SwitchMed II project in Egypt

PLASTIC PRODUCTION TRANSFORMATION IN EGYPT

Impact assessment of measures and initiatives on material flows

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Report by: CEDARE Egypt

Reporting period: 02/02/2023 to 30/06/2024

Funded by the European Union

Executive Summary

This report highlights existing material flows of plastics and plastic products ("cradle to grave") in Egypt, an important country with economy in transition. Impacts on these flows from national and international initiatives, industry plannings and technological potentials to reduce the problems of plastics pollution are investigated.

Each of the 5 major thermoplastics PE, PET, PP, PS and PVC is manufactured in Egypt (raw material production, resulting in pellets) in quantities of more than 100.000 t/year. The total production exceeds 2 million t/year. Imports are in a dimension of 6 million t/year. The production happens at 8 manufacturers. It is based on fossil sources and is characterized by close linkages to other products of the mineral oil industry such as caustic soda, ethylene derivates, hydrochloric acid etc.

Measures, targeted at directly reducing the production of the 5 thermoplastics will have significant impacts on material flows of chemical by-products, changing the structure of the petrochemical and chemical industry and the availability of non-plastic products in Egypt. Flexibility of manufacturers concerning current production volumes is low as the existing technologies required huge financial investments that still need to be paid back. Flexibility exists concerning future planning of new and extended capacities and should be used for further dialogue. Awareness is high at the concerned stakeholders.

Measures targeted at the processing and use of pellets (about 50 processing companies in Egypt) seem to be promising related to the reduction of plastic pollution in Egypt. Extended recycling flows can be established, coming from the municipal level as well as from the informal collectors and going as cleaned input material to the plastic processing, resulting e.g., in plastic films as a semi-finished product used to produce plastic end products. Such recycling flows are currently underdeveloped in Egypt and offer the potential to reduce unwanted releases to the environment. National measures seem to be well targeted and will be further supported by planned international measures. Examples of major technology potentials are provided in the report. Awareness at concerned companies exists at a very different level, awareness raising campaigns seem to be necessary to generate required know-how and understanding. Such measures have impacts upstream, which can be compensated with modified imports, exports and plannings. Downstream impacts are reduced plastic pollution and potentially reduced variety of end-products.

Measures targeted at the plastic end-product manufacturers in Egypt (more than 5,200 companies) need to be product specific, as the potentials for re-use, recycling, substitution are very different. For the reduction of plastic waste pollution, a clear focus on single use products is recommended. Their share in the total production is about 36% and these products are addressed

by national initiatives and international plannings. A wide range of technologies exist to change single use to multiple use (e.g., thicker bags). Impacts on upstream suppliers mainly result in reduced demand for pellets or raw materials. On the other hand, due to the fast-growing population and increasing life standards the demand for plastics in Egypt is expected to expand significantly. This means, a decreasing demand due to measures targeted at plastic end products might compensate such expected growth of plastics material flows. Awareness and know-how are considered essential for the implementation of above-described measures but are still widely missing at end-product manufacturers and consumers.

Current waste flows of plastics in Egypt are not very well known, calculations give a range between 3.6 and 5.4 million t per year, assuming one third being dumped, one third being incinerated and the rest going to recycling. The waste flows define the dimension of the plastic waste pollution in Egypt. Measures that target the waste flows directly will be analyzed together with their impacts in phase II of the project.

Overall conclusion: There is need for action to reduce plastic pollution in Egypt. A minimum target should be to compensate the expected growth in plastics demand with measures to reduce material flows. Ambitious targets should go significantly further and reduce the dumping of plastic waste. Existing and planned national and international initiatives with a focus on single use plastics would enable reaching such a target if adequately enforced.

Economic and social benefits can be generated along the supply chains, if awareness and exchange on existing potentials, know-how and plannings are increased.

Background:

This report has been elaborated on behalf of CEDARE under the UNEP/SwitchMed II Project: "To accelerate the implementation of Sustainable Consumption and Production, Circular Economy and Blue Economy".

The overall objective of this SwitchMed activity is to develop an industry assessment/report and a set of recommendations for plastic production transformation in Egypt. The report is expected to explain what it entails for the chemical industry in Egypt to transform from the current technology and processes which deliver plastic that is single use, non-recyclable to plastics designed for reuse and for recycling. The report is based on desktop research, national data collection and interviews with national stakeholders. It is designed as an interim report that completes phase I of the project and will be followed by a final report of the closure of phase II.

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Table of Content

1 Introduction and Methodology

1.1 Purpose of the report

The report is targeted as a contribution in the context of the international activities to reduce plastics production. # Quotation INC Document

It should explain what it entails for the industry in a country with economy in transition to transform from the current technology and processes which deliver plastic that is single use, non-recyclable to plastics designed for reuse and for recycling.

It shall highlight existing material flows of plastics and plastic products ("cradle to grave") as well as impacts on these flows from national and international initiatives, industry plannings and technological potentials.

Egypt has been selected as pilot case as it is an important emerging country with

- Significant own plastics production (over 2 million tons/year production capacity)
- High import / export volumes (e.g., imports of plastics about 6 million tons/year)
- Broad use and application structure of plastics
- Environmental and health problems due to plastics pollution

The report has been elaborated in a short timeframe by 3 international experts with the support of UNEP and CEDARE.

Derived recommendations reflect the opinion of the 3 authors.

1.2 Selected plastics including justification

The following plastics have been selected for the study:

1) Polyethylene (PE) with a differentiation into LLDPE (linear low-density polyethylene) and HDPE (high density polyethylene)
2) Polyethylene Terephthalate (PET)
3) Polypropylene
4) Polystyrene
5) Polyvinylchloride (PVC)

(# For characterization pictures of the different plastics, eventually typical products in Egypt (e.g., water pipes, plastic bags etc.) evtl. formulas of the substances)

For the selection it was essential that all these plastics are manufactured in Egypt in large quantities (each > 100.000 t/y). Furthermore, these substances are imported in large volumes (## each > 200.000t/y?).

They have as well the major share in disposal (#% or volume) and recycling (#% or volume) of all plastics in Egypt.

Finally, these plastics contribute to important environmental and health problems such as

- contribution to climate change (# percentage of Egypt´s CO_2 emissions)

-lethal and sublethal effects on organisms of species in marine, freshwater and terrestrial environments # quote INC

-health burdens for humans, in particular caused by additives and decomposition products of plastics

Therefore, the main environmental, health and economic dimensions of the plastics issue in Egypt can be assessed with the above-mentioned selection.

The selection is also consistent with UNEP INC 4 global observations.

Justification and quote UNEP here

It as well reflects the point of view of the Egyptian government stating (# quotation if possible)

Thermosets are not investigated in this study. Substances such as polyurethanes, fibres and epoxy resins are globally as well important (see # UNEP INC, with a relation of x# compared to thermoplastics y%), but they have limited possibilities for recycling and re-use, production is not as important in Egypt as for thermoplastics.

Bio- based plastics and biodegradable plastics are included into the report under chapter 5 “technology options”, but due to their reduced importance no complete material flows are elaborated.

1.3 Applied Methodology

Material flow analysis

Material flows of plastics are described from "cradle to grave". These flows are the backbone of the assessment of expected and potential impacts.

The authors are convinced that it is essential to understand the upstream production steps of plastics and their causalities as plannings to increase or decrease capacities or to change technologies have a major impact on plastics entering the markets and finally entering the environment. This includes the role of import and export flows.

„Helicopter perspective"

Due to time and resource restrictions possibilities for collection of detailed data have been very limited. The team of authors follows an approach to focus on the elaboration of structures of material flows to generating precise data. With such a "helicopter perspective" priorities for initiatives and measures to reduce plastics pollution in Egypt can be recommended for stakeholders.

Scenario analysis

Material flows and plastics pollution are influenced by various parameters, typically adding up to a "cocktail effect" that is difficult to predict. Therefore, for the importance of single measures and actions it is necessary to elaborate scenarios and show resulting causalities.

Example: If the design of plastic bags is changed in a way that they are suitable for multi- instead of single use, an impact on plastic pollution can be achieved. However, if such recycling bags are more expensive and imports of single use bags are possible and will happen to benefit from the cost advantage, no impact can be achieved. Therefore, various influencing parameters need to be analysed, at least for recommended priority actions.

The scenario analysis as well concerns the handling of uncertainties. Example: In Egypt there are many companies that define an "informal" sector as their activities are nearly not visible to authorities and official data collection. Ignoring this "informal" sector would generate misleading recommendations. In a scenario the assumption is made that the number of companies and employees in the informal sector is similar to the formally registered companies. Based on this assumption recommendations are elaborated.

Impact assessment

Impacts are assessed for the environmental, economic and social dimension.

Case studies

Case studies enable a deeper look into awareness, plannings and expected impacts of measures of stakeholders.

Technology options assessment

The assessment of technology options in chapter 5 is based on existing experiences (e.g. from other countries), research and development as reported in literature.

1.4 Data sources

Data from international institutions

Data on the international negotiations within the INC process have been provided by UNEP. CEDARE supported the team with data to the situation in Egypt and other Arabic countries.

Interviews

Personal interviews have been conducted with representatives of Egyptian plastic manufacturers (# number), representatives of industry associations (# number), authorities (# number), consumer organisations (# number) and the Egyptian government (# number).

Case studies

The following case studies are suggested:

manufacturing of PE

manufacturing of PVC

recycling of PET

Official statistics, existing reports, and literature

See literature list.

Special importance for the results of this report had the following sources:

- UNIDO, study on plastic value chain in Egypt, 2021
- ##
- ##
- ##

2 Current situation of plastic material flows in Egypt

2.1 Raw Material Manufacturers

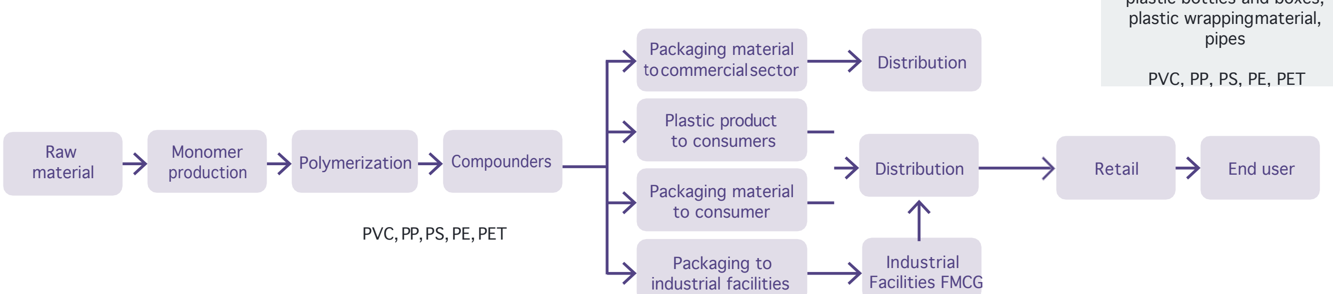
The Egyptian plastics market depends on both locally produced and imported plastic raw materials. Egyptian petrochemical companies produce around 2 million tons of various types of plastics annually, which contribute to only 24 per cent of plastic raw materials required by the market.

The key activities are:
Extraction of plastic raw materials from natural gas and polymerization process to produce petro-based plastic pellets (PP/PE/PET/PS/PVC). The key existing technologies are the natural gas cracking processes, and then polymerization process to produce pellets. The interviewed raw material manufacturers produce PE and PP chips with a total production of 200 K tons/ year and 1200 K tons/year respectively. Although the produced raw materials by the eight petrochemical Companies contribute to nearly a quarter of the local demand by the plastics industry in Egypt, their production is divided between local and export markets with the percentages: both interviewed manufacturers confirmed that their supply feeds 60 per cent local and 40 per cent export. The strengths of this manufacturing segment are shown in their internal product quality testing labs and their investment in R&D to develop their products.

Entity	Location	Products	Capacities (Ton/year)
SidiKerirPetrochemicalCo (SIDPEC)	Alexandria	HDPE, LLDPE	225,000
Egyptian Ethylene and Derivatives Company (ETHYDCO)	Alexandria	HDPE, LLDPE	400,000
Egyptian Petrochemicals Company (EPC)	Alexandria	PVC & PVC compound	80,000
Egyptian Styrenics Co for polystyrene (Estyrenics)	Alexandria	PS (HI, GP)	200,000
Egyptian Propylene and Polypropylene Company (EPPC)	Port Said		350,000

		PP compl ex	
Oriental Petrochemical for Polypropylene (PP) (Now Holding Carbon Co.)	Suez	PP	160,000
Egyptian Indian Polyester Company (EIPET)	Ain Sokhna	PET	420,000
IndianPetrochemicalIndustry TCI Sanmar group	Port Said	PVC & PVC compo und	200,000

2.2 Plastic Production overview



2.3 Technologies and material flow for PE

In Egypt, the production of polyethylene (PE) involves a series of advanced technologies and material flows. Here's an overview of the process:

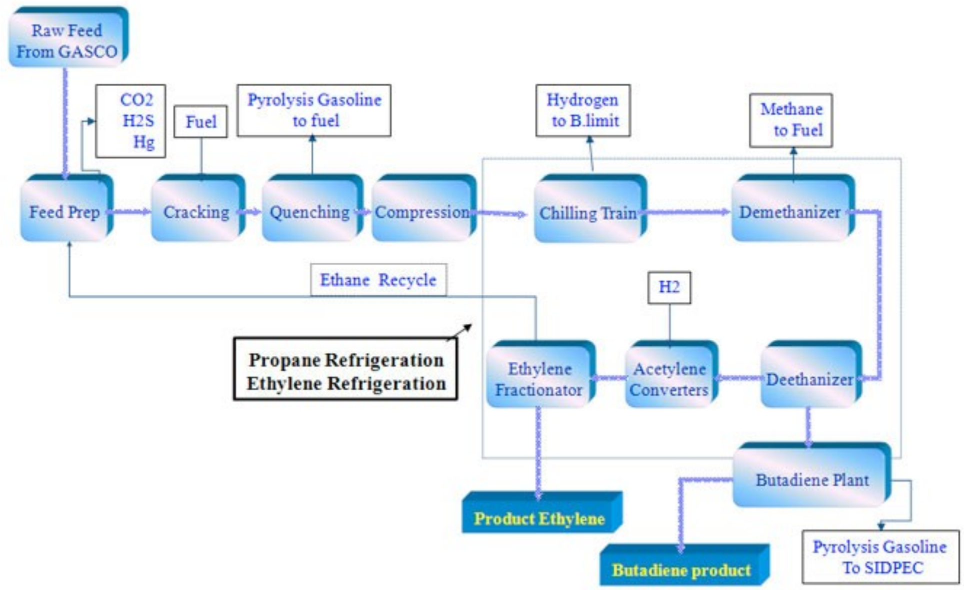
Feedstock Preparation: The process begins with the preparation of feedstock, which is typically a mixture of ethane and propane. This mixture is supplied by companies like GASCO.

Thermal Cracking: The feedstock undergoes thermal cracking at high temperatures to produce ethylene, the main building block for polyethylene.

Quenching: The cracked gases are rapidly cooled to stop the reaction and prepare them for further processing.

Gas Compression and Treatment: The gases are compressed and treated to remove impurities, ensuring that the ethylene is of high quality for polymerization.

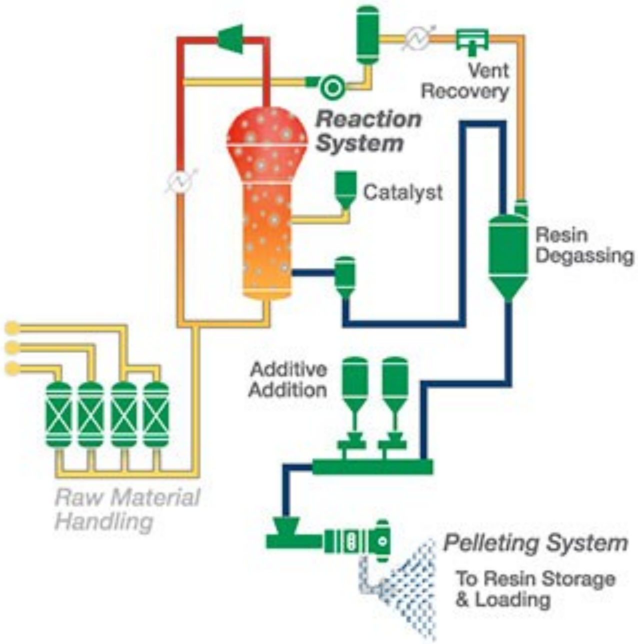
Ethylene Purification: The ethylene gas is further purified to meet the stringent quality standards required for polyethylene production.



Block Flow Diagram of Ethylene Process

Polymerization: The purified ethylene is polymerized using technologies such as the UNIPOL™ PE gas phase process. In this process, ethylene and co-monomer react as gases at low pressure, in the presence of a catalyst, using fluidized bed conditions to produce granular products. This technology allows for the production of a wide range of commercial products, including high-density, medium-density, linear low-density PE, and bimodal capabilities.

Product Formation: The polymerized ethylene is formed into granular products, the final polyethylene product.



Polyethylene using UNIPOL™ PE gas phase process

Quality Control and Packaging: The granular products undergo rigorous quality control testing. Once they pass these tests, they are packaged and prepared for distribution.
This process is supported by the National Petrochemicals Master Plan, which aims to develop the petrochemical industries in Egypt. Companies like ETHYDCO are key players in this field, utilizing advanced polyethylene technology from Univation Technologies of the U.S. for their production. The material flow and technologies used in the production of PE in Egypt reflect the country's commitment to economic growth and the development of its petrochemical industry. With projects like the construction of the largest polyethylene industrial complex in the Middle East, Egypt is poised to cover local needs, decrease imports, and provide a significant portion of the industrial requirements for infrastructure projects.

Source:
(1) Polyethylene Industry Outlook in Egypt to 2028 - GlobalData. https://www.globaldata.com/store/report/egypt-polyethylene-market-analysis/.
(2) Polyethylene Technology. https://www.ethydco-eg.com/en/pages/polyethylene-technology.
(3) TOYO Awarded Polyethylene Plant of Ethydco in Egypt. https://ethydco-eg.com/en/media-coverages/toyo-awarded-polyethylene-plant-of-ethydco-in-egypt.
(4) Egypt's president orders constructing largest polyethylene complex in .... https://www.egypttoday.com/Article/1/118055/Egypt%E2%80%99s-president-orders-constructing-largest-polyethylene-complex-in-Middle-East.
(5) Polyethylene Industry Outlook in Egypt to 2028 - GlobalData. https://bing.com/search?q=polyethylene+production+technologies+in+Egypt.
(6) Polyethylene Industry Outlook in Egypt to 2022 - GlobalData. https://www.globaldata.com/store/report/polyethylene-industry-outlook-in-egypt-to-2022-market-size-company-share-price-trends-capacity-forecasts-of-all-active-and-planned-plants/.
(7) Polyethylene Terephthalate (PET) Industry Outlook in Egypt to 2028 .... https://www.globaldata.com/store/report/egypt-polyethylene-terephthalate-market-analysis/.
(8) PROCESS FLOW DIAGRAM POLYETHYLENE - learnche.org. https://learnche.org/wiki_4N4/images/7/73/4N4-2012-SDL-talks-2.pdf.

The Import and export flows of polyethylene (PE) within the production material flow in Egypt are a crucial aspect of the country's plastic industry. Here's an overview based on the latest data:

Plastic Material Flow: Egypt produces approximately 2.0 million tonnes of plastic per year, with polyethylene being a significant part of this production.
Plastic Consumption: The country consumes around 8.0 million tonnes of plastic per year, indicating a high demand for plastic materials, including PE[1].
Plastic Waste: Annually, Egypt generates about 4.5 million tonnes of plastic waste, which includes post-consumer PE waste.
Recycling Rate: Approximately 30% of the plastic waste is recycled, which would also encompass PE recycling efforts.

2.3.1 Import Export flows within production material flow

In terms of international trade:

Exports: In 2022, Egypt exported $488 million worth of ethylene polymers, which includes PE. The main destinations for these exports were Belgium, the United Kingdom, Spain, Turkey, and Italy.
Imports: Egypt imported $1.27 billion worth of ethylene polymers in the same year, with the primary origins being Saudi Arabia, the United Arab Emirates, India, China, and South Korea.
The trade balance data shows that Egypt is a net importer of ethylene polymers, including PE, with imports significantly exceeding exports. This reflects the country's need to fulfill its domestic demand for PE, which is not entirely met by local production.

The import and export activities are governed by various policies and regulations. For instance, there are restrictions on the trade of plastics, with certain HS codes requiring the Environmental Affairs Agency's approval for imports, and an export fee is imposed on plastic waste.
Investments in waste management and plastics circularity are also part of the landscape, with private investments focusing on recovery and recycling, which are crucial for managing the material flow of PE and other plastics.

This trade and material flow information is essential for understanding the dynamics of the PE industry in Egypt and its impact on the economy and environment.

Source:
(1) Investments to Tackle Plastic Pollution EGYPT. https://countryfactsheets.thecirculateinitiative.org/assets/images/pdf/Egypt.pdf.
(2) Ethylene Polymers in Egypt | The Observatory of Economic Complexity. https://oec.world/en/profile/bilateral-product/ethylene-polymers/reporter/egy.
(3) Polyethylene Industry Outlook in Egypt to 2028 - GlobalData. https://bing.com/search?q=Import+and+export+of+polyethylene+in+Egypt.
(4) Polyethylene Industry Outlook in Egypt to 2028 - GlobalData. https://www.globaldata.com/store/report/egypt-polyethylene-market-analysis/.
(5) Polyethylene Industry Outlook in Egypt to 2022 - GlobalData. https://www.globaldata.com/store/report/polyethylene-industry-outlook-in-egypt-to-2022-market-size-company-share-price-trends-capacity-forecasts-of-all-active-and-planned-plants/.
(6) Polyethylene Terephthalate (PET) Industry Outlook in Egypt to 2028 .... https://www.globaldata.com/store/report/egypt-polyethylene-terephthalate-market-analysis/.
(7) undefined. https://www.thecirculateinitiative.org/plastics-circularity-investment-tracker.

2.3.2 Application of PE, differentiated into sectors and products

Polyethylene (PE) is a versatile material with a wide range of applications across various sectors. Here's how PE is utilized in different industries and the products it's used to make:

1. Packaging Sector:
    - Packaging Foils: Used for wrapping food items and consumer goods.
    - Bags: Shopping bags, garbage bags, and carrier bags.
    - Bottles: Containers for beverages, detergents, and other liquids.
    - Food Industry: As an alternative to cardboard containers for packaging food products.
2. Construction Industry:
    - Pipes: HDPE pipes for water and sewage due to their durability and corrosion resistance.

- Sheets: Used in damp proofing, landfills, and as barriers.
- Insulation Materials: For thermal and electrical insulation purposes.

3. Medical Field:
   - Syringes: Due to its biocompatibility and chemical resistance.
   - Catheters: Used for various medical procedures.
   - Joint Implants: As a material for artificial joints.
   - Medical Tubing: For fluid transfer and other medical applications.
4. Automotive Industry:
   - Bumpers: For impact resistance and lightweight properties.
   - Fuel Tanks: Resistant to chemicals and lightweight.
   - Interior Trims: Durable and easy to mold into various shapes.
   - Electrical Insulation: For wiring and electronic components.
5. Household Items:
   - Toys: Safe and durable for children's play items.
   - Kitchenware: For containers, cutting boards, and utensils.
   - Furniture: Outdoor furniture for its weather-resistant properties.
6. Agriculture:
   - Mulch Film: To control weed growth and conserve soil moisture.
   - Greenhouse Covers: For creating controlled growing environments.
7. Textiles:
   - Non-woven Fabrics: For bags, packaging, and disposable clothing.
8. Electronics:
   - Casing and Insulation: For electronic devices and wiring.

The widespread use of PE is due to its properties such as durability, flexibility, and resistance to chemicals. It's important to note that while PE has many beneficial uses, its environmental impact, particularly in terms of waste and non-biodegradability, is a significant concern that needs to be addressed through recycling and the development of biodegradable alternatives.

Source:
(1) Polyethylene PE properties and applications - Plastipol. https://plastipol.pl/en/polyethylene-pe-properties-and-applications/.
(2) Introductory Chapter: Polyethylene – Its Properties and Application in .... https://www.intechopen.com/chapters/1157745.
(3) Understanding Polyethylene: Properties, Uses, and FAQs. https://smartturf.com/polyethylene-explained/.
(4) What is Polyethylene(PE)? – Types, Properties, Structure, Uses & more. https://scrapc.com/blog/what-is-polyethylenepe-types-properties-structure-uses-more/.

2.3.3 Import Export flows for application of PE

The import and export flows for the application of polyethylene (PE) in Egypt are a critical component of the country's industrial and economic activities. Here's a summary of the latest data:

1. **Imports**: Egypt imports significant quantities of PE, with the main sources being Saudi Arabia, the United Arab Emirates, and the United States. In 2020, Egypt imported PE worth $354.63 million, with a total quantity of 325,312,000 Kg.

2. **Exports**: The main destinations for Egyptian PE exports include Belgium, the United Kingdom, Spain, Turkey, and Italy. The export markets have been growing, with Turkey, Greece, and Slovenia being the fastest-growing destinations for Egyptian PE between 2021 and 2022.
3. **Trade Balance**: Egypt is a net importer of PE, with imports exceeding exports. This reflects the high domestic demand for PE, which is not entirely met by local production.
4. **Investments**: There are investments in waste management and plastics circularity, focusing on recovery and recycling, which are crucial for managing the material flow of PE and other plastics. Private investments in plastics circularity solutions amounted to $31.8 million.
5. **Future Prospects**: Egypt is constructing the largest polyethylene industrial complex in the Middle East, which will conform to European specifications and open up prospects for export, especially to African countries with free trade agreements with Egypt.

These import and export flows are influenced by various factors, including global market trends, domestic production capacities, and environmental policies. Egypt's strategic investments and development plans aim to enhance the PE industry's sustainability and economic contribution.

Source:
1. Egypt, Arab Rep. Polyethylene having a specific gravity <0.94, i ...
2. Ethylene Polymers in Egypt | The Observatory of Economic Complexity
3. Investments to Tackle Plastic Pollution EGYPT
4. Egypt's president orders constructing largest polyethylene complex in ...
5. Egypt Exports of plastics - 2024 Data 2025 Forecast 1994-2023 Historical
6. https://www.thecirculateinitiative.org/plastics-circularity-investment-tracker

2.3.4 Recycling flows

The recycling flows of polyethylene (PE) in Egypt are part of the country's efforts to manage plastic waste and promote sustainability. Here's an overview of the current situation:

1. Plastic Waste Generation**: Egypt generates about** 4.5 million tonnes **of plastic waste per year, which includes PE waste.**
2. **Recycling Rate**: The recycling rate for plastics in Egypt is approximately **30%**, which indicates that a significant portion of PE is being recycled.
3. **Recycling Infrastructure**: Investments in waste management and plastics circularity are ongoing, with private investments focusing on recovery and recycling. These investments aim to improve the recycling flows and manage the material flow of PE and other plastics.
4. **Challenges**: Despite these efforts, there are challenges in the recycling sector, such as the need for better waste segregation and the establishment of extended producer responsibility. The low recycling rates for plastics, at around **11%** of total plastic waste, highlight the need for improvement in the recycling flows of PE.
5. **Environmental Impact**: Recycling PE helps reduce the environmental impact of plastic pollution by decreasing the amount of waste that ends up in landfills or the natural environment. It also conserves resources by reducing the demand for virgin materials.
6. **Future Prospects**: With the construction of new recycling facilities and the implementation of policies aimed at tackling plastic pollution, Egypt is working towards enhancing its recycling flows. This includes addressing plastic leakage, which amounts to **0.3 million tonnes** per year, and improving plastic waste management practices.

The focus on recycling flows is crucial for Egypt's transition to a circular economy, where materials like PE are reused and recycled, minimizing waste and environmental impact.

Source:
1. Investments to Tackle Plastic Pollution EGYPT
2. Egypt's Circular Economy - AUC The American University in Cairo
3. PROMOTING SUSTAINABLE AND CIRCULAR PLASTICS USE IN EGIPT WITH ... - Sciendo
4. https://www.thecirculateinitiative.org/plastics-circularity-investment-tracker

2.3.5 Disposal flows

The disposal flows of polyethylene (PE) in Egypt are a critical aspect of the country's waste management system. Here are some key points regarding the disposal of PE:

1. **Waste Generation**: Egypt generates about **4.5 million tonnes** of plastic waste annually, which includes PE.
2. **Plastic Leakage**: Approximately **0.3 million tonnes** of plastic leak into the environment each year, contributing to land and marine pollution.
3. **Recycling**: Around **30%** of plastic waste is recycled, which includes PE. However, this also indicates that a significant portion of PE is not being recycled and may end up in landfills or the environment [
4. **Landfilling**: Landfilling is a common disposal method for non-recycled PE. However, due to PE's non-biodegradable nature, it can persist in landfills for a very long time.
5. **Incineration**: Some PE waste may be incinerated, which can lead to the release of toxic substances if not properly managed.
6. **Policy Measures**: Egypt has implemented policies to manage plastic pollution, such as a ban on single-use plastics and restrictions on plastic waste trade. These policies aim to reduce the amount of PE that needs to be disposed of and encourage recycling.
7. **Investments**: There have been investments in waste management and plastics circularity solutions, focusing on recovery and recycling, to improve the disposal flows of PE and other plastics.

Efforts are ongoing to enhance the disposal flows of PE in Egypt, with a focus on reducing environmental impact and promoting sustainability through better waste management practices and increased recycling rates.

Source:
1. Investments to Tackle Plastic Pollution EGYPT
2. Coming to grips with plastic: Egypt's waste management challenge
3. Marine-plastic pollution is growing, and Egypt is a major contributor ...
4. Egypt s Efforts to Reduce Plastic Pollution (SUPBs) - UNIDO
5. https://www.thecirculateinitiative.org/plastics-circularity-investment-tracker

2.4 Technologies and material flow until the production of PET

The production process flow of Polyethylene Terephthalate (PET) in Egypt involves several key steps, from raw material preparation to the final product ready for distribution. Here's a detailed overview:

1. **Raw Material Preparation**: The main ingredients for PET production are terephthalic acid (TPA) and ethylene glycol (EG), which are derived from petroleum feedstock.
2. **Esterification/Transesterification**: TPA and EG undergo a chemical reaction to form monomers, either through esterification or transesterification.
3. **Melt-Phase Polycondensation**: The monomers are then polymerized in a melt-phase polycondensation process, forming the PET polymer.
4. **Solid-State Polymerization**: To improve its properties, the PET polymer may go through solid-state polymerization, which increases its molecular weight.
5. **Pelletizing**: The PET polymer is cut into small pellets, which are the final product that can be used in various applications, such as making bottles and containers.
6. **Quality Control**: The pellets are rigorously tested to ensure they meet the required quality standards.
7. **Packaging and Distribution**: Once approved, the pellets are packaged and distributed to manufacturers who will transform them into final products.

In terms of specific companies and facilities, Egyptian-Indian Polyester (EIPET) is constructing a PET resin plant in Ain Sokhna, Egypt. This facility is expected to produce PET resin used for packaging bottles for food and fast-moving consumer goods (FMCG). The plant is designed to manufacture 1,200 tons of PET resin per day, with a significant portion of the production intended for export to European and North American markets.

The production of PET in Egypt is part of the country's broader efforts to develop its petrochemical industry and enhance sustainability practices. With investments in recycling facilities and advanced manufacturing technologies, Egypt is working towards improving the efficiency of its material flows and reducing the environmental impact of PET production.

Source:

1. Polyethylene Terephthalate (PET)
2. Egyptian-Indian Polyester (EIPET) PET Resin Manufacturing Plant
3. Global Polyethylene Terephthalate (PET) Plastic Supply Chain Resource ...
4. PET Factory in Egypt | PET Company in Egypt | PET Manufacturer | Egypt
5. Polyethylene Terephthalate (PET) production in plastics & polymers ...
6. en.wikipedia.org

2.4.1 Import Export flows within production material flow

The import and export flows of Polyethylene Terephthalate (PET) within the production material flows in Egypt can be explained through the lens of the country's industrial dynamics and environmental policies. Here's a detailed explanation:

1. **Raw Material Imports**: Egypt imports raw materials necessary for PET production, such as purified terephthalic acid (PTA) and monoethylene glycol (MEG), which are the building blocks for creating PET polymers.
2. **Domestic Production**: Using these imported raw materials, Egypt produces PET through a process that includes esterification, polycondensation, and pelletizing. The produced PET is used domestically for various applications, primarily in packaging.
3. **Finished Product Exports**: Egypt exports finished PET products, including bottles and fibers, to international markets. These exports contribute to the country's economy and are part of its trade activities.
4. **Recycling and rPET**: Egypt also has a growing focus on recycling PET to produce recycled PET (rPET). This involves collecting post-consumer PET waste, sorting, cleaning, and processing it into flakes, which are then purified and transformed into rPET pellets for reuse.
5. **Import of Recycled Materials**: While Egypt is developing its recycling capabilities, it may also import rPET materials to meet the demand for recycled content in various products.
6. **Export of Recycled Materials**: As the recycling infrastructure improves, Egypt aims to increase the export of rPET, contributing to the global supply of recycled materials and reducing the environmental impact of PET.
7. **Environmental Policies**: Egypt's environmental policies impact the import and export flows of PET. For instance, there are restrictions on the trade of plastics, with certain HS codes requiring the Environmental Affairs Agency's approval for imports, and an export fee is imposed on plastic waste.
8. **Investments**: Investments in waste management and plastics circularity are part of the landscape, with private investments focusing on recovery and recycling, which are crucial for managing the material flow of PET and other plastics.
9. **Sustainability Efforts**: Studies suggest that improving resource efficiency and emission reduction strategies in the PET industry can lead to significant reductions in carbon emissions, which is a key consideration for Egypt's PET production and trade.

In summary, the import and export flows of PET in Egypt are shaped by the country's need for raw materials, its production capacity, the growing recycling industry, and the environmental policies that govern trade and sustainability practices. These factors collectively influence Egypt's position in the global PET market and its efforts towards a circular economy.

Source:

1. Investments to Tackle Plastic Pollution EGYPT
2. Global Polyethylene Terephthalate (PET) Plastic Supply Chain Resource ...
3. Plastics Recyclers Europe: PET imports to impact EU recycled content ...
4. https://doi.org/10.3390/su16103926
5. https://www.thecirculateinitiative.org/plastics-circularity-investment-tracker

2.4.2 Application of PET, differentiated into sectors and products

In Egypt, Polyethylene Terephthalate (PET) is applied across various sectors, each with its specific products. Here's how PET is utilized in different industries:

1. **Packaging Industry**:
    - **Bottles**: For water, soft drinks, juices, and other beverages.
    - **Food Containers**: For packaging and preserving a variety of food items.
    - **Pharmaceuticals**: In the form of blister packs and medicine bottles.
2. **Textile Sector**:
    - **Polyester Fibers:** Used in clothing, home textiles, and industrial textiles.
    - **Non-woven fabrics:** For hygiene products, filters, and geotextiles.
3. **Automotive Industry**:
    - **Interior Panels:** Due to its lightweight and durable nature.
    - **Under-the-Hood Components:** For parts that require chemical resistance.
4. **Electronics**:
    - **Insulating Materials:** For cables and electrical components.
    - **Components:** For various electronic devices due to its insulating properties.
5. **Construction**:
    - **Insulation:** As thermal insulation in buildings.
    - **Roofing Materials**: For its durability and resistance to environmental factors.

The use of PET in Egypt reflects its versatility and the growing demand for sustainable materials. The country's focus on recycling PET also indicates a move towards a circular economy, aiming to reduce the environmental impact of plastic use.

Source:
1. The pet industry in Egypt - GlobalPETS
2. TGM Pet Care Report 2024 | Insights in Egypt - TGM Research
3. Egypt Pet Products Market 2024 - StrategyHelix
4. Pet Products in Egypt | Market Research Report | Euromonitor

2.4.3 Import Export flows for application of PET

The import and export flows for the application of Polyethylene Terephthalate (PET) in Egypt are an important aspect of the country's industrial and economic activities. Here's a comprehensive look at these flows:

1. **Imports**:
    - Egypt imports raw materials necessary for PET production, such as purified terephthalic acid (PTA) and monoethylene glycol (MEG), which are the building blocks for creating PET polymers.
    - The country also imports finished PET products to meet domestic demand, especially in sectors where local production does not suffice.
2. **Exports**:

- Egypt exports PET products, including packaging materials like bottles and fibers, to various countries. These exports are part of Egypt's trade activities and contribute to the economy.
- The export markets for Egyptian PET products are diverse, with the Middle East, Europe, and North America being significant destinations.

3. **Trade Balance**:
   - The trade balance for PET reflects Egypt's position as both an importer of raw materials and an exporter of finished goods.
   - Efforts are being made to enhance PET production capabilities to reduce reliance on imports and increase exports.
4. **Recycling and rPET**:
   - Egypt is focusing on recycling PET to produce recycled PET (rPET). This involves collecting post-consumer PET waste, sorting, cleaning, and processing it into flakes, which are then transformed into rPET pellets for reuse.
   - The recycling efforts aim to improve the material flow efficiency and reduce the environmental impact of PET.
5. **Sustainability Efforts**:
   - Investments in the PET recycling sector aim to improve the material flow efficiency and reduce environmental impact.
   - Improving resource efficiency and emission reduction strategies in the PET industry can lead to significant reductions in carbon emissions, aligning with Egypt's sustainability goals.

These import and export flows are influenced by global market trends, domestic production capacities, and environmental policies. Egypt's strategic investments and development plans aim to enhance the PET industry's sustainability and economic contribution. The country's commitment to advancing PET production technologies and improving material flow efficiency reflects its efforts to enhance its petrochemical industry and sustainability practices.

Source:

1. Export cats and dogs to Egypt: certificate 3900 - GOV.UK
2. Egypt Pet Transport | Bringing and Importing Dogs & Cats to Egypt ...
3. Egypt - Obtain a Pet Passport (Import Export or Transport Pet)

2.4.4 Recycling flows

Recycling flows of Polyethylene Terephthalate (PET) in Egypt have been gaining momentum as part of the country's efforts to enhance sustainability and manage plastic waste. Here's an overview of the PET recycling process and the current state of recycling flows in Egypt:

1. **Collection**: The process begins with the collection of post-consumer PET waste, which includes items like water bottles, food packaging, and other PET products.
2. **Sorting**: Collected PET waste is sorted to separate PET materials from other types of plastics and contaminants. This step is crucial for ensuring the quality of the recycled material.

3. **Cleaning**: The sorted PET is then cleaned to remove labels, adhesives, and any residual content. This step is essential to prevent contamination during the recycling process.
4. **Shredding**: Cleaned PET materials are shredded into flakes. These flakes are then washed and further processed to eliminate any remaining impurities.
5. **Pelletizing**: The clean PET flakes are melted and formed into small pellets. These pellets, known as rPET, can be used to manufacture new PET products.
6. **Manufacturing**: The rPET pellets are then used as raw material for producing new PET items, closing the loop in the recycling process.

In recent developments, **BariQ for Techno and Advanced Industries** has been a leader in the PET recycling industry in Egypt. They have constructed a new PET bottle-to-bottle recycling plant in Giza Governorate, which features the latest plastic sorting systems from Tomra Recycling [1]. This facility is designed to produce more than **35,000 metric tons** of food-grade rPET per annum while saving more than **80,000 tons** of CO2 emissions [1]. The plant complements an existing facility that has been operational since 2010, processing more than **3 tons** of PET bottles per hour [3].
The European Bank for Reconstruction and Development (EBRD) and the European Union (EU) have also supported the Egyptian plastic recycling industry, highlighting the importance of energy savings and sustainability in the sector [2].
These efforts reflect Egypt's commitment to improving recycling flows, reducing environmental impact, and promoting a circular economy. The advancements in recycling technology and infrastructure are crucial for managing the material flow of PET and ensuring that plastic waste is effectively recycled and reused.

Source:
1. New PET recycling plant in Egypt with Tomra sorting solutions
2. New bottle-to-bottle recycling plant in Egypt – PETplanet
3. EBRD and EU support Egyptian plastic recycling industry
4. New charter: Reconceptualising plastic waste in Egypt
5. (PDF) Alternative framings of transnational waste flows: reflections ...

2.4.5 Disposal flows

The disposal flows of Polyethylene Terephthalate (PET) in Egypt involve several stages, from waste generation to recycling and landfilling. Here's an overview:

1. **Waste Generation**: Egypt produces significant amounts of plastic waste, including PET, which is commonly used in packaging.
2. **Collection and Sorting**: PET waste is collected and sorted from other types of waste. This step is crucial for the recycling process.
3. **Recycling**: A portion of the PET waste is recycled. Companies like BariQ have established facilities to recycle PET bottles into food-grade pellets. The European Bank for Reconstruction and Development (EBRD) and the European Union (EU) support the Egyptian plastic recycling industry, highlighting the importance of energy savings and sustainability in the sector.
4. **Disposal**: Non-recycled PET waste is often disposed of in landfills or incinerated. However, improper disposal can lead to environmental pollution.

5. **Leakage**: Some PET waste leaks into the environment, contributing to land and marine pollution. Egypt generates about **0.3 million tonnes** of plastic leakage per year.
6. **Investments**: Investments in waste management and plastics circularity solutions are being made to improve the disposal flows of PET and other plastics. Private investments in plastics circularity solutions amounted to **$31.8 million**.
7. **Policies**: Egypt has implemented policies impacting plastic pollution, such as a ban on single-use plastics and restrictions on plastic waste trade. Plastics are listed under HS codes that require the Environmental Affairs Agency's approval for imports, and there is also an export fee on plastic waste.

These disposal flows reflect Egypt's efforts to manage PET waste and promote sustainability through recycling and improved waste management practices. The country is working towards enhancing its recycling flows, reducing environmental impact, and promoting a circular economy.

Source:
1. EBRD and EU support Egyptian plastic recycling industry
2. Investments to Tackle Plastic Pollution EGYPT
3. New PET recycling plant in Egypt with Tomra sorting solutions
4. Egypt Pet Transport | Bringing and Importing Dogs & Cats to Egypt ...
5. https://www.thecirculateinitiative.org/plastics-circularity-investment-tracker

2.5 Technologies and material flow until production of PP

In Egypt, the production of polypropylene (PP) involves advanced technologies and a series of material flows. Here's an overview of the process:

1. **Feedstock Preparation**: The primary feedstock for PP production is propane, which is sourced domestically or imported.
2. **Propane Dehydrogenation (PDH)**: Propane is converted into propylene through the PDH process. Egyptian Propylene & Polypropylene Company (EPP) uses the STAR process technology licensed by Uhde for this step.
3. **Polymerization:** The propylene is then polymerized to form polypropylene. EPP employs LyondellBasell's Spheripol Technology, which is a leading technology for PP production.
4. **Pelletizing**: The polymerized propylene is formed into pellets, which are the final product ready for various applications.
5. **Quality Control:** The pellets undergo rigorous testing to ensure they meet the required standards.
6. **Packaging and Distribution**: Once approved, the pellets are packaged and distributed to manufacturers who will transform them into final products.

EPP is the first integrated and largest propylene and polypropylene producer in Egypt and North Africa, strategically positioned to supply products over a wide geographical reach. The company's products are used in a variety of applications, from carpeting to packaging to cable insulation[2].

The material flow in PP production starts with the collection of propane feedstock, followed by its conversion to propylene, polymerization to polypropylene, and ends with the distribution of PP pellets. This process is supported by investments in research and development capacities, ensuring high-quality products and efficient production.

Egypt's commitment to advancing PP production technologies and improving material flow efficiency reflects the country's efforts to enhance its petrochemical industry and sustainability practices.

Source:
(1) Egyptian Propylene & Polypropylene (EPP) - Omar Kassem Alesayi Group. https://alesayi.com/portfolio/egyptian-propylene-polypropylene-epp/.
(2) index [epp-eg.com]. https://epp-eg.com/.
(3) . https://bing.com/search?q=polypropylene+production+technologies+in+Egypt.
(4) corporate-profile. https://www.epp-eg.com/corporate-profile.html.
(5) Investments to Tackle Plastic Pollution EGYPT. https://countryfactsheets.thecirculateinitiative.org/assets/images/pdf/Egypt.pdf.
(6) PROMOTING SUSTAINABLE AND CIRCULAR PLASTICS USE IN EGIPT WITH ... - Sciendo. https://sciendo.com/pdf/10.2478/czoto-2019-0057.
(7) Egyptian Propylene & Polypropylene exports 75% of production to Europe .... https://www.dailynewsegypt.com/2021/09/27/egyptian-propylene-polypropylene-exports-75-of-production-to-europe-turkey-latin-america-ceo/.
(8) Marine-plastic pollution is growing, and Egypt is a major contributor .... https://enterprise.press/stories/2022/03/15/marine-plastic-pollution-is-growing-and-egypt-is-a-major-contributor-on-a-global-scale-66974/.
(9) undefined. https://www.thecirculateinitiative.org/plastics-circularity-investment-tracker.

2.5.1 Import Export flows within production material flow

The import and export flows of polypropylene (PP) within the production material flow in Egypt are a significant part of the country's petrochemical industry. Here's an overview based on the latest data:

- **Exports:** In 2019, Egypt exported PP worth approximately **$348.97 million** and a total quantity of **259,463,000 Kg**. The main export destinations included Turkey, Belgium, Bulgaria, Portugal, and Italy. Egyptian Propylene & Polypropylene Company (EPP), Egypt's and North Africa's largest and only integrated producer, manufactures 350,000 tonnes of polypropylene annually, of which **75%** is exported to Europe, Turkey, and Latin America.
- **Imports:** Imports of commodity group 3902, which includes polymers of propylene or other olefins in primary forms, accounted for **0.863%** of the total import flow to Egypt as of early 2024. This indicates that Egypt imports a significant amount of raw materials and polymers for its PP production needs.

The trade balance data suggests that Egypt is a net exporter of PP, with exports exceeding imports. This reflects the country's strong position in the PP market and its ability to meet both domestic and international demand. The export of PP contributes to Egypt's economy and is aligned with the country's strategic focus on developing its petrochemical sector. Investments in technology and infrastructure have enabled Egypt to produce high-quality PP and maintain a competitive edge in the global market.

Source:
(1) Egypt, Arab Rep. Polypropylene, in primary forms exports by country ....
https://wits.worldbank.org/trade/comtrade/en/country/EGY/year/2019/tradeflow/Exports/partner/ALL/product/390210.
(2) Egyptian Propylene & Polypropylene exports 75% of production to Europe ....
https://www.dailynewsegypt.com/2021/09/27/egyptian-propylene-polypropylene-exports-75-of-production-to-europe-turkey-latin-america-ceo/.

(3) Egypt | Imports and Exports | World | Polymers of propylene or of other ....
https://trendeconomy.com/data/h2/Egypt/3902.
(4) Polypropylene industry worldwide - statistics & facts | Statista. https://www.statista.com/topics/11793/polypropylene-industry-worldwide/.

2.5.2 Application of PP, differentiated into sectors and products

Polypropylene (PP) is widely used in various sectors in Egypt due to its versatility and durability. Here are some of the key applications differentiated by sectors and products:

1. **Packaging Sector**:
    - **Fiber**: Used in a variety of applications, particularly carpet yarns. PP fiber is thermoplastic and resilient.
    - **Raffia**: A medium-flow homopolymer with a conventional molecular weight distribution, formulated with a general-purpose additive package. It's used for woven products like sacks, bags, and packaging materials.
    - **Film**: Designed to produce BOPP (biaxially oriented polypropylene), which is used for metallizable film, both as monolayer and in coextruded structures.
2. **Textile Industry**:
    - **Spunbond**: Used in extrusion applications, SB Grade PP has a very narrow molecular weight distribution and is formulated with an anti-gas fading stabilization package. It's commonly used in non-woven fabrics for hygiene products, filters, and geotextiles.
3. **Automotive Sector**:
    - **Injection Molding**: Suitable for injection molding applications, PP exhibits high fluidity combined with good stiffness. It's used for various automotive components such as bumpers, dashboards, and interior trims.
4. **Consumer Goods**:
    - **Household Items**: PP is used for making durable household items like containers, toys, and garden furniture due to its resistance to fatigue and ability to be sterilized.
5. **Construction Industry**:
    - **Cable Insulation**: PP is used for cable insulation because of its excellent electrical properties.
6. **Medical Sector**:
    - **Medical Devices**: Due to its biocompatibility and resistance to various sterilization methods, PP is used in medical devices and packaging.
7. **Agriculture**:
    - **Agricultural Films**: PP is used for agricultural films and mulching materials.

These applications demonstrate the wide-ranging use of PP in Egypt's industrial landscape. The country's strategic position allows it to supply these products over a broad geographical reach, benefiting from trade agreements such as COMESA, EFTA, MERCOSUR, and the Turkey Free Trade Agreement. The Egyptian Propylene & Polypropylene Company (EPP) is a key player in this sector, providing a variety of PP products for essential applications today.

Source:
1. index [epp-eg.com]
2. Research and application of polypropylene: a review
3. Egypt Polypropylene Market: Current Analysis and Forecast (2023-2030)

4. Egypt Polypropylene Market: Size, Growth & Forecast to 2030

2.5.3 Import Export flows for application of PP

2.5.4 Recycling flows

In Egypt, the recycling flows of polypropylene (PP) are part of a broader effort to manage plastic waste and promote sustainability. Here's an overview of the current situation:

1. **Plastic Waste Generation**: Egypt generates about **4.5 million tonnes** of plastic waste annually, which includes PP.
2. **Recycling Rate**: The recycling rate for plastics in Egypt is approximately **30%**, indicating that a significant portion of PP is being recycled.
3. **Informal Sector**: A considerable amount of recycling is carried out by the informal sector, including the zabbaleen in Cairo, who collect and recycle a large percentage of the city's waste.
4. **Investments**: There have been investments in waste management and plastics circularity solutions, focusing on recovery and recycling, to improve the recycling flows of PP and other plastics. Private investments in plastics circularity solutions amounted to **$31.8 million**.
5. **Challenges**: Despite these efforts, there are challenges in the recycling sector, such as the need for better waste segregation and the establishment of extended producer responsibility. The low recycling rates for plastics, at around **11%** of total plastic waste, highlight the need for improvement in the recycling flows of PP.
6. **Environmental Impact**: Recycling PP helps reduce the environmental impact of plastic pollution by decreasing the amount of waste that ends up in landfills or the natural environment. It also conserves resources by reducing the demand for virgin materials.
7. **Future Prospects**: With the construction of new recycling facilities and the implementation of policies aimed at tackling plastic pollution, Egypt is working towards enhancing its recycling flows. This includes addressing plastic leakage, which amounts to **0.3 million tonnes** per year, and improving plastic waste management practices.

The focus on recycling flows is crucial for Egypt's transition to a circular economy, where materials like PP are reused and recycled, minimizing waste and environmental impact.

Source:
1. Investments to Tackle Plastic Pollution EGYPT
2. Egypt's Circular Economy - AUC The American University in Cairo
3. PROMOTING SUSTAINABLE AND CIRCULAR PLASTICS USE IN EGIPT WITH ... - Sciendo
4. https://www.thecirculateinitiative.org/plastics-circularity-investment-tracker

2.5.5 Disposal flows

2.6 Technologies and material flow until production of PS

In Egypt, the production of Polystyrene (PS) involves advanced technologies and a well-defined material flow.

The **INEOS/Lummus technology** is employed for the manufacture of High Impact Polystyrene (HIPS) and General Purpose Polystyrene (GPPS) at facilities like E-Styrenics.

2.6.1 Material Flow:

Styrene Monomer Production: The first phase involves producing styrene monomer, which is the precursor to PS. This is often sourced locally or imported.
Polystyrene Production: Using the styrene monomer, PS is produced through polymerization processes. E-Styrenics, for instance, is a leading integrated producer of polystyrene in Egypt.
Market and Production Capacity:
E-Styrenics is among the largest petrochemical concerns in Egypt, indicating a significant production capacity for PS. The plant can produce 200,000 metric tons per year (MTA) of Polystyrene based on 8000 hours per year. The plant will consist of two (2) – 100,000 MTA parallel lines. The Swing line will be capable of producing HIPS or GPPS, while the HIPS line will produce HIPS only.
The company plans to expand by constructing a styrene production plant out of local Benzene and Ethylene components, which will further integrate the material flow from raw materials to finished PS products.
This integrated approach to PS production, leveraging advanced technologies and local resources, positions Egypt to meet both domestic and international demand for various PS applications.

Source:
1. E.Styrenics
2. About Us – E.Styrenics
3. Our Company – E.Styrenics
4. Expandable Polystyrene Production and Market Survey- A review
5. UK's New Perspective to Supply Egypt with Styrene
6. Egyptian Styrene & Polystyrene Production - ZoomInfo
7. http://ejchem.journals.ekb.eg/
8. en.wikipedia.org

2.6.2 Import Export flows within production material flow

The import and export flows of Polystyrene (PS) within the production material flow in Egypt are characterized by the following:
Production: Egypt has a significant production capacity for PS, particularly through companies like E-Styrenics, which utilize advanced technologies such as INEOS/Lummus for High Impact Polystyrene (HIPS) and General Purpose Polystyrene (GPPS).
Import: The country imports styrene monomer, the primary raw material for PS production. Comparing the production volumes with import data, approximately 70% of plastic consumption in Egypt in primary form and as a product was imported.

Export: Egypt exports PS in various forms, including primary forms and finished products like expandable polystyrene (EPS). EPS is used for disposable trays, plates, bowls, cups, packaging applications, construction, and insulation applications.
Market Dynamics: The PS market in Egypt is influenced by global consumption trends and the availability of raw materials. The country's strategic location allows it to serve as a hub for the import and export of PS and its related products.
Sustainability Efforts: There is an increasing focus on ensuring environmentally sound end-of-life management of PS through recycling and energy recovery, although these practices are still developing in Africa.
These factors collectively contribute to the complex material flow of PS production in Egypt, reflecting the country's role in the global PS market and the efforts to balance industrial activity with environmental considerations.

Source:
1. Ensuring sustainability in plastics use in Africa ... - SpringerOpen
2. Expandable Polystyrene Production and Market Survey- A review
3. Expandable Polystyrene (EPS) Industry Outlook in Egypt to 2028 - GlobalData
4. Egypt's Polystyrene Market Report 2024 - Prices, Size ... - IndexBox
5. http://ejchem.journals.ekb.eg/

2.6.3 Application of PS, differentiated into sectors and products

Polystyrene (PS) in Egypt is utilized across various sectors, each with specific products that cater to different needs. Here's a breakdown of its applications by sector:

Packaging Sector: PS is widely used in the packaging industry due to its lightweight and insulating properties. Products include:
- **Food Packaging**: For containers, cups, trays, and cutlery.
- **Protective Packaging**: For electronics and fragile items during shipping.

Building and Construction: PS, particularly in its expanded form (EPS), is used for insulation and construction applications. Products include:
- **Insulation Materials**: For walls, roofs, and floors.
- **Construction Elements**: Such as void-forming materials in concrete.

Electrical and Electronics: PS's electrical insulation properties make it suitable for this sector. Products include:
- **Casing for Appliances**: Like TVs and computers.
- **Components**: For electrical insulation and safety.

Consumer Goods: Due to its versatility, PS is used in a variety of everyday products. These include:
- **Household Items**: Like CD cases, toys, and stationery.
- **Medical Equipment**: Disposable items like petri dishes and test tubes.

Others: PS's adaptability allows for its use in numerous other products, such as:
- **Decorations**: For festive and event decorations.
- **Automotive**: For parts that require a durable yet lightweight material.

E-Styrenics, a leading producer in Egypt, manufactures both High Impact Polystyrene (HIPS) and General Purpose Polystyrene (GPPS), catering to these diverse market needs. The focus on sustainability is evident in the efforts to ensure environmentally sound end-of-life management of PS through recycling and energy recovery.

Source:
1. E.Styrenics
2. Expandable Polystyrene Production and Market Survey- A review
3. Aly, E.A.H., El Nadi, M. H., Khater, E.M.H. - International Journal of ...
4. Home - INSUTECH - International Company For Insulation Technology
5. Polystyrene manufacturers in Egypt - Company directory
6. Polystyrene Manufacturers, Suppliers & Companies In Egypt
7. Expandable Polystyrene (EPS) Industry Outlook in Egypt to 2028 - GlobalData
8. Egypt Polystyrene Market (2021 - 2027) | Trends, Outlook & Forecast
9. http://ejchem.journals.ekb.eg/

2.6.4 Import Export flows for application of PS

The import and export flows for the application of Polystyrene (PS) in Egypt are an important aspect of the country's industrial sector. Here's a concise overview based on the latest data:

Exports: Egypt has seen a substantial increase in PS exports, with Expandable Polystyrene (EPS) being a significant export product. EPS is used for disposable trays, plates, bowls, cups, packaging applications, construction, and insulation applications.

Imports: While Egypt produces a considerable amount of PS, it also imports raw materials and certain PS products. The import trends have shown a relatively flat pattern, with a notable rate of growth in 2019.

Trade Balance: The trade balance data from 2014 to 2028 indicates that Egypt's PS industry has been dynamic, with import and export data suggesting a balance between domestic demand and international trade.

These flows reflect Egypt's role in the global PS market and its efforts to cater to both domestic needs and international demands. The focus on sustainability is also evident in the management of PS products' end-of-life through recycling and energy recovery initiatives.

Source:
1. Expandable Polystyrene Production and Market Survey- A review
2. Egypt's Polystyrene Market Report 2024 - Prices, Size ... - IndexBox
3. Expandable Polystyrene (EPS) Industry Outlook in Egypt to 2028 - GlobalData
4. http://ejchem.journals.ekb.eg/

2.6.5 Recycling flows PS

2.6.6 Disposal flows PS

2.7 Technologies and material flow until production of PVC

Import Export flows within production material flow

Application of PVC, differentiated into sectors and products

Import Export flows for application of PVC

Recycling flows

Disposal flows

3 National Initiatives and measures concerning plastics in Egypt

3.1 Legal framework for plastics

GoE does have regulations to allow for both import and export of plastic waste. The following are the laws and regulations that tackle the plastic value chain on different levels, such as trade and recycling

Article 27 in Waste Management Regulatory Law No. 202 of 2020 concerning limits the manufacturing, import, export, use, and free distribution of single-use plastic bags in Egypt.

Governor Decree No. 167 of 2019 concerning banning single-use or disposable plastics in the Red Sea governorate

Presidential Decree No. 419 of 2018 concerning conformity with the latest version of the international Harmonized System (HS)

Ministerial Decree No. 489 of 2017 concerning factories importing and recycling plastic waste

Ministerial Decree No. 43 of 2016 concerning specific conditions for some HS codes

Ministerial Decree No. 121 of 2016 concerning export fees on plastic waste

Presidential Decree No. 25 of 2016 concerning raising import tariffs on plastics among other products

Presidential Decree No. 2 of 1957 concerning the establishment of the Egyptian Organization for Standards

The main aspects of these laws regarding plastics will be discussed below.

3.1.1 Waste Management Regulatory Law No. 202 of 2020, article 27

The waste management law seeks to limit the manufacturing, import, export, use, and free distribution of single-use plastic bags in Egypt by requiring that specific controls and requirements be put in place to promote alternatives to single-use plastic bags. The Law establishes that:

- Single-use plastic bag manufacturing, importing or exporting shall be in accordance with the technical controls, requirements, and specifications issued by a decision issued by the Minister of Trade and Industry, including their ban in case of components with inputs or materials that seriously harm the environment; Single-use plastic bag sale, circulation, storage, free distribution, or disposal may take place only in accordance with the controls, conditions and technical specifications determined by the executive regulations of this Law;

- It will issue a system of financial and economic incentives and tax and customs exemptions to encourage the import, production, and manufacture of safe, environmentally friendly alternatives for single-use plastic bags.

3.1.2 Governor Decree No. 167 of 2019 concerning banning single-use or disposable plastics in the Red Sea governorate

The Red Sea is the first Egyptian governorate to ban single-use or disposable plastics. Ahmed Abdullah, Governor of the Red Sea, issued Decree No. 167 for 2019, which bans single-use or disposable plastics in the Red Sea governorate. The decree's objective is to protect threatened and endangered species, which are severely affected by ingestion, starvation, suffocation, drowning, entanglement and toxicity from plastic remains, which also affects human health negatively. The ban applies to any food outlets, such as restaurants, cafes, and fisheries, as well as bans food cutlery, such as knives, spoons, forks, cups, and dishes. Furthermore, the governorate will not give authorization for factories to produce plastic bags. The governorate has collaborated with The Hurghada Environmental Protection and Conservation Association (HEPCA) to implement a campaign to raise awareness about the negative effects of plastics through social media, events, workshops, clean-ups, and providing alternatives such as reusable bags[36]. The decree does not take a position on biodegradable plastics.

3.1.3 Presidential Decree No. 419 of 2018 concerning conformity with the latest version of the international Harmonized System (HS)

The decree aims to bring Egypt's customs tariffs into conformity with the latest version of the international HS, reform and eliminate distortions in tariff systems, safeguard national interests, and abide by international standards. Egypt joined the International Convention on the Simplification and Harmonization of Customs Procedures (Kyoto Convention) in 2007.

Accordingly, plastics and rubbers are listed under chapter 39. Headings 39.01 - 39.14 tackle "primary forms", the expression applies only to liquids and pastes, blocks of irregular shape, lumps, powders, granules, flakes, and similar bulk forms. Headings 39.16 - 39.26 are for processed plastics in profile shapes, semi-finished, or finished products, while 39.15 is applied for plastic waste, parings, and scrap not transformed into primary forms of headings 39.01 to 39.14.

3.1.4 Ministerial Decree No. 489 of 2017 concerning factories importing and recycling plastic waste

The minister of trade and Industry has issued Decree No. 489 of 2017, replacing Article 55 of Decree No. 165 of 2002, pertaining the list of hazardous wastes restricted from importation, and lifting the import ban on plastics. Article 55, which originally classified recycle PET, PE, and PT as hazardous wastes, has been altered to allow their importation, under specific conditions. The first condition is that the shipment must include an inspection certificate authorized by an internationally recognized entity that states that the shipment does not include any ingredients classified as hazardous (poisonous, inflammable, active corrosion), and if present to be in quantities that does not exceed those specified by the Treaty of Basel[41]. The second condition is that the import is allowed for factories operating in recycling and that are licensed by IDA.

3.1.5 Ministerial Decree No. 43 of 2016 concerning specific conditions for some HS codes

The Decree lists HS codes that cannot be imported to Egypt before the registration of the manufacturing factories and the owners of the trademarks (which are located outside Egypt) on the GOEIC database of qualified factories to export to Egypt. Plastics are listed under these HS codes with the condition of obtaining approval from EEAA before importation.

3.1.6 Ministerial Decree No.121 of 2016 concerning export fees on plastic waste

The MTI issued a Decree raising the fees on waste and plastic scraps' export from EGP 3,000/ ton to EGP 5,000/ton in 2017.

3.1.7 Presidential Decree No. 25 of 2016 concerning raising import tariffs on plastics

Presidential Decree No. 25 of 2016, raised import tariffs on a wide range of products, including household appliances, electronic devices, plastics, clothing, shoes, watches, as well as food for dogs and cats and some agricultural products. For plastics import tariffs, plastic scrap and waste are mostly subject to a zero or 2 per cent customs tariff (59 out of 92 items in headings 39.01 to

39.15), while 31 items are subject to a 5 per cent tariff and eight items are subject to 10 per cent tariff. As for processed plastics in profile shapes, semi-finished, or finished products, 33 items are subject to zero to 2 per cent tariff, 67 items are subject to 5 per cent to 10 per cent tariff, while 49 items are subject to 20 per cent to 60 per cent tariff.

3.1.8 Presidential Decree No. 2 of 1957 concerning the establishment of the Egyptian Organization for Standards

The presidential decree established The Egyptian Organization for Standards (EOS) and in the same year EOS became an ISO member. In 1979, a new Presidential Decree No. 392 of 1979 was issued, reorganizing EOS as the only official and competent authority entrusted with all matters related to standardization, quality control and metrology. While Presidential Decree No. 83 of 2005 renamed EOS to The Egyptian Organization for Standards and Quality. The EOS provides standards and specifications for waste management and recycled materials. These standards and specifications should be understood and applied by recyclers, manufacturers, and stakeholders dealing with waste materials or products emanating from these materials. These standards can be found on the EOS website and need to be purchased by concerned stakeholders. The below table gives a sample of waste management and recycled materials listed on the website.

Summary of the legal framework for plastics in Egypt

Law	Issued by	Plastic value chain	Summary	Impact/ Refection
Waste Management Regulatory Law No. 202 of 2020	MoE	Recycling/ trade	Limiting the use of single-useplasticbags	Decrease the amount of plastic waste, and encourage using of alternative materials to plastic bags
Decree No. 167of 2019	Governor Decree	Generation of waste	Bans single-use or dis-posable plastics in the Red Sea governorate	Decreases the amount of plastic waste and encourages the usage and production of alternatives
Decree No. 419 of 2018	Presidential decree	Trade	Conforms with the latest version of the international Harmonized System (HS)	Facilitates the trade in plastics in general
Decree No. 489 of 2017	Ministry of Trade and Industry	Recycling	Allows import of plastics by recycling factories	Facilitates the importation of plastic waste, which Egypt, though, has an abundance of. This could mean that recycling factories suffer from the inability to access plastic waste (hence a problem with collection), or which is a result of the above, from the improper pricing of waste
Decree No. 43 of 2016	Ministry of Trade and Industry	Trade	Obliges importers of plastics to get approval from the EEAA beforehand	Hurdles: the importation of plastic waste
Decree No. 121 of 2016	Ministry of Trade and Industry	Trade	Raises the fees on waste and plastic scraps' export	Discourages the exportation of plastic waste, which could mean either increasing the recycling of plastics or the landfilling of plastics.

Decree No. 25 of 2016	Presidential decree	Trade	Raises the import tariffs on plastics	Discourages the importation of plastic waste or processed plastics, which could encourage the recycling of existing plastic waste and encourage local production of plastic products
Decree No. 2 of 1957	Presidential decree	Recycling	Establishes the Egyptian Organization for Standards	Enhances the market of plastic waste recycling

3.2 Standards and specifications for waste management and recycled materials provided by the EOS

Standard	Description
6123 /2007	Recycling symbols Society of the Plastics Industry (SPI) (obligatory)
6619 / 2008	Separation and washing of recycled plastics prior to testing (not obligatory)
6909 /2009	Techniquestoseparateandidentifycontaminationinrecycledplastics(not obligatory)
7049 / 2009	Determination of contamination in recycled poly (ethylene terephthalate) (PET) flakes and chips using a plaque test (not obligatory)
7786 / 2014	RecycledPlasticMaterialsandArticlesIntendedtoComeintoContactwithFood(not obligatory)

3.3 Plastics Initiative in Egypt

Major public or public-private initiatives to build plastics management capacity are few and far between in Egypt. Whereas international donor organizations and environmental NGOs play a prominent role in helping other lower-income countries build such capacity, with a few exceptions (including UN agencies) they have extremely limited involvement in Egypt. Multinational companies and social enterprises (domestic and foreign) are pursuing initiatives of their own, but most of these are small in scale or have relatively narrow objectives, such as river or sea clean-up or banning single-use plastic bags. There are currently no multi-stakeholder initiatives underway designed to bring about system-wide change—for example, combining financial support with technical assistance, policy advice, awareness-building, and other elements.

Opportunities exist, then, for international organizations—donors, NGOs, and business alliances—to step in and provide financial and other forms of support that Egypt needs to build its plastics management capacity. Their involvement should build upon the stakeholder efforts that are already underway, some of which we describe below.

3.3.1 Banning single-use plastics

Single-use plastics are a particular focus of the government's Waste Management Law of 2020, which places limits on the use of plastic bags and encourages the search for alternatives. This is partly a result of years of vocal advocacy for an outright ban on such bags and other plastic items from domestic initiatives such as Egypt Ban Plastic, a coalition of over 20 NGOs and social enterprises formed in 2019, initially focusing on the Red Sea but since expanding its activities to Cairo and elsewhere.

Many of the coalition's members, such as Banlastic, an Alexandria-based social enterprise, conduct clean-up campaigns and awareness-building activities in the cities where they are based. According to one of its co-founders, Ahmed Yassin, the enterprise was formed in 2018 to mobilize action to clean Alexandria's Mediterranean coastline of plastic litter. A point of difference for Banlastic, Mr. Yassin says, is that, in addition to the aforementioned activities common to most civic organizations dealing with plastic, it also organizes the manufacture and supply of alternative-material bags, containers, and utensils to local retailers and food shops. "We need to do more than just educate shop owners on the virtues of plastic-free bags and other items," says Mr Yassin. "We need to provide them with the alternatives as well."

The UN Environment Programme (UNEP) and EU, through its SwitchMed program, have also supported efforts to help reduce plastic bag consumption in Egypt. The Japan International Cooperation Agency (JICA) is investing US$3.6m in a program run by the UN Industrial Development Organization (UNIDO), in co-operation with the Egyptian environment ministry, to reduce single-use plastics in the country.

3.3.2 Improving waste collection and recycling

Helping to improve the work of the informal sector in collecting, processing, and recycling plastic waste is the focus of a small number of initiatives. One of these is managed by Plastic Bank, which is seeking to introduce an "ethical model" of recycling with financial incentives and technology in four governates (Cairo, Qalyubia, Fayum, and Port Said). According to Mr Elkady, the model includes using digital wallets to pay informal waste collectors (see "Digitalizing the Zabbaleen") as well as introducing a medical insurance scheme for collectors that was developed and proven in other countries where Plastic Bank works. Individual parts of the initiative, such as establishing waste collection centers, have attracted the support of multinational companies such as Henkel.

Another social enterprise, Bassita, is pursuing a different tack to transform the collection and processing of post-consumer plastic, starting on one island in the Nile and encouraging fishermen and local communities to take responsibility for it themselves.

3.3.3 Extended producer responsibility

As the government prepares to implement EPR, it is receiving advice on the scheme's design from foreign and domestic partners. One is GIZ, Germany's international development agency, which recently commissioned a report from two German consultancies proposing an EPR regime for Egypt that incorporates best practices from EU countries.

Another initiative, the brainchild of Ms Iskandar and CID Consulting, started life in 2019 as an initiative to incentivize the informal sector to increase the collection of PET (polyethylene terephthalate) bottles, with a pilot conducted in Cairo. It has since evolved into a more ambitious plan to implement EPR in several cities. Nestlé has championed the project from the start, and it has been joined more recently by Pepsico and Al Ahram Beverages. According to Ms. Iskandar, the EPR plan is at the center of the Post-Consumer.
Plastic Waste Pact that the aforementioned and other producers have signed with the environment ministry.

3.3.4 Summary of Selected Plastic Waste Initiatives in Egypt

Key organizers/sponsors	Initiatives	Launched/ founded	Activities/objectives
Bassita	VeryNile	2018	• Organize Nile fishermen in Cairo to collect plastic waste

			• Establish fully functioning plastic waste management systems on selected Nile islands
24 domestic NGOs and social enterprises	Egypt Ban Plastic Coalition	2019	• Raise awareness among consumers, retailers and manufacturers about the impact of plastic consumption. • Advocacy for a ban on single-use plastic
Nestlé, Pepsico (Al-Ahram Beverages to join in 2022)	Plastic Recovery Scheme (EPR)	2019	• Commit to participating in an EPR system in Egypt (designed by CID Consulting)
UNEP, EU	Reducing Plastic Bag Consumption in Egypt (SwitchMed in Egypt)	2020	• Research opportunities for replacing plastic bags with alternatives • Solicit commitment from producers, retailers, consumer groups, government agencies and NGOs to reduce the use of plastic bags
GIZ	Research and advice to Egypt Ministry of Environment on establishing an EPR scheme	2021	• Commissioned a study by a German consultancies that propose a design for an EPR system for packaging waste
Ministry of Environment of the Government of Egypt, Nestlé, Procter & Gamble, Pepsico, Coca-Cola, Unilever, Al-Ahram Beverages	Post-Consumer Plastic Waste Pact	2021	• Commit to participating in an EPR system in Egypt
Plastic Bank, Henkel	Establishment of plastic waste	2021	• Three centres are currently operating in Cairo

	collection centres		• Eventually plan to establish 400 collection points • Reach annual collection capacity of 5,000 tonnes by 2023
World Bank	Foster regional co-ordination of efforts to combat marine plastic pollution	2021	• Sponsored multi-lateral meeting in March 2021 involving environment ministers of eight Middle East and North Africa countries, including Egypt
JICA, UNIDO	Funding of efforts to promote circular economy practices in single-use plastics	Duration: 2021-24	• Conduct research on Egypt's plastic value chain • Technical assistance to small enterprises involved in developing plastic waste solutions • US$3.57m in funding

Source

1- STUDY ON PLASTIC VALUE CHAIN IN EGYPT - NOVEMBER 2021
2- COMING TO GRIPS WITH PLASTIC:EGYPT'S WASTE MANAGEMENT CHALLENGE

4 International discussed measures

5 Technologies, Innovation and Research that might change material flows

5.1 Introduction

In this chapter, we provide an overview of the emerging technologies that could help Egypt's transition to more sustainable production and use of plastics. It gives literature review divided in emerging technologies in

- Production
- Plastics processing
- Waste management
- Substitution of chemicals in plastics

Most plastics are derived from fossil hydrocarbons, typically sourced from naphtha—a by-product of refining crude oil into fuels—or from natural gas condensates such as propane and ethane. These raw materials are then cracked to produce monomers like propylene and ethylene, which are subsequently polymerized to create virgin polymers such as polypropylene (PP) and polyethylene (PE). The virgin polymers, usually in the form of granulates, are blended with various additives to achieve the desired properties for their intended applications through a process called compounding. These compounded plastics are then transformed into products via molding, blowing, or extrusion. The final products are either sold directly to consumers or used as components in more complex products. Ongoing research concerns in particular ###, see chapter ##

Plastic materials have a significant role in modern life. They are also essential to many aspects of sustainability: improving fuel efficiency because of lower weight compared to other materials, improving energy efficiency as insulation material or reducing food waste due to increasing food shelf life. Ongoing research concerns e.g., ##, see chapter ##

Increasing consumption of plastic leads to environmental impacts of plastic waste, emissions of greenhouse gases and use of fossil resources. These concerns caused the need to reduce consumption and production of plastic by transition to circular economy, reuse and recycling and use of renewable resources in plastic production (bioplastic). Ongoing research concerns in particular ###, see chapter ##

5.2 Emerging Technologies in plastic polymer production

The plastic value chain can undergo transformation through the adoption of emerging technologies, which possess the capability to significantly alter the existing plastic materials landscape in various ways.

- Implementation of Industry 4.0 technologies (Internet of Things (IoT), Big Data and Analytics, Artificial Intelligence (AI) and Machine Learning, Robotics and Automation) increasing efficiency and automation capabilities, improving plastic waste management

- Bio-based systems facilitating the development of high-added value products from biological materials, and
- Chemical recycling reducing the need for raw materials to produce high-quality recycled plastic,
- Distributed economies enabling a shift in the production-consumption system.

5.2.1 Implementation of Industry 4.0 technologies

Implementation of Industry 4.0 technologies is a great step towards transforming plastic value chain by production process optimization, improved waste management, closing the loop.

Significant optimization in the plastic production processes can be done. Artificial Intelligence handles the logic and data processing either from real-time inputs provided by IoT sensors or based on historical performance data (Big Data). This combination becomes even more powerful when incorporating autonomous robots, as it allows AI to control manufacturing devices, enabling continuous monitoring and optimization of performance and processes.

The efficiency-driven Process Intensification (PI) model uses chemical engineering and process optimization techniques to achieve a cleaner and more efficient use of manufacturing resources. PI enhances resource efficiency and reduces waste by maximizing mass, heat, and momentum transfer throughout the production stages. The impact of PI can be further amplified by integrating it with other emerging technologies, such as additive manufacturing, which allows for the "printing" of custom-made parts.

Technologies to close the loop and reintroduce materials back into the system either through remanufacturing, recycling, or extracting valuable materials from waste involves blockchain, but also chemical recycling, biopolymers, and biorefineries.

Blockchain' foundational feature, a shared and immutable ledger, has unlocked new opportunities for secure and transparent transactions involving both tangible and intangible assets. Businesses leverage blockchain to streamline operations, track valuable assets, and enhance trust and efficiency in their transactions. This technology's ability to provide quick and unalterable information in real-time fosters transparency and trust, enabling businesses to identify innovative ways to enhance their operations.

Blockchain technology provides a secure and transparent platform for recording every step in the materials along the entire value chain.

5.2.2 Bio-based polymers for plastics

Monomers for synthesis of polymers for bioplastic are extracted or synthesized from biomass compounds (i.e., sugars in plants). These polymers are direct replacement for existing plastic, such as polyethylene (PE), or novel polymers, such as polyhydroxyalkanoates (PHAs). Biomass extraction can also yield non-synthetic natural polymers, such as starch, natural rubber and proteins.

Almost all monomers derived from fossil resources needed to produce polymers for plastic can be produced from biomass. Additionally, biomass can support the synthesis of novel polymers that are not easily derived from fossil resources (figure 1).

Leveraging the benefits of local or regional production and the 'economies of scope' model, the bio-based systems paradigm offers a viable alternative to the systemic reliance on fossil fuels.

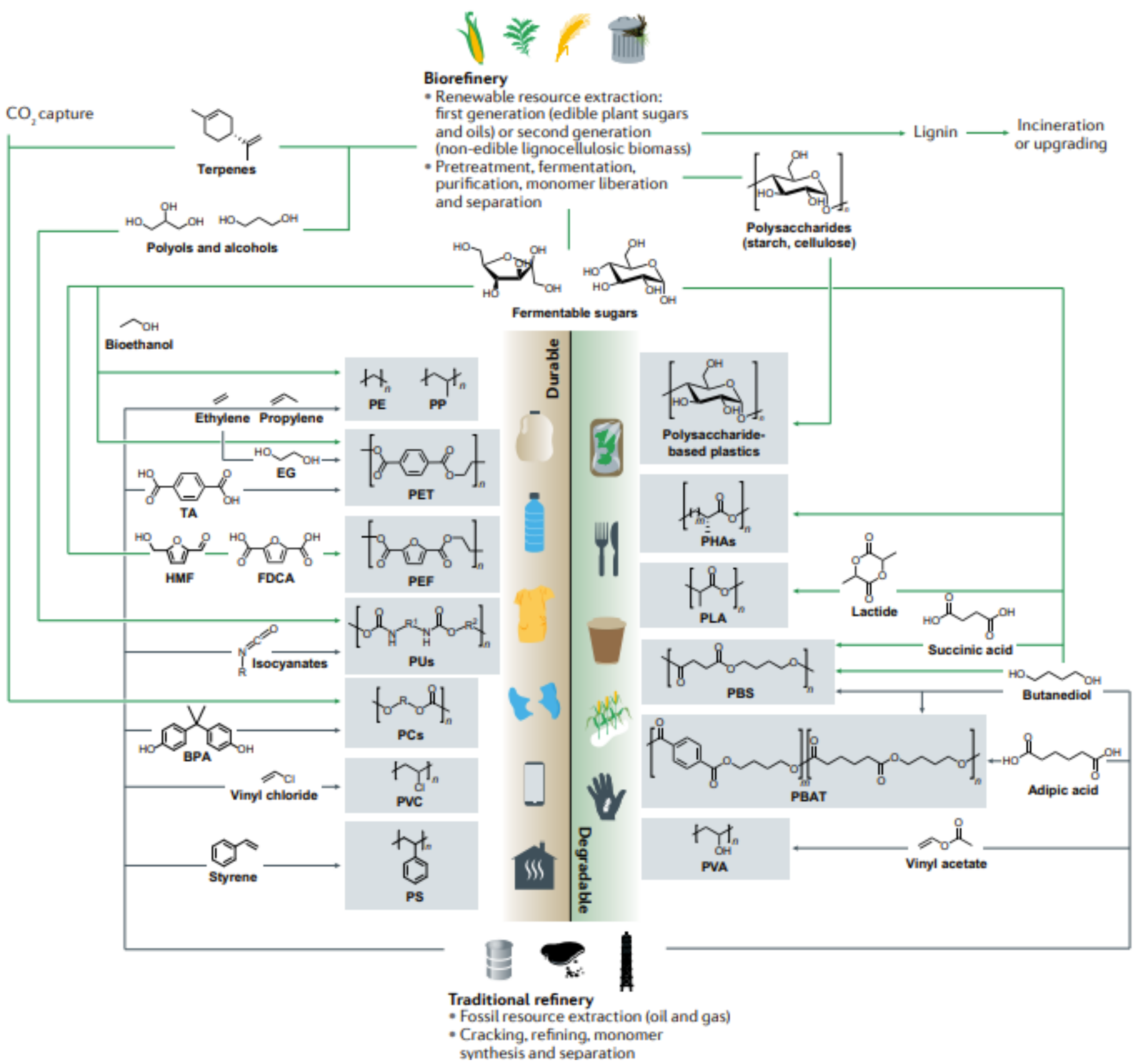


Figure 1 – Monomers produced from fossil resources and biomass[1]

Biomass is divided into first-generation and second-generation feedstocks.
The first-generation biomass comes from edible polysaccharide (i.e., corn and sugarcane), and edible vegetable oils. Second-generation biomass describes various non-edible biowastes.

In the plastic materials industry, technologies for producing bio-based polymers like PLA, PCL, and PHA are undergoing testing and scaling, making them increasingly viable both economically and environmentally as alternatives to fossil-based plastics. This section presents these commercially relevant polymers for bioplastic manufacturing.

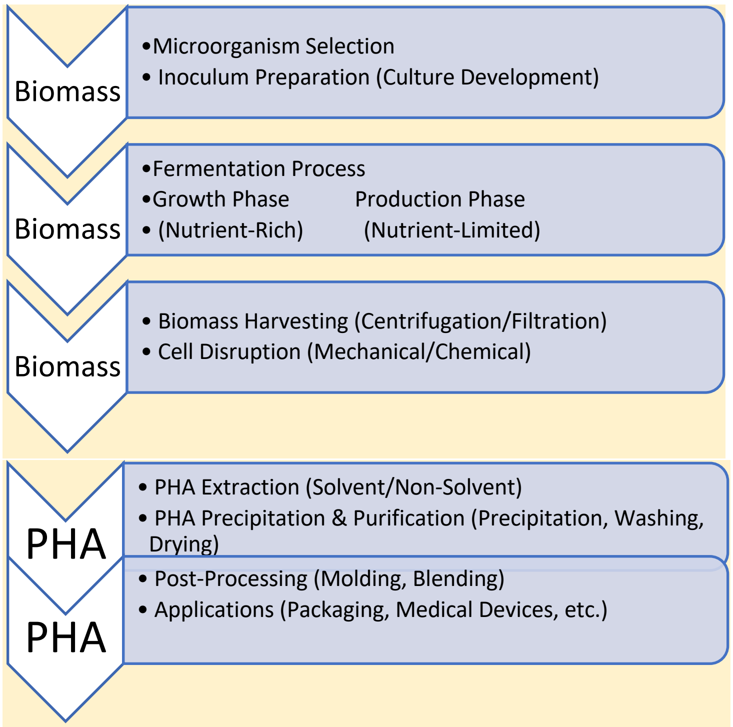
Polyhydroxyalkanoates (PHAs) are a class of biodegradable plastics produced by microbial fermentation. PHAs offer a versatile and sustainable alternative to conventional plastics, helping to address environmental concerns associated with plastic waste and pollution. It can replace several types of conventional plastics including:

- Polyethylene (PE), one of the most used plastics, used for products like plastic bags, packaging films, and containers.
- Polypropylene (PP) which is widely used in packaging, automotive parts, textiles, etc.
- Polystyrene (PS) which is used in products like disposable cutlery, cups, and packaging materials.
- Polyvinyl Chloride (PVC) is used in packaging, medical devices, and construction materials. While direct replacement of PVC with PHA might not always be feasible due to different material properties, in certain applications where biodegradability is a priority, PHAs can serve as an alternative.
- Polyethylene Terephthalate (PET) is used in bottles, food containers, and packaging. PHAs can be used as an alternative in some of these applications, especially in food packaging where biodegradability is beneficial.

While PHAs can replace these types of plastics, the choice of using PHAs often depends on the specific requirements of the application, including mechanical properties, cost considerations, and the desired rate of biodegradation.

Producing Polyhydroxyalkanoates (PHAs) involves a series of biotechnological processes, relying on microbial fermentation.
Below is a simplified flowchart of the PHA production process.

[1] Source Bioplastics for a circular economy, Nature Reviews | materials, volume 7 | February 2022, p. 123



Flowchart 1 – PHA production process

The production of PHAs involves sophisticated biotechnological processes that encompass microbial fermentation, recovery, and purification techniques, along with continuous optimization to improve efficiency and sustainability. Parameters such as fermentation time, nutrient feed strategy, and bioreactor design are optimized to improve the efficiency and cost-effectiveness of the production process. To improve yield and tailor the properties of PHAs, genetic engineering of microbial strains is often undertaken. Combining PHAs with other biodegradable polymers is undertaken as well to enhance specific properties.

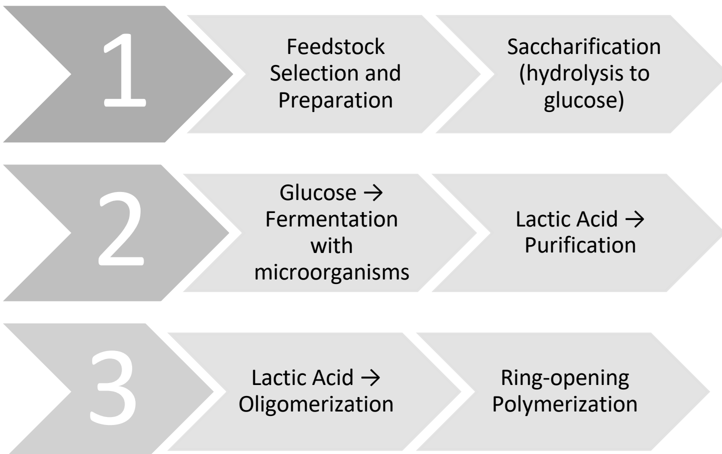
Polylactic Acid (PLA) is a biopolymer derived from renewable resources, such as corn starch, sugarcane, or other biomass materials. It has gained significant attention as a sustainable alternative to conventional plastics made from fossil fuels due to their biodegradability, lower carbon footprint, and potential for reducing reliance on non-renewable resources.

PLA is more brittle and has a lower thermal resistance compared to some conventional plastics, limiting its use in high-temperature applications. The addition of reinforcing fibers, micro- and/or nanofillers, and selected additives within PLA matrix is considered as a powerful method for obtaining specific end-use characteristics and major improvements of properties.

It can replace several types of conventional plastics including Polyethylene Terephthalate (PET), Polypropylene (PP), Polyethylene (PE), Polystyrene (PS). Polyvinyl Chloride (PVC) and Acrylonitrile Butadiene Styrene (ABS).

Each of these fossil resource-derived plastics has different properties that make them suitable for various applications. When substituting PLA, it is necessary to consider the specific requirements of the application, such as mechanical strength, flexibility, thermal resistance, and environmental impact.

Below is a simplified flowchart of the PLA production process.



Flowchart 2 – Production of Polylactic Acid (PLA)

PLA is biodegradable, but it requires specific industrial composting conditions (temperature, humidity, microbial activity) to break down effectively. It does not degrade efficiently in natural environments or standard landfills.

PLA represents a promising step towards more sustainable materials in the plastic industry. Continued research and development are essential to overcome its current limitations and expand its application potential.

Polycaprolactone (PCL) is a biodegradable polyester with a low melting point and a range of applications, particularly in biomedical fields and as a biodegradable plastic. When produced from biomass, PCL can serve as a more sustainable alternative to conventional petroleum-based plastics.

PCL can replace polyethylene (PE) in applications where biodegradability is a desired feature. For instance, PCL is used in the production of biodegradable bags, packaging films, and agricultural mulch films. It can also be used instead of polypropylene (PP), Polyvinyl Chloride (PVC), Polystyrene (PS) and Polyethylene terephthalate (PET) where biodegradability is required but the mechanical strength and transparency of PET are not critical.

Below is a simplified flowchart of the PLA production process.

1
- Feedstock Selection and Preparation (agricultural residues, wood chips etc.)

2
- Biomass-derived intermediates (like sugars) are converted to caprolactone through chemical or biological processes.
- Bio-based Routes: Employing bio-catalysis or fermentation to produce ε-caprolactone from bio-based precursors.

3
- Ring-opening polymerization (ROP) of ε-caprolactone.

Flowchart 3 – Production of Polycaprolactone (PCL)

PCL is susceptible to microbial attack, leading to its decomposition into biomass, CO_2, and water under appropriate conditions.

5.3 Emerging technologies in plastic processing

Plastic processing has undergone significant advancements in recent years, fueled by emerging technologies and a growing demand for efficient, cost-effective, and sustainable production methods. Industry 4.0 technologies enable manufacturers to optimize production processes, minimize downtime, and improve overall efficiency. Additionally, predictive maintenance and machine learning algorithms can identify potential issues before they lead to major disruptions, thereby reducing costs and enhancing product quality.
Implementation of digital twins (virtual replicas of physical assets, processes, or systems) enable real-time monitoring, analysis, and optimization. They allow simulation and testing of different scenarios, predicting performance, and optimization of processes before implementation in the processing.
3D printing has revolutionized the plastic manufacturing industry. It is becoming increasingly popular in manufacturing processes due to its efficiency and cost-effectiveness in producing goods and components. This technology allows for the creation of products with complex geometry and intricate details, utilizing a wide range of materials. Additionally, 3D printing facilitates custom manufacturing, enabling the production of products tailored to specific customer needs. It also significantly reduces waste by producing complex components with minimal support structures and material use. Furthermore, 3D printing allows for on-demand production, eliminating the delays associated with traditional manufacturing methods. This approach is more cost-effective for small batch sizes, as it reduces the need for tooling and production line setup.

5.3.1 The latest trends in substitutions of plastic products

The substitution of plastic with alternative materials is driven by the need to mitigate the significant environmental and human-health impacts of traditional plastics.

While bioplastics are practical alternatives, they are not the ultimate solution for tackling plastic waste. Besides higher production cost, the successful decomposition of some bioplastics is possible only under specialized industrial composting facilities, and their inclusion in regular waste recycling streams may lead to contamination problems.

Glass, metal, and wood are gaining renewed attention for their durability and recyclability, particularly in industries like construction and consumer goods.

Several sustainable materials such as natural fibers (hemp, flax, and bamboo) are emerging as viable alternatives to conventional plastics, offering comparable functionality with reduced environmental impact. They are being incorporated into composites to replace plastic in applications ranging from packaging to automotive components.

Advances in materials science have led to the development of innovative alternatives, some, developed by biotech start-up companies are presented below.

To substitute Styrofoam that degrades very slowly a biodegradable alternative has been developed. Two unlikely elements hemp hurd — the woody inner layer of the hemp stalk — and mycelium — the root of fungi like mushrooms were combined. This product matches the performance of traditional materials like polystyrene foam. Moreover, this product is completely composted in 45 days. It can be used for i.e., corner protectors for furniture and IT equipment, or as packaging materials.

A biodegradable, medium-chain-length polyhydroxyalkanoate (mclPHA) biopolymer is an ideal alternative for single-use plastics, including drinking straws, utensils, and plastic bags. It is produced from plant-based oils through a microbial fermentation process and can fully biodegrade in soil, water, and marine conditions within a matter of weeks without leaving behind harmful microplastics.

A significant advancement lies in the potential of seaweed to create food-grade bioplastic wraps that decompose within a few months when disposed of in the environment. These groundbreaking wraps provide a sustainable option compared to traditional plastic wraps, which, despite being effective in keeping food fresh, are often difficult to recycle due to their thinness. However, manual processing contributes to higher production costs compared to conventional plastics and meeting global demand, seaweed farming would require substantial technological improvements. The expanding research and ongoing innovation highlight the rising potential of seaweed as a more environmentally friendly alternative to plastic wraps.

So called “vegan leather” is produced from different plants like cactus, apple peels, waste from corn industry pineapple leaves etc.

Although many solutions contribute to addressing the problem by using natural, compostable materials, the solution must also involve reducing plastic consumption.

5.4 Emerging technologies in waste management

Blockchain technology is a crucial asset in waste management. It can track waste throughout its entire lifecycle, from generation to collection, transportation, recycling, and disposal. Each transaction is documented on the blockchain, allowing for real-time monitoring and verification of waste-related data. This system offers detailed information about the material composition of end-products, helping recyclers determine the appropriate recycling methods.
Identifiers for waste in a blockchain system can vary based on the specific requirements of each system. These identifiers might include Quick Response (QR) codes or specialized Radio Frequency Identification/Near Field Communication (RFID/NFC) chips. QR codes, which can be easily scanned with smartphones or special readers, allow for the storage of large amounts of information and can be printed on various materials. Placing a QR code on product packaging enables users to scan it and access blockchain records detailing the waste's origin.

RFID/NFC (Radio frequency identification/ Near Field Communication) technology, on the other hand, allows items to be tracked remotely using radio waves. This automatic tracking process is weatherproof, with data stored directly on the chip and linked to the blockchain as a NFT token (Non-Fungible Token). The choice of identifier depends on several factors, including the type of waste, available infrastructure, cost, and security requirements. Additionally, different identification technologies can be combined to meet the specific needs of a waste management system.
Developing a product-tracking ecosystem involves integrating advanced technologies with well-designed processes and fostering extensive collaboration among all supply chain stakeholders. Implementing these solutions to ensure transparency in the recycling process is crucial for sustainable waste management. As modern societies increasingly prioritize responsible resource use, transparent recycling processes are essential for gaining the trust of consumers and stakeholders.

5.4.1 Chemical recycling of plastic waste

The conventional lifecycle of most plastic materials is linear, primarily due to the constraints of mechanical recycling. This dominant method reshapes waste plastics through mechanical force and heat, with the quality of the recycled product highly dependent on the quality of the input material. Consequently, well-sorted and contamination-free plastic waste is essential but often scarce. In a circular economy model, plastics should be produced from recycled or renewable resources. (Figure)
Chemical recycling can play a critical role in reducing plastic waste and promoting sustainable resource use. Various forms of chemical recycling provide a more robust and adaptable approach for processing mixed and contaminated plastic waste, including multilayer materials. Chemical recycling of plastic refers to a set of technologies that break down plastic waste into its chemical

building blocks, which can then be reassembled into new plastic products or other valuable chemicals.

However, these processes are more complex and costly, particularly during the initial implementation phase, and thus require financial incentives.

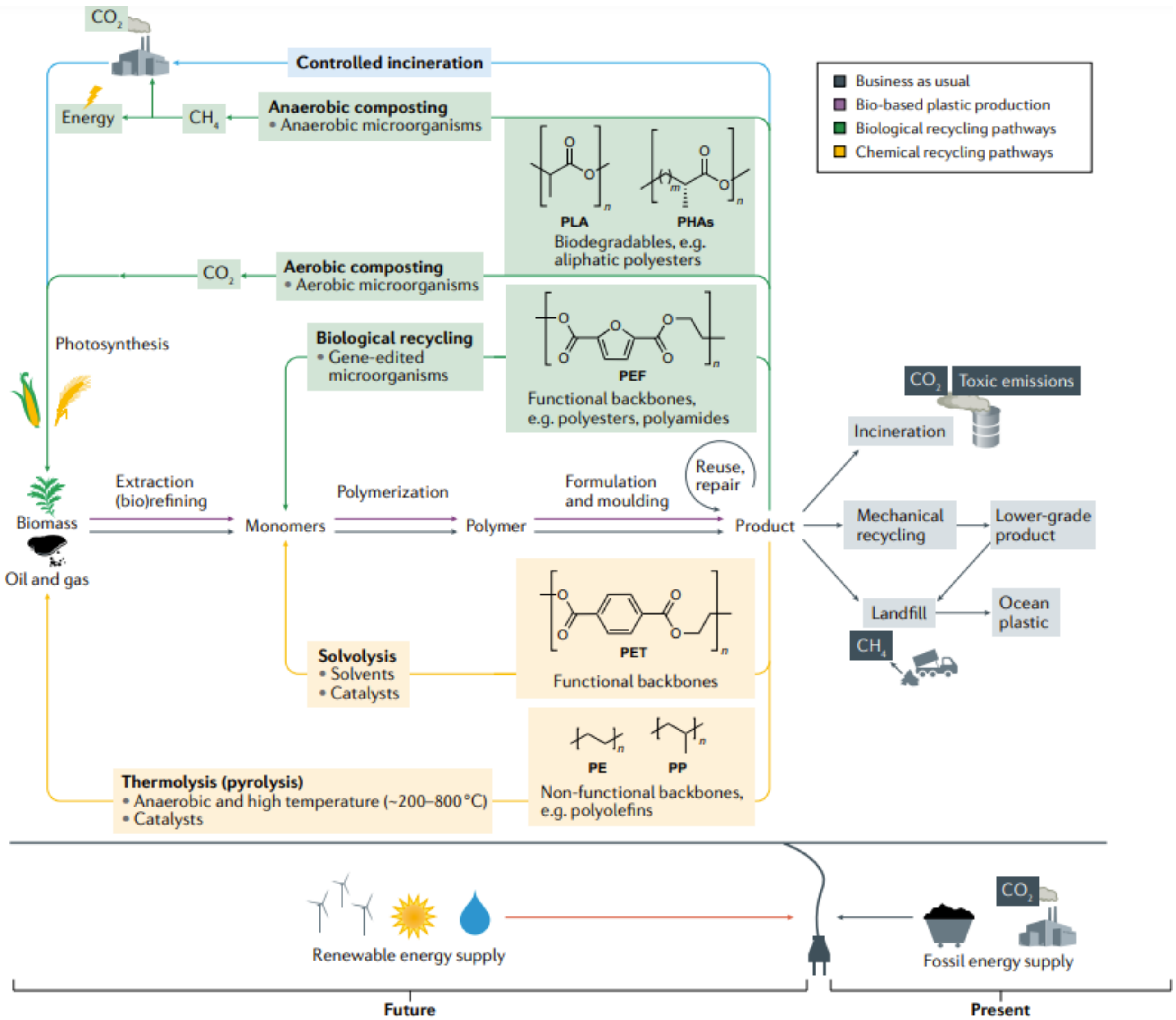


Figure 2 - The circular plastic economy[2]

There are several types of chemical recycling: conversion (pyrolysis and gasification), depolymerization (solvolyzes, hydrolyzes) and dissolution (Figure).

[2] Source Bioplastics for a circular economy, Nature Reviews | materials, volume 7 | February 2022, p. 121

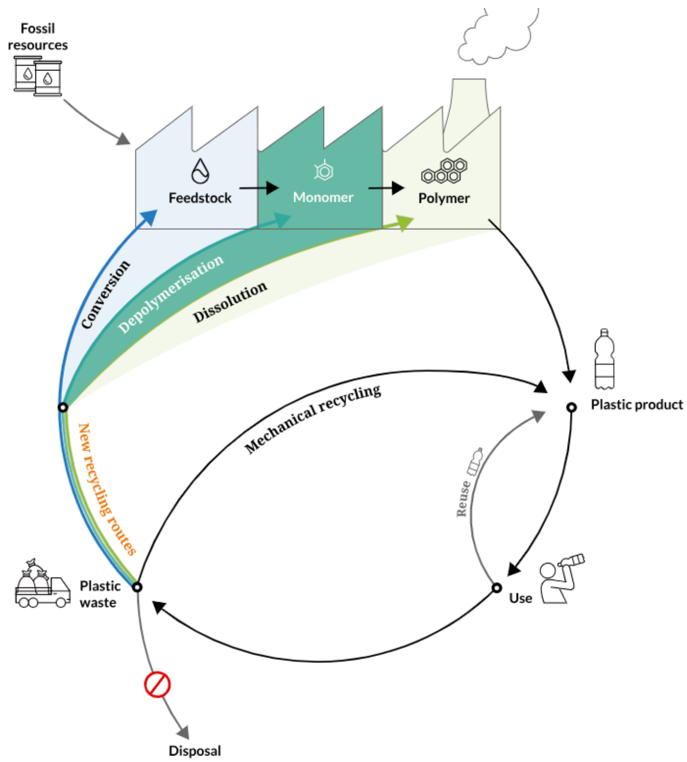


Figure 3 – Types of chemical recycling[3]

Pyrolysis involves heating plastic waste in the absence of oxygen to break it down into smaller molecules, primarily converting it into liquid oil and gas. Thermolysis is most suitable for hydrocarbon polyolefin materials such as (bio)PE, (bio)PP and polystyrene. Mixed and contaminated waste can be handled, and the output can be used as a feedstock for new plastics or as fuels. This process requires high energy input and results in a complex mixture of products that need further refining. A concern is the generation of potentially toxic gases due to the often-unknown additives, necessitating proper capture mechanisms. Polyesters, along with other oxygen-bearing, nitrogen-bearing, and sulfur-bearing polymers, emit greenhouse gases such as CO, CO2, NOx, and SOx. Meanwhile, halogenated polymers like PVC produce HCl gas and chlorobenzene.

Gasification involves plastic waste heating in a controlled amount of oxygen to produce syngas (a mixture of hydrogen and carbon monoxide). Syngas can be used to produce new chemicals and fuels. By this process efficient conversion of waste to energy or feedstock for new plastics is achieved. Gasification is technically complex and capital-intensive process.

Hydrolysis uses water and heat, sometimes in the presence of catalysts, to break down plastics into their monomers. Monomers can be purified and repolymerized into new plastics. High-quality monomers suitable for making new virgin-quality plastics are produced. This process requires pure feedstock, and it is specific to certain types of plastic such as, Polybutylene succinate (PBS), Polylactic Acid (PLA), or

[3] Source: https://cefic.org/a-solution-provider-for-sustainability/chemical-recycling-making-plastics-circular/

Polyhydroxyalkanoates (PHAs). Depending on the process setup, hydrolysis can be resource-intensive, requiring significant amounts of water and energy, which could offset some of its environmental benefits if not managed properly.

Solvolysis (including glycolysis, methanolysis, and others) uses solvents to dissolve and depolymerize plastics. Products are monomers or oligomers that can be used to produce new plastics. This process is especially effective for specific polymers like PET**.** Solvent recovery and reuse can be complex and costly.

The dissolution recycling process begins with the sorting and preparation of plastic waste for subsequent processing. This method involves applying heat and solvents to dissolve the plastic into a solution composed of its original polymers and additives. Next, the additives are separated from the polymers, which are then recovered from the solution. Importantly, the polymer structure remains unchanged throughout the dissolution process. In the final step, new additives are introduced to the polymers to create new recycled plastic.

5.5 Distributed economies concept

The concept of distributed economies involves transitioning to more localized or even personal systems of sourcing, manufacturing, consumption, and recycling. Adopting these technologies in the plastic manufacturing value chain can completely redefine the notions of 'waste' and 'value', promote material re-utilization, and effectively manage mixed waste streams through decentralized sorting and collection methods.

This shift is facilitated by emerging technologies such as 3D printing, IoT, blockchain, AI, and cloud computing, as well as small-scale chemical transformation processes. Unlike previous advancements focused on efficiency and automation, these technologies enable fundamental changes in production-consumption and socio-economic systems. Examples of these innovative solutions include 'micro recycling', 'peer-to-peer circularity', and 3D printing-enabled sociotechnical systems.

This approach promises significant societal impact by fostering self-sufficiency and localizing production, potentially making activities currently seen as non-profitable economically viable.

5.6 Chemicals in plastics

More than 13,000 chemicals are linked to plastics and their production across various applications. Among these, over 3,200 (out of 7,000 substances for which extensive scientific data on the potential adverse impacts exist) monomers, additives, processing aids, and non-intentionally added substances are potentially hazardous. These hazards include carcinogenicity, mutagenicity, reproductive toxicity, specific target organ toxicity, endocrine disruption, ecotoxicity, bioaccumulation potential, environmental persistence, and mobility, with the possibility of long-range environmental transport to remote areas.

In addition to certain monomers, ten groups of chemicals associated with plastics have been identified as being of major concern due to their known toxicity and potential to be released from plastics. Outlined below are the groups of these chemicals.

Shall we add a para saying that these components are often a barrier to recycling and circular economy??

Recycling plastic and bioplastic is generally complicated by the presence of fillers and additives in almost every finished plastic product. Mechanical recycling cannot effectively remove these contaminants and additives from polymer waste. Combined with the inherent thermal and mechanical stress, this often leads to 'downcycling,' where materials are converted into lower-quality products. Additional complications arise from colored or low-density materials (such as films and foams) and medical contaminants, which can render products non-recyclable.

Flame retardants are a class of additives used to reduce flammability and the spread of fire in plastics. They are used in many consumer products, such as electronic devices, vehicles, furniture, insulation foams, and certain textiles. Flame retardants used in plastic include brominated and chlorinated flame retardants, often used with antimony (Sb) as a synergist; organophosphorus compounds, and Inorganic flame retardants such as aluminum and magnesium hydroxides and boron.

Several flame retardants were listed as POPs under the Stockholm Convention, including Polybrominated diphenyl ethers (PBDEs), Hexabromocyclododecane (HBCDD), hexabromobiphenyl (HBB), and Short-chain chlorinated paraffins (SCCPs).

Per- and polyfluoroalkyl substances (PFASs) consist of thousands of synthetic organic fluorinated compounds, each containing at least one fully fluorinated methyl or methylene carbon atom. A major use of PFOS, PFOA, and related substances (precursors) was in the manufacturing of side-chain fluorinated polymers. These polymers are utilized as linings for food containers and wrappers, and as surface treatments for plastic fibers in textiles to repel water, oil, and dirt.

Phthalic acid esters or phthalates are a family of additives used as plasticizers, mainly in PVC production. The EU has restricted Di-2-Ethylhexyl phthalate; Di-2-ethylhexyl phthalate (DEHP), dibutyl phthalate (DBP), benzyl butyl phthalate (BBP), and diisobutyl phthalate (DIBP) in toys, childcare articles, and all indoor and outdoor articles with prolonged contact with human skin. Additionally, some phthalates are restricted for use in toys and childcare articles that children can place in their mouths.

Bisphenols are a group of aromatic compounds with two hydroxyphenyl functionalities. They are used for production of polycarbonate plastic products (water bottles, food storage containers and packaging, sports equipment), thermal paper, and of the epoxy resin liners of aluminum cans. The most produced chemical in this class is bisphenol A that is used as monomer for polycarbonate plastic and production of epoxy resins. Some plastic products containing BPA, in particular baby bottles, are restricted in several countries.

Certain alkylphenols and alkylphenol ethoxylates (APEOs) such as Nonylphenol (NP) is commonly used as a stabilizer and intermediate in plastics production. Additionally, 4-tert-octylphenol as well as branched and linear 4-nonylphenol are included on ECHA's SVHC list.

Polycyclic aromatic hydrocarbons (PAHs) are a class of chemicals that occur naturally in coal, crude oil, and gasoline and are formed during pyrolysis or incomplete combustion processes. This class of chemicals can be found in many consumer goods made of rubber or elastomers. Eight

PAHs are classified as carcinogens category 1B (JRC 2018) and restricted in the EU under REACH in plastic and rubber parts of articles that can be used by consumers, particularly by children.

Biocides are antimicrobial substances (bactericides, fungicides, insecticides, and rodenticides) that are added to plastic to protect it from attack and degradation by microorganisms. The major fields of application are PVC material (e.g., synthetic leather, or synthetic shoe insoles). Several biocides are restricted in the EU by the Biocidal Products Regulation (Regulation 528/2012).

UV stabilizers prolong the lifespan of plastics by protecting them from photo-degradation initiated by UV light. The most common UV stabilizers for plastic are benzophenones, benzotriazoles (BZTs), hindered amine light stabilizers (HALS), and their combinations. UV-320, UV-327, UV-328, and UV-350 have already been classified as SVHC in the EU and are on the list of substances subject to Authorization under EU REACH due to their Persistent, Bioaccumulative, and Toxic/very Persistent and very Bioaccumulative properties. UV-328 was evaluated by the POPRC of the Stockholm Convention and it meets the Annex D criteria for POPs properties (and recommended its listing as a POP in Annex A to the Convention (elimination).

Metals and metalloids are group of additives containing metals, including antimony, cadmium, chromium, lead, mercury, cobalt, tin, and zinc. Heavy metal based pigments (cadmium, lead, chromium) are used as colorants for plastic. Some metal-containing additives are also used as antimicrobials, accelerators, and catalysts. use of the four most hazardous metals (cadmium, hexavalent chromium, lead, and mercury) in plastic packaging has been regulated since 1994 under European Commission (EC) Directive 94/62/EC on packaging and packaging waste (European Commission 1994).

Non-intentionally added substances (NIAS) originate from different sources and include breakdown products of polymers, impurities in starting materials, unwanted side-products, and various contaminants from recycling processes.

The substitution of substances of concern in plastics is a complex but essential aspect of modern manufacturing. It requires a combination of innovation, regulation, and collaboration across industries to ensure that safer, more sustainable materials are used without compromising product quality and performance.
Strategies for substitution include material substitution by replacing hazardous plastics with safer polymers such as polymers from bio-based resources, finding safer additives to replace hazardous ones (for instance, using non-phthalate plasticizers or halogen-free flame retardants), modifying manufacturing processes to eliminate the need for certain chemicals (for example, using high-energy curing methods that do not require solvents), and redesigning products to eliminate the need for hazardous materials (For instance, designing electronics that do not require flame retardants).

6 Awareness and plannings of stakeholders

7 Expected and Potential Impacts of measures and plannings

8 Questions of policy makers and potential answers

Awareness

Question: To what extent exists awareness on the problem of plastic pollution, in particular at industrial stakeholders?

Egyptian manufacturers of plastics (from the beginning of the material flow to the production of polymers (polymerisation reaction) are aware on the problems of plastic pollution. They see mainly the following topics that require improvements and solutions in the future: # to be further elaborated, based on interviews, if necessary, differentiation between the 5 plastics

1)

2)

3)

Egyptian manufacturers further downstream have less awareness, mainly small companies and companies of the informal sector have only little or no knowledge on existing problems.

further elaboration based on interviews, if necessary, differentiation between the 5 plastics

The awareness at the level of applicants and consumers seems to be different.

The following problems are noted by some stakeholders:

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For most of the Egyptian consumers awareness on plastic problems obviously does (nearly) not exist. # to be checked and further elaboration based on interviews and literature, if necessary, differentiation between the 5 plastics

Plannings and positions of the Egyptian industry

Question: What are the planned actions of industry to reduce plastic pollution in the context of the country?

Industry in Egypt has the following plans to reduce plastic pollution:

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further elaboration based on interviews, differentiated for the 5 plastics; reference to material flows (chapter 2 and plannings chapter 3)

Potential changes in feedstock and production of plastics

Question: Are there possibilities to change the feedstock and composition of products for a more sustainable production?

- Bio-plastics
- Biodegradable plastics
- Changed additives
- Recycled feedstock
- Change from single use plastics to more durable products

further elaboration based on interviews, differentiated for the 5 plastics, results of previous chapters

Obstacles and challenges concerning transformations in the material flows

Question: Which concerns and barriers exist for a transformation of the plastics industry?

- Existing investments (e.g. naphtha crackers) and their expected life time)
- Use of by-products and existing synergies with other products in the petrochemical industry
- Demand structure of the Egyptian industry
- Demand structure due to the growth of the Egyptian population, industry and income situation.

further elaboration based on interviews, differentiated for the 5 plastics, results of previous chapters

The following measures, that are discussed on national or international level, are welcomed by the Egyptian industry:

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-

further elaboration based on interviews

The following measures, that are discussed on national or international level, are not appreciated by the Egyptian industry:

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further elaboration based on interviews

9 Recommendations, based on questions of policy makers

Question: How to create and increase awareness?

Question: How to address challenges from by-products and existing synergies of material flows?

Question: What role could be played by legislative measures?

Further recommendations, to be further elaborated

Focus on single use products, transfer to circular economy:

Coordination with manufacturers of plastics is important, if new production plants are erected, the products will find its ways into the Egyptian market, as there is strong and rising demand.

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