Printemps des Sciences 2018

LIÈGE université

Microplastiques et Océan

Part 1: Philippe Lecomte: Chimiste

LIÈGE université CESAM

ERM

fnrs LA LIBERTÉ DE CHERCHER

Part 2: Krishna Das: Océanologue

Mercredi 14 mars 2018 (18h00 – 20h30)

Questions

What is a plastic?

What is a bio-plastic?

How are produced plastics?

What is the amount of plastics produced in the world?

Why do we need plastics?

What is the impact on environment?

Are plastics useful to develop green technologies?

What is the end-life of plastics?

End-life in oceans → **Part 2 by Krishna Das**

What is a Plastic?

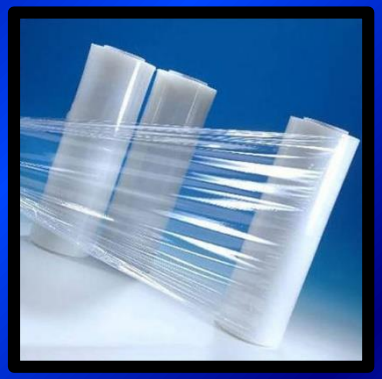
Plastics = macromolecules = chains, which behaves at the molecular level like spaghettis

The entanglement of chains impart excellent mechanical properties and you can process polymers into various objects of various shapes by different techniques (extrusion, molding…)

thermoplastic

synthetic polymer

film



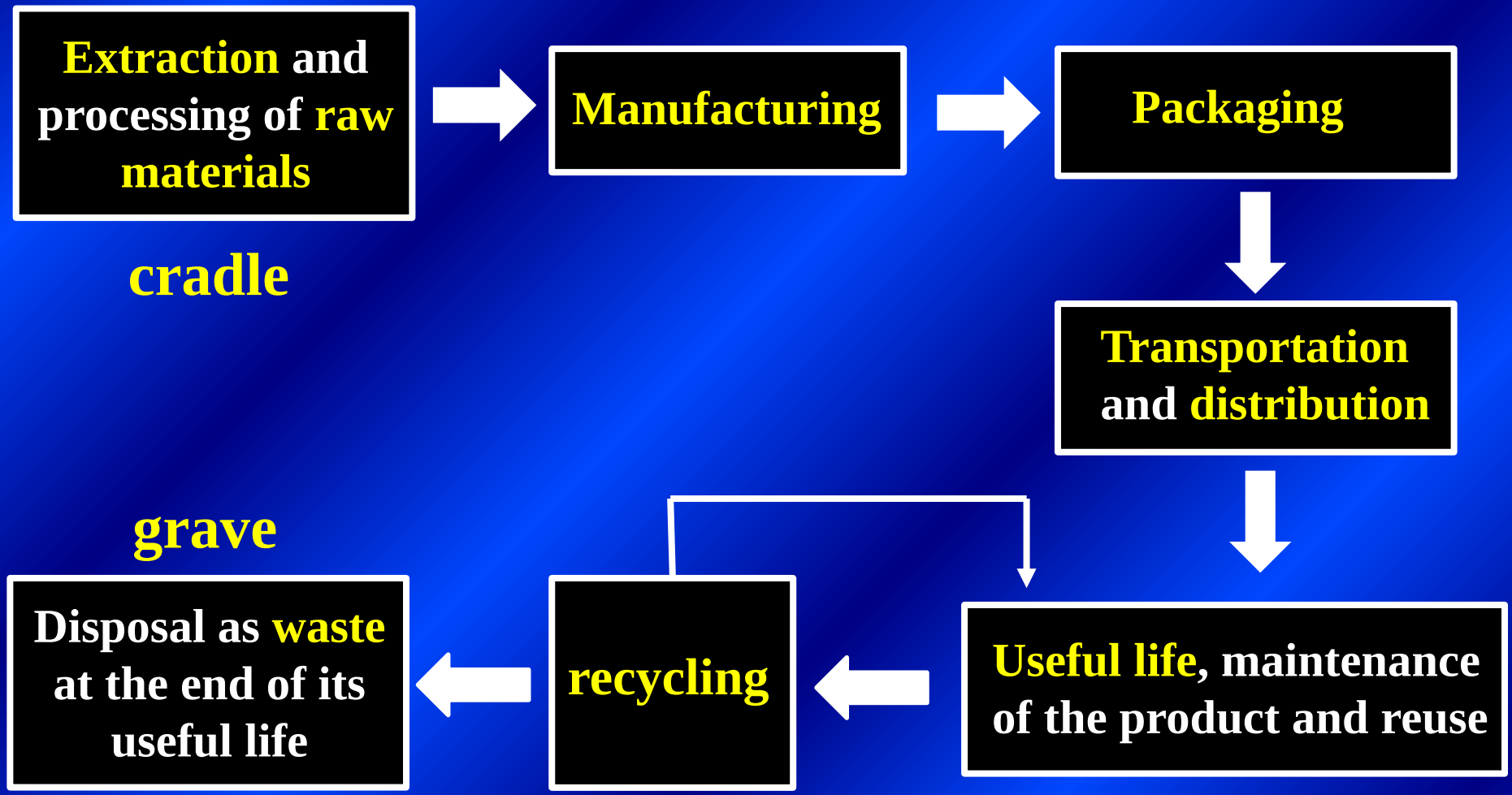
rubber

natural polymer

thermoset

synthetic polymer

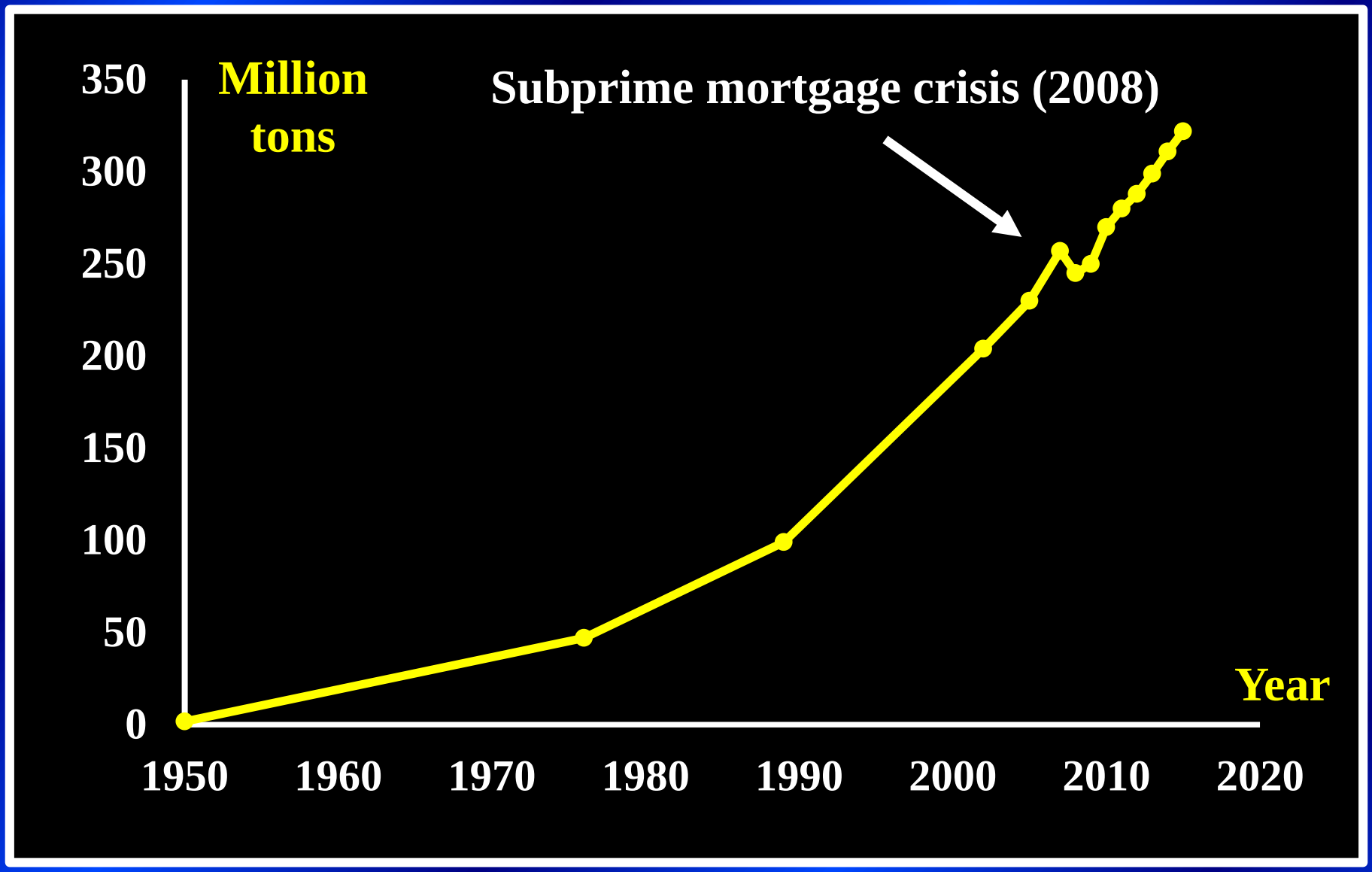
Impact on Environment



The Life Cycle Assessment (LCA) is a recognized technique used to quantify the environmental impact of products during their entire life cycle as an international standard-setting process via the ISO 14040 series (1997 and revised in 2006).

Production of plastics

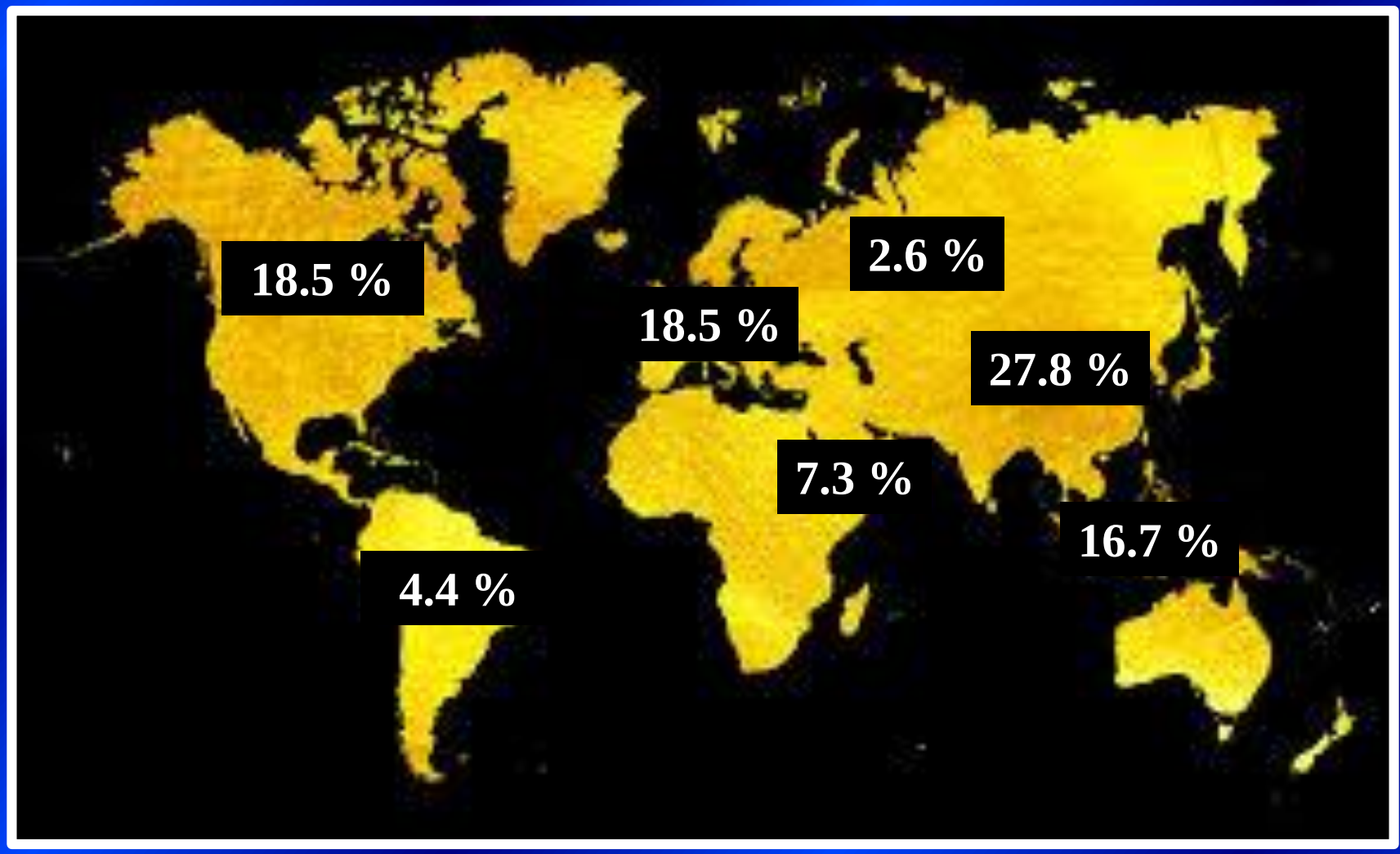
Plastic Production in the World



Plastics Europe, Association of Plastics Manufacturers

Plastic Production

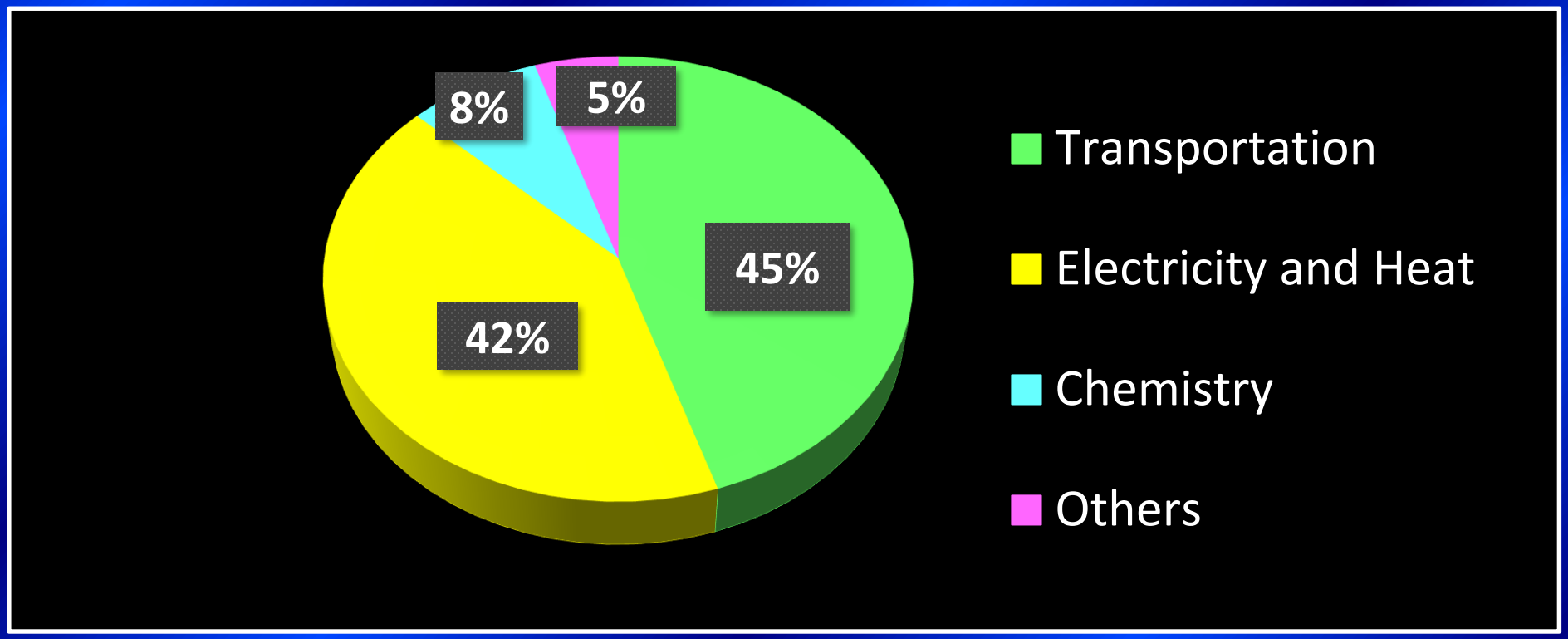
In 2015, 269 million tons were produced worldwide, with the following distribution:



Plastics Europe, Association of Plastics Manufacturers, 2016

Oil-Based Polymer

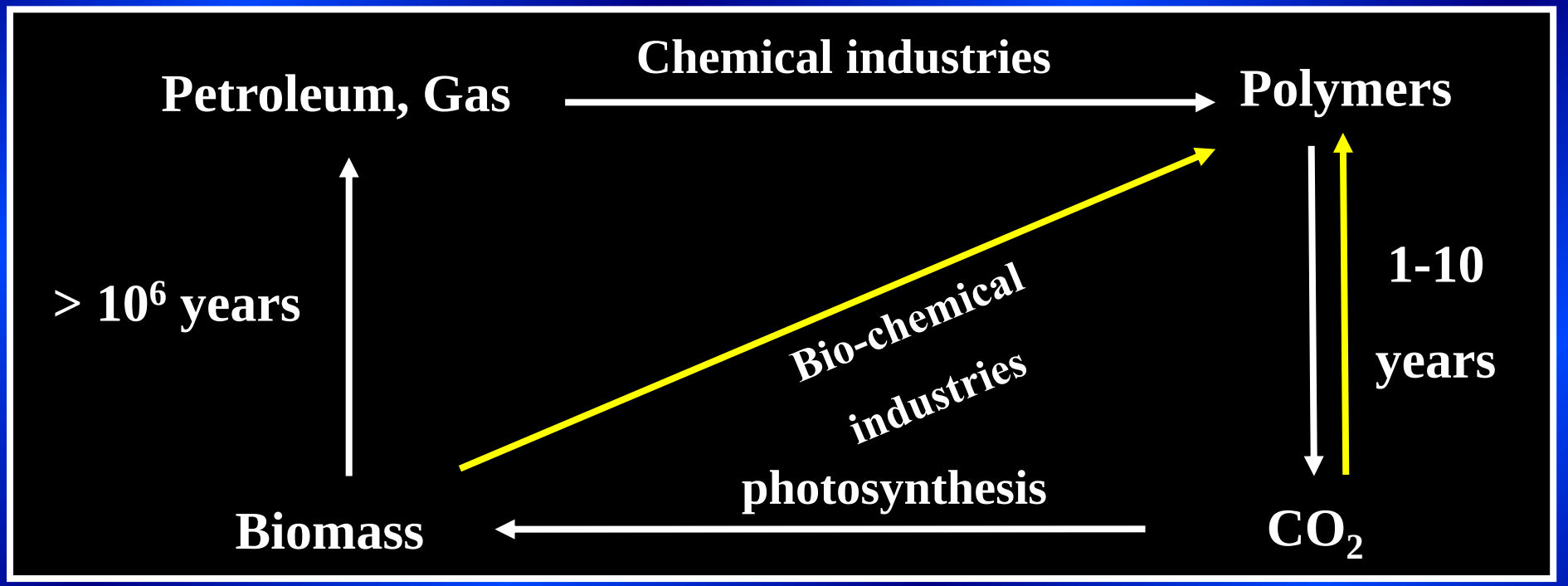
What is the ratio of oil and gas produced worldwide used for the production of plastics?



Only 8 % is used for petrochemicals and, among them, only around 4 to 6% for plastics !!!

Plastics Europe, Association of Plastics Manufacturers, 2016

Bio-Sourced Polymer



How to avoid the accumulation of CO_2 in the atmosphere in order limit the global warming, climate change and acidification of oceans?

Bio-sourced polymers are produced from biomass (living matter).

Biomass = renewable resource.

Bioplastics = Bio-sourced polymers = plastics produced from biomass.

Many bio-sourced polymers are not natural polymers but synthetic ones.

Global Warming and Climate Change

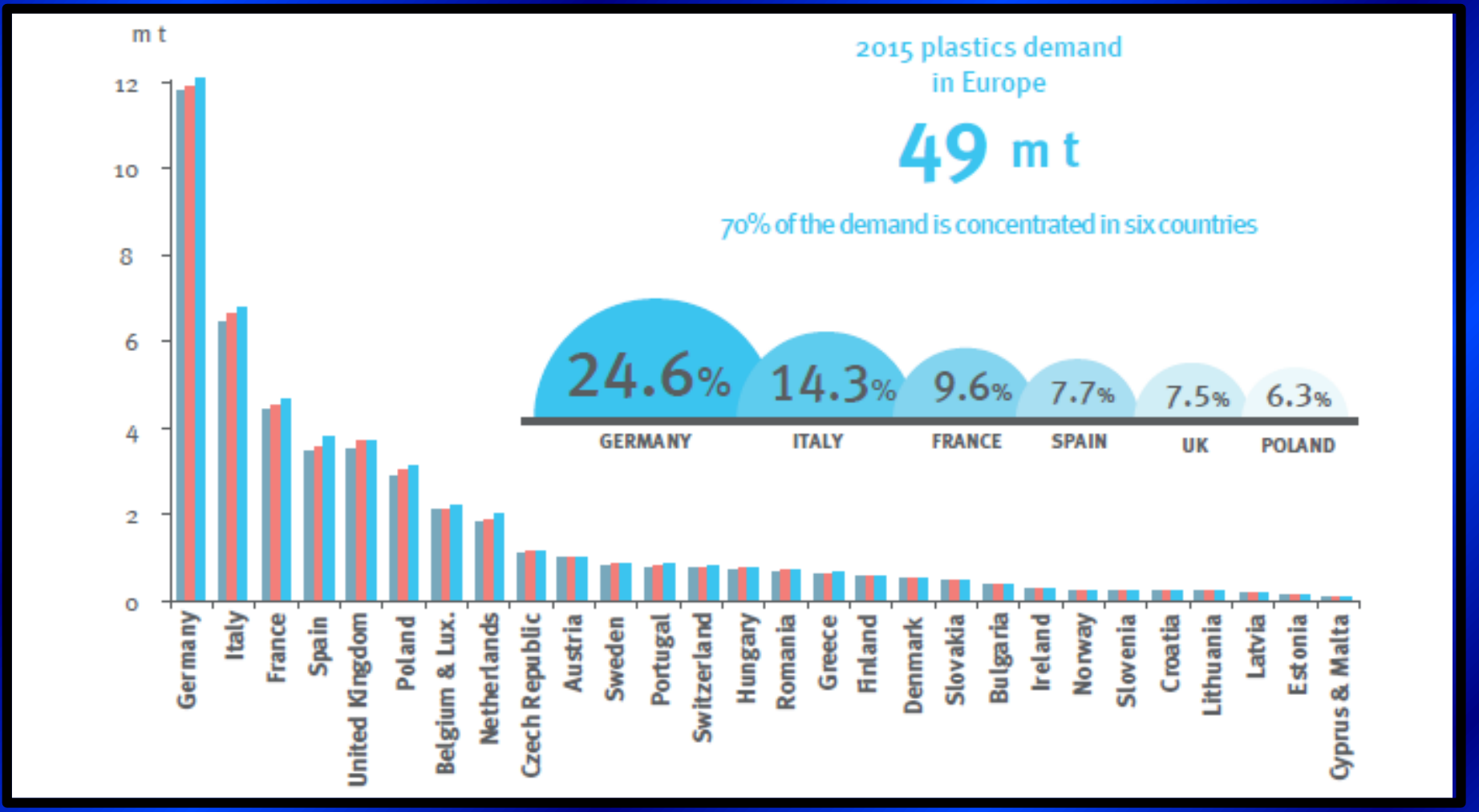
Consumption of oil as a source of carbon as far as oil-sourced polymers are concerned.

Consumption of oil as energy all along the plastic life:

- **Extraction of starting materials**
- **Preparation of polymers (chemistry)**
- **Processing of materials**
- **Transportation**
- **Application** → **End-life**

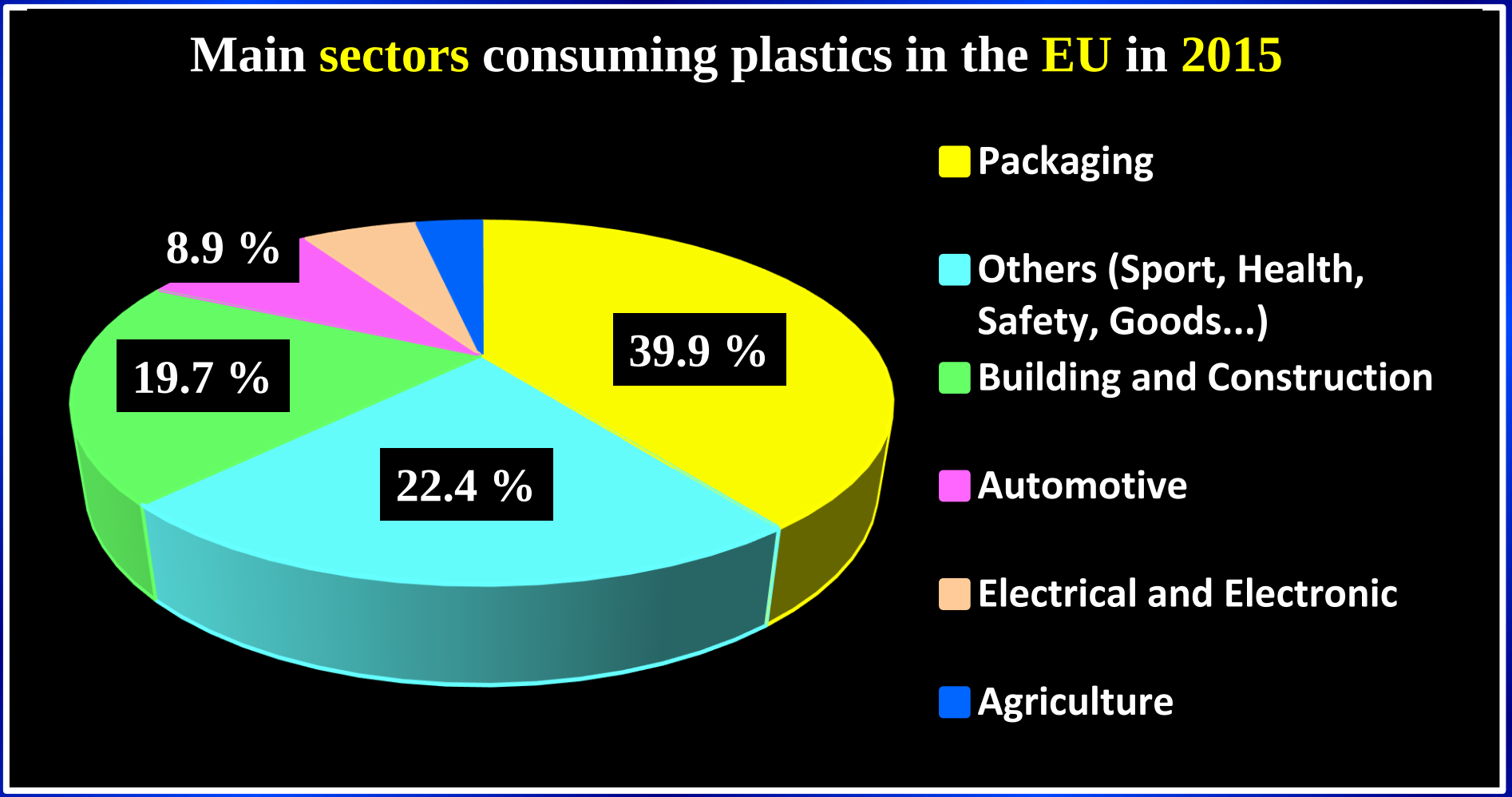
Consumption of plastics

Plastic Demand



Plastics Europe, Association of Plastics Manufacturers, 2016

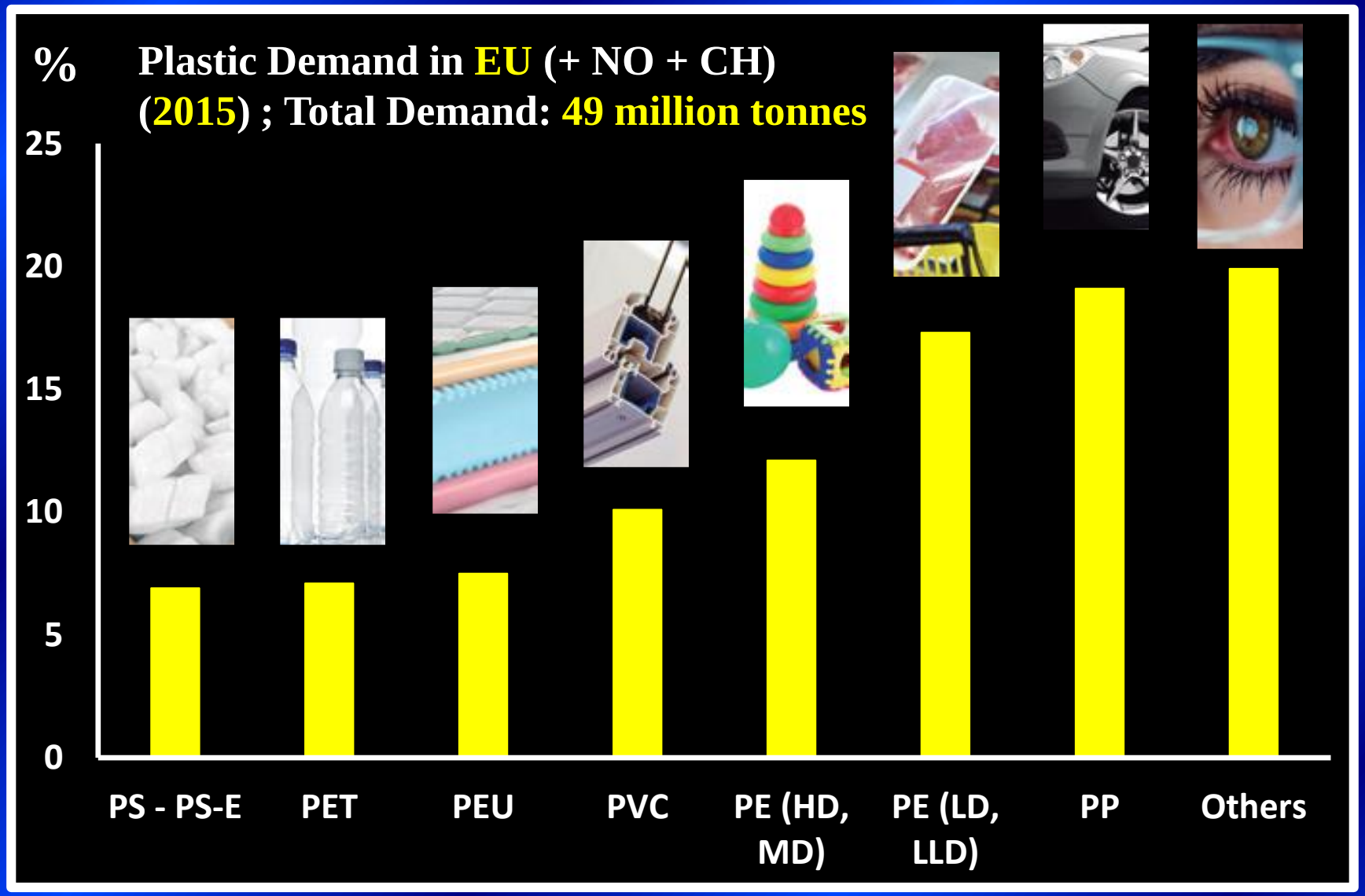
Application: Polymer



Packaging has also a **noble** action, for instance to protect food for storage (due to good barrier properties).

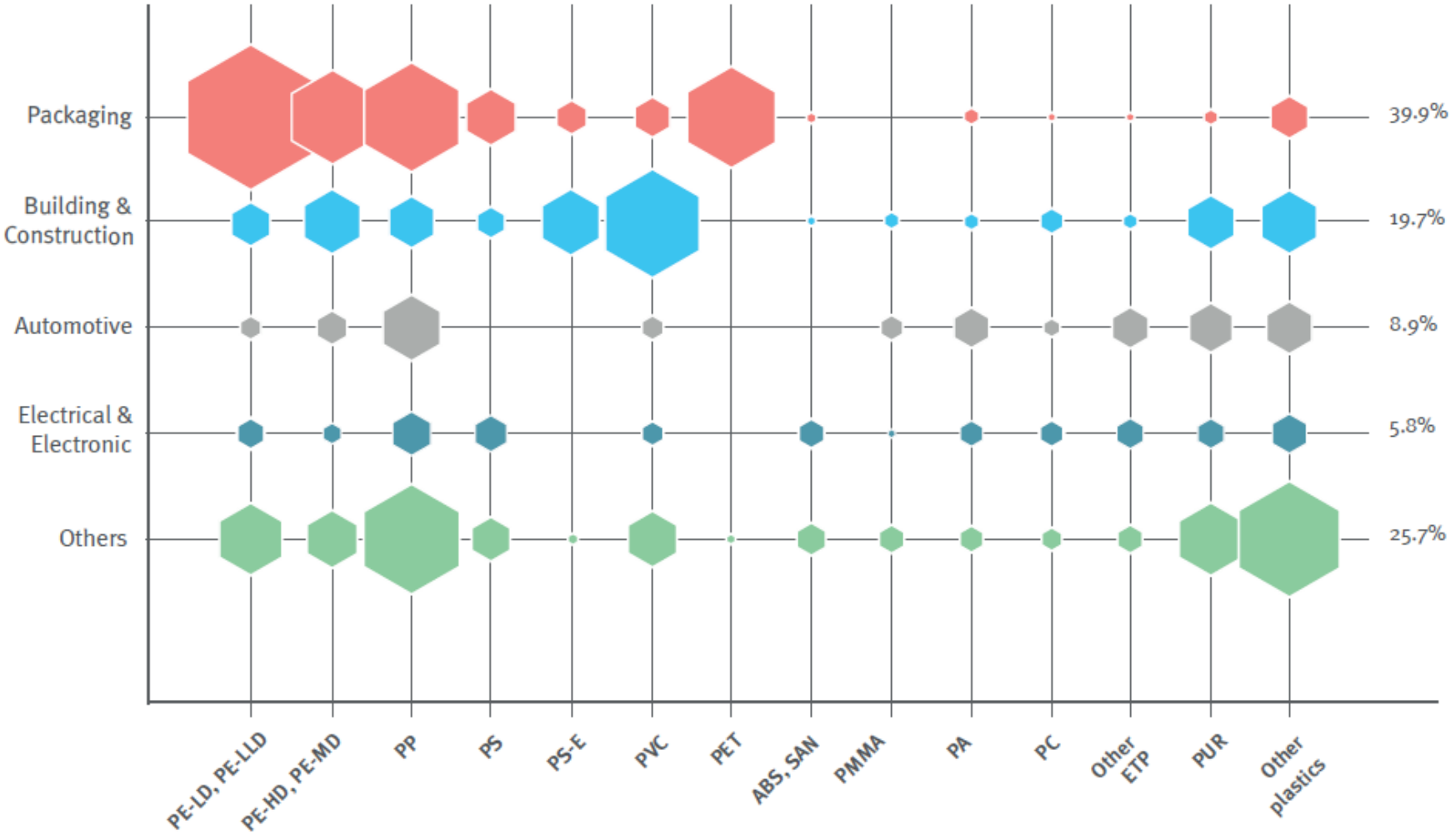
Plastics are **lighter** than glass → **Spare of energy** during transport

Plastic Consumption



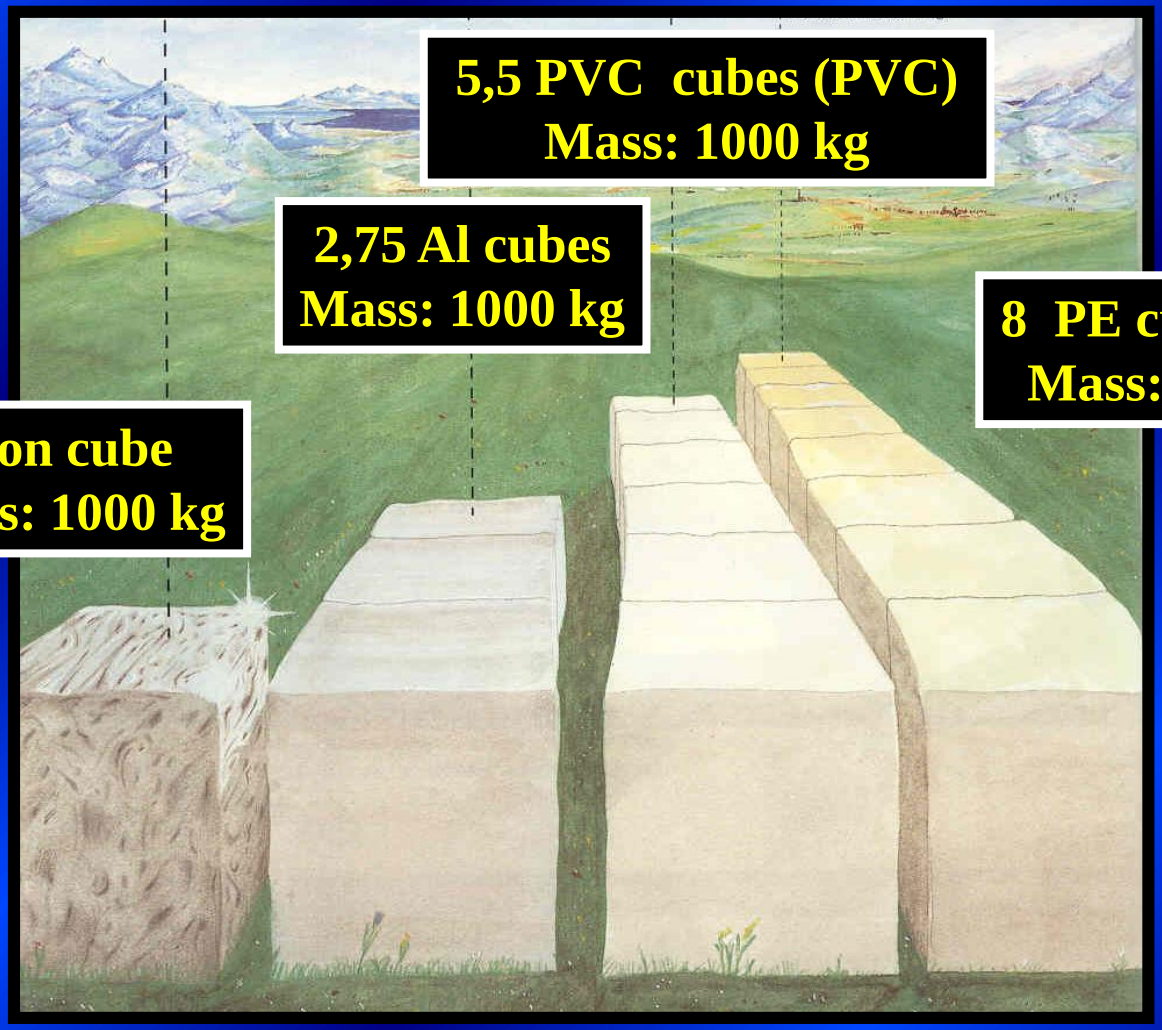
Plastics Europe, Association of Plastics Manufacturers, 2016

Plastic Production



Plastics Europe, Association of Plastics Manufacturers, 2016

Energy



Energy is spared during transportation due to the lower densities of polymers compared to metals

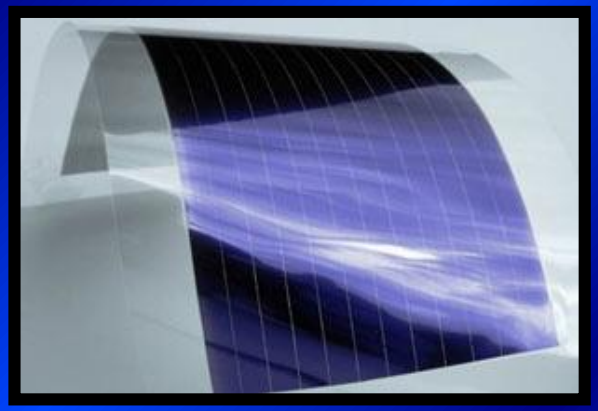
Plastics = Useful Material to save energy

Importance of the decrease of the weight in the transport sector (cars, airplanes):

- ✓ **decrease of the consumption of fuel**
- ✓ **decrease of pollution**
- ✓ **decrease of costs**

For efficient production of power energy by wind turbines, blades have to be bigger, stiffer, lighter !!!

Polymers = excellent materials for blades due to excellent mechanical properties and low weight



Polymers for solar cell:

Advantages: flexibility, light, low cost
Efficiency: < 11%
Durability: < 10 years

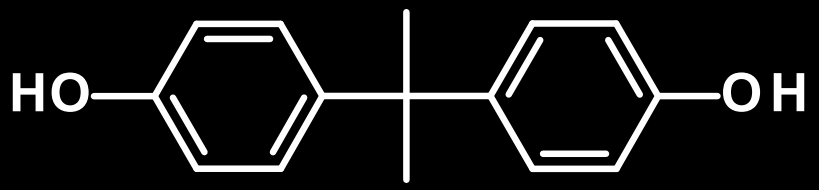
Plastics Materials
=
Polymer + Additives

Additives + Impurities

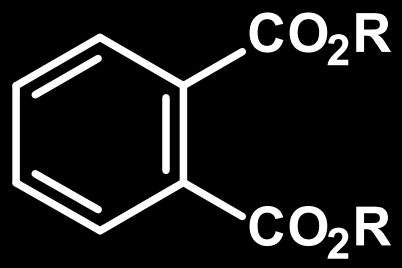
In a plastic, the polymer is often contaminated by impurities and blended with additives:

- **unreacted monomers.**
- **catalytical remnants, initiators.**
- **products formed by the degradation polymers.**
- **additives such as antioxidants and plasticizers.**

Bisphenol-A (monomer for the synthesis of PC and epoxy resins)

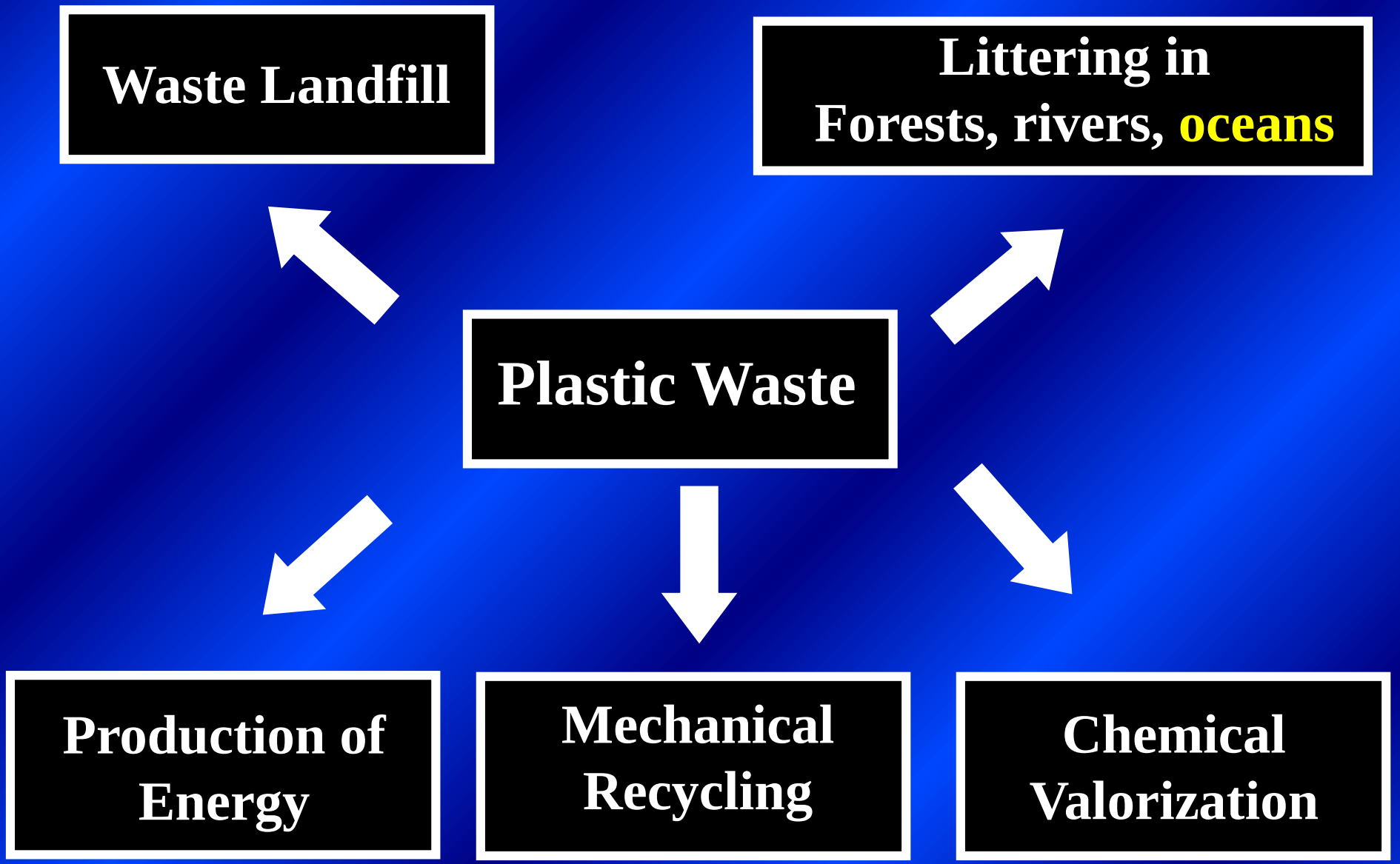


Phthalates (plasticizer of PVC)



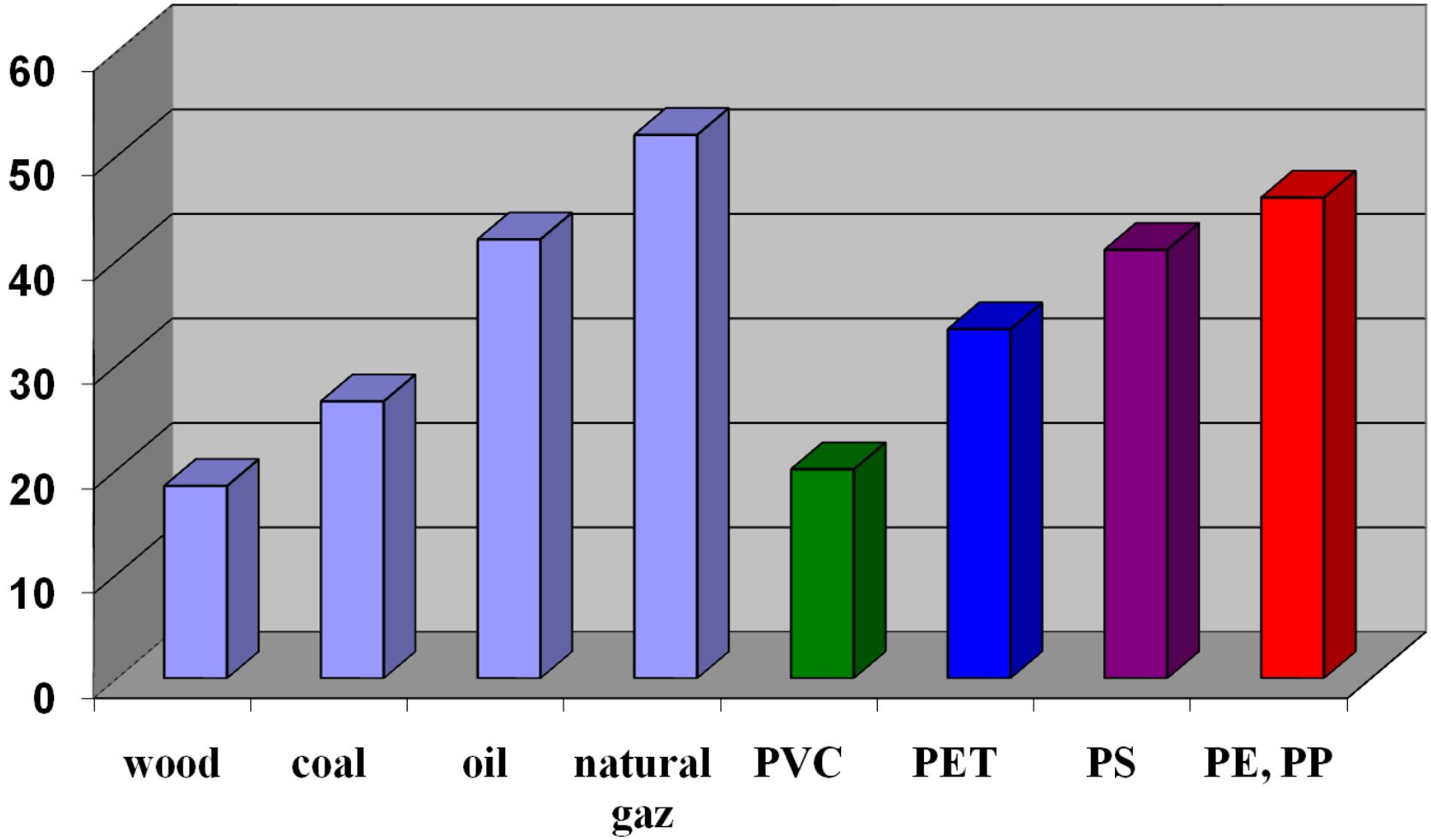
How to get rid of polymers after use?

End of Life: Valorization



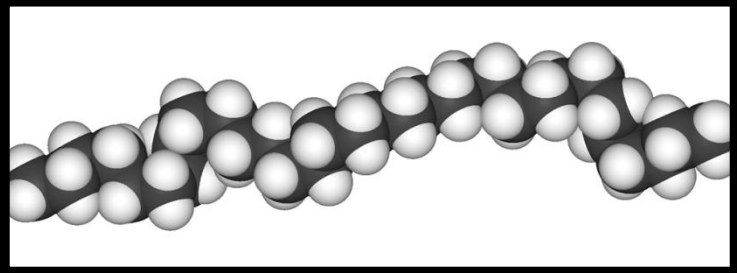
End of Life: Incinaration

Comparison of the calorific power (MJ/kg) of polymers with other common heat sources.



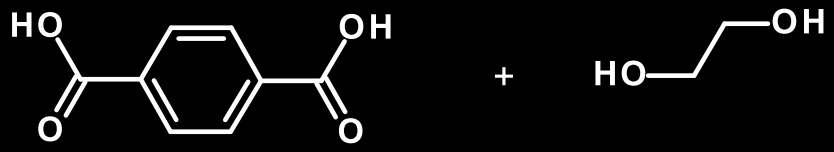
End of Life: Recycling

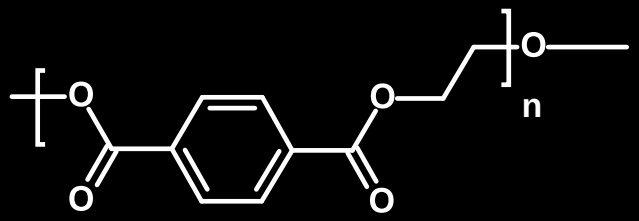
PE



PEHD: high density polyethylene

PET: poly(ethylene terephtalate)





End of Life: Recycling

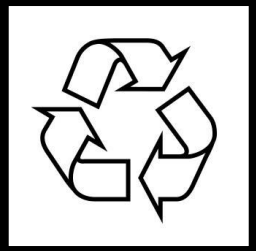
Mechanical recycling of plastics refers to processes which involve the melting, shredding or granulation of waste plastics.

The chemical structure of the macromolecules remains unmodified.

Plastics must be sorted prior to mechanical recycling.

Example: recycling of PET

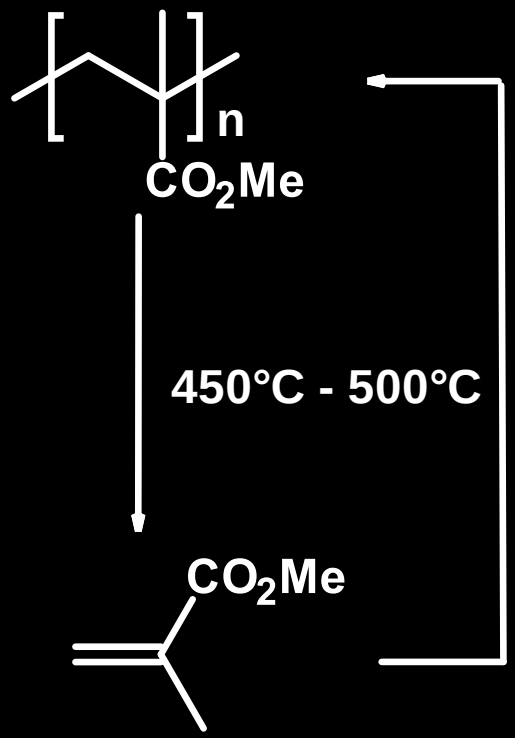
27 bottles in PET



1 pullover

End of Life: Pyrolysis

Depolymerization of PMMA

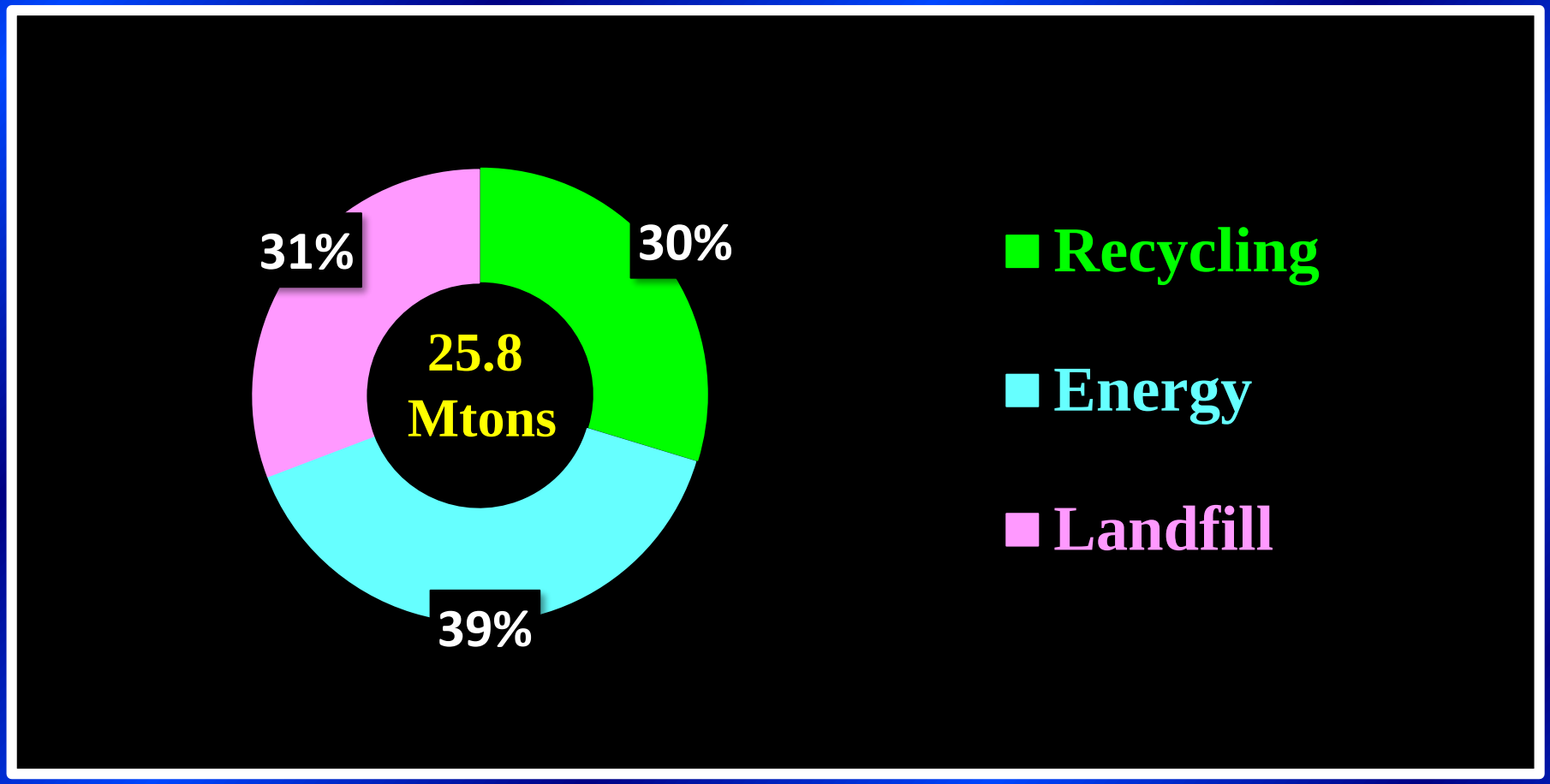


Polymerization

- **Depolymerization** within a few minutes
- 97% recovery of MMA

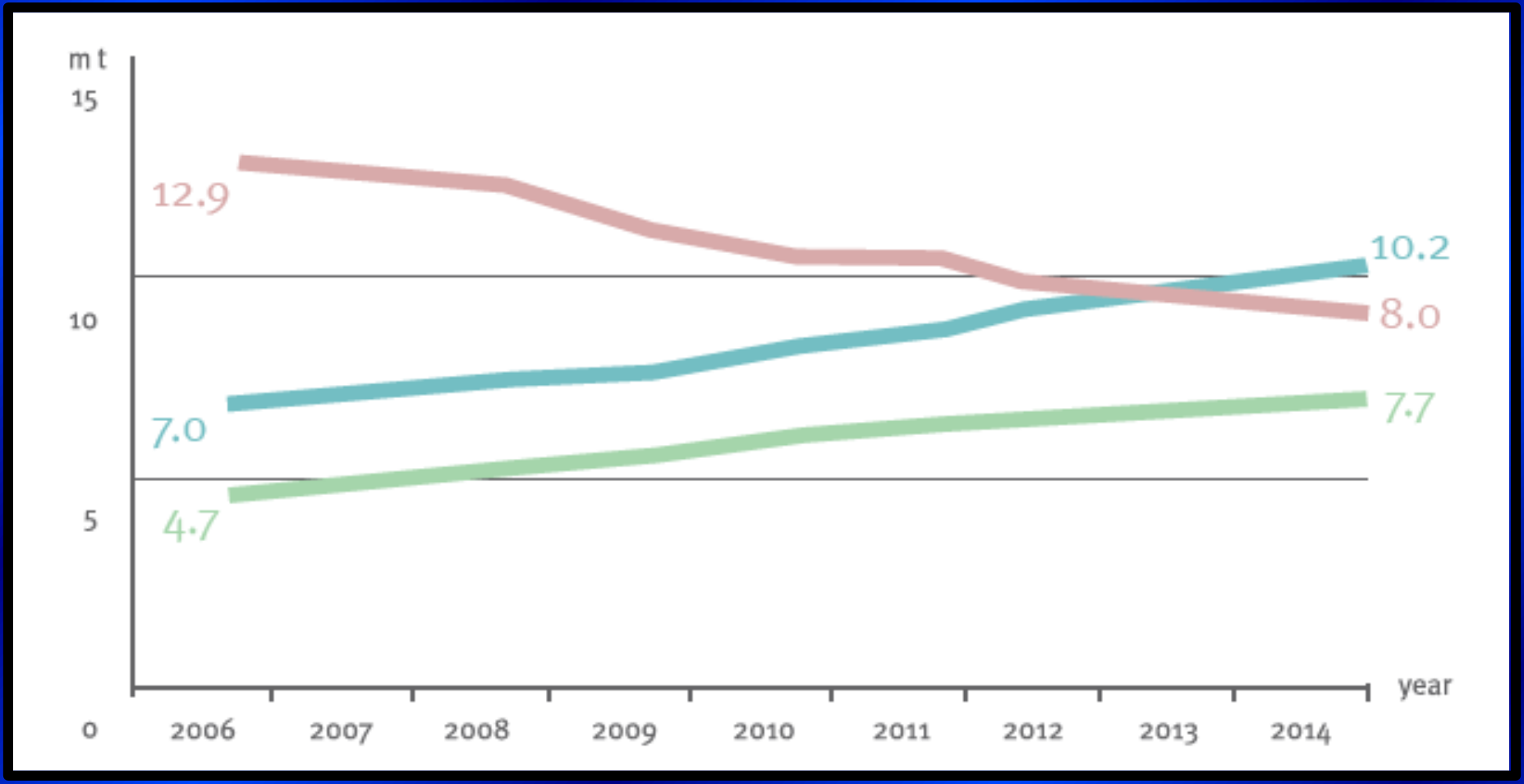
Plastics Waste Treatment

What is the fate of plastics after use in the EU (28 + 2) in 2014?



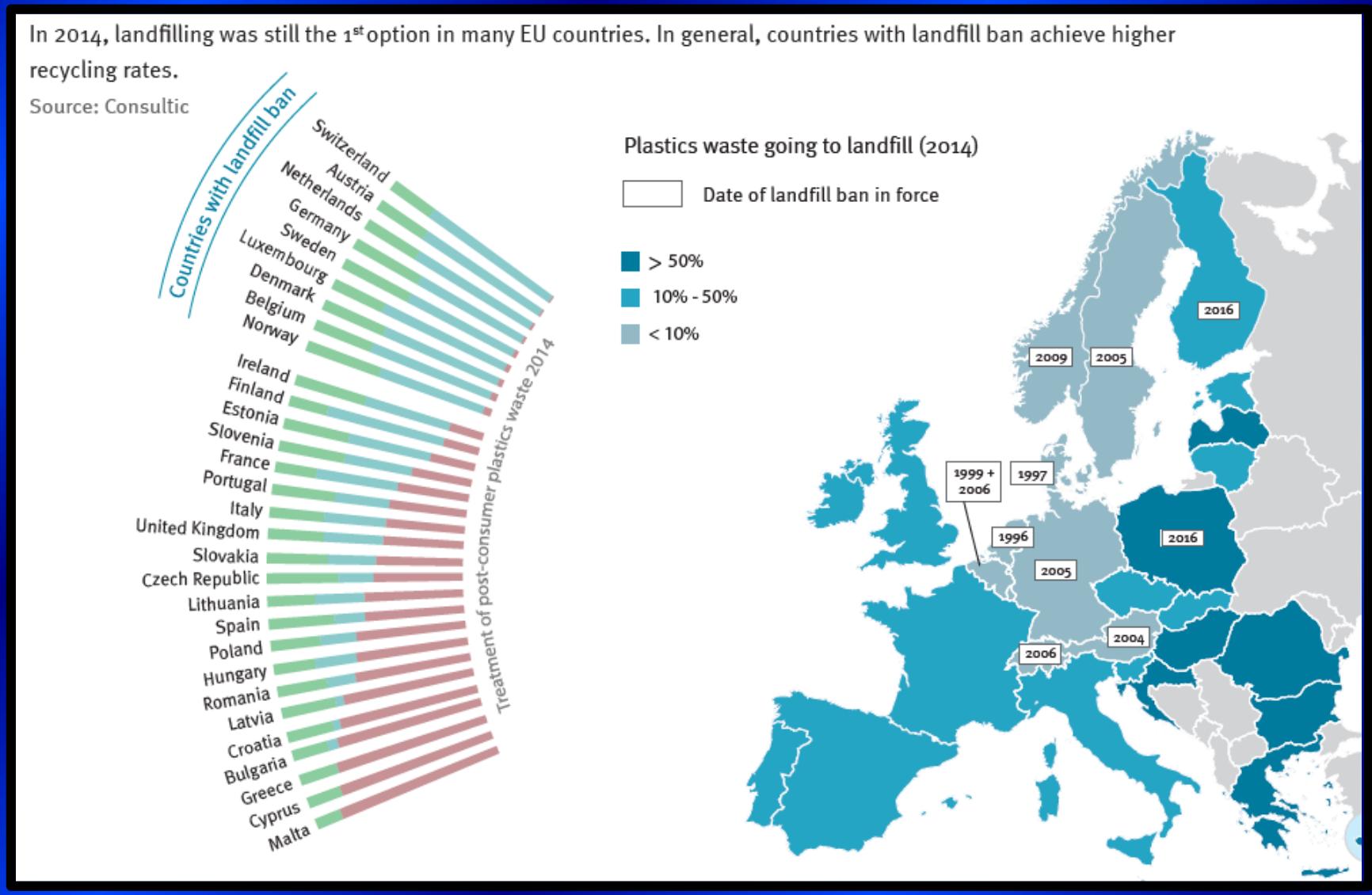
Plastics Europe, Association of Plastics Manufacturers, 2016

Plastics Waste Treatment (EU 28+2)



Plastics Europe, Association of Plastics Manufacturers, 2016

Plastics Waste Treatment (2014)



Plastics Europe, Association of Plastics Manufacturers, 2016

(Bio)degradable polymers

Biodegradation

Biodegradable polymer materials:

- retain their **performances during use.**
- degrade after use into low molar mass compounds under biological stimuli.
- ultimately **degrade into CO_2** and/or **CH_4**, **H_2O**, and **biomass** at comparable and **commensurable rate** and **extent**, as known for environmentally degradable materials like yard waste and paper, and leaves no persistent or toxic residues.

Biodegradation is not immediate :

- At which speed are degradation products released?
- What are the released products? (degradation products, additives,…)
- In which amout are they released?
- What is the toxicity of released products?

→ **Release in Oceans**

Fate of Plastics in the environment

Step 1:

Polymer material after use

Disintegration

Mechanical, UV, thermal

and/or

Biofragmentation

Bacteria, champignons, vers de terre, insects,…

Increase of the contact surface with microorganisms

Step 2:

Bioassimilation

Digestion by microorganisms and enzymes

métabolites

CO_2/CH_4, H_2O

Mineralization

End of Life: (Bio)degradation

The EN 13432 standard: the need to recover packaging waste on the basis of industrial composting.

Requirements:

- **Chemical composition: the standard sets the limits for volatile matter, heavy metals and fluorine;**
- **Biodegradation: at least 90% of the material has to be broken down into CO_2, water, minerals by biological action within 6 months;**
- **Desintegration: at least 90% of the material should be able to pass through a 2x2 mm mesh after 12 weeks;**
- **Quality of the final compost and ecotoxicity: the germination and biomass production of plants should not be affected by the influence of the composted packaging.**

http://www.okcompost.be/en/recognising-ok-environment-logos/ok-compost-amp-ok-compost-home/

End of Life: (Bio)degradation

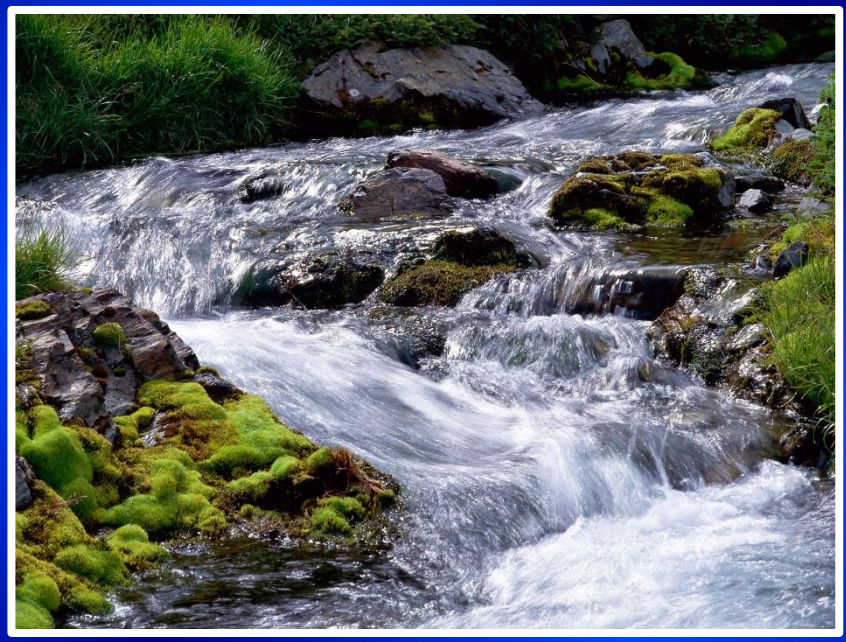
OK Biodegradable SOIL

Biodegradability in the soil offers huge benefits for agricultural and horticultural products, as they can be left to break down in situ after being used. The OK biodegradable SOIL label is a guarantee a product will completely biodegrade in the soil without adversely affecting the environment.

http://www.okcompost.be/en/recognising-ok-environment-logos/ok-biodegradable-soil-amp-ok-biodegradable-water/

End of Life: (Bio)degradation

OK Biodegradable in WATER



Products certified for OK Biodegradable WATER guarantee biodegradation in a natural fresh water environment, and thus substantially contribute to the reduction of waste in rivers, lakes or any natural fresh water. Note that this not automatically guarantees biodegradation in marine waters.

http://www.okcompost.be/en/recognising-ok-environment-logos/ok-biodegradable-soil-amp-ok-biodegradable-water/

End of Life: (Bio)degradation

OK compost

Packaging or products featuring the OK compost label are guaranteed as biodegradable in an industrial composting plant. This applies to all components, inks and additives. The sole reference point for the certification programme is the harmonised EN 13432: 2000 standard.

In any event any product featuring the OK compost logo complies with the requirements of the EU Packaging Directive (94/62/EEC).

http://www.okcompost.be/en/recognising-ok-environment-logos/ok-compost-amp-ok-compost-home/

End of Life: (Bio)degradation

OK compost HOME

Owing to the comparatively smaller volume of waste involved, the temperature in a garden compost heap is clearly lower and less constant than in an industrial composting environment. This is why composting in the garden is a more difficult, slower-paced process.

The certification OK compost HOME from Vinçotte guarantees complete biodegradability in the light of specific requirements, even in your garden compost heap.

http://www.okcompost.be/en/recognising-ok-environment-logos/ok-compost-amp-ok-compost-home/

Meaning of Bio for Plastics

The term « bioplastic » is used in relation to its origin

The biodegradability is a property of the polymer

For example, PCL is a synthetic polymer (not natural)

Industrial PCL is currently not a bioplastic
because it is an oil –based polymer

but is biodegradable !!!
Patents are reported for the production of bio-sourced PCL.

Let us point out that confusion regarding the meaning of "bio".
"bio" says nothing about the respect for environment