Plastic's Tipping Point

Roland Geyer, PhD, Dipl.-Phys.
Bren School of Environmental Science and Management

https://rolandgeyer.com

MARINE POLLUTION **Science** 13 Feb 2015

Plastic waste inputs from land into the ocean

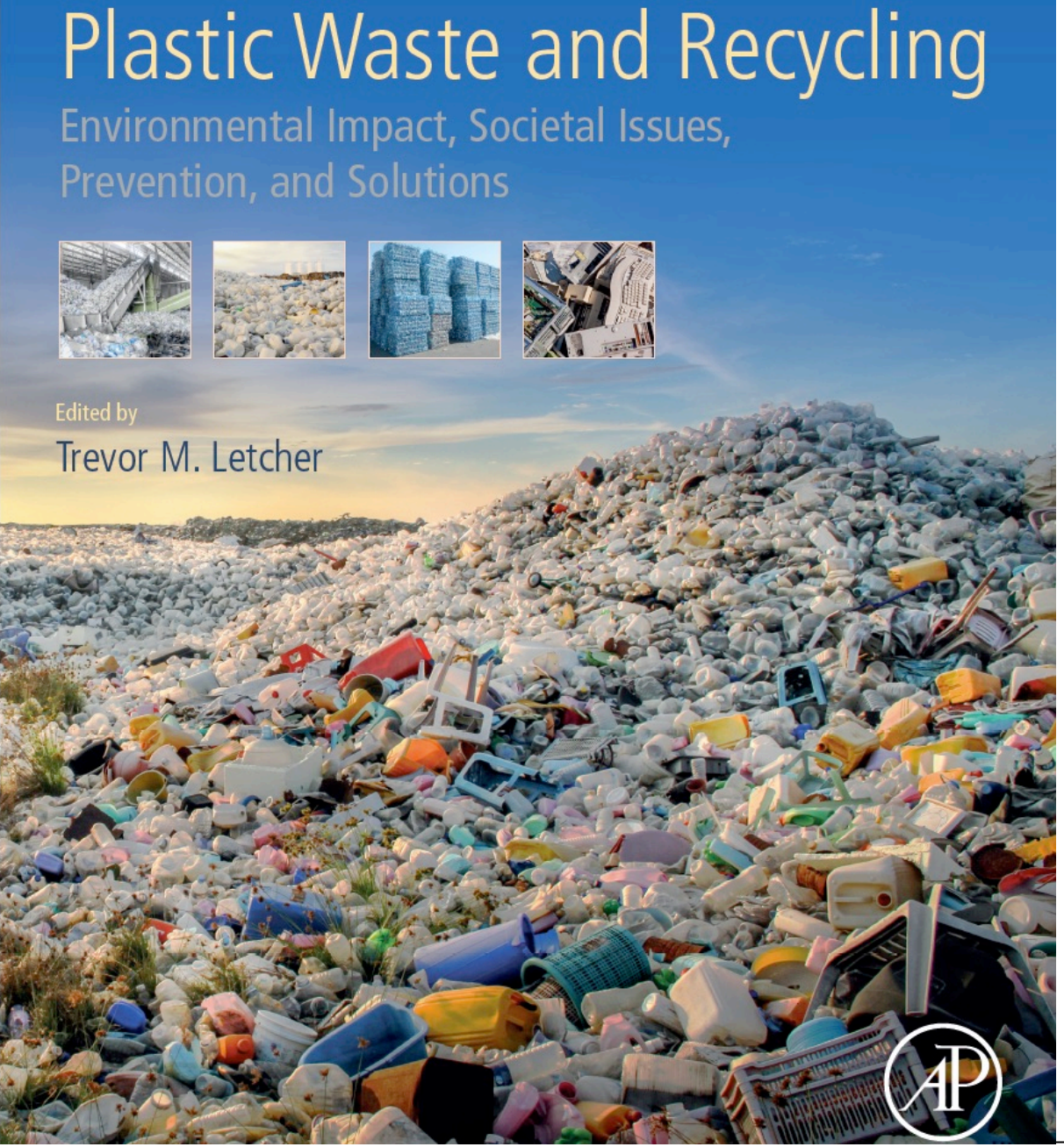
Jenna R. Jambeck,[1]* Roland Geyer,[2] Chris Wilcox,[3] Theodore R. Siegler,[4] Miriam Perryman,[1] Anthony Andrady,[5] Ramani Narayan,[6] Kara Lavender Law[7]

SCIENCE ADVANCES | RESEARCH ARTICLE 19 July 2017

PLASTICS

Production, use, and fate of all plastics ever made

Roland Geyer,[1]* Jenna R. Jambeck,[2] Kara Lavender Law[3]



Chapter 2:
Production, use, and fate of synthetic polymers

Roland Geyer
Bren School
UCSB

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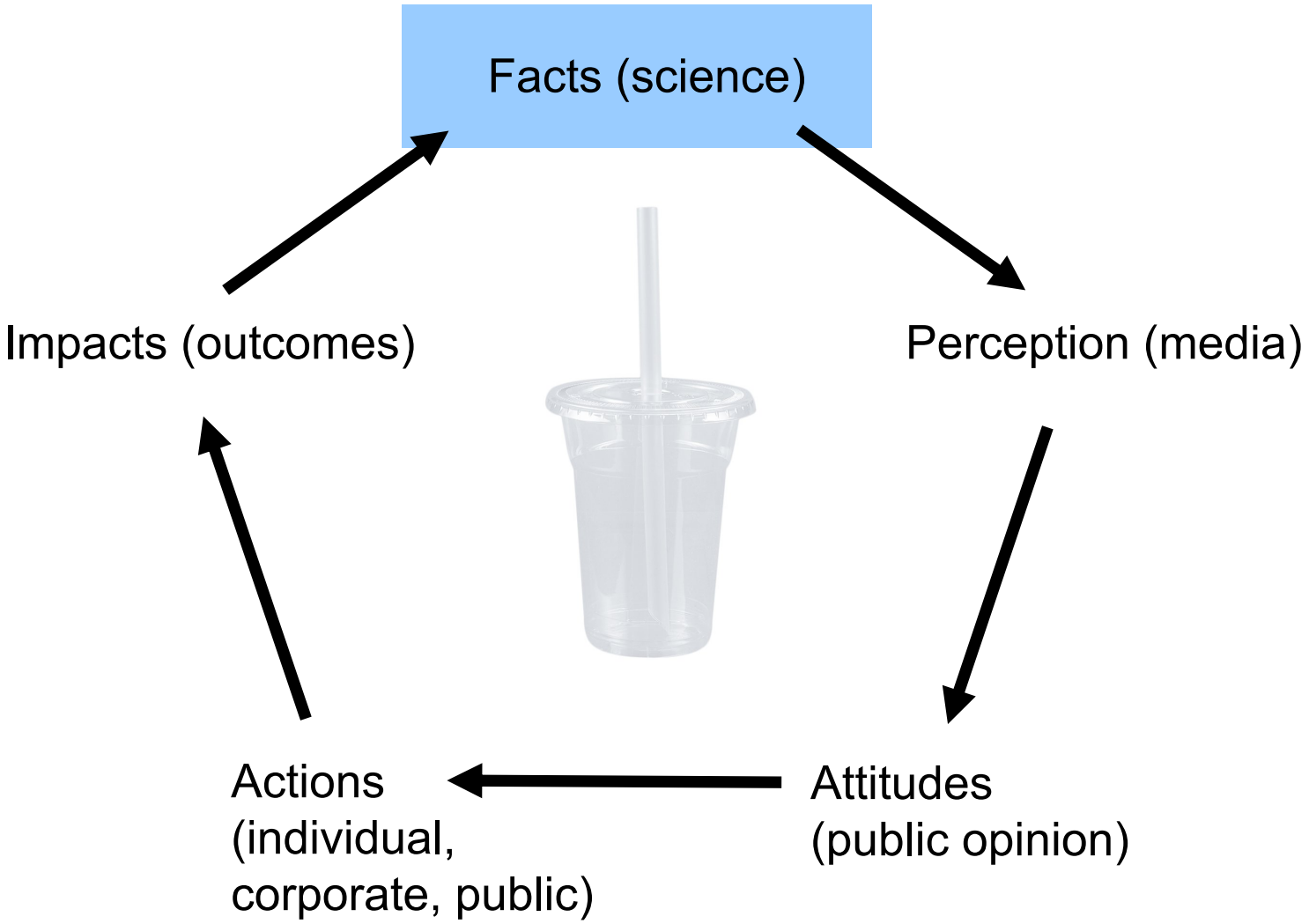
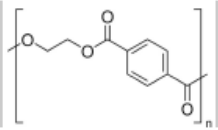
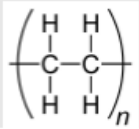
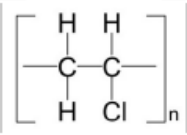
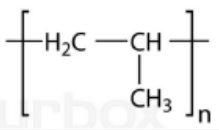
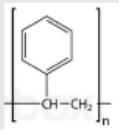
Roland's Theory of Change



Origins and Taxonomy

- 1850s/60s Invention of Cellulloid/Parkesine
- 1907 Invention of Bakelite
- 1920s Polyvinyl Chloride (blended with plasticizers)
- 1930s Nylon 6,6 and 6, Polystyrene, Polyethylene (PE)
- 1940s Polyethylene Terephthalate (PET)
- 1950s Polypropylene, catalytic polymerization of PE
- 1950 Commonly used to mark the begin of mass production

Types of Plastics

Plastic	Code	Name	Structure	Typical uses
PET	1 PET	Polyethylene terephthalate		Beverage bottles, textiles
HDPE	2 HDPE	High density polyethylene		Containers, fuel tanks
PVC	3 PVC	Polyvinyl chloride		Pipes, wire coating, bottles, blister pack
(L)LDPE	4 LDPE	(Linear) low density polyethylene	Branched PE	Film, grocery bags
PP	5 PP	Polypropylene		Automotive parts, outdoor furniture, containers
(HI)PS	6 PS	(High impact) polystyrene		EPS foam, CD cases, hangers, toys, TV housings, keyboards
PC, ABS, PC/ABS, PA66, PLA	7 OTHER	various	various	Electronics, auto interiors, appliances

The two categories of plastics

Thermoplastics

are a family of plastics that can be melted when heated and hardened when cooled. These characteristics, which lend the material its name, are reversible. That is, it can be reheated, reshaped and frozen repeatedly.

- Polyethylene (PE)
- Polypropylene (PP)
- Polyvinyl-chloride (PVC)
- Polyethylene Terephthalate (PET)
- Polystyrene (PS)
- Expanded polystyrene (EPS)
- ABS
- SAN
- Polyamides (PA)
- Polycarbonate (PC)
- Poly methyl methacrylate (PMMA)
- Thermoplastic elastomers (TPE)
- Polyarylsulfone (PSU)
- Fluoropolymers
- PEEK
- POM
- PBT
- Etc.

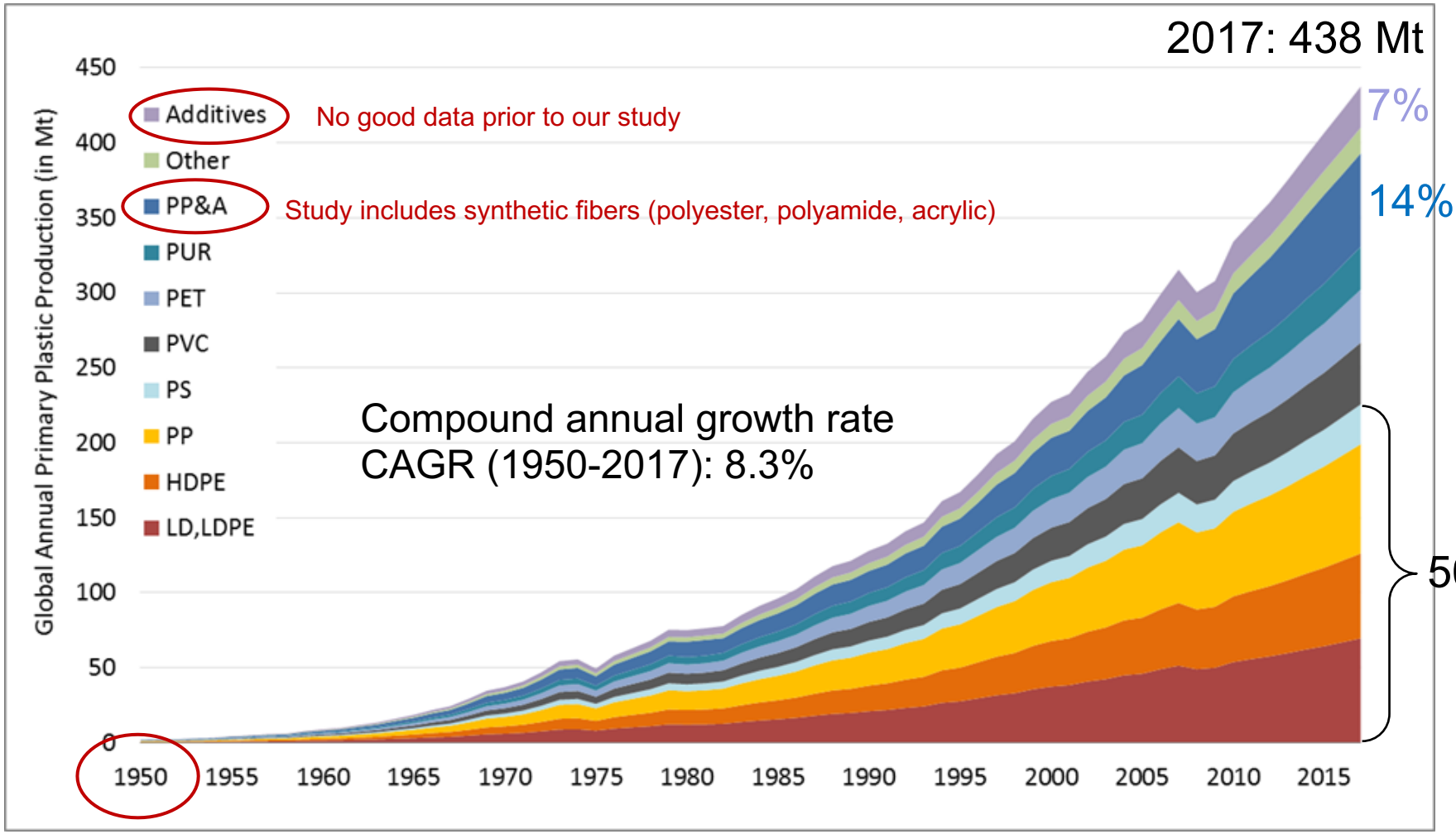
Thermosets

are a family of plastics that undergo a chemical change when heated, creating a three dimensional network. After they are heated and formed these plastics cannot be re-melted and reformed.

- Polyurethane (PUR)
- Unsaturated polyester
- Epoxy resins
- Melamine resin
- Vinyl ester
- Silicone
- Phenol - formaldeyhde
- Urea - formaldeyhde
- Phenolic resins
- Acrylic resins
- Etc.

Production

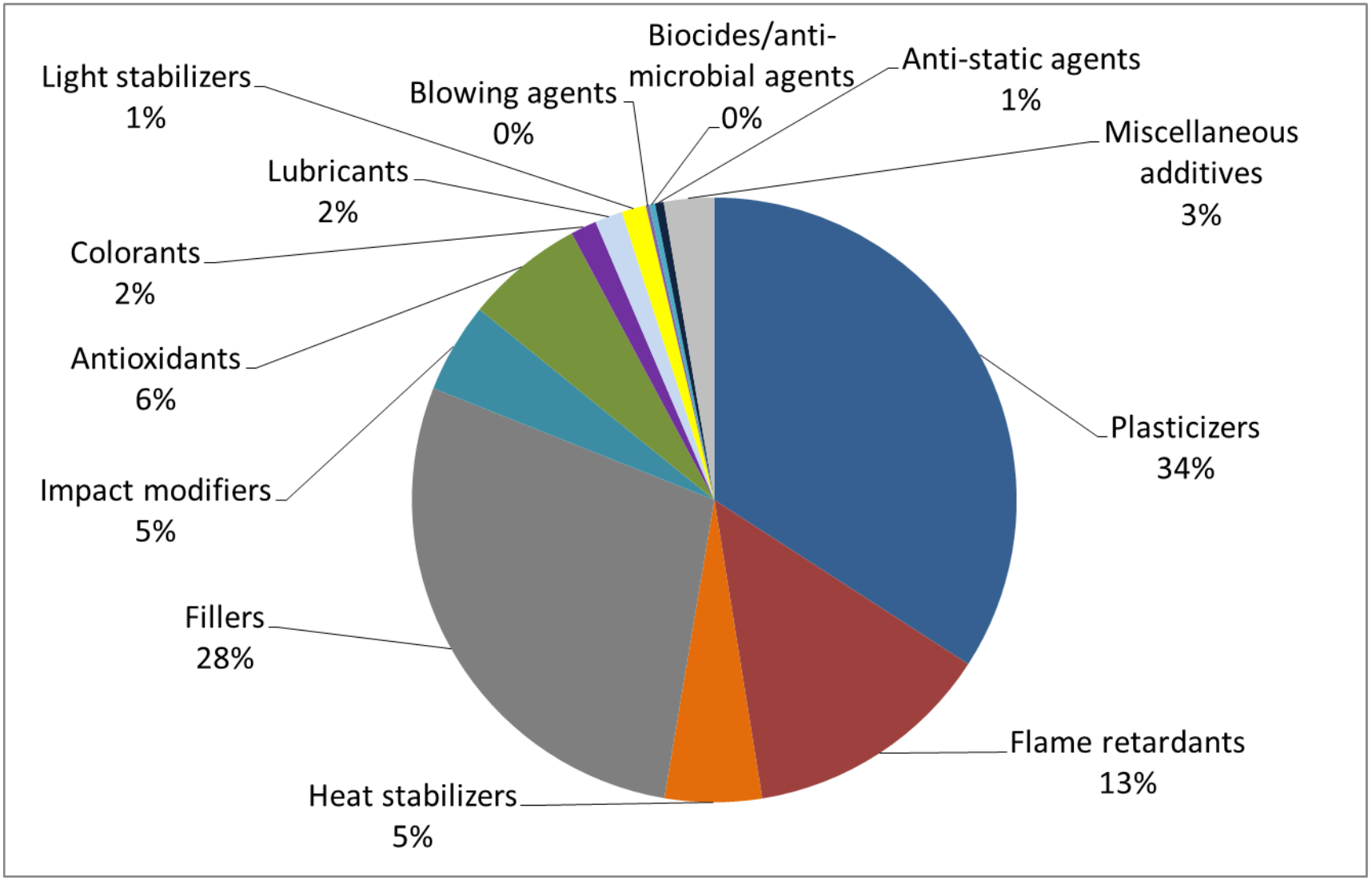
Global primary plastics production by polymer (in million metric tons, or Mt)



Production of all plastics ever made

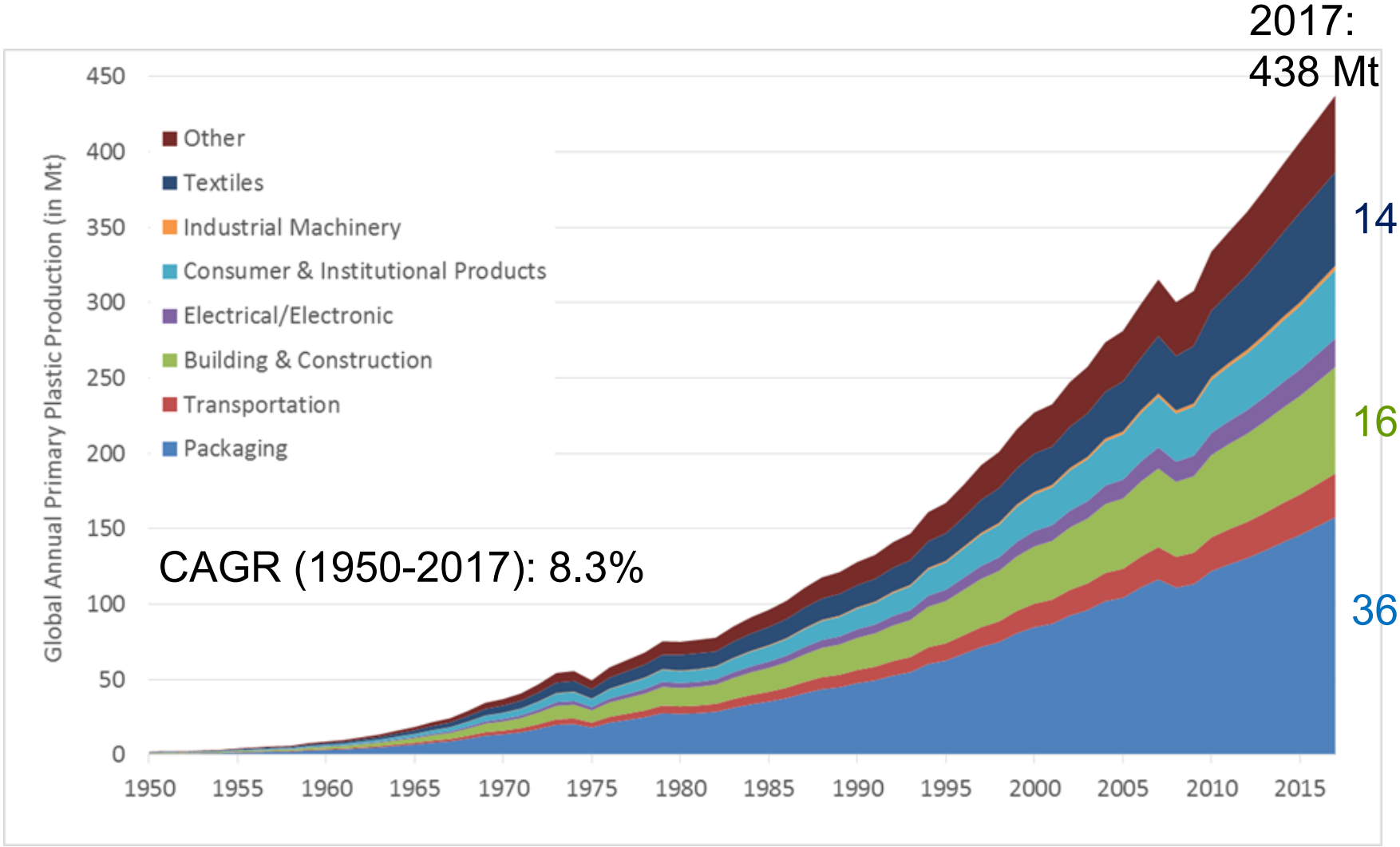
Source: Geyer, Jambeck, Lavender Law

Global Use of Additives



Source: Geyer, Jambeck, Lavender Law

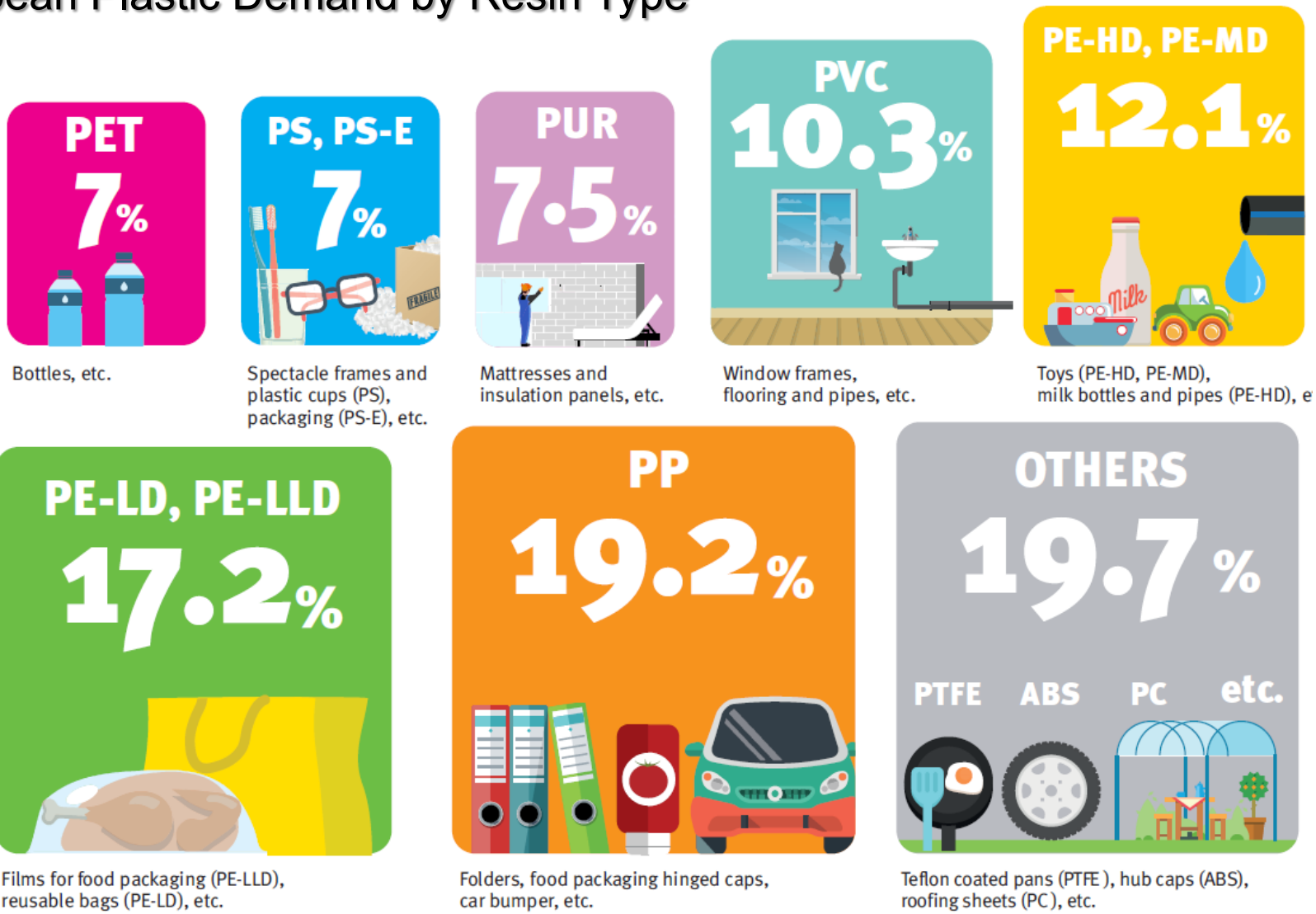
Global primary plastics production by consuming sector



Source: Geyer, Jambeck, Lavender Law

Use

European Plastic Demand by Resin Type



European plastics demand* by polymer type 2014

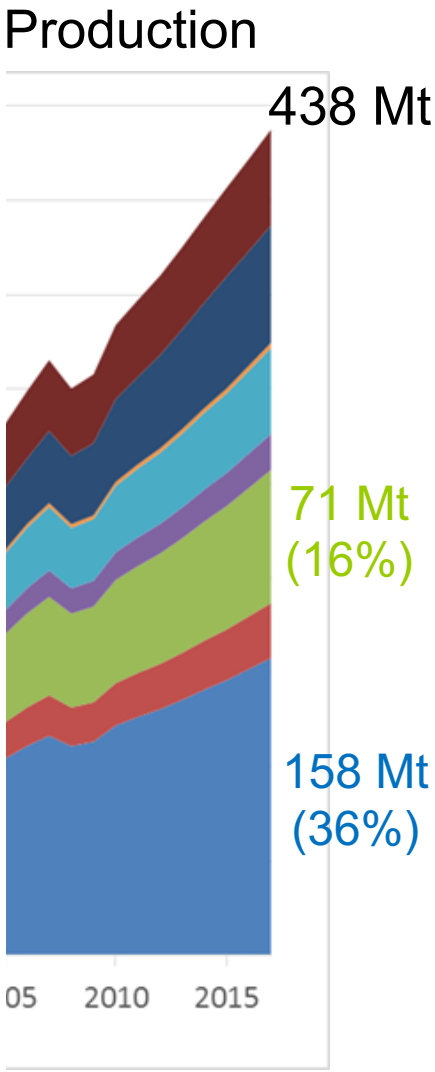
Source: PlasticsEurope (PEMRG) / Consultic / myCeppi
* EU-28+NO/CH

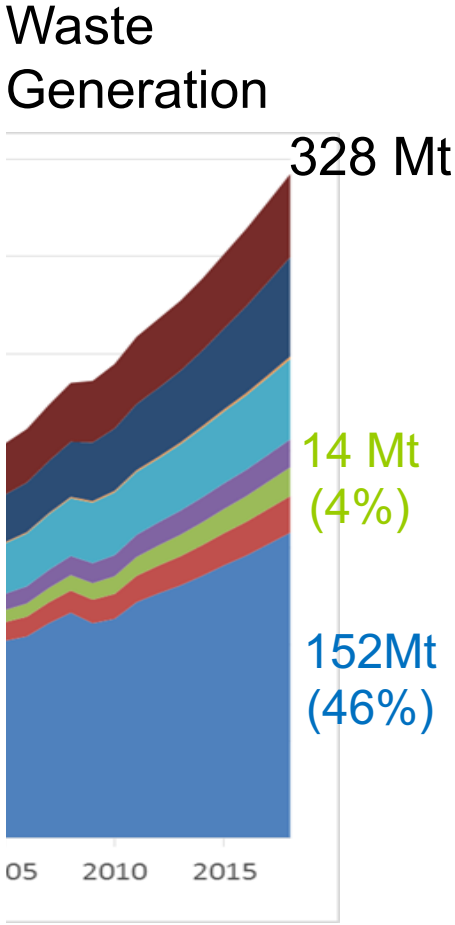
Source: Plastics Europe, excludes fibers

Plastic waste generation

Household waste generation		Plastic content
USA:	5.7 lbs/person/day	13%
France:	4.2 lbs/person/day	10%
Mexico:	2.7 lbs/person/day	7%

Continued growth in production means that the in-use stock is also growing





Year 2017:

438 Mt primary plastic produced

↓

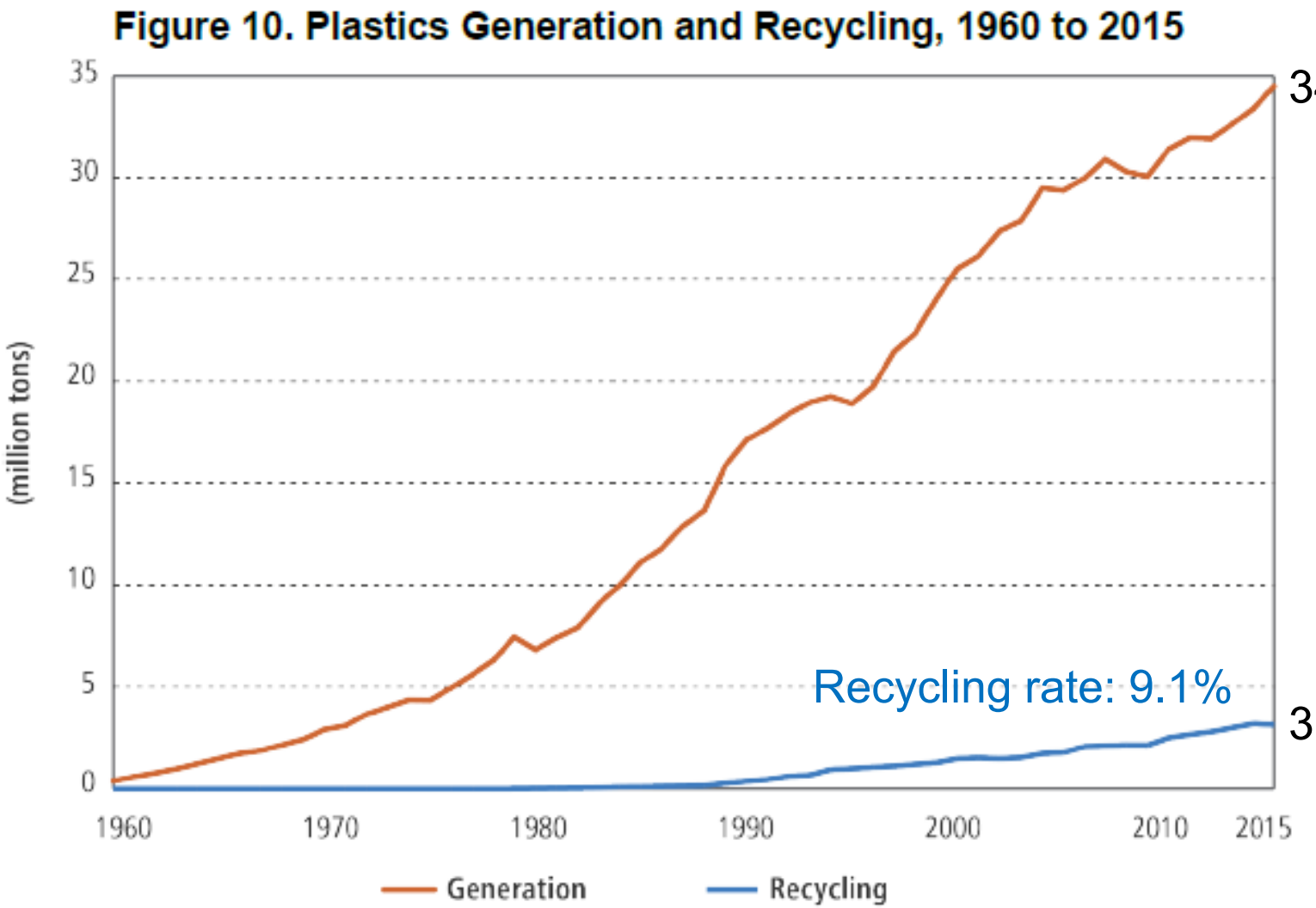
110 Mt added to in-use stock

↓

328 Mt plastic waste generated

Fate of plastic waste

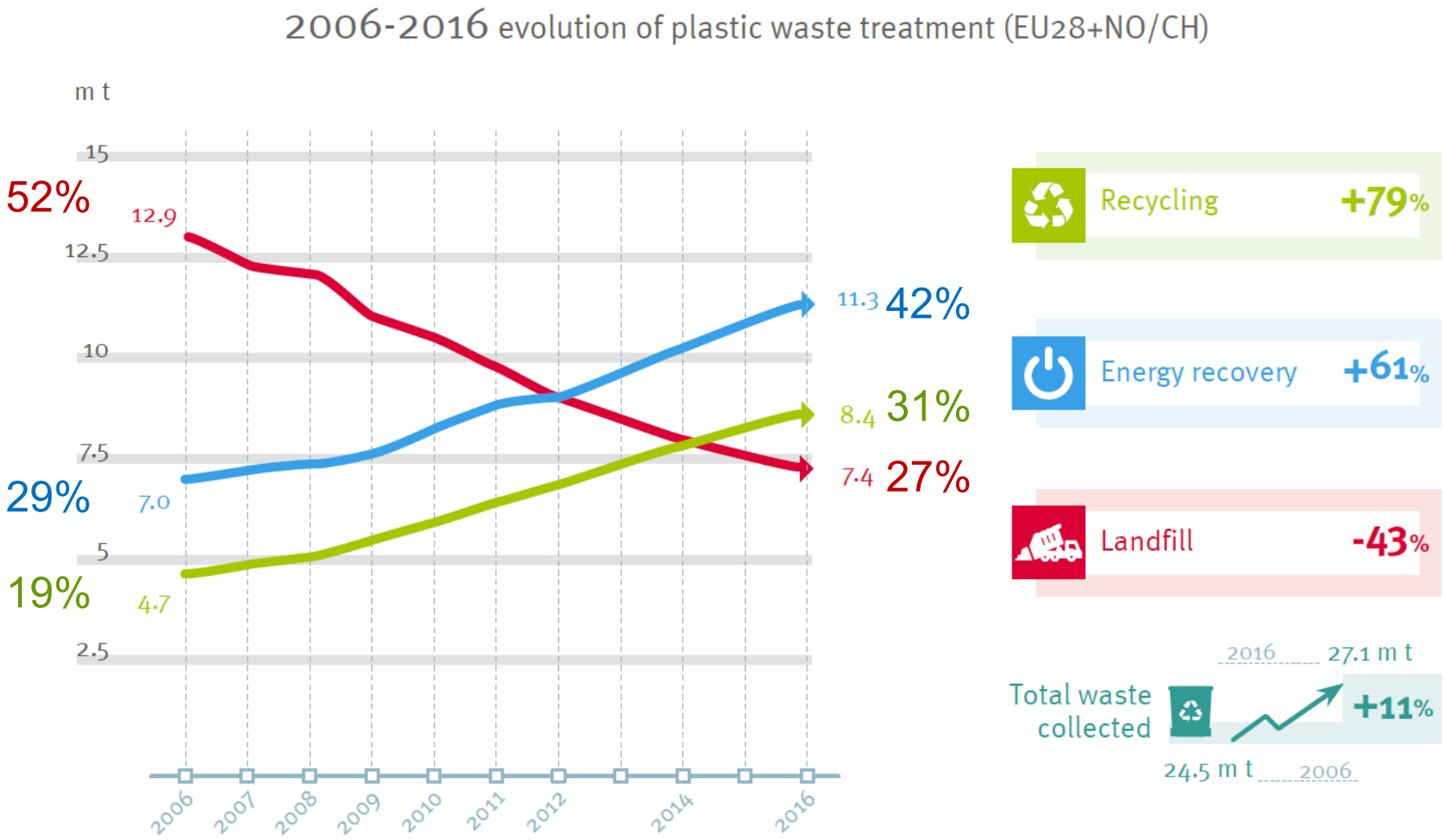
Plastic waste management in the U.S.



Incineration: 1
Landfill: 75%

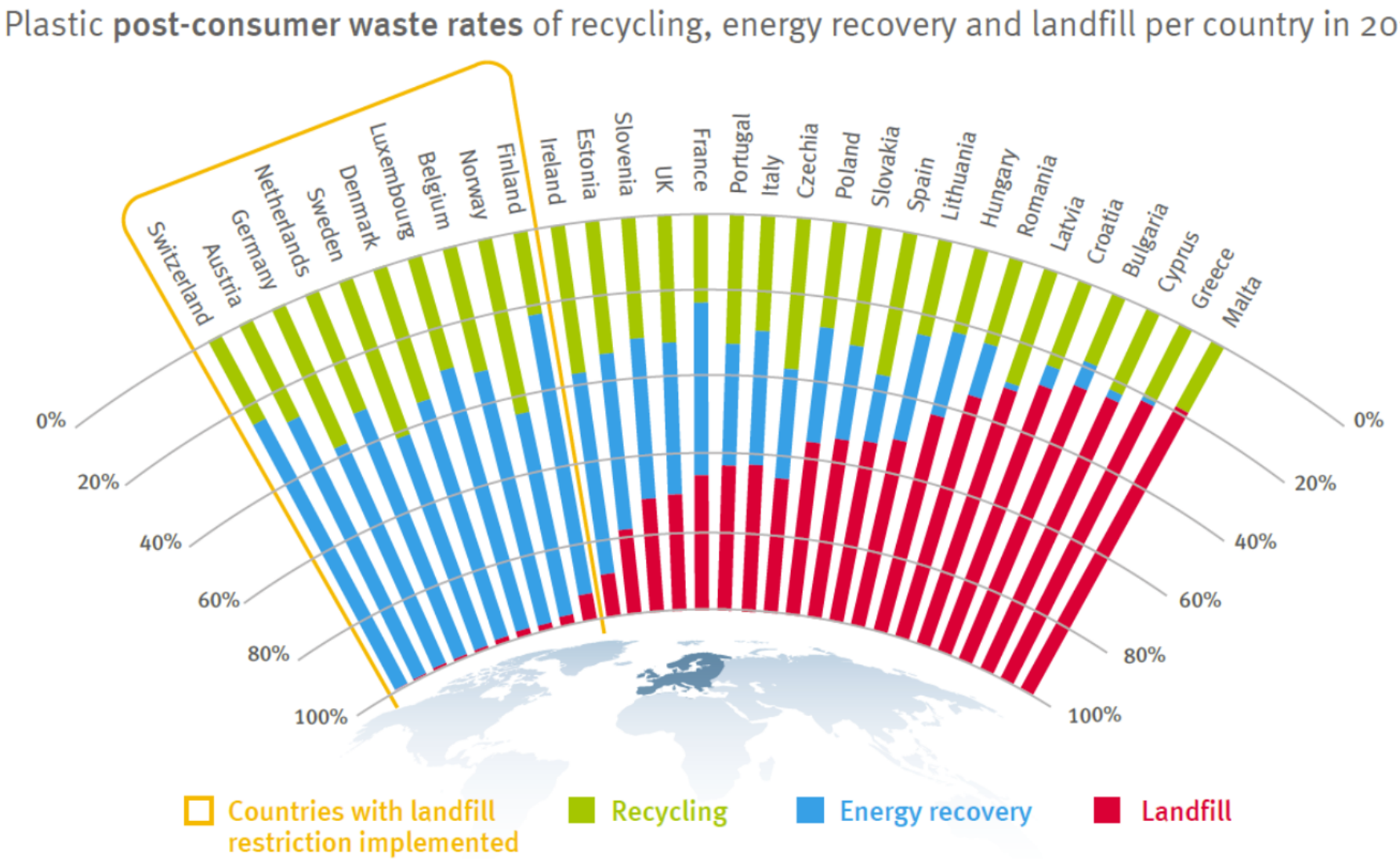
Source: U.S. EPA 2018

Plastic waste management in Europe 2006-2014



Source: Consultic

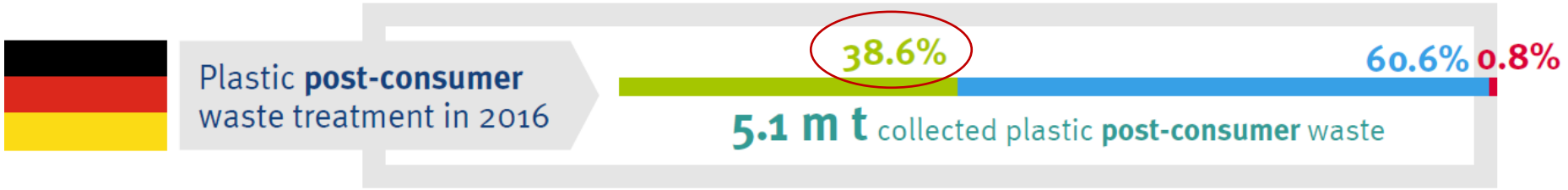
Plastic waste management in Europe by country



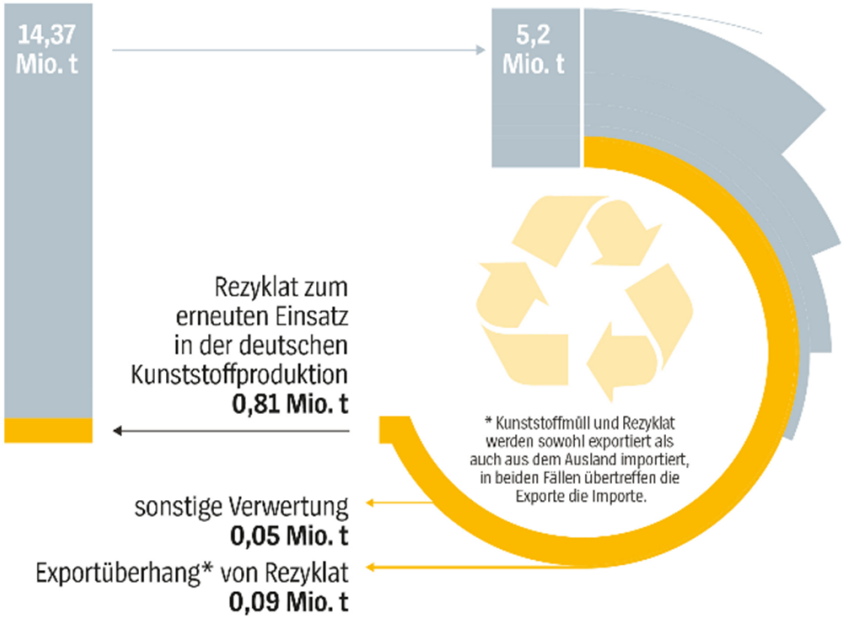
Source: Conversio Market & Strategy

Plastic waste management in Germany

Recycling rate (official number)



Source: Plastics Europe 2018

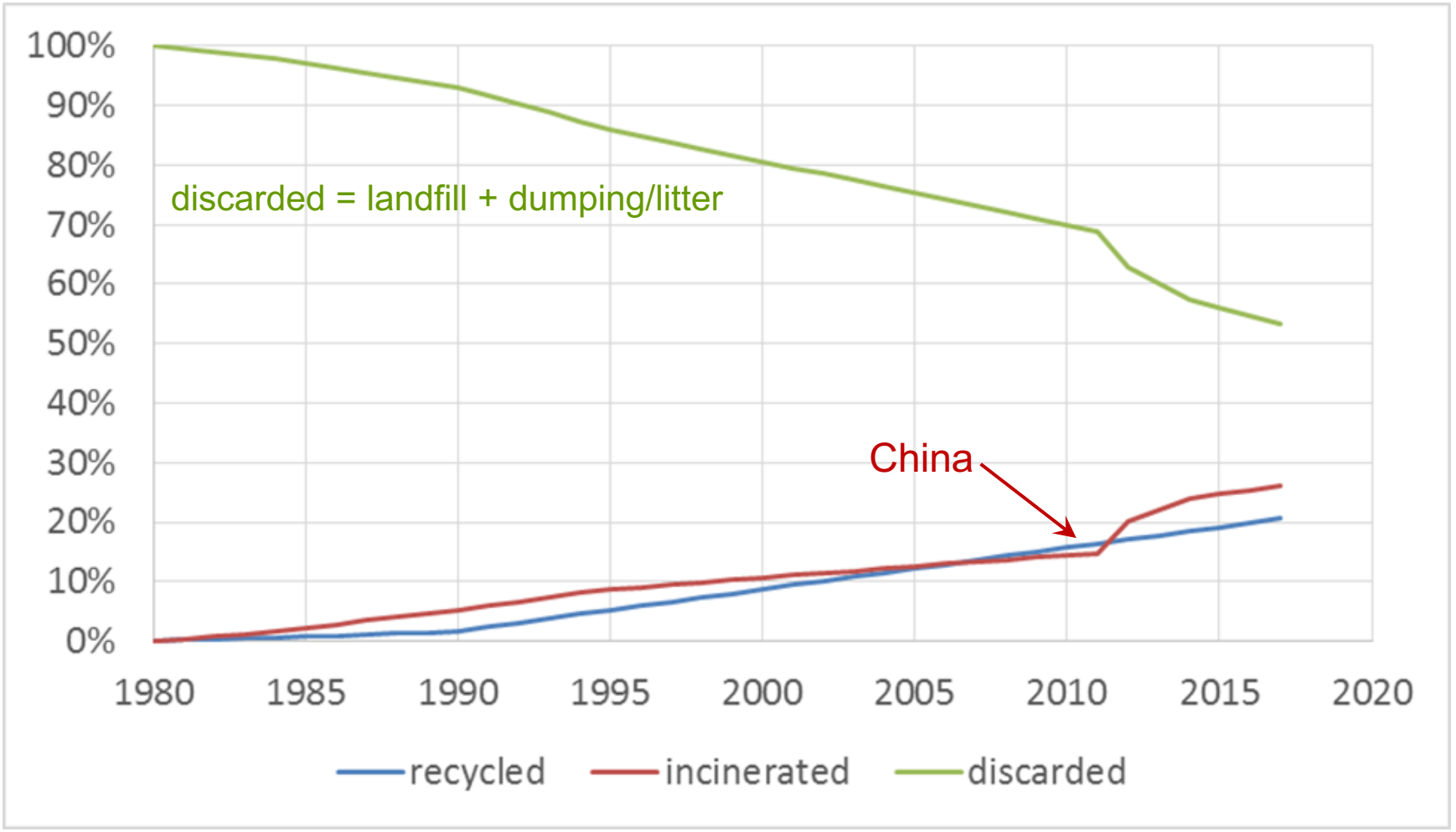


Recycling rate (estimate from German research institute)

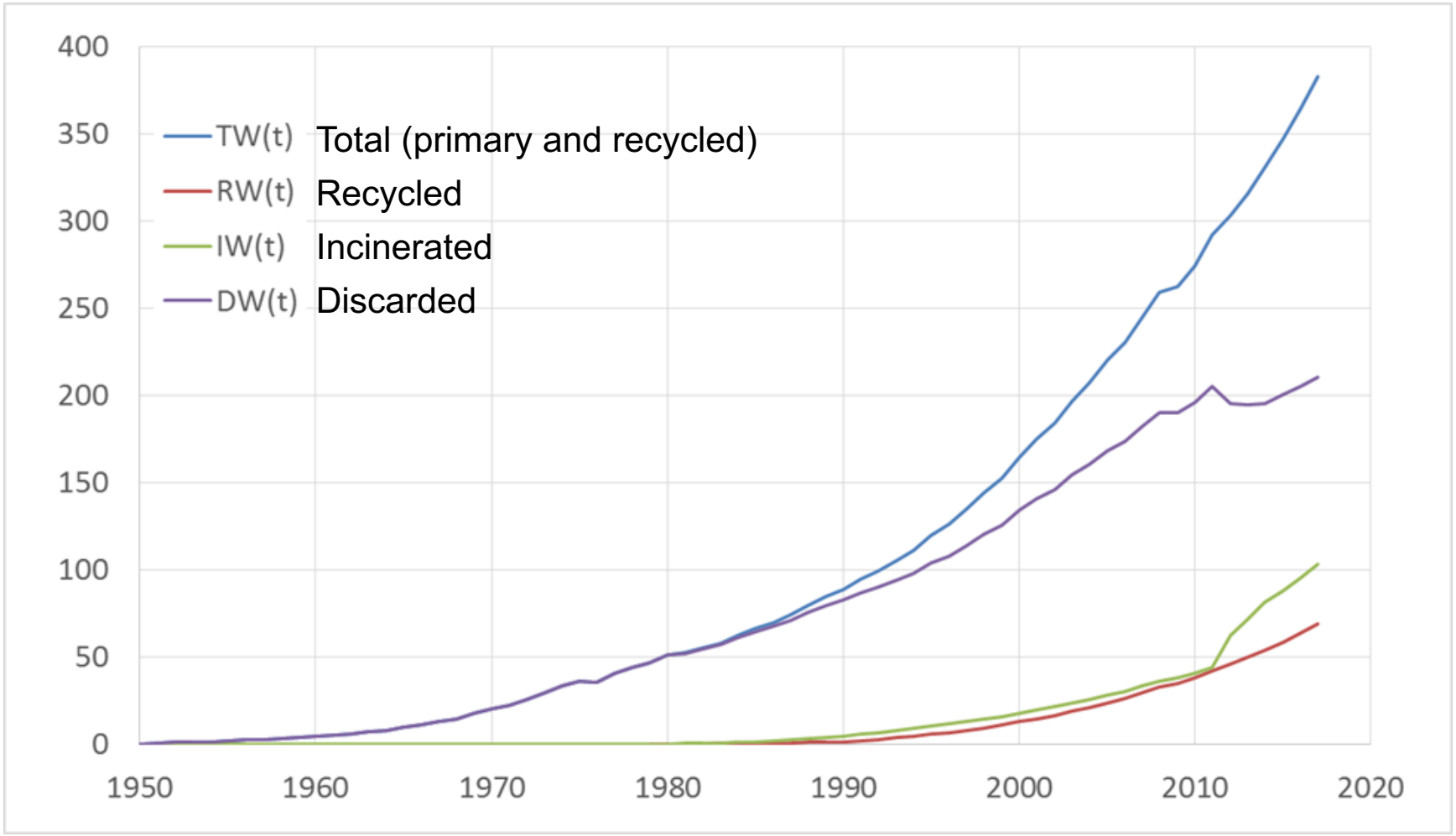
17%

Source: Der Spiegel/Henning Wilts, 2019

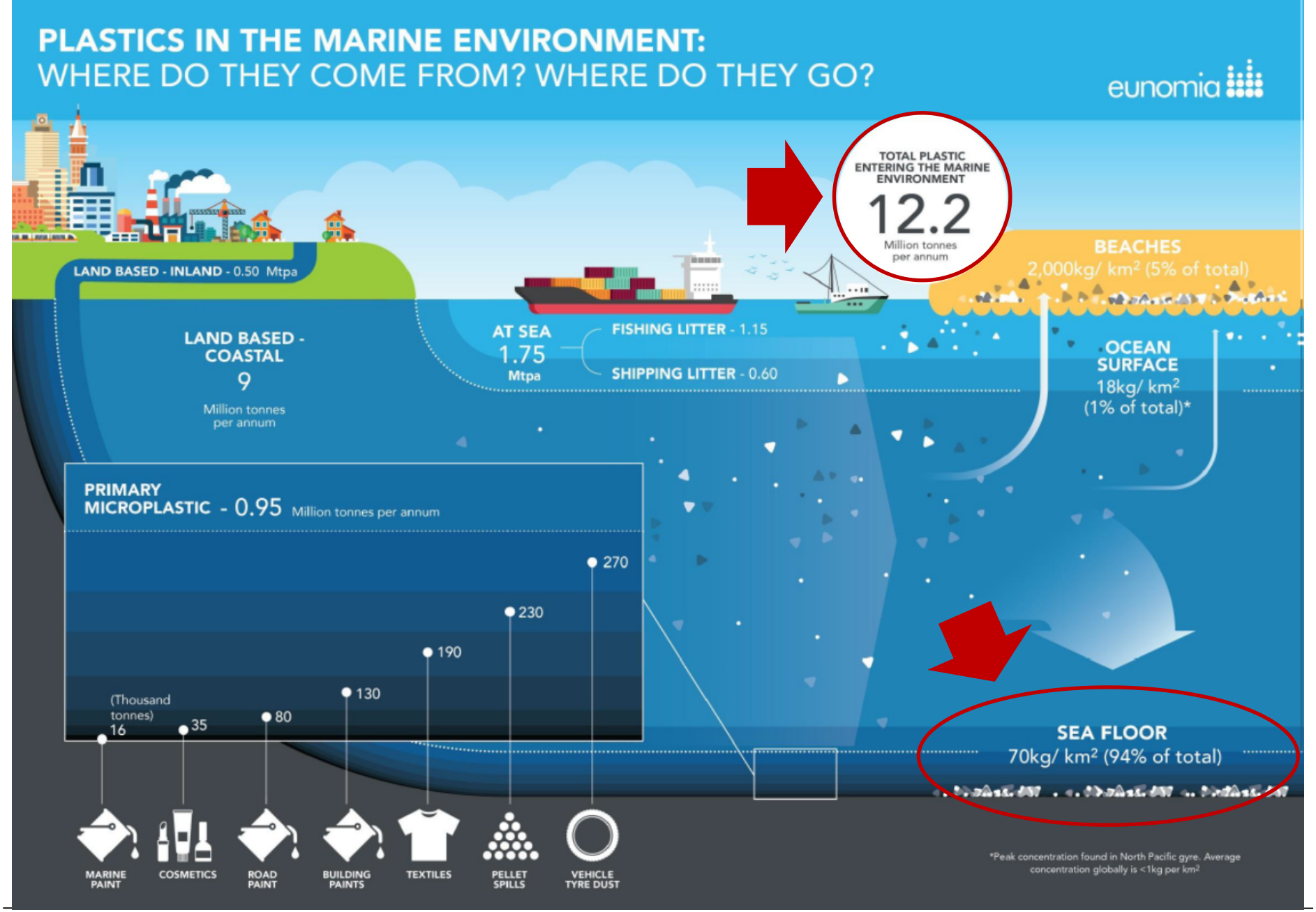
Estimated global recycling, incineration, and discard rates for non-fiber plastics



Generation and fate of annual global total plastic waste (1950-2017, in Mt)

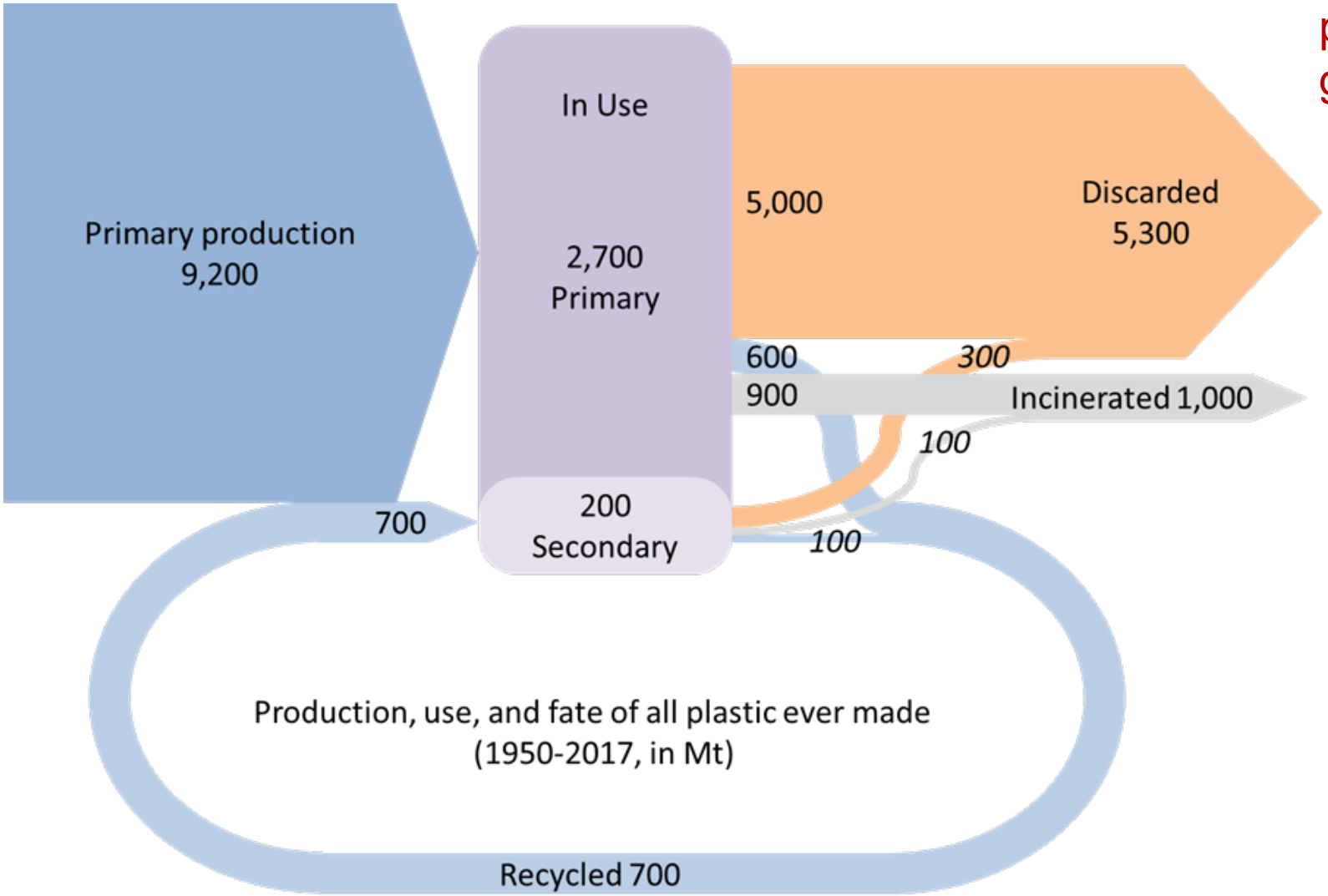


Source: Geyer, Jambeck, Lavender Law


PLASTICS IN THE MARINE ENVIRONMENT:
WHERE DO THEY COME FROM? WHERE DO THEY GO?
eunomia
TOTAL PLASTIC ENTERING THE MARINE ENVIRONMENT
12.2
Million tonnes per annum
LAND BASED - INLAND - 0.50 Mtpa
LAND BASED - COASTAL
9
Million tonnes per annum
AT SEA
1.75
Mtpa
FISHING LITTER - 1.15
SHIPPING LITTER - 0.60
BEACHES
2,000kg/ km² (5% of total)
OCEAN SURFACE
18kg/ km²
(1% of total)*
PRIMARY MICROPLASTIC - 0.95 Million tonnes per annum
(Thousand tonnes)
16
35
80
130
190
230
270
MARINE PAINT
COSMETICS
ROAD PAINT
BUILDING PAINTS
TEXTILES
PELLET SPILLS
VEHICLE TYRE DUST
SEA FLOOR
70kg/ km² (94% of total)
*Peak concentration found in North Pacific gyre. Average concentration globally is <1kg per km²

Cumulative 1950-2017

Production, use, and fate of all plastics ever made, 1950-2017, in Mt



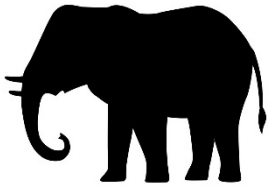
7,000 Mt of plastic waste generated

76% discarded

14% incinerated

10% recycled

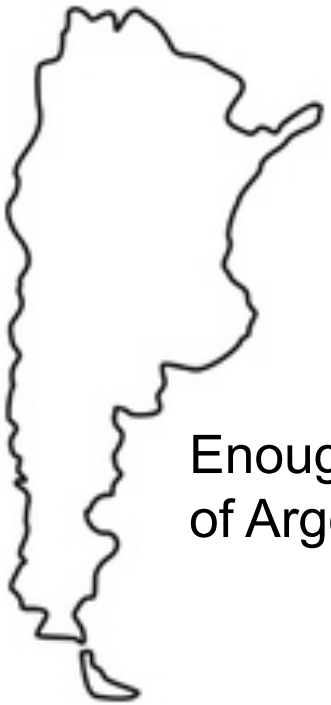
How much is 9.2 billion metric tons?



1,200,000,000

88,000,000

900,000

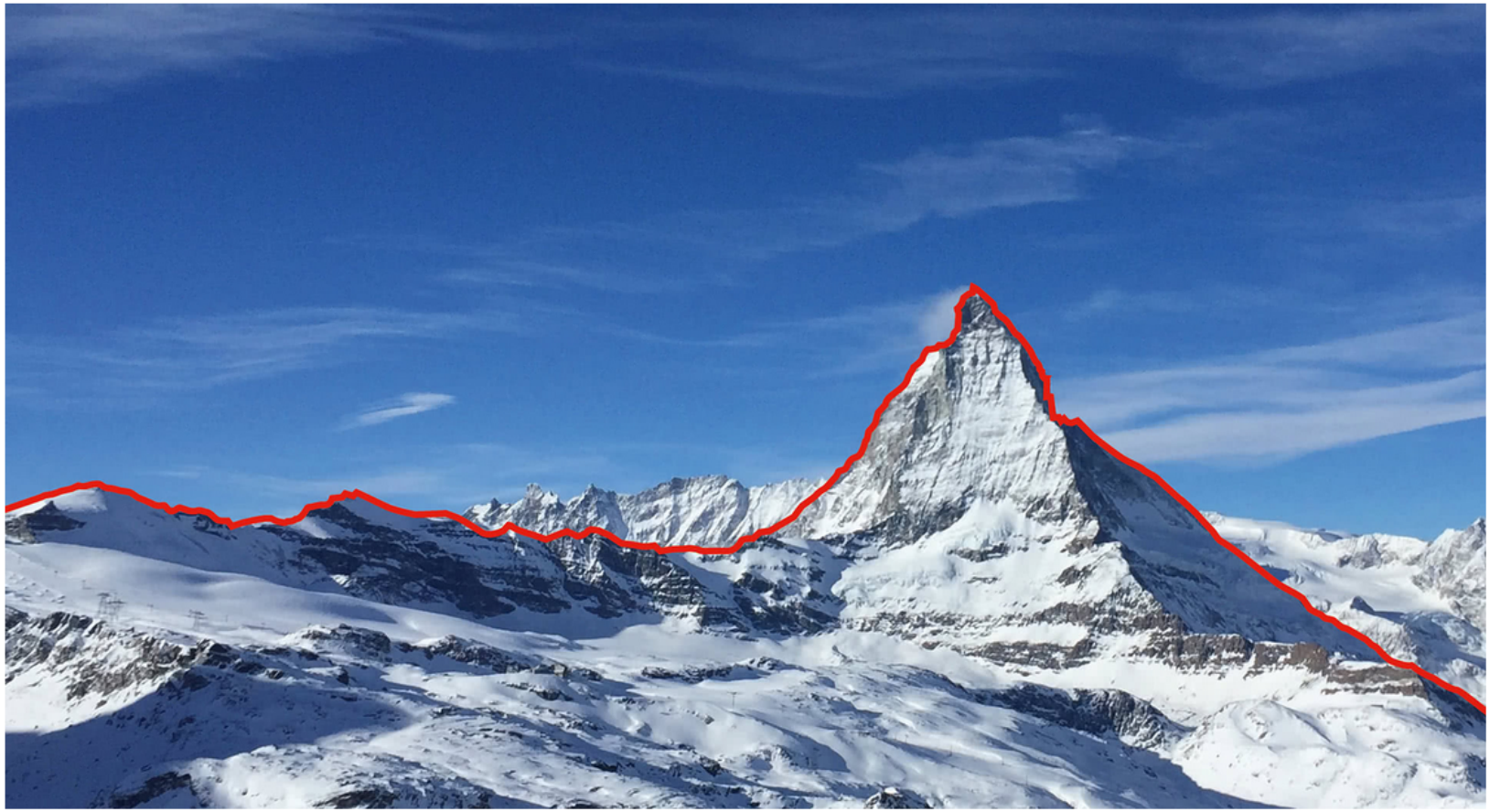


Enough to cover an area the size of Argentina ankle deep in plastic.

Fun fact: Half of the plastic humankind ever made was produced since 2004.

"EARTH PLASTIC VIEW" - AN ART PROJECT BY BRANKO ŠMON

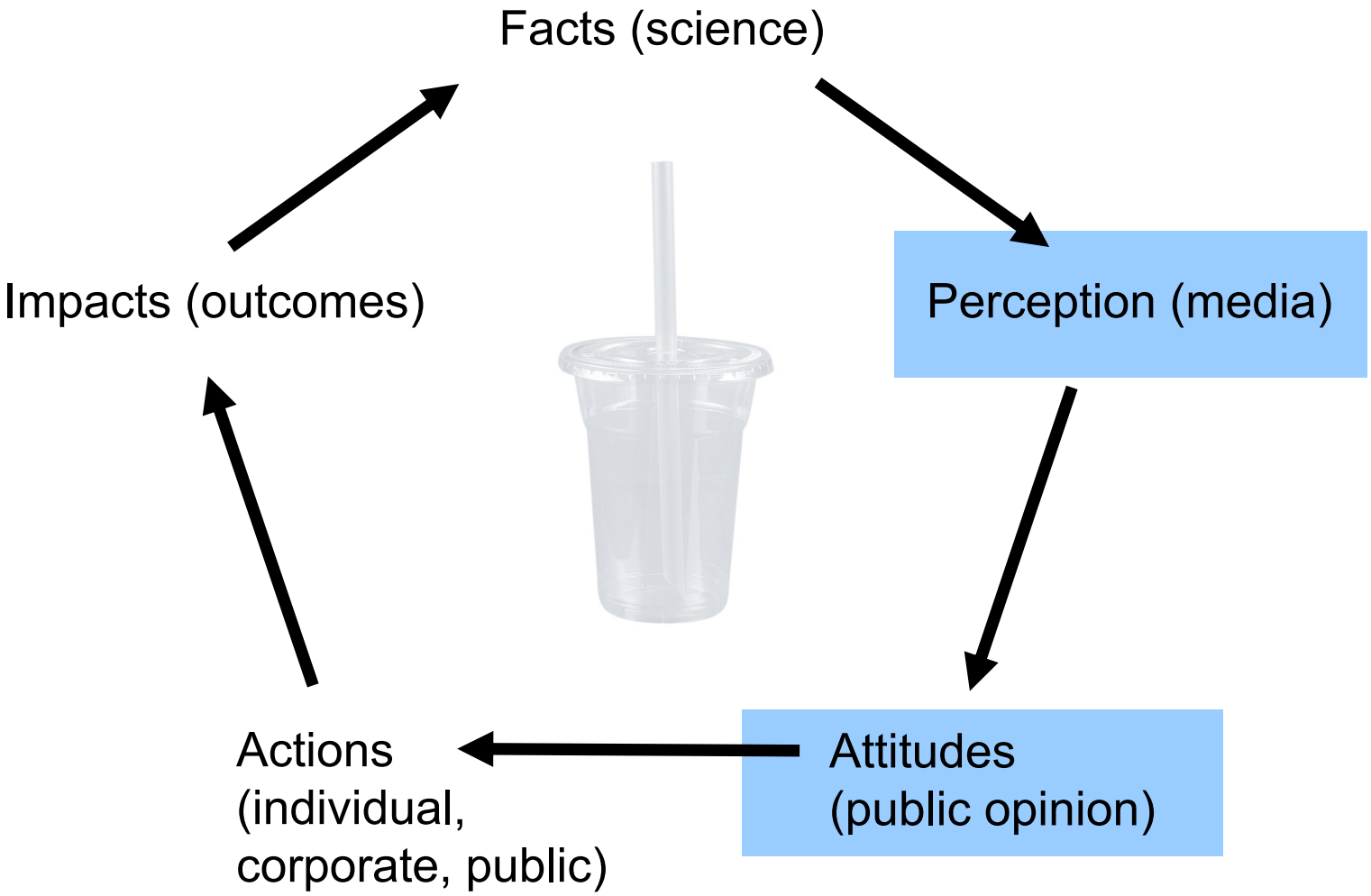
VISUALISATION OF THE WORLDWIDE PLASTIC STOCK
MAKING THE UNBELIEVABLE VISIBLE

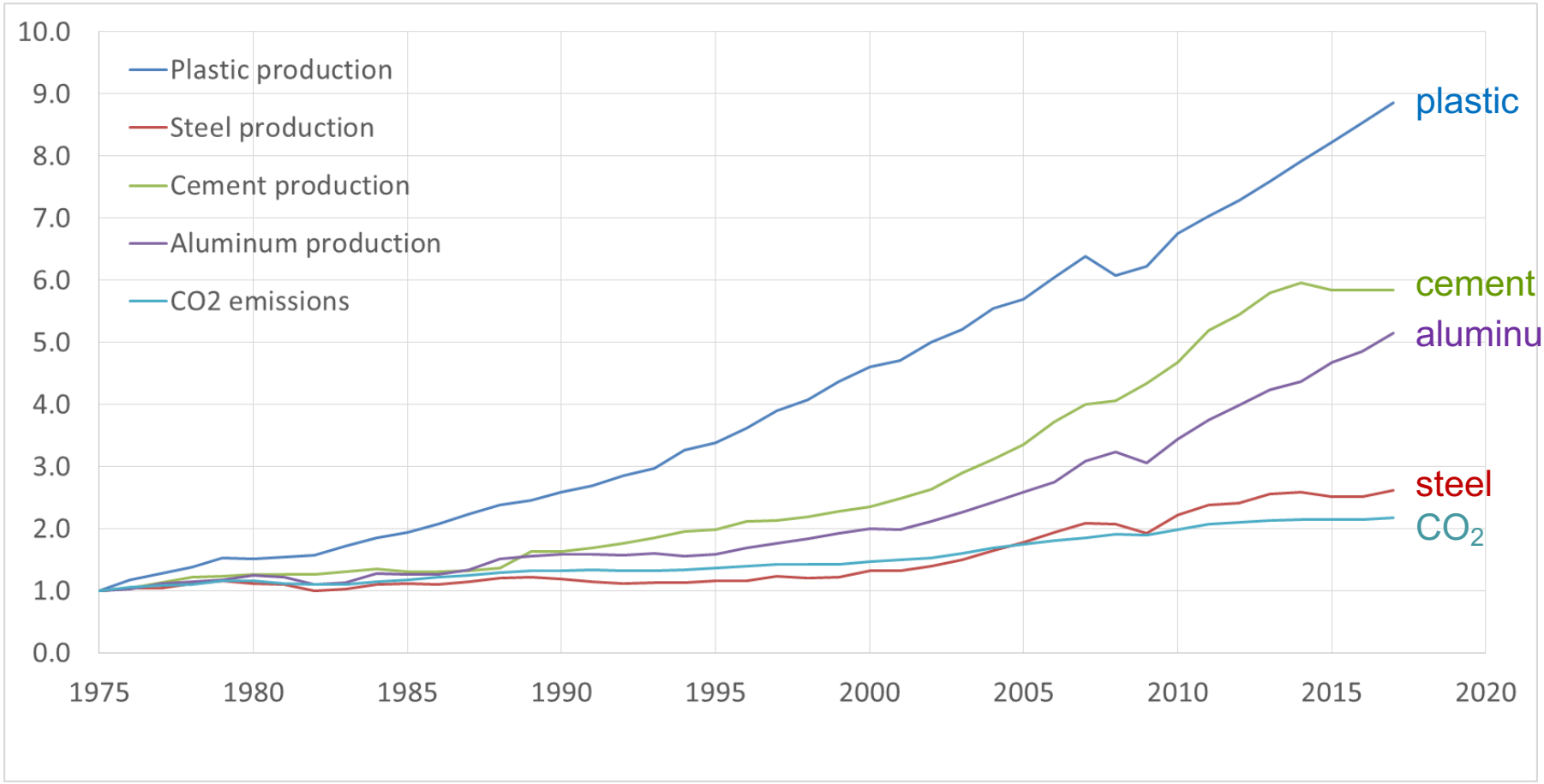


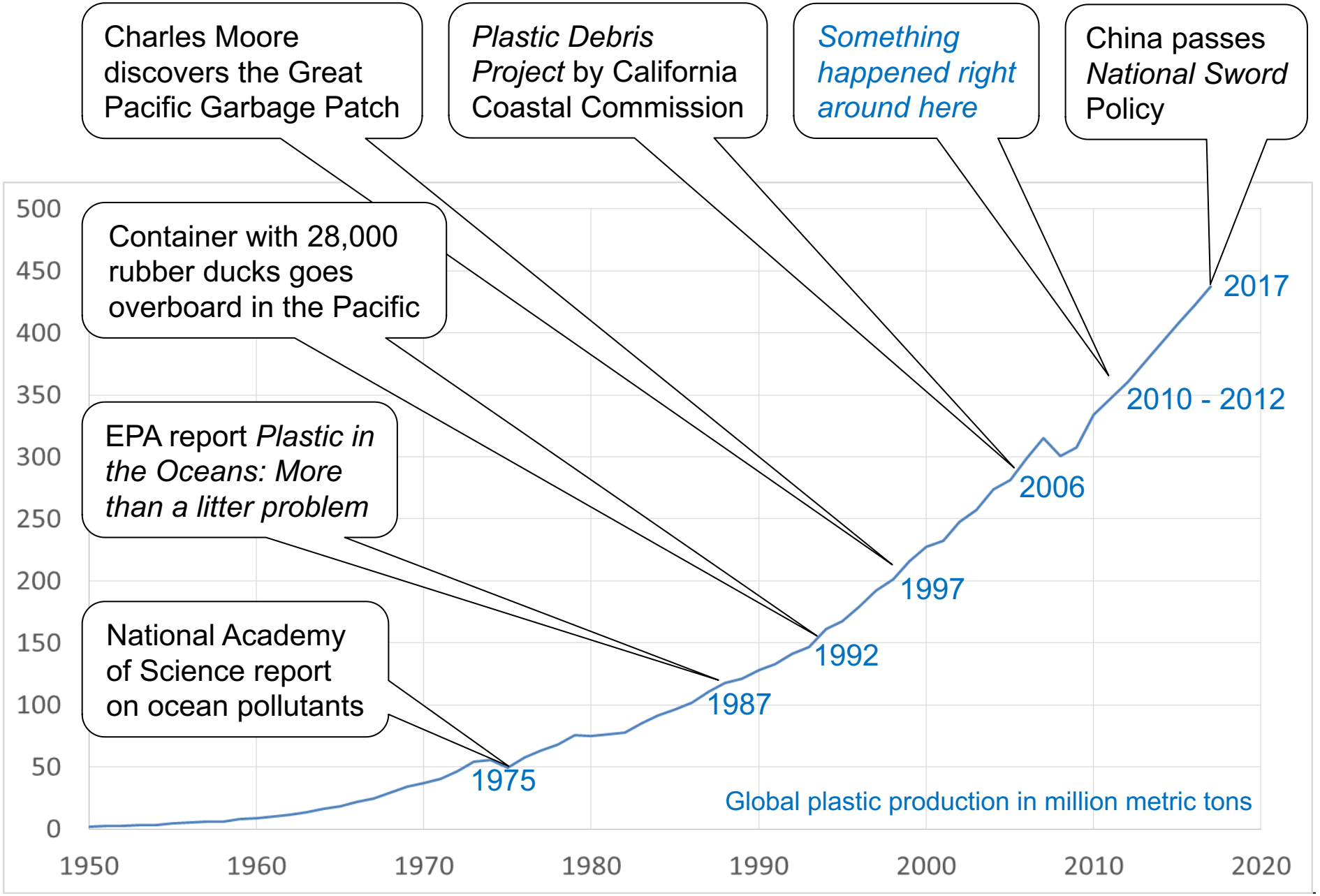
7 billion tonnes of plastic, 14km³ volume, 1 earth

ART CAN CHANGE
AN ART PROJECT FOR A GLOBAL RETHINKING IN PLASTIC

Source: https://earth-plastic-view.de/ 2019

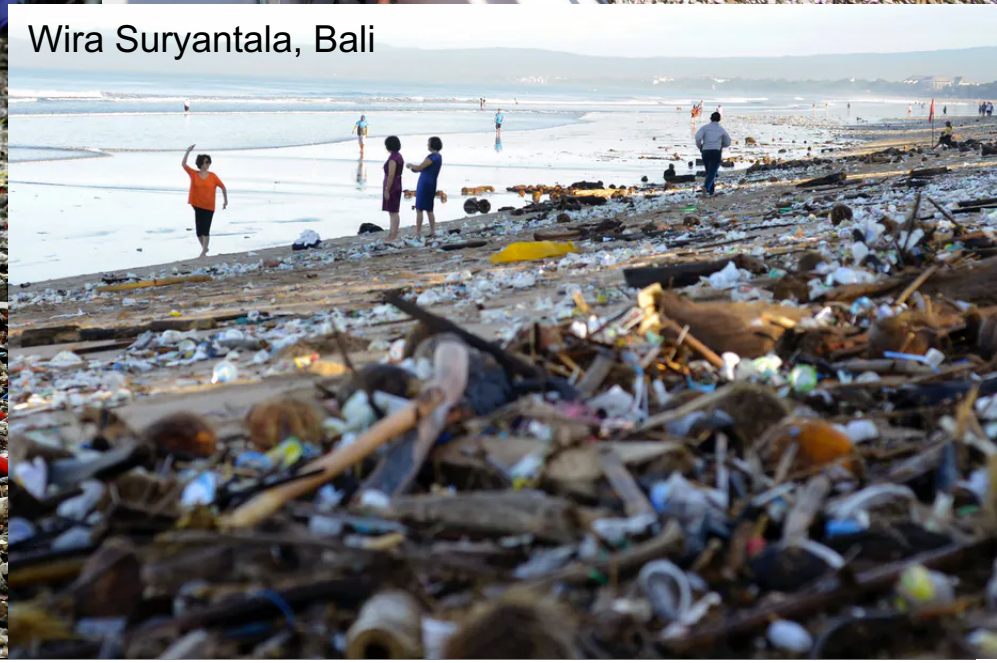

Facts (science)
Perception (media)
Attitudes
(public opinion)
Actions
(individual,
corporate, public)
Impacts (outcomes)


10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Plastic production
Steel production
Cement production
Aluminum production
CO2 emissions
plastic
cement
aluminum
steel
CO_2


Charles Moore discovers the Great Pacific Garbage Patch
Plastic Debris Project by California Coastal Commission
Something happened right around here
China passes *National Sword* Policy
Container with 28,000 rubber ducks goes overboard in the Pacific
EPA report *Plastic in the Oceans: More than a litter problem*
National Academy of Science report on ocean pollutants
500
450
400
350
300
250
200
150
100
50
0
1950
1960
1970
1980
1990
2000
2010
2020
1975
1987
1992
1997
2006
2010 - 2012
2017
Global plastic production in million metric tons


Alison Teal, Maldives


Caroline Power, Roatan


Wira Suryantala, Bali

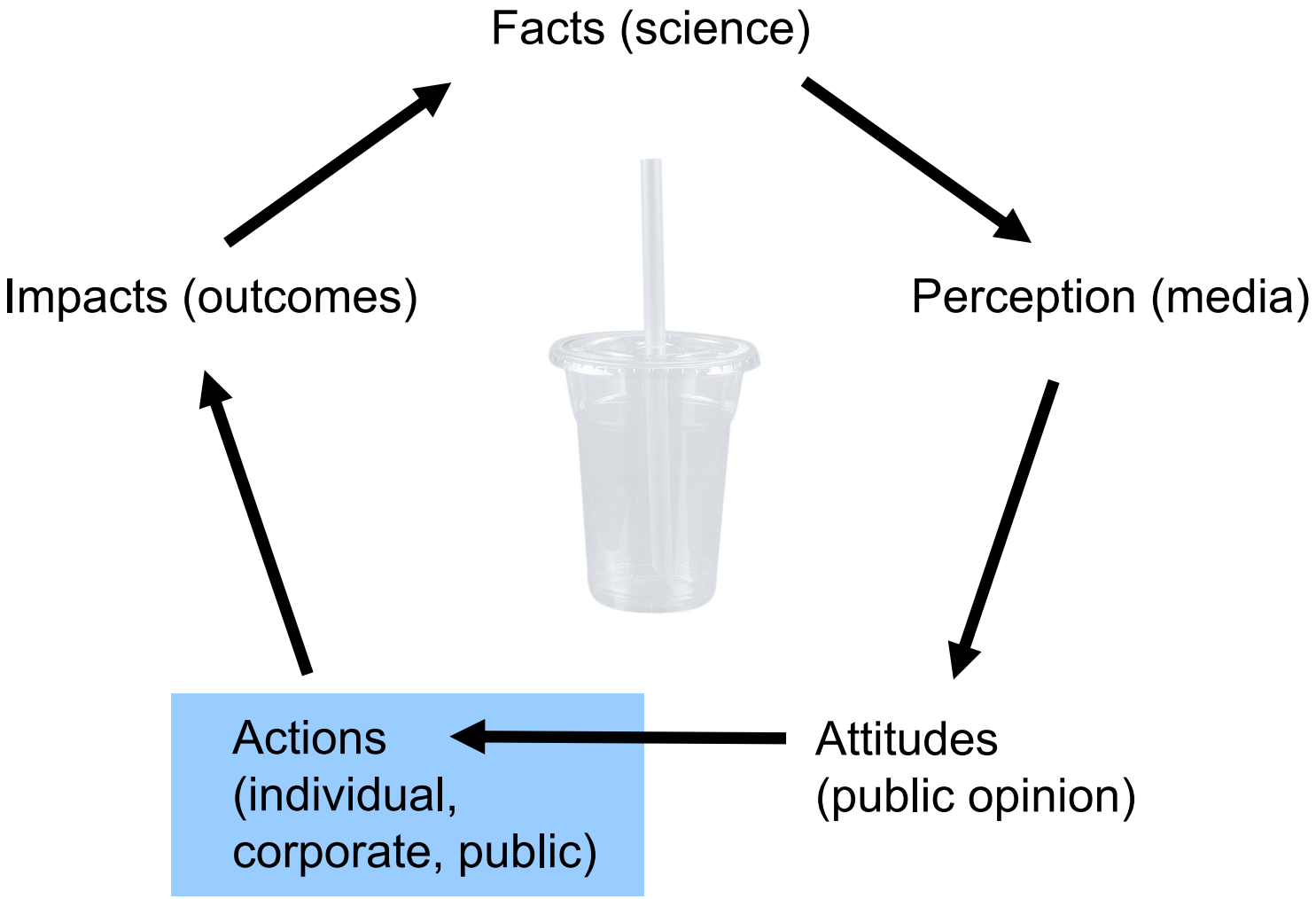

1) - PAUL SOUDERS (WORLDFOTO)
2) - FLIP NICKLIN (MINDEN PICTURES)
3) - SETH PATTERSON (NPL/MINDEN PICTURES)
4) - JIM RATHERT (MISSOURI DEPT OF CONSERVATION)
5) - J R COMPTON
6) - STOCKTREK IMAGES, INC. (ALAMY STOCK PHOTO)
7) - JOHN CANCALOSI (NG IMAGE COLLECTION)


Francis Pérez


Dan Clark


Justin Hofman

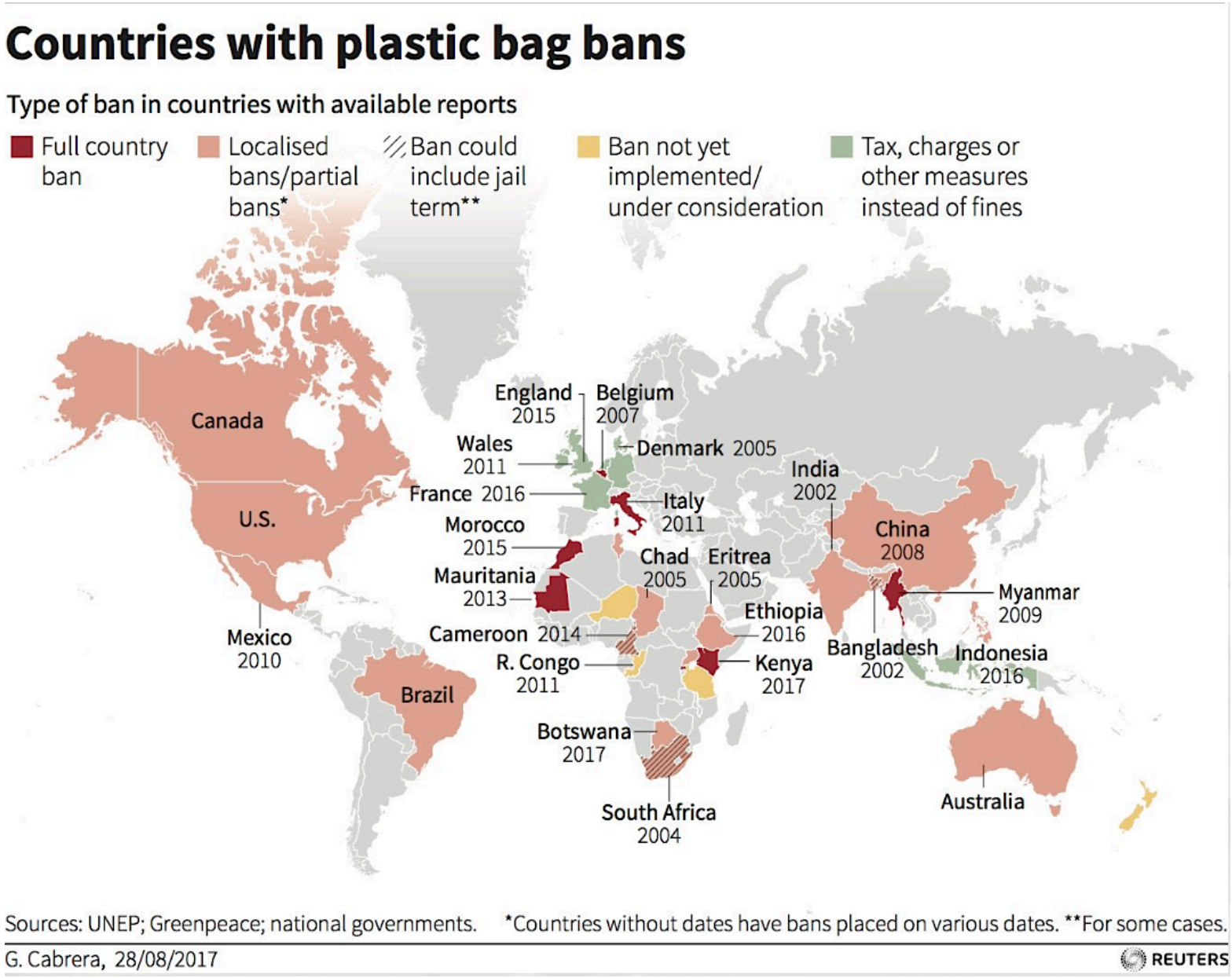

Christine Figgener


Facts (science)
Perception (media)
Attitudes
(public opinion)
Actions
(individual,
corporate, public)
Impacts (outcomes)

What can be done about plastic pollution?

- Remediation
  - Beach cleanups
  - The Ocean Cleanup
- Pollution Control
  - Landfill
  - Incineration
- Pollution Prevention
  - **Source reduction (use less)**
  - Reuse & recycling (use again)
  - Material substitution (use something else)

What is being done about plastic pollution?


Countries with plastic bag bans
Type of ban in countries with available reports
Full country ban
Localised bans/partial bans*
Ban could include jail term**
Ban not yet implemented/ under consideration
Tax, charges or other measures instead of fines
Canada
U.S.
Mexico 2010
Brazil
England 2015
Belgium 2007
Wales 2011
Denmark 2005
France 2016
Italy 2011
Morocco 2015
Mauritania 2013
Chad 2005
Eritrea 2005
Cameroon 2014
R. Congo 2011
Botswana 2017
South Africa 2004
India 2002
China 2008
Myanmar 2009
Ethiopia 2016
Kenya 2017
Bangladesh 2002
Indonesia 2016
Australia
Sources: UNEP; Greenpeace; national governments.
*Countries without dates have bans placed on various dates. **For some cases.
G. Cabrera, 28/08/2017
REUTERS

European Strategy for Plastics in a Circular Economy

and

Single-Use Plastics Directive

Measures:

- Ban on selected items
- Measures to reduce consumption
- Extended producer responsibility schemes
- Collection targets

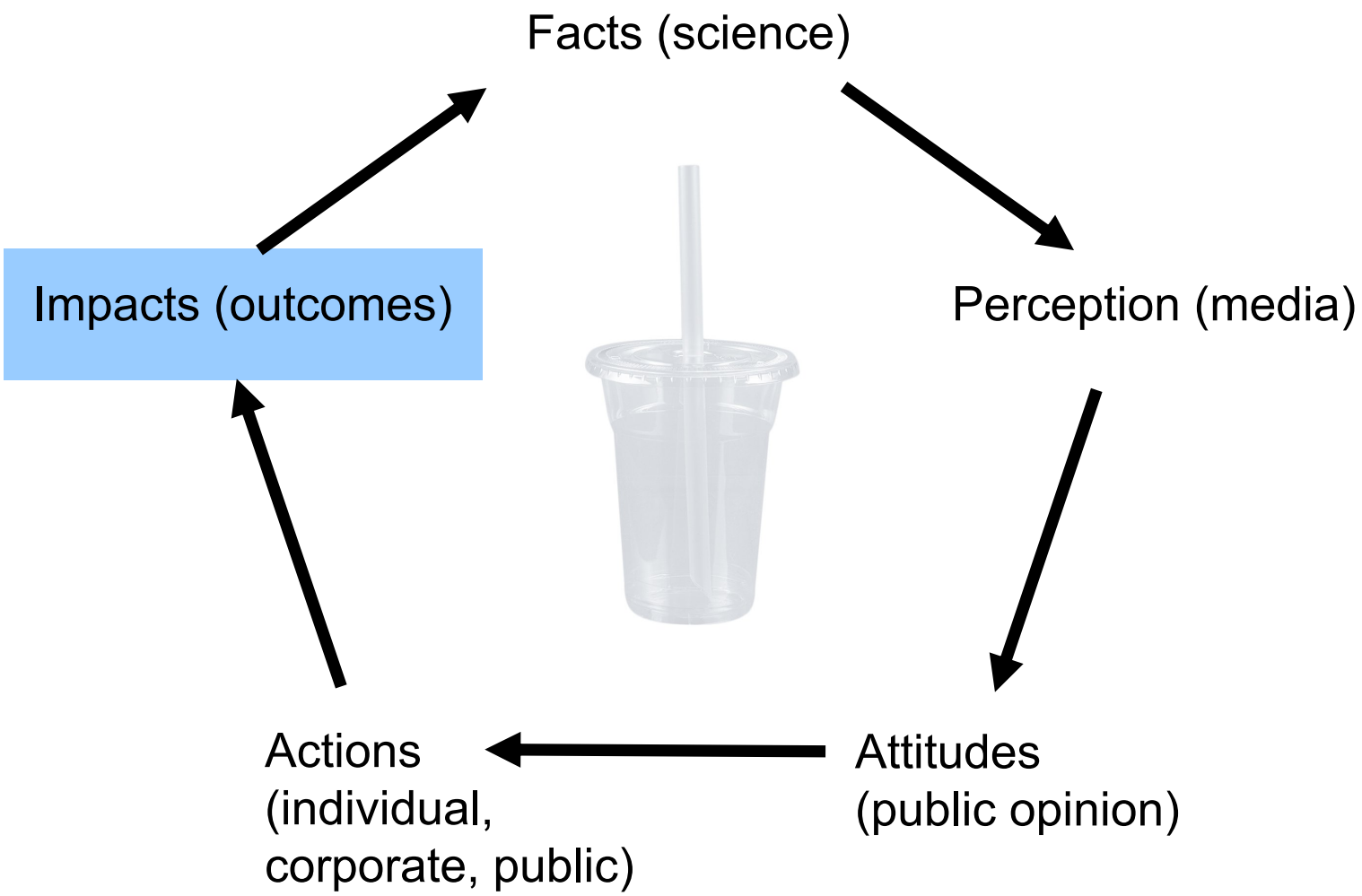
(AB 1080 / SB 54) California Circular Economy and Plastic Pollution Reduction Act

Stalled

75% of single-use packaging and products sold in California source-reduced, recyclable, or compostable by 2030

AB 792 passed
Progressive recycled content mandate for plastic beverage containers (50% by 2030)

AB 1884 signed
Single-use plastic straws only upon request


Facts (science)
Perception (media)
Attitudes
(public opinion)
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(individual,
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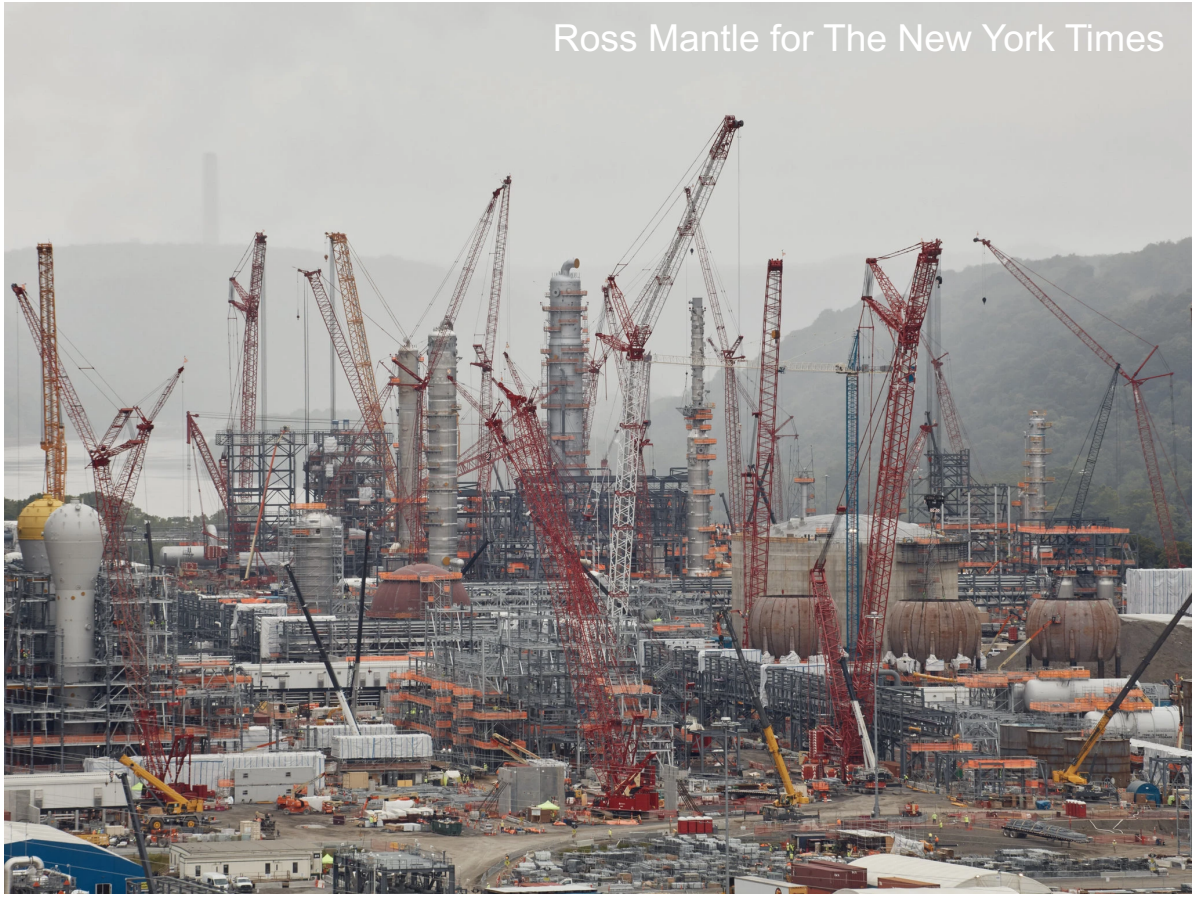
Impacts (outcomes)

Shell is currently building a 1 million ton per year polyethylene plant in Monaca, PA



“Petrochemicals are rapidly becoming the largest driver of global oil consumption.”
International Energy Agency, 2018

“The entire plastics sector will account for 20% of total oil consumption by 2050.”
World Economic Forum, 2016

Historical and projected global annual plastic production in Mt