Sustainable Systems Research Foundation

Sustainable Procurement

2020.06.04

Today's presentation:

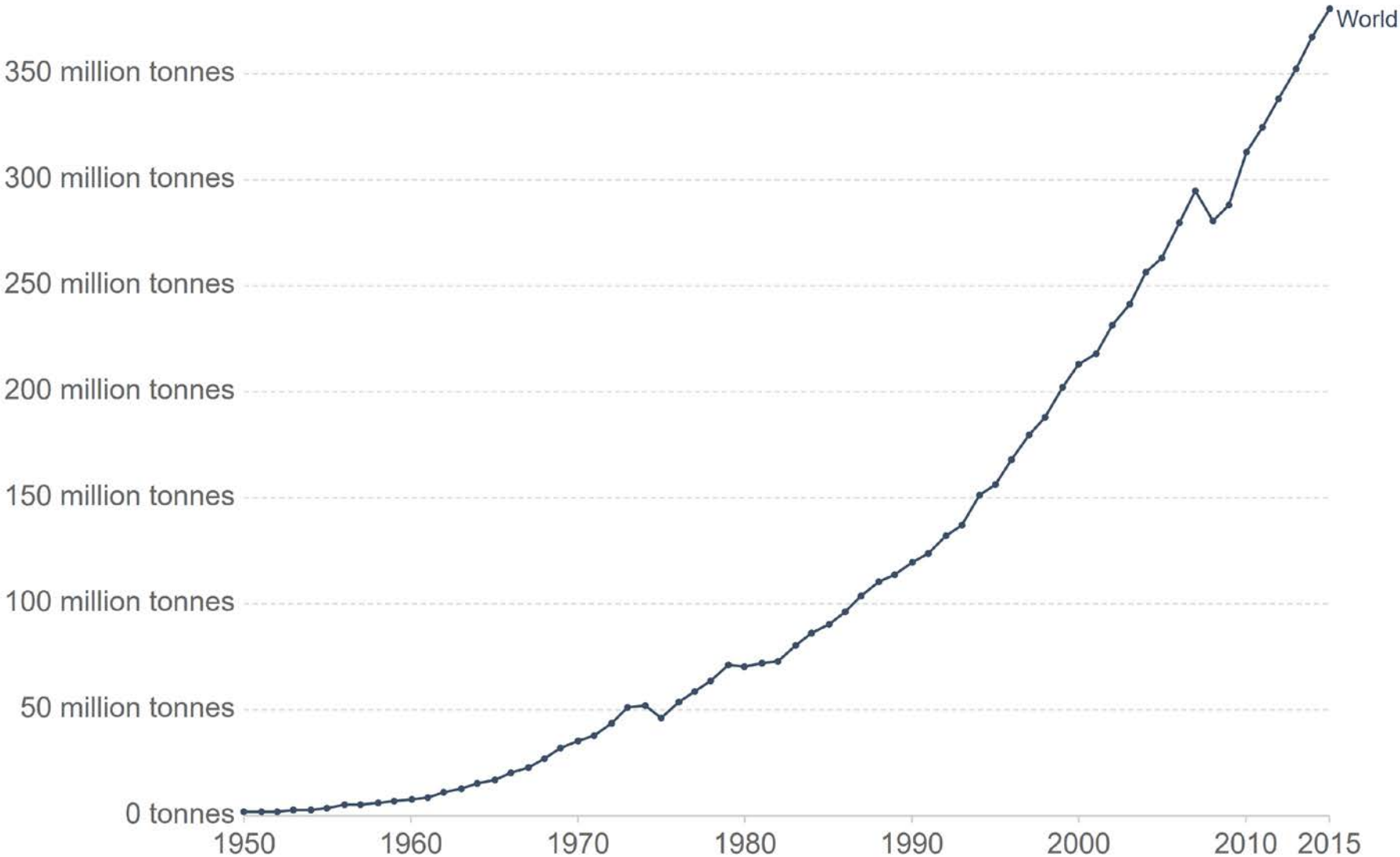
- The approach
- The problem
- Why plastic recycling has failed
- Bottom-up, top-down, middle-out
- Our story thus far

Sustainable Procurement Integration Network (SPIN)

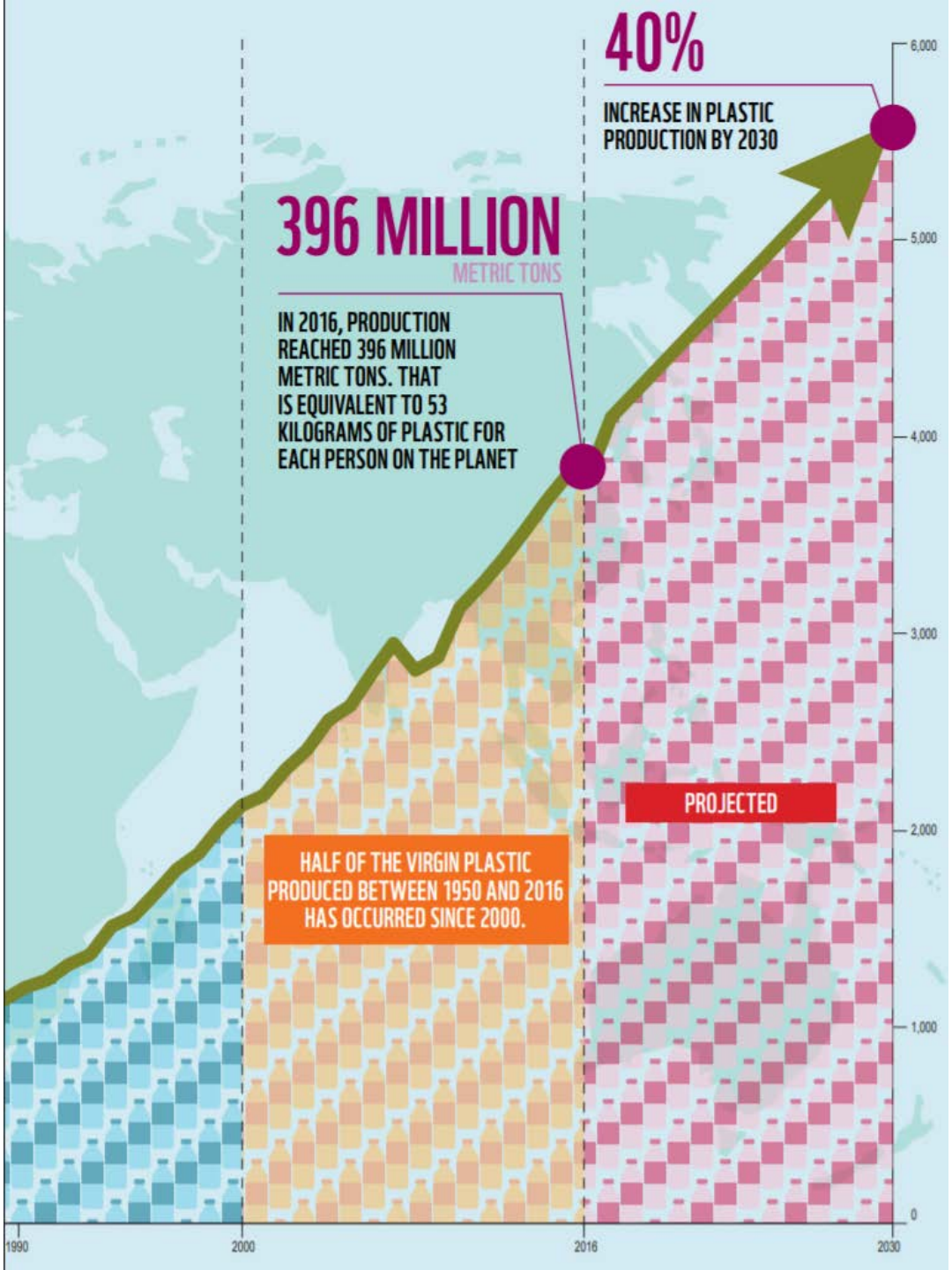
- A systems approach to propagating emerging best practice
- Build cooperative relationships with regional/local stakeholders to inform and transform default procurement choices
  - Agricultural producers
  - Regional food manufacturers
  - Local grocery chains
  - Institutions
  - Restaurants and take out
  - Local governments
- **Middle-out: focus on the leveraging the interface between distribution and wholesale/institutional purchasers**
- **Simplify the back end by de-emphasizing recycling**

Global plastics production, 1950 to 2015

Annual global polymer resin and fiber production (plastic production), measured in metric tonnes per year.



Source: Geyer et al. (2017)



Source: WWF 2019

SHELL SCENARIOS

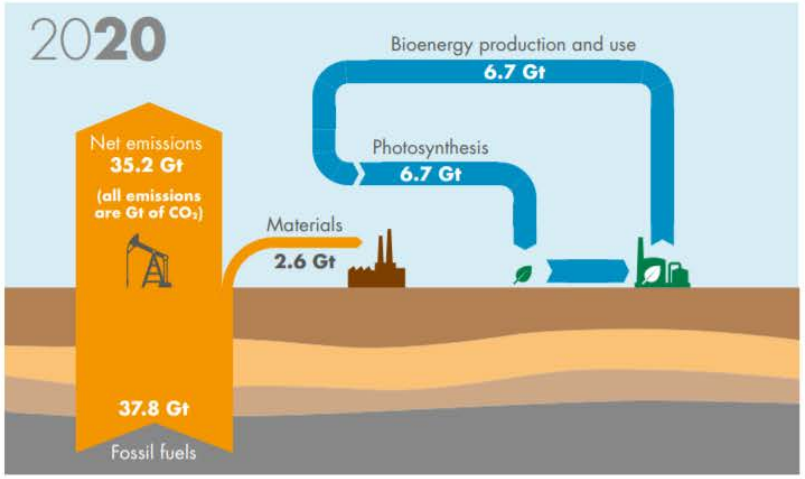
Sky

MEETING THE GOALS OF THE PARIS AGREEMENT

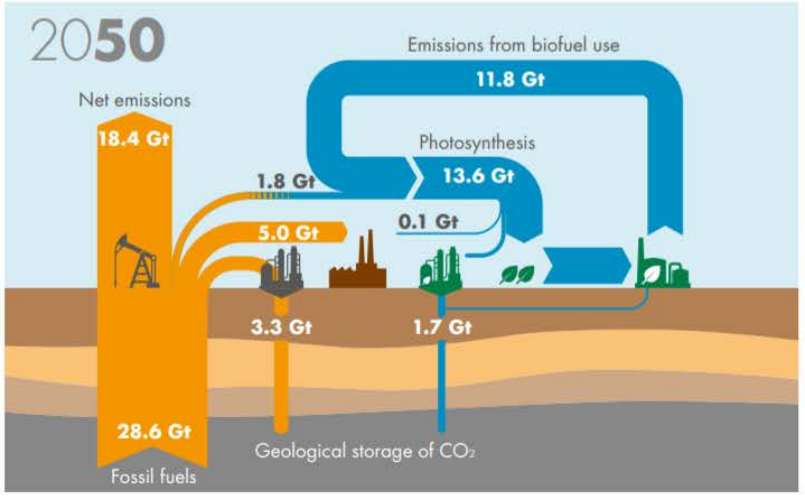
"The ***Sky*** scenario illustrates a technically possible, but challenging pathway for society to achieve the goals of the Paris Agreement. ***Sky*** builds on previous Shell scenarios publications and is our most optimistic scenario in terms of climate outcomes."

THE EVOLVING ENERGY SYSTEM CO_2 BALANCE SHEET IN **SKY**

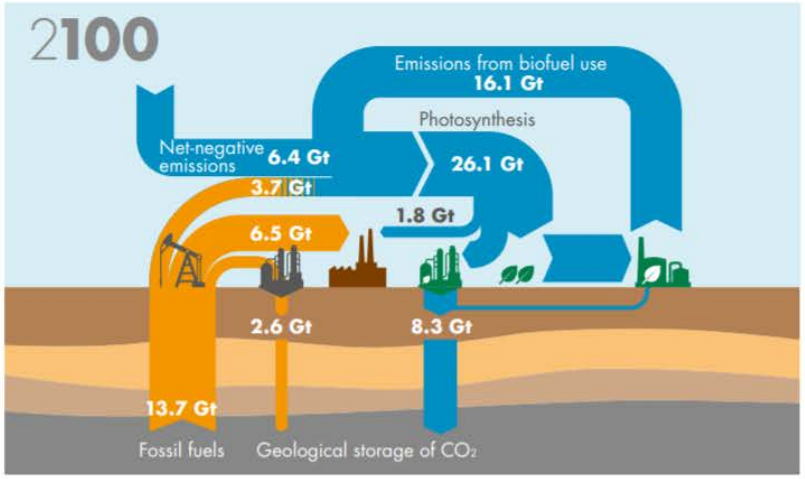
Fossil fuel production | CCS | Biofuel production | Bioenergy with CCS | Carbon in products | Growing biomass



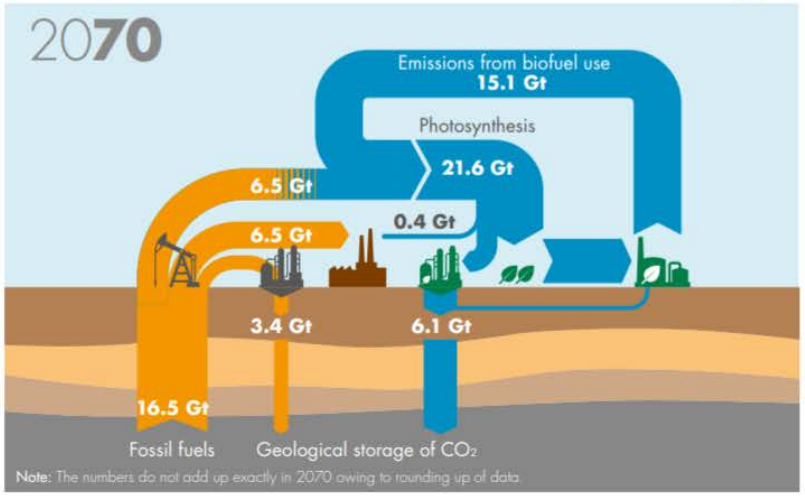
Today, most carbon in fossil energy production is burned and emitted to the atmosphere, while the CO_2 absorbed by wood and other plants used for energy is also returned to the atmosphere.



In **Sky**, in 2050, the storage of CO_2 is rapidly scaling up. There are equal contributions from the embedded carbon in materials production and CCS. Fossil energy CCS leads the way, but bioenergy CCS (BECCS) is close behind.



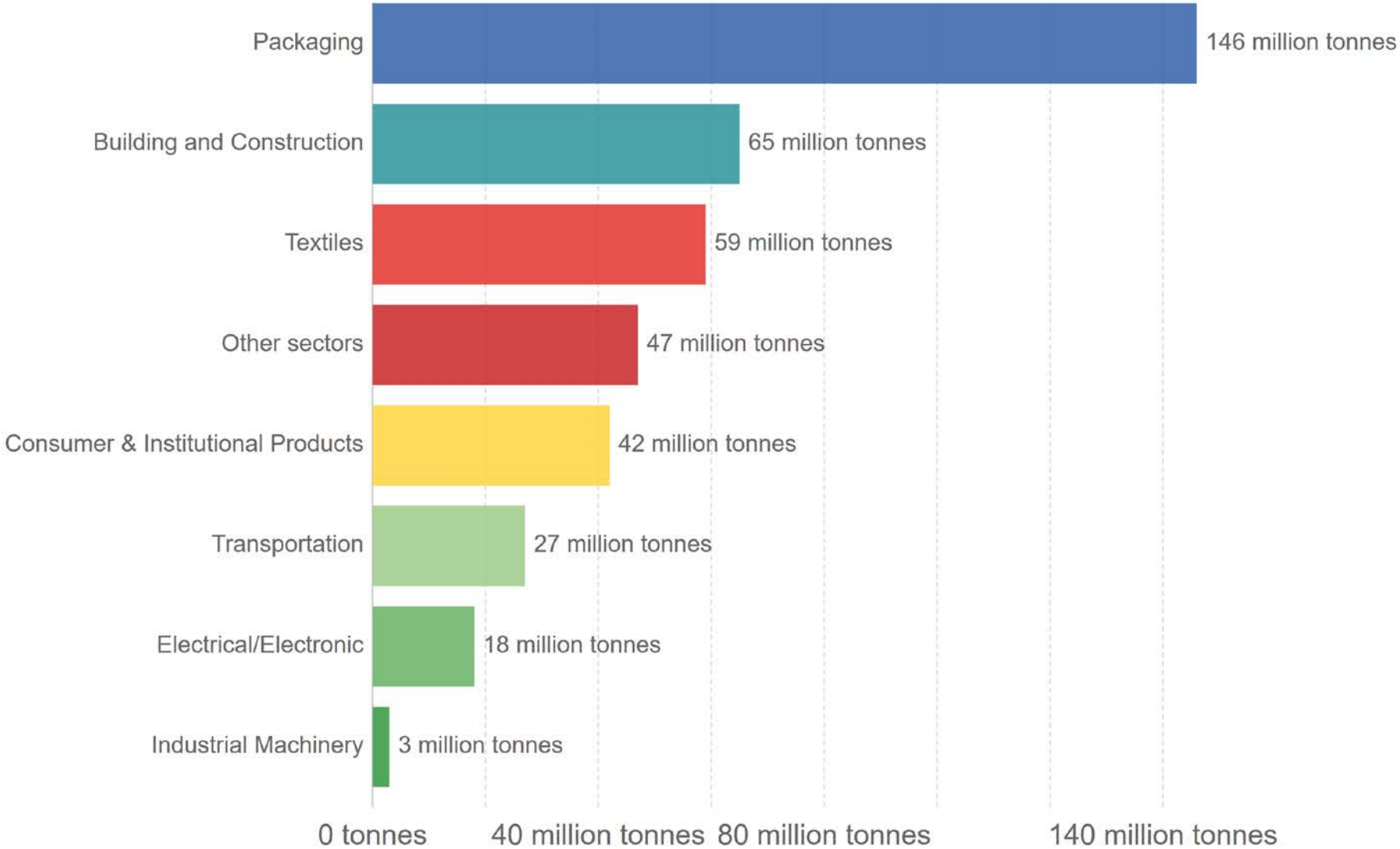
In **Sky**, at 2100, the bioenergy system has reached its resource base limit and is twice the size of the fossil energy system in CO_2 terms. The active management of CO_2 means that the total energy system is providing a drawdown of CO_2 from the atmosphere.



In **Sky**, in 2070, the energy system has achieved net-zero emissions. Fossil energy production is less than half today's level. Alongside direct CCS and the use of carbon for materials, the remaining fossil energy emissions are fully offset by captured CO_2 from an expanded bioenergy system.

Primary plastic production by industrial sector, 2015

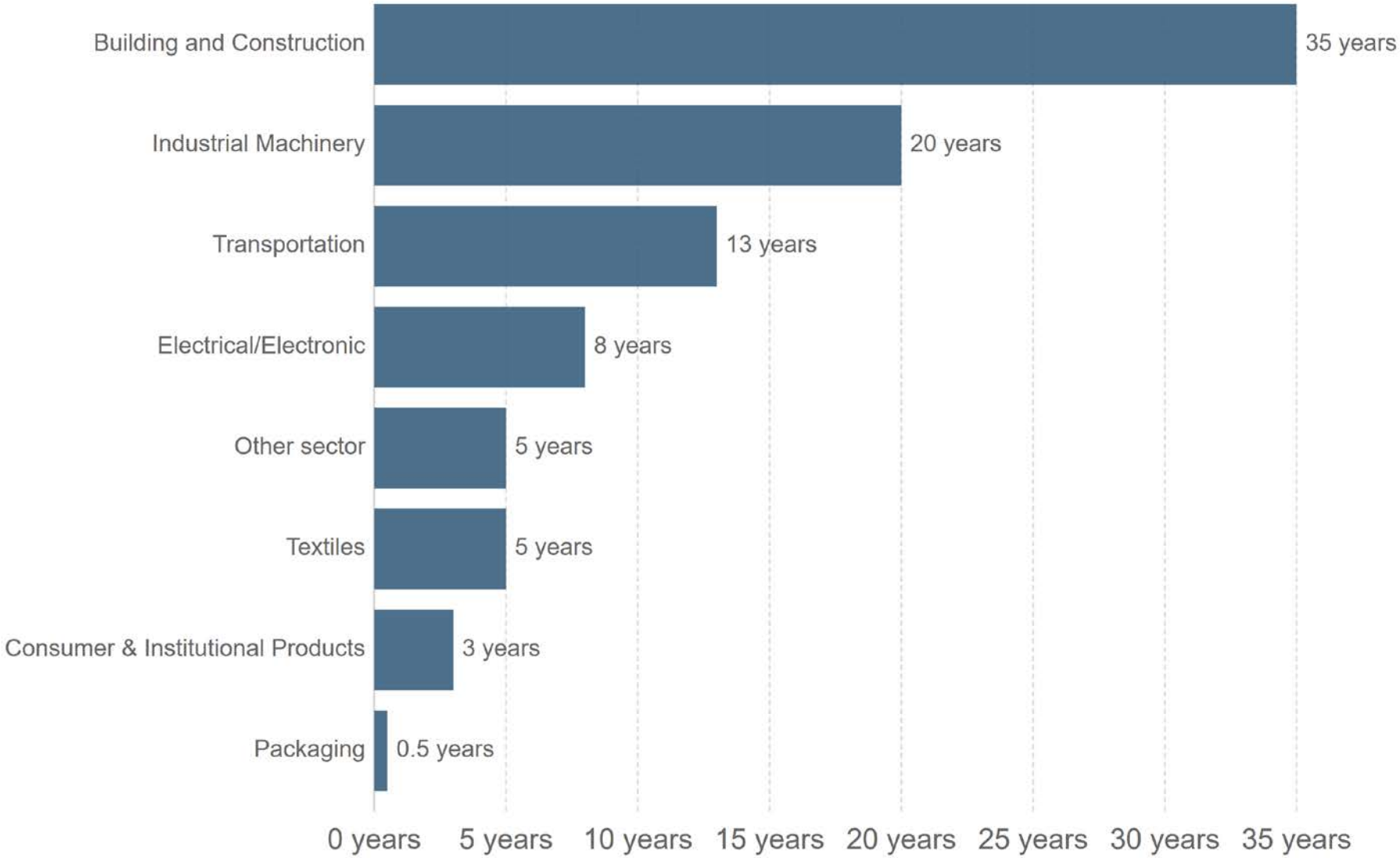
Primary global plastic production by industrial sector allocation, measured in tonnes per year.



Source: Geyer et al. (2017)

Mean product lifetime of plastic uses, 2015

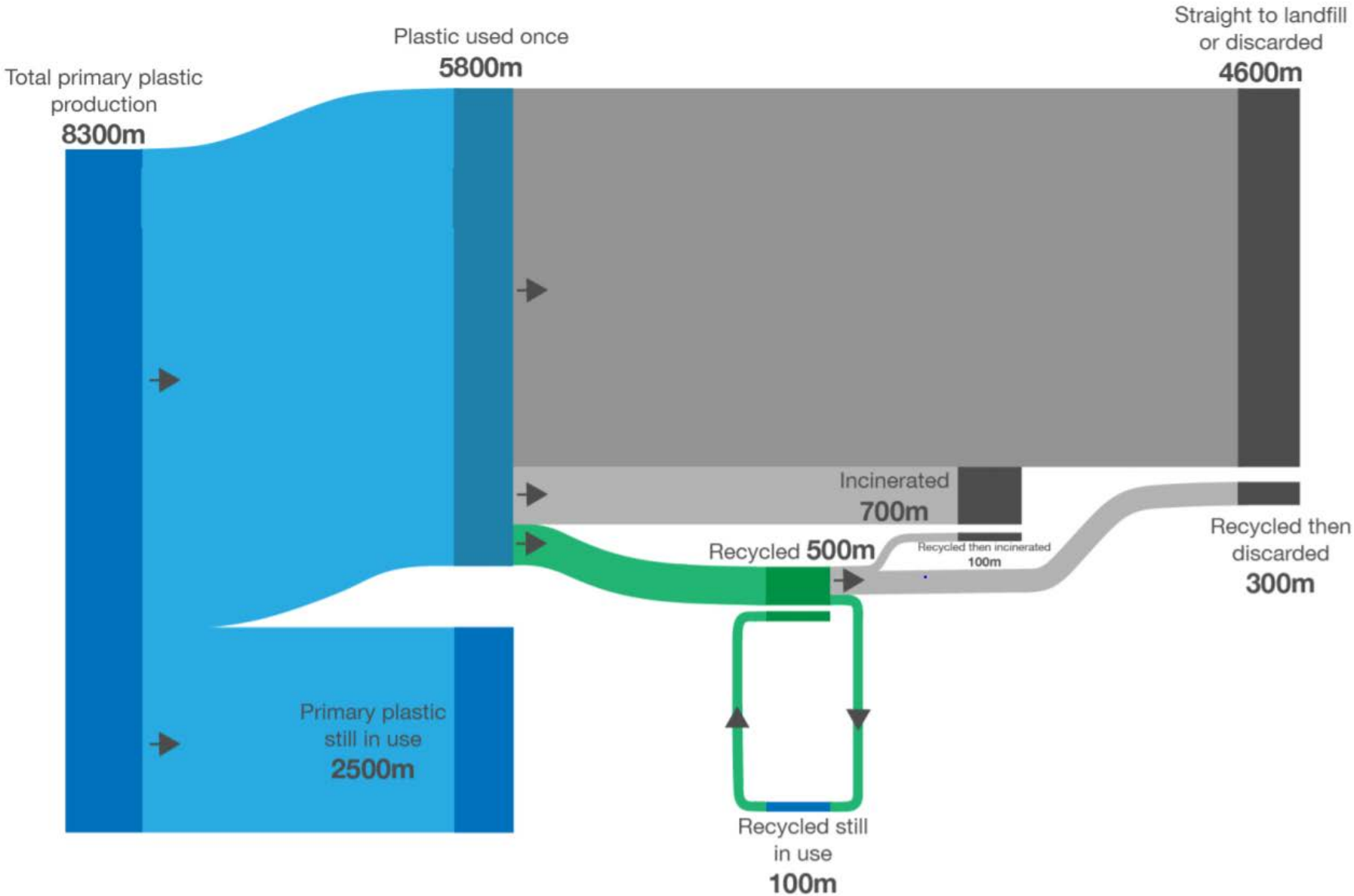
Mean product lifetime (from production to disposal) of different uses of plastic products, measured in years.



Source: Geyer et al. (2017)

Balance of plastic production and fate (m = million tonnes)

8300m produced → 4900m discarded + 800m incinerated + 2600m still in use (100m of recycled plastic)



Source: based on Geyer et al. (2017). Production, use, and fate of all plastics ever made.

STOP! ALTO!

Removing Cans and Bottles is Theft! SCMC 6.12.035

Removiendo Botellas y Latas es Robando! SCMC 6.12.035

Call 911 to Report Theft

Plastic recycling doesn't work

There are on the order of 20,000 plastics additives in common use today.[1]

Industry-imposed plastic type identification codes are largely useless for recycling/upcycling. There is limited to zero industry standardization.

Recyclability is not just a function of plastic type, but of additive compatibility, recycling process, and previous life cycle history. Contamination, provenance, partial material degradation, and inconsistent properties are difficult and expensive to reliably control.

Single down-cycling to landfill/incineration is the default plastic "recycling" path.

Complicated, confusing, inconsistent, shifting "acceptable" individual behavior expectations is inefficient, ineffective, and evades manufacturer responsibility via cultural shaming.

"Compostable" plastics can cross-contaminate both recycling and compost streams.

High-resolution sorting, closed loop infrastructure, and materials standardization are necessary, but complicated, expensive and ultimately insufficient. They are essentially niche solutions.

[1] Goodsmith 2007

Fig. 2. *The colour change in HDPE can be clearly seen after 10 process cycles. Virgin material (top left), material injection moulded and re-granulated 10 times (bottom left).*

Source: Goodship 2007

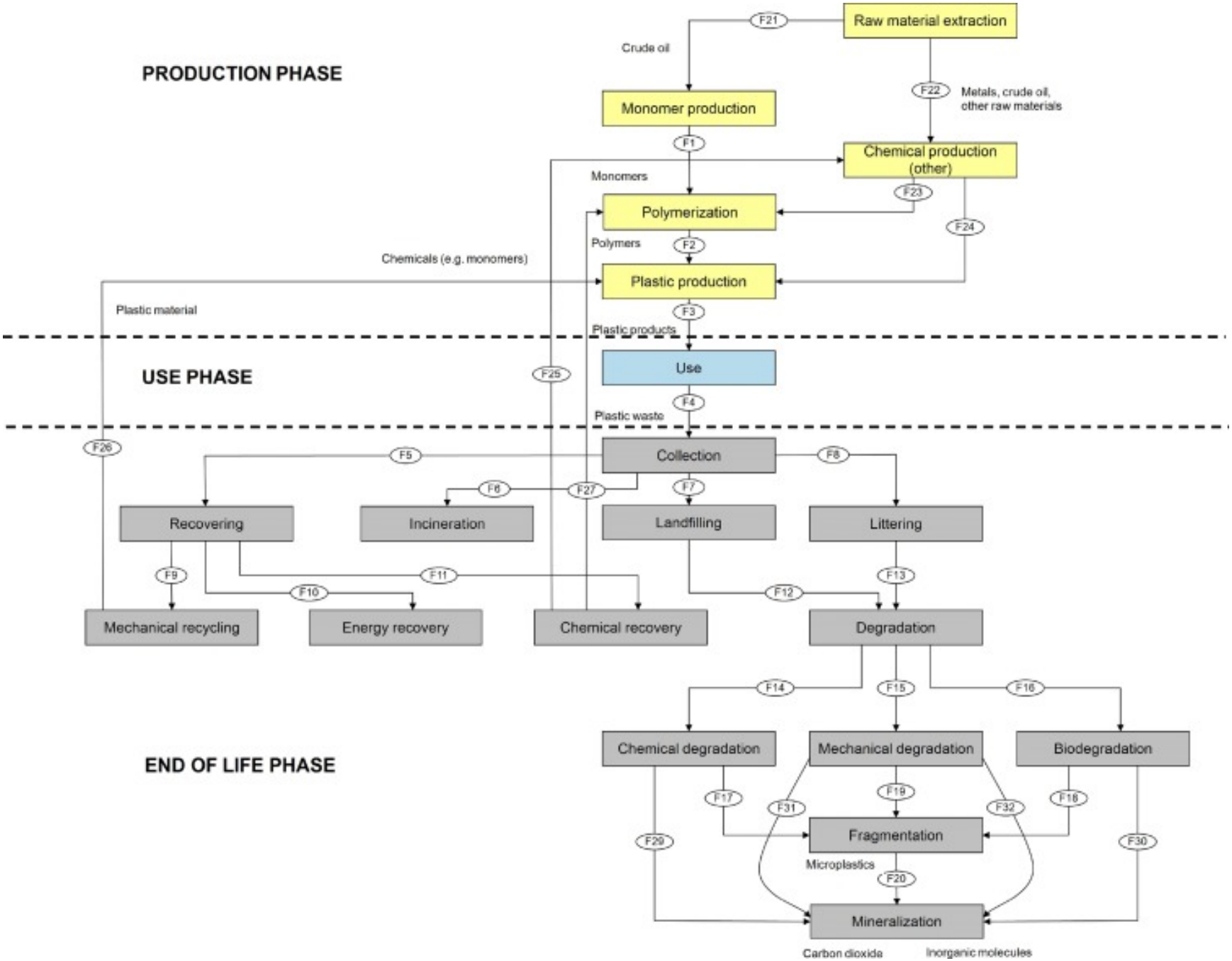
Table 2. *Common additives for plastics*

Additive	Purpose
Calcium carbonate	Filler: generally used for cost reduction as much cheaper than polymer
Pigments	Give the plastic a colour. Generally for aesthetic properties
Glass fibre	Increased strength and stiffness
Flame retardants	Increase fire resistance
Heat stabilisers	Increased resistance to heat exposure
Light stabilisers	Increased resistance to light exposure
Plasticisers	Process aid which reduces viscosity
Foaming agents	Lightness and stiffness

Source: Goodship 2007

Additive type	Example substance	Used in which plastics?
Plasticisers	Short, medium and long chain chlorinate paraffins. Phthalates: Bis (2-ethylhexyl)phthalate (DEHP), dibutylphthalate (DBP), dipehnylphthalate (DPP). Adipates: diheptyl adipate (DHA), heptyl adipate (HAD), heptyl octyl adipate (HOA).	Mostly used in PVC and cellulose based polymers where they can make up to 75% w/w of the final product.
Flame retardants	Brominated flame retardants; polybrominated diphenylethers (PBDEs), decabromodiphenylethane. Phosphorous flame retardants; tris (2-chloroethyl)phosphate (TCEP), tris (2-chlorisopropyl)phosphate (TCPP).	Brominated compounds can reach 25% w/w of the final polymer.
Stabilisers, ultraviolet stabilisers, antioxidants	Bisphenol A (BPA) Cadmium and lead compounds Nonylphenols, octylphenols Butylated hydroxytoluene	Up to 3% w/w; phenolics generally added at lower amounts.
Slip agents	Fatty acid amides Fatty acid esters Zinc stearate	Added at up to 3% w/w depending on the polymer type.
Biocides	Organotins Arsenic compounds Triclosan	Added primarily to soft PVC and polyurethane foams.
Inorganic pigments	Cadmium, chromium and lead compounds Zinc oxide Iron oxide Titanium dioxide Lead carbonate Aluminium and copper powders	Non-fluorescing substances show lower migration rates.
Organic pigments	Cobalt(II) diacetate	Insoluble, low migration tendencies.
Fillers	Calcium carbonate Zinc oxide Barium sulphate Glass microspheres Nanomaterials Clays	Can make up to 50% w/w.

Source: Galloway 2019



Source: Hahaidakis 2018


Put in Mixed Recycling
Aluminum Cans
No foil or trays
Steel Cans
No scrap metal
Cardboard & Pizza Boxes
No food or heavy grease
Remove recyclables from plastic or paper bag. All items must be loose.
Office Paper, Magazines, Newspaper, Paperbacks, Paper Boxes, Paper Cartons
Plastic Bottles, Plastic Tubs, Plastic To-Go Containers
Leave caps and lids on
No liquid or food waste
Rigid Plastics
No electronics
Must fit in 96 gal cart
Minimal metal
DO NOT put in Mixed Recycling
If you are not sure about an item, ask the attendant!
Glass must go in the Glass Recycling
No plastic bags
No Styrofoam
No paper towels
No shredded paper
No aluminum trays
No aluminum foil
No hoses or other tanglers
No cotainers that had hazardous materials


YES KEEP IT SIMPLE, KEEP IT CLEAN!
SANTA CRUZ
Paper and Flattened Cardboard
Papel y cajas de cartón desarmadas
Glass Bottles and Jars
Botellas y frascos de vidrio
Metal Cans & Aluminum
Latas de metal y aluminio
Plastic Bottles Jugs, Jars & Tubs
Botellas y contenedores de plástico
Plastic Bags Clean & Dry
Bag your bags
Bolsas de plástico
Pongalas en una bolsa
Recycle Right! • Don't Bag Recyclables • Keep Recycling Loose • Dejar el Reciclaje Suelto
NO NOT ACCEPTED IN THE BLUE CART NO
No Single Plastic Bags
No Food, Liquids or Garbage
No Cartons
No Plastic Food Boxes
No Polystyrene
No Glassware or Ceramics
No Pizza Boxes
No Clothes or Linens
No Tanglers
hoses, wire, chain, electric cords
No Big Items
Scrap metal, buckets, furniture
When in Doubt - Find Out! • 420-5593 • cityofsantacruz.com/recycleright


EMPTY.
CLEAN.
DRY.
It Matters.
RECYCLE RIGHT

Recyclable, compostable, or landfill?

“Sustainable” plastic is complicated

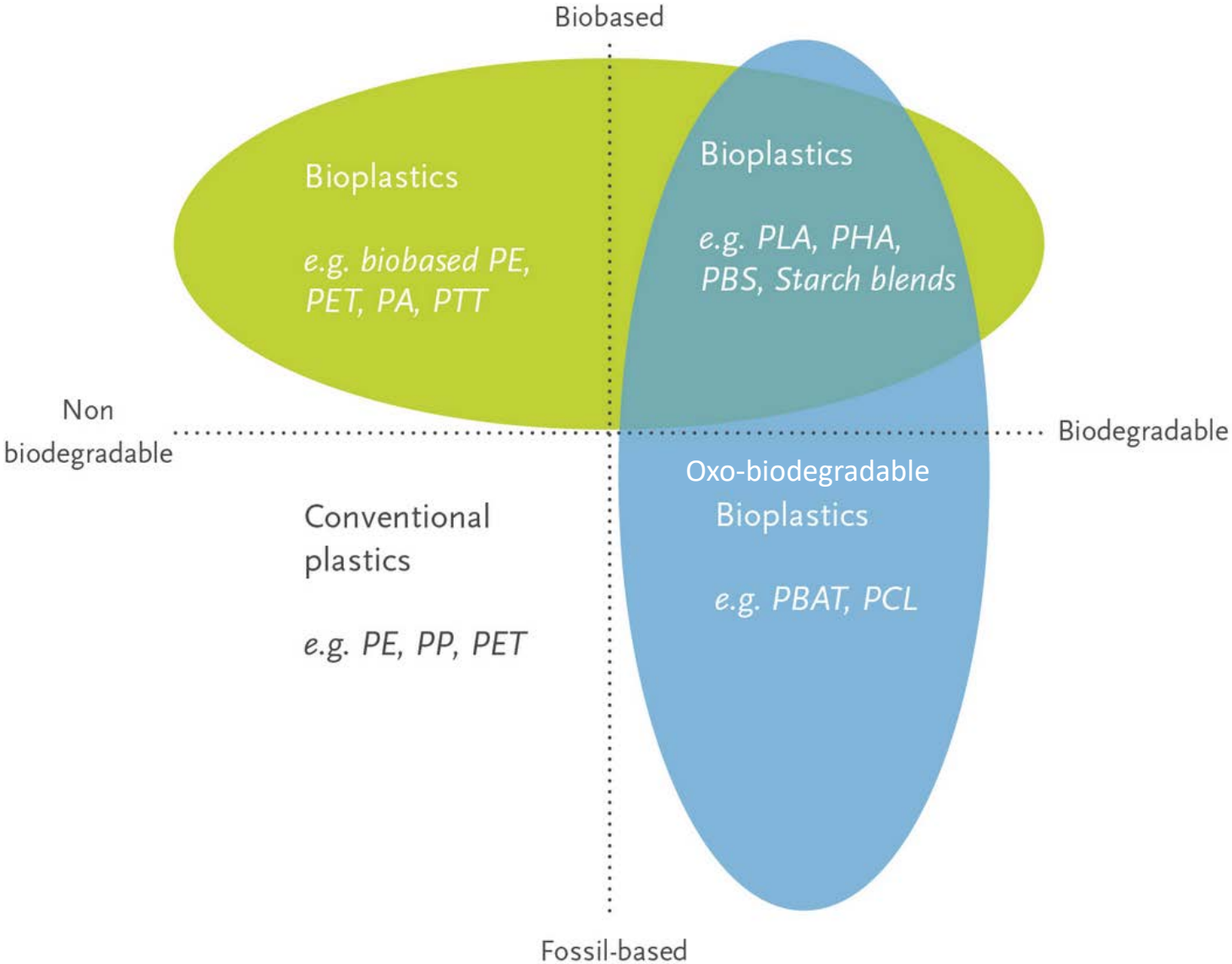
- Bio-based
- Degradable
- Biodegradable
- Compostable
- Composite

Each term implies very different characteristics. They are sometimes mutually exclusive. They are routinely used interchangeably to obfuscate the nature and implications of the materials they describe.

With a single exception (PHA variants), **none** are currently sustainable, compostable bioplastics. As with bioenergy, we’re still waiting for algae to save the day, real soon.

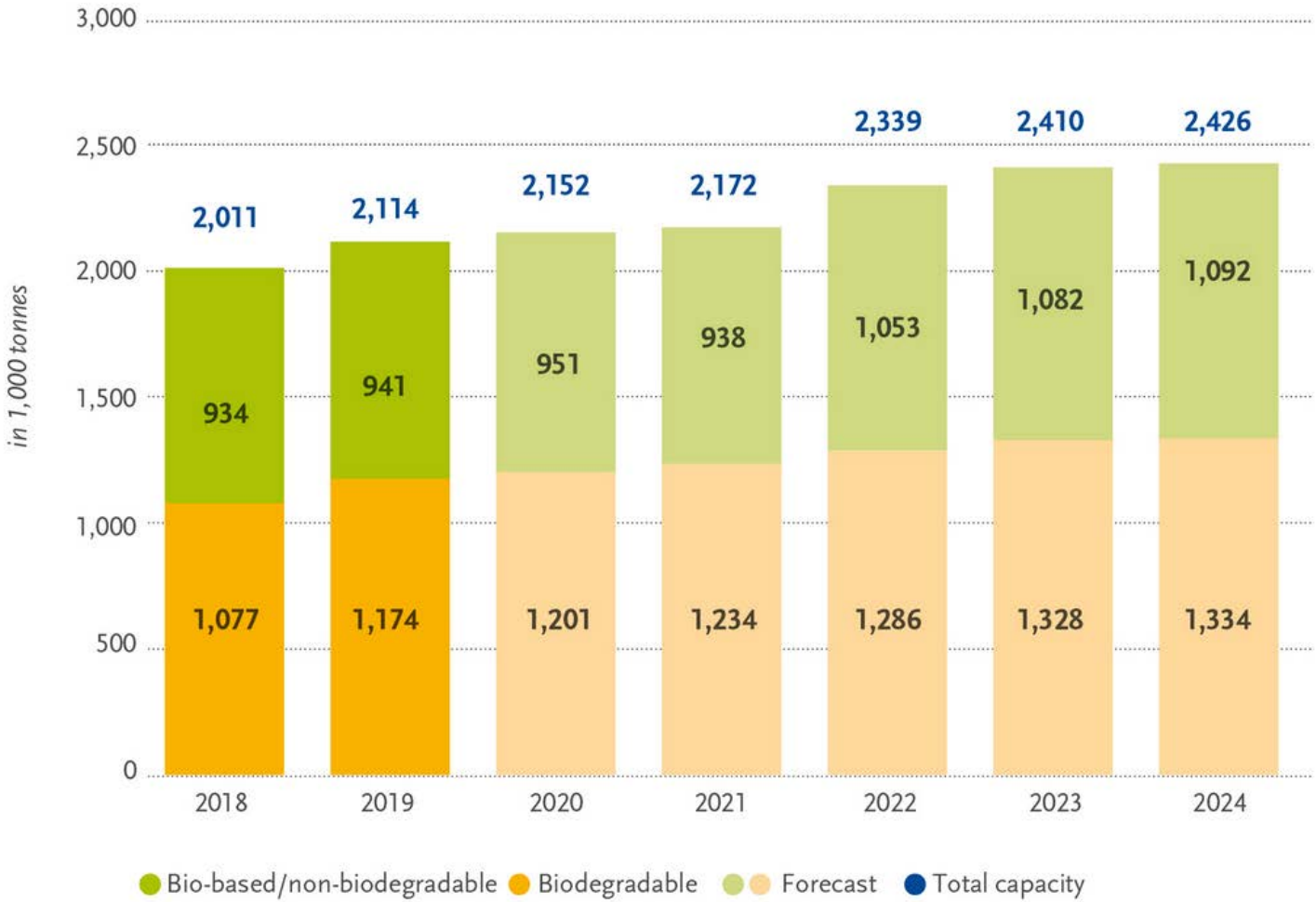
Some “sustainable” packaging solutions are as bad or worse than conventional plastics.

- Biobased or partially biobased non-biodegradable plastics such as biobased PE, PP, or PET (so-called drop-ins) and biobased technical performance polymers such as PTT or TPC-ET;
- Plastics that are both biobased and biodegradable, such as PLA and PHA or PBS;
- Plastics that are based on fossil resources and are biodegradable, such as PBAT.



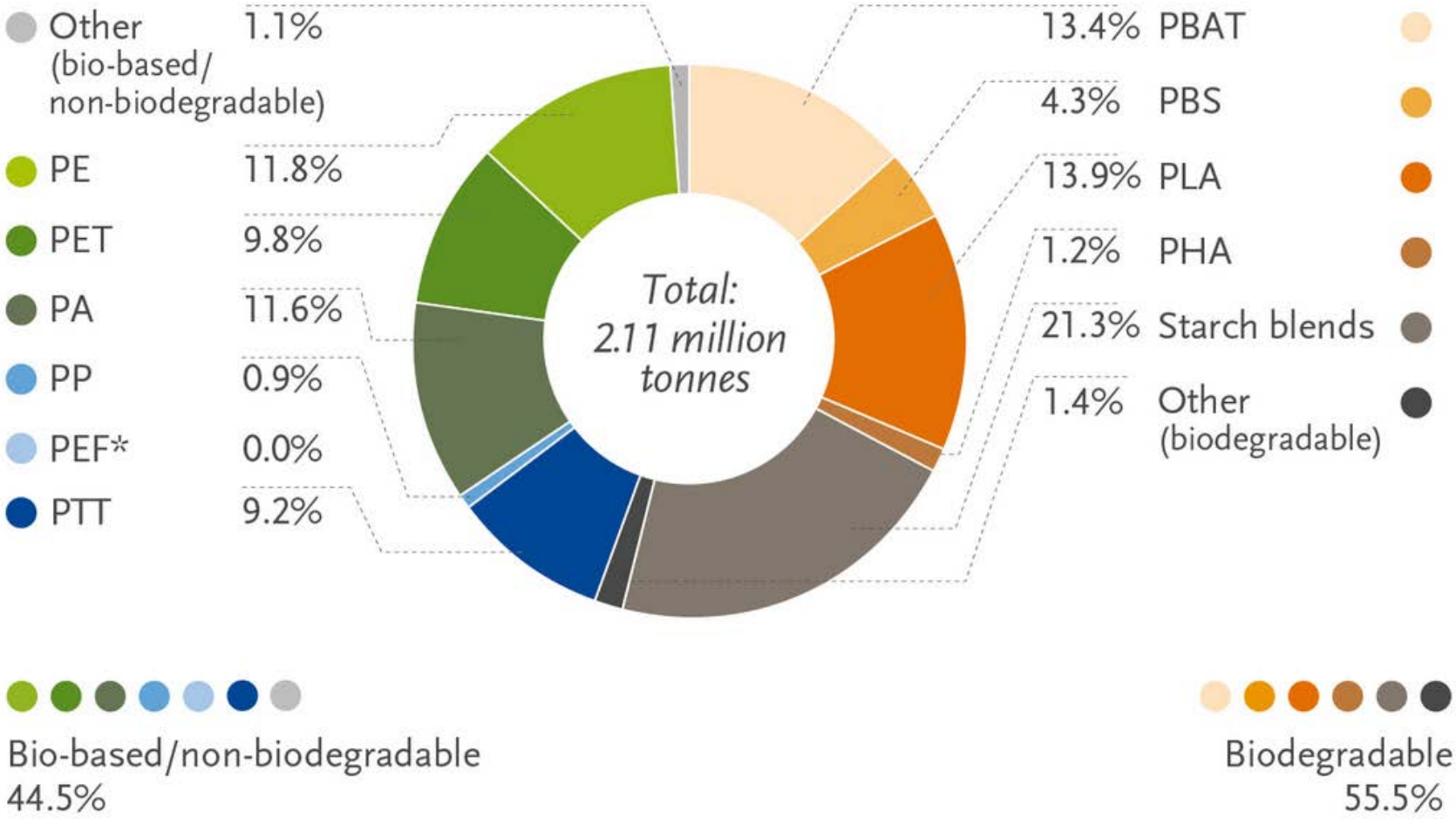
Source: European Bioplastics 2019

Global production capacities of bioplastics



Source: European Bioplastics, nova-Institute (2019)
More information: ***www.european-bioplastics.org/market*** *and* ***www.bio-based.eu/markets***

Global production capacities of bioplastics 2019 (by material type)



*PEF is currently in development and predicted to be available in commercial scale in 2023.

Source: European Bioplastics, nova-Institute (2019)
More information: **www.european-bioplastics.org/market** and **www.bio-based.eu/markets**

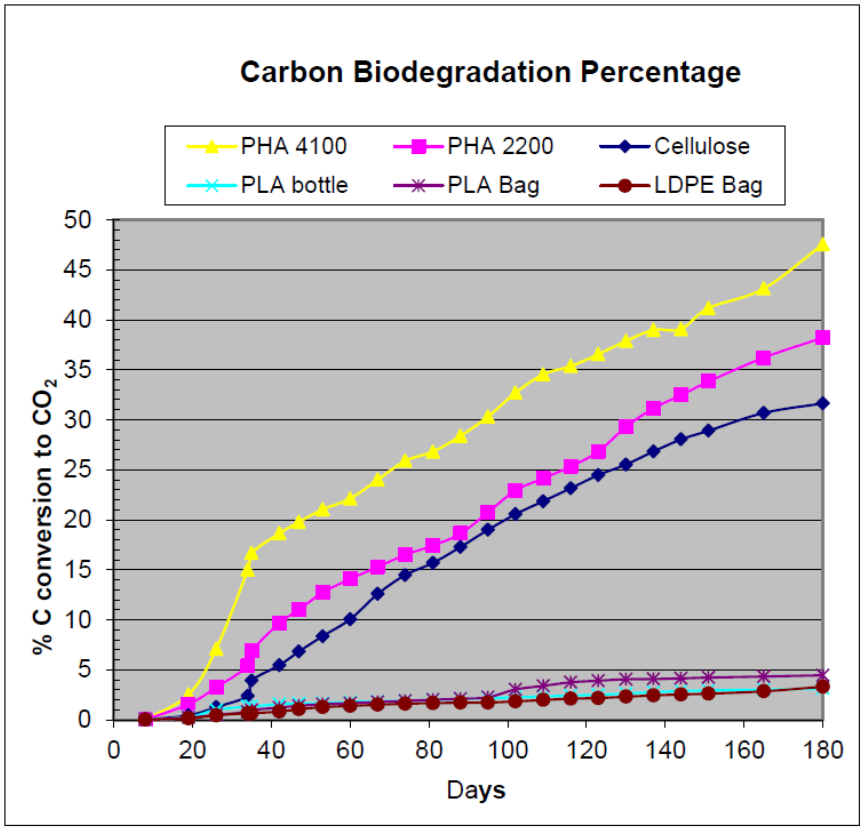
- PLA is more degradable than biodegradable.
- Enzymes which hydrolyze PLA are not available in the environment except on very rare occasions.

Ecological studies on the abundance of PLA-degrading microorganisms in different environments have confirmed that PLA-degraders are not widely distributed, and thus it is less susceptible to microbial attack compared to other microbial and synthetic aliphatic polymers [10,11,34]. The degradation of PLA in soil is slow and that takes a long time for degradation to start [47,48].

Source: Tokiwa et. al. 2009

Material	Initial % Carbon in 1 g sample	Cumulative Carbon Dioxide evolution after 180 days, g	% Biodegradation after 180 days
Mirel 4100 film	24.45	0.4041	45.08
Mirel 2200 film	24.12	0.3380	38.22
Cellulose powder	16.96	0.2071	33.31
PLA bag	17.09	0.0279	4.45
PLA bottle	17.43	0.0199	3.11
LDPE film	20.98	0.0254	3.3

Marine Degradation Reality



Source: CalRecycle 2012

"We support applying the precautionary principle by banning oxo-degradable plastic packaging from the market until extensive, independent third-party research and testing based on international standards… possibly combined with technological progress and innovation, clearly confirms sufficient biodegradation of the plastic fragments in different environments, and over a time-scale short enough for particles not to accumulate in ecosystems."

"To create a system in which plastic packaging never becomes waste, we support innovation that designs out waste and pollution, and keeps products and materials in high-value use."

PLA doesn't have a lower carbon footprint

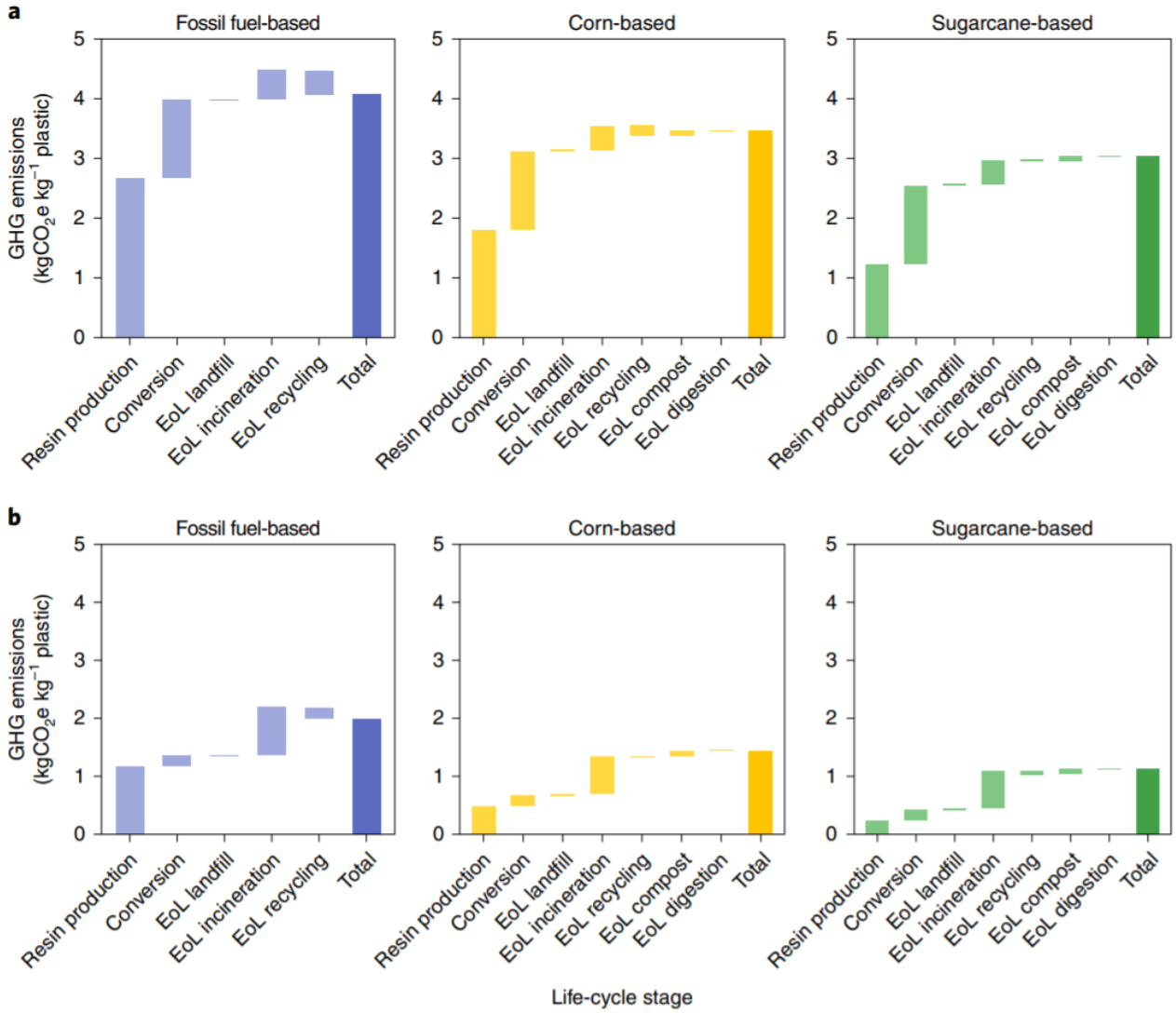


Fig. 3 | GHG-emissions breakdown by life-cycle stage of plastics derived from different feedstock types under two energy-mix scenarios in 2050. **a**, GHG emissions under the current energy-mix scenario in 2050. **b**, GHG emissions under a 100%-renewable-energy scenario in 2050. Emissions results are based on the scenario with a 4% yr^{-1} growth rate for plastics demand and the projected EoL-management mix (Supplementary Table 10). Carbon credits generated by recycling are considered.

Source: Zhang 2019

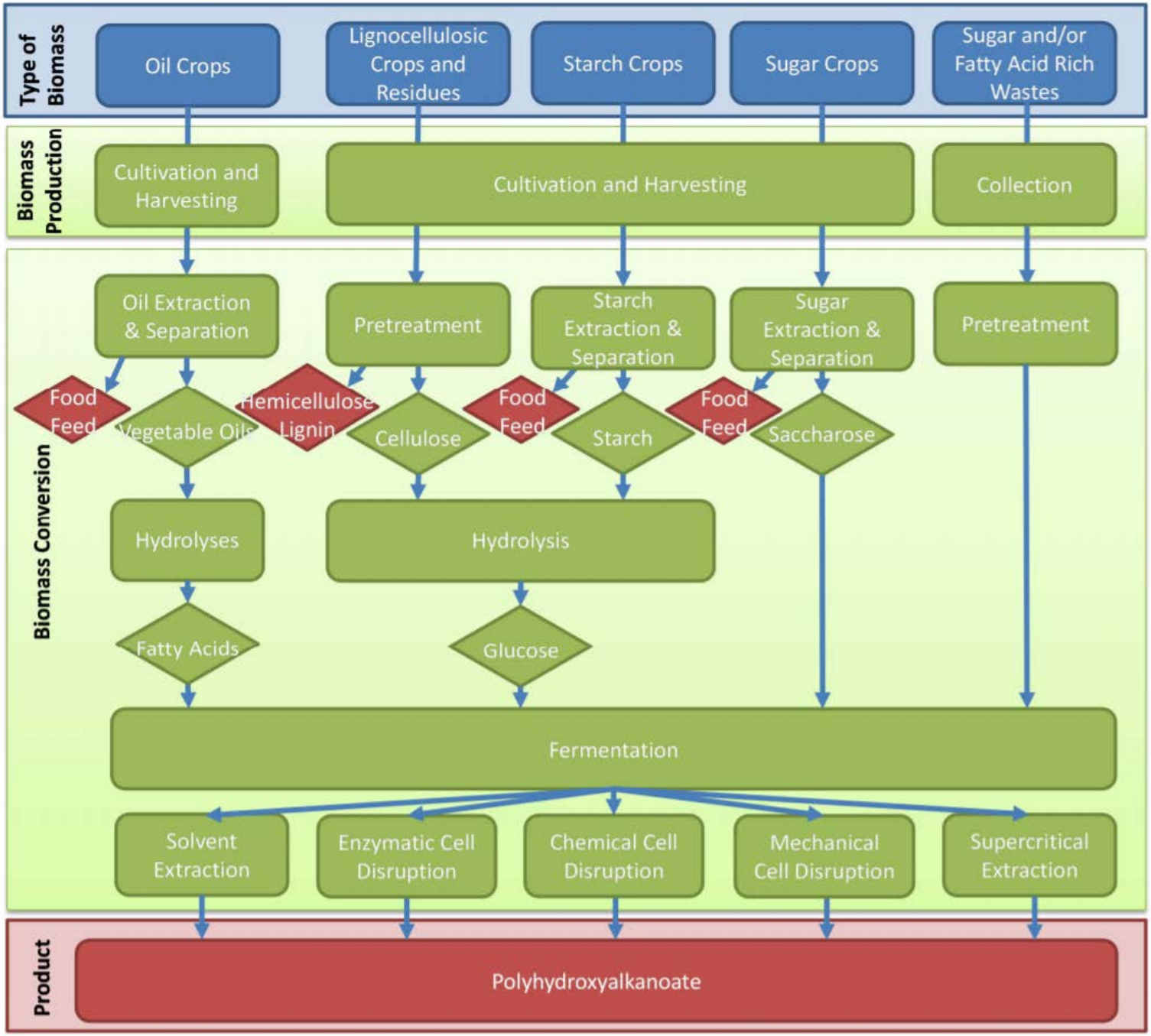
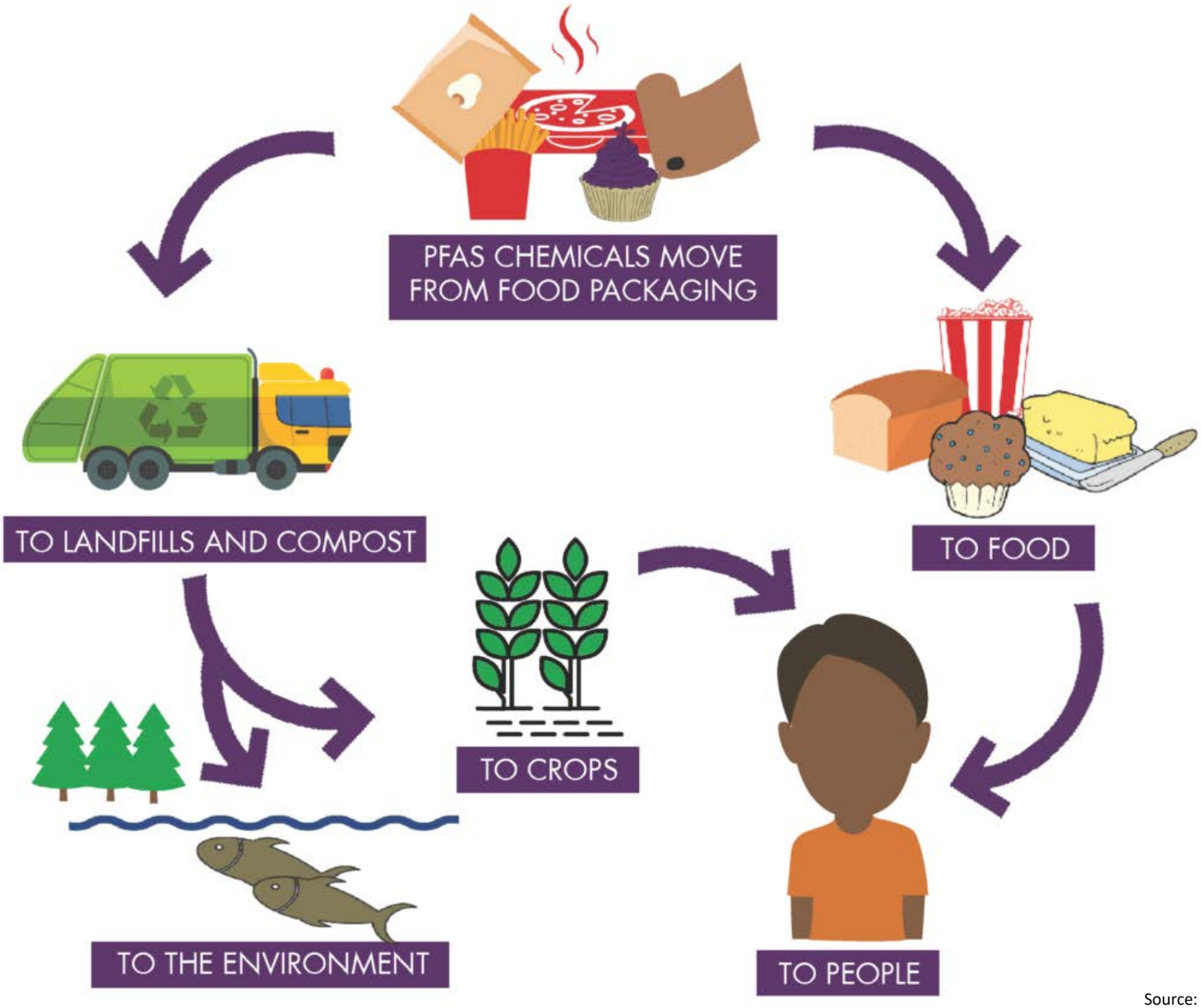


Figure 1. *PHA production chains*

Source: EC 2014

Skipping plastic single use items entirely is a great alternative, but…
…widely marketed "compostable" paper/wood/fiber alternatives are sometimes worse



Source: Toxic-Free Future 2018

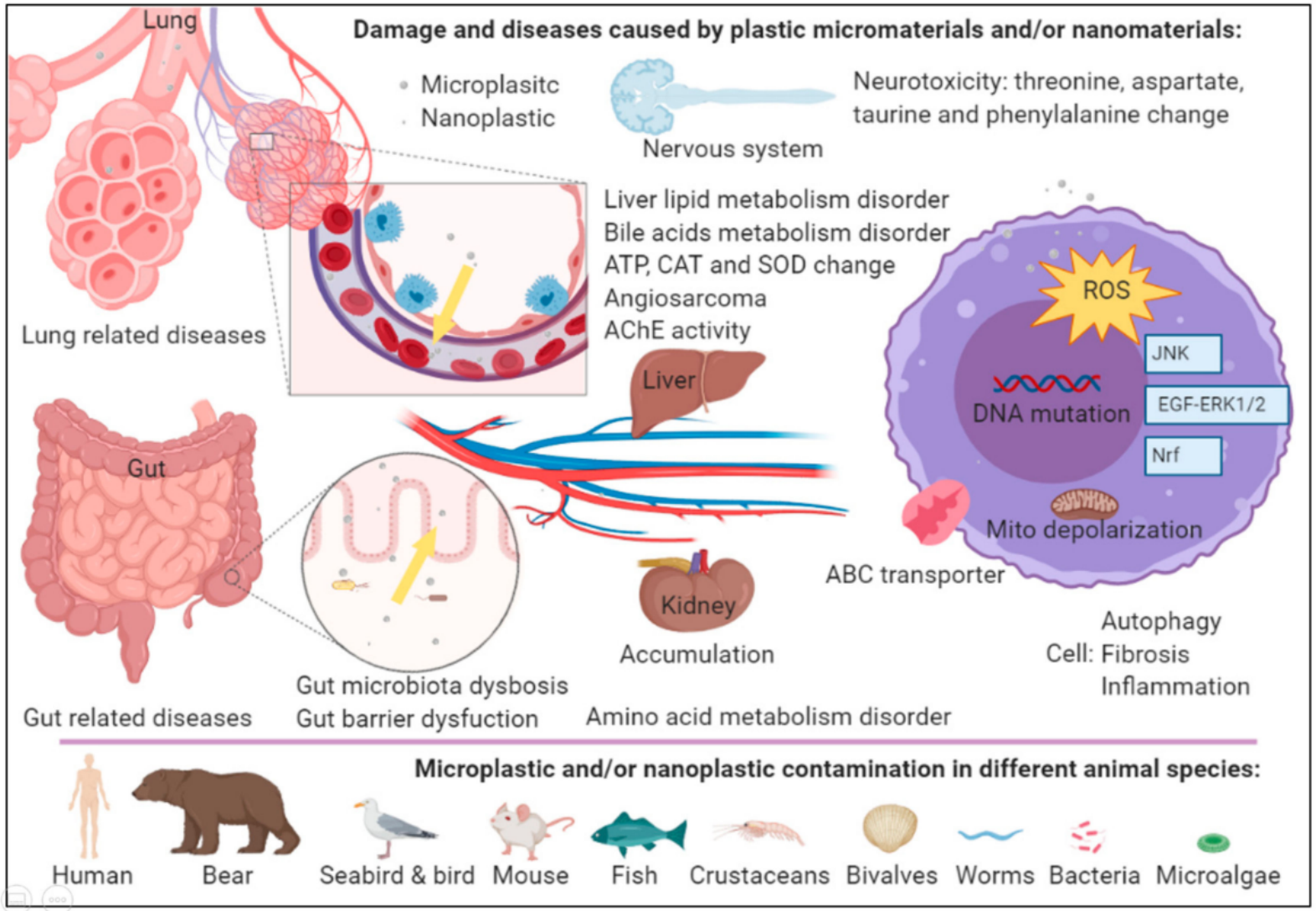


Figure 3. Impact of plastic micromaterials and nanomaterials in organisms. Microplastics and/or nanoplastics can enter the circulation from the gut and lungs and accumulate in the gut, liver, and kidney resulting in several diseases. At the cell level, microplastics or nanoplastics can inhibit the efflux pump and mitochondria depolarization, induce reactive oxygen species (ROS). They also affect several signaling pathways, cause fibrosis, autophagy, and even DNA mutations. Many animal species have been contaminated by microplastics and/or nanoplastics. The figure was created with BioRender.com.

Source: Wang 2020

Our story thus far…

Comprehensive identification of best-practice products proceeds
Compostable certification standards propagate obfuscation
Lots of vaporware and corporate consolidation
Manufacturers often not forthcoming about material specifications

- Mira
- Biofase

Distribution chain is dominated by a few large companies.
Smaller distributors and direct contact with suppliers is promising
Working with food producers is promising
Group buys may be a place to start
Identifying good packaging design is promising

Mapping wholesale sourcing decisions is complicated sometimes
Working with institutions is surprisingly random
Working with retail stores/restaurants is promising
Many municipal governments are surprisingly obtuse

Please stay in touch

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Updates and references at:
https://sustainablesystemsfoundation.com/projects/waste/spin/