ALTERNATIVE POLICY SOLUTIONS

BACKGROUND PAPER

Egypt's Circular Economy: Challenges and Opportunities in Textiles, Plastics and Cement

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Alternative Policy Solutions

113 Qasr al-Einy street

PO Box 12511

Cairo - Postal Code: 11511

Egypt

+02 2797 6970

http://aps.aucegypt.edu – solutions@aucegypt.edu

This background paper was prepared by Leila Roberts, researcher at APS, under the supervision of Soha Abdelaty, APS' Deputy Director.

Alternative Policy Solutions is a non-partisan, public policy research project at The American University in Cairo. Using rigorous, in-depth research and a participatory process of consultations with a diverse range of stakeholders, we propose evidence-based policy solutions to some of the most difficult challenges facing Egypt. Our solutions are innovative, forward-looking and designed to support decision makers' efforts to introduce inclusive public policies.

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1. Introduction

The circular economy model, based on the principles of regenerative growth, minimizing waste and pollution and product and material reuse, has been recognized as a significant opportunity to curb Egypt's environmental degradation and support Egypt's industrial base. Egypt is listed as one of the largest 'Grow Countries', which are characterized by rapid industrialization, increasing material consumption and the expansion of the middle class, and would thus benefit by prioritizing resource efficiency, renewable energy and material recycling, according to the 2021 Circularity Gap Report (Circle Economy, 2021). Egypt has experienced significant growth of 32% in per capita primary energy consumption from 1990 to 2014 (Egyptian Environmental Affairs Agency [EEAA], 2018), and despite being the 25th largest oil producer in the world, Egypt's oil reserves are depleting rapidly (Abdallah & El-Shennawy, 2020). The latest figure given for Egypt's oil reserves-to-production ratio – the number of years that current reserves would last if their rate of use did not change – is 12.3 years from 2019 (British Petroleum [BP], 2020). Industry is responsible for 37% of Egypt's total energy consumption (EEAA, 2018), higher than the EU's share of 26% (ODYSSEE-MURE, 2015). Furthermore, there is scope for improved energy efficiency. Egypt's economy is six times more energy intensive than the EU average (European Bank for Reconstruction and Development [EBRD], 2017), and according to the United Nations Industrial Development Organization (2014), "the final energy consumption per unit of output in the most important industries in Egypt is typically 10 to 50% higher than the international average" (p. 1).

Equally concerning is the risk of water scarcity, where increasing demand for water from agriculture, industry and domestic consumption places pressure on Egypt's limited water resources, and water recovery remains minimal (EEAA, 2018); Egypt suffers from a deficit of 30 million cubic meters (Kandil, 2021), and is below the water scarcity threshold (1000m^3), as the annual per capita water share stands at 570m^3 (Egypt Today, 2021b). Additionally, the quality of the Nile water, which accounts for the majority of Egypt's water availability, has been severely impacted by pollution including industrial wastewater, agricultural drainage and sewage discharge (EEAA, 2018). Circular economy practices have been recognized as not only necessary for the achievement of climate neutrality by 2050 and the decoupling of economic growth from resource use, but also as a vehicle for job-creation, innovation and increasing competitiveness (European Commission, 2020; European Parliament, 2021).

The manufacturing sector is a key contributor to Egypt's environmental degradation and resource consumption. Only half of the total wastewater produced in Egypt is treated, and 0.7% is formally reused for irrigation (Abdel Wahaab, 2014). Industrial water use reached 5.4 billion cubic meters/year in 2017 (Ministry of State for Environment Affairs [MSEA], 2017). Consequently, the majority of untreated industrial wastewater is transferred to waterways or public sewage networks where it poses environmental and health risks, and its potential for reuse is limited. Manufacturing is one of the fastest growing sources of Egypt's CO_2 emissions, contributing 9.7% of Egypt's CO_2 emissions in 2016, where manufacturing and construction also represented 20% of the energy sector's CO_2 emissions contribution (Enterprise, 2020e). While recent data regarding Egypt's solid waste generation and its composition is lacking, data from 2012 reveals that Egypt generated 89 million tons of solid waste, 6 million tons of which was non-hazardous industrial waste, and figures for hazardous industrial waste vary from 260,000 to 500,000 tons (SWEEP-NET, 2014).

The cement, plastics and packaging and textile manufacturing sectors are among the industries that have a significant environmental footprint. Egypt's cement sector is a high energy-consuming and polluting sector, it accounts for 17.17% of industrial energy consumption (Ministry of Electricity and Renewable Energy [MoERE], 2018a) and 51% of greenhouse gas (GHG) emissions from Egypt's industrial processes and product use (IPPU) sector in 2015 (EEAA, 2018). The textiles and apparel sector is highly water-intensive; the usage of chemicals such as bleaches and dyes requires large amounts of water estimated to be at a rate of 200 L/kg of product (EEAA, 2003) and the sector contributes the heaviest organic load of industrial wastewater, at almost 52% (Malato et al., 2011). Egypt is the biggest plastic polluter of the Mediterranean, with 250,000 tons of plastic from Egypt leaking into the sea a year, and in the Arab world, producing 5.4 million tons of plastic waste a year (World Wildlife Fund, 2019; Noureldin, 2020). Plastics account for 13% of Egypt's waste composition (SWEEP-NET, 2014). Current recycling rates for plastics are low, at around 11% of total plastic waste (Mahmoud et al., 2020). Therefore, these sectors have been singled out for their unique and considerable environmental impacts and their alignment to the global circularity focus on industrial sectors.

Despite the institutional commitment in Egypt to sustainable and inclusive growth in various national strategies, including Vision 2030 and the Industrial Trade and Development Strategy 2016-2020, existing resource efficiency initiatives appear to be largely donor-reliant and discontinuous. While many of these initiatives focus on building the technical capabilities of enterprises in respective sectors, they are insufficient to tackle the institutional barriers to circular economy practices, including the weak enforcement of environmental legislation, inadequacy of existing strategies and regulations to embed circular economy concepts, and financial instruments, as well as an absence of coordination and overlapping responsibilities between the multiple governmental entities involved in cross-cutting measures such as wastewater treatment, solid waste management, and energy efficiency. Circularity policies therefore need to be in place to strengthen the respective institutional frameworks of these cross-cutting measures to support circular economy practices, as well as to target sector-specific challenges preventing the expansion of circular economy practices, such as in the cement, plastics and textiles manufacturing sectors. This paper aims to provide background on the environmental impacts and green opportunities in the cement, plastics and packaging and textiles manufacturing sectors, as well as an overview of current and historical policies, strategies and initiatives aimed at fostering inclusive, sustainable growth and encouraging resource efficiency practices in Egypt's industry. It will then describe the main barriers to adopt circular economy practices as relating to said cross-cutting measures and sector-specific challenges. The final section of the paper will provide an overview of the policy areas that need to be amended based on a survey of the existing literature.

2. Background

Circular economy practices have been globally recognized as both necessary for the achievement of climate neutrality and highly beneficial for growth and employment. In the case of the EU, it is estimated that circular economy practices have the potential to increase EU GDP by almost 0.5% by 2030, and have a net employment increase of around 700,000 new jobs (Cambridge Econometrics et al., 2018). Accordingly, strategies to support the transition to a circular economy have been developed at city, national and regional levels. To foster sustainable and inclusive growth, the European Commission adopted a Circular Economy Action Plan (CEAP) in 2015. This plan covers both legislative and non-legislative initiatives, targeting key product value chains including packaging, plastics and textiles; waste prevention and recycling; and product sustainability (European Commission, 2020). Indicators suggest that the CEAP has had a positive impact on the EU economy, with repair, reuse and recycling activities generating almost EUR155 billion in value-added in 2017. Furthermore, the EU experienced a 6% increase in jobs in the recycling sector, repair and reuse sector, and rental and leasing sector between 2012 and 2016 (Ellen MacArthur Foundation, 2020a).

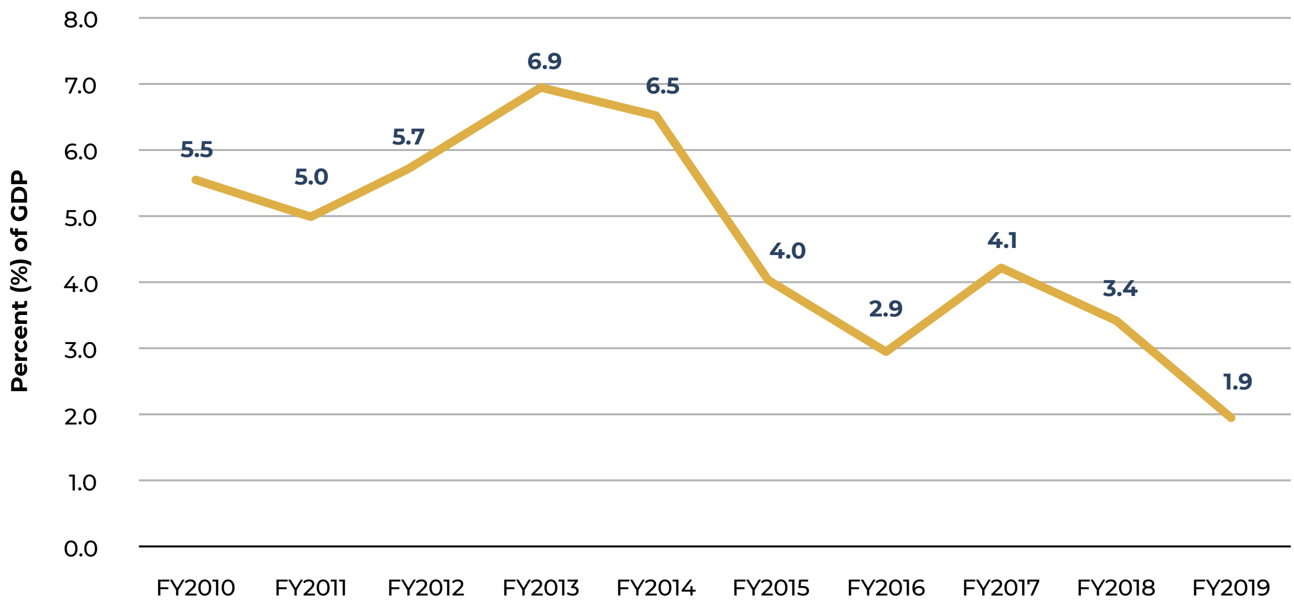
Similarly, the resource-poor Republic of Korea has taken actions to transition to a circular economy to achieve greater resource security and sustainability, enacting legislation and policies including the Framework Act on Resource Circulation (FARC), the Master Plan on Resource Circulation 2019-2027 and the Master Plan on Resource Development 2020-2029. FARC and the Master Plans focus on resource efficiency; circular use of waste such as waste-to-energy; product sustainability; renewable energy and recycling raw materials (Lee & Cha, 2021). Likewise, the Western Cape government in South Africa launched an Industrial Symbiosis Program (WISP) in 2013 to create mutually beneficial links between companies, allowing them to realize the benefits of using unused or residual resources. This program has managed to divert more than 104,900 tons of waste from landfills, generate over USD8.5 million and create 218 jobs (Ellen MacArthur Foundation, 2020b). In the Southern Mediterranean, the SwitchMed Initiative, funded by the EU and implemented by UNIDO and the United Nations Environment Programme (UNEP), has implemented policy pilots in eight countries including Egypt. By providing direct support to the private sector and supporting the development of policy frameworks, SwitchMed has generated savings of EUR41.7 million in annual production costs, and savings of 197,525 tons in CO_2 emissions (SwitchMed, n.d.).

2.1. Egypt's environmental profile

Circular economy practices represent an important pathway to curb environmental degradation in the face of rapid population growth and high consumption patterns. Egypt was listed as one of the six largest "Grow Countries" by the 2021 Circularity Gap Report, along with China, Indonesia, Brazil, Mexico and Vietnam; Grow Countries are manufacturing hubs, claiming 47% of global emissions and 51% of global resource extraction, and should consequently prioritize the following: sustainable agriculture; "mainstreaming resource-efficient and low-carbon construction materials"; switching to renewable energy where possible; and "establishing infrastructure for effective material cycling, including construction and demolition waste" (Circle Economy, 2021, p. 48).

While Egypt had previously been able to meet energy needs through local production, Egypt's per capita primary energy consumption grew by 32% from 1990 to 2014, encouraged by energy subsidies, exceeding local energy production and resulting in shortages of electricity from 2012 (EEAA, 2018). In response, the government reduced natural gas supplies to energy-intensive sectors, including the cement sector (by 50%), introduced measures to eliminate energy subsidies (see Figure 1) and diversify the energy mix (EEAA, 2018). This includes the development of the Benban Solar Park, a complex of 41 solar power plants and currently the fourth largest solar power plant in the world (World Bank, 2020).

Figure 1
Egypt's Energy Subsidies, FY2010/11 - FY2019/2020

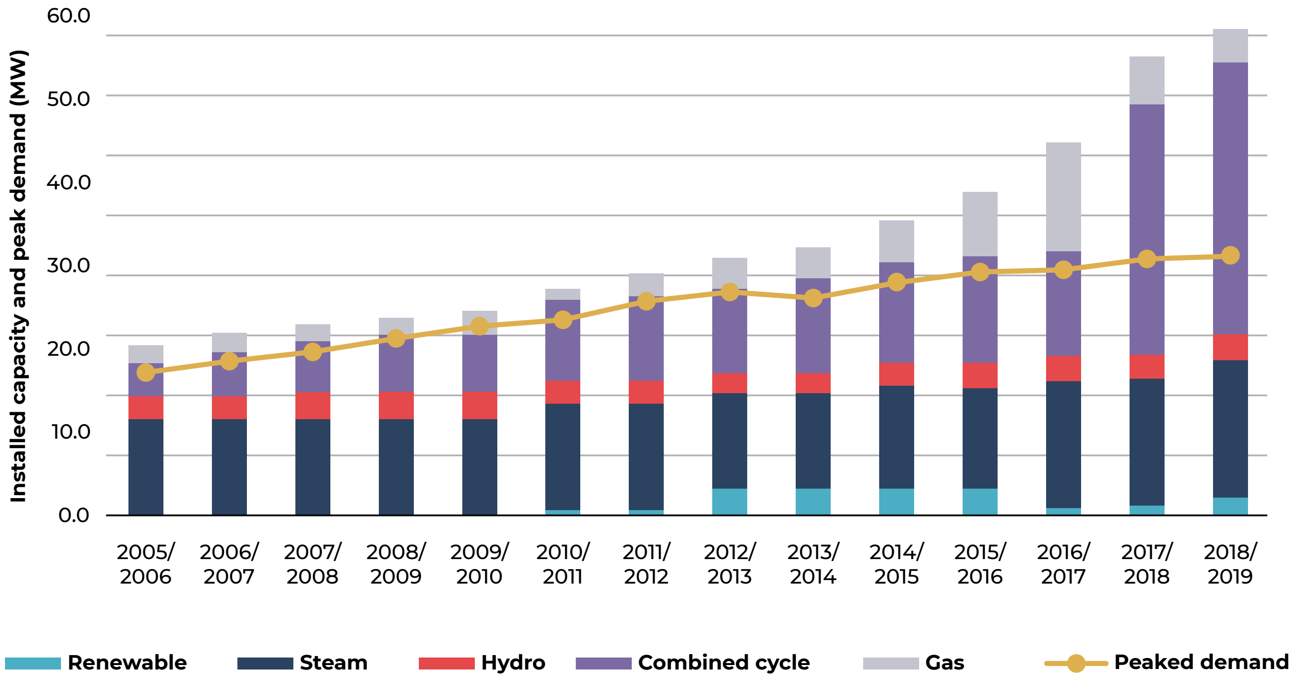


Source: World Bank, 2020

Additionally, investments in new plants increased installed capacity to 58.3 GW in FY2018/19 (MoERE, 2019), exceeding peak demand of 31.4 GW (see Figure 2). In FY2018/19, 3.1% of installed capacity was renewable (wind and solar), compared to 2.1% in FY2017/18 (MoERE, 2019, 2018b). Resource efficiency forms a core objective of strategies including Vision 2030, the Integrated Sustainable Energy Strategy (ISES 2035) and the National Energy Efficiency Action Plan 2018-2022 (NEEAP II), discussed in section 3.

Figure 2

Installed Capacity/Peak Load in Egypt, FY2005/6 - FY2018/9



Source: Hasan et al., 2020

Egypt's environmental profile reveals increasing energy consumption and GHG emissions, the risk of water scarcity, alongside the risks to human health and the environment posed by air pollution and inefficient waste management. Egypt's GHG emissions have increased by 31% from 2005 to 2015 at an average annual growth rate of 2.35%. Notably, GHG emissions from the energy, IPPU and waste sectors have increased by 40%, 49% and 34% respectively over this time period. Data regarding Egypt's CO_2 emissions in 2015 demonstrates that the energy sector is the biggest contributor to GHG emissions (64.5%), (of which 23% related to manufacturing and construction), followed by the agriculture, forestry and other land use (AFOLU) sector (14.9%), IPPU (12.5%) and waste (8.1%) (EEAA, 2018).

Furthermore, the human cost of ambient air pollution, mainly caused by open burning of waste, motor vehicles and industry, in Egypt is substantially high: despite experiencing a substantial decline in exposure to $PM_{2.5}$, Egypt ranked first in $PM_{2.5}$-attributable deaths in the Arab world, and second in Africa, at 91,000 deaths in 2019 (Health Effects Institute, 2020). A World Bank study found that the cost of ambient air pollution per million people in Greater Cairo alone (at EGP2.7 billion) exceeds the nationwide cost per million people of inadequate water, sanitation and hygiene by almost seven times (Larsen, 2019).

In 2012 Egypt generated 89 million tons of solid waste, which included 21 million tons of municipal solid waste (MSW), 30 million tons of agricultural waste and six million tons of non-hazardous industrial waste. It is unclear how much hazardous industrial waste is produced, as estimated figures range between 260,000 to 500,000 tons (SWEEP-NET, 2014). MSW is often mixed with industrial wastes and it is estimated that only 60% of waste is collected and more than 80% of collected waste is left in random, open-air dumpsites, with only 2.5% recycled (SWEEP-NET, 2014; MSEA et al., 2017). The informal waste collectors (Zabbaleen), who separate waste and collect recyclables, are exposed to toxic gases resulting from the decomposition of organic waste and have been known to contract hepatitis C from discarded needles (Badr, 2017). Egypt's limited water resources and increasing demand for water from agriculture, industry and domestic consumption, increase the risk of water scarcity. Industrial water use increased from 1.2 billion cubic meters/year in 2012 to 5.4 billion in

2017 (MSEA, 2017, Food and Agriculture Organization [FAO], 2017). While the global average for water-use efficiency[1] was a little over USD15/m³ in 2018, (FAO, 2018), Egypt's water-use efficiency stood at USD4.58/m³ in 2018[2] (UN Water, n.d.). Egypt already suffers from a deficit of 30 million m³ (Kandil, 2021), and is below the water scarcity threshold (1000m³), as the annual per capita water share stands at 570m³ (Egypt Today, 2021b). The UN predicts Egypt will be approaching a state of "absolute water crisis" by 2025 (Ezz & Arafat, 2015). Egypt produces approximately 7.6 billion m³ of wastewater a year, of which half is treated, and only 0.7 billion is formally reused in irrigation (Abdel Wahaab, 2014).

The majority of untreated industrial wastewater is transferred to waterways or public sewage networks. Despite the stipulation in Decree 44/2000 that "discharges of industrial wastewater [...] into public or private wastewater treatment systems should meet the pretreatment (sic) and monitoring requirements of the sewer treatment system into which it discharges" (EcoConServ, 2016, p. 24), a study found that 50% of industries in Egypt violate the law and discharge their effluents into the public network pre-treatment (Monayeri et al., 2011). Consequently, industrial wastewater only contributed 1% of total direct drainage to the Nile in 2017, from 11 establishments, seven of which were sugar production facilities (MSEA, 2017). However, the Nile does suffer from indirect industrial wastewater through the transfer to agricultural drains, such as its Rosetta branch. Other sinks of agricultural drains include the Northern Lakes, Lake Qaroun and Wadi-al Rayan (Rady & Omar, 2018).

Untreated wastewater poses environmental and health risks due to the high levels of organic, heavy metals, corrosive toxic or microbial loaded matter. This includes threatening contaminating drinking water supplies, disrupting the biological processeduring treatment, destruction of agriculture (e.g. contamination of soil, crops and groundwater) and local aquatic life (Monayeri et al., 2011; Abdel-Shafy & Kamel, 2016); industrial and agricultural wastewater are the primary source of metal poisoning to fish in Egypt (Bayomy et al., 2015). Furthermore, only 40% of treated wastewater undergoes secondary treatment, consequently, the quality of treated wastewater is questionable, limiting its potential for irrigation use (Soulie, 2013). While the EEAA has started several education programs to improve compliance, these efforts have been described as "minor and insufficient" (Malato et al., 2011, p. 9).

3. Governing Framework and Recent Policies

Multiple governmental entities play a role in supporting a green transition in Egypt's industry, often overseeing multiple aspects of cleaner production. These are outlined here.

1. The **Ministry of Trade and Industry (MoTI)** is responsible for setting industry and trade policies; preparing industrial plans; attracting investments for industrial projects; overseeing standardization, inspection and accreditation authorities (UNIDO, 2015); its mission is to "provide an adequate environment for sustainable inclusive economy" (MoTI, n.d.-c).

2. The **Ministry of Planning and Economic Development (MoPED)** leads the development and implementation of Egypt Vision 2030 in coordination with ministries, stakeholders and development partners. Its mandate also includes monitoring the implementation of the UN Sustainable Development Strategy and ensuring consistency between the implementation of the national strategic vision and regional development plans (MoPED, n.d.).

3. The **Egyptian Environmental Affairs Agency (EEAA)** is the executive arm of the MSEA. Its responsibilities include drafting environmental laws; establishing criteria and conditions, such as permissible pollutant levels, "which owners of projects and establishments must observe before the start of construction

1 Water-use efficiency is defined as "the ratio of dollar value added to the volume of water used" (UN Water, n.d.).
2 Last available data.

and during the operation of these projects" (EEAA, n.d.-b); ensuring compliance of said criteria and conditions; implementing projects to protect the environment from pollution, such as the Egyptian Pollution Abatement Program (detailed below); proposing economic measures to incentivize better environmental practices; and planning environmental training (EEAA, n.d.-b; Elshishini, 2015). As mentioned earlier, attached to the EEAA is the NNIEM, established in 1998, which monitors emissions to ensure compliance with pollutant limits through its electronic network (EEAA, n.d.-a). As of December 2020, it is linked to the self-monitoring systems of 76 industrial entities operating in cement, fertilizer, petrochemicals, iron and steel plants, among others (Hashem, 2020; Hassan, 2017). According to the EEAA, the NNIEM is linked to all cement plants operating in Egypt (EEAA, n.d.-a).

4. The **Egyptian National Cleaner Production Center (ENCPC)** "operates through a steering committee chaired by the Minister of Trade and Industry" (International Labour Organization [ILO], 2018). The ENCPC promotes green technologies and innovation and provides technical assistance for Egyptian enterprises in resource efficiency, energy efficiency, industrial waste valorization and renewable energy applications. The ENCPC offers assistance on industrial waste, comprising "assessment of generated waste in terms of quantity and characteristics [...] [and] the identification of the best options for management and handling of waste" (Elshishini, 2015, p. 10).

5. The **Industrial Development Authority (IDA)**, affiliated with the MoTI albeit legally independent, is responsible for managing the industrial sector, implementing industrial policies and development plans, including the support of industrial waste recycling initiatives (Elshishini, 2015; UNIDO, 2015; Riad & Riad, 2018). It is the only body competent with granting necessary licenses and approvals for operating industrial facilities (Riad & Riad, 2018).

6. The **Industrial Control Authority (ICA)**, under the umbrella of the MoTI, conducts inspections for product quality control, and is charged with ensuring "the availability of applications and conditions for environment protection", and can notify the EEAA in case of violations (MoTI, n.d.-a).

7. The **Industrial Modernization Center (IMC)** is mandated to "support industrial targeted enterprises; individually and sectorally, according to the business development plans through comprehensive programs aiming at sustainable growth" (MoTI, n.d.-b) through activities which include "launching initiatives in the different areas of sustainable industrial development through bilateral and multilateral agreements" (UNIDO, 2015, p. 12).

8. The **Egyptian Organization for Standardization and Quality (EOS)** aims at increasing the competitiveness of Egyptian products in international markets by developing product standards to comply with international standards; conducting quality control studies; as well as providing information services and training on all activities regarding standards and quality (UNIDO, 2015; Elshishini, 2015).

9. The **National Climate Change Council (NCCC)**, was formed in 2015 through Prime Minister Decree 1912/2015. The NCCC is chaired by the Minister of Environment, and comprises representatives from various ministries as well as non-governmental representatives. Its mandate includes the development of a comprehensive national strategy for climate change, the organization and implementation of national research efforts on climate change and projects, the vetting of projects submitted to the Green Climate Fund; and proposals of financial annual allocations in the state's general budget for each ministry's climate change efforts (EEAA, 2018; FAO, 2015).

10. The **Environmental Compliance Office (ECO) of the Federation of Egyptian Industries (FEI)** offers loans to help enterprises comply with environmental standards as well as technical support and training for cleaner production (UNIDO, 2015). These loans, given through the ECO's Revolving Fund program, are available only to credit-worthy SMEs with FEI membership in particular sectors, including textiles, ready-

made garments, printing and packaging and chemicals. Such loans are for funding new environmentally compliant industrial equipment, and have a maximum of EGP7 million per enterprise at a 3.5% annual interest rate (ECO-FEI, n.d.).

The main legislation regarding the environment is Law 4/1994, known as the Environmental Law. This established the EEAA as the highest national body for the environment in Egypt and the Environmental Protection Fund to stimulate investment in the environment; the law further called for a system of incentives for environmental protection projects and penalties against those who violate its provisions. It further forbids the handling of hazardous substances and wastes or the construction of facilities to treat these substances without a license and obliges those engaged in their production and circulation with taking the necessary precautions to prevent environmental damage. The law further stipulates that establishments subject to the law must ensure their emissions and leakages of air pollutants do not exceed the maximum level. It is also prohibited to dispose, burn or treat garbage and solid waste except in special sites determined by the law's executive regulations. The law was amended by Law 9/2009, which prohibited the open burning of solid wastes and further increased the penalties for improper disposal of hazardous emissions (Bakry, 2015; SwitchMed, 2015; FAO, 1994, 2009).

Financing instruments for cleaner production appear to be primarily reliant on external donor funding. These instruments include the EEAA's Egyptian Pollution Abatement Program, which comprises two financing initiatives, the Egyptian Pollution Abatement Project (EPAP III, 2017-2020) and the Private Public Sector Industry (PPSI) package. EPAP III is financed by donors including the European Investment Bank (EIB), French Development Agency (AFD) and German Development Bank (KfW), and receives institutional and technical support from EIB, and funding is available for businesses with industrial activities in Greater Cairo and Alexandria. Furthermore, the PPSI package is supported by KfW, and preferential financing is given to small and medium companies (SMEs) with an annual turnover of less than EGP20 million. PPSI is available to private and public companies, excluding multinationals, in Upper and Lower Egypt, excluding Greater Cairo and Alexandria. Projects eligible for finance under both packages include EOP treatment for air emissions and wastewater, hazardous waste management, and energy conservation, among others (EEAA, n.d.-c). Additionally, in 2014, the Green Economy Financing Facility (GEFF), supported by donors including the EBRD, EIB and AFD, was established. The GEFF is a credit line of EUR140 million for green investments in energy efficiency and renewable energy by private enterprises, comprising of low-interest loans of up to USD5 million, free technical assistance and investment grants of 10-15% of the loan value (EBRD, n.d.-b).

In 2020, the EBRD, alongside the EU and Green Climate Fund (GCF), established two new on-lending programs, complemented by EU grants and GCF technical assistance. The first of which is the Green Value Chain program (EUR70 million) for SMEs to invest in "advanced technologies and climate mitigation and adaptation solutions" (Zgheib, 2020); it offers loans of EUR300,000 for small investments in "high-performing equipment" from the EBRD's pre-approved, country-specific directory of products (EBRD, n.d.-a), and loans of EUR1 million for larger-sized projects aimed at financing a "complete technological solution or improvement of processes" (EBRD, 2021). The second program is an EUR150 million extension of the GEFF for green investments in the agricultural, construction, commercial and manufacturing sectors (Zgheib, 2020).

The Cabinet approved the issuance of the Environmental Sustainability Standards Guide in October 2020; this guide was produced under the guidance of the MoPED and the MSEA. These standards will be integrated into the state's plans for sustainable development and will be a factor when allocating budgets for projects; priority will be granted to projects that meet these standards, according to Minister of Planning Hala Al-Said, who further stated that the FY2020/21 budget contained 691 green projects at an estimated cost of EGP447.3 billion (Bakr, 2020). As outlined in the guide, the strategic goals which are prioritized are the reduction of industrial pollution; encouraging the manufacture of environmentally friendly products and cleaner production technology; rationalizing the consumption of raw materials and improving resource efficiency; and improving the quality, competitiveness and productivity of industrial products by ensuring their compliance with industrial and environmental standards. The guide further states that certain projects and initiatives will be prioritized with regard to funding, these include green industrial complexes and cities; production of renewable energy and energy-efficient equipment; low-carbon manufacturing technology; equipment for desalination plants; capacity-building for green technological jobs; and limiting the manufacture and use of single plastic bags (MoPED & MSEA, 2021).

3.1. Industrial waste management

In addition to the provisions outlined in the Environmental Law as amended by Law 9/2009, Law 38/1967 as amended by the Law 31/1976 is the main law relating to solid waste management and regulates the collection and disposal of solid wastes from residential areas as well as commercial and industrial establishments (ElShishini, 2015). Furthermore, in October 2020, the new Waste Management Law 202/2020 was ratified, which established the Waste Management Regulatory Authority (WMRA). The WMRA replaces the Waste Management Authority (WMA) established under the Prime Ministerial Decree 3005/2015. Its mandate includes regulating, monitoring and evaluating waste activities; developing investment opportunities; issuing necessary licenses and permits; as well as developing a national strategy to improve waste management and recycling (Lynx, 2020).

The new Waste Management Law introduces key reforms including a ban on open-air waste incineration; limitations on the manufacture and distribution of single-use plastics; the establishment of a sanitation fund in each governorate for municipal waste collection; the introduction of a 'Green Label' certification to encourage the use of recyclables and minimization of waste; and further obliges those involved in industrial activity to keep a periodically updated industrial waste register. In order to encourage investment in waste collection, treatment and disposal, the law also extends eligibility for the tax breaks and incentives under Investment Law 72/2017 to any company whose primary business is waste management. The law also stipulates that a system of economic incentives, including tax and customs exemptions, will be developed to promote the production and import of environmentally friendly alternatives to single-use plastic bags (Shalakany, 2020). The executive regulations are yet to be issued.

The WMRA is supported by the National Solid Waste Management Program (NSWMP) which was initially established in 2012 under the MSEA. The NSWMP is co-financed by the MSEA (30%), the EU, German Federal Ministry for Economic Cooperation and Development and Swiss Secretariat for Economic Affairs (international institutions accounting for 70% of funding), with a total fund of EUR71.9 million. Covering four governorates – Qena, Assuit, Kafr El Sheikh and Gharbia – it aims at building the institutional and legislative frameworks for waste management as well as providing technical support and financial incentives to the private sector (NSWMP, n.d.).

Further developments in reusing industrial waste include waste-to-energy plans. Officials from the MoERE have revealed that the government is planning to generate 300 MW of electricity from waste by 2025, using 4.2 Mt of solid waste, however, maximum capacity currently stands at 13 MW (Salem, 2020). Prime Minister Decree 41/2019 approved the feed-in tariff for electricity generated from waste-to-energy plants using MSW and extracted biogas from landfills at a value of 140 piasters per kilowatt; the feed-in tariff is the responsibility of the WMRA and the Egyptian Electric Utility & Consumer Protection Regulatory Agency (EgyptERA) (WMRA, 2019). According to the Minister of Environment, 93 companies applied for tender, and eight were selected to develop waste-to-energy plants in eight governorates with investments of USD385 million (Egypt Today, 2021a).

3.2. Wastewater

Legislation regarding wastewater discharge and treatment includes the aforementioned Decree 44/2000 regarding quality standards for discharge into public sewer networks, as well as:

- Law 93/1962 and its executive regulations in Decree 649/1962, for discharge of wastewaters, which prohibits liquid industrial waste disposal in public sewers without a license.

- Law 48/1982 and its executive regulations outlined in Decree 8/1983, (modified by Decree 9/1989) which controls discharges into the Nile, canals, drains and groundwater through licensing. Licenses are granted by the Ministry of Water Resources and Irrigation, which is also empowered with administrative and policing means for its enforcement.

The Holding Company of Water and Wastewater (HCWW), established by Presidential Decree 135/2004, is the primary entity responsible for water and sanitation infrastructure in Egypt (Drechsel & Hanjra, 2018; Abdallah, 2014). While the HCWW and its affiliated companies are responsible for the operation of wastewater treatment plants, multiple entities are involved in water management (see Appendix 1).

As of May 2021, parliament has approved the new Water Resources bill, which awaits final approval (Ali, 2021). This bill prioritizes water resource efficiency and quality and is said to include provisions which define the roles of all the relevant entities involved; update water standards; and introduce mechanisms for private sector involvement in drainage system management (Enterprise, 2020a). Egypt has also invested more money to building capacity for wastewater treatment, including what will be the largest wastewater treatment plant in the world in Bahr Al-Baqar, and 52 wastewater treatment plants are being developed in Upper Egypt, which will have a combined capacity of 418 million cubic meters a year (Egypt Today, 2019, 2020).

3.3. Energy efficiency

Egypt's legal framework for energy efficiency is sparse. Law 87/2015, the Electricity Law, includes a chapter on energy efficiency, with stipulations including that enterprises with a capacity of 500 kW or more are required to keep an energy efficiency register and appoint an energy efficiency manager and that the government will implement energy efficiency improvement projects for industrial buildings. Furthermore, the Executive Regulations of the Electricity Law detail the qualification requirements for the aforementioned managerial role and the requirements of the energy register and its monitoring (MoERE, 2018a; ILO, 2018). The NEEAP II is the national strategy for energy efficiency, cross-cutting several sectors and outlining the proposed energy efficiency procedures in industry, including the use of low-carbon technologies, solar power for heating processes and use of highly efficient electric motors (MoERE, 2018a). In line with the latter proposal, in October 2020, the Minister of Trade and Industry issued Decree 463/2020, regarding the energy performance standards of electric motors. This Decree obliges producers and importers of electric motors to ensure such engines are in accordance with Egyptian Standard No. 2623-3/2017, and further stipulates that such engines must be subject to energy efficiency testing or accompanied by an approved certificate to ensure their accordance with Egyptian standard specifications No.M.M.M. 2623-1-2015. Additionally, Decree 474/2020 grants producers and importers a period of six months from the date of issuance to meet their obligations to install a special dashboard for each engine in a visible place which displays data required by Egyptian Standard No.8268-1/2019 (MoTI, 2020).

Multiple entities are involved in energy efficiency (see Appendix 2). The MoERE, in addition to overseeing and regulating the generation, transmission and distribution of electricity, hosts the Regional Center for Renewable Energy and Energy Efficiency (RCREEE), an intergovernmental organization leading renewable energy and energy efficiency initiatives, including funding (see below) and capacity building (ILO, 2018). Additionally, the Energy Efficiency Unit (EEU) established under the Cabinet is responsible for coordinating and streamlining national energy efficiency efforts and also provides technical support to the SEC (Deutsche Gesellschaft für Internationale Zusammenarbeit [GIZ], 2016; UNIDO, 2015).

Energy efficiency initiatives in Egypt's industrial sector appear intermittent and primarily dependent on donor support. This includes the Global Environment Fund (GEF)/UNDP project "Improving Energy Efficiency of Lighting & Building Appliances" from 2010 to 2019, which consisted of a number of pilot projects in which traditional lighting systems were replaced with more energy-efficient lighting including LEDs (RCREEE, 2017). Additionally, the Industrial Energy Efficiency Project (IEE), established by MSEA with UNIDO support from 2013 to 2018, aimed at energy savings of 1277 GWh/year and GHG emission reductions of 2.9 Mt/year. The IEE aimed to improve industrial energy efficiency through developing a national energy management standard, energy efficiency services, as well as improving access to finance, local capacity and awareness of energy efficiency services. While the project met or nearly met its respective direct targets, such as energy savings of 1246 GWh/year, the sustainability of the project's immediate benefits was evaluated as "moderately unlikely", as despite the establishment of a sector unit within MoTI as advised, the unit was described as "understaffed and has been given a wide-ranging portfolio of policy responsibilities" (UNIDO, 2018b, p. 48).

In addition to the donor-funded credit facilities outlined in the beginning of section 4, energy efficiency is promoted through exemptions from custom duties for energy efficient equipment (MeetMED, 2019). Despite the completion of UNIDO's IEE project, the Industrial Energy Efficiency Fund (IEEF) serves as a continuation of the project, as is managed by RCREEE. This financial instrument was launched from 2018 to January 2021, and supported the delivery of technical services (i.e. identifying energy consumption, related costs, low/no-cost energy saving measures, and developing an action plan) to industrial enterprises (Atef, 2019).

4. Circularity and Manufacturing

Egypt has expressed a commitment to sustainable, inclusive growth and greener economic practices in its Sustainable Development Strategy known as 'Vision 2030', the first pillar of which is economic development, with the goal that by 2030, the Egyptian economy is "characterized by a stable macroeconomic environment, capable of achieving sustainable inclusive growth" (Government of Egypt [GoE], 2014, p. 12). The vision for the energy sector describes "an energy sector meeting national sustainable development requirements [...] maximizing the efficient use of various traditional and renewable resources contributing to economic growth, competitiveness, achieving social justice, and preserving the environment" (GoE, 2014, p. 12).

Likewise, the vision for the environment is one that is "integrated in all economic sectors to preserve natural resources and support their efficient use and investment, while ensuring next generations' rights" as well as "clean, safe and healthy [...] leading to diversified production resources and economic activities, supporting competitiveness, providing new jobs, eliminating poverty and achieving social justice" (GoE, 2014, p. 14). Accordingly, the environmental targets include that, by 2030, the percentage of municipal waste regularly collected and managed is 80% with a collection efficiency of 90%, and that the percentage of loss in water treatment plans is less than 10% by 2030.

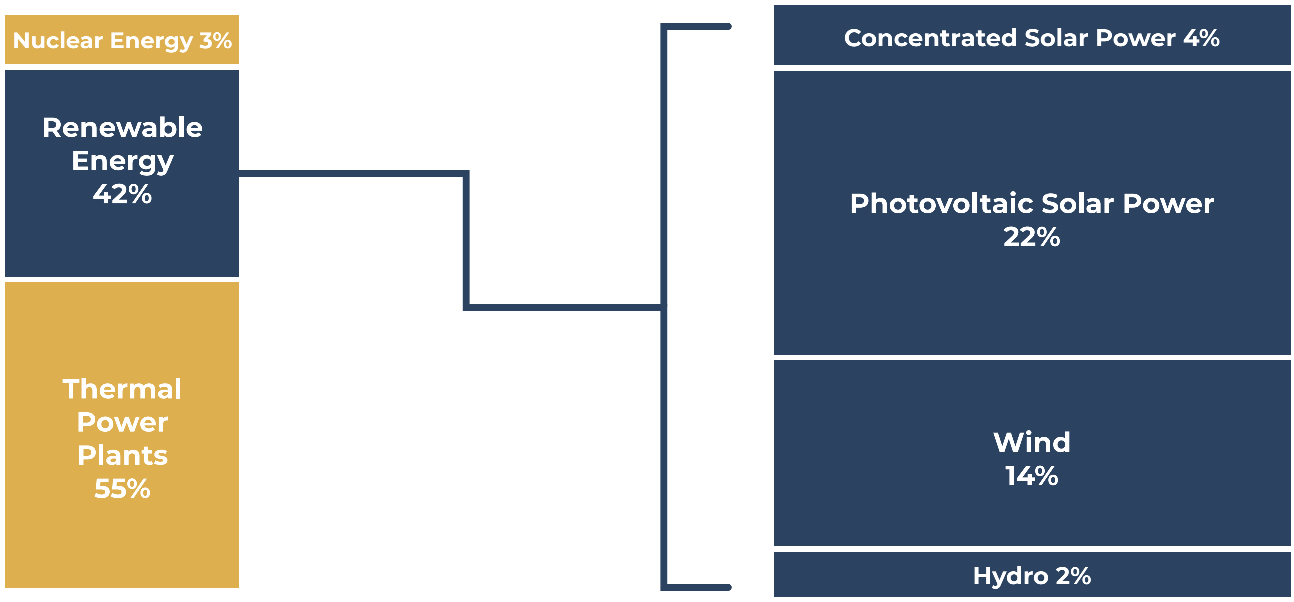
Similarly, Ministry of Trade and Industry's (MoTI) Industrial Trade and Development Strategy 2016-2020 expresses the vision that:

> Industrial development [is] to be the engine of sustainable and inclusive economic development in Egypt, which meet domestic demand and enhance exports growth, for Egypt to become a key player in the global economy and capable of adjusting to international developments (MoTI, 2016, p. 15).

For cement, this consists of "specialized technical services for energy saving" with the expressed goals of reducing costs, enabling compliance to international standards, improving export competitiveness and encouraging use of alternative energy sources (MoTI, 2016, p. 65). The strategy's goals for textiles manufacturing include increased production efficiency, reduction of resource waste, increased added value and increased exports. Plastics and packaging are also recognized as a "rapid growth industry" which can "provide required job opportunities and realize economic, social, and environmental goals" (MoTI, 2016, p. 37).

The Integrated Sustainable Energy Strategy up to 2035 (known as ISES 2035), approved by the Cabinet in 2016, details a commitment to producing 20% of Egypt's energy from renewables by 2022, and 42% by 2035, as detailed in Figure (3). This energy mix is expected to include 16% coal (International Renewable Energy Agency [IRENA], 2018).

Figure 3
Electricity Production Targets for 2035



Source: New and Renewable Energy Authority, n.d.

The ISES 2035 also aims to reduce 18% of overall energy demand by 2035 through improved energy efficiency, particularly in buildings, transport and industry, with expected combined savings of 20 Mtoe (Hasan et al., 2020). ISES 2035 consists of four pillars: securing the energy supply; ensuring the energy sector's sustainability; developing institutional and corporate governance; and enhancing competitive energy markets and regulation (MoERE, 2018a). In October 2018, the second National Energy Efficiency Action Plan 2018-2022 (NEEAP II) was approved by the Supreme Energy Council (SEC). The NEEAP II aims at improving the institutional framework and optimizing financial support for energy efficiency (MoERE, 2018a).

4.1. Background on manufacturing sector

4.1.1 Cement

Egypt's cement sector contributes nearly 1% of GDP, and 10% of GNP, and employs around 50,000 direct workers and 200,000 indirect workers (Lafarge Egypt, 2021; Cement Industry Division, 2019). The cement sector has been suffering from a fall in demand and oversupply, made worse by the establishment of a military-owned cement plant in 2018; the six-month ban on construction until November 2020; and the ongoing COVID-19 pandemic. When running at full capacity, the military's cement plant in Beni Suef holds a 26% market share; the plant has added 13 Mta of capacity; thus current overcapacity now amounts to 33 Mta (Enterprise, 2020b; Cemnet, 2020).

The fall in net cement prices, pressured by the oversupply and pandemic, has resulted in losses for multiple companies; only two of seven cement companies listed on the local stock market made a profit in 2019 (Mounir, 2020; Reuters, 2020). Lafarge Egypt's CEO Solomon Baumgartner Aviles has warned that five or six companies may be forced to shut down if the oversupply crisis is not mitigated (Mounir, 2020). Moreover, Baumgartner Aviles suggested that environmental solutions “based on emissions rates can also salvage the industry” (Lafarge Egypt, 2021, p. 3). While the government has responded by lowering natural gas prices for the cement industry from USD6/mmbtu to USD4.5/mmbtu and reducing the electricity tariff by EGP0.10/KWh, Pharos (2020a) reports that this will not prevent losses, suggesting that the government should set volume quotas to help raise prices (2020b). On July 5th, 2021, the Egyptian Competition Authority (ECA) approved a request by cement producers to reduce production by 10.69%, with additional cuts of 2.81% for each production line and further cuts dependent on the company's age; these quotas came into force on July 15th, 2021 and will be in place for one year to help curb the oversupply (Werr, 2021).

Cement production is a capital-intensive, energy-consuming sector with a large environmental footprint, accounting for 51% of CO_2 emissions from Egypt's IPPU sector in 2015 (EEAA, 2018), and 17.17% of total energy consumption in Egypt's industry sector (MoERE, 2018a), with a total thermal energy consumption estimated at 245,927,985 GJ/year (UNIDO, 2014). The cost of energy represents between 50 to 70% of total production costs in Egypt's cement sector (Cement Industry Division, n.d.-a). Natural gas shortages and the removal of fuel subsidies resulted in the switch to cheaper coal for cement manufacturing, approved by the Government in 2014. Furthermore, locally produced petroleum coke (petcoke), a by-product of the petroleum sector, is used as another cheap alternative fuel in some cement plants (International Finance Corporation [IFC], 2016). Coal is rare in Egypt with only one mine – El Maghara in the Sinai Peninsula, of low heat quality (Abdallah & El-Shennawy, 2020). Consequently, Egypt relies on imported thermal coal; imports reached 6.32 Mt in 2019, rising by 31% against the previous year, and spiked by 174% in 2018 (4.81 million Mt) against 2017 figures (1.75 million Mt) (Matthews & Flint, 2020).

Both the combustion process of coal and petcoke produce more CO_2 per unit of energy and per ton than natural gas. Coal has an emission factor almost double that of natural gas (El Safty & Siha, 2013), and petcoke emits between 5% to 10% more CO_2 than coal on per unit of energy (Oil Change International, 2013). Accordingly, Vanderborght et al. (2016) estimate that the transition from natural gas to coal and petcoke will increase CO_2 emissions from cement production by up to 15%, equivalent to about 820 kg CO_2/ton of cement, and at this rate, by 2030, Egypt's cement sector would be within the 2% most CO_2 intensive worldwide.

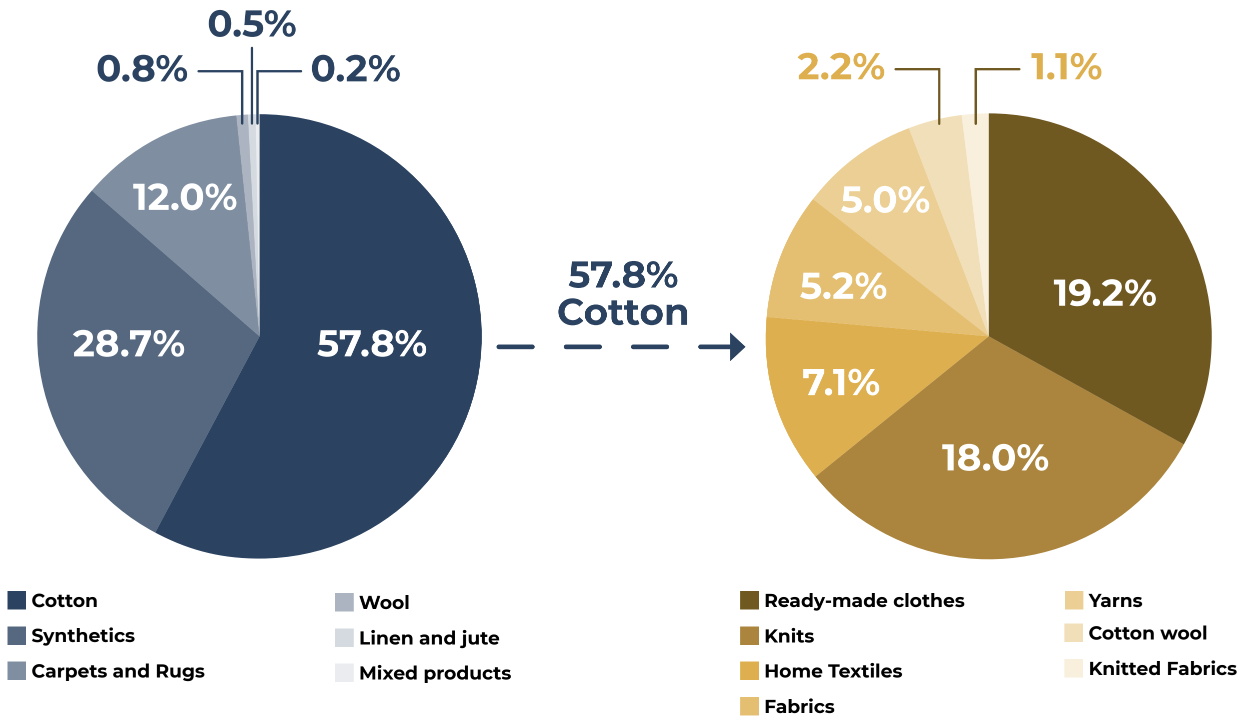
The combustion of coal and petcoke not only contributes to CO_2 emissions, but also produces sulfur dioxide (SO_2), nitrogen oxides (NOx), and particulate matter, contributing to air pollution; the manufacture of cement, lime and plaster accounts for 28.3% of Egypt's air pollution load (Salman, 2017). The aforementioned pollutants pose various challenges to public health and the environment. These include reducing biodiversity, contributing to smog and the acidification of bodies of water, increasing the risks of asthma and cardiovascular diseases and potentially causing chronic obstructive pulmonary disease and lung cancers (Munawer, 2018). Beyond the combustion of fuels, cement dust, produced in the manufacturing process, may cause further respiratory illnesses (Fell et al., 2010; Meo, 2004). It is estimated that 2 to 2.5 million tons of cement dust are discarded and landfilled in Egypt annually (Vanderborght et al., 2016).

4.1.2 Textiles

Textile manufacturing in Egypt is one of the most important sectors in terms of employment and exports. It is one of the top labor-absorbing sectors for both male and female employment (Korashi, 2021), accounting for almost a third of the industrial labor force (Ecorys, 2014). It accounts for 12% of Egypt's overall exports, almost 3% of GDP (Circle Economy & UNIDO, 2020), and is the fifth largest source of foreign earnings (Abdel-Fatah et al., 2019). The textiles and apparel sector is mainly focused on cotton-based products, as shown in Figure (3) (IFC, 2020). Egypt's textile industry has major competitive advantages, including local production of cotton; flexible production lines; and duty-free and quota-free market access to the US and EU (Raza et al., 2020). Egypt is the largest producer of long-staple and extra-long staple cotton fibers (Ecoyrs, 2014); in the market year 2019/20, approximately 67 kT of cotton lint were produced in Egypt, 48kT of which were exported, the remaining used for the local spinning industry. Beyond the export of raw cotton fibre, Egypt produces approximately 105kT of cotton yarns per year, 43% of which is exported. However, most yarns are produced with imported short-staple fibers (Circle Economy & UNIDO, 2020), as production of short-staple fibers is insignificant (Raza et al., 2020). Large imports have led to a negative trade balance, as 80% of raw materials are imported from countries including China and Turkey (IFC, 2020; El-Haddad, 2021). Furthermore, despite the sector's advantages, less than 20% of firms export and exports to the EU have either been stagnating or declining (IFC, 2020).

Figure 4

Textile and Apparel Exports of Egypt, January - June 2020 in EGP Thousands



Source: Data from Textile Consolidation Fund, 2020

In the EU, textiles are the fourth highest-pressure category for the use of primary raw materials and water, after food, housing and transport, and fifth for GHG emissions (European Environment Agency, 2019). In 2015, water consumption of the global textiles and apparel sector reached 79 billion cubic meters, and the sector generated 1715 Mt of CO_2 and 92 Mt of waste (SwitchMed, 2020b). Likewise, the textiles manufacturing industry in Egypt is very water intensive; it is estimated that a reduction of 1% in water consumption across the textile sector would save more than 2.5 million cubic meters of water per year (Abdel-Fatah et al., 2019).

Egypt's textile manufacturing sector (specifically the dyeing process) is also one of the largest producers of wastewater, contributing the heaviest organic load of industrial wastewater, at almost 52% (Malato et al., 2011). Such wastewater contains chemicals from wet processing (the stage at which textiles are treated with various chemicals, including dyes) which are not only toxic, but also low in biodegradability and increase treatment costs by reacting to form inorganic products in biological reactors (Abou-Taleb et al., 2020). These liquid wastes dominate over air emissions and solid wastes as they present a severer environmental impact.

Solid wastes are largely non-hazardous (EEAA, 1999) and there have been pilot initiatives to recycle them to create new fibers, as discussed in section 3.2.2. Furthermore, electricity accounts for 5%–10% of total production costs (Raza et al., 2020). Wet processing is the most energy-intensive stage, as it involves high temperatures, followed by spinning and weaving, both of which consume mainly electrical energy (UNIDO, 2018a).

4.1.3 Plastics

Egypt's plastics and packaging sector is recognized as a "rapid growth industry" (MoTI, 2016, p. 37). The year 2019 witnessed investments in 122 new factories and the sector has achieved a growth rate in exports and production between 16 and 17%, according to the Chairman of the Chemical and Fertilizers Export Council and the Plastic Division of the FEI (ElBalad, 2020). It is also worth noting that the plastics and rubber manufacturing sector experienced a growth rate of net value added of nearly 700% between 2013 and 2018 (Korashi, 2021), and, in the first ten months of 2020, plastic exports were the top exported products from Egypt's chemical and fertilizer industry, accounting for 33% (Business Today Egypt, 2020).

Egypt's plastics manufacturing sector is mainly focused on packaging, both packaging containers and packaging film, which represents 36% of the market – followed by pipes and fittings (24%) – and consumes 38% of total plastic raw materials (ElBalad, 2020; Farag & Korachy, 2017). Local plastics production is mainly derived from petrochemicals; while the local petrochemical sector produces plastic raw materials, it is insufficient. The high plastics raw material consumption of the plastic sector (approximately 2.2Mt/year) exceeds local production (1.1Mt/year), and therefore Egypt relies on imported polymers and additives for the plastics manufacturing (Farag & Korachy, 2017; Mahmoud et al., 2020). Between 2012 and 2016, imports – both of raw materials and finished products – account for 72% of Egypt's plastic consumption. Egypt's plastic demand is expected to continue to grow at an annual growth rate of 10% between 2017 and 2027, which will make Egypt first in Africa in plastic consumption (Farag & Korachy, 2017).

According to a report issued by the Chemical and Fertilizers Export Council, Egypt's volume of plastics consumption reached USD9.35 billion in 2019, at an annual growth rate of 9.7% (ElBalad, 2020). But the growth in Egypt's plastic consumption has a heavy price. Egypt is the biggest source of Mediterranean plastic pollution, with 250,000 tons of plastic leaking into the sea a year, and the biggest polluter in the Arab world, producing 5.4 million tons of plastic waste a year (Noureldin, 2020). Using data from 2010, Jambeck et al. (2015) found that Egypt ranked seventh in the world's top countries contributing to mismanaged plastic waste, accounting for 3.04% of global mismanaged plastic waste, and project that, in 2025, Egypt will still be a top polluting country, ranking ninth, at 2.8%. Egyptian consumption of plastic bags alone reached 12 billion in 2015 (SwitchMed, 2020a). While data from 2014 indicated that plastics accounted for 13% of Egypt's waste composition (SWEEP-NET, 2014), this figure may be higher now. Recycling rates for plastics differ between sources, ranging from around 11% to 30% of total plastic waste; this plastic is recycled mostly at local plastic recycling facilities (Mahmoud et al., 2020; Farag & Korachy, 2017). A third of plastic waste is not collected, and another third is landfilled, where it takes decades to degrade (Mahmoud et al., 2020). Improper disposal of plastic waste can pose a threat to human and animal health, and the environment as a whole (Pinto Da Costa et al., 2020). According to Raza et al. (2020), plastic contamination of water in uncleansed canals is widespread. Furthermore, burning plastic waste releases toxic chemicals which can cause cancer and neurological damage, as well as aggravate respiratory conditions and increase the risk of heart disease (Verma et al., 2016; Farag & Korachy, 2017).

4.2. Developments and opportunities

Circular economic practices such as cleaner production offer great benefits for Egypt's industrial sector, as it will generate savings in the consumption of energy and raw materials, as well as in the cost of waste treatment, in addition to creating a safer work environment for industrial employees. A recent study modelling circular economy practices in Egypt has found that adopting circular economy practices would result in an improvement in Egypt's trade balance, as well as increased investment, consumption and GDP, where by 2030, in the circular economy scenario, the GDP is 1% higher than the baseline scenario (Mahmoud et al., 2020). The study also found that such practices would result in a net increase of 101,000 jobs, the majority of which is concentrated in the agricultural sector, followed by the waste management sector. Furthermore, improving energy efficiency through modernizing technology can also generate increases in operational productivity. With the rapid increase in green consumerism, there is growing demand for environmentally friendly products, including imports. Therefore, circular economic practices in Egypt's export-oriented manufacturing sectors can help give Egyptian products a competitive edge and therefore increase export opportunities.

4.2.1 Cement

A low-carbon roadmap for the Egyptian cement sector was adopted by the MoTI and EEAA in 2016, focusing on four main mechanisms: lowering the clinker content in cement; increasing the use of alternative fuels and raw materials (AFR) substitution; improving energy efficiency; and increasing capacity utilization (Vanderborght et al., 2016; EEAA, 2018). More than half of cement sector emissions are intrinsically linked to the production of clinker, an intermediary product formed in the cement manufacturing process (Lehne & Preston, 2018); high clinker content also contributes to increased specific electric power consumption. Clinker is ground and used as binder in cement; Egypt's 89% clinker content is 15% higher than the world average and within the highest 2% worldwide (Vanderborght et al., 2016). Egypt's mitigation target is to lower the sector average clinker content to 80% by 2030 (EEAA, 2018). Limestone calcined clay cement, known as LC_3, a low-carbon blended cement, has been identified as a potential strategy to achieve this target (Cementis, n.d.).

The combustion of fuel accounts for 40% of emissions in cement plants (Cement Industry Division, n.d.-b). According to the IFC (2016), in 2014, AFR substitution rates across Egypt's cement sector averaged at 6.4%, and the majority of enterprises interviewed demonstrated a willingness to increase their respective substitution rates. The appetite for AFR in Egypt's cement sector is supported by the environmental mitigation requirements of coal operating licenses and the corporate-wide AFR substitution targets, as 64% of installed capacity is managed by multinational conglomerates. The study further revealed that the predominant source of AFR was agricultural waste, accounting for 60%, followed by refuse-derived fuels (RDF) (31%), and tire-derived fuel from scrap tires (9%). The agricultural waste used as AFR is mostly tree trimming residue, as it is available in large volumes all year round and easy to transport, store and prepare, yet agricultural waste is often burned quickly by farmers to prepare land for the next crop. Increasing the AFR substitution rate to 20% could generate annual savings of USD51 million per year, and 3.9 Mt of CO_2 emissions (IFC, 2016). As of 2018, existing projects at various cement plants in Egypt involving partial fuel switching have resulted in estimated emission reductions of 562,325 tCO_2e a year. As part of the low-carbon roadmap, Egypt aims to increase the average AFR substitution rate to 8%, of which 50% will come from biomass and 50% from fossil fuels (EEAA, 2018).

As part of Egypt's second Pollution Abatement Project (EPAP II), implemented from 2006 to 2012, new filters were installed in multiple cement plants for dust collection and filtration, reducing particulate emission levels (EEAA, 2013, n.d.-d). While such filters need regular replacing, and thus constitute a high cost, this should not be an issue as it is standard practice in cement plants globally, and such replacement may be necessitated by corporations' emissions targets (World Bank, 2017). Furthermore, continuous monitoring systems were installed at several cement plants, connected to the EEAA's National Network for Monitoring Industrial Emissions (NNIEM). According to the World Bank (2017), the EEAA's use of these continuous stack monitoring systems "proved very effective in ensuring the continuous availability and reliability of data" regarding emissions quantity and quality from participating sites (p. 3). Such data enables monitoring compliance with emission limits, developing warning systems in case of exceeding said limits and assessing health and environmental impacts on surrounding areas (EEAA, n.d.-a).

A study by UNIDO (2015) estimated the annual potential energy savings of Egypt's cement sector at 38%, using international best available technology (BAT) values. The potential for waste as alternative fuel has been recognized in Egypt, as the Egyptian government encourages the cement sector to increase its usage of RDF to 15% by 2030 (Al-Aees, 2016). The multinational cement company Cemex operates a plant in Assiut, which, in 2010, had a AFR substitution rate of 23%, using mainly agricultural wastes, however, this figure may be higher now (Cemnet, 2010). Cemex produces, manages and transports this agricultural waste, using edges and trimmings of Casuarina trees planted on the Cemex farm (Cemex Egypt, n.d.). In 2019, a waste management platform in Ain El Sokhna was inaugurated, this program promises an annual capacity of 400,000 tons of alternative fuel from agricultural, industrial and municipal wastes, to be used in Lafarge Egypt's cement plant in Ain El Sokhna (Lafarge Egypt, 2019).

4.2.2 Textiles

Egypt's textile sector modernization strategy 'Vision 2025' was developed under the guidance of the Ministry of Trade, with the intention of enhancing the sector's competitiveness to become the leading exporter in the MENA region. It aims to increase exports from USD3.1 billion in 2018 to USD12 billion by 2025. This development strategy includes creating one million jobs, strengthening SMEs, developing human capital, developing 20 million m^2 of textile cities and increasing productivity of Egyptian cotton (Raza et al., 2020). Beyond the Ministry of Trade and its constituent bodies, the

Holding Company for Cotton, Spinning, Weaving and Clothes is responsible for managing Egypt's public sector textile and apparel companies. As part of Vision 2025, a significant reduction in the number of state-owned enterprises is underway through mergers, with its 31 subsidiaries planned to be reduced to 10 (Zawya, 2019). Additionally, in keeping with Vision 2025, in June 2019, the Holding Company initiated a modernization program worth EUR1 billion, supported by the Egyptian government, aiming to upgrade the textile industry to improve its competitiveness.

The valorization of textile waste represents an opportunity to meet the growing global demand for environmentally friendly fibers (Textile Exchange, 2018). Recycling cotton waste as an input for cotton yarns is a nascent development in Egypt's textiles sector and is a pillar of SwitchMed's MED TEST III project in Egypt. As part of MED TEST III, in addition to engaging stakeholders in the valorization of textile waste, UNIDO is collaborating with the ZDHC Foundation until 2023 to develop local capacities and a roadmap for safer chemical compliance (SwitchMed, 2020b). The Egyptian Cotton Project, implemented by UNIDO, represents a viable opportunity of recycling cotton-textile waste to produce, and thus substitute the importation of, short-staple fibre. Within their pilot, which produced a blended cotton yarn composed of both recycled and virgin material, their assessment found that the water consumption, CO_2-eq emissions and energy demand for the regenerated yarn in their scaled scenario were significantly lower than that of virgin cotton yarn. In the scaled scenario, water consumption per kilo of virgin cotton yarn ranges between 8.97 to 21.74 m^3/kg, while the blended cotton yarn achieved a water consumption of 6.65 m^3/kg. Similarly, the blended cotton yarn produced less CO_2-eq emissions (8.22 kg CO_2-eq) compared to virgin cotton yarn (which ranges between 8.57 and 14.82 kg CO_2-eq). The total energy demand in the scaled scenario for the blended cotton yarn requires 123.08 MJ, also lower than the range for virgin cotton yarn (between 129.09 and 204.30 MJ). Additionally, the study found that the production of recycled yarn had a strong business case and would achieve immense savings based on lower costs for energy, labor, and procurement of virgin cotton fibers, achieving an estimated gross profit of EUR4.20 per kg of output (Circle Economy & UNIDO, 2020).

Another possible opportunity to mitigate the textile sector's high import-dependency is the recycling of plastic waste to create manmade fibers, as fibers "including polyester fiber textured and filament yarn, spun yarn, and fabric represent 74 percent of Egypt's imports of manmade fiber products" (IFC, 2020, p. 83). In 2019, polyester fibers had a 52% share in the global fiber production, of which the share of recycled fibers grew from 9% in 2009 to 19% in 2019, the majority of which is made from PET plastic bottles. Key suppliers include the U.S, Italy, China, India and Japan (Textile Exchange, 2020). The production of recycled polyester fibers may also be economically feasible, as recycled polyester fibers require 30% to 50% less energy to produce than virgin polyester and synthetic fibers require fewer chemicals for their production compared to cotton (Manshoven et al., 2021). Furthermore, the average water consumption in textile dyeing and finishing is lower for synthetic fibers, at 10-100 L/kg, than for cotton (50-200 L/kg) or wool (75-200 L/kg) (El-Messiry et al., 2016). The use of plastic waste to produce fuel also represents an opportunity to reduce its accumulation in landfills and reduce resource consumption. Fahim et al. (2021) concluded that the production of fuel from plastic waste via pyrolysis is a feasible opportunity in Egypt and could constitute a sustainable and continuous fuel source, decreasing CO_2 emissions caused by plastic waste by 8% in the first year of application, increasing to 30% after five years, with lower carbon emissions produced than the use of diesel and gasoline (c.f. Handawy et al., 2021).

Investments in improving energy efficiency within the textile sector can generate cost savings. Successful case studies found that low-cost interventions resulted in "significant financial savings and environmental improvements [...] which payback period was almost immediate, including energy conservation and process optimization" (UNIDO, 2018a, p. 22), with one case study reaching a reduction in electricity consumption by 40% (UNIDO, 2018a). Such case studies included savings in steam energy, electricity and water, through means including but not limited to replacing old equipment, adding steam traps and adding efficient lighting systems. Furthermore, Grumiller et al. (2020) note that better cleaner production in textile manufacturing, such as better wastewater management and dyeing practices, including the use of natural dyes, would "open the possibility of certification under various sustainability standards, such as OEKO-TEX®, Better Cotton Initiative, Organic Content Standards (OCS) and Global Organic Textile Standard (GOTS)" (p. 3). Such an embrace of sustainability will improve the competitiveness of Egyptian textile and apparel exports due to the growing demand for sustainable production in the European and American markets (IFC, 2020). While these certificates are not normally required by countries, in general they are required by clients, as they qualify retailers to use green consumer labels (UNIDO, 2018a).

4.2.3 Plastics

Some initiatives aimed at curbing plastic pollution exist, these include the Red Sea Governorate's ban on single-use plastics, and the new Waste Management Law (discussed in section 4), which places limitations on the manufacture and distribution of single-use plastic bags. Furthermore, UNIDO – with support from the Japan International Cooperation Agency (JICA) – is expected to implement a three-year project to support alternative circular economy practices in plastics manufacturing (Magoum, 2021). This project is part of UNIDO's 'Programme for Country Partnership (PCP) for Egypt', launched in February 2020, which aims at achieving sustainable and inclusive industrial development (UNIDO, n.d.). Further support to the plastic sector is offered through the Plastic Technology Center (PTC), based in Alexandria, which provides a variety of services for plastic stakeholders, including plastic and raw material manufacturers and importers. Such services include training, quality testing, technology transfer and technical consultations. Furthermore, the MoTI is establishing industrial clusters for the plastic sector, including the Merghem cluster in Alexandria which will accommodate approximately 120 MSMEs (Farag & Korachy, 2017).

According to the Minister of Environment, the strategy for plastics consists of two axes: recycling plastic bottles and reducing consumption of single-use plastics (Al-Aees, 2020). Consequently, several private-sector initiatives have been launched under the auspices of the MSEA, including Nestlé Egypt's Dorna Initiative, which aims to encourage the collection and recycling of plastic packaging waste. Through its Dorna Initiative, Nestlé Egypt has established a digital platform known as a 'Reverse Credit System' through which waste collectors, intermediate sorters and PET processors can register and record quantities of recycled plastics and receive payment upon reaching their monthly targets (Al-Aees, 2020; Nestlé Middle East, 2020). In collaboration with the Dorna Initiative's Reverse Credit System, PepsiCo Egypt launched its Recycle for Tomorrow platform which aims to recycle 8 million kg of plastic waste in 2021 (Daily News Egypt, 2021). Additionally, to support a circular economy for plastics, in March 2021, the MSEA launched the Egyptian Charter for the Recycling of Plastic Waste, calling on the private sector to sign as an affirmation of their commitment to the Waste Management Law and other regulations and to leadership of public awareness and educational activities (Al-Iraqi, 2021).

Furthermore, a representative from the MSEA announced that the Ministry is working with the Ministry of Finance to develop taxes on the use of plastic bags and incentives for supermarkets to use alternatives, and also announced that the EOS is working on changes to the standards of plastic bag manufacturing, in order to make the bags thicker (Samir, 2021). However, thicker bags use more plastic, and therefore produce more waste (Martinko, 2019), and attempts to switch to thicker plastic bags – with the underlying logic that increased thickness encourages reuse – have not led to decreased plastics usage and are even attributed to an increase in plastics usage in the UK (Clukey, 2019; Laville, 2019).

4.3. Challenges

Throughout this section on sector-specific challenges to cleaner production and challenges in the energy efficiency and waste management frameworks, recurrent themes emerge, most noticeably the weak enforcement and inadequacy of existing environmental legislation, as well as an absence of coordination, and oftentimes leadership, between governmental entities (ILO, 2018). Despite the significant potential for substantial energy and cost savings, institutional, financial and cultural barriers pose challenges for better energy efficiency practices. The cheap price of energy has resulted in weak demand for energy efficiency from the private sector; it is not a priority. Consequently, the private sector suffers from inadequate awareness and capacity for EE and its benefits. Increasing energy costs resulting from the rollback in subsidies may mitigate this risk.

The governance of energy efficiency has also been characterized as suffering from a "lack of integration and synchronization between the different implementing entities" (UNIDO, 2015, p. x) as well as unclear delineation of government stakeholders' responsibilities, and weak enforcement mechanisms and experience in energy efficiency strategy. In a similar vein, the lack of institutional leadership on energy efficiency has been recognized as another obstacle, accordingly, Lihidheb et al. (2020) call for a designated energy efficiency regulatory agency.

Further obstacles to improving industrial energy efficiency include the lack of clear regulations in the IEE domain. Egypt is lacking in sufficient energy efficiency legislation, as it is exclusively addressed in the Electricity Law. Additionally, there is a lack of comprehensive and reliable data to support evidence-based policymaking. Financial barriers to energy efficiency include the cost of modernizing equipment and high financing interest rates, as well as the low capacity for manufacturing and servicing energy-efficient products (UNIDO, 2015; MeetMED, 2019).

The most commonly cited obstacles to good wastewater governance on the national level are the under-capacity of existing wastewater treatment plants; the significant volume of industrial wastewater discharge into water bodies pre-treatment; poor dissemination of information to the public; uncertain quality of distributed water; and the absence of good, clear, priority-driven policies and action plans on wastewater management (Shaalan, 2003; Kampa et al., 2011; Zimmo & Imseih, 2011).

The wide range of actors involved in the planning, investment, operation and maintenance of wastewater treatment "can lead to overlapping jurisdictions between agencies if a perfect coordination is not assured which is always difficult for organizations that are independent from each other" (Soulie, 2013, p. 33). Such overlapping jurisdictions have been cited as a bureaucratic impediment to private sector involvement, with the Head of the Egyptian Federation of Construction Contractors explaining to Enterprise that the overlap "has been a major headache for contractors [...] [who] signed agreements with the regional water distribution companies but it was the HCWW that signed off on the delivery and both companies relied on different specifications" (Enterprise, 2020d). Further impediments to good governance include the absence of a clear delineation of responsibilities and limited coordination between involved entities (Zimmo & Imseih, 2011).

The existing standards regarding treated wastewater reuse (found in Egyptian Code for the Reuse of Treated Wastewater in Agriculture 501/2005) have been described as "strict [...] practically leading to impossible enforcement" (Shaalan, 2003, p. 63), limiting the application of treated wastewater to very few types of crops. With regard to sewage sludge, the residual slurry by-product of wastewater treatment, Rady and Omar (2018) note that "the role of institutional managers and users, as well as their mutual relations, remains unclear." Furthermore, as noted by Kampa et al. (2011), such standards are related to direct reuse, and are thus inapplicable for the common practice of indirect reuse of wastewater via agricultural drains. While laws regulate the standards for discharge into said drains, no restrictions exist for crops irrigated with drainage canal water, and neither are discharge standards by type of activity applied (Rady & Omar, 2018).

With regard to private sector involvement in wastewater treatment, there are no efficient financial incentive programs in place for depolluting industrial discharge (Rady & Omar, 2018; Soulie, 2013). The non-application of the 'polluter pays' principle – which stipulates that those who produce pollution should bear the costs of managing it – is attributed by Soulie (2013) to the limited capacity for inspection, monitoring and enforcement. Furthermore, the generally low price of freshwater enabled by water subsidies has encouraged overconsumption and has made cost recovery via the sale of wastewater unviable (Drechsel & Hanjra, 2018).

4.3.1 Textiles

According to the Textile Consolidation Fund (2020), microenterprises make up 88.8% of textile and apparel enterprises, followed by SMEs (11%) and large enterprises (0.2%). Barriers to cleaner production include the financial cost of investment required for the purchase of expensive, more resource-efficient machinery, given the sector's use of outdated technology (Grumiller et al., 2020, IFC, 2020) and exacerbated by SMEs' limited capacity and lack of adequate finance (Korashi, 2021). Another barrier is the lack of skilled labor and management and the lack of awareness of global trends to help compete internationally, the latter exacerbated by the 40% duty on clothing imports, "which distorts incentives for local firms to compete in global markets" (IFC, 2020, p. 82; Grumiller et al., 2020). The sector has been further disrupted by the COVID-19 pandemic; due to the drop in domestic and foreign demand and disruptions in global supply chains, many textile factories have stopped production or are utilizing less of their productive capacity (Breisinger et al., 2020). Public textile companies experienced losses of EGP2.7 billion due to increasing production costs and debts; as well as a deficit of trained workers; lack of modernization; and financial support, the latter point leading Mary Bishara, Chairman of the Export Council for Ready-Made Garments, to call on the CBE to launch special initiatives to finance the spinning and weaving sector (Maher, 2021).

Recycling post-industrial textile waste includes challenges such as the potential loss of quality that arises from the mechanical recycling process, in which scraps are shredded, which can make fibers shorter and are consequently downcycled into filling materials (Palacios-Mateo et al., 2021). Textile garments are often a blend of various fibers, making separation of fibers very challenging (Rengel, 2017). While some textile firms have their own wastewater treatment plants (Abou-Taleb et al., 2020), there is insufficient information in the public domain to determine how widespread this practice is. Furthermore, Raza et al. (2020) note that limited wastewater treatment remains an obstacle to sustainable practices.

4.3.2 Cement

Some circular economy practices face financial barriers due to their added costs in the cement sector. For example, landfilling cement dust is a cheap method of disposal, while the technology for dust treatment and recycling requires high freshwater consumption: 1 ton of water is required for 1.5 tons of dust, which makes it economically unfeasible and environmentally unwise in Egypt's environment (Vanderborght et al., 2016). There are other possible uses for cement dust, including road base, soil and wastewater stabilization; as a partial replacement for cement in the production of concrete, cement bricks and pavements; and in the production of coloured glass and glass-ceramic products (Stevulova et al., 2021; Khater, 2006; Askar et al., 2010). A recent study into the viability of cement dust in Egypt's pavement roads found that adding between 3 to 5% of cement dust reduced the cost of construction (Awed et al., 2020). However, according to Vanderborght et al. (2016), such applications do not mitigate the energy and CO_2 emission balance, and reusable quantities are small. Furthermore, lowering clinker content can be achieved through partial substitution by other constituents that cause little to no CO_2 emissions, however the availability of such constituents in Egypt is significantly limited, with the exception of limestone, which cannot sufficiently lower the clinker content alone. The production of composite cements such as LC_3 to lower clinker content would require changes to Egypt's construction codes, which currently prohibit certain cements for use in reinforced concrete (Vanderborght et al., 2016).

Waste Heat Recovery (WHR), in which thermal energy is partially recovered and converted to electrical or mechanical energy via a steam boiler and turbine, represents an opportunity for the cement sector. It can provide up to 30% of a cement plant's total electricity needs, and it reduces power consumption and associated costs and helps to mitigate the impact of future energy price increases (IFC, 2014). No WHR power generation systems exist in Egypt's cement sector (IFC, 2016). One estimate for Egypt's WHR potential placed recovery figures between 175 to 300 MW (IFC, 2014). However, given the high investment required to install WHR systems, further research is needed to assess the feasibility of WHR in Egypt (Vanderborght et al., 2016).

Refuse-derived fuels and other forms of AFR need to be competitively priced in order to encourage the transition away from fossil fuels, however, according to the IFC (2016), "several AFR providers had been selling AFR to cement companies on the same pricing scale as that for imported coal and petcoke" (IFC, 2016, p. 97). Coal remains the cheaper alternative, aided by the drop in coal prices; furthermore, coal is considered more cost-efficient, as "it generates twice the thermal energy RDF does" (Enterprise, 2020c). Challenges in using RDF in particular include possible variations in moisture content affecting fuel quality, the complex preparation required to separate elements usable as fuel from those which are not, consequently, RDF requires significant capital and operating costs (IFC, 2016). These challenges are exacerbated by the weak enforcement of waste management legislation, such as the ban on unauthorized landfills; inadequate financial incentives to encourage private sector involvement; low waste collection rates; and the fragmented governance of MSW, which includes overlapping responsibilities between national, governorate and municipal entities and the lack of a nationwide collection infrastructure (Enterprise, 2020c; IFC, 2016). Consequently, Enterprise (2020c) reports that despite the interest in RDF which emerged during the natural gas crisis of 2012, at least a dozen RDF companies have been forced to shut down.

4.3.3 Plastic

The fragmented governance and low collections of MSW also poses a barrier to plastics recycling, which faces further challenges specific to plastic. The majority of Egypt's plastics recycling sector is informal, and MSMEs account for 90% of Egypt's plastics manufacturing and recycling enterprises (Farag & Korachy, 2017), and consequently have limited access to finance, equipment, quality testing and skilled labor (Mahmoud et al., 2020) and consequently produce low-quality products (Gunsilius et al., 2011). Despite cooperation between formal and informal waste collectors – such as plastic recycling startups like BariQ – problems persist, including contaminated plastic PET, further reducing the amount salvageable for the recycling process (MSEA et al., 2017). Furthermore, with regard to the cooperation between formal and informal enterprises, SWEEP-NET (2014, p. 12) reported that "the overall experience and results of private sector involvement were less than adequate". More broadly across Egypt's industry, barriers to recycling include the insufficiency of waste reduction and waste separation at source on a country-wide scale (Mostafa, 2020), and legislation allowing for establishments to use contractors for the transport and disposal of waste, the polluter's responsibility and liability is transferred onto the contractor, making it impossible to enforce the law (Elshishini, 2015).

According to Farag & Korachy (2017), Egypt's plastic recyclers conduct only mechanical recycling, in which plastic waste is processed into secondary raw material or products without changing the plastic's chemical structure, for which the contamination of plastic is a difficult obstacle to surmount (Vollmer et al., 2020). Most different types of plastic are not compatible due to "inherent immiscibility at the molecular level" and "differences in processing requirements at a macro-scale" (Abdel Mohsen, 2014, p. 23). Consequently, the quality of collected plastic waste is inconsistent and it is time-consuming to find and separate the high-value materials, which may account for a small percentage of overall plastic waste. These aforementioned challenges also apply to recycled synthetic fibers, whose processing costs may limit their use to companies that can support a higher cost structure (Textile World, 2019). Additionally, low crude oil prices reduce the price of virgin plastics, therefore lowering demand for recycled plastics (MSEA et al., 2017).

5. Conclusion

The examination of both Egypt's energy efficiency, waste and wastewater management national frameworks and existing and potential circular economy developments for cement, textiles and plastics reveals several challenges impeding a transition to a circular economy. Addressing these challenges must include reforms of cross-cutting resource governance to ensure the sustainability of progress made by intermittent donor-led projects, as well as to enable stronger enforcement of existing environmental regulations. This entails the clear delineation of government stakeholders' respective responsibilities, as well as the introduction and enforcement of policies currently non-existent, including a policy regarding pretreatment of industrial effluents before discharge; a regulatory framework to harmonize waste collection; IEE regulations; and application of the 'polluter pays' principle in both wastewater and solid waste management, such as a comprehensive tipping fee policy to incentivize both a market for RDF and other alternative uses of waste products, and better resource efficiency. Furthermore, a consistent challenge mentioned across the literature is the absence of comprehensive, reliable and recent data; accordingly, institutional capacity building must entail the establishment of robust data management systems and practices to enable evidence-based policymaking on energy efficiency, wastewater treatment and industrial and municipal solid waste management.

Facilitating access to finance is essential to enable resource efficiency and production of high-quality recycled goods in textile and plastics MSMEs, in addition to addressing the skills gap inherent in both sectors. Incentives should be put in place for further research in WHR opportunities in the cement sector, and the feasibility of potential opportunities such as recycled plastic waste for textile fibers. The IFC (2020) recommends further analysis to determine the effect of tariff and export rebates across the textiles and apparel sector on its export competitiveness.

For Egypt's cement sector, to reach Egypt's mitigation target for clinker content reduction, Vanderborght et al. (2016) suggest allowing the import of clinker substitutes unavailable in Egypt, such as foreign fly ash, slag and pouzzolana, and adapting the construction codes to enable use of low-carbon cements such as LC_3. Furthermore, to support the transition toward alternative fuels, the IFC (2016) proposes directing taxes levied on coal imports to investment in AFR and facilitating collaboration between producers of agricultural waste and cement producers to reduce the burning of agricultural waste products and develop a collection and supply chain.

This background paper has attempted to provide an overview of the challenges and opportunities for circular economy practices present in Egypt's cement, textiles and plastics sectors to highlight possible areas for policy interventions. Access to finance and the financial costs associated with certain circular economy practices constitute an obstacle to resource efficient practices and the accompanying opportunities for cost savings, import substitution, and emissions reduction. Equally concerning are the institutional inefficiencies which jeopardize the achievements of periodic circular economy projects in collaboration with institutions like UNIDO. A strong, comprehensive circular economy strategy that addresses these challenges can help Egypt capitalize on its industrial strengths and ensure the sustainability of green investments.

6. References

- Abdallah, M. N. (2014). Wastewater Operation and Maintenance in Egypt (Specific Challenges and Current Responses). *International Journal of Sciences: Basic and Applied Research 18(2)*, 125-142. https://core.ac.uk/download pdf/249334383.pdf

- Abdallah, L., & El-Shennawy, T. (2020). Evaluation of CO_2 emission from Egypt's future power plants. *Euro-Mediterranean Journal for Environmental Integration* 5, 49. https://doi.org/10.1007/s41207-020-00184-w

- Abdel-Fatah, M. A., Hafez, A. I., Gaber, A. H., & Kamal, M. (2019). Alternative solutions of industrial wastewater management in the textile industry. *International Journal of Petrochemical Science & Engineering, 4(3)*, 90-95. https://medcraveonline.com/IPCSE/IPCSE-04-00108.pdf

- Abdel Mohsen, R. (2014). *Investigation of reinforced foam waste with natural or synthetic fibers*. American University of Cairo: Thesis. https://cutt.ly/IboYxcZ

- Abdel-Shafy, H. I., & Kamel, A. H. (2016). Groundwater in Egypt Issue: Resources, Location, Amount, Contamination, Protection, Renewal, Future Overview. *Egyptian Journal of Chemistry 59(3), 321-362*. https://cutt.ly/TboYbug

- Abou-Taleb, E. M., Ali, M. E. M., Hellal, M. S., Kamal, K. H., Abdel Moniem, S. M., Ammar, N. S., & Ibrahim, H. S. (2020). Sustainable solutions for urban wastewater management and remediation. *Egyptian Journal of Chemistry 63(2)*. 405-415. https://cutt.ly/pboYQsS

- Abdel Wahaab, R. (2014). *Wastewater reuse code in Egypt*. SWIM-Sustain Water MED 12–16 May 2014, Djerba Plaza, Tunisia. Retrieved 29 March from https://goo.gl/nQpKra

- Al-Aees, S. (2016). *Cabinet obliges cement plants to use 15% of waste as alternative fuel sources in 2030*. Daily News Egypt. https://dailynewsegypt.com/2016/10/31/582294/

- Al-Aees, S. (2020). *Nestlé Egypt launches plastic recycling initiative to preserve environment*. Daily News Egypt. https://cutt.ly/MboYHe5

- Ali, I. (2021, May 9). *The new law for "irrigation" sets a clear definition for "the sanctuary of the Nile River" ... Know the details*. [Al-qanun al-jadid l-il-"ray" yada' ta'reefan wadihan li-"hirm nahr al-nil" ... a'rif al-tafasil]. Youm7. [In Arabic]. https://cutt.ly/mboYZNH

- Al-Iraqi, R. (2021). *Minister of Environment: An Egyptian charter for plastic waste to create a circular economy and capitalize on its value*. [Wazirat albee'at: mithaq misri l-il-mukhalafat al-blastikiyat li-'insha' iqtisad da'iri wa-l-istifadat min qimatuha]. AlMasry AlYoum. [In Arabic]. https://www.almasryalyoum.com/news/details/2298592

- Askar, Y., Jago, P., Mourad, M. M., & Huisingh, D. (2010). *The cement industry in Egypt: Challenges and innovative cleaner production solutions*. Knowledge Collaboration & Learning for Sustainable Innovation ERSCP-EMSU conference, Delft, The Netherlands, October 25-29.

- Atef, A. (2019). *Energy management assistance (EnMA) service: Industrial energy efficiency fund* [PowerPoint slides]. December 11, 2019. https://cutt.ly/KboIGha

- Awed, A.M., Aboelela, A.E., El-Ashwah, A.S., Allam, M., & El-Badawy, S. M. (2020). Improvement of unbound granular pavement layers and subgrade with cement dust in Egypt. *International Journal of Pavement Research and Technology*, 13, 621–629. https://doi.org/10.1007/s42947-020-6010-9

- Badr, H. (2017). *Garbage recycling in Egypt: Trading health for livelihood*. SciDev.Net. https://cutt.ly/MboIJRH

- Bakr, M. (2020). *Egypt: Towards a greener economy*. Ahram Online. https://cutt.ly/aboICM4

- Bakry, H. (2015). *Grappling with Cairo's garbage: Informal sector integration as a means to urban sustainability*. American University of Cairo: Thesis.

- Bayomy, M. F. F., Alne-na-ei, A. A., Gaber, H. S., Sayed, H. A., & Khairy, D. M. (2015). Environmental and physiological impacts of heavy metals on Nile tilapia (Oreochromis niloticus). *Journal of Bioscience and Applied Research 1(2)*, 52-58. https://cutt.ly/bboINGs

- Breisinger, C., Raouf, M., Wiebelt, M., Kamaly, A., & Karara, M. (2020). *Impact of COVID-19 on the Egyptian economy: Economic sectors, jobs, and households* (Regional Program Policy Note 06). International Food Policy Research Institute: Middle East and North Africa & Ministry of Planning and Economic Development.

- British Petroleum. (2020). *Statistical Review of World Energy 2020 | 69th edition*. https://cutt.ly/HboI1Fw

- Business Today Egypt. (2020). *4% drop in Egyptian export growth in first 10M of 2020.* https://cutt.ly/SboOidr

- Cambridge Econometrics, Trinomics, & ICF. (2018). *Impacts of circular economy policies on the labour market - final report*. European Commission. https://cutt.ly/BboOcsW

- Cement Industry Division. (n.d.-a). *Cement industry In Egypt*. https://cutt.ly/DboOAEr

- Cement Industry Division. (n.d.-b). *Environment*. https://cutt.ly/2boOSUp

- Cement Industry Division. (2019). *Dr. Noha Bakr: Egypt has become a center for regional and international conferences in the building materials sector*. https://cutt.ly/XboODX3

- Cementis. (n.d.). *EBRD low CO2 cement reflected in local construction code*. https://cutt.ly/SboOK6T

- Cemex Egypt. (n.d.). *Farm*. https://cutt.ly/bboOCqm

- Cemnet. (2010). *Cemex sets new records of alternative fuels usage*. https://cutt.ly/6boONc7

- Cemnet. (2020). *MENA outlook: Egypt and Saudi Arabia market prospects*. https://cutt.ly/CboOoqM

- Circle Economy. (2021). *The Circularity gap report 2021*. https://www.circularity-gap.world/2021

- Circle Economy & United Nations Industrial Development Organization. (2020). *RE.ACT: Environmental and economic assessment of post-industrial cotton waste recycling*. https://cutt.ly/CboO9Gv

- Climate Watch. (n.d.). *Data explorer*. https://cutt.ly/IboO31s

- Clukey, K. (2019). *New York's thick plastic bag demands vex efforts to reduce waste.* Bloomberg Law. https://cutt.ly/XboO7Dc

- Daily News Egypt. (2021). *PepsiCo Egypt launches 'recycle for tomorrow' platform for waste management*. https://cutt.ly/lboPwmG

- Deutsche Gesellschaft für Internationale Zusammenarbeit. (2016). *Regional project RE-ACTIVATE: Country roadmap Egypt.* https://cutt.ly/2boPX3x

- Drechsel, P., & Hanjra, M.A. (2018). Wastewater for fruit and wood production (Egypt) - Case study. In M. Otoo, P. Drechsel (Eds.). *Resource recovery from waste: business models for energy, nutrient and water reuse in low- and middle-income countries* (pp.556-568). Routledge.

- EcoConServ. (2016). *Environmental and social impact assessment for rural clusters under phase 2 of ISSIP II Assuit governorate final report.* Holding Company for Water and Wastewater. https://cutt.ly/VboFqXs

- Ecorys. (2014). *Trade sustainability impact assessment in support of negotiations of a DCFTA between the EU and Egypt*. European Commission. https://cutt.ly/5boFuo1

- Egyptian Environmental Affairs Agency. (n.d.-a). *About the national network for monitoring industrial emissions.* https://cutt.ly/nboFpnr

- Egyptian Environmental Affairs Agency. (n.d.-b). *EEAA mission.* https://cutt.ly/IboFaEl

- Egyptian Environmental Affairs Agency. (n.d.-c). *Egyptian pollution abatement programme.* https://cutt.ly/NboFd2v

- Egyptian Environmental Affairs Agency. (n.d.-d). *Significant reduction in dust emissions from line 8 clinker production - Tourah Portland cement company, Cairo, Egypt.* https://cutt.ly/2boFh4r

- Egyptian Environmental Affairs Agency. (1999). SEAM Project. *Textile sector report: Cleaner production opportunities.*

- Egyptian Environmental Affairs Agency. (2003). *Textile industry: Self-monitoring manual.* https://cutt.ly/sboFv5z

- Egyptian Environmental Affairs Agency. (2013). *EPAP II summary of pipeline projects December 2013.* https://cutt.ly/iboFcZw

- Egyptian Environmental Affairs Agency. (2018). *Egypt's first biennial update report to the United Nations Framework Convention on Climate Change.* https://cutt.ly/LboFnUM

- EgyptSEFF. (n.d.). *The pilot.* https://cutt.ly/uboFQhB

- Egypt Today. (2019). *52 sewage treatment plants are built in Upper Egypt: Housing min.* Egypt Today. https://cutt.ly/wboFLCk

- Egypt Today. (2020). *Sisi: Egypt to inaugurate the world's largest wastewater treatment plant in 8 months.* https://cutt.ly/GboFXLJ

- Egypt Today. (2021a). *3 ministers review progress rate of Egypt's municipal solid waste system.* https://cutt.ly/XboFBAH

- Egypt Today. (2021b). *Egypt's census to reach 119.8 million by 2030: CPAMAS.* https://cutt.ly/FmtywnO

- ElBalad. (2020). *After the President approved the reduction in the use of plastic bags | Find out how much Egypt is consumed.* [Ba'd tasdiq al-ra'is 'ala taqlil istikhdam akyas al-blastik, i'raf hajm istihlak misr]. [In Arabic]. https://www.elbalad.news/4540867

- El-Haddad, M. (2021). *The textile industry is catching up on the development train.* [Sina'at al-mansujat tulhiq biiqatar al-tatwir]. Ahram. [In Arabic]. https://gate.ahram.org.eg/News/2607248.aspx

- Ellen MacArthur Foundation. (2020a). *The EU's circular economy action plan: Setting the world's largest single market on a transition towards a circular economy.* https://cutt.ly/HboGdn5

- Ellen MacArthur Foundation. (2020b). *Africa's first industrial symbiosis programme: Generating multiple benefits for the manufacturing industry.* https://cutt.ly/oboGlbR

- El-Messiry, M., Aloufy, A., & Elmor, M. (2016). *Assessment of nanofibers filtration for textile waste-water treatment. Journal of Applied Mechanical Engineering, 5(3)*, 211. https://cutt.ly/pboGx2j

- El Safty, A., & Siha, M. (2013). *Environmental and health impact of coal use for energy production. Egyptian Journal of Occupational Medicine, 37(2)*, 181-194. https://dx.doi.org/10.21608/ejom.2013.783

- Elshishini, S. (2015). *Review of status and actual practices of industrial waste management in Egypt.* Green Growth: Industrial Waste Management and SME Entrepreneurship Hub in Egypt. https://cutt.ly/HboGmg8

- Enterprise. (2020a). *What are lawmakers and regulators doing to avert water wars?* https://cutt.ly/mboGUHW

- Enterprise. (2020b). *Cement looks set for another tough year in 2020.* https://cutt.ly/eboGOhC

- Enterprise. (2020c). *Where did things go wrong with Egypt's waste management?* https://cutt.ly/gboGPms

- Enterprise. (2020d). *What the state needs to do to plug leaks in our water network.* https://cutt.ly/RboGA61

- Enterprise. (2020e). *A look at Egypt's most polluting sectors.* https://cutt.ly/jboGDoS

- Environmental Compliance Office of the Federation of Egyptian Industries. (n.d.). *Financial support program for industrial facilities.* http://www.eco-fei.org/financial-support/

- European Bank for Reconstruction and Development. (n.d.-a). *Financing and partners.* https://ebrdgeff.com/egypt-gvc/the-programme/stakeholders/

- European Bank for Reconstruction and Development. (n.d.-b). *The facility.* https://ebrdgeff.com/egypt/the-programme/the-facility/

- European Bank for Reconstruction and Development. (2017). *Strategy for Egypt as approved by the board of directors at its meeting on 8 February 2017.* https://cutt.ly/1boGX1s

- European Bank for Reconstruction and Development. (2021). *Egypt green value chain financing facility: Financing solutions to improve your business competitiveness.* https://cutt.ly/RboGVnY

- European Commission. (2020). *A new circular economy action plan for a cleaner and more competitive Europe.* https://cutt.ly/VboHy9k

- European Environment Agency. (2019). *Private consumption: Textiles EU's fourth largest cause of environmental pressures after food, housing, transport.* https://cutt.ly/kboHhyF

- European Parliament. (2021). *Circular economy: definition, importance and benefits.* https://cutt.ly/zboHAU5

- Ezz, M., & Arafat, N. (2015). *'We woke up in a desert' – the water crisis taking hold across Egypt.* The Guardian. https://cutt.ly/kboHDHI

- Fahim, I., Mohsen, O., & ElKayaly, D. (2021). *Production of fuel from plastic waste: A feasible business. Polymers, 13*, 915. https://doi.org/10.3390/polym13060915

- Farag, M. G., & Korachy, A. (2017). *Strengthening entrepreneurship and enterprise development (SEED): Plastic value chain mapping and assessment* (Technical Report No. 20). AECOM/USAID. https://cutt.ly/4boHGgV

- Fell, A. K., Sikkeland, L. I., Svendsen, M. V., & Kongerud, J. (2010). *Airway inflammation in cement production workers. Occup Environ Med, 67*(6), 395-400. https://doi.org/10.1136/oem.2009.047852

- Food and Agriculture Organization. (1994). *Law 4/1994: Promulgating the environmental law and its executive regulation.* http://extwprlegs1.fao.org/docs/pdf/egy4984E.pdf

- Food and Agriculture Organization. (2009). *Environmental Law 9/2009.* [Qanun l-il-bee'a raqam 9 li-sanat 2009]. [In Arabic]. http://extwprlegs1.fao.org/docs/pdf/egy152133.pdf

- Food and Agriculture Organization. (2015). *Prime Minister Decree No.1912 of 2015 establishing the National Council for Climate Change.* [Qarar ra'ees majlis al-wuzara' raqam 1912 li-sanat 2015]. [In Arabic]. http://extwprlegs1.fao.org/docs/pdf/egy152204.pdf

- Food and Agriculture Organization. (2017). *AQUASTAT Database.* AQUASTAT Website accessed on May 4 2021. http://www.fao.org/aquastat/statistics/query/index.html

- Food and Agriculture Organization. (2018). *Progress on water use efficiency - Global baseline for SDG 6 indicator 6.4.1.* Food and Agriculture Organization/UN-Water. https://cutt.ly/iboH9TG

- Government of Egypt. (2014). *Sustainable development strategy: Vision 2030.* https://cutt.ly/IboJy1y

- Grumiller, J., Raza, W. G., & Grohs, H. (2020). *Strategies for sustainable upgrading in global value chains: The Egyptian textile and apparel sector* (ÖFSE Policy Note, No. 33/2020). Austrian Foundation for Development Research (ÖFSE). https://cutt.ly/2boJa8v

- Gunsilius, E., Chaturvedi, B., & Scheinberg, A. (2011). *The economics of the informal sector in solid waste management.* CWG - Collaborative Working Group on Solid Waste Management in Low- and Middle-income Countries/Deutsche Gesellschaft für Internationale Zusammenarbeit. https://cutt.ly/rboJjtB

- Handawy, M. K., Snegirev, A. Y., Stepanov, V. V., Talalov, V. A. (2021). Energy recovery strategies as a sustainable solutions for municipal solid waste in Egypt. *IOP Conference Series: Materials Science and Engineering, 1100, 012052*. https://cutt.ly/6boJRxI

- Hasan, S., Al-Aqeel, T., & El Salmawy, H. (2020). *Electricity sector liberalization in Egypt: Features, challenges and opportunities for market integration*. King Abdullah Petroleum Studies and Research Center. https://www.doi.org/10.30573/KS--2020-DP20

- Hashem, R. (2020). *Establishing the first instantaneous station for monitoring air pollution and improving its quality in Sheikh Zayed.* [Insha' awal mahatat lahziyat li-rasd talawuth al-hawa' wa tahsin jawdatih bi-l-shaykh zayid]. Elwatan. [In Arabic]. https://www.elwatannews.com/news/details/5087082

- Hassan, A. (2017). *Self-monitoring emission points rise to 215: Ministry of environment. Egypt Independent.* https://cutt.ly/1boJ1yg

- Health Effects Institute. (2020). *State of global air 2020* (Special Report). https://cutt.ly/FboJ4Qt

- International Finance Corporation. (2014). *Waste heat recovery for the cement sector: Market and supplier analysis*. https://cutt.ly/OboKw44

- International Finance Corporation. (2016). *Unlocking value: Alternative fuels for Egypt's cement industry*. https://cutt.ly/CboKtHz

- International Finance Corporation. (2020). *Country private sector diagnostic: Creating markets in Egypt: Realizing the full potential of a productive private sector.* https://cutt.ly/xboKihk

- International Labour Organization. (2018). *Skills for green jobs in Egypt*. https://cutt.ly/kboKa8I

- International Renewable Energy Agency. (2018). *Renewable energy outlook - Egypt - executive summary.* https://cutt.ly/jboKgdt

- Jambeck, J. R., Geyer, R., Wilcox, C., Siegler, T. R., Perryman, M., Andrady, A., Narayan, R., & Law, K. L. (2015). Plastic waste inputs from land into the ocean. *Science Magazine, 347(6223)*, 768-771. https://cutt.ly/gboKlFc

- Kandil, A. (2021). *Egypt's irrigation minister calls for rationing water amid GERD crisis.* Ahram Online. https://cutt.ly/anT2qAr

- Kampa, E., Choukr-Allah, R., Ahmed, M. T., & Fürhacker, M. (2011). Constraints of application of wastewater treatment and reuse in Mediterranean partner countries. In D. Barceló & M. Petrovic, *Waste water treatment and reuse in the Mediterranean region* (pp.92-124). Springer. https://cutt.ly/lboKc9g

- Khater, G.A. (2006). Use of bypass cement dust for production of glass ceramic materials. *Advances in Applied Ceramics, 105, 107–111.* https://cutt.ly/xbo4THL

- Korashi, H. (2021). *Unleashing employment potential in the manufacturing sector: Assessing existing policies and the way forward* (Background Paper). Alternative Policy Solutions. https://cutt.ly/Zbo4AiA

- Lafarge Egypt. (2019). *Geocycle Egypt inaugurates its waste management platform in Sokhna.* https://cutt.ly/rbo4LuL

- Lafarge Egypt. (2021). *Egyptian promise.* https://cutt.ly/Vbo4XoC

- Larsen, B. (2019). *Arab republic of Egypt: Cost of environmental degradation - Air and water pollution*. The World Bank. https://openknowledge.worldbank.org/handle/10986/32513

- Laville, S. (2019). *'Bags for life' making plastic problem worse, say campaigners*. The Guardian. https://cutt.ly/Ibo4Mfu

- Lee, K., & Cha, J. (2021). *Towards improved circular economy and resource security in South Korea. Sustainability, 13*(1), 17. https://dx.doi.org/10.3390/su13010017

- Lehne, J., & Preston, F. (2018). *Making concrete change: Innovation in low-carbon cement and concrete* (Executive Summary). Chatham House. https://cutt.ly/Ebo44bX

- Lihidheb, K., Missaoui, R., & Shariff, J. (2020). *Innovative energy efficiency instruments for the MENA region.* Deutsche Gesellschaft für Internationale Zusammenarbeit. https://cutt.ly/abo46ap
- Lynx. (2020). *Egypt's waste management law.* http://www.lynxegypt.com/assets/pdfs/Waste-Management-Law.pdf
- Magoum, I. (2021). *Egypt: JICA allocates $3.57 million for single-use plastics management.* Afrik21. https://cutt.ly/amtus8f
- Maher, B. (2021). *Spinning and weaving... the state devises a plan to "restore the golden age".* [Al-ghazl w-al-nasij ... al-dawla tada' khuta li-isti'adat <<al-'asr al-dhahabi>>]. Elwatan. [In Arabic]. https://www.elwatannews.com/news/details/5357147
- Mahmoud, M., Rademaekers, K., Hemkhaus, M., Ahlers, J., Van Hummeln, S., Chewpreecha, U., Smith, A., & McGovern, M. (2020). *Circular economy in Africa-EU cooperation: Country report for Egypt*. Trinomics. European Commission. https://cutt.ly/Qbo7lWg
- Malato, S., Oller, I., Fernández-Ibáñez, P., & Fuerhacker, M. (2011). Technologies for advanced wastewater treatment in the Mediterranean region. In D. Barceló & M. Petrovic, *Waste water treatment and reuse in the Mediterranean region* (pp.1-24). Springer. https://cutt.ly/ubo7csx
- Manshoven, S., Smeets, A., Arnold, M., & Fogh Mortensen, L. (2021). *Plastic in textiles: Potentials for circularity and reduced environmental and climate impacts* (ETC/WMGE 2021/1). European Topic Centre on Waste and Materials in a Green Economy. https://cutt.ly/Xbo7mVP
- Martinko, K. (2019). *Thicker bags don't solve the plastics problem*. Treehugger. https://www.treehugger.com/thicker-bags-dont-solve-plastics-problem-4851065
- Matthews, S., & Flint, A. (2020). *Egypt 2019 thermal coal imports rise 31% on cement sector demand*. S&P Global Platts. https://cutt.ly/sbo7R43
- MeetMED. (2019). *Energy efficiency and renewable energy strategies and policies.* Mediterranean Association of the National Agencies for Energy Management and the Regional Center for Renewable Energy and Energy Efficiency. https://www.rcreee.org/sites/default/files/meetmed_report_a1_1_final_191009.pdf
- Meo, S. A. (2004). Health hazards of cement dust. *Saudi Medical Journal, 25*(9), 1153-9. https://cutt.ly/Lbo7PsO
- Ministry of Electricity and Renewable Energy. (2018a). *National energy efficiency action plan 2018-2022*. https://cutt.ly/Mbo7DLC
- Ministry of Electricity and Renewable Energy. (2018b). *Egyptian electricity holding company annual report 2017/2018.* http://www.moee.gov.eg/english_new/EEHC_Rep/2017-2018en.pdf
- Ministry of Electricity and Renewable Energy. (2019). *Egyptian electricity holding company Annual report 2018/2019.* http://www.moee.gov.eg/english_new/EEHC_Rep/2018-2019en.pdf
- Ministry of Planning and Economic Development. (n.d.). *Vision and mission*. https://mped.gov.eg/MinistryVision?lang=en
- Ministry of Planning and Economic Development & Ministry of State for Environmental Affairs. (2021). *Environmental sustainability standards guide: The strategic framework for green recovery.* [Daleel ma'ayir al-astidamat al-be'iya: al-itar al-istratijiya l-il-ta'afi al-akhdar]. [In Arabic]. https://cutt.ly/xbo5CyB
- Ministry of State for Environmental Affairs. (2017). *State of the environment 2017.* [Taqrir halat al-bi'a 2017] [In Arabic]. https://cutt.ly/hbo7oxc
- Ministry of State for Environmental Affairs, National Solid Waste Management Programme & Waste Management Regulatory Authority. (2017). *Success stories of Egypt's waste companies*. http://www.bariq-eg.com/wp-content/uploads/2018/08/egypts-success-stories-en.pdf

- Ministry of Trade and Industry. (n.d.-a). *Industrial control authority - activities.* https://cutt.ly/wbo5gOn

- Ministry of Trade and Industry. (n.d.-b). *Industrial modernisation center - activities.* https://cutt.ly/Xbo5hnm

- Ministry of Trade and Industry. (n.d.-c). *Ministry's mission and objectives.* https://cutt.ly/Sbo5xGs

- Ministry of Trade and Industry. (2016). *Industrial trade and development strategy, 2016-2020.* https://cutt.ly/Qbo5cXe

- Ministry of Trade and Industry. (2020). *The Minister of Trade and Industry issues a decision to oblige producers and importers of electric motors to control production and import according to the specification.* [Wazirat al-tijarat wa-l-sina'at tasdur qararan bi-l-zam al-munitijin wa-l-mustawradin l-il-muharikat al-kahraba'iyat bi-dawabit al-intaj wa-l-istirad tibqan l-il-muasafa]. [In Arabic]. https://cutt.ly/SbY11XV

- Monayeri D.S.E., Monayeri O.D.E., Gohary E.H.E., Aboul-fotoh A.M. (2011). Industrial wastewater treatment systems in Egypt: Difficulties and proposed solutions. In Atimtay A., Sikdar S. (Eds.). *Security of Industrial Water Supply and Management* (pp. 209-230). NATO Science for Peace and Security Series C: Environmental Security. Springer, Dordrecht. https://doi.org/10.1007/978-94-007-1805-0_14

- Mostafa, N. (2020). Logistics of waste management with perspectives from Egypt. In A. M. Negm, N. Shareef (Eds.) *Waste management in MENA regions* (pp. 171-192). Springer. https://link.springer.com/content/pdf/10.1007%2F978-3-030-18350-9.pdf

- Mounir, S. (2020). *Egypt: Crisis of cement.* Ahram Online. https://cutt.ly/Vbo6h8L

- Munawer, M. E. (2018). Human health and environmental impacts of coal combustion and post-combustion wastes. *Journal of Sustainable Mining*, 17(2), 87-96. https://doi.org/10.1016/j.jsm.2017.12.007

- National Solid Waste Management Programme. (n.d.). *About NSWMP.* https://nswmp.net/about-nswmp/

- Nestlé Middle East. (2020). *Nestlé Egypt launched its initiative, DORNA which aims to boost the recycling of plastic packaging material in attempt to preserve the environment.* https://cutt.ly/Ibo6z6M

- New and Renewable Energy Authority. (n.d.). *Renewable energy targets.* http://nrea.gov.eg/test/en/About/Strategy

- Noureldin, O. (2020). *Plastic in the time of pandemic.* American Chamber of Commerce in Egypt. https://cutt.ly/ibo6b63

- ODYSSEE-MURE. (2015). *Energy efficiency trends and policies In industry: An analysis based on the ODYSSEE and MURE databases.* https://cutt.ly/Xbo6UIV

- Oil Change International. (2013). *Petroleum coke: the coal hiding in the tar sands.* http://priceofoil.org/content/uploads/2013/01/OCI.Petcoke.FINALSCREEN.pdf

- Palacios-Mateo, C., van der Meer, Y. & Seide, G. (2021). Analysis of the polyester clothing value chain to identify key intervention points for sustainability. *Environmental Sciences Europe*, 33, 2. https://doi.org/10.1186/s12302-020-00447-x

- Pharos. (2020a). *New incentives to offer respite but will not prevent losses.* https://cutt.ly/lbo6BjH

- Pharos. (2020b). *Egypt equity strategy 2021: Reverting to the mean.* https://cutt.ly/7bo6NOj

- Pinto Da Costa, J., Rocha-Santos, T., & Duarte, A. C. (2020). *The environmental impacts of plastics and micro-plastics use, waste and pollution: EU and national measures.* European Parliament. https://cutt.ly/3bo6Kfc

- Rady, R., & Omar, M. E. (2018). *Background paper: Water resources management in Egypt: Assessment and recommendations.* Alternative Policy Solutions. https://cutt.ly/cbo68Tm

- Raza, W., Grumiller, J., Grohs, H., & Alexander, H. (2020). *Value chain analysis for apparel from Egypt. Austrian Foundation for Development Research* (ÖFSE). https://cutt.ly/wbo66oo

- Regional Center for Renewable Energy and Energy Efficiency. (2017). *Key energy efficiency actions and Initiatives in Egypt*. https://cutt.ly/vb2qwoT

- Rengel, A. (2017). *Recycled textile fibres and textile recycling: An overview of the market and its possibilities for public procurers in Switzerland*. Be Sustainable. https://cutt.ly/qb2quqo

- Reuters. (2020). *Coronavirus widens the cracks in Egypt's cement industry*. Egypt Independent. https://cutt.ly/fboFSSW

- Riad & Riad. (2018). *New law regulating the Industrial Development Authority (IDA)*. https://cutt.ly/mb2qoOC

- Salem, O. (2020). *The government plans to generate 300 megawatts of electrical energy from waste*. [Al-hukumat tukhatit li-tawlid 300 megawatt taqat kahraba'iyat min al-mukhalafat]. AlMal. [In Arabic]. https://cutt.ly/3b2qp3E

- Salman, D. (2017). An assessment to the oligopoly cement industry in Egypt: Is it a curse or a blessing? *International Journal of Green Economics, 11*(1), 41-61. https://cutt.ly/Fb2qb26

- Samir, S. (2021). *How does Egypt get rid of single-use plastic bag?* Egypt Today. https://cutt.ly/Jb2qmXe

- Shaalan, N.S. (2003). *Egypt country paper*. Joint FAO/WHO Consultation for Launching the Regional Network on Wastewater Re-use in the Near East. http://www.fao.org/3/y5186e/y5186e.pdf

- Shalakany. (2020). *New waste-management law brings Egypt closer to going green*. https://cutt.ly/cb2qYVy

- Soulie, M. (2013). *Review and analysis of status of implementation of wastewater strategies and/or action plans: National report- Egypt: Work package (WP1) "Water governance and mainstreaming» - Activity 1.1.2*. Sustainable Water Integrated Management - Support Mechanism (SWIM-SM). https://cutt.ly/Ab2qKaV

- Stevulova, N., Strigac, J., Junak, J., Terpakova, E., & Holub, M. (2021). Incorporation of cement bypass dust in hydraulic road binder. *Materials, 14*, 41. https://dx.doi.org/10.3390/ma14010041

- SWEEP-NET. (2014). *Country report on the solid waste management in Egypt*. Deutsche Gesellschaft für Internationale Zusammenarbeit. https://www.resource-recovery.net/sites/default/files/egypt_ra_ang_14_1.pdf

- SwitchMed. (n.d.). *About us*. https://switchmed.eu/about-us/

- SwitchMed. (2015). *National action plan for sustainable consumption and production (SCP) in Egypt*. https://cutt.ly/Ib2qC1G

- SwitchMed. (2020a). *Reducing plastic bag consumption in Egypt*. https://cutt.ly/Hb2qMV5

- SwitchMed. (2020b). *MED test III: Promoting circular value chains for a greener and more competitive textile industry in Egypt*. https://switchmed.eu/wp-content/uploads/2020/12/MED-TEST-III-Egypt_Textile-EN.pdf

- Textile Consolidation Fund. (2020). *Statement of Egyptian exports of various textile products during the period January-June 2020 compared to January-June 2019*. [Bayan al-sadirat al-misriat min mukhtalaf al-muntajat al-nasjiyat khilal al-fatrat yanayir/yuniu 2020 muqarin bi-l-fatrat yanayir/yuniu 2019]. [In Arabic]. 32-49. https://cutt.ly/Xb2wYrz

- Textile Exchange. (2018). *Preferred fiber and materials: Market report 2018*. https://cutt.ly/hb2wPgR

- Textile Exchange. (2020). *Preferred fiber and materials: Market report 2020*. https://cutt.ly/Pb2wZCl

- Textile World. (2019). *Challenges facing recycled polyester*. https://cutt.ly/Jb2wCFb

- United Nations Department of Economic and Social Affairs. (2014). *Water scarcity: International decade for action 'water for life' 2005-2015*. Retrieved 29 March 2021, from https://www.un.org/waterforlifedecade/scarcity.shtml

- United Nations Industrial Development Organization. (n.d.). *Programme For country partnership Egypt*. https://cutt.ly/Xb2w1I3
- United Nations Industrial Development Organization. (2014). *Industrial energy efficiency project: Benchmarking report for the cement sector*. http://ieeegypt.org/wp-content/uploads/2016/04/Cement.pdf
- United Nations Industrial Development Organization. (2015). *Industrial energy efficiency in Egypt: Industry energy efficiency strategies and policies*. http://ieeegypt.org/wp-content/uploads/2017/01/UNIDO-IEE-policy-report.pdf
- United Nations Industrial Development Organization. (2018a). *Industrial energy efficiency in Egypt: Industrial energy efficiency project: Integration of energy efficiency into textile sector strategy*. http://ieeegypt.org/wp-content/uploads/2016/04/Textile-EE-strategy.pdf
- United Nations Industrial Development Organization. (2018b). *Independent terminal evaluation: Industrial energy efficiency in Egypt*. https://cutt.ly/Xb2w3lj
- United Nations Water. (n.d.). *Indicator 6.4.1 – Water use efficiency*. https://sdg6data.org/indicator/6.4.1
- Vanderborght, B., Koch, F., Grimmeissen, L., Wehner, S., Heersche, P. H., & Degré, J. (2016). *Low-carbon roadmap for the Egyptian cement industry*. European Bank for Reconstruction and Development. https://cutt.ly/Qb9HpgZ
- Verma, R., Vinoda, K. S., Papireddy, M., Gowda, A. N. S. (2016). Toxic pollutants from plastic waste- a review, *Procedia Environmental Sciences, 35*, 701-708. https://doi.org/10.1016/j.proenv.2016.07.069
- Vollmer, I., Jenks, M. J. F., Roelands, M. C. P., White, R. J., van Harmelen, T., de Wild, P., van der Laan, G. P., Meirer, F., Keurentjes, J. T. F., & Weckhuysen, B. M. (2020). Beyond mechanical recycling: Giving new life to plastic waste. *Angewandte Chemie - International Edition, 59*, 15402-15423. http://doi.org/10.1002/anie.201915651
- Waste Management Regulatory Authority. (2019). *Executive guidelines for investment in W2E*. https://www.ecrg.de/images/Download_pdf/Executive_Guidelines.pdf
- Werr, P. (2021). *Exclusive-Egypt's competition authority approves cement quotas, document says*. Reuters. https://www.reuters.com/article/us-egypt-cement-exclusive-idUSKCN2ECoZZ
- World Bank. (2017). *Project performance assessment report: Arab republic of Egypt: Second pollution abatement project* (Report No. 113565). Washington, D.C.: World Bank Group. https://cutt.ly/Rb9HbOJ
- World Bank. (2020). *Implementation completion and results report IBRD-85710, 86850, 88030 on a loan in the amount of US$3.15 billion to the the Arab Republic of Egypt for the first, second, and third fiscal consolidation, sustainable energy, and competitiveness programmatic development policy financing* (Report No. ICR00005121). Washington, D.C.: World Bank Group. https://cutt.ly/Xb9HWrF
- World Wildlife Fund. (2019). *Stop the flood of plastic: How Mediterranean countries can save their sea*. https://cutt.ly/Ub9HTXh
- Zawya. (2019). *Egyptian Cotton & Textile Industries Holding inks contract with PwC for merger*. https://cutt.ly/ob9HUkO
- Zgheib, N. (2020). *EBRD, EU and partners boost green finance in Egypt*. European Bank for Reconstruction and Development. https://cutt.ly/jb9HO05
- Zimmo, O. R., & Imseih, N. (2011). Overview of wastewater management practices in the Mediterranean Region. In D. Barceló & M. Petrovic, *Waste water treatment and reuse in the Mediterranean region* (pp.155-182). Springer. https://cutt.ly/Bb9HSHM

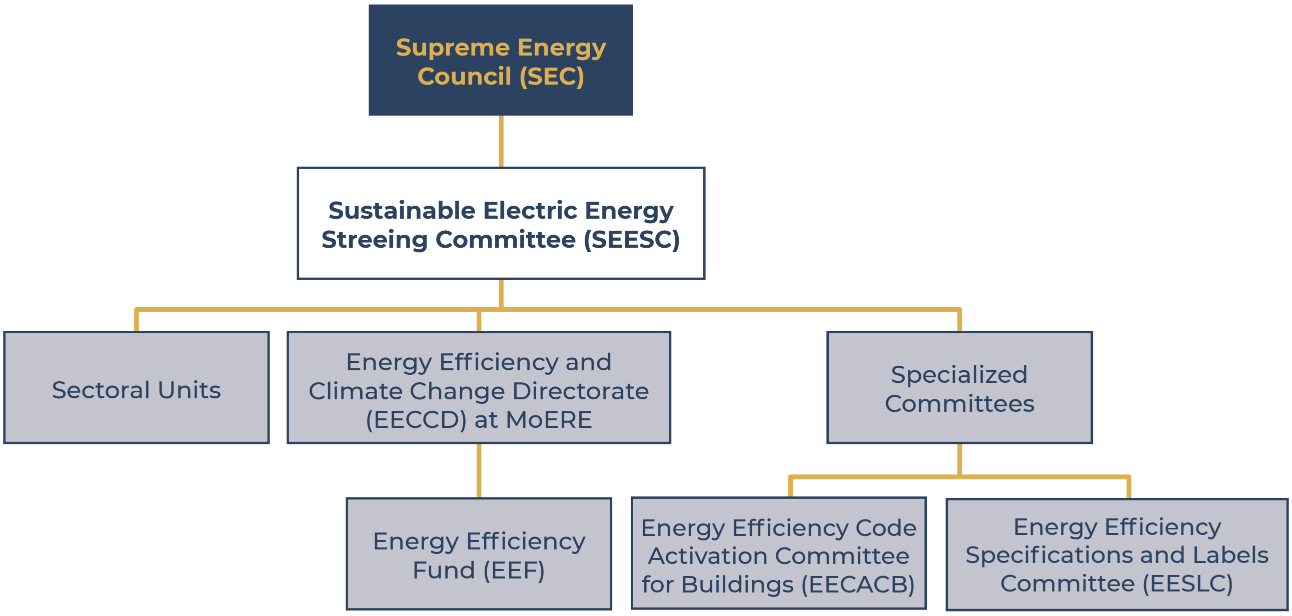
7. Appendices

Appendix 1
List of Agencies and Ministries Involved in Wastewater Governance

1. Ministry of Water Resources and Irrigation (MWRI)
2. Ministry of State for Environmental Affairs (MSEA)
3. Ministry of Water and Wastewater Utilities (MWWU)
4. Ministry Of Health and Population (MOHP)
5. Ministry of Finance
6. Ministry of Interior
7. Ministry of Agriculture and Land Reclamation
8. Ministry of Local Development
9. Ministry of Trade and Industry
10. Egyptian Environmental Affairs Agency (EEAA)
11. Egyptian Water and Wastewater Regulatory Agency (EWRA)
12. National Organization for Potable Water and Sanitary Drainage (NOPWASD)
13. Construction Authority for Potable Water and Wastewater (CAPW)
14. National Water Research Center

Source: Soulie, 2013

Appendix 2
Energy Efficiency Institutional Framework



Source: MoERE, 2018a

The institutional framework for energy efficiency comprises of:

1. The **Supreme Energy Council (SEC)**, composed of various ministers, oversees the development of ISES 2035 and guides the restructuring of energy markets.

2. The **Sustainable Electric Energy Steering Committee (SEESC)** supervises the Energy Efficiency Fund (EEF); the implementation of NEEAP II; the elimination of non-energy efficient appliances; ratification of energy efficiency indicators; and securing funds for capacity building programs.

3. The **Energy Efficiency and Climate Change Directorate (EECCD)**, affiliated with the MoERE, is responsible for securing funds for energy efficiency activities; establishing, verifying and accrediting energy managers and registers; monitoring and evaluating programs regarding the elimination of non-energy efficient appliances; and coordinating with stakeholders and concerned entities.

4. The **Energy Efficiency Specifications and Labels Committee (EESLC)** is headed by the Egyptian Organization for Standards and Quality (EOS); it is responsible for awareness-raising programs on energy efficient equipment and energy efficiency labels; proposing standards for ceasing imports and production of non-energy efficient devices; laying mechanisms for monitoring, verifying and enforcing energy efficiency labels as required by Article 51 of the Electricity Law.

5. The **Energy Efficiency Code Activation Committee for Buildings (EECACB)** is composed of officials from the Ministry of Housing, Local Development, New Urban Communities Authority (NUCA), EECCD, and representatives of the various governorates. It is responsible for raising awareness, developing capacity-building programs, and coordinating stakeholders regarding the activation of the energy efficiency code for buildings.

6. **Sectoral Units:** energy efficiency units have been established within ministries including the MoTI, the Ministry of Public Business Sector, Petroleum, Transport, Education and Local Development, where they are responsible for developing capacity-building programs within their respective sector; evaluating sector-specific energy efficiency programs; proposing sector-specific energy efficiency indicators and ensuring the availability of information required (MoERE, 2018a).