Secondary Raw Materials: Recycling Plastics and Polymers

IAMC Toolkit

Innovative Approaches for the Sound Management of Chemicals and Chemical Waste

UNIDO UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

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Introduction

- In the production of plastic materials, raw material consumption and plastic waste after use has important life cycle impacts on society and the environment.

- Companies can innovate to recycle and reuse plastic products after use in save material, water and energy resources.

- This presentation provides guidance on the different types of waste management options and shows examples of how plastics and polymers can be physically recycled into new plastic products, or chemically recycled into virgin polymers and used as raw materials in the manufacture of plastic products

Contents

Production of Plastics and Waste

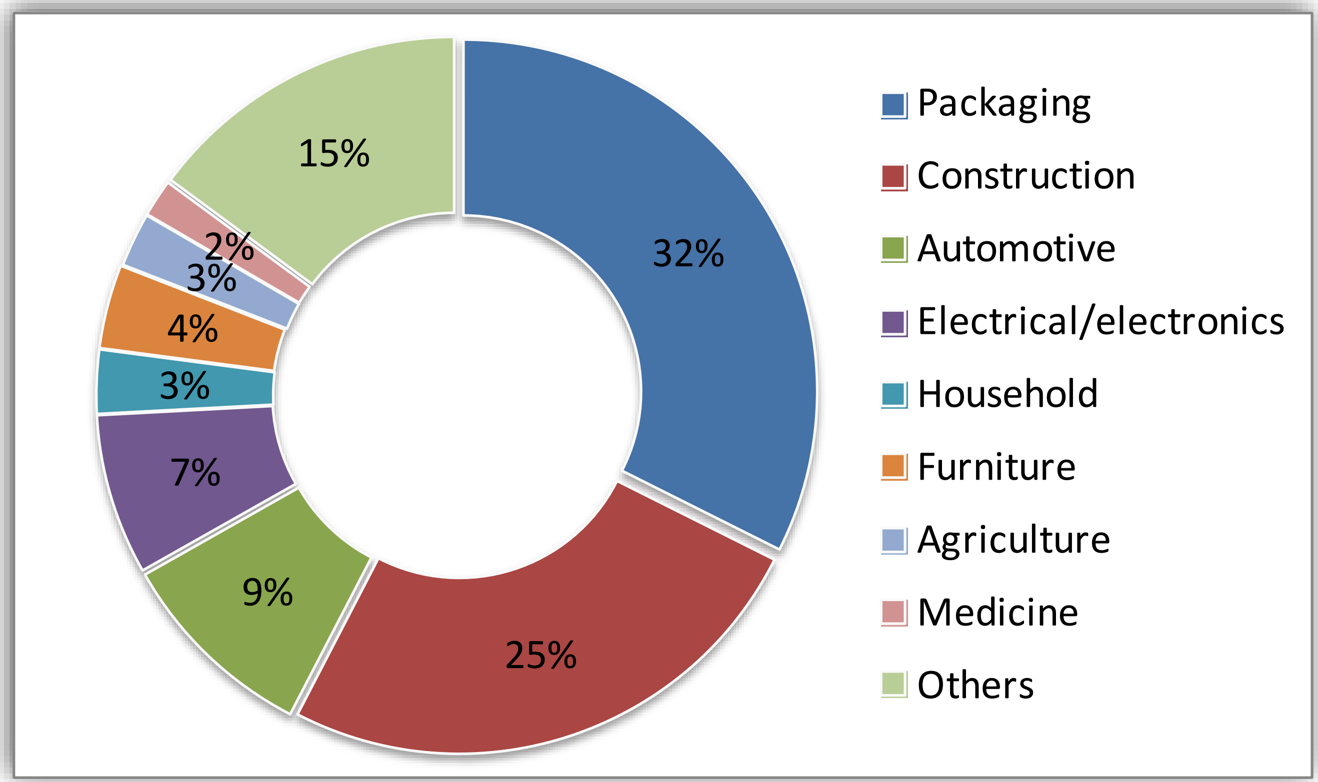
- **Global production**
- **Life cycle impacts**
- **Waste and waste management options**

Global Plastics Production

- Plastics are an indispensable part of modern life.
- Increase in global annual plastics production for more than 50 years
- 2013: Approx. 299 million tons produced
- Production requires about 8% of global petroleum consumption
  - (4% feedstock, 4% energy source)
- Five dominating groups of plastics account for 70-75% of demand:
  - Polyethylene (PE)
  - Polypropylene (PP)
  - Polyvinyl chloride (PVC)
  - Polystyrene (rigid PS and expanded/expandable EPS)
  - Polyethylene terephthalate (PET)

Economic Sectors Using Plastics

Distribution of processed plastics by sector in Germany 2007



Economic Sectors & Corresponding Plastic Type

Proportion of plastic types used in the **packaging, construction, automotive and electrical/electronic sector** in Germany in 2007

	LDPE (low-density poly-ethylene)	HDPE (high-density poly-ethylene)	PP (poly-propylene)	PVC (polyvinyl chloride)	PET (poly-ethylene terephtha-late)	Other
Packaging					~500 kt	
Construction						
Automotive						
Electrics/ electronics						

Production of Plastics and Waste

- Global production
- **Life cycle impacts**
- Waste and waste management options

Life Cycle Impacts of Plastics

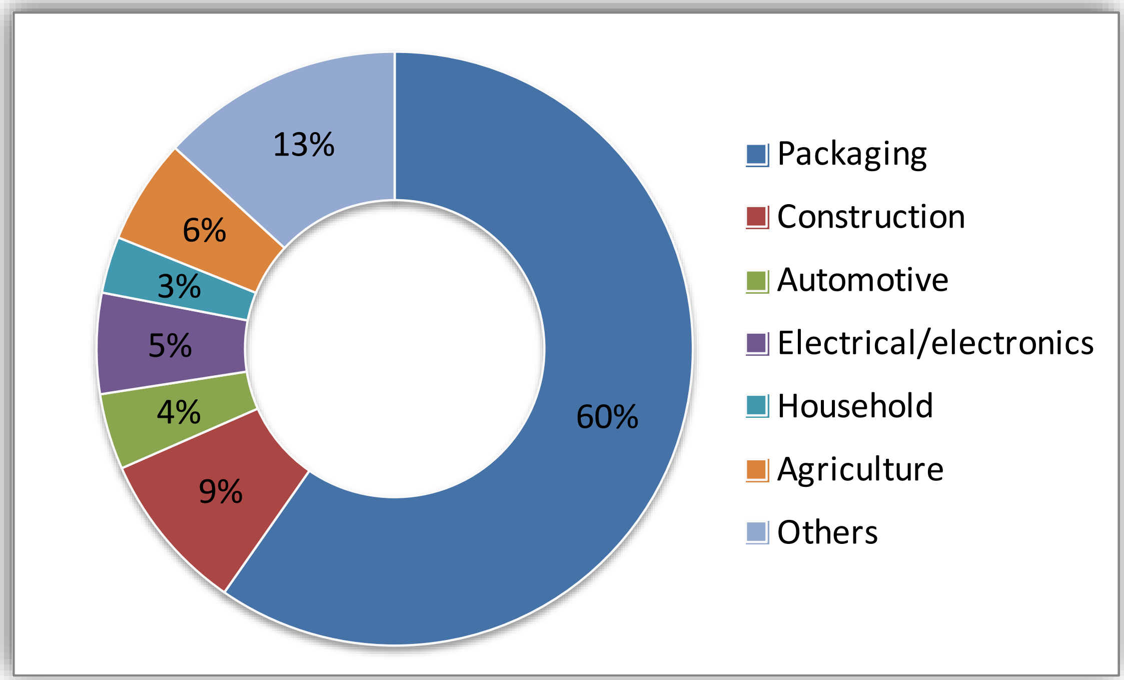
Plastics have a large impact on the environment.

Examples:

- Production of one 0.5 l bottle consumes 5.3 l of water
- Approx. 480 kJ of energy required for producing a plastic bag (HDPE)
- (Toxic) emissions to air and water during production and waste treatment
- Incineration of plastics contributes to climate change (incineration of one plastic pallet releases approx. 1,180 kg of CO_2)
- Plastic waste pollutes the oceans

Global Plastic Waste

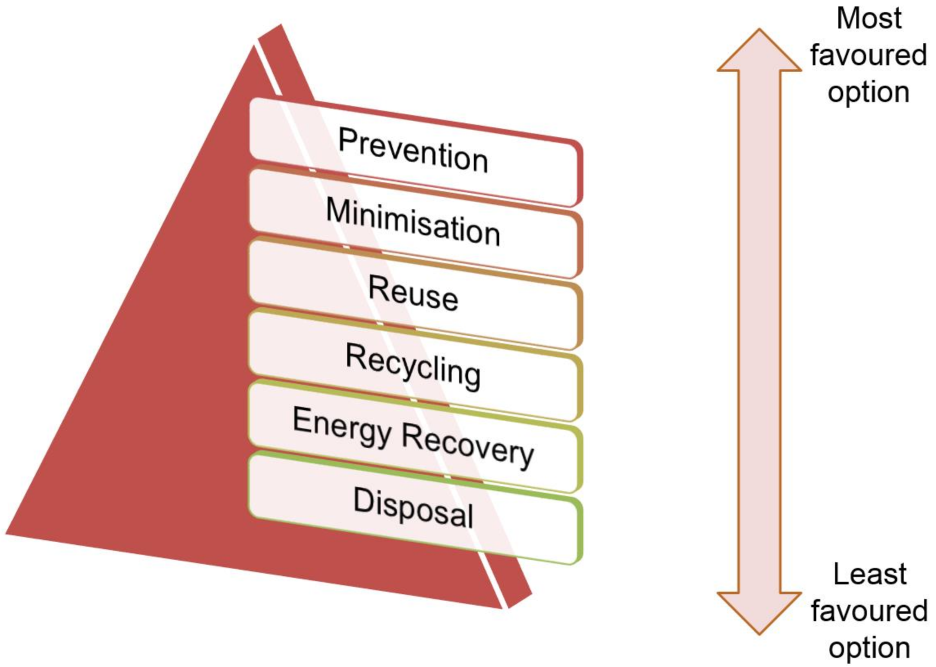
- More than 60% of plastic waste comes from packaging
- Example Germany:
  - Proportion of post-consumer waste by sector in 2007



Production of Plastics and Waste

- Global production
- Life cycle impacts
- **Waste and waste management options**

Waste Management Options (I)



Limited resources and increasing production and consumption make the prevention of plastic waste the most favoured option.

Disposal in landfills should be the last option as resources are wasted.

Waste Management Options (II)

- Worldwide, 22-43% of all plastics are disposed of in landfills where they make up about 20% of the volume.

- Example Europe 2012
  - 26% (6.6 million tons) recycled
  - 36% incinerated for energy generation
  - 38% disposed of in landfills

- BUT: Innovative companies can find and forge market opportunities favouring an environmentally profitable solution. Local context and drivers need to be observed.

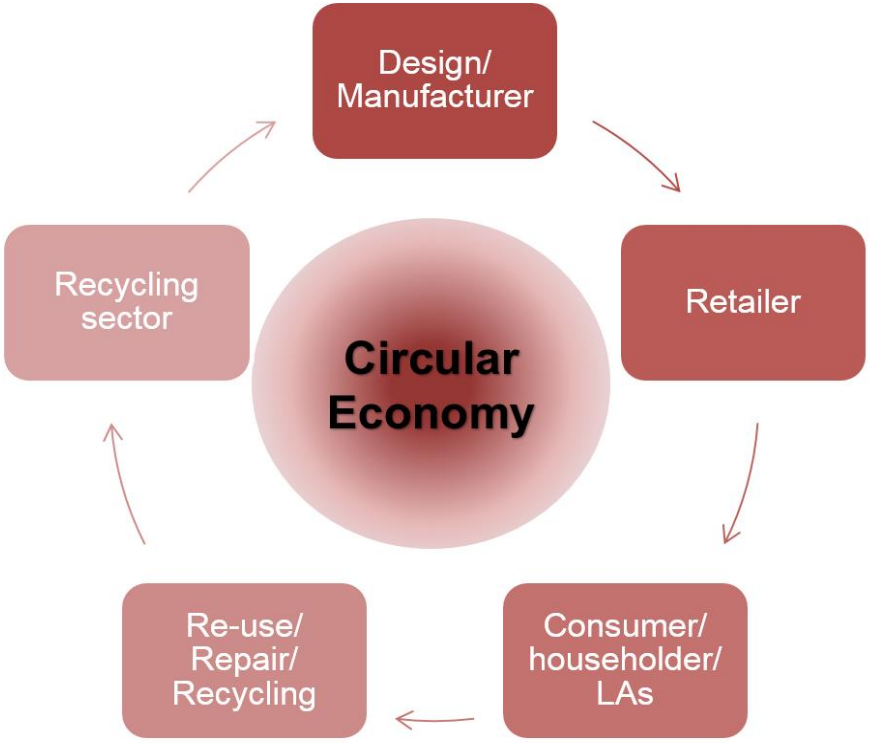
Options for the Environmentally Sound Management of Plastics

- Circular economy as a concept to prevent (plastics) waste and save resources:

  - Step 1: reduction of consumption and waste generation

  - Step 2 : products are continuously re-used, repaired or recycled

→ Closed loop of (chemical) raw materials by means of different types of recycling, substitution of feedstock by recyclates



Benefits of Recycling

- Reducing the consumption of raw materials as a result of closed material cycles
  → Substitution of raw materials
  - Improvement of resource efficiency
  - Overcoming resource scarcity
- Reducing energy consumption
- Potential reduction of hazardous or harmful substances in the upstream production chain
  → Substitution of hazardous substances by end-of-life material
- Reducing the cost for
  - Energy supply
  - Raw materials
  - Disposal of by-products and disused products

Recycling of Plastics and Polymers

- **Possibilities for recycling**
- Types of recycling
- Case studies

Recycling Options for Companies

Effort, value chain engagement, innovation, life cycle impact

Recycle internally

- Minimization of process waste in your company
- Example: Lanxess AG

Use secondary raw materials

- Your company processes recycled feedstock from an external provider
- Example: IntracoPallet

Reclaim waste and recycle

- Directly reclaim waste and recycle your product
- Example: DuPont

Example: Internal Recycling

Lanxess AG

- Plastic material typically consists of 100% non-renewable resources.
- A new product line was developed that contains over 30% of recycled material.
- Benefits
  - Comparable quality
  - Reduced resource consumption
  - Lower environmental impact
- Outlook:
  - High quality PA (polyamides) and PBT (polybutylene terephthalate) may consist of up to 90% recycled material.

Example: External Recycling

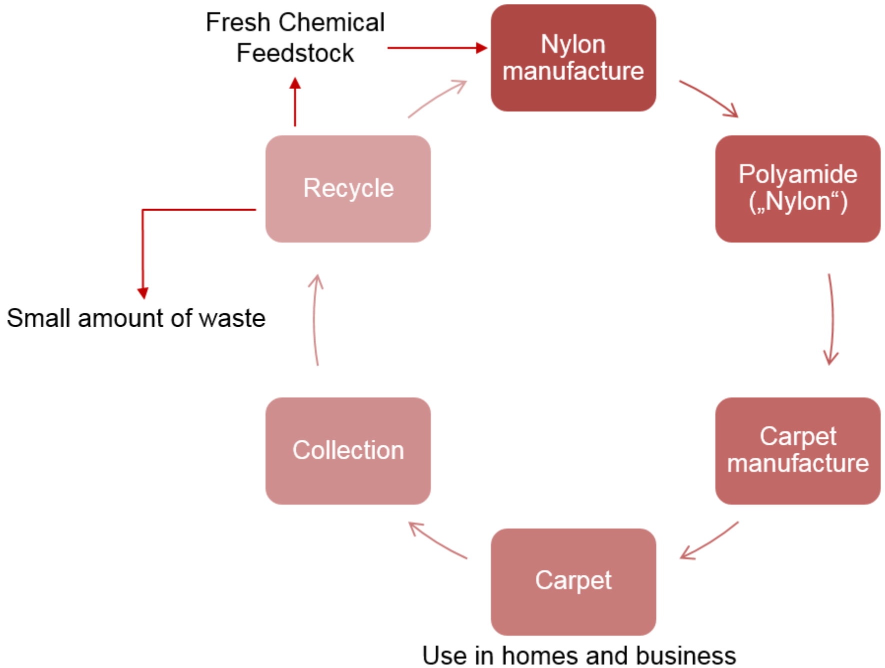
IntracoPallet, Malysia

- Production of environmentally friendly plastic pallets from plastic scrap
- Plastic scrap is collected by an external provider
- IntracoPallet purchases the scrap to produce plastic pallets
- Benefits:
  - Reduced environmental impacts
  - Economic savings for customers
  - Lightweight durable pallets

Example: Waste Reclamation

DuPont

- Reclamation and recycling programme for carpets since 1991
- Approx. 90% of the material (polyamide/nylon) can be recycled
- Ammonia to break the chains into smaller units



- Recycling to nylon
- Reused for the production of carpet fibre, floor tiles, carpet cushion and parts for cars
- "Closed-loop" recycling

Recycling of Plastics and Polymers

- Possibilities for recycling
- **Types of recycling**
- Case studies

Types of Recycling and Recovery

Recycling types in order of preference:

1. Mechanical recycling
2. Chemical recycling
3. Energy recovery*

* Incinerating plastic waste to recover energy is not recycling but it is preferable to landfilling.

→ Any form of recycling or recovery is better than landfilling.

Feasibility of Recycling Types

Questions you can ask to find a suitable solution for your company:

- Which recycling option suits my company best?
- Can I use recycled or recovered materials in my process to substitute feedstock materials?

The decision for a particular recycling option depends on:

- Quality of plastics
- Quantity of plastics
- Possibility to separate different types of plastics
- Demand for recyclates

Mechanical Recycling

- Chemical structure is not changed (significantly) but plastics are mechanically transformed at their end-of-life

- Best recycling option
  - Often low energy demand
  - Small amounts of waste produced

- Clean and sorted material is required

Mechanical recycling is the best option if:

- Large quantities of plastics are available
- Plastics can be easily separated into pure types
- Examples: PET bottles, PVC pipes, PUR seat upholstery from end-of-life vehicles, waste cables

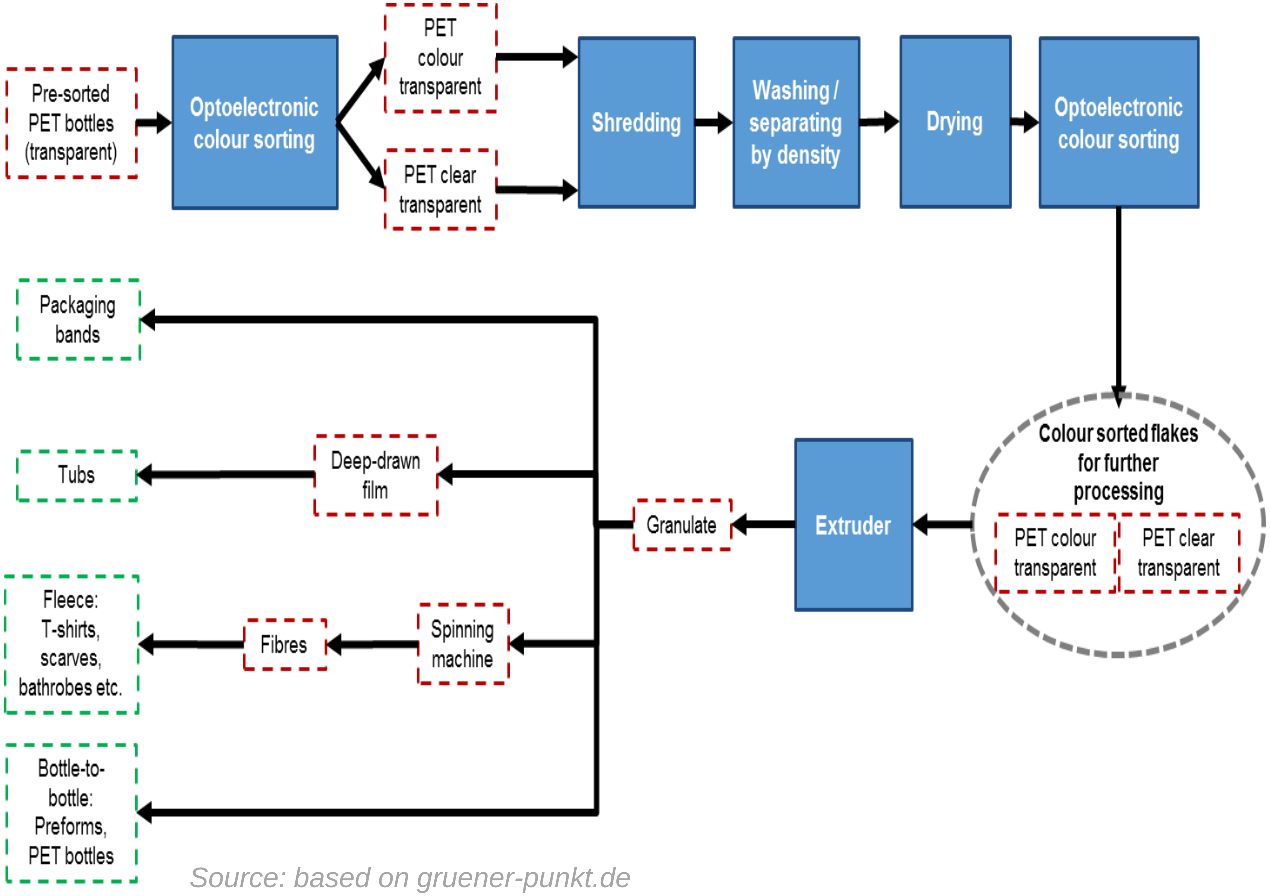
Recycling of Plastics and Polymers

- Possibilities for recycling
- Types of recycling
- **Case studies**

Example: Recycling of PET Bottles

PET bottles can be recycled to:

- Bottles
- Synthetic fabrics
- Other plastics like packaging, etc.



Source: based on gruener-punkt.de

Chemical Recycling

Chemical recycling = feedstock recycling

- Transformation of plastic products into molecules or monomers
  - Gasification (synthetic gas production, e.g. PER synthesis)
  - Pyrolysis
  - Hydrolysis

- **Chemical recycling should be used for plastics that are more difficult to recycle, such as**
  - Laminated and composite plastics
  - Mixed plastics
  - Contaminated plastics

Example: Chemical Recycling of PTFE (I)

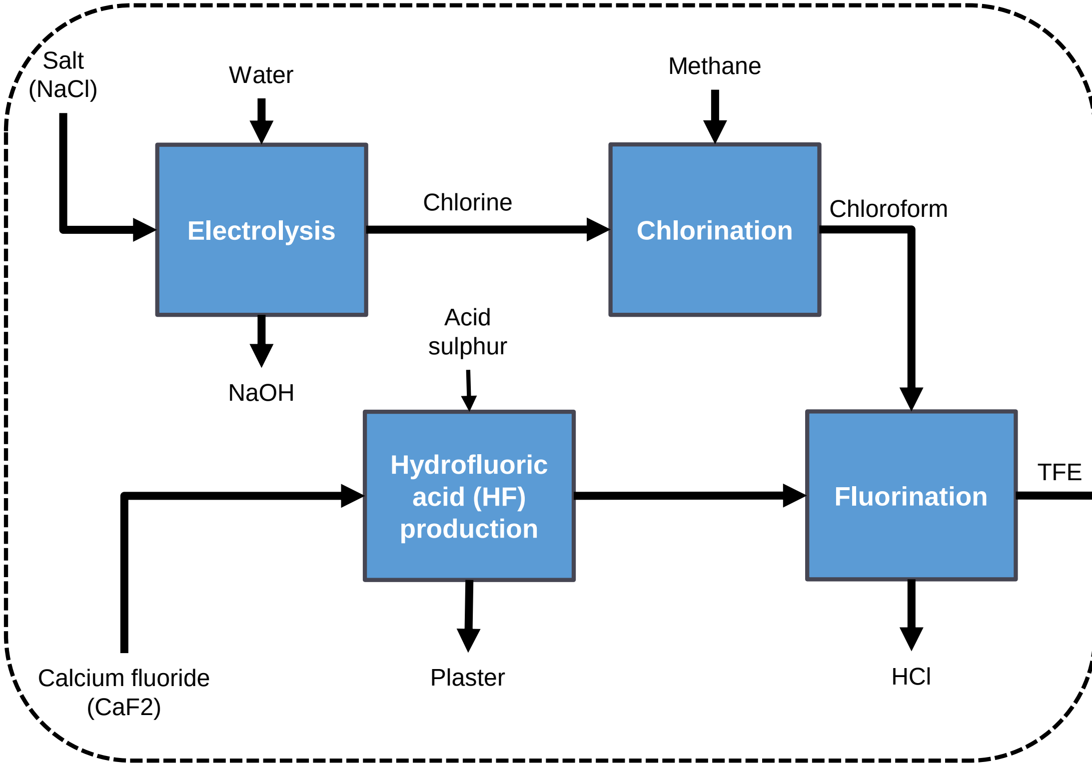
- PTFE (polytetrafluoroethylene) is the most important fluoropolymer (high-performance materials.

- Applications:
  - Wires and insulation
  - Coatings and sealants
  - Laboratory ware
  - Non-stick cookware

- Globally increasing demand

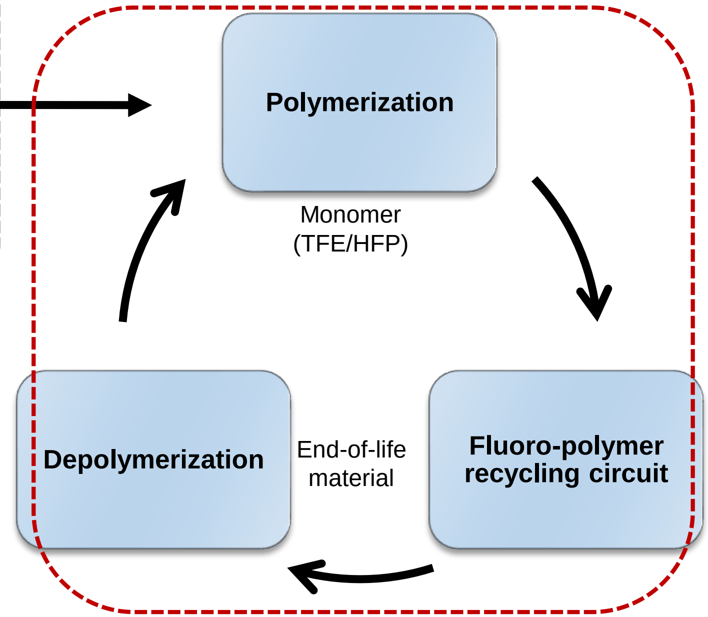
- Life cycle impacts:
  - High energy demand for the production of precursors
  - Exploitation of scarce resources
  - End-of-life: PTFE is often landfilled, as incineration releases corrosive acid (HF) damaging the incinerator

Example: Chemical Recycling of PTFE (II)



Conventional production of TFE (tetrafluoroethylene)

Chemical recycling of PTFE (poly-tetrafluoroethylene) by depolymerisation



Source: based on Dyneon

Example: Chemical Recycling of PTFE (III)

Reclamation of PTFE:

- End-of-life PTFE is collected for recycling from:
- Large consumers, e.g. architecture
- Processing waste (approx. 10% of PTFE production)

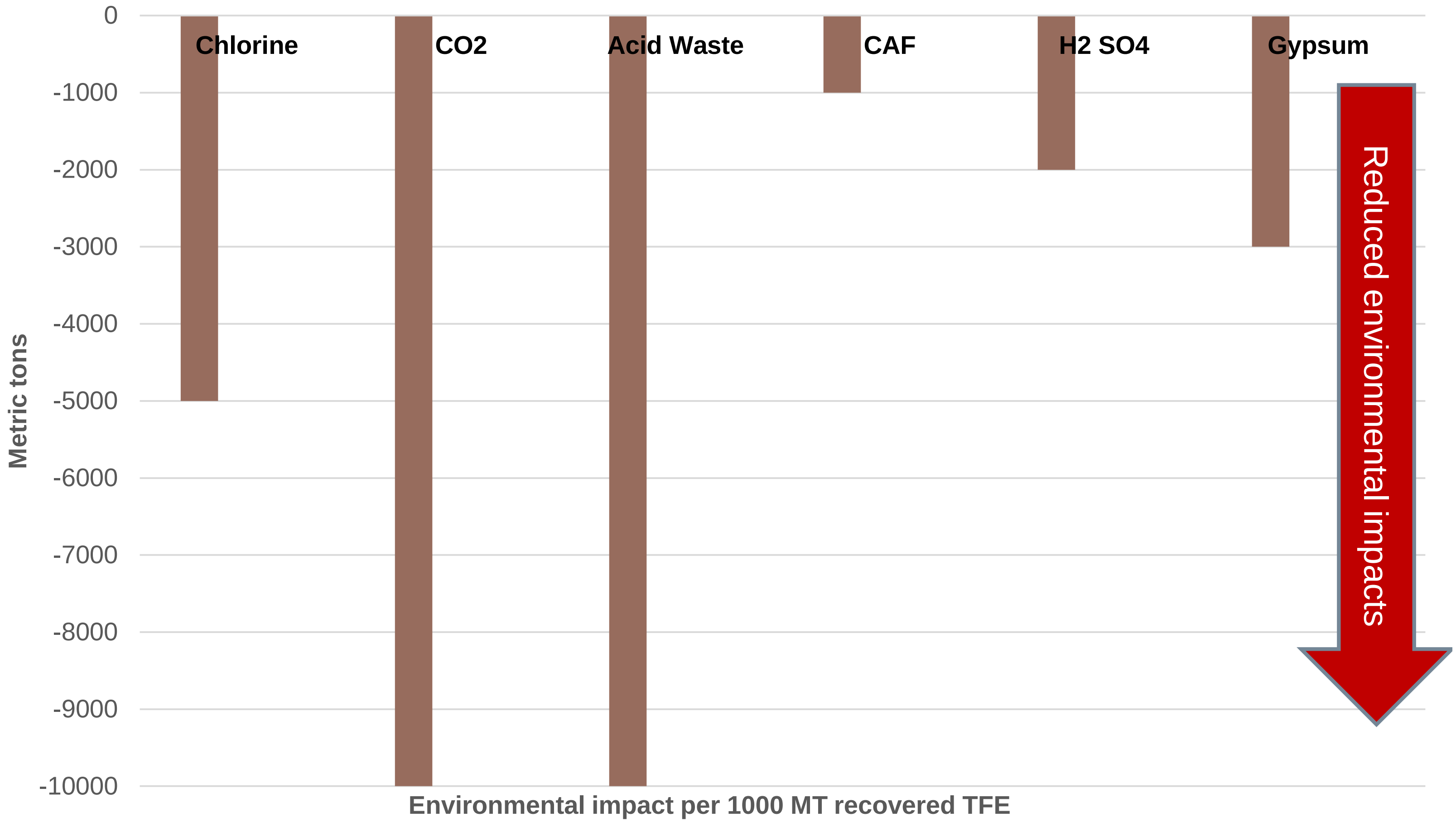
Reduced life cycle impacts due to recycling:

- Conserving scarce resources
- Reducing energy demand → economic savings
- Reducing environmental impacts:
  - Decreasing feedstock production (including hazardous acids)
  - Reducing CO_2 emissions
- Reducing waste in landfills and incinerators

Example: Chemical Recycling of PTFE (IV)

- Important considerations:
  - Some material is not recoverable for economic or technical reasons: for example, dispersion applications are too small to recover (e.g. sprays on clothes, coatings, etc.)
  - Collecting and processing end of life material presents many challenges to be overcome:
    - Locating the waste
    - Setting up a logistics system
    - Incentivizing SME users to return waste components (preventing business-as-usual mentality which is to incinerate)
    - Separation of PTFE from host object (may require new processes)
    - Only certain types of grades can be used, etc.

Example: Chemical Recycling of PTFE (V) - Reduced Raw Material, Waste and Energy



Energy Recovery

- Electricity or heat generation by burning plastic waste = recovering the energy “stored” in plastics
- Utilization as secondary fuel
- Preferred over disposal and incineration without energy recovery
- Energy recovery may be used to treat mixed, contaminated plastics

- However, energy recovery is not recycling!

Key Messages (1)

- Life Cycle Thinking – impacts of plastics and waste: Considering the entire production chain from raw materials extraction to end-of-life scenarios

- Recycling benefits:
  - Substituting raw materials
  - Increasing resource efficiency
  - Decreasing energy demand
  - Reducing pollution

- Stimulating the circular economy

Key Messages (2)

- Prevent and minimize plastic waste, reuse and recycle plastics

- Types of recycling:
  - Mechanical recycling (most favoured option)
  - Chemical recycling
  - Energy recovery

- Recycling steps:
  - Logistics: waste collection
  - Pre-treatment
    - Sorting of waste to obtain homogeneous material
    - Washing and drying
    - Shredding
  - Recycling (mechanical or chemical)
  - Reuse

Additional Information

- Organization for Economic Co-operation and Development (OECD) report on Sustainable Management and Recovery Potential of Non-packaging Plastic Waste from the Commercial and Private Household Sectors : http://www.oecd.org/env/waste/49804957.pdf

- UNIDO's information on Effective Energy and Gas Emission Savings Using Plastics Waste Recycling Technologies: http://www.unido.org/fileadmin/import/userfiles/ploutakm/shutov.pdf

- European Commission information on resource efficiency: http://ec.europa.eu/environment/resource_efficiency/about/roadmap/index_en.htm

- UN News Centre on plastic waste in the environment: http://www.un.org/apps/news/story.asp?NewsID=48113#.VYKAsfntlBc

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