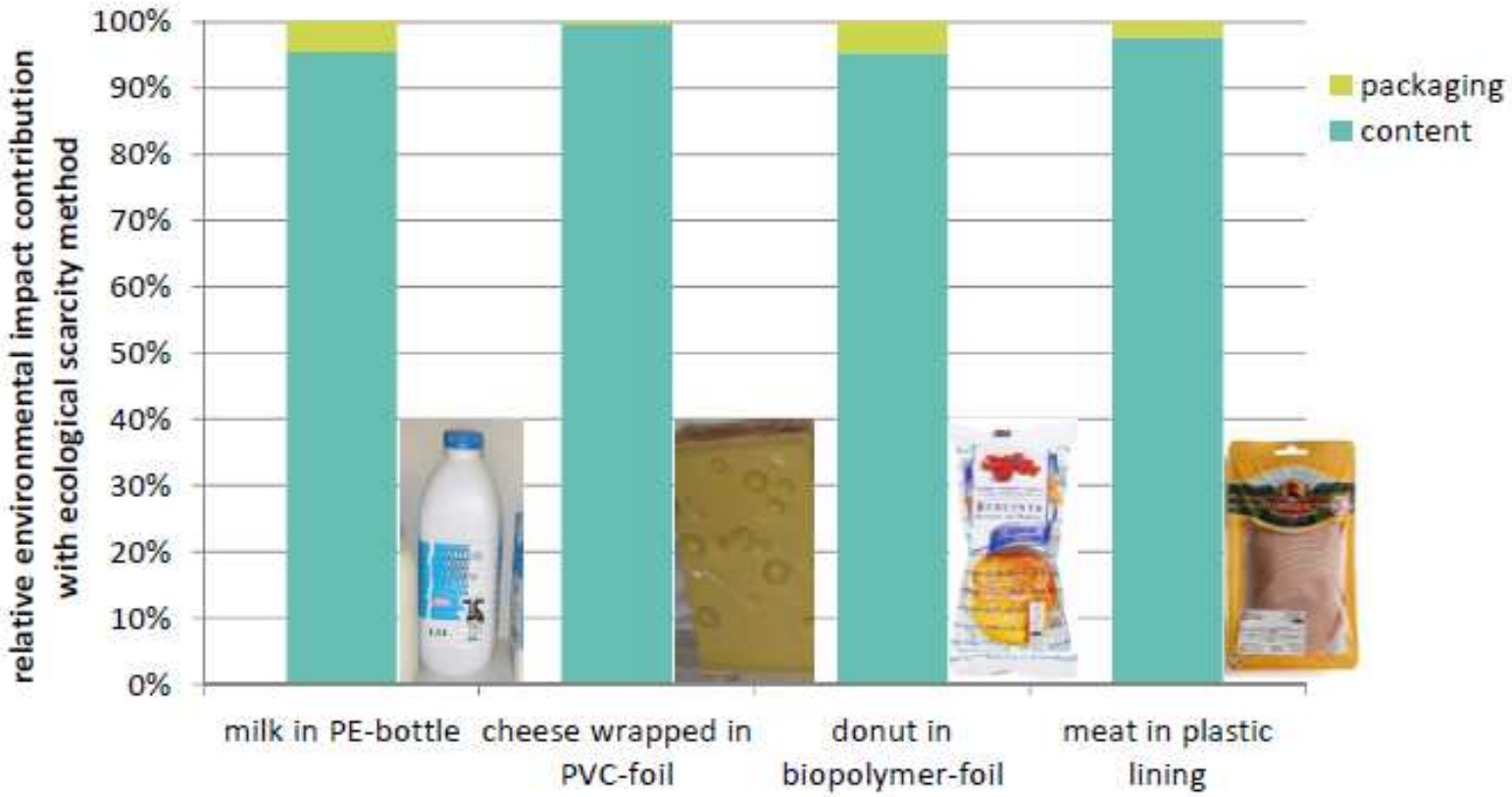
- ✓ Food Waste is the **third biggest source of carbon emissions** after USA and China
- ✓ About **30 percent of the environmental footprint of an average European** are linked to the production and distribution of food and to nutrition

Economic impact

- ✓ On a global scale, the **cost** (based on 2009 producer prices) of food wastage is **750 billion USD**
- ✓ This is equivalent to the GDP of Switzerland

Source FAO Study 2013; Carbotech, European Food & Beverage Plastic Packaging 2016

RELATIVE ENVIRONMENTAL IMPACT PACKAGING



- Food production has a considerable environmental impact
- Benefit of extended food preservation by packaging outweighs its environmental impact

Source: Carbotech, European Food & Beverage Plastic Packaging 2016

INNOVATION DRIVERS IN PACKAGING INDUSTRY

Protection
Preservation
Presentation
Increased shelf life
Enhanced functionality
Design/Shelf appeal

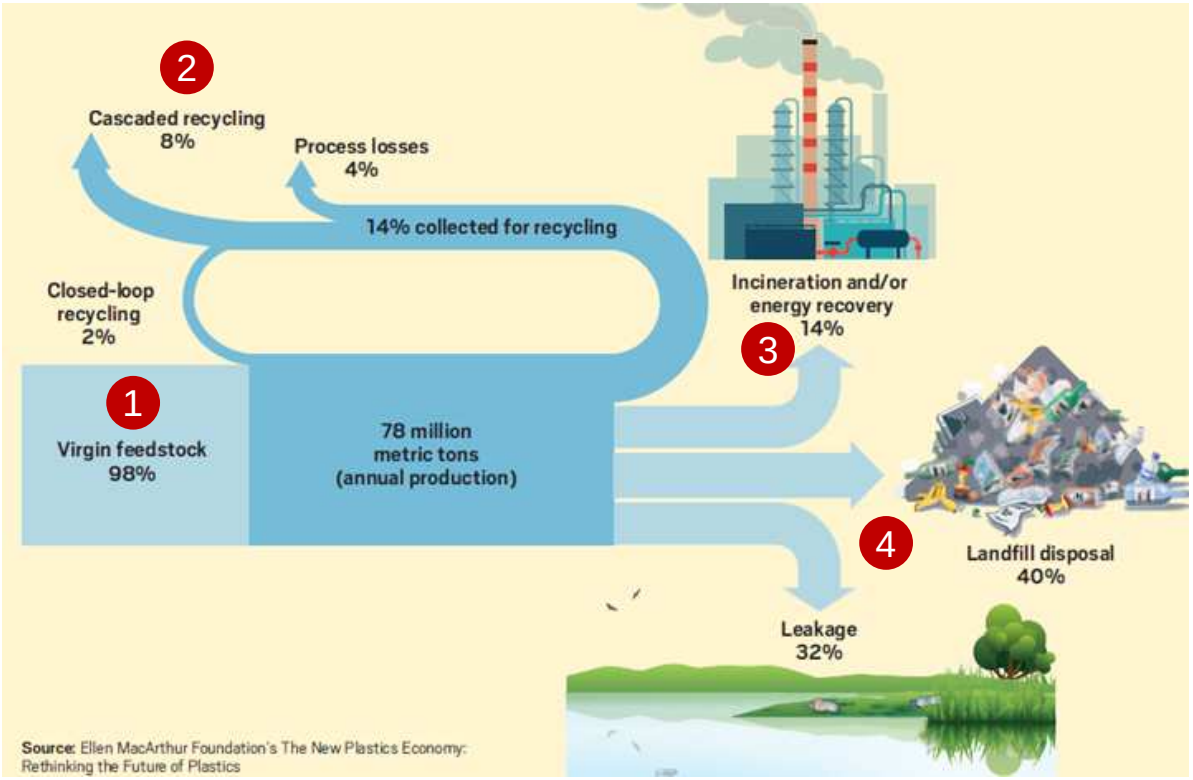
Compliance
Purity, Safety

Sustainability
Weight reduction
Circular economy (3 R's)

Consumer convenience
Easy open/reclose
Product handling
Consumer 'dialogue'

CLOSING THE VALUE CHAIN

LITTLE PLASTICS PACKAGING IS RECYCLED……..



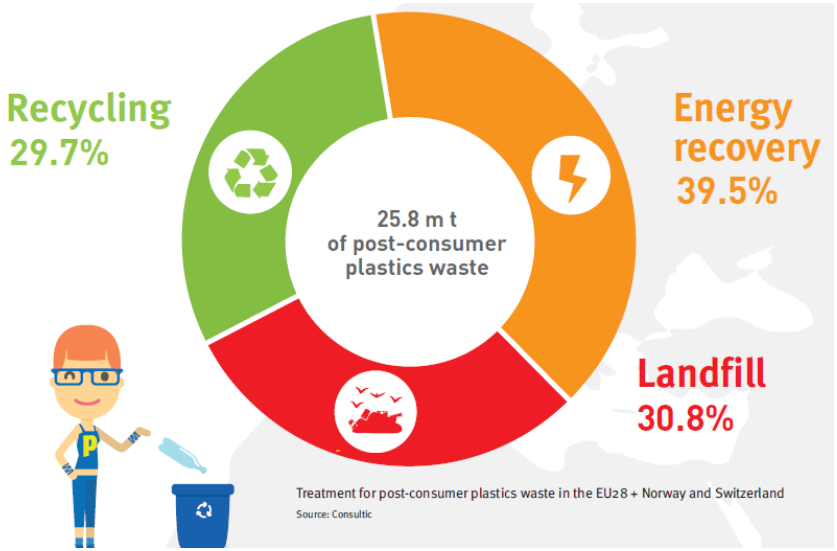
1. Use of scarce resources
2. Limited volume recycled
3. Hydrocarbons burnt
4. Improper disposal

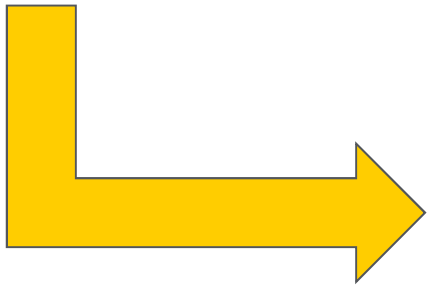
ELLEN MACARTHUR FOUNDATION
Rethink the future

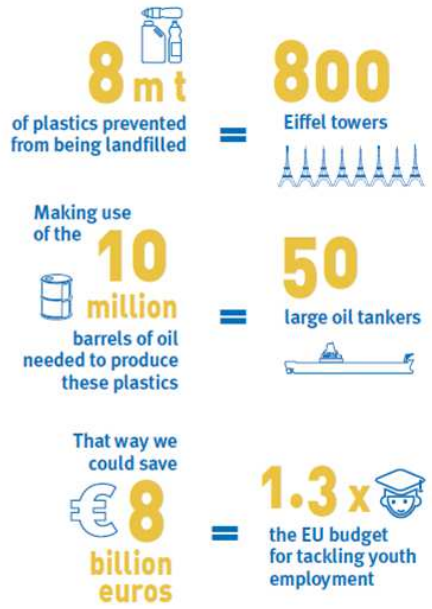
- ✓ More than 70% of the plastic produced globally ends up in the environment and 10% is effectively recycled
- ✓ Material leakage (e.g. marine litter) is an increasing global challenge. In particular in Asia (>90%) due to population growth and poor waste management.

Source: Ellen MacArthur Foundation – The New Plastics Economy – Rethinking the Future of Plastics – January 2016

EUROPE IS FRONTRUNNER BUT …..

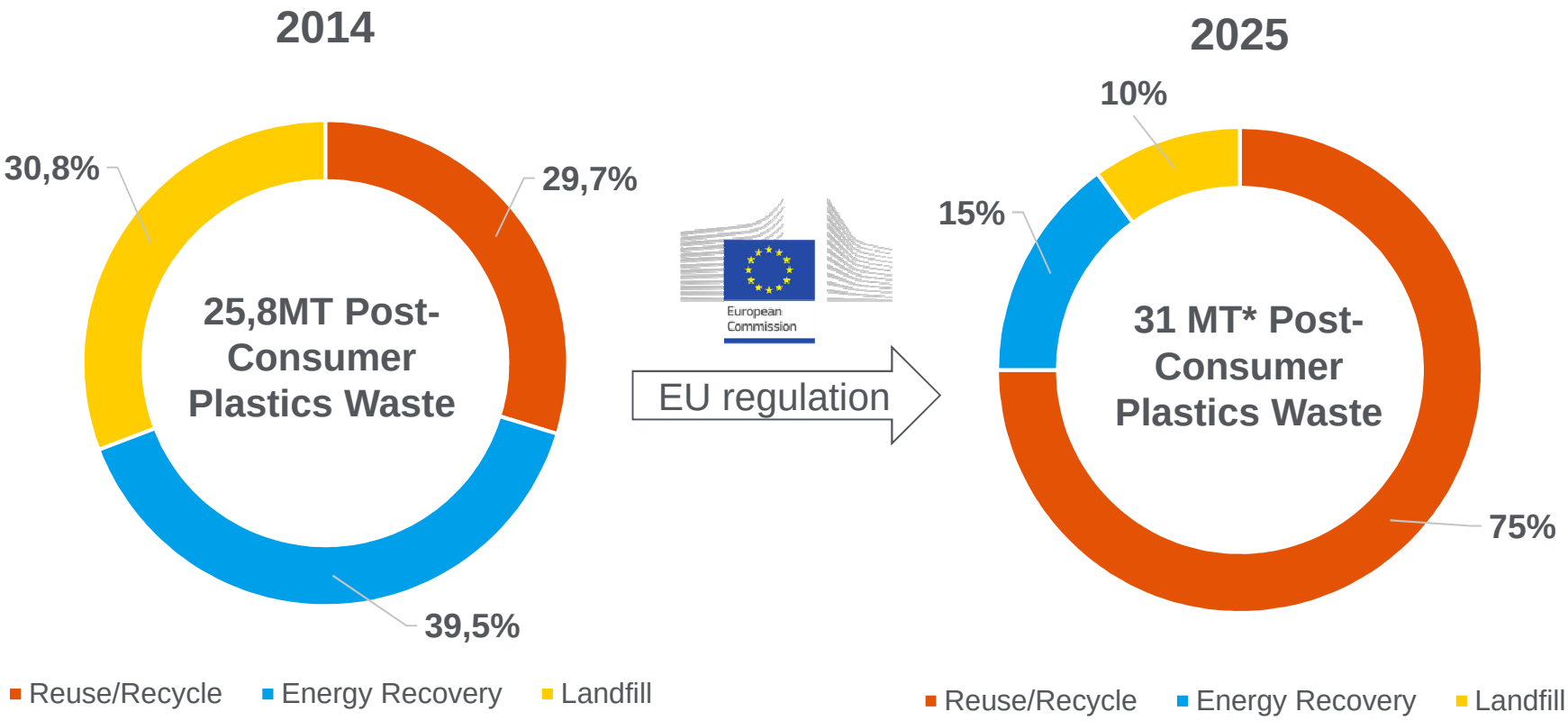






Source: PlasticsEurope – Plastics - The Facts 2016

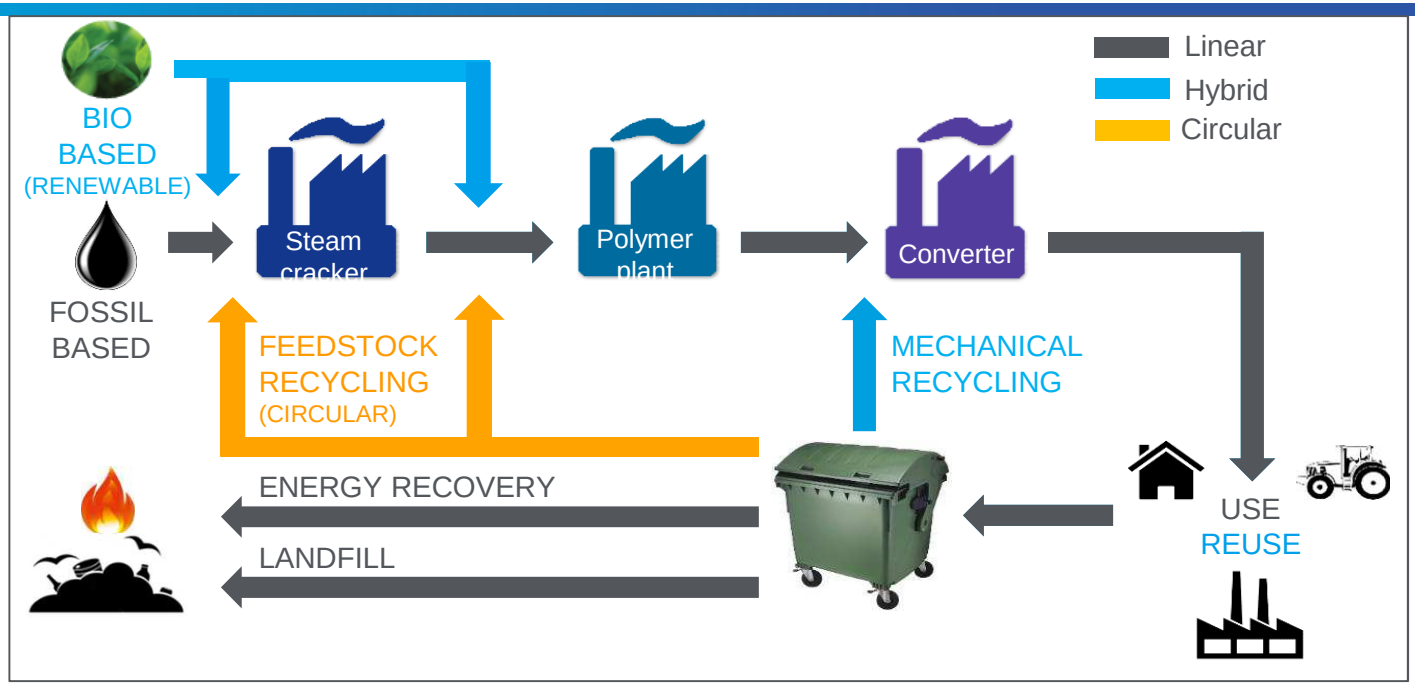
EUROPE IS FACING A HUGE CHALLENGE



- ✓ Europe is by far the most advanced with respect to Circular Economy technology and legislation
- ✓ Nevertheless the technology challenges are still huge to meet the EU regulation targets

Source: PlasticsEurope – The Facts 2016; EC CIRCULAR ECONOMY PACKAGE RELEASED ON DECEMBER 2, 2015

THERE IS NO SINGLE CIRCULAR SOLUTION



- ✓ Mechanical recycling is a delayed linear economy (i.e. downcycling) requiring defined/ closed waste streams (i.e. not MWP) combined with safety issues (i.e. no food approval)
- ✓ Feedstock recycling is a full circular option but requires technical breakthroughs and high investments
- ✓ Chemical, mechanical and energy recovery options should be preferred based on full LCA (incl. use phase)

BIOPLASTICS ARE NO SOLUTION FOR CIRCULAR ECONOMY

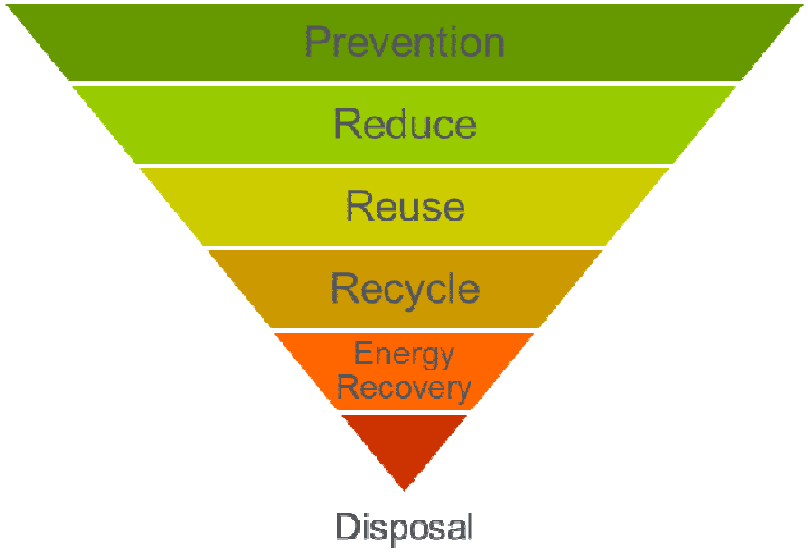
Bioplastics are a welcome addition but no solution for the circular economy

- Bioplastics are renewable and/or biodegradable
- If made from by-products or waste (i.e. 2nd generation), they can have lower environmental impacts
- Functional advantages for specific industries (healthcare, agriculture,….)

- The degradability has no added value if digestion or composting are considered and compared to MWI with energy recovery
- Complicate the recycling process and/or very strict composting conditions
- Cover a small portion of total global plastics market; i.e. remain niche
- Cost competiveness and installed capital employed …..

Source: Carbotech, European Food & Beverage Plastic Packaging 2016

FULL VALUE CHAIN ENGAGEMENT IS REQUIRED TO CLOSE LOOP



- Prevention, Reduce and Reuse are preferred over Recycling
- Full value chain engagement is a prerequisite for a successful circular economy
- The circular economy is as strong as the weakest link Circular economy solutions should ultimately be cost competitive (i.e. not subsidized)

SUMMARY

KEY TECHNOLOGY AND VALUE CHAIN INNOVATION CHALLENGES

Prevention (3P's, Convenience, Compliance)

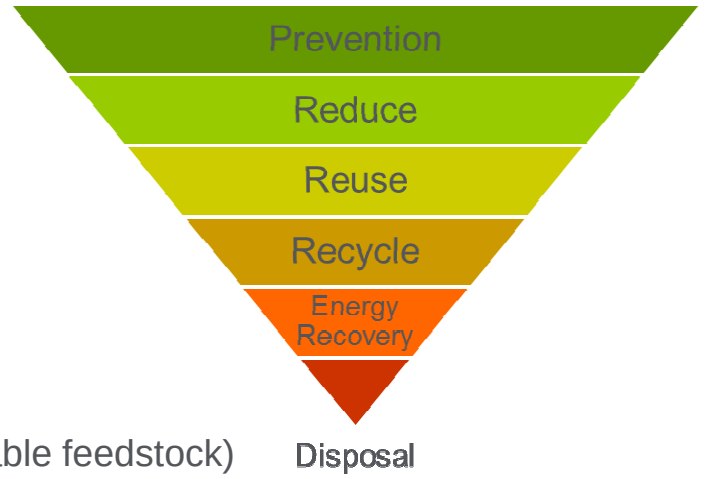
- Protection/Preservation (Barrier, Adhesion/Sealing, Sensors)
- Functionality (e.g. Easy-opening, Re-closability)
- Purity/Safety (e.g. Additives/ inks, NIAS)

Reduce & Reuse: lightweight and design for sustainability

Recycling

- Develop viable and cost competitive mechanical and chemical recycling technologies
- Improve waste management efficiency/technologies
- Full value chain commitment/involvement

Energy recovery remains option based on LCA

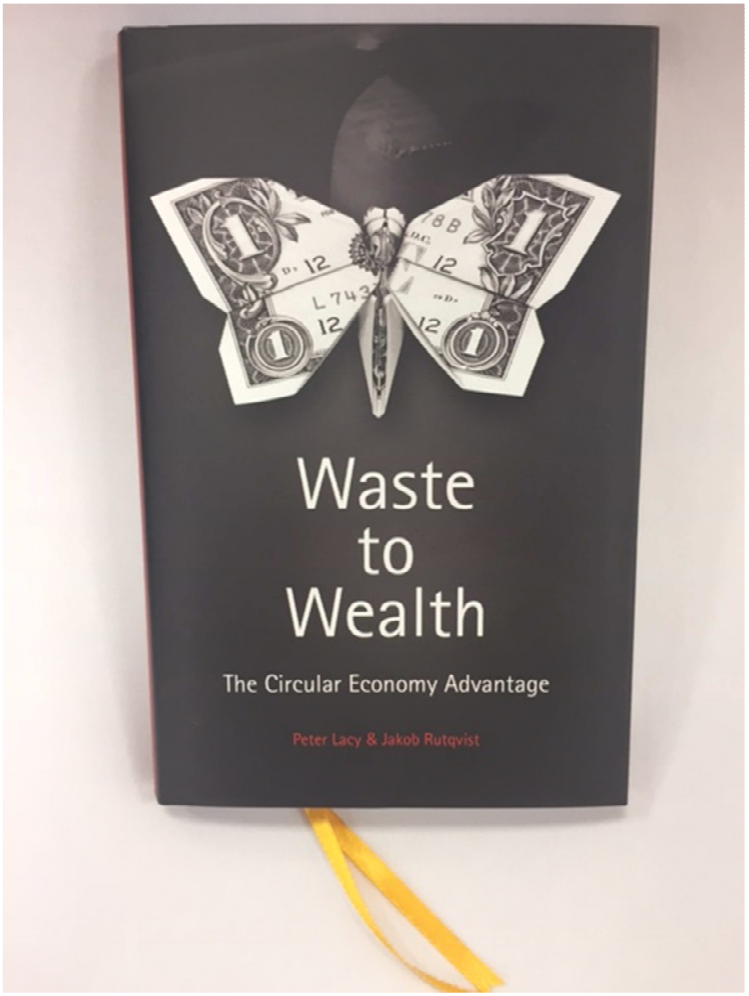


Disposal

- Divert from landfill completely
- Reduce leakage by improved awareness and waste management, in particular Asia (i.e. Plastic waste is valuable feedstock)

Closing the loop requires commitment of the complete value chain and cross-discipline academic collaboration

CIRCULAR ECONOMY IS DISRUPTIVE OPPORTUNITY



… "Circular economy represents a huge opportunity for companies to create competitive advantage, or as we put it, ***"Circular Advantage",*** *disrupting the way we produce and consume through innovative business models, digital technologies, and engineering, and enabling capabilities that support these systems."…..*

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