National Solid Waste Management Program (NSWMP), Egypt

Industrial Hazardous Waste Strategy

Commissioned by the German Agency for International Cooperation (GIZ) GmbH, NSWMP, Egypt

Written by **Black Forest Solutions GmbH, October 2020**

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Preface

With about 99.85 million inhabitants[1], Egypt is the most populous country in the Middle East. In 2016, around 21.7 million tons of municipal solid waste was generated. Driven by population growth and changing patterns of consumption, waste generation is expected to increase at a rate of 3.4% per year. Waste management services and infrastructure are unable to keep pace with these growth rates.

Only around 60% of the waste produced is collected at the moment, and less than 20% of this is adequately disposed of or recycled. While public spaces in some cities are kept clean, the situation in other parts of the country is problematic. A significant portion of the overall waste is disposed of in canals, rivers, streets, or open areas without any preventive measures to reduce the impact on the environment. This results in major environmental risks such as water, soil, and air pollution, and disfigures the landscape. It also poses a serious risk to human and animal health and negatively impacts the economy, especially the tourism sector.

Despite international support, the institutions responsible for waste collection and disposal are not performing their wide-ranging functions properly. The legal framework is inadequate, there is no strategic planning, and the allocation of responsibilities and tasks remains unclear. The waste disposal sector is significantly underfinanced and there is an enormous need for sustainable investment and services.

The National Solid Waste Management Programme (NSWMP) is being implemented jointly with the German Agency for International Cooperation (GIZ), the Kreditanstalt für Wiederaufbau (KfW) Development Bank, in cooperation with the European Commission and the Swiss State Secretariat for Economic Affairs. It is working to establish the structures required at the national level and – in addition to the contributions provided within the framework of financial cooperation – also supports the development of waste infrastructure in four governorates. Model waste-management approaches that are based on adapted technical solutions are being implemented with secure, long-term financing. Local expertise and capacities are being developed. At the national level, the Programme helps to put in place the necessary institutional, strategic, and legal frameworks.

The Programme supports the establishment of the Egyptian Waste Management Regulatory Authority (WMRA), which provides new services for the waste sector in cooperation with existing actors. These include policy and strategy development, support for and supervision of the governorates, and the creation of sustainable financing models.

[1] Central Agency for Public Mobilization and Statistics: January 2020

Inter-institutional coordination is being improved. Stakeholders from the public and private bodies, universities, and civil society are involved in planning, decision-making, and implementation processes, and networking between these groups has been improved.

New, decentralized approaches for waste collection and recycling will create 'green jobs' and promote the efficient use of resources.

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Abbreviations list

ADR	European Agreement concerning the International Carriage of Dangerous Goods by Road
AN	Annex
Ar	Article
BAT	Best Available Techniques
BATREF	Best Available Techniques Reference Documents
BFS	BlackForest Solutions GmbH
BMU	German Federal Ministry of the Environment, Nature Conservation and Nuclear Safety
BOT	Build-Operate-Transfer
CAPEX	Capital expenditures
CDW	Construction and Demolition Waste
CFCs	Chlorofluorocarbons
CIDA	Canadian international agency
CIP	Competitive Industrial Performance
ECC	Egyptian Cement Company
EEAA	Egyptian Environmental Affairs Agency
EGPC	Egyptian General Petroleum Corporation
EHSIMS	Egyptian Hazardous Substances Information & Management System
ELV	End-of-Life Vehicle
EPA	Environmental Protection Agency
EPR	Extended Producer Responsibility
ESM	Environmentally Sound Management
EU	European Union
EWC	European Waste Code
GCF	Gross Capital Formation
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GIZ	The German Agency for International Cooperation
HHW	Household Hazardous waste
HSE	Health Safety Environment
HW	Hazardous Waste
HWM	Hazardous Waste Management
HWTC	Hazardous Waste Treatment Center
IHW	Industrial Hazardous Waste
IHWMC	Integrated Hazardous Waste Management Centre
IMDG	International Maritime Dangerous Goods Regulation
IPPC	The European Integrated Pollution Prevention and Control
KfW	The Kreditanstalt für Wiederaufbau
KPIs	Key Performance Indicators

KrWG	Kreislaufwirtschaftsgesetz (Circular Economy Act)
LH	LafargeHolcim
MoA	Ministry of Agriculture
MoE	Ministry of Environment
MOEE	Ministry of Electricity and Renewable Energy
MoH	Ministry of Health
MoHUUC	Ministry of Utilities and Urban Communities
MoI	Ministry of Interior
MoP	Ministry of Petroleum
MoT	Ministry of Technology
MoT&I	Ministry of Trade and Industry
MSW	Municipal Solid Waste
NHWTC	Nasreya Hazardous Waste Treatment Center
NORM	Naturally Occurring Radioactive Material
NSWMP	The National Solid Waste Management Programme
OECD	Organisation for Economic Cooperation and Development
OPEX	Operational costs
PCB	Polychlorinated biphenyls
PCT	Physico-chemical treatment
Pr	Presentation
PRO	Producer Responsibility Organization
Rt	Report
SCC	Secondary Combustion Chamber
SMART	Specific, Measurable, Achievable, Relevant, and Time-bound
TRGS	Technische Regeln für Gefahrstoffe
UNARA	User´s Needs Assessment and Requirement Analysis
UNEP	United Nations Environment Programme
UNICO	United Oil Services Company
Web	Website
WEEE	Waste Electrical and Electronic Equipment
WHO	World Health Organization
WMRA	Waste Management Regulatory Authority
WSR	Waste Shipment Regulations

1. Executive summary

This report presents the national hazardous waste strategy for Egypt, including an extensive analysis of the hazardous waste management (HWM) system, as well as their general implications on the implementation of additional measures to improve the existing structure in the country. The assessment was carried out at a critical time as the country is presently reviewing its waste management practices and carrying out further waste management related projects within the framework of the NSWMP, jointly with the German Agency for International Cooperation (GIZ), the Kreditanstalt für Wiederaufbau (KfW) Development Bank in cooperation with the European Commission and the Swiss State Secretariat for Economic Affairs.

Definitions and terminologies are described at the beginning of the report to clarify different understandings of essential terms from the report.

The employed **methodology** for developing this study is founded on the user´s needs assessment and requirement analysis (UNARA). Based on this approach, data gathering via literature research and meetings with relevant stakeholders is conducted and enabled the identification of the main gaps and obstacles faced in Egypt related to hazardous waste.

One section is specifically dedicated to **hazardous waste management in Egypt**, focusing on the industrial generation of these waste streams. Despite the inaccurate/outdated data, the country has an estimate of 300,000 - 500,000 tons/year[20] in the production of industrial hazardous waste (IHW), mainly through eight industrial complexes. There are some treatment centres which include small incinerators, evaporation ponds, and hazardous waste landfills that are mainly located in the greater Cairo region. Co-processing is also applied for specific streams and represents an important outlet for hazardous waste since Egypt possesses the second largest cement plant worldwide.

After the analysis of the current hazardous waste management situation in the country, the main pillars for the German system are briefly described in the following chapter. **Germany** is well known for its developed technologies and innovative policymaking in waste management. Therefore, the country is **employed as a benchmark for the development of the national hazardous waste management strategy**. Besides a short overview of the relevant German legislation, main treatment technologies such as incineration, physico-chemical treatment, and hazardous waste landfill examples are provided. To conclude, specific hazardous waste fractions are correlated with their typical treatment/disposal methods and associated estimate costs. This provides a general understanding of financial demands, such as system requirements.

The strategy is presented in Chapter 6, including:

- Already existing **vision** for 2030, defined in 2015 by the Egyptian Environmental Affairs Agency and a specific suggestion related to hazardous waste;

- Five main **objectives**, which include (electronic) data monitoring, centralization of responsibilities, development of national treatment capacity, commitment from industrial waste generators and capacity building and knowledge transfer expansion;
- Twenty-one **targets** related to the above-mentioned objectives and **indicators** to measure whether these goals have been accomplished;
- Eight **recommended measures** to address the gaps and challenges identified in Egypt, including waste classification following the European Waste Code (EWC), stakeholder's responsibilities clarification and definition, enhancing cleaner production within industries, construction of integrated hazardous waste treatment centers, digitalization of waste monitoring, separate collection of hazardous household waste, establishment of extended producer responsibility (EPR) schemes for hazardous waste and implementation of professional tender processes.

Following this action plan, and after presenting these partial results to the governmental stakeholders, **financing schemes** are identified and briefly described in Chapter 7. Two mechanisms that are suitable for Egypt are described, namely: public subsidies via lower disposal fees or tax exemptions and financing by the private sector via the polluters pay principle.

Concluding the report, a **pilot assessment** of a chosen region is conducted. The 10th of Ramadhan city, including the El-Robikki leather cluster, was identified as a target area for a pilot project by the client and governmental authorities. The latter consists of a thermal treatment facility equipped with a rotary kiln. The 8th chapter of this report details the choice of the pilot regions as well as presents the minimal gate fee calculated to match the financial scheme and the hazardous waste stream generated in the area.

2. Definitions and terminology

Action plan	Sequence of steps that must be taken, or activities that must be well performed, for a strategy to succeed. An action plan has three major elements (1) Specific tasks: what will be done and by whom (2) Time horizons: when will it be done (3) Resource allocation: what specific funds are available for particular activities[2]
Agricultural waste	Waste produced from agricultural activities example: manure, oil, fertilizers, pesticides and herbicides, waste from slaughterhouses and poultry houses, veterinary medicines, etc[3]
Electronic waste	Any refuse created by discarded electronic devices and components as well as substances involved in their manufacture or use[4]
Extended Producer Responsibility	A policy approach under which producers are given a significant responsibility – financial and/or physical – for the treatment or disposal of post-consumer products[5]
Hazardous waste	Waste with properties that makes it dangerous or capable of provoking harmful effects on human health or the environment. Hazardous waste is generated from various sources, ranging from industrial manufacturing process wastes to batteries and may come in many forms, including liquids, solids, gases, and sludges[6]
Hazardous construction and demolition waste (CDW)	Waste streams generated during construction and demolition activities which meet the legal definition of hazardous waste. Examples of hazardous construction and demolition waste are waste paints, varnish, solvents, resins, contaminated drums, and containers, treated wood, etc[7]
Industrial waste	Waste generated from factories and industrial plants. Only a part of waste streams generated by industries has hazardous characteristics. The rest is similar to household waste[8]

[2] Business Dictionary (2020): Online Available at: http://www.businessdictionary.com/definition/action-plan.html (last consulted:30/03/2020)
[3] R. Ramírez-García (2019) V. Singh in Phytomanagement of Polluted Sites
[4] SearchDataCenter: Online Available at: https://searchdatacenter.techtarget.com/definition/e-waste (last consulted: 07/04/2020)
[5] OECD: Online Available at: https://www.oecd.org/env/tools-evaluation/extendedproducerresponsibility.htm (last consulted: 07/04/2020)
[6] The U.S. Environmental Protection Agency (EPA): Online Available at: https://www.epa.gov/hw/learn-basics-hazardous-waste (last consulted: 30/03/2020)
[7] EPA (2004) Construction, demolition, and renovation
[8] GIZ (2012): manual on industrial hazardous waste management for authorities in low- and middle-income economies.

Medical waste	Waste generated by health care activities includes a broad range of materials, from used needles and syringes to soiled dressings, body parts, diagnostic samples, blood, chemicals, pharmaceuticals, medical devices, and radioactive materials[9]
Recovery	The recovery of waste converting it into resources such as electricity, heat, compost, and fuel through thermal and biological treatment[10]. Waste can also be recovered through mechanical processes, retrieving valuable secondary raw materials
Recycling	It is the act of processing used materials into new products, materials, or substances for further use[11]
Strategy	Detailed plan to achieve success in situations such as politics, business, industry, sports or war[12] National waste management strategy: objective-based program that aims at developing, implementing, and maintaining a system of integrated waste management to minimize the negative impacts of improper waste management on the human health and the environment. It includes a general vision, concrete objectives, targets with key performance indicators, and measures to be implemented, aiming the achievement of these goals. Ideally, this strategy should be specific, measurable, achievable, relevant, and time-bound (SMART). The process should include a stakeholder exchange (e.g., in workshops and interviews) prior to the publication so that all concerned parties are involved in the strategy and proactively participate
Waste	Any substance or object which the holder discards or intends or is required to discard[13]
Waste Prevention	Also known as source reduction, means using less material to get a job done. Waste prevention methods help create less waste in the first place[14]

[9] World Health Organization (2020): Online Available at: https://www.who.int/topics/medical_waste/en/ (last consulted: 24/09/2020)
[10] http://www.belmont.wa.gov.au/Property/Pages/Reduce,Reuse,Recycle,Recover.aspx (last consulted: 09/04/2020)
[11] Collins Dictionary (2020):Online Available at: https://www.collinsdictionary.com/dictionary/english/recycling (last consulted: 18/09/2020)
[12] Cambridge dictionary (2020)
[13] Art. 3 Waste Framework Directive 2008/98/EC
[14] The U.S. Environmental Protection Agency(2016): Online available at :https://archive.epa.gov/epawaste/conserve/smm/wastewise/web/html/prevent.html (last consulted: 24/09/2020)

3. User needs assessment and Requirements Analysis (UNARA)

The UNARA is the essential first part of the National IHW Strategy and is based on four concrete steps:

- **Collection of data** and information about waste management in Egypt for the description of the current situation;
- **Recording and analysis of needs** (user needs) of relevant stakeholders involved in the waste management;
- **Deducing of gaps** by comparison of the current situation in Egypt with waste management systems to the state-of-the-art (benchmark to Germany) by the expert teams;
- **Deriving of requirements** to be met in the further course of the project or as part of the National Waste Management Strategy in the future.

3.1. Methodology

The UNARA methodology usually employs several work steps and methods to gather primary and secondary data such as:

- Documentation reviews;
- Meetings with WMRA staff;
- Questionnaires;
- Launch Event (Workshop);
- Interviews.

Due to time constraints, the methodology was adapted to the project framework in the best possible way and is represented by Figure 3-1.

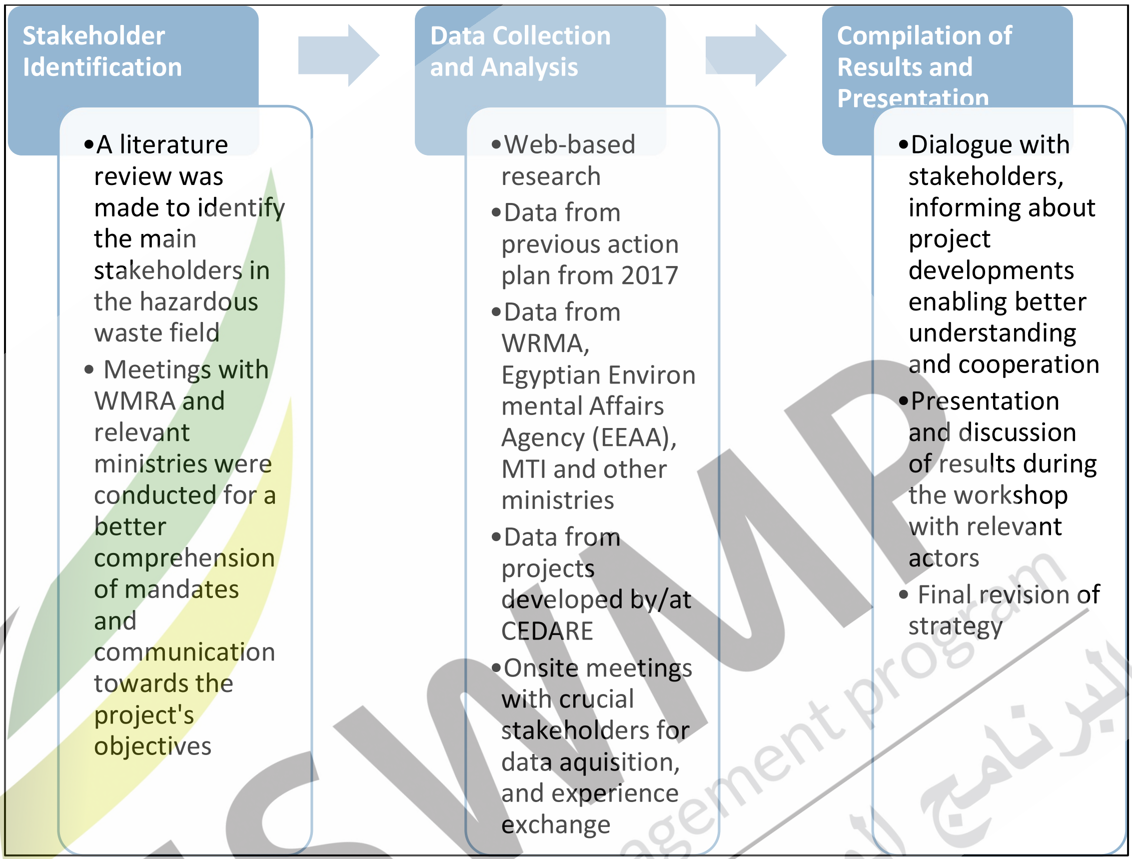

Figure 3-1 - Methodology for strategy development (Source: BFS, 2020)

After conducting the meetings and interviews, a follow-up process was required to collect feedback and related data from the identified stakeholders. All identified gaps and the requirements analysis in the field of waste management data are summarized within this report.

A brief register of research papers, books addressing waste management in Egypt is shown chronologically in a matrix in Annex 10.1.

3.2. Findings

Based on the proposed methodology and after the conduction of an onsite mission, some key aspects of the Egyptian HWM system were identified. Below, gaps and improvement opportunities are summarized.

3.2.1. Gaps and demands

Relevant stakeholders include, among others, hazardous waste (HW) generators from the private and public sectors, responsible authorities, non-profit organizations, and hazardous waste recovery and disposal facilities. Following the meetings with these actors and extensive data analysis from previous reports, the following gaps were identified:

1. Although in some cities such as 10th of Ramadhan and 6th of October data on waste types per industry and generated volumes are available or are currently being accessed, there is a **lack of reliable data along the whole hazardous waste generation chain**, from the waste generation, through the transportation until the final treatment and/or disposal in the majority of the country;
2. Lack of data is a partial consequence of the **shortage of monitoring and transparency** of national waste movements;
3. The waste **transportation manifest is manually filled,** and there is **no centralized compilation or verification of such information;**
4. The **inexistence of a harmonized waste coding system** favours the non-transparency, as **no clear definition of waste qualities exists;**
5. **Laboratories do not have sufficient capacities to analyse waste samples,** and several waste streams are categorized as "unknown" liquids or solids;
6. The process of representative HW **sampling** is not sufficiently defined and established in Egypt;
7. Approximately **13 certified treatment facilities serve in the country**. This capacity is not enough for treating the total volume of hazardous waste generated in the country (see Chapter 4). Significant under-capacities of hazardous waste treatment were identified, which shall be considered as a severe and immediate threat for maintaining environmental standards and sustainable economic growth in Egypt;
8. Existing incinerations, in several cases, do not match Egyptian or international standards. Specific incineration units for medical waste, in many cases, do not treat emissions;
9. One of the leading integrated treatment facilities in the country, **Nasreya, comprises one hazardous waste landfill, which is reaching its full capacity soon[15];**
10. The **existing hazardous waste treatment facilities** need **professional and regular auditing measures by the authorities;**
11. **A lack of packaging and collection units** (e.g. UN certified containers) was identified, as well as **a shortage of interim storage areas** for hazardous waste – and the lack of technical standards for the same;
12. Lack of **trained staff in the industry** – very restricted knowledge and education among workers dealing with hazardous waste;
13. Lack of **separate collection of hazardous waste from private households;**

[15] Reference to MoM with WMRA on the 05/05/2020

14. Besides, there are no **definitions of treatment standards**/legal definitions (such as TRGS 510[16], ADR[17], IMDG[18], rules of how to handle and treat hazardous waste, among others);
15. Lack of **compliance with international regulations** such as the Basel Convention and the Minamata Convention;
16. Lack of **legal implementation, enforcement, and penalties** for hazardous waste infringements;
17. Due to low enforcement, **hazardous waste producers do not pay/pay less** for the treatment of their generated residues, and the **development of viable treatment facilities is hindered;**
18. **Low level of technical knowledge** and **capacitated staff** within ministries and at decision-makers level;
19. Lack of **exchange between the national stakeholders**/strategic coordination between different responsible ministries ;
20. Lack of **available funds for proper management** of hazardous waste;
21. **Extended producer responsibility (EPR) and/or take-back schemes for hazardous waste,** e.g., for fluorescent tubes, batteries, solar panels (and other WEEE) are inexistent;
22. Lack of **public awareness campaigns on the threat of hazardous waste** and its consequences in human health.

3.2.2. Challenges and opportunities

Bearing in mind the above-mentioned obstacles Egypt must overcome to develop its HWM system; several challenges and opportunities are listed below:

1. To increase **transparency and supervision mechanisms**, an important measure is **monitoring and controlling hazardous waste producers, transportation, and treatment companies;**
2. For **clear definition and responsibilities** over the waste fractions, a **harmonization of the ministries in charge** for monitoring hazardous waste is required;
3. Closing the process loop by digitally **linking all involved parties in the life cycle of hazardous waste**: **waste producer** (industry), **logistics** (logistic companies), and licensed **treatment plants;**
4. **Create treatment capacity** and **develop the required technologies** in the country;
5. Develop **SMART targets**, which shall be maintained and cultivated.

[16] Technische Regeln für Gefahrstoffe - Lagerung von Gefahrstoffen in ortsbeweglichen Behältern (Technical Rules for Hazardous Substances - Storage of hazardous substances in nonstationary containers)
[17] Accord européen relatif au transport international des marchandises Dangereuses par Route (2020): (Agreement concerning the International Carriage of Dangerous Goods by Road)
[18] International Maritime Dangerous Goods Regulation (2020)

These opportunities will be further addressed in Chapter 6 as measures to be taken within the National Hazardous Waste National Strategy (NHWNS).

4. Hazardous waste management in Egypt

As described in Chapter 3, background research was conducted to obtain a deeper understanding of the IHW status in the Arab Republic of Egypt. This study enabled the identification of the following current data:

- Quantities and qualities of hazardous waste generated in the industrial sector in the year 2011;
- Main stakeholders in the IHW system;
- IHW management infrastructure, especially with reference to treatment facilities, packaging, collection, and transport;
- Hazardous waste legal framework;
- Financing models.

In addition to the above-mentioned data, the expert team identified a series of seven guidelines related to hazardous waste that were published by the Egyptian Ministry of Environment between the years 2001 and 2004. These documents (presented in Annex 10.2) are in accordance with the environmental law of the year 1994 and cover the following topics: HW classification, HW transportation, necessary authorizations for hazardous waste treatment centres, HW interim storage, safe treatment and disposal of HW, solvents treatment, and sections from the environmental law of the year 1994 that are related to HW. While these guidelines are a very good references of the hazardous waste sector in Egypt, they became outdated and require an update according to new national and international best practices and regulations.

Gathering these facts is a necessary first step towards the elaboration of a national management strategy for IHW in Egypt. The findings are presented in the following paragraphs of the report.

4.1. Hazardous waste data

Waste is considered hazardous if it has properties that make it dangerous or capable of having a harmful effect on human health or the environment[6]. This type of waste is generated from different sources such as industries, hospitals, households, and others.

To develop a HWM strategy for Egypt, one of the main milestones is to identify the prioritized HW streams in the country. During the meetings with governmental stakeholders, the following streams were labeled as priority HW in Egypt:

- **IHW**: including metallic dust and powder, explosive materials, contaminated container residues, and packaging, etc.;
- **Chemical waste**: including solvents, halogenated and non-halogenated organic substances, resins, glues, acid, and alkali solutions, etc.;
- **Oil waste**: mineral oils, oily substances, oil/water mixtures, etc.;

- **Agricultural waste**: pesticides, herbicides, fertilizers, sludge, etc.;
- **Medical waste**: infectious waste, cytotoxic waste, radioactive waste, pathological waste, etc.;
- **Waste Electrical and Electronic Equipment (WEEE)**: accumulators, fluorescent and energy-saving lamps, cooling equipment, IT, and telecommunication devices, etc.

This strategy focusses on industrial hazardous wastes. The generation of these waste streams, their treatment, and disposal are described in the following sub-chapters.

4.1.1. Industrial hazardous waste

The **increase in population** (99,848 million inhabitants in the year 2020[1]) has resulted not only in the **intensification** of municipal solid waste (MSW) production but also in an increase of **hazardous waste generation**. There is a growing demand for electrical and electronic devices, healthcare facilities, real estate, automobiles/mobility, and other daily needs. This scenario has led to an expansion of industrial production. Combined with a lack of waste treatment facilities (e.g., recycling), the national raw material needs, and the hazardous and non-hazardous waste production rose too.

Figure 4-1 illustrates the **locations of major industrial complexes, industrial zones, and free zones in Egypt**.

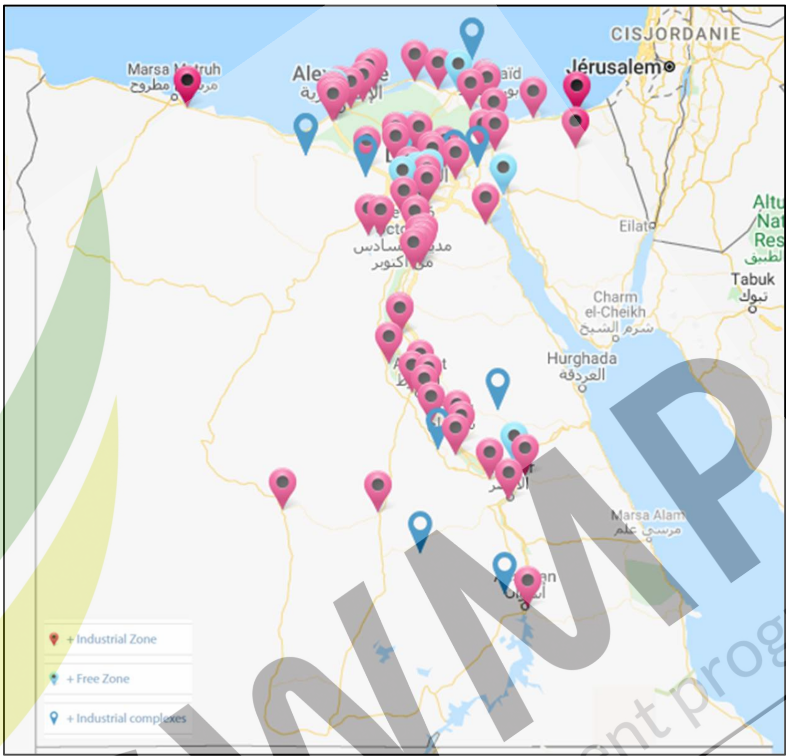

Figure 4-1 Map of industrial complexes, industrial zones and free zones in Egypt (Source: MOT&I, 2016)[19]

In the two major industrial city areas, Cairo (hosting e.g., the 6th of October and 10th of Ramadan Industrial zones) and Alexandria (hosting e.g. the Borg Al Arab Industrial zone), the quantity of industrial hazardous waste generated is roughly estimated with 60,000 tons/year, of which 28,000 are generated in Alexandria. There are nine major industrial areas in Egypt, generating different types and quantities of hazardous wastes. It is estimated that up to 200,000 tons/year of hazardous wastes are produced in these eight areas[20].

According to the GIZ country report on solid waste management in Egypt[20] ,there is a **lack of information regarding the exact amount of IHW generated in Egypt**. Two estimations were conducted for the years 2009 and 2011, with a yearly IHW generation of about 260,000 tons respectively **300,000 to 500,000 tons**.

To estimate the amount of hazardous waste production per year, there are simple methodologies that may be applied to receive rough figures. Two examples of these methods are the following:

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[19] Ministry of Trade & Industry (2016): Online available at:http://www.mti.gov.eg/english/InteractiveMaps/Pages/default.aspx (last consulted: 24/09/2020)

[20] GIZ (2013) Annual report for solid waste management in Egypt. Online available at: https://cairoclimatetalks.net/sites/default/files/EN%20Annual%20Report%20on%20Waste%20in%20Egypt_2013.pdf (Last Consulted: 23/09/2020)

- Methodology i.a described by United Nations Environment Programme (UNEP) and implemented i.a. by Fraunhofer Umsicht[21] in a reference country (during the elaboration of the Kuwait National Waste Master Plan);
- Methodology used in Jordan for hazardous waste data gathering.

These methodologies are detailed in Annex 10.3.

4.1.2. Emissions

Greenhouse gas (GHG) **emissions** were identified as **one priority environmental issue in Egypt**[22]. Even though the country only produces 0.6% of global GHG emissions, it is very affected by its environmental impacts, including climate change and the increase of sea levels. These effects might also increase flood risk, raise the groundwater table, and prolong waterlogging. Consequently, agricultural yields might be seriously reduced. During dry seasons, saline water might dominate, causing shortages of freshwater for agriculture[23]. Figure 4-2 represents the evolution of GHG emissions in Egypt between the years 1990 and 2013. Within the scope of this report, it shall be highlighted that the waste sector has risen its emission percentages throughout the years.

Medical waste treatment contributes to the total emissions significantly, resulting from the waste management sector. As a matter of fact, incineration is the main method used to treat waste from healthcare facilities (please refer to chapter 4.2.5 for more details). According to testimony from the representative of the Ministry of Health[24], the majority of these facilities are not equipped with flue gas treatment technology thus emit harmful particles to the human health such as lead, carbon monoxide, sulphur dioxide, nitrogen oxides among others. To minimize these emissions, limits were set for emissions from medical waste incineration units and were published in the amendment of the Executive Regulations of Law 4/1994[37]. However, there is a lack of guidelines for the construction and maintenance of medical waste incinerators.

The boost in waste-related GHG emissions results from the increase of generated amounts and the lack of appropriate treatment. And this underlines the importance of an implementation of a national (hazardous) waste management strategy in Egypt.

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[21] Reference: Fraunhofer Umsicht (2020): eMISK$_{Waste}$: Kuwait National Waste Management Strategy (NWMS)

[22] Ministry of Environment (2016): The state of the environment report in the Arab Republic of Egypt for the year

[23] Chen a et Al (1999) Major impacts of sea-level rise on agriculture.

[24] Comment from Ms. Samia Galal during the webinar for presentation of the partial results of the strategy on the 21/04/2020

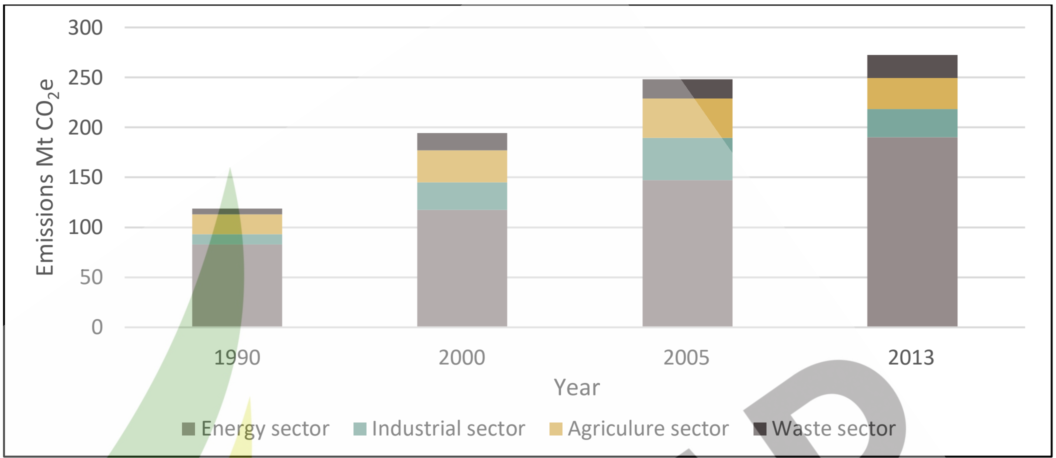

Figure 4-2 Yearly greenhouse gases emissions from the different sectors (Source: World Resources Institute, 2017[25])

4.2. Hazardous waste management infrastructure

The waste management sector in Egypt faces many challenges due to **inefficient collection, packaging, storage, and transportation systems** (e.g., no registration system for hazardous waste transportation companies), **lack of stakeholder awareness** in the processing chain, **lack of tracking and monitoring,** and most importantly, **very reduced number of recycling, treatment, and disposal facilities** compared to generated amounts of waste, among others.

Figure 4-3 shows the **current HWM infrastructure in Egypt**.

[25] World resources institute (2017). Online available at: https://www.wri.org/blog/2017/04/interactive-chart-explains-worlds-top-10-emitters-and-how-theyve-changed (last consulted 09/04/2020).

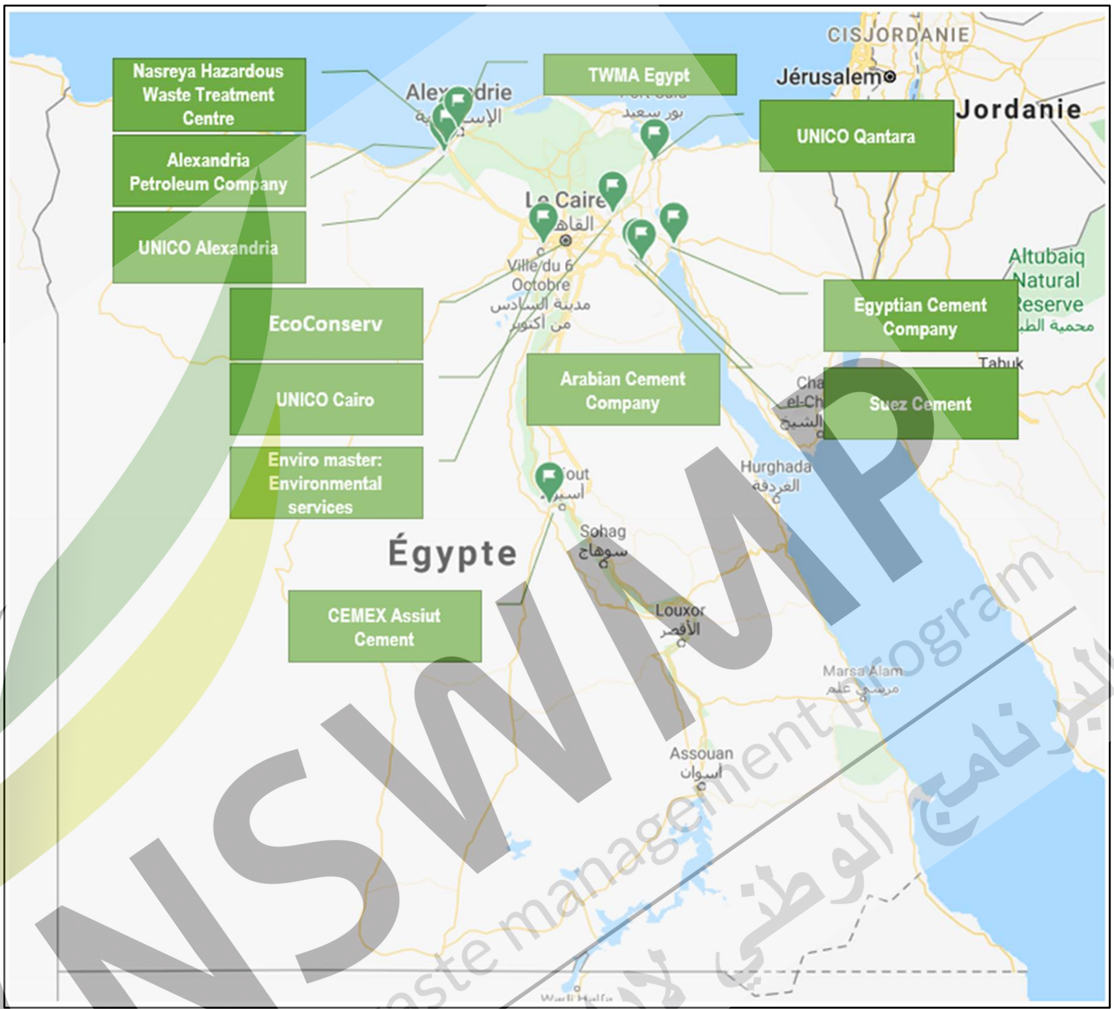

Figure 4-3 Map of hazardous waste treatment facilities in Egypt (Source: Google)

4.2.1. Nasreya hazardous waste treatment centre (NHWTC)

Located 60 km away from Alexandria, NHWTC is the **only public centre of its type in the country**. The facility was established in the year 2000 by a cooperation between the Egyptian Environmental Affairs Agency (EEAA), the Alexandria governorate, and the Ministry of Foreign Affairs of Finland. According to an interview[26], the centre is equipped with several facilities for the treatment and disposal of hazardous waste:

- A **sanitary landfill** extended on an area of 14,000m² and four evaporation ponds with a total surface of 5,000m², all designed according to European standards;

[26] Interview with the director of operation Eng. Amgad Yakoub (2020) Online available at: https://bit.ly/3aOdc4t (last consulted 02/04/2020)

- A **landfill for medical waste** with a capacity of 40,000 tons per year;
- A **physico-chemical treatment plant** for liquid hazardous waste;
- A physico-chemical treatment plant for highly soluble liquid waste;
- An **incineration plant;**
- A shredding unit for plastic recycling;
- **Two incineration plants for oil-contaminated waste.**

In addition to that, NHWTC coordinates with hazardous waste generators to take samples of HW, analyse them and schedules appropriate transportation.

The latest upgrade of NHWTC was conducted in the year of 2011 in collaboration with the Government of South Korea. The project aimed to establish a facility for the treatment of fluorescent bulb tubes and the safe recovery of mercury.

Figure 4-4 Nasreya Hazardous Waste Treatment Centre (NHWTC) (Source: Hazardous Waste - SAP 2017 [38])

4.2.2. Egyptian Hazardous Substances Information & Management System Certified hazardous waste treatment companies

- **Green Valley***

The company holds a special approval of EEAA issued by MoE to work in the field of **transport and the safe disposal of hazardous waste**. It offers the following services[27]:

- Managing hazardous waste **from industrial companies;**

***According to the PMU, as per July 2020, this facility is not licensed to handle HW**

[27] Company profile(2020):Online Available at: https://www.linkedin.com/company/green-valley-egypt/about/ (last consulted 09/04/2020)

- Providing **special vehicles to transport hazardous waste** compatible with the terms of environmental, health, safety and according to the Egyptian Environmental Law No. 4 of 1994;
- Recycling and incorporated non-hazardous waste (scrap) in manufacturing systems authorized from EEAA;
- Scrap segregation area management;
- **Petroleum tanks cleaning;**
- **Measuring of all exhausts emissions** as SO_x or NO_x, CO, CO_2, and particulates;
- Measuring of noise, lighting, wind speed and directions and issue the wind atlas and sea levels for industrial zones.

- **EcoConServ***

The current site at Elkorimat road, with an area of approximately 60,000 m^2, includes a green area for potential expansion, a **designated recycling area** (for valuable fractions), **evaporation ponds**, **3 hazardous waste landfill cells, and 4 incinerators**. The 3 hazardous landfill cells are equipped with leachate and gas collection systems and receive mostly incineration ashes.

Regarding its space disposition, approximately 30% of the land is empty for expansion, 20% is occupied with evaporation ponds, 20% reserved (yet empty) to start the recycling of paper and plastics.

From the 4 incinerators (1 fully installed, 3 others in commissioning), 3 setups accept 100 kg/hour; one unit will receive 300kg/hour. A fifth unit is expected to be incorporated soon[28].

At the beginning (2006/2008), the company started receiving medical waste only. First, the sterilization method was preferred. Later, autoclave systems were replaced by batch incinerators.

***According to the PMU, as per July 2020, this facility is not licensed to handle HW**

[28] Data acquired during a site visit on the 04/03/2020

Figure 4-5 EcoConserv hazardous waste treatment facility (Source: BFS, 2020)

- **Enviro master: Environmental services**

Located in 6th of October city in Cairo, this company is authorized by the EEAA to carry out hazardous waste management services. The company provides the following services[29]:

- **Waste collection service** from all residential and commercial units;
- **Construction and demolition waste collection services.**

4.2.3. Cement industries co-processing hazardous waste

Amongst authorized hazardous waste treatment facilities, **there are four cement kilns that are approved to also co-process hazardous waste**. They offer a less expensive alternative compared to dedicated HW incinerators (e.g., rotary kilns in Europe) for destruction of most HW types. The energy content of the waste is used to substitute fossil fuels. These facilities are the following.

- **Egyptian Cement Company (ECC): LafargeHolcim Group**

Located in Ain Sokhna, it is owned by LafargeHolcim (LH) Group. It is the second-largest cement plant worldwide with a cement production of 10 tons/year. ECC runs 5 kilns, each with a capacity of 5,000 t/d clinker. The cement kiln is used for the incineration of organic HW. Liquid HW can be injected directly into the main burner or in the pre-calciner of any of the 5 kilns. Solid waste feeding is only established for one kiln. The major clients are the oil industry and the pharmaceutical industry. Also, ECC is receiving contaminated soil from oil spills. Additionally, ECC is providing full services, including site remediation and transportation.

- Actual incoming flow of solid HW/year = 3,000 - 4,000 tons;
- Actual incoming flow of liquid HW/year = 1,500 - 2,500 tons[30].

[29] Master Company website (2020). Online available at: https://master4is.com/client/%D8%A7%D9%86%D9%81%D9%8A%D8%B1%D9%88-%D9%85%D8%A7%D8%B3%D8%AA%D8%B1-%D9%84%D9%84%D8%AE%D8%AF%D9%85%D8%A7%D8%AA-%D8%A7%D9%84%D8%A8%D9%8A%D8%A6%D9%8A%D8%A9/ (Last Consulted: 24/09/2020)

[30] International Finance Corporation (2014), "Waste Heat Recovery for the Cement Sector: Market and Supplier analysis Waste Heat Recovery for the Cement Sector".

Figure 4-6 Lafarge-Holcim cement industry in Ain Sokhna (Source: Egypt Independent, 2019)[31]

- **CEMEX Assiut**

The plant consists of 3 kilns and has a total clinker production of about 4.7 million tons/year[32]. By burning industrial and household waste, climafuel[33] and agriculture waste, CEMEX reduces CO_2 emissions and its heavy fuel consumption[34]

According to the annual report for solid waste management in Egypt for the year 2013, CEMEX cement was substituting, at that time, approximately 15.2% of their fuel with agricultural residues and was planning to expand to replace 50% of their energy by such residues by 2014[35].

- **Suez Cement**

Two of its plants Kattameya and Helwan use agriculture wastes and refused derived fuels as a partial replacement for conventional fossil fuels[36]

- **Arabian Cement Company (ACC)**

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[31] Egypt Independent (2019), "Egypt establishes waste management factory for alternative fuel in Ain Sokhna". Online available at: Online available at: https://egyptindependent.com/egypt-establishes-waste-management-factory-for-alternative-fuel-in-ain-sokhna/ (Last consulted: 25/09/2020)

[32] EEAA (2010) The cement Industry in Egypt: Challenges and innovative Cleaner Production solutions

[33] it's an alternative fuel derived from residual household and commercial waste, which is used in the heating of the cement kiln at the plant

[34] Cemex (2020). Online available at: https://www.cemex.com.eg/sustainability/environment (Last consulted: 24/09/2020)

[35] New center for Integrated studies of Land & Environment (2013) Annual Report for Solid Waste Management in Egypt

[36] Suezcement (2020). Online Available at: https://www.suezcement.com.eg/en/environmental-policy (Last consulted: 24/09/2020)

ACC utilizes alternate fuels like rejects from municipal solid wastes, dried sewage sludge from water treatment plants, agricultural wastes, and others in their plants.

By the end of 2013, ACC started burning alternative fuels and the target is to achieve 30% of its required energy substituted by these alternative fuels within 3 years.

4.2.4. Oil and Gas Industries Co-processing Hazardous Waste

The Egyptian General Petroleum Corporation (EGPC) operates as a state-owned corporation overseeing the petroleum industry in Egypt. All of Egypt's refineries are run by EGPC subsidiaries. EGPC also influences the private sector by issuing licenses and by coordinating service contracts. Waste oil management is one of the HW related issues that is organized by EGPC. The following are oil sector companies involved in HW treatment.

- **Alexandria Petroleum Company**

It has a waste oil recycling capacity of 30,000 tons/year, currently receiving 22,000 tons/year. The specification of waste oil that they can accept includes water content of 5%, low concentration of heavy metals, and volatile substances. The waste oil is collected mainly by two companies in Egypt: Misr Petroleum and Petro trade under the authorization of the EGPC. They deliver the collected used oil to Alexandria Petroleum.

- **United Oil Services Company (UNICO)**

It belongs to UNICO Group, an oil field company that offers environmental services in Egypt, and is certified by the EEAA to treat organic hazardous waste streams from the oil and gas industry. The company has ownership of three sites equipped for HW treatment in Egypt:

- Cairo - Alex Road: 10 feddans in an area located 60 kms from Alexandria where it operates a HW facility for treating liquid organic waste from the gas industry and an incinerator for solid oily waste with 50 t/d capacity;
- Cairo-Ismailia Road (10 Km from 10th of Ramadan): 22,000 m^2 landfill for the disposal of inorganic HW. They have 2 incinerators with 50 t/d capacity each;
- The Ismailia site also has evaporation pond for oily wastewater treatment;
- In 2007, the total quantity of treated solid oily waste at the Ismaleya site was about 15,000 tons;
- Qantara: third HW landfill receiving HW from the gas industry.

- **TWMA Egypt (Integrated Drilling Waste Management)**

Located in Amerya, Alexandria, for the treatment of waste oil, oily waters, contaminated cuttings, and other types of well drilling contaminated soil with hydrocarbon. The treatment principle adapted in this plant is the Thermo-Mechanical Cuttings Cleaner (TCC) technology from Halliburton.

4.2.5. Medical hazardous waste treatment facilities

There are **154,965 hospital beds in Egypt, and approximately 77,477 kg of hazardous medical waste are generated per day in the country**[37]. The **treated segment of hazardous medical waste in Greater Cairo** (Cairo, Giza, and Kalyobiya Governorates) **is about 27%**[37]. The **untreated hazardous medical waste is either mixed with municipal solid waste or illegally traded for recycling**. The problem is currently handled in Egypt through EEAA coordination with the Ministry of Health and Population and Ministry of Local Development to control the comprehensive system (segregation at source, collection, transfer, and final disposal processes). Hazardous medical waste treatment is generally conducted by thermal incineration. About 188 incinerators are distributed across the Governorates, in addition to 48 units of shredding autoclaves. The distribution of these facilities is illustrated by Figure 4-7 and Figure 4-8.

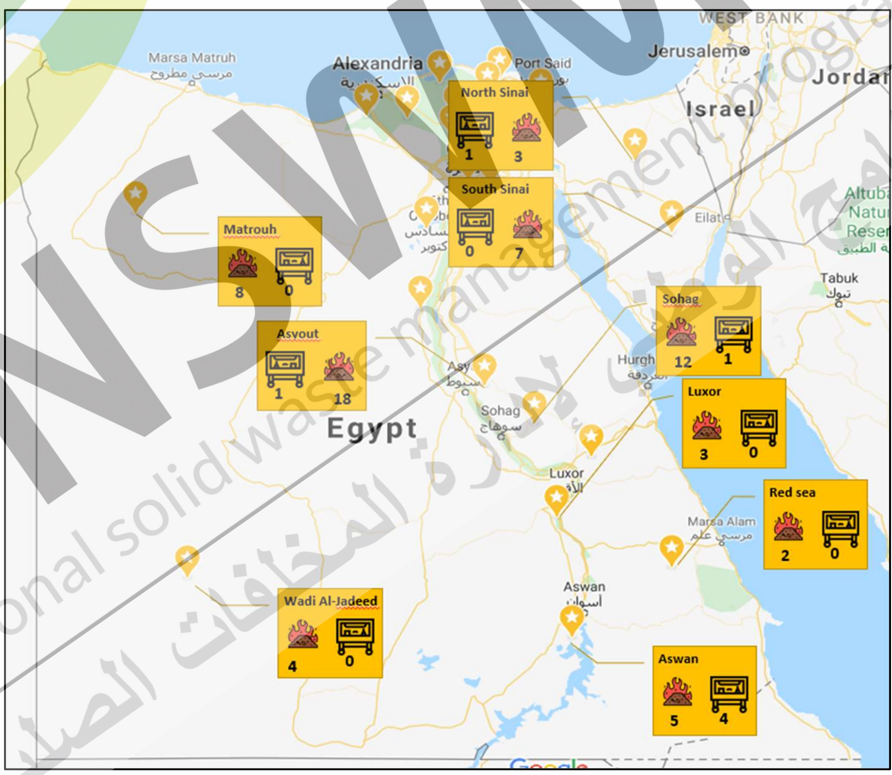


Figure 4-7 Map of medical waste treatment facilities in Egypt (Source: Google, 2020)

[37] GIZ: Country report on the solid waste management in EGYPT (2014):Online Available at: https://www.retech-germany.net/fileadmin/retech/05_mediathek/laenderinformationen/Aegypten_RA_ANG_14_1_Laenderprofile_sweep_net.pdf (Last consulted: 24/09/2020)

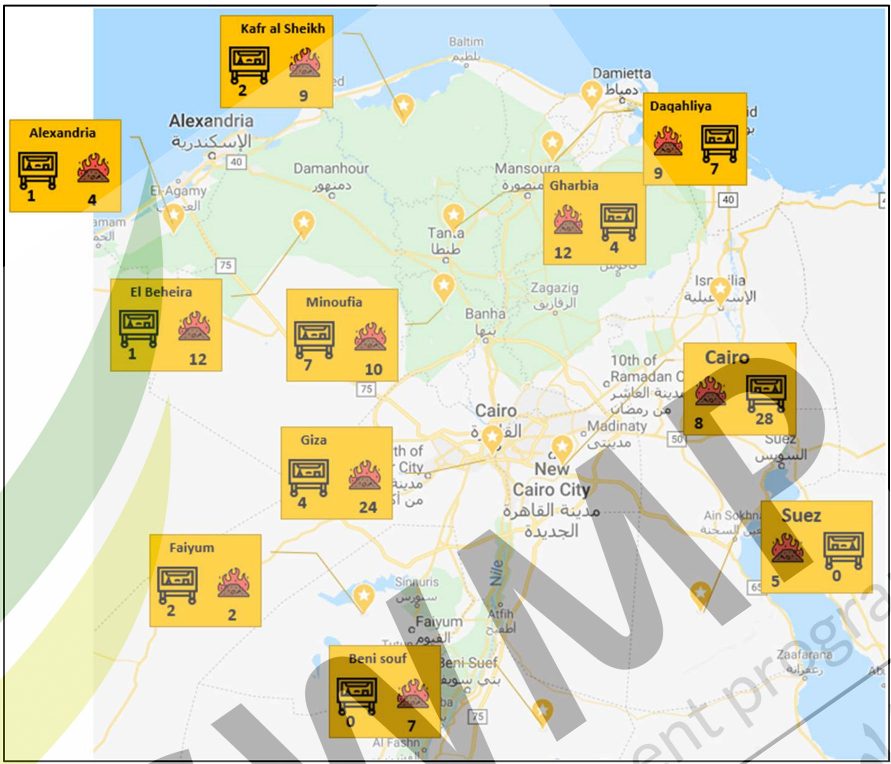


Figure 4-8 Map of medical waste treatment facilities in the north of Egypt (Source: Google, 2020)

4.3. Stakeholders overview

Mapping main stakeholders within the country is a crucial step to understand and recommend roles and responsibilities while establishing an IHW strategy.

The **major players** are grouped and shown in Figure 4-9.

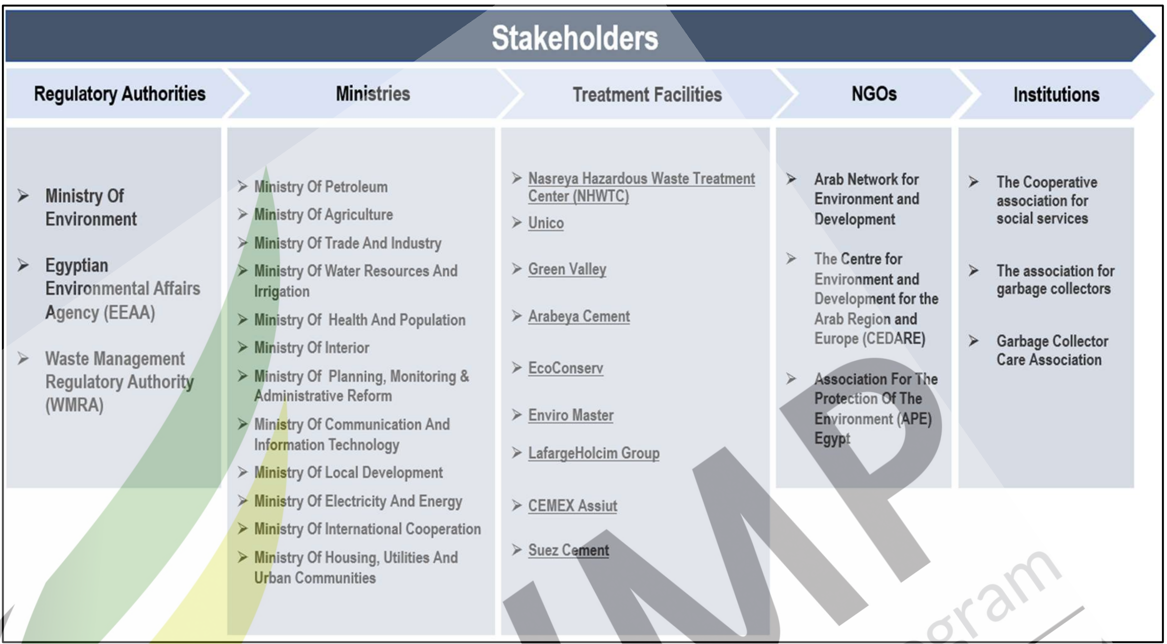


Figure 4-9 Stakeholders overview (Source: Hazardous waste - SAP 2017[38])

Besides the above-mentioned stakeholders, **large waste generators** (e.g., oil enterprises), **collection companies, universities, and the informal sector** for some specific valuable hazardous waste fractions (e.g., lead-acid batteries) are also relevant. Specifically related to hazardous waste, the roles of the ministries are described in Annex 10.5.

4.3.1. Hazardous waste responsibility per ministry

According to the Executive regulation of the law of the environment issued by a decision of the prime minister n°338 for the year 1995, **each ministry is required to provide a hazardous waste list generated by the activities covered by its mandate** (see annex 10.5). An **analysis of these lists was conducted** to check **responsibility overlapping between ministries** of main HW types. From this analysis, **chemical waste, contaminated packaging waste, and infectious waste were the most common streams** that overlapped between the lists provided by the ministries, namely the Ministry of Health (MoH), the Ministry of Interior (MoI), the Ministry of Agriculture (MoA) and the Ministry of Technology (MoT). Lists from the Ministry of Environment (MoE), Ministry of Trade and Industry (MT&I), Ministry of Petroleum (MoP), and Ministry of Electricity and Renewable Energy (MOEE) were not provided before the delivery of this report. These intersection raises the challenge of allocating responsibilities between governmental actors and hinders the development of a proper HW management system.

[38] National solid waste management program (2017) Hazardous waste – Sector action plan (SAP)

4.4. Legal aspects

For decades, the Arab Republic of Egypt had legislations and rules for activities related to the environment. The **environmental law of 1994 is considered the first official legal document in this field**. Since then, it has been updated and followed by laws and decrees in accordance with the continuously evolving environmental challenges in the country, and in line with the international environmental agreements. Annex 10.8. lists the current legislation relevant to hazardous waste in Egypt.

Despite existing legislation, several obstacles regarding the lack of enforcement and monitoring on the management of hazardous waste have been identified within the Chapter 3.2.1.

As of August 2020, the Egyptian House of Representatives approved the draft law regulating waste management. The key aspects of this law are[39]:

- The law stipulates that producers shall be responsible for the recycling of the company's consumed products and waste;
- 25% of the mortgage tax revenues that are given to every governorate shall be allocated for the waste management activities;
- The law prohibited burning agricultural waste, dumping it in waterways or disposing it in places rather than designated dumps;
- Manufacturers shall increase the percentage of recyclable inputs to limit rate of industrial waste;
- Whoever deliberately violates the law's provisions shall be punished by imprisonment for 5 years maximum. If the violations resulted in the injury of a person with a permanent disability, the violator shall be punished by 5 to 7 years in jail. The penalty shall be life imprisonment if the act results in the death of 3 or more people;
- Whoever releases dangerous materials or waste the territorial water or in Egypt's exclusive economic zone shall be punished with life imprisonment and a fine of not less than EGP 5 million and not more than EGP25 million.

➔ These new regulations are very prominent and present a strong basis for the enforcement and implementation of the herewith industrial hazardous waste strategy in Egypt.

4.5. Industrial hazardous waste monitoring in Egypt

Legislations in Egypt impose a duty of care responsibility on IHW generators, hence these entities are obliged to transport and treat their waste at authorized companies. This was regulated by the

[39] EU EGYPT DELEGATION PRESS REVIEW 25.08.2020

executive regulation of the law of the environment issued by decision of the Prime Minister n°338 for the year 1995.

Law 4/1994 and its executive regulations stipulate that handling of HW requires a license issued by a competent administrative authority. The purpose of such a license is to ensure that the movement of HW is carried out in accordance with necessary safety conditions and that proper measures are implemented to ensure the minimization the potential to public health and the environment.

In 2004, the Canadian international agency (CIDA) developed an electronic online system on hazardous waste from different sources. This program is called Egyptian Hazardous Substances Information & Management System (EHSIMS). Even though the project website is currently active, the tool is not functioning.

To **track** these **waste streams**, all **involved entities are required to fill a paper manifest** for all generated, transported, and treated waste.

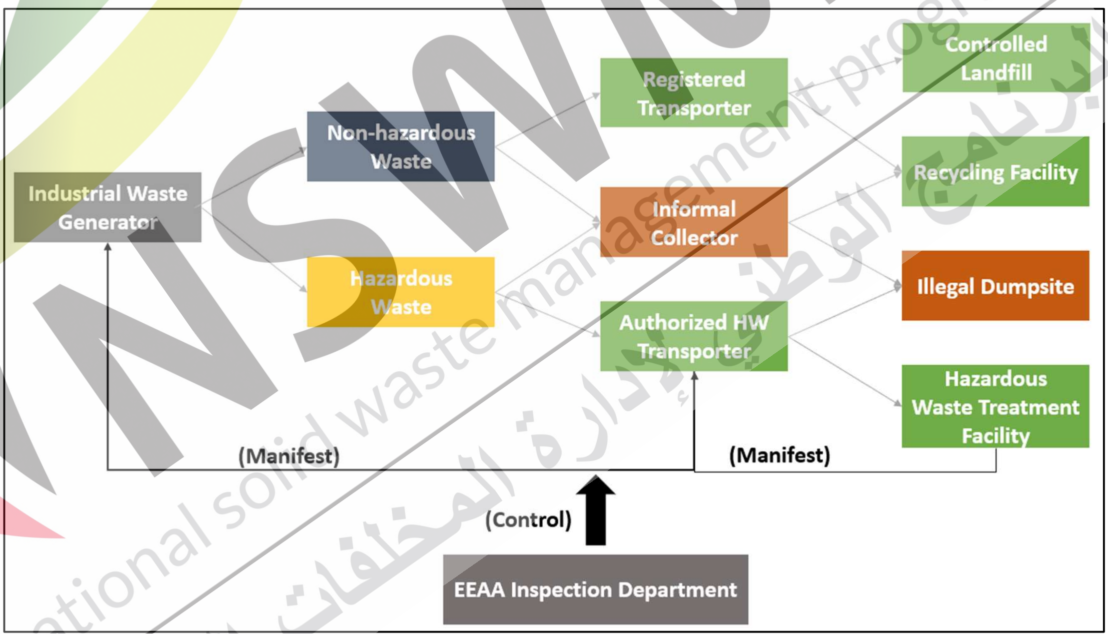


Figure 4-10 Industrial hazardous waste monitoring system in Egypt (Source: Hazardous waste - SAP 2017[38])

5. German benchmark[40]

As a result of continuous consumption of raw materials, drainage of natural resources, and shortage in landfill capacity, **Germany has made waste management and circular economy one of its priorities since the early 1990**s. Henceforth, the country has achieved remarkable recycling rates. As a matter of fact, 14% of raw materials used in the country's economy are recovered from waste, and 67% of household waste, 70% of commercial waste and around 90% of construction and demolition waste is recycled. **Since 2005 landfilling of untreated waste is banned** in Germany.

The **circular economy in Germany is not only observed in the recycling rates, but also from a business and job creation** perspective. According to the German Federal Ministry of the Environment, Nature Conservation and Nuclear Safety (BMU)[41],in 2014, more than 270,000 people were working in waste management, with an annual turnover of about 70 billion €.

5.1. Legal framework

Being part of the European Union (EU), Germany has a **common legal basis for HWM** as other member states which regulate the HWM within the country and outside its borders. These legal acts are formulated following international regulations such as the Basel, Rotterdam, and Stockholm conventions. The fundamental legal documents of the European community waste management policy are presented in Annex 10.8.

The **main lessons learned** from Germany is that the country has **taken measures to decouple waste generation from economic growth**. This means that, if the economy grows, the amount of waste does not automatically increase. That is one of the main goals that needs to be strategically achieved.

Waste intensity is an indicator of decoupling waste from economic output. As shown in Figure 5-1, it decreased by 28.6 %points between 2000 and 2017.

[40] Waste management in Germany 2018: Facts, data, diagrams by Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU)
[41] Jaron, A. (2018) Circular Economy

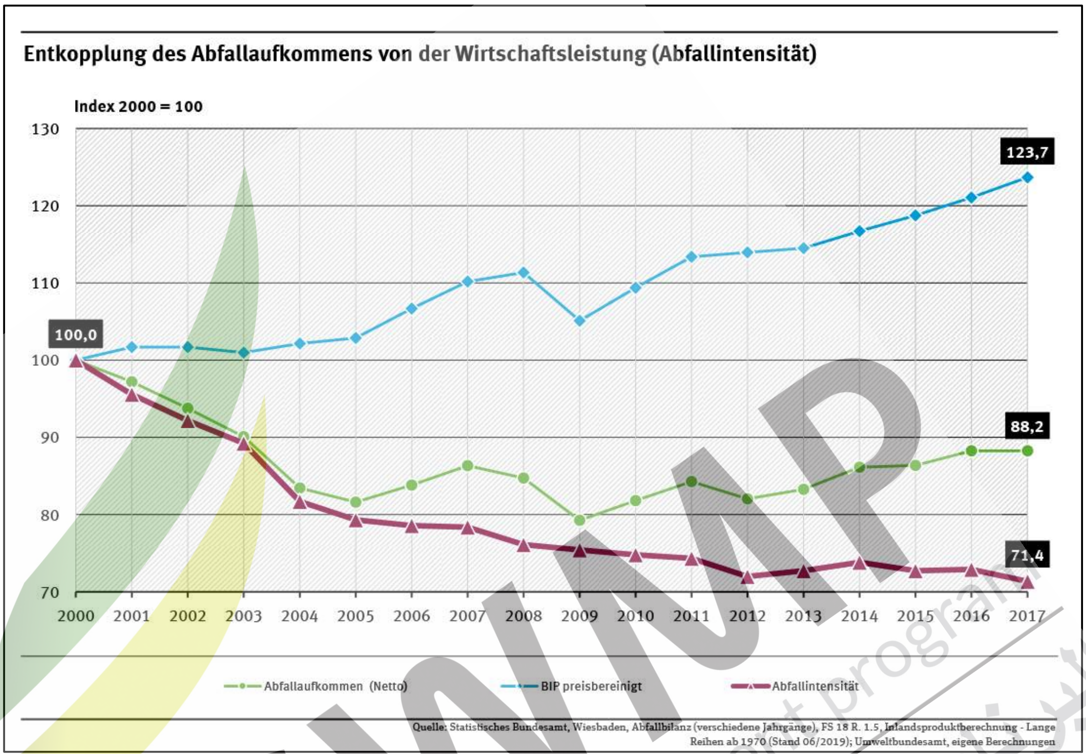


Figure 5-1 Decoupling waste from economic output in Germany (Source: UBA, 2020)[42]

The **classification of hazardous waste** was a major step towards the regulation of its packaging, storage, transportation, and transshipment in and outside of Germany.

Laying down **strict criteria for sanitary landfills** such as **mandatory treatment before disposal and ban of landfilling** for certain types of waste in the year 2005 has led to **increasing the number of waste recycling facilities, treatment plants and incinerators**, therefore, decreasing the landfilling rates in Germany significantly.

Thermal treatment is the pillar of waste treatment in Germany. The country has numerous types of installations dedicated to different kinds of waste where energy is recovered to generate heat and/or electricity. These facilities follow the EU directive 2010/75/EU that regulates emissions control for thermal treatment facilities and presents Best Available Techniques (BAT) reference documents, which set regulations for facilities to improve their environmental performances.

In Germany, **each federal state is responsible for issuing permits, monitor and inspect the industrial facilities at its territory**. The prosecutor is responsible for enforcement and prosecution of relative laws.

[42]Umweltbundesamt (2020). Abfallaufkommen. Online Available at: <https://www.umweltbundesamt.de/daten/ressourcen-abfall/abfallaufkommen#abfallintensitat> (Last Consulted 18/09/2020)

5.1.1. Hazardous waste monitoring

Starting from 2010, a digital hazardous waste tracking system was obligatory implemented in Germany. It was successfully tested in the states of Berlin and Brandenburg then generalized throughout the 16 states. The principal of the system is that every HW generator of more than 10 tons/year is obliged to register their waste data.

All stakeholders involved in the HWM chain (generation, transportation, and disposal) have access to a digital platform where they register the waste data at each step from its generation to its final destination.

Figure 5-2 shows an example of such a **digital manifest** in which you must include:

- **Waste definition and European waste code;**
- **Volume** in tons or cubic meters;
- **Contact details** from waste producer, logistics company and treatment facility – all three parties must input their online signature in the manifest;
- **Dates** in which the waste was collected and delivered to the facility.

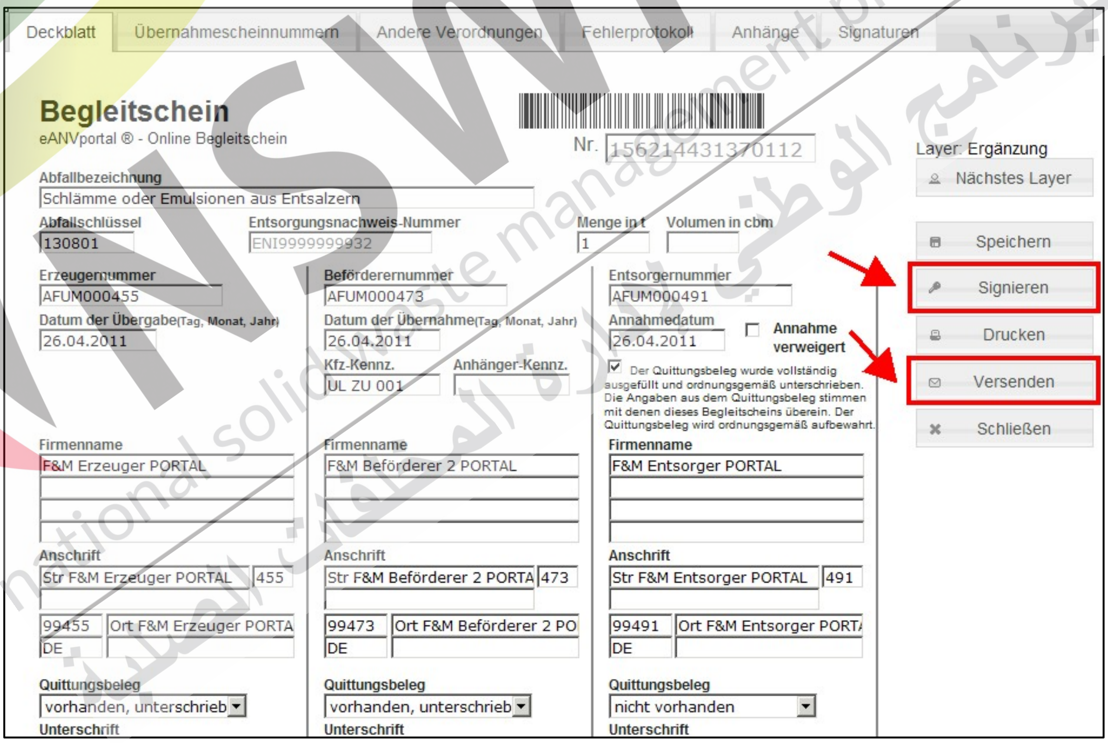


Figure 5-2 Digital transport manifest for hazardous waste in Germany (Source: eANV, 2020)[43]

[43] eANVportal (2020), "Eanvportal". Online Available at: <https://www.eanvportal.de/> (Last Consulted 16 September 2020).

5.2. Technical aspects

In the European Union, industrial installations must take into consideration certain technical specifications to minimize their emissions and operate in the best possible manner. These techniques are specified in the Best Available Techniques Reference Documents (BATREF) (UBA, 2014)[44]. Published by the European Integrated Pollution Prevention and Control (IPPC), BATREF are a series of reference documents resulting from an exchange of information between EU members, NGOs, and industry associations to determine the best technical practices.

5.2.1. Thermal treatment

The thermal treatment of hazardous waste means its **processing at high temperatures**. The choice of technology and process highly depends on the composition of waste: volatile content, inert component, compositions, consistency etc.

The main types of thermal treatment equipment for hazardous waste are:

- **Combustion chambers;**
- **Rotary kilns;**
- **Fluidized bed reactors;**
- **Plasma incineration.**

The continuous operation of a thermal treatment unit requires constant regulation of mass, material, and energy balance inside the apparatus to ensure an efficient process. Temperatures inside a rotary kiln range from 900°C to 1200°C[45].

A **continuously operated treatment facility for hazardous waste** is to be preferred compared with a batch operated system mainly due to less handling requirements in a continuous system, better burn-off results, and hence better economics.

Almost 100% of Central European thermal treatment facilities are operated in a continuous process.

[44]Umwelt Bundesamt (2014): Online available at: https://www.umweltbundesamt.de/en/topics/waste-resources/waste-management/waste-types/hazardous-waste (last consulted: 24/09/2020)

Figure 5-3 State-of-the-art rotary kiln for hazardous waste (Source: ALBA Group, 2016)

A **post-treatment process** is mandatory to ensure the purification of the flue gases before release in the atmosphere and recovery of the by-products in form of slag, ash, or dust as well as energy recovery.

There are **30 hazardous waste incineration facilities dedicated only to IHW**. The typical capacities per plant line in Germany are ranging from 20,000-100,000 tons/year[45]. The smallest kilns in Germany are around 25,000 tons/year, like MEAB mbH, in Brandenburg and larger ones with capacities close to 100,000 tons/year, like AVG mbH in Hamburg, AGR in North Rhine-Westphalia and GSB-Bayern, in Bavaria.

The total generation of hazardous waste to be treated in a **high temperature rotary kiln** in Germany is **240 thousand tons in the year 2016**[46] and its **thermal treatment capacity of hazardous waste incineration plants in Germany is about 1.5 million tons/year**. According to statistics made on transboundary shipment of hazardous waste, Germany is one of the top 3 importers of

[45] Scholz. R et Al (2008), Waste incineration systems; current technology and future developments in Germany
[46] Eurostat (2016): Online available at: https://ec.europa.eu/eurostat/statistics-explained/index.php/Waste_statistics#Total_waste_generation (last consulted: 24/09/2020)

hazardous waste in Europe[47]. This can be explained by the over treatment capacities of treatment in the country.

5.2.2. Physico-chemical treatment (PCT)

A percentage of **25% to 30% of hazardous waste in Germany is treated using physico-chemical processing**. Using this method, HW is either destroyed or stabilized into non-hazardous waste, which is then recycled or disposed of.

PCT is mostly used to treat liquid hazardous waste. The process usually starts with a concentration of the hazardous substances, for example through sedimentation, distillation, or filtration; this represents the physical part of the treatment, it improves the process yield and increases its cost-effectiveness. After that, HW is either neutralized, oxidised, or reduced using a combination of physical and chemical reactions, thus allowing it to be either recycled or disposed of.

The majority of PCT facilities in Germany use technologies that are based on the Best Available Technology document set up by the EU commission[48]. Usually, facilities are specific to a certain type of hazardous waste. Whenever a waste stream is delivered, it is analysed in a laboratory to identify its composition and chemical behaviour. The most applicable treatment method is then selected[48].

5.2.3. Hazardous waste landfill

In Germany, the option of a permanent underground storage is mainly foreseen for **hazardous waste that may not be easily decontaminated due to economical or ecological reasons**. Examples are **heavy metals containing filter dusts, specific contaminated soil, slags, sludges, linings, or construction waste containing PCB (polychlorinated biphenyls)**[49].

In the year 2016, about **24% of treated hazardous waste** in the country **was disposed of** in the landfill[50].

[47] Eurostat 2016. Top 10 Types Of Haz Wastes Shipped From EU MS, The Top 3 Types Of Treatment For Shipments Of These Wastes And The Top 3 Export And Import Countries According To The European Low (tons), online Available at: <https://ec.europa.eu/eurostat/statistics-explained/index.php?title=File:Top_10_types_of_haz_wastes_shipped_from_EU_MS,_the_top_3_types_of_treatment_for_shipments_of_these_wastes_and_the_top_3_export_and_import_countries_according_to_the_European_LoW_(tons),_2016.png> (Last Consulted 16/09/2020).

[48] Umwelt Bundesamt (2014): Online available at: https://www.umweltbundesamt.de/en/topics/waste-resources/waste-disposal/physicochemical-waste-treatment (last consulted 24/09/2020)
Umweltbundesamt Physicochemical Waste Treatment 2014). online Available at: <https://www.umweltbundesamt.de/en/topics/waste-resources/waste-disposal/physicochemical-waste-treatment> (Last Consulted 24/09/2020).

[49] Helge Wendenburg (2010) Underground Disposal – a Key Element of the German Waste Management Concept.

[50] Eurostat(2016): Online available at :https://ec.europa.eu/eurostat/statistics-explained/index.php?title=File:Hazardous_waste_treatment,_2016_(kg_per_inhabitant).png (last consulted 24/09/2020)

There are five landfill classes in Germany divided according to the type of waste they dispose of; Two of which are dedicated to hazardous waste:

- **Class: DK III**: for hazardous waste that can be deposited above ground;
- **Class DK IV**: for hazardous waste that must be deposited below the surface of the earth.

Additionally, to be disposed of in a landfill, hazardous waste must be pre-treated to fulfil the following requirements:

- Must **not be explosive** or self-igniting;
- Must **not be combustible under the storage conditions;**
- Must **not release gases** (may form neither explosive nor other pollutant gases);
- The components of the waste must **not be able to react with each other** or with the surrounding rock (e.g., salt rock);
- Must **not contain pathogens of contagious diseases;**
- Must **not swell.**

5.3. Financial plan

The costs for the treatment and/or proper disposition of hazardous waste are commonly higher than the willingness to pay from most of the waste generators. Based on the polluter pays principle, the generators are financially responsible for the waste they produce.

5.3.1. Polluter pays principle

This principle's adoption by the Organisation for Economic Cooperation and Development (OECD) goes back to the year 1972. It aimed at **allocating costs for pollution control**. This principle is simple: each polluter must bear the costs of steps that he is legally bound to take to protect the environment, such as measures to reduce the pollutant emissions and effluent treatment[51].

In Germany, this principle is enforced by the Environmental Liability Directive as a strategy element since the early 1990s to prevent and minimize damages on human health and the environment.

5.3.2. Hazardous waste treatment costs

Table 5-1 represents an example of some **common hazardous waste treatment costs** offered by the German HWM market.

[51] OECD (1992) The Polluter-Pays Principle OECD Analyses and Recommendations

Table 5-1 Treatment price list for hazardous waste treatment (Source: BFS, 2020)

Hazardous waste type	Treatment Type	Price range per mt (€)	Price range per mt (EGP[52])
Hazardous waste typically generated in the chemical industry			
Solvents, Containing Halogenated Solvents	PCT	400-800	7,000-14,000
Non-halogenated Solvents (including but not limited to alcohols, toluene, and acetone)	PCT	400-800	7,000-14,000
Profile of an unknown liquid for disposal purposes	PCT	3,400-3900	58,000-67,000
Paint contaminated with non - halogenated solvents and paint related material, brushes etc.	PCT	600-900	10,000-15,000
Laboratory Chemicals, Hydrogen Sulfate (Chemical Defense Equip. Kits), Water Purification/ Chlorination/ Testing Kits, etc.	PCT	1,400-1,900	24,000-32,000
Acids organic and inorganic (including but not limited to alcohols, toluene, and acetone)	PCT	1,400-1,900	24,000-32,000
Hypochlorite containing items (calcium hypochlorite, chlorine bleach, liquid and solid)	PCT	1,400-1,900	24,000-32,000
Bases and Mixtures of Bases (including but not limited to sodium hydroxide, potassium hydroxide)	PCT	1,400-1,900	24,000-32,000
Gas, Compressed Cylinders - including (but not limited to) chlorine, chlorofluorocarbons, fluorine, bromine, lliquefied petroleum gases, methyl ethers – Weight includes the cylinder.	Thermal treatment	2,900-3,400	50,000-60,000
Puttie and fillers, halogenated and non-halogenated	Thermal treatment	800-1,200	13,000-20,000
Hazardous waste typically generated in the oil and gas industry			
Waste petroleum liquid waste (mixtures of oil, water, antifreeze)	PCT	850-1100	15,000-19,000

[52] Conversion rate:1€=17,46 EGP (2020): Online Available at: https://www.xe.com/fr/currencyconverter/convert/?Amount=1&From=EUR&To=EGP (Last Consulted: 24/09/2020)

Hazardous waste type	Treatment Type	Price range per mt (€)	Price range per mt (EGP[52])
Filters, may be contaminated with (but not limited to) petroleum, oil, fuels	Thermal treatment	650-1,050	11,200-18,100
Oil contaminated Solids - including rags, absorbents, cardboard, etc. and POL Contaminated with hazardous substances	Thermal treatment	750-1,050	13,000-18,100
Cartridges, diesel starter, propane, etc.	PCT	750-1,050	13,000-18,100
Waste fuels	PCT	100-300	1,700-5,100
Hazardous waste typically generated in the agriculture sector			
Asbestos and Asbestos -Bearing Items - Including but not limited to safes, vaults, cabinets, brake-shoes, insulation materials, etc.	Hazardous Waste Landfill	100-500	1,700-5,100
Pesticides, Insecticides, Biocides	PCT	1,200-1,600	20,000-27,600
PCB Items < 50 ppm PCB	PCT	350-750	6,050-13,000
PCB Contaminated Soil >= 50 ppm	PCT	350-750	6,050-13,000
Other hazardous waste			
Drums and cans, plastic, and metal, contaminated with hazardous substances	Thermal treatment	500-900	8,650-15,500
Fluorescent Light Tubes and sodium/ mercury discharge lamps (SOX, HPL/HPI, SL/PL)	Recovery of mercury then disposal	1,000-2,000	17,000-34,500
Batterie, Nickel Cadmium and Nickel Metal Hydrid	Metals recovery then disposal	750-1,050	13,000-18,100
Batteries, Lithium	Metals recovery then disposal	2,000-3,000	34,500-52,000
Batteries, Mercury	Mercury recovery then disposal	8,100-8,500	140,000-147,000
Activated Carbon and Filters containing activated carbon with chromium	Thermal treatment	800-1,100	1,400-19,000

Hazardous waste type	Treatment Type	Price range per mt (€)	Price range per mt (EGP[52])
Fire extinguishers (Dry Powder, ABC, BC, etc. – May include liquid extinguishers)	Thermal treatment	900-1,200	15,560-20,750
Mercury and mercury containing items	Stabilisation of mercury then disposal in underground landfill	8,100-8,500	140,000-147,000
Printing products, toners, inks etc.	Thermal treatment	600-1,000	10,400-17,300

5.4. Action timeline for Germany

Achieving a successful national HWM system is a long-term process that requires strategic planning and a succession of measure progressively implemented in regard to national legislations, waste treatment infrastructure, compliance with international regulations, engagement of the polluters, among others. Germany is a model country for taking steps towards its now renown HWM system. Figure 5-4 represents the main milestones for the setup of the HWM system in Germany.

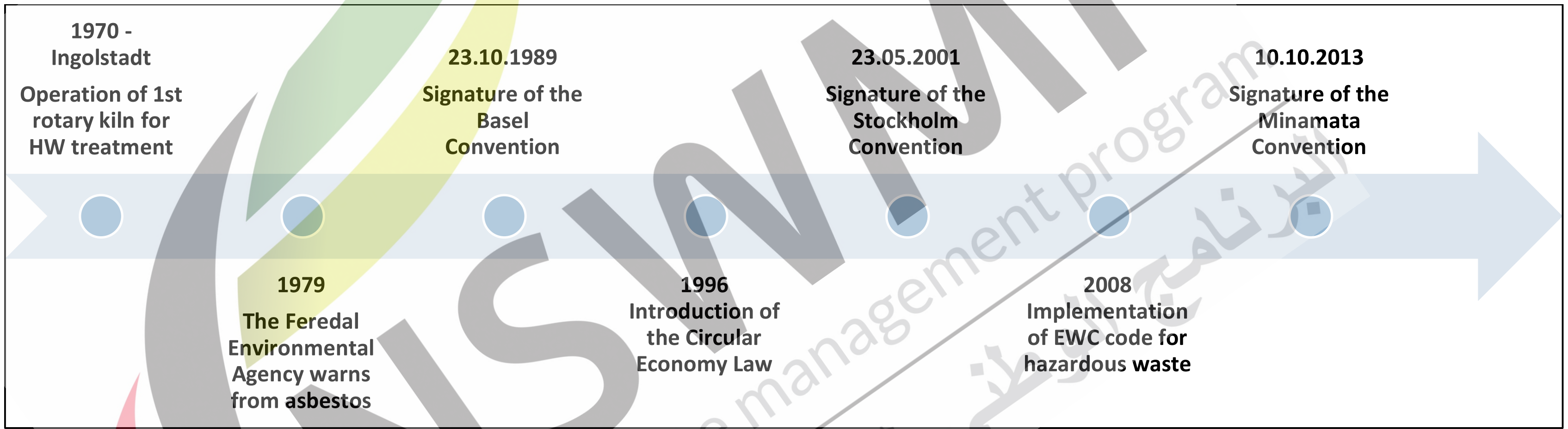


Figure 5-4 Milestones of the HWM system setup in Germany. (Source: BFS, 2020)

6. Strategy

The process takes the UNARA results as a starting point and aims at identifying all information that is needed for the development of the National HWM Strategy in Egypt. The following steps are applied:

- Screening of the UNARA findings to identify all challenges and needs that have been reported by different Egyptian stakeholders;
- Based on the screening, priority waste stream and priority issues are identified;
- Results are used to develop the vision, objectives, and targets;
- Implementation of measures are detailed.

According to international scientific practices for developing a national waste management strategy, the following element must be defined:

- A plan needs to set out a **vision** of what it intends to achieve;
- Long-range goal set through planning is specified and translated into **objectives;**
- Objectives are in turn specified and translated into **targets**, which shall be 'SMART': specific, measurable, achievable, relevant, and time-bound;
- **Measures** are recommended to achieve these targets.

In general terms, a strategy is defined as a detailed plan for to achieve success. As illustrated by Figure 6-1, there are five steps to develop a rewarding strategy:

- Develop a **vision**: where are we trying to go?
- Fix **objectives**: how are we going to go about it and when?
- Set **targets**: how will we reach the objectives?
- Think of **alternatives**: what are the possible ways?
- Create an **action plan**: what will change, what will be done, by whom, and by when?

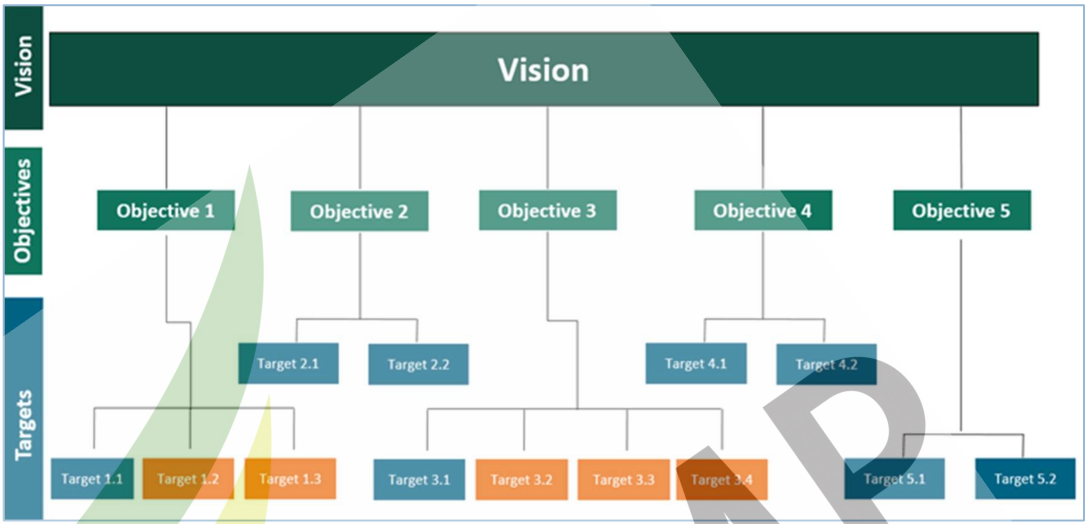


Figure 6-1 General strategy scheme (Source: BFS, 2020[53])

This chapter will be dedicated to developing the phases of a strategy for the creation of a national HWM plan in Egypt. This would be the basis for issuing legally binding laws and regulations by the authorities in Egypt in order to improve the industrial HWM in the country.

6.1. Vision for Egypt

Defining a vision is foreseeing the ideal set up which will be reached in case the current situation is dealt with perfectly. A vision statement should be brief, broad, inspiring, and understandable by a greater community. Accordingly, the **vision for the national HWM plan for Egypt was defined in 2015 by the Egyptian Environmental Affairs Agency** as the following:

"By the year 2030, the environmental dimension will be an essential axis in all development and economic sectors in a manner that achieves security of natural resources and supports the fair use and optimal exploitation of them and investment in them in a manner that guarantees the rights of future generations in them, and works to diversify the sources of production and economic activities, and which contributes to support competitiveness, Providing new job opportunities, eliminating poverty, and achieving social justice while providing a clean, healthy and safe environment for the Egyptian citizen."

Specifically, to hazardous waste, it is important to include in the vision the negative aspects that improper management may bring to the civil society. It includes not only environmental contamination but severe health issues. At the same time, safe HWM can trigger industrial and

[53] Development of National Waste Management Strategy in Kuwait

economic growth and direct foreign investment. Therefore, a **suggestion by the authors of this report** is described below:

*„The vision of the National Hazardous Waste Management Strategy Egypt is developing an effective hazardous waste management system which minimizes the negative effects of hazardous waste generation and treatment on the **people of Egypt** and the environment while targeting the decoupling of industrial economic growth from waste accumulation in Egypt."*

6.2. Objectives

The basis of a waste management strategy is a stated vision, which determines the general policy direction for waste management for a set period. In order to substantiate the adopted vision, the waste management strategy will have to list **more concrete objectives**.

Of particular importance for developing objectives are findings from the UNARA process. By considering the information of the UNARA, the authorities and relevant stakeholders may ensure that the chosen objectives and subsequently set targets fit into the reality of waste management in Egypt.

Based on this gathered information, priorities defined by the government and identified by the experts, the recommended five objectives for this strategy are:

1- **Gathering, tracking, and monitoring all hazardous waste data in the country**. Electronic data must be compiled and controlled by a centralized authority;
2- **Centralization of responsibilities** among different stakeholders and clear definition of public and private responsibilities by adopting and enforcing comprehensive legislations;
3- **Development of** sufficient **national treatment capacities** for priority hazardous waste streams;
4- **Integration and commitment from industrial waste generators** in taking financial responsibility in safe and professional handling of waste;
5- **Development of capacity building, knowledge transfer and awareness raising** among governmental bodies, public and private stakeholders, industry staff and citizens.

In the Figure 6-2 below, the objectives for the NWMS of Egypt are presented.

Figure 6-2 Overview of the five objectives for the NHWSP in Egypt (Source: BFS, 2020)

6.3. Targets

For each objective there are several specific, measurable, actionable, realistic, and time-bound targets. They are actions to make in order to attain a specific objective. **Targets are regularly updated and reassessed throughout the project's progress**. Every target must fulfil the following requirements to be considered efficiently:

- Targets are not ranked by their order and all of them have equal importance;
- Targets should not overlap;
- Each target needs to fulfil at least one of the objectives;
- Targets should be SMART (see Figure 6-3).

Figure 6-3 SMART Chart (Source: Apiary Financial, 2020[54])

6.3.1. Priority waste streams

Identifying the priority waste streams together with the stakeholders is the first step towards defining the national HWM strategy targets. During several discussions with stakeholders in the country, and after analysing current initiatives and efforts already dedicated to some specific waste fractions, POPs (including pesticides) and WEEE, **industrial hazardous waste** and hazardous CDW was defined as a priority waste stream for this strategy. Common hazardous CDW are mentioned in the Annex 10.12. The vision and objectives are the same for all priority waste streams, just the targets are different.

6.3.2. Targets per objective

Five objectives have been identified to implement the national HWM system in Egypt. Accordingly, targets are defined following the criteria mentioned above.

Table 6-1 Targets and timelines according to the strategy's objectives (Source: eMISK, 2019)[55]

#	Objectives	Targets	Timeline
1	**Gather, track, and monitor all hazardous waste data in the country. Data must be compiled**	(1.1) EWC system must be fully implemented in the country	Within 2 years after adoption of the strategy

[54] Apiary Financials (2020) online available at: https://apiaryfinancial.com.au/take-stock-summer-holiday/ (last consulted: 24/09/2020)

[55] Reference: Fraunhofer: eMISK$_{Waste}$: National Waste Management Strategy (NWMS) (Track 4)

	and controlled by a centralized entity	(1.2) At least 80% of industries and hazardous CDW generators must be audited once per year and report is published in the EEAA website	Within 2 year after adopting the strategy
		(1.3) Up to 90% of the total IHW and hazardous CDW produced in Egypt must be declared	Within 2 years after adoption of the strategy
		(1.4) Illegal dumping of waste outside the hazardous waste landfills rates must be maximum 10%	Within 5 years after adoption of the strategy
		(1.5) Digital waste manifest must be implemented in Egypt for 100% of industrial waste producers	Within 3 years after adopting the strategy
		(1.6) 70% from all logistic companies which transport hazardous waste must have appropriate licenses and participate in the digitalization of waste transport controlling	Within 2 year after adopting the strategy
2	**Centralization of responsibilities among different stakeholders and clear definition of public and private responsibilities by adopting and enforcing comprehensive legislations**	(2.1) Committee between stakeholders must be organized and functioning	Within 1 year after adopting the strategy
		(2.2) There must be one responsible entity for monitoring and controlling of HWM in Egypt	Within 2 years after the adoption of the strategy
		(2.3) There must a clear definition of roles and responsibilities between centralized entity and relevant stakeholders. This shall be announced through an official channel	Within 2 years after adoption of the strategy
3	**Development of national treatment capacity for priority hazardous waste streams**	(3.1) One integrated hazardous waste treatment center (IHWTC) shall constructed per industrial complex (see Figure 4-1)	Within 10 years after adoption of the strategy

		(3.2) Each IHWTC must encompass one laboratory for waste analysis	Within 10 years after adoption of the strategy
		(3.3) Each IHWTC must encompass one interim storage for hazardous waste	Within 10 years after adoption of the strategy
		(3.4) Existing treatment facilities must be audited once per year and report is published in the EEAA website	Within 1 year after adopting the strategy
		(3.5) One main hazardous waste tender, written by a professional, neutral, and experienced firm, must be released every 1 year	Within 2 years after adoption of the strategy
4	**Integration and commitment from industrial waste generators in taking financial responsibility in safe and professional handling of waste**	(4.1))70% of industrial waste generators must sign a Memorandum of Understanding (MoU) committing to allocate at least 1% of their revenues to proper waste treatment/disposal	Within 1 years after adopting the strategy
		(4.2) EPR scheme for hazardous waste with minimum 70% of participation from the industrial hazardous waste generators must be established	Within 3 years after adoption of the strategy
		(4.3) Penalties for illegal dumping of hazardous waste must be created/raised and enforced by centralized entity	Within 1 year after adoption of the strategy
5	**Development of capacity building, knowledge transfer and awareness raising among governmental bodies, public and private stakeholders, industry staff and citizens**	(5.1) At least 80% of hazardous waste related staff (from WMRA, MoE, MoH, EEAA, MT&I, among others) must be trained by external consultant. Trainings are conducted once every year and include revision/optimization of internal procedures, best practices on waste	Within 2 years after adoption of the strategy

		management, updates on upcoming legislation and international conventions and review of existing contracts	
		(5.2) At least 90% of industrial staff and staff at construction sites responsible for handling hazardous waste within the facility must be trained by external consultant once every two years. Training proof shall be shared with centralized regulatory agency	Within 3 years after adoption of the strategy
		(5.3) All companies with more than 10 staff must have an environmental officer, who is responsible and liable for all the generated hazardous waste	Within 2 years after adoption of the strategy
		(5.4) Establishment of one governmental program with purpose of informing citizens on HWM. This program shall implement collection schemes for household hazardous waste (HHW) fractions	Within 2 years after adoption of the strategy

Explicitly related to treatment capacity and processes (Objective #3),

Table 6-2 and

Table 6-3 suggest specific targets for hazardous waste from the industry and from the oil sector.

Table 6-2 Hazardous waste – Industry without oil sector (Source: BFS, 2020)

#	Measurable parameter	Landfill rate	Step in waste management process chain	Waste treatment
1	**Target value "moderate ambition**	56%	Alternative "moderate ambition	- Co- incineration in rotary kiln of cement production, after pre-treatment (25%) - Landfill (without exported waste being landfilled) (56 %)

				- Export (interim storage needed) (19 %) For hazardous CDW: -100% landfill
2	**Target value "medium ambition"**	56%	Alternative "medium ambition"	- Co-incineration in rotary kiln of cement production, after pre-treatment (25 %) - Landfill (without exported waste being landfilled) (56 %) - Export (interim storage needed) (5 %) - Mono hazardous waste incinerator (rotary kiln) (14 %)
3	**Target value "high ambition"**	56 %	Alternative "high ambition"	- Co-incineration in rotary kiln of cement production, after pre-treatment (25 %) - Chemical physical treatment, organic and inorganic (5 %) - Landfill (without exported waste being landfilled) (56 %)- Export (interim storage needed) (0,1 %) - Mono hazardous waste incinerator (rotary kiln) (9 %) - Recycling (5 %) For hazardous CDW: -100% landfill

Table 6-3 Hazardous waste – Oil industry (Source: BFS, 2020)

#	Measurable parameter	Landfill rate	Step in waste management process chain	Waste treatment
1	**Target value "moderate ambition**	1%	Alternative "moderate ambition	- Bioremediation (79 %)

				- Co-incineration in rotary kiln of cement production, after pre-treatment (10 %) - Landfill (without exported waste being landfilled) (1 %) - Export (interim storage needed) (10 %)
2	**Target value "medium ambition"**	1%	Alternative "medium ambition"	- Bioremediation (79 %) - Landfill (without exported waste being landfilled) (1 %) - Export (interim storage needed) (8 %) - Mono hazardous waste incinerator (rotary kiln) (12 %)
3	**Target value "high ambition"**	1 %	Alternative "high ambition"	- Bioremediation (79 %) - Landfill (without exported waste being landfilled) (1 %) - Export (interim storage needed) (2 %) - Mono hazardous waste incinerator (rotary kiln) (10 %) - Chemical physical treatment, organic and inorganic (1 %) - Recycling (7 %)

6.4. Indicators and strategy enforcement committee

In order to ensure the enforcement of the strategy, the implementation of the targets must be controlled and monitored. This control is conducted via key performance indicators (KPIs), that are defined specifically for each target. For example, for the above-mentioned target #5.1, "80% of the related staff of ministries shall be trained". In this case the number of totals "targeted staff" must be calculated and a timeline must be implemented on who exactly shall be trained until when by whom and which number of staff.

This monitoring task should be conducted by an independent expert group being the **strategy enforcement committee** with the responsibility to implement the strategy suggested in this report.

6.5. Action plan for industrial hazardous waste management

Based on the above-mentioned visions, the pre-defined objectives, and planned targets to concretely establishment a national HWM strategy, the proposed action plan is described below.

6.5.1. Classification and coding for hazardous waste (EWC)

The classification of waste is the EU is harmonized and based on:

- **European List of Waste** (Commission Decision 2000/532/EC);
- **Annex III to Directive 2008/98/EC;**

The waste coding provides an EU-wide **harmonized terminology** for waste classification to facilitate waste management, including for hazardous waste. This accordance serves in a broad variety of activities, involving the transport of waste, including transboundary shipment, facility permits (which often refer also to specific waste codes), or as a basis for waste statistics[56].

In 2018, the European Commission published technical guidance on the classification of waste (2018/C 124/01), providing guidance to national and local authorities, on the correct interpretation and application of waste coding. It covers a comprehensive overview of relevant EU legislation, gives examples of waste types for which classification is considered difficult by stakeholders, and provides step-by-step information on how to assess whether waste displays hazardous properties and on how to classify it. The document is available in all EU official languages[56].

The EWC is divided into **twenty main chapters**, as shown below:

1. Wastes resulting from exploration, mining, quarrying, physical and chemical treatment of minerals;
2. Wastes from agriculture, horticulture, aquaculture, forestry, hunting and fishing, food preparation and processing ;
3. Wastes from wood processing and the production of panels and furniture, pulp, paper, and cardboard;
4. Wastes from the leather, fur, and textile industries;
5. Wastes from petroleum refining, natural gas purification and pyrolytic treatment of coal;
6. Wastes from inorganic chemical processes;
7. Wastes from organic chemical processes;
8. Wastes from the manufacture, formulation, supply, and use (MFSU) of coatings (paints, varnishes, and vitreous enamels), sealants and printing inks;
9. Wastes from photographic industry;
10. Wastes from thermal processes;
11. Wastes from chemical surface treatment and coating of metals and other materials; non-ferrous hydrometallurgy;

[56] European Commission (2020), “Waste Classification - Environment - European Commission”. Online Available at: <https://ec.europa.eu/environment/waste/framework/list.htm> (Last Consulted 24/09/2020).

12. Wastes from shaping and physical and mechanical surface treatment of metals and plastics;
13. Oil wastes and wastes of liquid fuels (except edible oils, 05 and 12);
14. Waste organic solvents, refrigerants, and propellants (except 07 and 08);
15. Waste packaging; absorbents, wiping cloths, filter materials and protective clothing not otherwise specified;
16. Wastes not otherwise specified in the list;
17. Construction and demolition wastes (including excavated soil from contaminated sites);
18. Wastes from human or animal health care and/or related research (except kitchen and restaurant wastes not arising from immediate health care);
19. Wastes from waste management facilities, off-site wastewater treatment plants and the preparation of water intended for human consumption and water for industrial use;
20. Municipal wastes (household waste and similar commercial, industrial and institutional wastes) including separately collected fractions.

For each chapter, several waste streams are described in detail and marked with an asterisk, if they are hazardous waste streams.

An example is shown in Figure 6-4.

01	**WASTE RESULTING FROM EXPLORATION, MINING, QUARRYING, AND PHYSICAL AND CHEMICAL TREATMENT OF MINERALS**
01 01	**wastes from mineral excavation**
01 01 01	wastes from mineral metalliferous excavation
01 01 02	wastes from mineral non-metalliferous excavation
01 03	**wastes from physical and chemical processing of metalliferous minerals**
01 03 04*	acid-generating tailings from processing of sulphide ore
01 03 05*	other tailings containing dangerous substances
01 03 06	tailings other than those mentioned in 01 03 04 and 01 03 05
01 03 07*	other wastes containing dangerous substances from physical and chemical processing of metalliferous minerals
01 03 08	dusty and powdery wastes other than those mentioned in 01 03 07
01 03 09	red mud from alumina production other than the wastes mentioned in 01 03 07
01 03 99	wastes not otherwise specified
01 04	**wastes from physical and chemical processing of non-metalliferous minerals**
01 04 07*	waste containing dangerous substances from physical and chemical processing of non-metalliferous minerals
01 04 08	waste gravel and crushed rocks other than those mentioned in 01 04 07
01 04 09	waste sand and clays
01 04 10	dusty and powdery wastes other than those mentioned in 01 04 07
01 04 11	wastes from potash and rock salt processing other than those mentioned in 01 04 07

Figure 6-4 European Waste Code Extract (Source: EPA Ireland, 2002[57])

The application of a coding system in Egypt would not only **ease the overlapping waste streams among ministries**, reducing responsibility ambiguities but also **facilitate waste declaration**, **treatment** process and **billing** systems.

6.5.2. Communication between ministries

Currently, besides the regulatory agency WMRA, there are nine ministries in the country which are responsible for different types of hazardous waste. To address this matter and ensure efficiency in managing hazardous waste, two main approaches may be applied:

1. **Centralized system** ordered by Presidential Decree. Through this legal mechanism, an existing authority could be set higher in the decision-making hierarchy and have more influence in defining and establishing the directions that HWM should take in the country.

[57] EPA Ireland (2002), "European Waste Catalogue and Hazardous Waste Lis". Online Available at: http://www.nwcpo.ie/forms/EWC_code_book.pdf (last consulted: 24/09/2020)

This approach was conducted by Oman, creating their environmental regulatory agency BEAH[58];

2. **Legally set up a committee** consisting of all relevant stakeholders. During the onsite mission, it was stated by the actors that this committee has been already defined and its transitioning within the government for legal approval. A similar approach is currently being discussed in Kuwait during the current development of their National Waste Master Plan.

Both paths are considered accurate and present benefits and weaknesses. These are summarized in the SWOT analysis shown in Figure 6-5 SWOT Analysis for establishing a decree for a centralized approach Figure 6-5 and Figure 6-6.

It is also important to maintain continuous communication between the authorities and different stakeholders, namely IHW generators as well as chambers and entities which are closely related to hazardous waste in the country. This line of communication would keep all involved parties updated at all times about new measures in addition to being a direct reachable connection on which stakeholders can get answers to their requests for information from the authority. The communication tool can be, for example, a hotline provided by the regulatory authority.

58 Be'ah (2020): Online available at: https://www.beah.om/ (Last consulted: 24/09/2020)

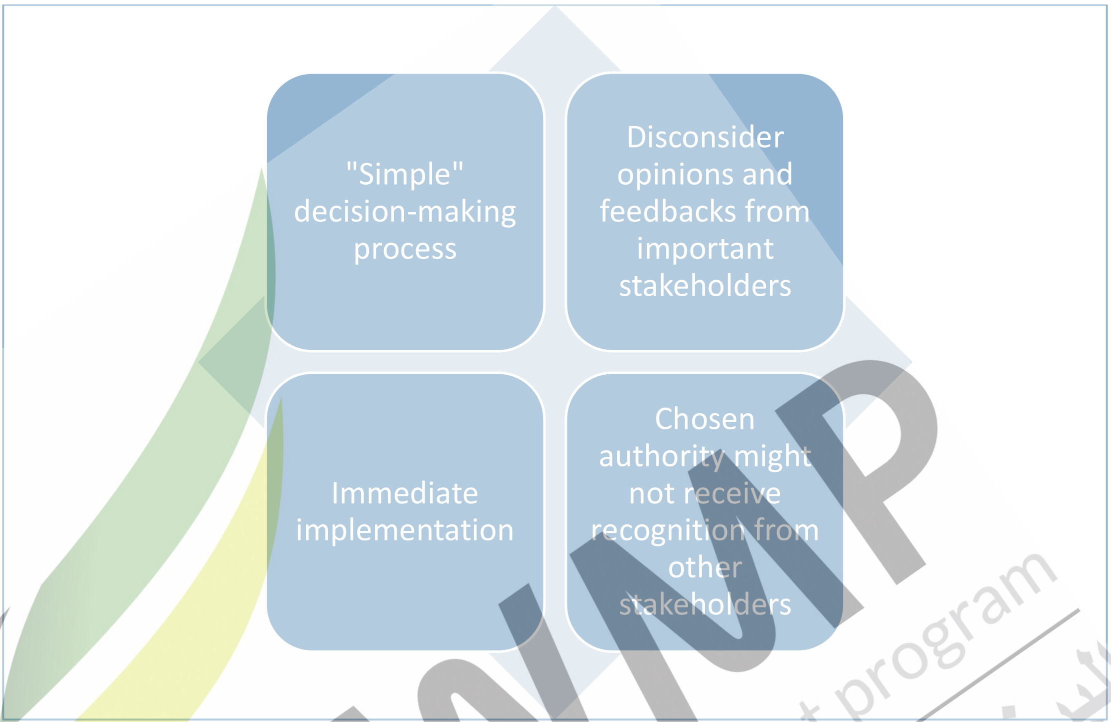


Figure 6-5 SWOT Analysis for establishing a decree for a centralized approach (#1) (Source: BFS, 2020)

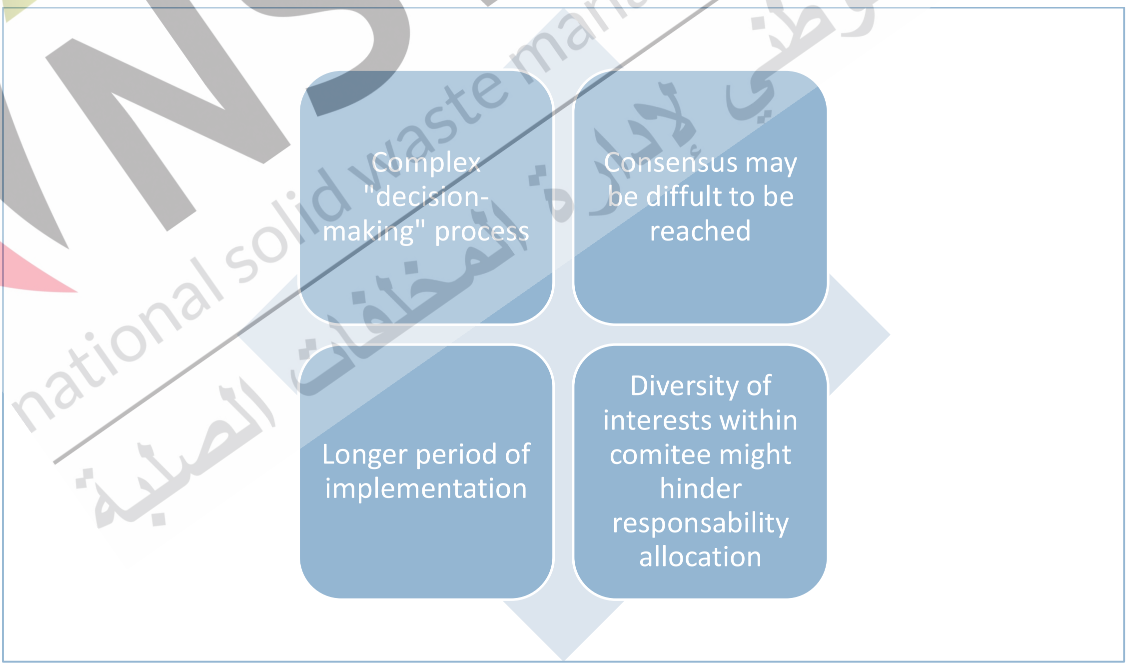


Figure 6-6 SWOT Analysis for setting up a committee (#2) (Source: BFS, 2020)

6.5.3. Cleaner production within industries

Cleaner production can reduce operating costs, improve profitability and worker safety, and reduce the environmental impact of the business. Frequently, minimal or no capital expenditure is required to achieve worthwhile gains, with fast payback periods. Waste handling and charges, raw material usage and insurance premiums can often be cut, along with potential risks. It is obvious that cleaner production techniques are good business for industry because it will:

- Reduce waste disposal cost;
- Reduce raw material cost;
- Reduce Health Safety Environment (HSE) damage cost;
- Improve public relations/image;
- Improve company's performance;
- Improve the local and international market competitiveness;
- Help comply with environmental protection regulations.

On a broader scale, cleaner production may alleviate the serious and increasing problems of air and water pollution, ozone depletion, global warming, landscape degradation, solid and liquid wastes, resource depletion, acidification of the natural and built environment, visual pollution, and reduced biodiversity.

An **industrial program in education must precede a successful reuse/recycling program** by acquainting plant personnel with the potential value contained in the waste. Detailed qualitative analysis of wastes should be made available over relatively long periods of time (one year)[59].

Since industries have different processes, incentives shall be promoted by the governmental authorities to foment cleaner production.

If an industrial plan has a reduction of X% on its total volume of hazardous waste, "rewards" will be provided. These rewards can vary depending on the region and/or demands from the industrial site. A suggestion could be tax reductions or discounted disposal fees following the reduction of produced waste.

6.5.4. Set up integrated hazardous waste treatment centres in industrial zones

Currently there are **no integrated hazardous waste management centers (IHWMC) available in the country**, despite high demand for disposal services in the industrial complexes.

[59] Dr.Salah M. El-Haggar PE (2007), "Sustainable Industrial Design and Waste Management"

The HWTCs can be designed to handle all hazardous wastes that accrue in the area/country, including the most hazardous waste qualities and infectious medical waste.

While avoiding unregulated and inadequate disposal of hazardous waste on landfills or dumpsites, it requires the export of many waste types now; a HWTC can be designed as a **modular system**, so the range of wastes and volumes managed and treated can be increased over time. In the end, only some inorganic hazardous waste like ashes or other less toxic materials must be landfilled (which reduces costs and prolong the hazardous waste landfill active lifecycle).

To guarantee producer responsibility and controlled disposal, an **electronic documentation system should be implemented** monitoring the whole process (see recommendation under Chapter 6.5.5). For special waste types (e.g., mercury), export per the Basel Convention regulations remains as an option.

The HWTC will **enable the local authorities to monitor the regional hazardous waste** management, to transform the waste problem into a solution being able to provide secure services to the local industry, population, and environment.

The focus is on the processes of landfilling, incineration, sludge management, and recycling. To provide the framework for these processes, a hazardous waste storage facility and a chemical-physical treatment facility will be required.

To provide hazardous waste management and disposal services to the local companies, the **first step shall be landfilling**. This will include solidification and stabilization, if necessary. The leachate shall be treated in a chemical-physical treatment facility (organic line first, the inorganic line later).

Landfilling is considered the least preferable method of disposal because the material may still pose a danger to people and the environment and must be monitored and maintained over a long time. Consequently, in a **second step, a hazardous waste incineration facility** shall be added to the hazardous waste management facility. These incinerators shall follow national and international standards, be equipped with emission treatment systems, and be used when there are no further treatment options.

Moving on from this point, **the facility can be expanded step-by-step to recycle more and more diverse types hazardous material** and act as a hub for hazardous waste management and disposal for the whole region.

Specific hazardous waste streams must be collected and exported for handling until they can be treated in the facility. This model includes optional concepts for the implementation of other profitable hazardous waste services, which can be added at a later stage of the project, such as lamp recycling (mercury-contaminated) and recycling of catalyst materials.

Based on the aforementioned influences, the following criteria for the determination of capacity and design for landfill, solidification/stabilization, leachate treatment plant, incineration plant and recycling plants shall be assumed:

- **Landfill:**
  - Internally generated residues from combustion must be quantified and considered in capacity planning and design. For example, residues from the flue gas cleaning process (limestone scrubbers) must be deposited in an isolated section of the landfill due to the risk of H_2S emissions in a mix with biodegradable waste;
  - Construction waste as the main fraction should be tested for recyclability and classified according to origin and degree of contamination. Criteria for the recycling of building materials must be defined to save landfill space.
- **Solidification/Stabilization (as a pre-treatment for landfilling):**
  - Internally generated residues from combustion must be quantified and considered in capacity planning and design e.g., flue dust and salts from spray dryer.
- **Incineration:**
  - Large quantities of contaminated polymeric filters and contaminated plastic empty containers (no PVC) require crushing before being fed into combustion (low bulk density);
  - Contaminated filters and contaminated plastic empty containers have a high calorific value of approx. 30 MJ/kg and must be considered in the design of the thermal capacity;
  - Large quantities and properties like extremely foul and obnoxious odours, high concentration of sulphur must be considered on the design of liquid feed system and removal capacity of SO_2;
  - Hydrocarbon sludges have a high calorific value of approx. 20-25 MJ/kg and must be considered in the design of the thermal capacity and design of feed system.
- **Recycling**
  - Technical design and profitability of separate recycling processes must be examined in detail. If volumes are restricted, it might not be justifiable to place specific recycling processes. A cross-regional approach to increase the quantities shall be examined;
  - For example, large quantities of oil sludge with fluctuating qualities require variable possibilities of treatment such as recycling, e.g. with centrifuge technology (decanter/tricanter) or energy generation through combustion in a rotary kiln. The application of the centrifuge technology demands energy due to the viscosity of oily sludge and nitrogen, which could be extracted from the incineration process respectively attendant facilities of the incineration plant.

Final products like solids could be incinerated in existing incinerators and the water fraction in the existing leachate treatment plant.

Each IHWTC shall include one **laboratory**. It essentially has a monitoring and control function and provides corresponding data for the special plant processes like incineration solidification/stabilization, chemical-physical treatment, and recycling. The main issues of this functions are for incineration

- Daily preparation of the incineration input mix in coordination with the shift supervisor of the incineration plant and daily mixture parameters for the solidification/stabilization plant;
- Implementation of input, process, and residual material analysis in the following recommended scope.

To construct an **interim storage**, it is highly recommended to follow the "Technical Guidelines for Hazardous Substances" (TRGS 510[16]). The TRGS 510 serves the safe storage of hazardous substances and chemical products. Almost every class of hazardous substances and chemical products, especially inflammable liquids, organic peroxides, and toxic gases can be stored in such a warehouse. These guidelines contain especially the storage of hazardous substances and represents the basis for the framework conditions for the planning and operation of an intermediate warehouse for hazardous substances in Germany. Proper storage is needed to minimize the hazards associated with mixing incompatible hazardous materials. A compatibility table is shown in Figure 6-7.

Class or Subsidiary Risk				TOXIC GAS 2								TOXIC 6	CORROSIVE 8
FLAMMABLE GASES		OK TO STORE TOGETHER	OK TO STORE TOGETHER	SEGREGATE At least 3m	SEGREGATE At least 3m	SEGREGATE At least 5m	SEGREGATE At least 5m	SEGREGATE At least 5m	SEGREGATE At least 5m	SEGREGATE At least 3m	ISOLATE	SEGREGATE At least 3m	SEGREGATE At least 5m
NON TOXIC NON FLAMMABLE GASES		OK TO STORE TOGETHER	OK TO STORE TOGETHER	OK TO STORE TOGETHER	OK TO STORE TOGETHER	SEGREGATE At least 5m	SEGREGATE At least 5m	SEGREGATE At least 5m	SEGREGATE At least 5m	SEGREGATE At least 3m	ISOLATE	SEGREGATE At least 3m	SEGREGATE At least 5m
TOXIC GAS	TOXIC GAS 2	SEGREGATE At least 3m	OK TO STORE TOGETHER	MAY NOT BE COMPATIBLE CHECK MSDS AND NOTES	SEGREGATE At least 3m	SEGREGATE At least 5m	SEGREGATE At least 5m	SEGREGATE At least 5m	SEGREGATE At least 5m	SEGREGATE At least 3m	ISOLATE	SEGREGATE At least 3m	SEGREGATE At least 5m
OXIDIZING GAS		SEGREGATE At least 3m	OK TO STORE TOGETHER	SEGREGATE At least 3m	OK TO STORE TOGETHER	SEGREGATE At least 5m	SEGREGATE At least 5m	SEGREGATE At least 5m	SEGREGATE At least 5m	SEGREGATE At least 3m	ISOLATE	SEGREGATE At least 3m	SEGREGATE At least 5m
FLAMMABLE LIQUIDS + COMBUSTIBLE LIQUIDS		SEGREGATE At least 5m	SEGREGATE At least 5m	SEGREGATE At least 5m	SEGREGATE At least 5m	OK TO STORE TOGETHER	SEGREGATE At least 3m	SEGREGATE At least 5m	SEGREGATE At least 5m	SEGREGATE At least 5m	ISOLATE	SEGREGATE At least 5m	SEGREGATE At least 3m
FLAMMABLE SOLID		SEGREGATE At least 5m	SEGREGATE At least 5m	SEGREGATE At least 5m	SEGREGATE At least 5m	SEGREGATE At least 3m	OK TO STORE TOGETHER	SEGREGATE At least 3m	SEGREGATE At least 5m	SEGREGATE At least 3m	ISOLATE	SEGREGATE At least 3m	MAY NOT BE COMPATIBLE CHECK MSDS AND NOTES
SPONTANEOUSLY COMBUSTIBLE		SEGREGATE At least 5m	SEGREGATE At least 5m	SEGREGATE At least 5m	SEGREGATE At least 5m	SEGREGATE At least 5m	SEGREGATE At least 3m	OK TO STORE TOGETHER	SEGREGATE At least 5m	SEGREGATE At least 5m	ISOLATE	SEGREGATE At least 3m	SEGREGATE At least 3m
DANGEROUS WHEN WET		SEGREGATE At least 5m	SEGREGATE At least 5m	SEGREGATE At least 5m	SEGREGATE At least 5m	SEGREGATE At least 5m	SEGREGATE At least 5m	SEGREGATE At least 5m	OK TO STORE TOGETHER	SEGREGATE At least 5m	ISOLATE	SEGREGATE At least 3m	SEGREGATE At least 5m
OXIDIZING AGENT		SEGREGATE At least 3m	SEGREGATE At least 3m	SEGREGATE At least 3m	SEGREGATE At least 3m	SEGREGATE At least 5m	KEEP APART	SEGREGATE At least 5m	SEGREGATE At least 5m	MAY NOT BE COMPATIBLE CHECK MSDS AND NOTES	ISOLATE	SEGREGATE At least 3m	SEGREGATE At least 3m
ORGANIC PEROXIDE		ISOLATE	ISOLATE	ISOLATE	ISOLATE	ISOLATE	ISOLATE	ISOLATE	ISOLATE	ISOLATE	OK TO STORE TOGETHER	ISOLATE	SEGREGATE At least 3m

Figure 6-7 Hazardous waste compatibility chart (Source: Outdoor Industry, 2017)[60]

These rules must be closely attained to avoid any accidents, explosions, or flames within the hangar.

In Figure 6-8, a **general setup of an integrated hazardous waste treatment centre** is show. Besides the above-mentioned core activities, co-processing in the cement industry is also considered.

Depending on the activities of the industrial complex – if there any health units- mobile medical waste units such as sterilization and/or autoclaves can be placed to treat this waste stream.

[60] Outdoor Industry (2017). Online available at: https://outdoorindustry.org/chemical-manuals/1/en/topic/storage (last consulted: 24/09/2020)

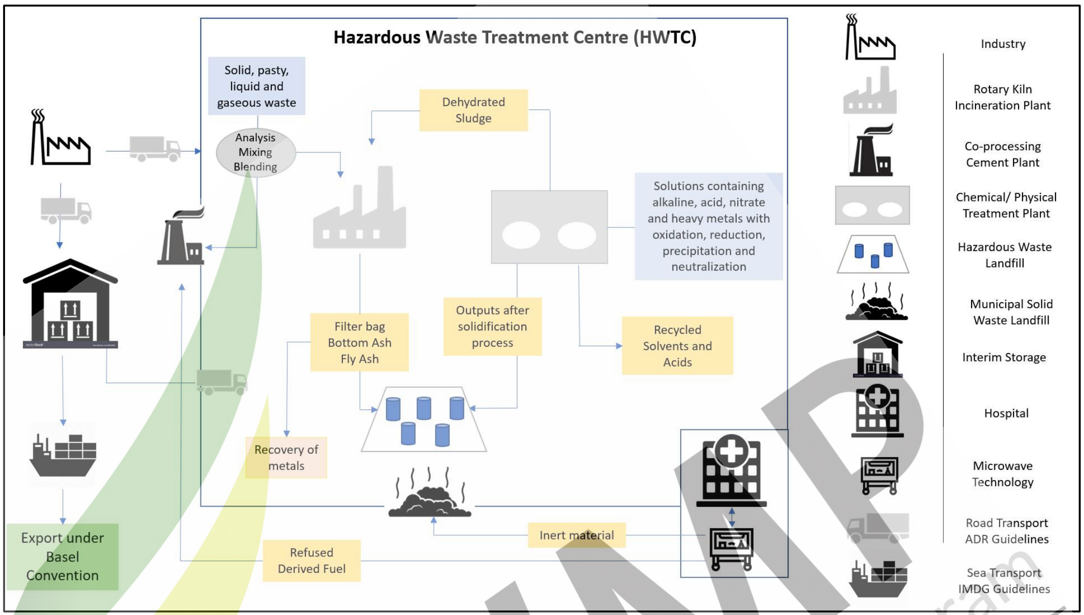


Figure 6-8 Integrated hazardous waste treatment center scheme (Source: BFS, 2020)

Some specific types of hazardous waste usually occur in restricted volume and /or require special treatment processes, namely mercury waste, naturally occurring radioactive material (NORM) waste, cytotoxic waste among a few other. These, due to the low viability of local treatment must be exported according to the Basel Convention.

6.5.5. Digital hazardous waste tracking system

As described along with this report, lack of data and monitoring is a major gap in the HWM system in Egypt, and it hinders the development of proper technology/solutions for these waste streams. The **HW is transported daily**, using **logistic companies** that are **not registered or regulated**, and while most use **paper manifest forms**, there is no central repository for such information. Lastly, hazardous waste is transported to various treatment centres, but it cannot be confirmed that some of the waste is not being disposed of illegally.

The waste sector needs a solution that provides **consistent tracking of HW**, providing real-time or near real-time information about such waste covering generation, transport, and disposal. Such a solution needs to centralize all records in order to support analysis while providing all stakeholders appropriate levels of access. The solution must be robust enough to handle a large number of users across different sectors (primarily industrial and health, but other sectors as well).

To address this matter, it is recommended that the country establishes a **national digital hazardous waste tracking system**. This system shall include data from the waste generator, from the transportation company and from the treatment facility.

To register hazardous waste data, every stakeholder would need a chip-card, a reader, and a computer. They shall fill in a manifest with the required waste data (quantity, class, hazard type etc.) then sign the document with a unique e-signature.

The data is then gathered in one digital location accessible by the central coordination authority, which verifies the digital tracking of waste. In Germany, all these systems are synchronized, and all data is accessible by the KSZ. A general overview of the system is shown in Figure 6-9.

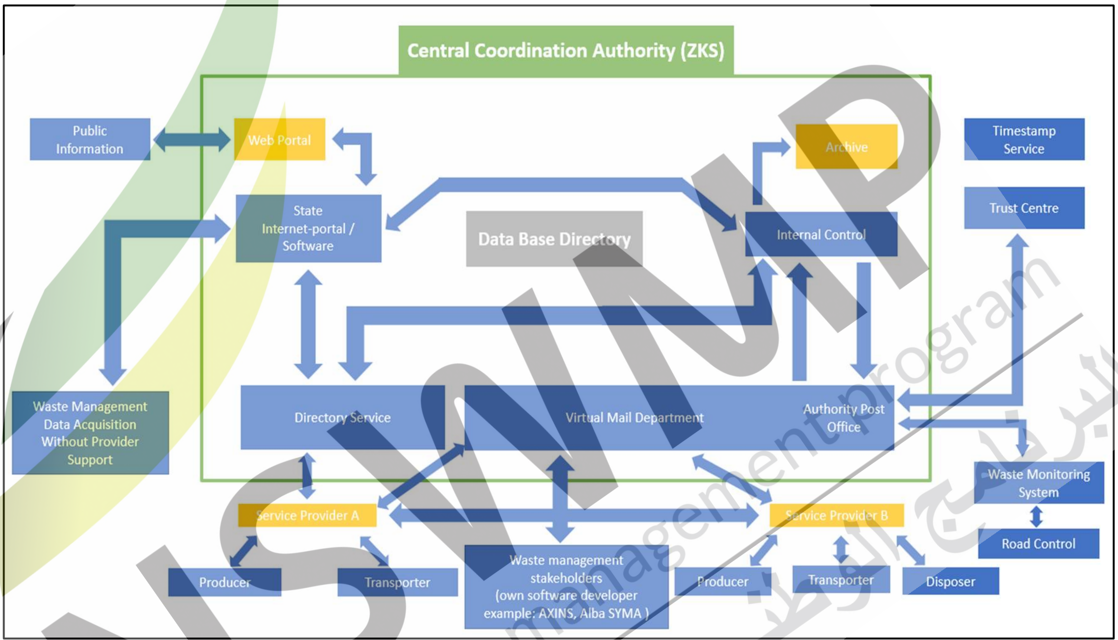


Figure 6-9 Waste monitoring scheme in Germany (Source: ZKS-Abfall, 2020)[61]

In Egypt, this solution shall allow authorized users (generation, transport and disposal) to capture their credentials without having to enter any information and waste information (type and quantity) to be entered at two junctures and thereby ensure that there are no 'leaks':

- Upon transfer from generator to transporter;
- Upon transfer from transporter to disposer.

The **solution shall also allow authorized users to track movements of hazardous waste**, and single vehicles to collect multiple shipments of hazardous waste from different locations, as long as the nature of such waste does not preclude it being transported with other types. Lastly, the solution shall permit data records to be aggregated and analysed, necessitating solid archiving tools. Example usages of this solution include:

[61] ZKS - Zentrale Koordinierungsstelle Der Länder (ZKS-Abfall) (2020). Online Available at: <https://www.zks-abfall.de/de/zks-abfall> (Last consulted: 24/09/020).

- The disposal centre representative enters information describing the received waste. Any difference with the information entered by the generator shall be flagged;
- A vehicle transports multiple shipments collected from several points of generation. The system shall differentiate where each shipment was loaded.

Further options could include:

- Providing each user (generation, transport, and disposal) with their own smart card for authentication purposes;
- Real-time or near real-time tracking of all authorized vehicles;
- One single solution covering all stages, or it could be set up whereby multiple providers sell their service to the stakeholders, with data records being replicated into one single consolidated database;
- Cloud-based;
- Storing transactions in case of communication network failure, although in such a case tracking of vehicles and shipments would not function.

Recommendations of the main functions of the system are shown in Annex 10.9

6.5.6. Separate collection of household hazardous waste

HHW encompasses several waste streams such as **lamps, thermometers, batteries, paints, cleaning materials, expired medicine,** among others. Due to a lack of awareness from the citizens and no separate collection potions, these fractions are commonly disposed of in landfills.

Bearing in mind that the **separation of hazardous waste from MSW is crucial for further processing** (e.g., mechanical biological treatment, waste-to-energy), it is highly recommended that these governmental authorities implement HHW separate collection programs.

To address this matter, it is proposed to integrate **hazardous waste collection vehicles** (see Figure 6-10 and Figure 6-11) to the MSW logistic scheme. Such vehicles can be used for the collection of different types of batteries as a start and then later for most of the 400 different hazardous waste types (solid and liquid).

Vehicles may stay in one fixed place, to where citizens shall bring their hazardous waste. This approach drastically reduces operational costs from such an initiative but requires strong awareness-raising programmes from local authorities to achieve success.

Technical specifications from such trucks are exemplified in Annex 10.10.

Figure 6-10 Household waste collection vehicle (Source: ALBA Group, 2017)

Figure 6-11 Citizens bringing their household hazardous waste to the collection vehicle (Source: ALBA Group, 2017)

6.5.7. Establishing of an extended producer responsibility scheme for hazardous waste (including WEEE)

In the European Union, **EPR is mandatory within the context of the WEEE, batteries, and end-of-life vehicles** (ELV), which put the responsibility for the financing of collection, recycling, and responsible end-of-life disposal of these fractions on producers. Additional waste streams for which producer responsibility organisations have been most identified within the European Union include tyres, waste oil, paper and card, and construction and demolition waste[62].

Commonly for WEEE and batteries, **producers must**:

- **Register with the appropriate environmental regulator;**
- **Accurately record the tonnage and composition of devices** placed on the market.

Registration depends on the type of battery/WEEE is sold and the amounts put on the market.

In terms of operations, an EPR for e-waste or batteries is not much different from any other producer responsibility organization (PRO), except than unlike packaging PROs, they tend to take over operational responsibility of the take-back system, which comes often (but not always) with the obligation to monitor the compliance of the reverse chain to certain standards.

In relation to e-waste treatment, there are various standards applicable, whether public, private or in between, namely CENELEC, WEEELABEX, R2, e-STEWARD, S3, among others.

A detailed analysis of EPR systems for batteries and WEEE in the EU is shown in Annex 10.11.

EPR schemes can also be applied for medical waste, e.g., for sharps. The regulations aim to promote the safe and effective disposal of medical sharps. **As any EPR scheme, producers are obliged to**:

- Provide consumers with a **safe and convenient way to dispose of used sharps;**
- Ensure **safe transport and disposal** of used sharps;
- **Educate** and promote safe disposal of used sharps to consumers;
- Report annually on the **quantity of sharps collected.**

Extended producer responsibility legislation for medical sharps is relatively new but already implemented in countries like France and Canada.

Penalties shall be applied to companies which are not participating – the so-called “free riders” in the system (if mandatory).

[62] European Commission (2014): Online Available at: https://ec.europa.eu/environment/archives/waste/eu_guidance/introduction.html (last consulted: 24/09/2020)

Figure 6-12 EPR scheme for sharps (Source: International Stewardship Forum 2019 Paris)

In order to establish an EPR for industrial hazardous waste for producers and importers, the general and legal framework must be well established, clear definition of the obligation shall be pre-defined, together with private and public stakeholders, the criteria for listing products, etc. Besides, the new waste management draft law, approved by the House of Representatives in August 2020 (please refer to paragraph 4.4 for more details), represents a big step towards implementing and enforcing a proper EPR system in Egypt.

6.5.8. Implement general tender processes for hazardous waste management

For most public and private sector administrators, waste services are a necessary commoditized cost. Intelligent waste management can yield direct cost benefits, as well as potentially shared revenue streams. Government agencies should aim to achieve value for efficiency and innovation whenever they procure waste management services. Another dimension is the governmental duty towards its society and environment to provide a certain level of waste treatment capacities, to enforce waste-related regulations (e.g., by tracking HW generation and proper disposal) and to safeguard all involved stakeholders' interests.

This duty can either be fulfilled via a free-market approach with (or without) state incentives for pro-active investments (e.g., in a HW treatment facility next to an industrial zone) or by monitoring state demands and channeling the requirements to pre-selected (or any suitable) bidders via standardized tender processes in different business setups (e.g., limited operation licenses, public-private partnerships, build-operate-transfer (BOT) setups, and others). It is in any case recommended to categorize hazardous waste treatment facilities as critical infrastructure and consequentially define strict rules and standardized processes to assure that the national demand for handling/treatment/disposal capacities are fulfilled concerning quantities and qualities.

To tender is to request bids for a project or accept a formal offer such as a takeover bid. Tendering usually refers to the process whereby governments and financial institutions request bids for large projects that must be submitted within a finite deadline[63].

It is recommended that professional tender processes for hazardous waste are implemented in Egypt. These tenders may include the development of treatment capacity in the country, (proper) disposal of a specific hazardous waste stream, construction of interim storages, among others.

In this regard, a tender evaluation process using weighted criteria should be adopted to compare tenders and identify the tenderer with the best performance record in terms of time, cost, and value for money. The weighted criteria tender assessment process is usually based on the following principles[64]:

- Selection criteria that reflect the critical elements of the project;
- A 'fail or pass' process based on the technical proposals from all bidders to reduce evaluation efforts;
- Weightings that reflect the relative importance of selection criteria;
- Scores that are based on information submitted with the tender bid;
- Normalizing the non–price criteria and the tender price before applying the weightings to allow for the true effect and advantage of the weighting system.

The goal of implementing either defined free-market incentives and/or state-channeled tender processes is to shape a structure for the future hazardous waste management system in the country. Another target is to attract foreign investments in this field through process transparency, investment securities, and long-term perspectives of operations (e.g., limited license base, long-term BOT contracts, etc.).

In an optimal case, a state-channeled shaping of the national HW management system via public tender processes and/or free-market incentives is linked and the response to a comprehensive UNARA and national gap analysis concerning the HW generation, transportation, logistics, tracking, treatment, and disposal within the country.

6.5.9. Prioritization of measures

[64] Tasmanian Government (2019) Guidelines on tender evaluation using weighted criteria for building works and services

To enable an optimal implementation of the proposed measures, the following priority list is recommended as shown in Figure 6-13.

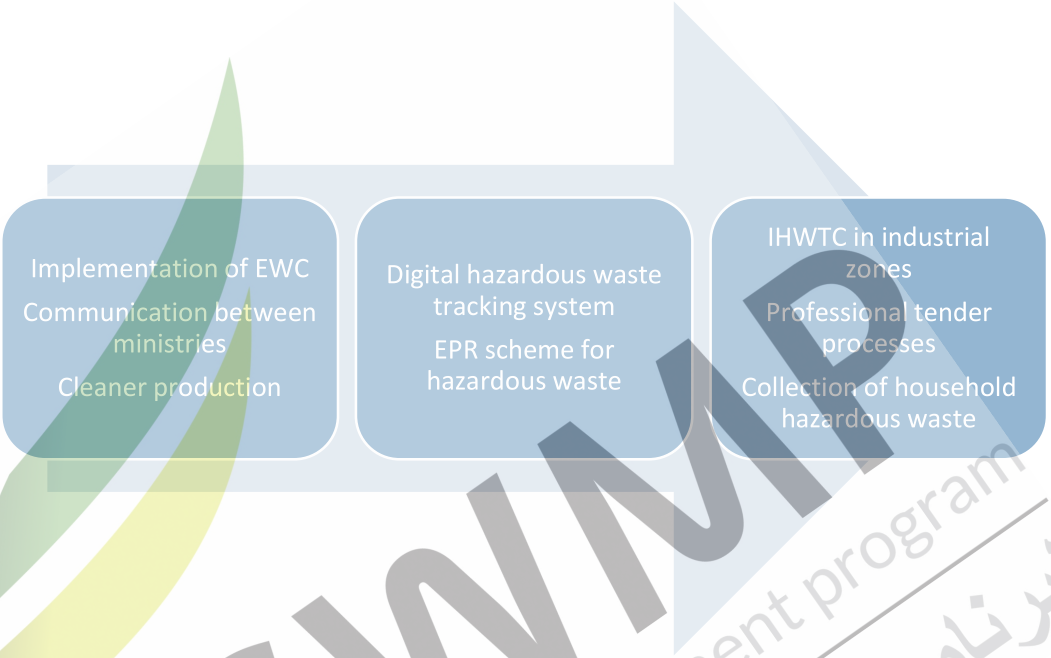


Figure 6-13 Suggested timeline for the implementation of action plan (Source: BFS, 2020)

As illustrated by Figure 6-14, some of the targets can start as soon as the strategy is approved, such as the implementation of the European waste code (EWC), hazardous waste data gathering, as well as the centralization of responsibilities among stakeholders. On the other hand, other actions will depend on previous measures like the designation of an independent/neutral responsible entity for controlling and monitoring hazardous waste or the professional hazardous waste tender writing process. An important measure that would allow subsequently, the approval of the action plan is to **designate responsible entities** who will supervise the progress and the accomplishment of each target.

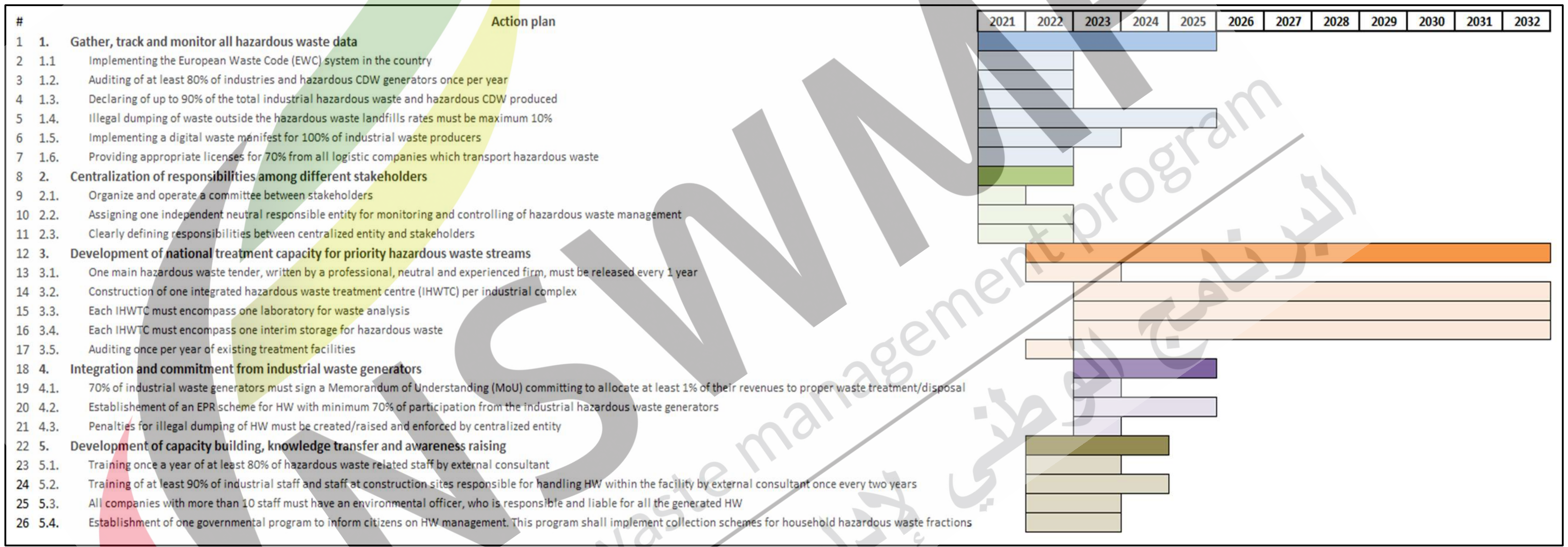


Figure 6-14 Action plan and timeline for the implementation of a HWM strategy in Egypt (Source: BFS, 2020)

7. Financing

Bearing in mind that IHW usually does not have a positive value, financing its treatment is always challenging.

To finance industrial hazardous waste treatment and/or disposal, there are two major ways:

- Public subsidies via lower disposal fees, tax exemptions;
- Financing by the private sector via polluters pay principle.

Bearing in mind that the industrial sector in the country is well developed, the second variant is the most recommended. In this case, it is necessary to calculate the minimum required gate fee in which a treatment facility (e.g., rotary kiln) must receive in order to operate.

Based on this estimation, it is suggested to estipulate a ramp-up approach aiming the achievement of this minimum fee within 10 years. This provides sufficient time for the waste producers to adjust to these changes and for the waste treatment stakeholders to develop treatment capacity in the country.

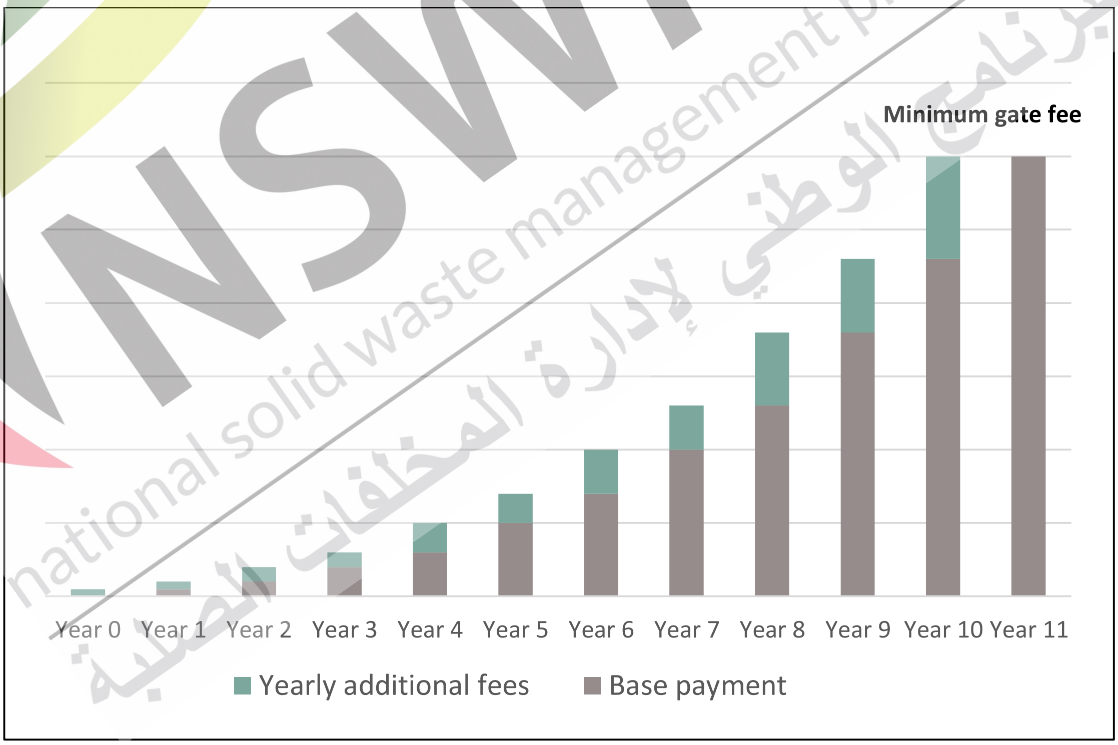


Figure 7-1 Ramp up payment scheme (Source: BFS, 2020)

To ensure payment of these fees, monitoring (digital tracking system) is crucial for the functioning of the above-mentioned measure.

This minimum gate fee must be part of the law and increase a determined percentage annual to provide security to private investors/operators for technological development and system optimization.

Besides the mandatory gate fee, a list of hazardous waste types must include in the legislation. In this list, it should be clearly stated (via EWC) which types of waste must be handled via rotary kiln, physico-chemical, hazardous waste landfill or exported (see Annex 10.13).

Taking into consideration the hazardous waste generated from homes, markets and commercial buildings, an idea would be to allocate part of the cleaning fees to partially finance the hazardous waste system.

These cleaning fees are being collected with the electricity bill, and the number of subscribers in the electrical network at the national level of Egypt is slightly above 20 million subscribers. The average collection sum is of 7.5 pounds per house, hence the annual income is around one billion and 800 million pounds, of which partly is transferred to garbage collectors in major cities only. It is recommended to transfer an amount of these revenues to finance the household HWM system.

EPR schemes for hazardous waste such as fluorescent lamps, medicine, electronics, batteries shall be established in the country to cover costs for the collection and treatment of these fractions. In Germany, since the Stiftung GRS was set up in 1998, the number of our users has risen to over 4,600 manufacturers. While in previous years, we have always been slightly above the statutorily required collection quota of 45%, in 2019 we have significantly exceeded it (Figure 7-2). Backbone of the continuously increasing takeback quantities is the nationwide network with thousands of collection points both in retail centers and in municipalities, industry, and the trades. The cooperation within this network enables us to offer consumers a disposal option that is both simple and close to their homes (Figure 7-3).

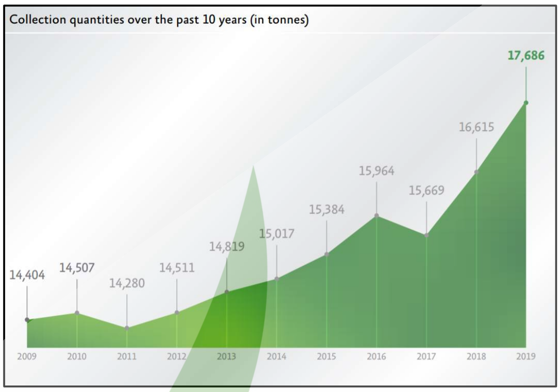


Figure 7-2 – Battery collection quantities over the past 10 years in tons (Source: GRS Batterien, 2019[65])

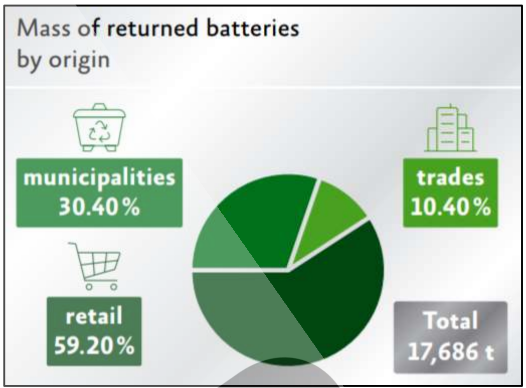


Figure 7-3 – Returned battery by origin (Source: GRS Batterien, 2019[65])

[65] GRS Batterien Annual Report (2019): Online Available at: http://www.grs-batterien.com/fileadmin/user_upload/Download/Dokumente_2019/GRS_AnnualReview2019Web.pdf (Last consulted: 24/09/2020)

8. Pilot project

To conclude the industrial hazardous waste strategy for Egypt, BFS suggests the setup of a pilot project in one of the industrial zones. This pilot consists of the construction of an incineration plant equipped with a rotary kiln for treatment of industrial hazardous waste.

Rotary kiln incinerators are cylindrical, refractory-lined steel shells, slightly inclined on their horizontal axis. They are supported by steel trundles that ride on rollers, allowing the kiln to rotate on its horizontal axis[66]. They are very robust and where almost any composition of waste can be incinerated. Mostly used for hazardous and medical waste, rotary kilns operate on a temperature range from 900°C to 1450 °C. Throughout the incineration, waste is conveyed inside the kiln by gravity as it rotates. Several feeding techniques are depending on the waste type. For example, liquid or pasty waste can be directly injected into the kiln through burner nozzles or a water-cooled tube, while solid wastes are usually fed through a non-rotary hopper. The residence time in the kiln depends on the inclination angle and rotation speed of the vessel. For solid waste, it ranges from 30 to 90 minutes to achieve sufficient waste burnout[67].

As mentioned in the previous chapter, a minimum gate fee shall be calculated to determine the operational parameters of the rotary kiln facility. For these calculations, the most important parameter to be considered is the throughput of waste composition. Therefore, a pilot area needed to be selected.

8.1. Selection of the pilot area

To determine a suitable area for a pilot project, the following information were requested from relevant governmental stakeholders:

- The types of industries in the area;
- The types of waste produced by these industries;
- The quantity of hazardous waste produced.

Based on these criteria, the 10th of Ramadhan industrial area, including the Robbiki leather cluster, was selected for the pilot project. In fact, an in-depth study of the industries and waste generation in this zone was conducted in 2017[68], providing an inventory with the necessary data for the minimum gate fee calculation.

[66] Salah M. El-Haggar (2007) Current Practice and Future Sustainability
[67] Industrial Emissions Directive 2010/75/EU. Best Available Techniques (BAT) Reference Document for Waste Incineration
[68] IWEX Egypt (2017) Industrial Waste Management & SME Entrepreneurship Hub in Egypt

As illustrated by Figure 8-1, 10th of Ramadhan is located in the governorate of Ash-Sharqiyah and is part of Greater Cairo. It was established in 1977 as the first of the new urban industrial cities in Egypt for the purpose of creating new job opportunities, solving housing problems, attracting investors, and capital, among others[69]. As for the Robbiki leather cluster, it is one of the pioneer leather-clusters in the middle east and Africa. It covers all phases of the leather industry manufacturing value chain and its by-products in accordance with international standards and regulations[70].

Figure 8-1 Location of 10th of Ramadhan industrial city and the Robbiki leather cluster (source: BFS, 2020)

[69] 10th Ramadancity (2018): Online Available at: http://www.10ramadancity.net/ (last consulted 24/09/2020)
[70] Pan African Leather Fair (2020): Online Available at: https://www.panafricanleatherfair.com/en/exhibit/Visit_ELRoubiki_City.html (last consulted 24/09/2020)

8.2. Gate fee estimation

To calculate a gate fee for the pilot project with a ramp-up system aiming to achieve profitability within 10 years, the plant shall first be designed according to the throughput waste composition. A capacity of **7,000 tons per year** of hazardous waste was set to be treated in the pilot facility. The latter would operate **7,500 hours per year**, which is equivalent to **85.62%** annual availability.

Figure 8-2 illustrates the process to follow in order to achieve the gate fee value.

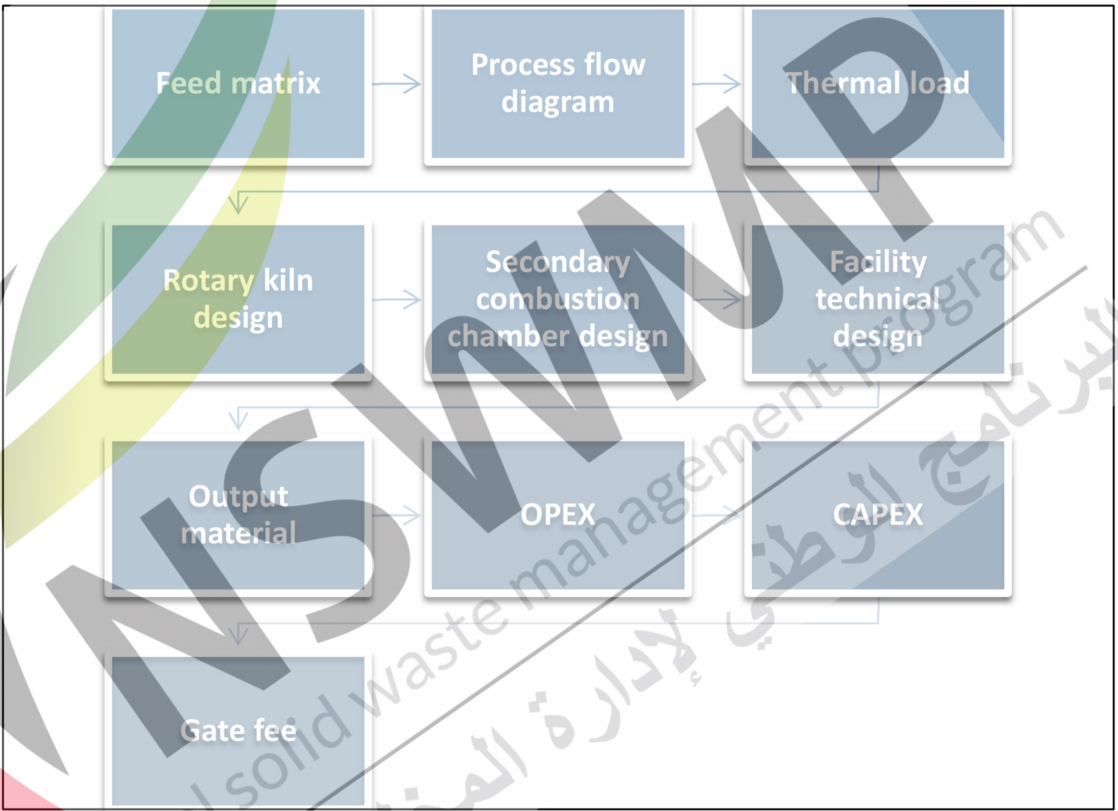


Figure 8-2 Gate fee calculation process scheme (Source: BFS, 2020)

The following sub-chapters are dedicated to elaborating each step of this process and explaining the calculation process adapted to the chosen pilot area.

8.2.1. Feed matrix

The first step of dimensioning a rotary kiln is to determine the input waste composition. Incineration plant designs change according to the waste type. The key drivers are the waste chemical and physical composition, as well as its thermal characteristics. The throughput material has to be balanced in a way that its average calorific value ensures the reach of a minimum temperature inside the kiln. According to German regulations, waste incineration plants are to operate at a minimum temperature of 850°C that shall be maintained throughout the incineration process. If the waste is hazardous and has a halogen content originating from organo-halogen substances of more than 1%, a minimum temperature of 1100°C is to be maintained[71]. Therefore, the throughput waste composition is a crucial parameter to be fixed at the very beginning.

According to a mapping of industries in the pilot area, conducted by IWEX Egypt[68], there are more than 2,000 industrial establishments in 10th of Ramadhan city. They are active in various fields including leather, chemicals, textile, pharmaceuticals, plastic, engineering, ceramic, paper, among others. After the identification of existing industries, waste surveys were conducted to discern the types of waste streams and their respective quantities generated in the area. Table 8-1 represents the top 30 waste materials that are completely wasted; hence they are either stored or disposed of without treatment in the pilot area.

Table 8-1 Type and quantities of waste generated in the 10th of Ramadhan industrial city (Source: IWEX Egypt, 2020)[68]

#	Type of waste	Tons/year
1	**Discarded moulds**	21,103.00
2	**Mixed waste (similar to household)**	9,003.11
3	**Organic sludge**	6,664.63
4	**Off-specifications items and unused products**	5,818.12
5	**Non-Organic sludge**	2,910.80
6	**Asphalt**	2,400.00
7	**Gypsum**	1,678.50
8	**Food waste**	791.05
9	**Particles and dust**	695.60
10	**Soil and gravel**	679.20
11	**Sludges from on-site effluent treatment (1)**	605.00
12	**Sludges from on-site effluent treatment (2)**	498.80
13	**Waste not otherwise specified**	324.39
14	**Concrete and unglazed tiles**	294.10
15	**Waste from processed textile fibre**	161.00
16	**Textiles**	133.12

[71] Seventeenth ordinance for the implementation of the Federal Emission Control Act (ordinance on the incineration and co-incineration of waste - 17th BImSchV)

#	Type of waste	Tons/year
17	**Wood**	120.31
18	**Calcium-based reaction wastes**	110.12
19	**Natural stone**	96.00
20	**Paper**	95.36
21	**Waste preparation mixture**	82.50
22	**Tires**	82.18
23	**Discarded machinery**	80.06
24	**Plastic – PP**	65.41
25	**Spent catalysts**	55.00
26	**Organic solvents**	53.49
27	**Other plastics**	50.63
28	**Plastic HDEP**	48.70
29	**Batteries and accumulators**	48.09
30	**Waste glass in small particles**	48.00

The hazardous waste types that could be treated in a rotary kiln were identified from Table 8-1, and were then classified into **3 categories: sludges, solvents, and solid waste**. After that, the throughput percentages of each category into the incineration facility was determined according to their yearly generated amounts and in a way that balances the calorific value. Figure 8-3 presents the throughput waste characteristics for the pilot plant. Due to the relatively low calorific value from the waste, natural gas is added to the input as support for the combustion to reach the required incineration temperature. It is very important to determine the elementary composition of the waste fraction as it has consequences on the thermal capacity and the composition of the output material from the facility.

Waste characteristics						
Operation time		7500 h/a	Availibility		85,62%	
Type		Natural gas	Sludge	Solvents	Solid waste	Average
Parameter						
C	wt%	68,4	26	60	24	25,98
H	wt%	22,8	4,2	13	3,2	4,149
N	wt%	0	0,7	0	0,7	0,7
O	wt%	0	11,8	26,8	11,4	11,837
S	wt%	0	0,3	0,2	1	0,366
Cl	wt%	0	1,5	0,1	1	1,4455
H2O	wt%	0	50	0	30	47,85
Inerts	wt%	0	5,5	0	29	7,705
CO2	wt%	0,3	0	0	0	0
N2	wt%	8,5	0	0	0	0
Total	wt%	100	100	100	100	100
Calorific value	kJ/kg	39000	11604	30000	9458	11492,11
Throughput	kg/h	0	850	5	84	939
	t/a	0	6375	38	630	
Total throughput	t/a		7043			

Figure 8-3 Pilot facility - Throughput waste characteristics (Source: BFS, 2020)

8.2.2. Process flow diagram

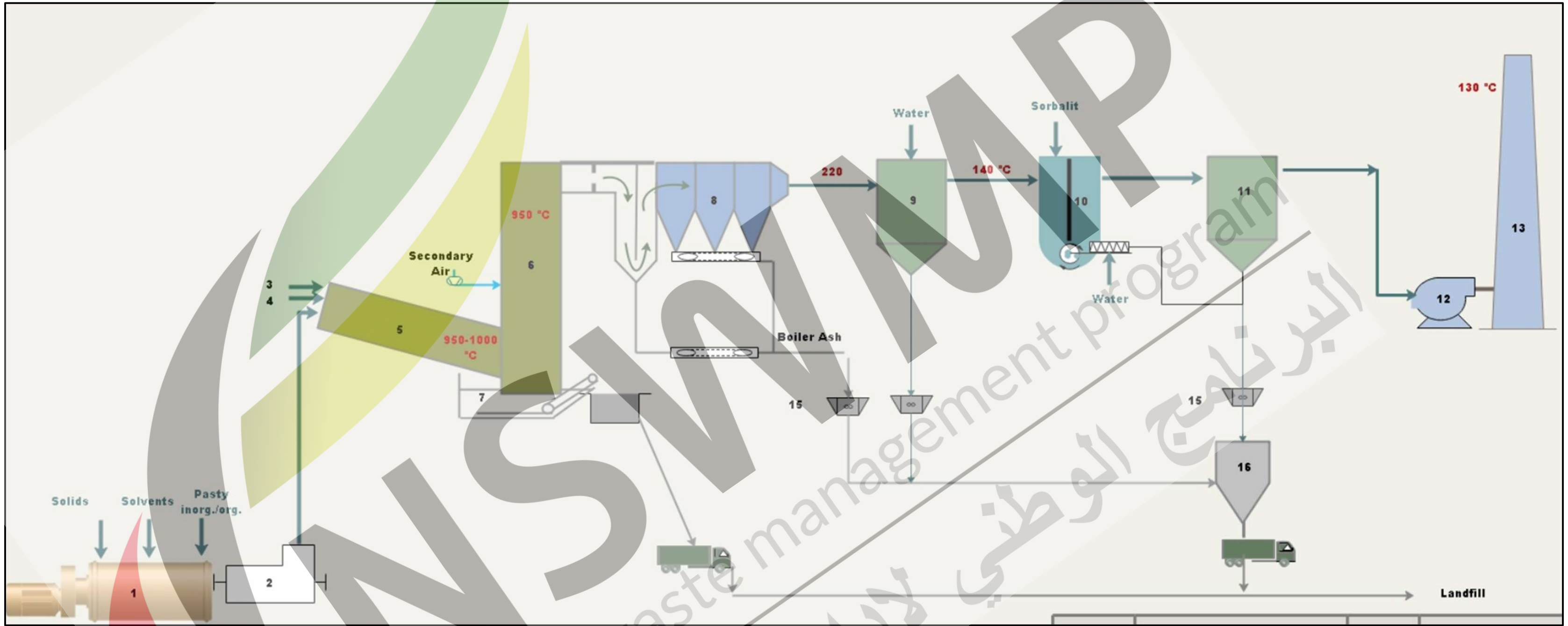


Figure 8-4 Pilot facility - Process flow diagram (Source: BFS, 2020)

1	2	3	4	5	6	7	8
Mixer	Pistol pump	Feed system	Natural gas feed	Rotary kiln	Secondary combustion chamber	Wet deslagger	Boiler
9	10	11	12	13	14	15	16
Quench	Loop reactor	Fabric filter	ID- Fan	Stack	Evaporative cooler	Roller crusher	Ash silo

8.2.3. Thermal load

To input the waste mixture in the rotary kiln, a feeding system composed of a mixing chamber, a piston pump and a screw was chosen. This system has a capacity of 1.5 tons per hour and an energy consumption of 4MW.

According to the operation parameters chosen for the pilot facility, a load thermal capacity of 150kW/m³ is recommended. Accordingly, the thermal surface load, thermal cross section area, and the permanent thermal capacity were calculated. A maximum supported calorific value is of 15,000kJ/kg was fixed, which enabled the calculation of the maximum thermal capacity.

Figure 8-3 summarizes the thermal load calculations for the pilot facility.

	Waste input				Feeding system	
	Throughput		Calorific Value	Heat capacity	Pumps	Maximal capacity
	kg/h	t/a	kJ/kg	kj/h		
Mixed sludge	850	6375	11604	9863400	Mixing chamber / piston pump / screw	1,5 t/h
Solids	84	630	9458	794472		
Solvents	5	38	30000	150000		
Front wall burner natural gas	60	450	39000	2340000	4 MW	
Total feed ; average heat value	999	7493	13148	13134724,13		
Total waste feed	939	7043				
	Unit		Calculated Value		Recommended value	
Load thermal capacity	kW/m³		145,94		150	
	MW		3,65			
Thermal surface load	GJ/m²h		0,26		<1	
	kW/m²		73,04			
Thermal cross section area	GJ/m²h		4,20		6 - 8	
	kW/m²		1167,53			
Permanante thermal capacity	GJ/h		13,13			
	MW/h		3,65			
Thermal capacity max	GJ/h		15,02			
	MW/h		4,17			

Figure 8-5 Pilot facility - Thermal load (Source: BFS, 2020)

8.2.4. Rotary kiln design

After determining the thermal load parameters, the rotary kiln dimensions can be calculated. The standard design for a rotary kiln with a capacity of 7,000 tons per year sets its length to a value of 8 meters. Figure 8-6 summarizes the rotary kiln parameters calculation for the pilot facility.

Rotary kiln technical parameters				
Parameter	Symbol/Formula	Unit	Value	Experimental value comment
Inlet diameter	d(i)	m	2	
Outlet diameter	d(a)	m	2,3	
Length	L	m	8	
Ratio Length/diameter	L/d(i)		4	3 - 3,3 VDI 3640
Throghput	D	t/h	0,999	
	D	t/a	7492,50	
Average calorific value	H(u)	kcal/kg	3142,42	
		kJ/kg	13147,87	
Maximal calorific value	H(u)	kcal/kg	3585,09	
		kJ/kg	15000	
Operation time	T(op)	h	7500	
Cross sectional area	$A(cs) = (3,14*d(i)^2)/4$	m^2	3,13	
Area	A(rk) = 3,14*d(i)*L	m^2	50	
Volume	V(rk) = A(cs)*L	m^3	25	
Thermal load				
Load thermal capacity	Q(fr) = H(u)*D/V(rk)	GJ/m^3h	0,53	
		kW/m^3	145,94	
Thermal surface load	Q(fr) = H(u)*D/A(rk)	GJ/m^2h	0,26	
		kW/m^2	73,04	
Thermal cross section area	Q(fr) = H(u)*D/A(cs)	GJ/m^2h	4,20	
		kW/m^2	1167,53	
Permanante thermal capacity	Q= H(u)*D	GJ/h	13,13	
		MW/h	3,65	
Thermal capacity max		GJ/h	15,02	
		MW/h	4,17	

Figure 8-6 Pilot facility - Rotary kiln design parameters (Source: BFS, 2020)

8.2.5. Secondary combustion chamber design

The secondary combustion chamber (SCC) is an equipment where the volatiles released from the rotary kiln are received after combustion to be completely burned under high temperature and excess of air and injected oxygen[72]. In Europe, the emissions released into the atmosphere from chimneys are regulated by the EU Industrial Emissions Directive 2010/75/EC, which is why the SSC shall insure clean and hazard-free emissions into the atmosphere.

To dimension the secondary combustion chamber, a minimum residence time of 2 seconds and a temperature of 910°C are fixed according to experimental values. Then the thermal values and

[72] Lawinsider Dictionary (2020): https://www.lawinsider.com/dictionary/secondary-combustion-chamber (last consulted 24/09/2020)

dimensions are determined according to the heat value of the waste stream and facility operational parameters. Finally, the real residence time is calculated accordingly. Figure 8-7 summarizes the SSC parameters for the pilot facility.

Secondary combustion chamber parameters					
Parameter	Symbol/formula	Unit	Calculated value	Experience value	Comment
Temperatur	T(scc)	K		1183,14	
Heat capacity	H(0)		11492,11		
Oxygen content		Vol%			
Residence time at 950°C	t(res) = h(ssc)/V(fg)	s	3,2	7,1	
Gas flow		Nm³/h	7492		
Operating volume flow at 950°C			32465		
Flue gas velocity		m/s	2,34375	2 ~ 5	
Inlet diameter	d(i)	m	2,2		
Hight	h	m	7,5		
Hight - 1m secondary air level		m	6,5		
Throughput	D	t/h	1		
	D	t/a	7043		
Permanante heat value	H(u)	kcal/kg	2746,68021		
	H(u)	kJ/kg	11492,11		
Operation time	t(op)	h	7500		
Cross section area	A(cs)=(3,14*d(i)²)/4	m²	3,8		
Volume	V(scc)=A(cas)*L	m³	28		
Thermal capacity					
Thermal capacity per volume	Q(scc)= H(u)*D/V(SCC)	MJ/m³h	0,38	0.4 ~ 1,2	
		kW/m³	105	111,1 ~ 333,4	
Thermal cross section	Q(fr)=H(u)*D/A(cs)	MJ/m²h	2,8	4 ~ 6	
		kW/m²			

Figure 8-7 Pilot facility - Secondary combustion chamber parameters (Source: BFS, 2020)

8.2.6. Facility technical design

In this stage of the facility design, operational parameters as well as dimensions of the rotary kiln and secondary combustion chamber are summarized as illustrated by Figure 8-8. This makes easier proceeding to the remaining components of the facility; namely: the boiler, the sorbalit, the quench, the bag filter, and the chimney.

Parameter		Unit	Value
Capacity	Mixed sludge	kg/h	850
	Solid		85
	Solvents		5
	Throughput/day	t/d	4.9
	Working hours	h/a	7500
Thermal capacity		MW	3,65
Availibility		%	85,62%
Rotary kiln	Primary air volume	Nm^3/hr	5618
	operational temperature	°C	900 - 1000
	Rotation speed	rpm	2 ~ 3
	Outlet diameter	mm	2300
	Intlet diameter		2000
	Length		8000
	Volume	m^3	25,12
	Waste mix		
	Counter current flow	grad	1.5 - 2.5
	Slag	kg/h	18
Secondary combustion chamber	Temperature	°C	900-1000
		Nm^3/hr	1000-1500
	Residence time	s	3,2
	Gas velocity	m/s	2,4
	Oxygene volume	vol%	7,1
	length	m	6500
	Outlet diameter		2540
	Intlet diameter		2200
burner	at < 850°C automatically in operation		

Figure 8-8 Pilot facility - Parameters overview (Source: BFS, 2020)

i. The boiler

The facility would be equipped with an energy recovery system consisting of a steam generation system, i.e. a boiler. It has tubes where water circulates and is heated by the heat energy from waste incineration[73]. As illustrated by Figure 8-9, gas from SCC enters the boiler at 910°C and exits at a temperature of 220°C producing 3.2 tons of steam per hour at 180°C.

[73] Günther et Al (2014) Steam generator for producing superheated steam in a waste incineration plant

	Parameter	Unit	Value
Boiler	Inlet temperature	°C	910
	Outlet temperature		220
	Oxygene volume	vol%	7,1
	Max Steam prodution	t/h	3,2
	Steam parameters	bar	10
		°C	180

Figure 8-9 Pilot facility - Boiler parameters (Source: BFS, 2020)

ii. The sorbalit

Sorbalit is a chemical product that is used in waste incineration plants for flue gas treatment. It is an absorbent composed of a lime-carbon mixture and can remove a range of pollutants, including acidic components, volatile heavy metals, and organic materials. The suggested Sorbalit for the pilot facility has a composition of 80% lime, 10% trace powder and 10% activated carbon, as illustrated by Figure 8-10.

	Parameter	Unit	Value
Sorbalit injection in front of the bag filter	inlet stream	kg/h	82
	yearly amount	t/a	718
Sorbalit	Composition	80% lime, 10% trass powder, 10% activated charbon	

Figure 8-10 Pilot facility - Sorbalit parameters (Source: BFS, 2020)

iii. The quench

Before its release to the air, the flue gas from an incineration plant goes through a temperature reduction process. The method suggested for this pilot facility is to quench the combustion gases with water. Figure 8-11 presents the dimensions and the gas parameters before and after the quench unit.

	Parameter	Unit	Value
Quench	Inlet temperature	°C	220
	Outlet temperature		140
	Diameter	mm	700
	Hight		50000
	water in the quench	kg/h	330

Figure 8-11 Pilot facility - Quench parameters (Source: BFS, 2020)

iv. The filtering system

Bag filters are used in waste-to-energy facilities to further reduce the particles emissions like NO_x, SO_2, CO, mercury, and others from the combustion gas before their release to the environment. For the pilot facility, it is suggested to use a filter chamber made of polytetrafluoroethylene (PTFE) with a filtering surface of 140m². Figure 8-12 illustrates further parameters of the filtering system suggested for the pilot facility.

	Parameter	Unit	Value
Bag filter	Inlet temperature	°C	140
	Number of chambers		1
	filter material		PTFE
	maximal pressure difference	mbar	25
	filter surface	m²	140
	number of filter tubes		120
	gas volume	Nm³/hr	7800
		m/h	11,835
	Filterflächenbelastung	m³/m³h	85
			yes
	number of filter chambers		1
	Filter bags per chamber		120
	filter bag diameter	mm	120
	filter bag length	mm	3000
	filter chamber hight	mm	5900
Chimney	flue gas temperature chimney	°C	130-140

Figure 8-12 Pilot facility - Filtering system parameters (Source: BFS, 2020)

The gas emissions from the filtering system are then piped and guided using a fan to the chimney where they are released to the environment.

v. Emissions

As briefly mentioned above, emission limit values are set in the EU based on BATREF by the directive 2010/75/EU of the European Parliament and the Council on Industrial Emissions. Figure 8-13 represents the yearly average value which will be emitted by the pilot facility compared to the limit value.

emissions measurment	yearly average		limit value
Corg	02 ~ 03	mg/Nm³	10
CO		mg/Nm³	50
HF	<0,1	mg/Nm³	1
HCl	0,6-0,7	mg/Nm³	10
SO2	17,57	mg/Nm³	50
Nox	138	mg/Nm³	200
Dust	0,26	mg/Nm³	10
Dioxine/Furane	0,005	ng TE/Nm³	0,1
Mercury	<2		0,05
Meavy metals	0,026	mg/Nm³	0,5

Figure 8-13 Pilot facility - Emissions (Source: BFS, 2020)

8.2.7. Output material

As illustrated by the process flow diagram, there are several outputs from the facility in multiple units of the waste combustion process, mainly from the combustion chamber, the boiler, the filtering unit and the sorbalit. This phase of the process is dedicated to estimating the quantities of the output material, which will then be used to calculate the operational costs of the facility. The estimation is made according to the elemental analysis of the throughput material conducted in the beginning of the process (represented by Figure 8-3). Figure 8-14 summarizes the estimated quantities generated per hour as output material from the pilot facility.

Parameter	Unit	Value
Slag	kg/h	62,4
Boiler ash	kg/h	0,8
Bag filter lime residue	kg/h	220,8
Sorbalit	kg/h	89,6
Urea 10% SNCR	kg/h	32,8

Figure 8-14 Pilot facility - Output material (Source: BFS, 2020)

8.2.8. Capital expenditures (CAPEX)

The capital expenditures of the pilot facility are estimated according to quotations and from experience in the European market. A percentage of 20% of total costs is added to the total costs as unforeseeable costs related to the machinery and equipment. A summary of the CAPEX estimation of the pilot facility is summarized in Figure 8-15.

	Trice per unit	Amount	Total	Comment
MP-System - Mixing, pumping for solids, paste and solvents	1.500.000,00 €	1	1.500.000,00 €	
Front burner with natural gas	85.000,00 €	1	85.000,00 €	Combustion support due to low calorific value
Supply burner Secondary Combustion Chamber	85.000,00 €	1	85.000,00 €	Minimum temperature set by the German law
SPS - S7	400.000,00 €	1	400.000,00 €	
electric power deviation	150.000,00 €	1	150.000,00 €	
Stages, Rails	300.000,00 €	1	300.000,00 €	
Tubes and corrosion protection	150.000,00 €	1	150.000,00 €	
Pressure air supply system	150.000,00 €	1	150.000,00 €	
Combustion chamber - Rotary kiln with barrel feeding (60 l) and secondary combustion chamber	1.800.000,00 €	1	1.800.000,00 €	
wet deslagger with screw release	300.000,00 €	1	300.000,00 €	
energy recovery - Boiler including boilter feed water system	900.000,00 €	1	900.000,00 €	
Flue gas treatment including SNCR, Quench, Fabric with recirculation, Loop reactor, Fan, Stack	1.900.000,00 €	1	1.900.000,00 €	
Emission control measurement	315.000,00 €	1	315.000,00 €	
Subtotal			8.035.000,00 €	
Planning 3% of investment	241.050,00 €	1	241.050,00 €	
commissioning	100.000,00 €	1	100.000,00 €	
		Total	8.376.050,00 €	
Unforseeables related to machinery and equipment	20%		1.675.210,00 €	
		Total	10.051.260,00 €	

Figure 8-15 Pilot facility - CAPEX (Source: BFS, 2020)

8.2.9. Operational costs (OPEX) and gate fee

The operational costs of the pilot facility include: the disposal costs of produced residues (ash, slag, residues from the filtering system, etc.) in addition to staff expenses and maintenance costs. All costs were adapted to the local context of Egypt.

As support for the combustion, two sources of energy are presented: natural gas and refuse-derived fuels. The costs of these two options differ, which is why, and as illustrated by Figure 8-16, two different values of the OPEX were calculated. It is then up to the operational of the facility to decide whether to go with one of the two options.

As mentioned in chapter 7, the gate fee was calculated to reach the break-even point by the 10th year of its operation, meaning covering all its costs. As per CAPEX and OPEX, a minimum gate fee of **900€/ton** was estimated. In addition to the gate fee, the facility would have revenues selling the steam produced in the boiler as a source of energy for 0.03€/kWh. This gate fee does not present any profit for the operator; it covers all defined expenses.

It is important to note that the calculations did not take into consideration any economic assumptions such as loans, interest rates, foreign capital rates, etc.

	Cost per unit	Unit	Waste		Combustion support		Total
			t/a	€/a	kWh/h	kWh/a	€/a
Slag	92,18	€/t	468	43.140,24			43.140,24
Boiler ash	92,18	€/t	6	553,08			553,08
Bag filter lime residue	192,78	€/t	1656	319.243,68			319.243,68
Sorbalit	105	€/t	672	70.560,00			70.560,00
Urea 10% SNCR	236	€/t	246	58.056,00			58.056,00
Activated carbon	0	€/t	67	0,00			0,00
Natural gas (combustion support)	0,03	€/kWh			650	4875000	146.250,00
RDF (combustion support)	40	€/t				450	18.000,00
Lubricants, N2, pressure air, etc.	0,59	€/t	7043	4.155,37			4.155,37
Other disposal costs	0,26	€/t	7043	1.831,18			1.831,18
						Total	497.539,55
						€/t	€/a
Cost of RDF as combustion support						73	514.139,00
Cost of Natural gas as combustion support						89	626.827,00

	Cost per unit	Unit	Number of units	Total
Electric Energy	0,02	€/kWh	30	225.000,00 €
Fuel	0,4 5	€/l km/h	3	2.300,00 €
Plant manager	1.000,00	€/month	1	12.000,00 €
Maintenance team	800,00	€/month	3	28.800,00 €
shift leader	800,00	€/month	2	19.200,00 €
machine operator	500,00	€/month	6	36.000,00 €
Quality control/ Laboratory	800,00	€/month	3	28.800,00 €
Administration	500,00	€/month	3	18.000,00 €
Laboratory costs	10.000,00	€/month		120.000,00 €
maintenance 5% investment cost	10.000.000,00		5%	500.000,00 €
OPEX incl. RDF as combustion support				2.001.778,55 €
OPEX incl. Natura gas as combustion support				2.114.466,55 €
Steam sales (10 bar, 180°C)	0,03	€/kWh	23893	716,79 €
Gate fee	900	€/t		6.338.700,00 €

Figure 8-16 Pilot facility - OPEX (Source: BFS, 2020)

8.2.10. Facility profitability

As illustrated by Figure 8-17 and Figure 8-18, the pilot facility profitability was calculated according to the fixed gate fee for both cases: using RDF or natural gas as support for the combustion. Using RDF would generate profits starting from the 10th year, while natural gas within 11 years.

RDF to support combustion

Costs/Revenues	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15
Total CAPEX	-10.051.260 €	-502.563 €	-502.563 €	-502.563 €	-502.563 €	-502.563 €	-502.563 €	-502.563 €	-502.563 €	-502.563 €	-502.563 €	-502.563 €	-502.563 €	-502.563 €	-502.563 €
Total OPEX	-2.001.779 €	-2.001.779 €	-2.001.779 €	-2.001.779 €	-2.001.779 €	-2.001.779 €	-2.001.779 €	-2.001.779 €	-2.001.779 €	-2.001.779 €	-2.001.779 €	-2.001.779 €	-2.001.779 €	-2.001.779 €	-2.001.779 €
Gate fee	633.870 €	1.267.740 €	1.901.610 €	2.535.480 €	3.169.350 €	3.803.220 €	4.437.090 €	5.070.960 €	5.704.830 €	6.338.700 €	6.338.700 €	6.338.700 €	6.338.700 €	6.338.700 €	6.338.700 €
Total Revenues	634.587 €	1.268.457 €	1.902.327 €	2.536.197 €	3.170.067 €	3.803.937 €	4.437.807 €	5.071.677 €	5.705.547 €	6.339.417 €	6.339.417 €	6.339.417 €	6.339.417 €	6.339.417 €	6.339.417 €
Profit per year	-11.418.452 €	-1.235.885 €	-602.015 €	31.855 €	665.725 €	1.299.595 €	1.933.465 €	2.567.335 €	3.201.205 €	3.835.075 €	3.835.075 €	3.835.075 €	3.835.075 €	3.835.075 €	3.835.075 €
Cumulative profit	-11.418.452 €	-12.654.337 €	-13.256.351 €	-13.224.496 €	-12.558.771 €	-11.259.176 €	-9.325.710 €	-6.758.375 €	-3.557.170 €	277.905 €	4.112.981 €	7.948.056 €	11.783.131 €	15.618.206 €	19.453.282 €

Natural gas to support combustion

Costs/Revenues	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15
Total CAPEX	-10.051.260 €	-502.563 €	-502.563 €	-502.563 €	-502.563 €	-502.563 €	-502.563 €	-502.563 €	-502.563 €	-502.563 €	-502.563 €	-502.563 €	-502.563 €	-502.563 €	-502.563 €
Total OPEX	-2.114.467 €	-2.114.467 €	-2.114.467 €	-2.114.467 €	-2.114.467 €	-2.114.467 €	-2.114.467 €	-2.114.467 €	-2.114.467 €	-2.114.467 €	-2.114.467 €	-2.114.467 €	-2.114.467 €	-2.114.467 €	-2.114.467 €
Gate fee	633.870 €	1.267.740 €	1.901.610 €	2.535.480 €	3.169.350 €	3.803.220 €	4.437.090 €	5.070.960 €	5.704.830 €	6.338.700 €	6.338.700 €	6.338.700 €	6.338.700 €	6.338.700 €	6.338.700 €
Total Revenues	634.587 €	1.268.457 €	1.902.327 €	2.536.197 €	3.170.067 €	3.803.937 €	4.437.807 €	5.071.677 €	5.705.547 €	6.339.417 €	6.339.417 €	6.339.417 €	6.339.417 €	6.339.417 €	6.339.417 €
Profit per year	-11.531.140 €	-1.348.573 €	-714.703 €	-80.833 €	553.037 €	1.186.907 €	1.820.777 €	2.454.647 €	3.088.517 €	3.722.387 €	3.722.387 €	3.722.387 €	3.722.387 €	3.722.387 €	3.722.387 €
Cumulative profit	-11.531.140 €	-12.879.713 €	-13.594.415 €	-13.675.248 €	-13.122.211 €	-11.935.304 €	-10.114.526 €	-7.659.879 €	-4.571.362 €	-848.975 €	2.873.413 €	6.595.800 €	10.318.187 €	14.040.574 €	17.762.962 €

Figure 8-17 Pilot facility - Profitability estimation for 15 years of the facility operation (Source: BFS, 2020)

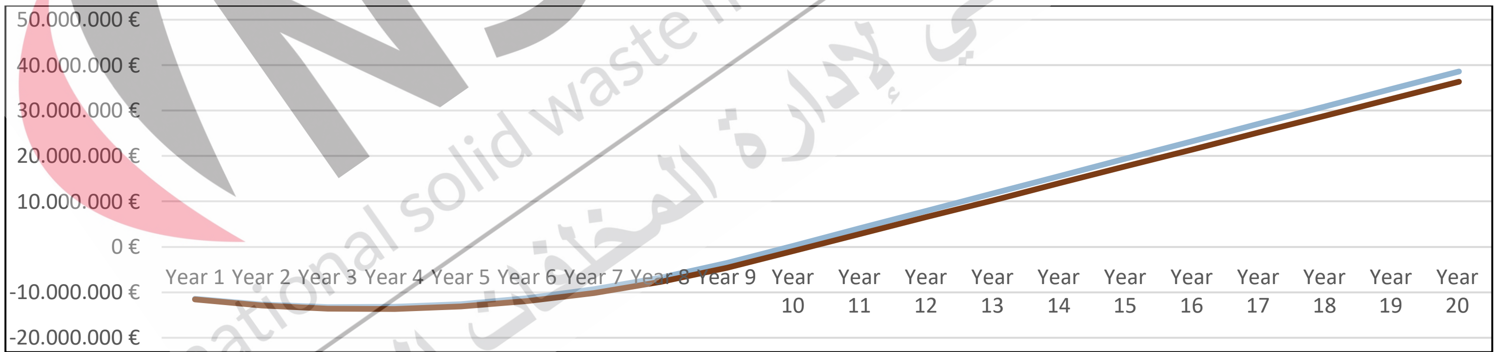


Figure 8-18 Pilot facility - Profitability plot (Source: BFS, 2020)

8.2.11. Facility operation

The operation of a thermal treatment facility equipped with a rotary kiln shall be carried out by an experienced and specialized staff in the field of thermal hazardous waste treatment. There are several aspects that shall be monitored at all times mainly the throughput control and safety of the staff.

- Throughput control: in spite of fixing the admissible waste stream in the facility, it can occur that a delivery does not match the criteria. Which is why, the quality of the throughput should be checked at all times prior to the feeding system. With experience, it can be visually detected if the waste input is inappropriate. Having HW experts would mitigate the threats of explosions and malfunctioning inside the rotary kiln;

- Health and safety: similar to other hazardous waste treatment technologies, thermal treatment also presents risks on the health of the workers onsite. For rotary kilns, as mentioned in the previous point, explosions can occur due to an inappropriate waste composition. Thus, all the facility staff need to be trained in health and safety (including hazardous waste handling, first aid training, firefighting, awareness training for personal protection equipment etc.).

It is also important to note that rotary kilns are flexible hazardous waste treatment technologies. Meaning, usually a facility is initially conceptualised to receive certain types of waste streams. However, by time, new industrial activities in the region develop, some specific waste stream might increase, or a raise of demand for a certain waste treatment can occur, the facility can be adapted accordingly by altering components of the process or adding appropriate equipment. It can also be the case that the facility operator decides to change the combustion support media (for example using RFD instead of natural gas) this is also possible by making a few changes in the facility.

9. Final Considerations

Inapt hazardous waste management in Egypt bears dire peril to the health of the country's citizens as well as the environment. This sector requires optimization on many levels, namely legal, technical, and managerial. That being said, Egypt has established an environmental legal basis since the nineties to build its waste management strategy on. The law n°4 of 1994 defines terms also related to hazardous waste, substance handling, waste management, waste disposal, etc. Additionally, Egypt has signed HW related international conventions, such as Basel Convention. However, enforcement and general practices in the country do not reflect these legal texts in praxis. This lack of compliance with the regulations results mainly from a lack of a national strategy aiming to organize and develop the sector.

A thorough study of the status quo of industrial hazardous waste management in Egypt was performed through a combination of stakeholder consultation rounds, knowledge exchange with local and international experts, background research, and experience in the MENA region. This combination of actions set up the ground for BFS to assess the local situation and develop a proper strategy for the management of industrial hazardous waste in the country. When it comes to hazardous waste, the first and foremost aspect to prioritise is human health, and it is in Egypt's biggest interest to be no exception to this. Accordingly, five objectives were stipulated to meet the strategy's vision.

Gathering, tracking, and monitoring all hazardous waste data in the country

The first and most encountered challenge faced in the process of strategy development was the absence of up-to-date data about IHW in Egypt. This point was also underlined during the review of the draft strategy presented to the stakeholders. The lack of data is a reflex of an inexistent centralized authority responsible for gathering, tracking and monitoring for all hazardous waste in the country. To address this point, BFS suggests the development of a national HW tracking system in Egypt, meaning that all data shall be compiled and controlled by a centralized authority in an electronic system. This database shall be kept updated by implementing a connected monitoring system to track hazardous waste at its generation, transportation, treatment, and final disposal.

Centralization of responsibilities among different stakeholders and clear definition of public and private responsibilities

There is no clear definition of a single authority that coordinates the different stakeholders related to hazardous waste production in Egypt. A central organization should be designated/created to direct HW related decisions in the country. Communication between stakeholders and authorities is a key factor in keeping a harmonized waste management system. It is advised to involve all related parties during the establishment of new regulations.

Development of sufficient national treatment capacities for priority hazardous waste streams

BFS suggests an integrated hazardous waste treatment facility equipped with a sanitary landfill, physico-chemical treatment, thermal treatment, and recycling technologies close to the industrial zones. It is understood that Egypt has a solid cement industry, and some hazardous waste fractions could be treated inside their kilns. It is also important to highlight that not all fractions are apt to be treated in the cement kilns, that some technical adaptations shall be made within the plants to accept hazardous waste and that the estimated produced quantities still exceed the current treatment capacity in the country.

It is also suggested to establish a general tendering process fo hazardous waste management. By monitoring state demands and channeling the requirements to pre-selected and suitable bidders via standardized tender processes in different business setups (e.g., limited operation licenses, public-private partnerships, build-operate-transfer (BOT) setups, and others). It is recommended to categorize hazardous waste treatment facilities as critical infrastructure and consequentially define strict rules and standardized processes to ensure the fulfillment of the national demand for handling/treatment/disposal capacities in quantities and qualities.

In addition to increasing the HW treatment capacity, it is highly recommended to adopt the European waste code in Egypt. Countries that have signed the Basel Convention were responsible for ratifying the convention's requirements in their laws, including the EWC. The latter ensures a harmonized waste classification worldwide.

Integration and commitment from industrial waste generators in taking financial responsibility in safe and professional handling of waste

Despite the common understanding that HW generators shall be responsible for their waste, this concept is not legally enforced in Egypt. The present strategy suggests establishing an EPR system for certain waste fractions, namely WEEE, batteries, and medical waste. This would require an appropriate legal framework, the definition of a PRO, interaction of stakeholders, among other factors.

Additionally, cleaner production within industries shall be encouraged. The latter is highly beneficial for industries as it reduces waste disposal cost and raw material costs, decreases damages, improves public relations/image, among others. These practices can be enhanced by reducing a certain percentage of the industry’s taxes, for example.

Development of capacity building, knowledge transfer and awareness-raising among governmental bodies, public and private stakeholders, industry staff and citizens

Awareness-raising is essential for the successful implementation of the objectives described in this strategy. BFS highly recommends capacity building around hazardous waste among all involved parties, not only at the HW generators and regulation authorities but also to citizens who are in contact with hazardous waste substances at their homes. BFS suggests the establishment of a take-back system of hazardous waste from households. For this system to be successful, the public must be informed throughout awareness-raising campaigns on their exposure to hazardous substances, the risks these exposures encompass and how to safely and properly dispose of the HW generated at home.

Outlook scenario

Besides implementing the recommended measures (Chapter 6.5), BFS suggests starting with a pilot project in one of the industrial cities in Egypt. The pilot project consists of constructing a thermal treatment facility equipped with a rotary kiln which would receive specific types of hazardous waste generated at 10th of Ramadan City (including the Robbiki leather cluster).

The minimum required gate fee for the operations of the thermal facility was calculated based on assumed input fractions, defined throughput capacity, energy, and mass balances. It is important to highlight that the fee was based on estimated CAPEX (using Germany as a benchmark) and OPEX. It does not include any profit for the operator and shall be used as an indication for a minimum price required to operate such a facility under the described circumstances and project boundaries described in Chapter 8.

A safe, sustainable, and profitable HW sector can be successfully created in Egypt by combining legislation implementation and enforcement, infrastructure development, and awareness-raising. There are significant efforts to establish a safer and healthier environment in the country. An example is the latest waste management law agreed by the House of Representatives in August 2020. This law is one of the many steps currently being taken to achieve a better and healthier environment in Egypt.

10. Annexes

10.1. Data list

Table 10-1 Data list (Source: BFS, 2020)

Title	Type*	Legislation	UNARA	Strategy	Statistic	Data from Egypt	Data from Germany	Industrial Hazardous waste	Medical waste	Chemical waste	Oil waste	Agriculture waste	WEEE
Fraunhofer UMSICHT (2020): Presentation and discussion of targets for the NWMS	Pr			×									
Survey and Establishment of a comprehensive Database for Waste Management in Kuwait – eMISK$_{Waste}$ User Need Assessment and	Rt		×	×				×	×	×	×	×	×

Title	Type*	Legislation	UNARA	Strategy	Statistic	Data from Egypt	Data from Germany	Industrial Hazardous waste	Medical waste	Chemical waste	Oil waste	Agriculture waste	WEEE
Requirement Analysis Report													
Survey and Establishment of a comprehensive Database for Waste Management in Kuwait – eMISKWaste Conceptual Design Report on National Waste Management Strategy	Rt		×	×				×	×	×	×	×	×
I.Tarek (2016) Review of existing regulations	Rt	×				×							

Title	Type*	Legislation	UNARA	Strategy	Statistic	Data from Egypt	Data from Germany	Industrial Hazardous waste	Medical waste	Chemical waste	Oil waste	Agriculture waste	WEEE
and legislations addressing the area of Industrial waste management in Egypt													
GIZ (2015) manual on industrial hazardous waste management for authorities in low- and middle-income economies.	Rt	×		×	×		×	×	×	×	×	×	×
https://ec.europa.eu/eurostat/data/database	Web				×		×						
GIZ (2013) Annual	Rt					×		×	×	×	×	×	×

Title	Type*	Legislation	UNARA	Strategy	Statistic	Data from Egypt	Data from Germany	Industrial Hazardous waste	Medical waste	Chemical waste	Oil waste	Agriculture waste	WEEE
report for solid waste management in Egypt													
GIZ (2014) Country report on the solid waste management in Egypt	Rt					×		×	×	×	×	×	×
SECO (2017) Hazardous Waste - Sector Action Plan for Egypt	Rt	×		×		×		×		×	×	×	
MoE: List of industrial processes generating hazardous waste	AN					×		×	×	×	×	×	×
X Chen a et Al (1999) Major	Ar											×	

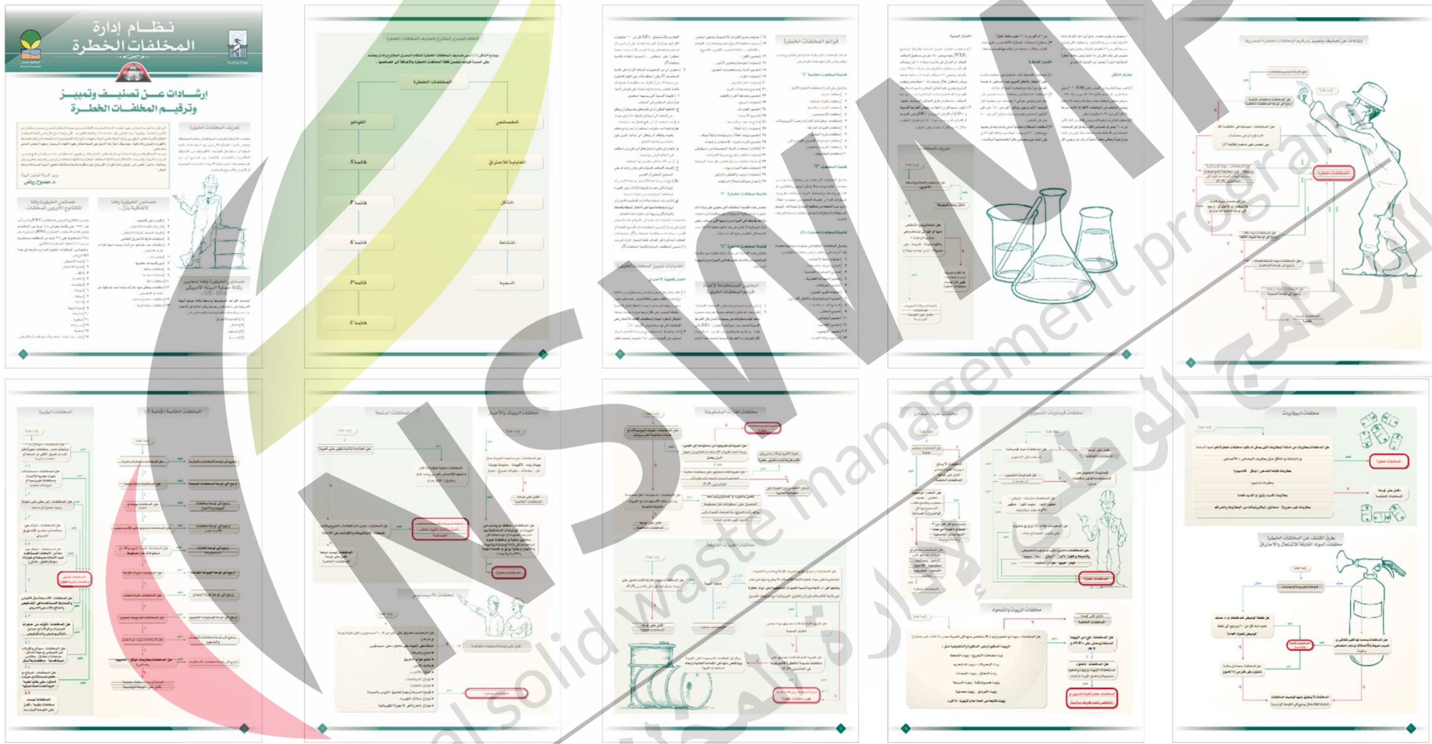
Title	Type*	Legislation	UNARA	Strategy	Statistic	Data from Egypt	Data from Germany	Industrial Hazardous waste	Medical waste	Chemical waste	Oil waste	Agriculture waste	WEEE
impacts of sea-level rise on agriculture													
Ministry of Environment (2016) The state of the environment report in the Arab Republic of Egypt for the year 2016	Rt	×			×	×		×	×	×	×	×	×
Scholz. R et Al (2008) Waste incineration systems; Current technology and future developments in Germany	Ar						×	×		×	×	×	

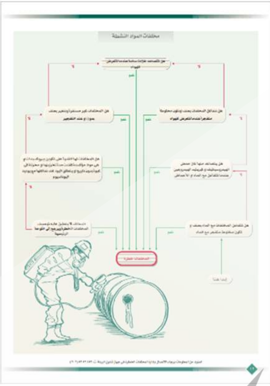
Title	Type*	Legislation	UNARA	Strategy	Statistic	Data from Egypt	Data from Germany	Industrial Hazardous waste	Medical waste	Chemical waste	Oil waste	Agriculture waste	WEEE
Umweltbundesamt - https://www.umweltbundesamt.de/en/	Web	×					×	×	×	×	×	×	×

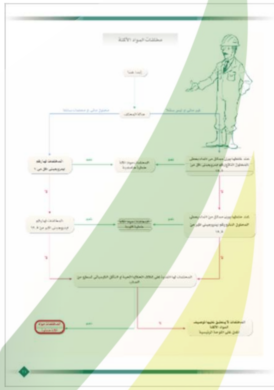
*Pr: Presentation; Ar: Article; Web: Website; AN: Annex; Rt: Report

10.2. Hazardous waste guidelines

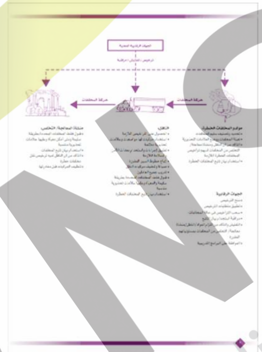
Hazardous waste classification:

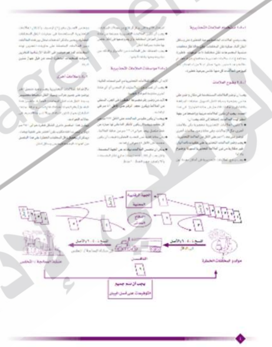






Hazardous waste transportation





Necessary authorizations for operating a hazardous waste treatment facility


نظام إدارة المخلفات الخطرة

متطلبات تراخيص إدارة المخلفات الخطرة وفقا لقانون البيئة رقم " ٤ " لعام ١٩٩٤

Hazardous waste interim storage

Hazardous waste treatment and disposal


نظام إدارة المخلفات الخطرة

الخطوط الارشادية للمعالجة والتخلص الآمن من المخلفات الخطرة

Solvents treatment


نظام إدارة المخلفات الخطرة
تدوير مخلفات المذيبات

Hazardous waste related legislations


نظام إدارة المخلفات الخطرة

الفقرات الخاصة بإدارة النفايات الخطرة بقانون البيئة رقم ٤ ولائحته التنفيذية

10.3. Hazardous waste production estimation methodologies

The methodology described by the United Nations Environment Programme (UNEP) and implemented by Fraunhofer Umsicht.

It consists in correlating the number of employees per industry and the amount of waste produced per year. The results are an estimation only and can be questioned, especially in the case when no comparison with primary data is possible.

From countries with comprehensive waste and data collection systems (total industrial waste and number of employees), the comparison is relatively simple (see Table 10-2). For western industrialized countries, **ranges vary between 300-800kg of IHW/ employee**.

Table 10-2 Industrial hazardous waste generation for exemplary EU countries (Source: Eurostat, 2016)

Country	IHW in 2016 (tons)[74]	Employees in the industrial sector in 2016[75]	IHW 2016 (Kg/ employee)
Austria	528,662	639	827.3
Czech Republic	550,971	1,329	414.6
Croatia	30,098	254	118.5
Estonia	45,098	115	392.2
France	2,731,046	3,118	875.9
Germany	5,252,271	7,577	693.2
Poland	815,784	3,054	267.2
Portugal	213,600	726	294.2
United Kingdom	1,291,631	2,661	486.4

In countries with no systematic waste and data collection, several extrapolation methods can be utilized, such as:

- Extrapolation per employee after primary data collection (e.g. a certain number of onsite interviews with representatives of all sectors);
- Evaluation of the waste data that is already accepted in the hazardous waste treatment plants;
- Extrapolation per employee based on a reference country.

If there is no primary data analysis and no acceptance data, it is recommended to completely estimate using **a reference country**. Accuracy can significantly increase if extrapolation is not conducted for the entire industry as above, but to branches of the industry, e.g., it makes a big

[74] Eurostat (2016) EU Hazardous waste statistics
[75] Eurostat (2016) EU employment statistics

difference whether employees work in the chemical or food industry or whether they also produce hazardous waste.

Table 10-3 exemplifies the data which was calculated for Kuwait (based on the reference country Estonia).

Table 10-3 Example of industrial hazardous waste production estimates in Kuwait (Source: eMISK, 2020)[21]

Industry Type	No of Ind. Employees in Kuwait (2018)	IHW per employee [kg/a]	IHW in Kuwait [tons/year]
Food, beverages & tobacco	18,000	33	600
Textiles, clothing & leather product	1,500	5	7
Wood & wood products, furniture	4,500	60	270
Paper, paper products, printing & publishing	5,300	96	500
Chemicals, petroleum products, coal, rubber & plastic	16,950	1,200	20,500
Non–metallic minerals (except petrol)	16,000	210	3,500
Metal products machinery & equipment	33,400	600	20,000
Other industrial manufacturing	2,000	2,500	4,500
Oil Industry	16,800	5,350	90,000
Total	**114,600**	**1,250**	**~145,000**
Subtotal (no oil industry)	**98,000**	**560**	**55,000**

As estimated above, the average waste generation per employee in Kuwait is high (1,250 kg/a) compared to other industrialized countries (e.g., Germany). Without the oil industry, which is prominent (and rather automatized) in the country, the average ratio is 560 kg/a. These results elucidate the importance of performing such extrapolations per industry and based on numbers of a comparable country. Some **criteria** might be useful when choosing a country benchmark:

- **Data availability**
  - Only a country with reliable documentation of waste generation shall be used as benchmark.
- **Degree of industrialization**
  - Value added by medium-high technological industrial sectors divided by the total value added of the industry (called MHVAsh);

  - The MHVAsh is a subcategory of the competitive industrial performance (CIP) indicator of the United Nations Industrial Development Organization (UNIDO), publicly available;
  - Criterion shall establish maximum deviation, e.g., + -0.05;
  - Important to highlight that different automatization levels have a considering impact on the waste per employee-correlation;
- **Gross capital formation (GCF) as percentage of the gross domestic product (GDP)**
  - Criterion shall establish maximum deviation, e.g., + -2%.
- **Industrial history** (based on literature research)
  - When and to what extent was industrialization done?
  - Have there been major upheavals since then?
- **Special branches of industry**
  - Countries have specific industrial activities;
  - For example, Kuwait´s economy is highly based on the oil industry. If country benchmark does not present this characteristic, information must be generated from primary data.

The above-mentioned methodology may be used for waste estimations but is limited to data availability and accuracy from reference countries.

Besides variations in waste quantities, different industrial processes produce several hazardous waste streams. To exemplify, related to the hardening of steel, cyanide-, nitrate-, or nitrate-containing sludge and spent hardening salt are generated. A holistic list of industry types, production processes, and generated hazardous waste fractions are shown in Annex 10.4.

Methodology used in Jordan for hazardous waste data gathering

This method is based on data collection through auditing a representative number of waste generators from each sector, producing hazardous waste in the country. There are four steps to follow as illustrated in Figure 10-1

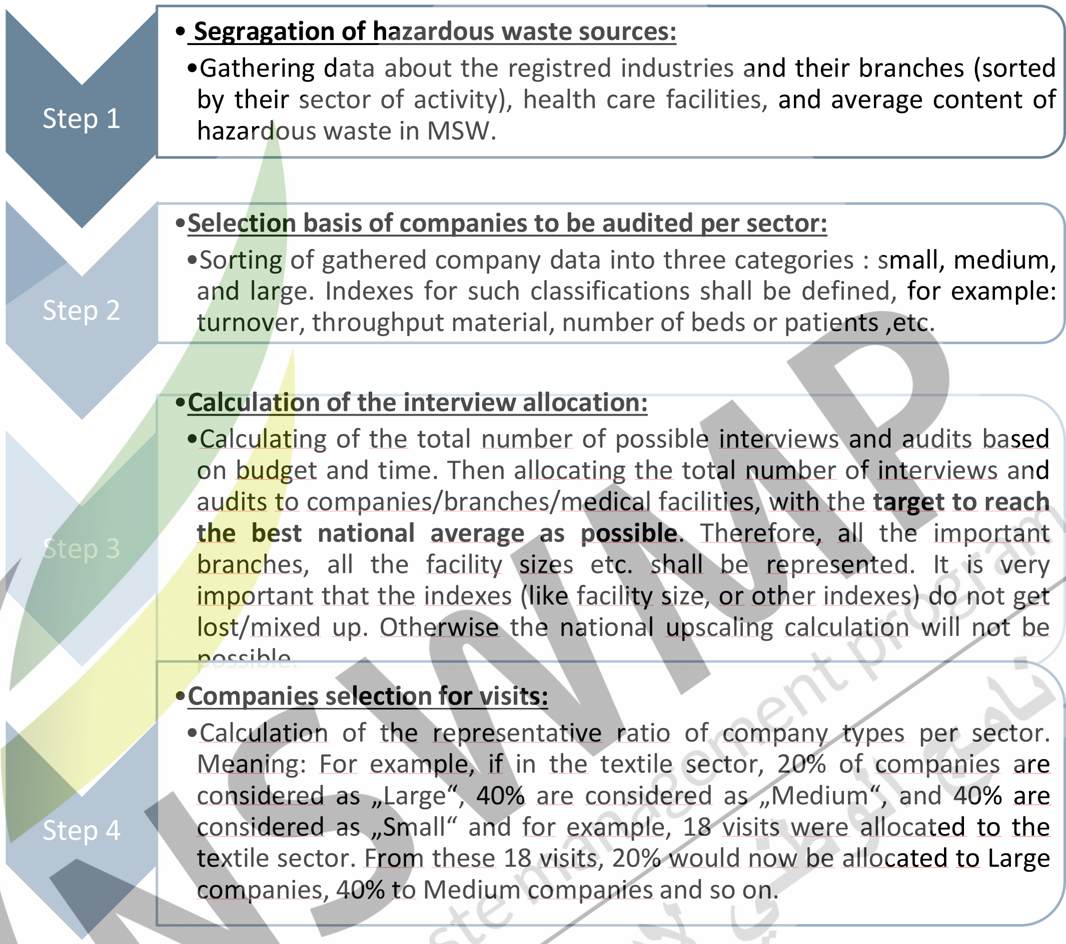


Figure 10-1 Methodology used in Jordan for hazardous waste data gathering (Source: BFS, 2020)

10.4. List of processes generating hazardous wastes in Egypt

Table 10-4 List of main industrial activities, processes and generated hazardous waste types in Egypt (Source, MoE, 2020)[76]

#	Processes	Hazardous Waste
	Oil and gas industry	
1.	Petrochemical processes and pyrolytic operations	▪ Furnace/reactor residue and debris ▪ Tarry residues ▪ Oily sludge emulsion ▪ Organic residues ▪ Residues from alkali wash of fuels ▪ Still bottoms from distillation process ▪ Spent catalyst and molecular sieves ▪ Slop oil from wastewater
2.	Drilling operation for oil and gas production	▪ Drill cuttings containing oil ▪ Sludge containing oil ▪ Drilling mud and other drilling wastes
3.	Cleaning, emptying and maintenance of petroleum oil storage tanks including ships	▪ Oil-containing cargo residue, washing water and sludge ▪ Chemical-containing cargo residue and sludge ▪ Sludge and filters contaminated with oil ▪ Ballast water containing oil from ships.
4.	Petroleum refining/re-processing of used oil/recycling of waste oil	▪ Oily sludge/emulsion ▪ Spent catalyst ▪ Slop oil ▪ Organic residues from process ▪ Spent clay containing oil
5.	Industrial operations using mineral/synthetic oil as lubricant in hydraulic systems or other applications	▪ Used/spent oil ▪ Wastes/residues containing oil
	Metalwork industry	

[76] Technical Review Committee constituted by MoE

#	Processes	Hazardous Waste
6.	Secondary production and/or industrial use of zinc	▪ Sludge and filter press cake arising out of production of Zinc Sulphate and other Zinc Compounds ▪ Zinc fines/dust/ash/skimmings (dispersible form) ▪ Other residues from processing of zinc ash/skimmings ▪ Flue gas dust and other particulates
7.	Primary production of zinc/lead/copper and other non-ferrous metals except aluminum	▪ Flue gas dust from roasting ▪ Process residues ▪ Arsenic-bearing sludge ▪ Nonferrous metal bearing sludge and residue ▪ Sludge from scrubbers
8.	Secondary production of copper	▪ Spent electrolytic solutions ▪ Sludges and filter cakes ▪ Flue gas dust and other particulates
9.	Secondary production of lead	▪ Lead bearing residues ▪ Lead ash/particulate from flue gas
10.	Production and/or industrial use of cadmium and arsenic and their compounds	▪ Residues containing cadmium and arsenic
11.	Production of primary and secondary aluminum	▪ Sludges from off-gas treatment ▪ Cathode residues including pot lining wastes ▪ Tar containing wastes ▪ Flue gas dust and other particulates ▪ Wastes from treatment of salt slags and black drosses
12.	Metal surface treatment, such as etching, staining, polishing, galvanizing, cleaning, degreasing, plating, etc.	▪ Acid residues ▪ Alkali residues ▪ Spent bath/sludge containing sulphide, cyanide and toxic metals ▪ Sludge from bath containing organic solvents ▪ Phosphate sludge ▪ Sludge From staining bath ▪ Copper etching residues ▪ Plating metal sludge

#	Processes	Hazardous Waste
13	Production of iron and steel including other ferrous alloys (electric furnaces; steel rolling and finishing mills; Coke oven and by product plant)	▪ Sludge from acid recovery unit ▪ Benzol acid sludge ▪ Decanter tank tar sludge ▪ Tar storage tank residue
14.	Hardening of steel	▪ Cyanide-, nitrate-, or nitrite-containing sludge ▪ Spent hardening salt
	Chemical industry	
15.	Production of asbestos or asbestos-containing materials	▪ Asbestos-containing residues ▪ Discarded asbestos ▪ Dust/particulates from exhaust gas treatment
16.	Production of caustic soda and chlorine	▪ Mercury bearing sludge ▪ Residue/sludges and filter cakes ▪ Brine sludge containing mercury
17.	Production of mineral acids	▪ Residues, dusts, or filter cakes ▪ Spent catalyst
18.	Production of nitrogenous and complex fertilizers	▪ Spent catalyst ▪ Spent carbon ▪ Sludge/residue containing arsenic ▪ Chromium sludge from water cooling tower
19.	Production of phenol	▪ Residue/sludge containing phenol
20.	Production and/or industrial use of solvents	▪ Contaminated aromatic, aliphatic or napthenic solvents may or may not be fit for reuse ▪ Spent solvents ▪ Distillation residues
21.	Production and/or industrial use of paints, pigments, lacquers, varnishes, plastics, and inks	▪ Process wastes, residues & sludges ▪ Fillers residues
22.	Production of plastic raw materials	▪ Residues of additives used in plastics manufacture like dyestuffs, stabilizers, flame retardants, etc ▪ Residues and waste of plasticizers ▪ Residues from vinylchloride monomer production ▪ Residues from acrylonitrile production

#	Processes	Hazardous Waste
		▪ Non-polymerized residues
23.	Production and/or industrial use of glues, cements, adhesive and resins	▪ Wastes/residues (not made with vegetable or animal materials)
24.	Production of canvas and textiles	▪ Chemical residues
25.	Industrial production and formulation of wood preservatives	▪ Chemical residues ▪ Residues from wood alkali bath
26.	Production or industrial use of synthetic dyes, dye-intermediates, and pigments	▪ Process waste sludge/residues containing acid or other toxic metals or organic complexes ▪ Dust from air filtration system
27.	Production of organo-silicone compounds	▪ Process residues
28.	Production/formulation of drugs/ pharmaceuticals & health care product	▪ Process Residues and wastes ▪ Spent catalyst / spent carbon ▪ Off specification products ▪ Date-expired, discarded and off- specification drugs/ medicines ▪ 28.5. Spent organic solvents
29.	Production, and formulation of pesticides including stockpiles	▪ Process wastes/residues ▪ Chemical sludge containing residue pesticides ▪ Date-expired and off-specification pesticides
30.	Leather tanneries	▪ Chromium bearing residues and sludges
31.	Electronic Industry	▪ Process residues and wastes ▪ Spent etching chemicals and solvents
32.	Pulp & Paper Industry	▪ Spent chemicals ▪ Corrosive wastes arising from use of strong acid and bases ▪ Process sludge containing adsorbable organic halides [AOx]
33.	Disposal of barrels / containers used for handling of hazardous wastes / chemicals	▪ Chemical-containing residue arising from decontamination. ▪ Sludge from treatment of wastewater arising out of cleaning / disposal of barrels / containers ▪ Discarded containers / barrels / liners contaminated with hazardous wastes/chemicals

#	Processes	Hazardous Waste
34.	Purification and treatment of exhaust air, water & waste from the processes in this schedule and common industrial effluent treatment plants (CETP's)	▪ Flue gas cleaning residue ▪ Spent ion exchange resin containing toxic metals ▪ Chemical sludge from wastewater treatment ▪ Oil and grease skimming residues ▪ Chromium sludge from cooling water
35.	Purification process for organic compounds/solvents	▪ Filters and filter material which have organic liquids in them, e.g. mineral oil, synthetic oil, and organic chlorine compounds ▪ Spent catalyst ▪ Spent carbon
36.	Hazardous waste treatment processes, e.g. incineration, distillation, separation, and concentration techniques	▪ Sludge from wet scrubbers ▪ Ash from incineration of hazardous waste, flue gas cleaning residues ▪ Spent acid from batteries ▪ Distillation residues from contaminated organic solvents

10.5. Ministries involved in hazardous waste management in Egypt

The Ministry of Environment (MoE) is responsible for defining environmental policies, setting priorities, and implementing initiatives within a context of sustainable development. MoE works in close collaboration with the national and international development partners. The EEAA and WMRA are the two executive arms of the Ministry having different functions as per environmental law 4/1994 amended by Law 9/2009 and decree 3005/2015 for the establishment of WMRA. The MoE along with EEAA are responsible for the overall management of HW in Egypt and WMRA is the main regulatory authority.

According to the executive regulations of the environmental law 4/1994 amended by Law 9/2009 (Article 25), it is prohibited to handle hazardous materials and wastes without a license issued by the competent authority as follows:

- Agricultural hazardous waste: Ministry of Agriculture;
- Medical and healthcare hazardous waste: Ministry of health and population;
- Industrial hazardous waste: Ministry of Trade and Industry;
- Petroleum hazardous waste: Ministry of Petroleum;
- Hazardous materials and waste that emit radiation: Ministry of Electricity - Atomic Energy Authority;
- Explosive and flammable hazardous materials and waste: Ministry of Interior;
- Other hazardous materials and wastes: A decision is issued by the minister for environmental affairs to determine the competent authority to issue a license for handling, based on the proposal of the EEAA (under the Ministry of Environment - MoE).

Each Minister of the above ministries shall issue a table of hazardous materials and waste, each within the scope of his competence in coordination with the Minister of Health and Population and the EEAA under the MoE. The table should include:

- The type of hazardous materials and wastes that fall within the scope of the ministry's jurisdiction and the degree of severity of each;
- The controls to be observed when handling the hazardous waste;
- The method of disposing empty packages of these materials after handling them;
- Any other controls or conditions that the Ministry deems important to add.

<u>**Summary of roles and responsibilities of different ministries in HWM as per national laws**</u>

<u>All ministries mentioned above (Agriculture, Health, Trade and Industry, Petroleum, Electricity & Interior):</u>

- Issue a table for hazardous substances and waste under their jurisdiction in coordination with the EEAA and the Ministry of health and Population (reviewed by EEAA);

- Issue licenses for handling hazardous substances and waste (based on the table mentioned earlier).

Role of Ministry of health and population related to hazardous healthcare waste management (in addition to the above):

- Issue guidelines and controls for hazardous waste handling. For example, guidelines and instructions on cleaning hazardous waste containers after each use;
- Provides consultation for Governorates prior to issuing permits for the establishment of hazardous waste treatment facilities;
- Provides consultation for the Ministry of Utilities and Urban Communities (MoHUUC) prior to issuing permits for the locations and conditions of disposal of hazardous waste.
- Provides consultation for all relevant ministries on conditions required to issue permits for handling hazardous substances and wastes.

Role of Ministry of Local Development:

- Provides consultation for Governorates prior to issuing permits for the establishment of hazardous waste treatment facilities.

Role of MoHUUC:

- The Minister of Housing, Utilities and Urban Communities determines the locations and conditions for issuing licenses for the disposal of hazardous waste after taking the opinion of the competent ministry, the Ministry of Health and Population and the EEAA.

In addition to the above, representatives from the following ministries are members in the board of directors of WMRA headed by the Minister of Environment: Ministry of Local Development, Ministry of Agriculture, Ministry of Trade and Industry, Ministry of Housing Utilities and Urban Communities, Ministry of Health and population, Ministry of Defense, Ministry of Interior, and Ministry of Military Production.

Finally, a protocol/agreement was signed on the 6th of June of this year between the MoE and MoID to enhance coordination between EEAA and the IDA. The agreement comes within the framework of the two ministries' desire to enhance cooperation and achieve integration between the licensing, monitoring and inspection stages for industrial establishments, in a way that contributes to encouraging industrial investments while providing a safe and healthy environment.

10.6. Lists of hazardous waste responsibility per ministry

Table 10-5 List of hazardous waste per Ministry (Source: WMRA, 2020)

<table>
<tr><th>Ministry of Health</th></tr>
<tr><th>Infectious waste</th></tr>
<tr><td>1. It is waste that contains infectious germs (bacteria - viruses - parasites - fungi) such as:
▪ Cultures, farms, and bacteriological, viral, and laboratory experimental animals;
▪ Waste of isolation patients (infectious diseases);
▪ Waste of the dialysis room;
▪ Operation rooms waste such as masks, shoe covers, gloves, etc.;
▪ Dental clinics waste, such as syringes, mugs, gloves, etc.;
▪ Contaminated tools such as curtains of all kinds - contaminated medical gauze and cotton refills - blood transfusion devices;
▪ Gypsum and tool kits from waste contaminated with the patient's body fluids and patient secretions.
2. Pathological waste:
▪ Waste of delivery rooms, the most important of which is the placenta;
▪ Human organs and human tissues;
▪ Removed tumors;
▪ Blood and body fluids. It is classified as an infectious waste even though it contains healthy parts, tissues, and human organs, and it needs special care in its disposal.
3. Special, piercing or scratching tools for contaminated skin:
▪ Causes skin wounds - scratches - puncture. Such as syringes - lancets - equipment solutions - broken glass, whether or not tainted - ampoules, slides, etc.</td></tr>
<tr><th>Chemical hazardous waste</th></tr>
<tr><td>4. It is waste containing or consisting of chemicals that do not conform to specifications or which have expired according to the list of hazardous materials of the Ministry of Health and Population. It is divided into:
▪ Pharmacokinetics: Waste resulting from the production and preparation of pharmaceutical products, including pharmaceutical products that do not meet specifications or have expired. The most dangerous of them are drugs that affect genes: such as cancer treatment medications;
▪ Emerging waste: On the production, installation and use of household and public health pesticides that are not in conformity with specifications, which have expired, or that are not suitable for the intended use originally;
▪ Waste of research and testing laboratories and the waste of equipment and detergents: It is either solid, liquid, or gaseous.
5. The effects of this waste:
▪ Poisonous;
▪ Caustic;
▪ Flammable;
▪ Explosive;</td></tr>
</table>

- Corrosive.

6. Among the most famous hazardous wastes resulting from medical activity:
   - Formaldehyde;
   - Chemical waste in displaying and fixing x-rays;
   - Organic solvents: such as methylene chloride, chloroform;
   - Organic chemical waste, such as some disinfectants and detergents;
   - Inorganic chemical waste: acids and alkalis such as sulfuric acid - hydrochloric - nitric-hydroxide.
7. Waste containing heavy metals: It is very toxic, such as:
   - Mercury compounds: Produced from some broken medical devices such as thermometers - damaged blood pressure monitors - residual dental restorations;
   - Cadmium: from batteries-electrodes;
   - Radiology waste: (used or damaged films).

Radioactive waste

8. Waste containing or consisting of radioactive materials:
   - Unused Radium UR-226;
   - Exhausted Technium-99 Generators;
   - Unused Cobalt Tablets-60;
   - Unused Therapeutic Cobalt - 60.
9. Solid or liquid waste resulting from the use of the following isotopes:
   - Trinium;
   - Sodium – 22;
   - Phosphorus-32;
   - Chlorine – 36;
   - Calcium – 47;
   - Cobalt – 57;
   - Iron – 59;
   - Selenium – 75;
   - Petrium- 90;
   - Iods – 125;
   - Xenon – 197;
   - Mercury – 203;
   - Carbon – 14;
   - Sulfur – 25;
   - Calcium – 45;
   - Chrome – 51.

All of these isotopes are used in medical measurements and biological research except chlorine - 36 only used in biological research.

- Other radioactive isotopes may be generated and result in waste;
- All radioactive waste is dangerous if a person is exposed to radiation without necessity and are very dangerous if a person gets contaminated from the outside or the inside;
- Any radioactive waste released to the environment ultimately ends up in a human body;

▪ Radioactive waste is dealt with through trained and specialized personnel and they are retrained; ▪ The Atomic Energy Commission takes over the receipt, treatment, and permanent reservation of these wastes.
Packaging waste
▪ Container waste and containers containing any of the hazardous waste included in this list and containing any of the dangerous substances listed in the list of hazardous materials for the Ministry of Health and Population; ▪ Waste aerosol packaging containing any of the dangerous substances listed on the Ministry of Health list or pesticides; ▪ It follows its importance that it can explode if placed in a crematorium.
Ministry of Industry and Technological Development
Metal and metal-containing wastes
10. Metallic wastes and waste consisting of any mixture of any of the following: ▪ Antimony; ▪ Arsenic; ▪ Beryllium; ▪ Cadmium; ▪ Lead; ▪ Mercury; ▪ Selenium; ▪ Tellurium; ▪ Thallium. 11. Except for clean, untainted scrap metal which includes the following metal that come in mixtures and in bulks: ▪ The antimony scrap and its compounds; ▪ The beryllium scrap and its compounds; ▪ Cadmium scrap and its compounds; ▪ Lead scrap and his vehicles; ▪ Selenium scrap and its compounds; ▪ Tellurium scrap and his compounds. 12. Waste containing elements or pollutants from any of the following: ▪ Arsenic and its compounds; ▪ Mercury and its compounds, ▪ Thallium and its compounds; ▪ Metallic carbonate; ▪ Hexavalent chromium compounds. 13. Galvanic sludges. 14. Liquid solution waste from chemical surface clean-up operations (Pickling). 15. Residual washing and dissection from zinc, dust, resulting sludge, jarosite, hematite, and succession. 16. Zinc residues, containing lead and cadmium at concentrations sufficient to demonstrate a hazardous characteristic. 17. Ash from the burning of isolated copper wire. 18. Dust and residues from gas filtration systems in copper smelters.

19. Electrolytic solutions resulting from electrolysis, copper extraction using electricity. 20. Sludge wastes resulting from the purification and extraction of copper by electrical analysis, with the exception of anode deposits. 21. Used corrosive solutions (H solutions) containing molten copper. 22. Copper chloride wastes and catalysts for copper cyanide. 23. Precious-metal ash from printed circuit boards. 24. Waste lead acid batteries excluding lead scrap extracted from batteries on condition that they are clean and in a non-deformation state. 25. Unclassified batteries. 26. Waste resulting from assembly operations of electrical or electronic or scrap containing components of the accumulator batteries blocked and the keys of the connectors mercury glass composite pipe by the cathode rays and other types of Glass product and a couple of PCB and PCB or contaminated with any hazardous elements concentrations sufficient to exhibit one of the hazardous characteristics.
Wastes containing inorganic elements that may contain metals and organic substances
27. Glass breaking from LPL lamps and other activated glass. 28. Non-organic fluorine wastes in the form of liquids or sludge. 29. Waste catalysts. 30. Cast wastes from industrial processes contaminated with hazardous elements to the extent that they acquire any of the hazardous characteristics. **31.** Asbestos waste.
Wastes containing organic elements that may contain metals and organic substances
32. Wastes resulting from the production or processing of Petroleum and bitumen Cook. 33. Waste metal oils not suitable for their original use. 34. Thermal fluid waste (heat transfer operations). 35. Waste from production, preparation and use of resins, latex, plastics, and adhesives. 36. Nitrite cellulose waste. 37. Phenol waste and compounds. 38. Ether waste and compounds. 39. Waste dust ash, sludge particles of flour caused by the leather industries waste report and other waste of leather or of composition leather not suitable for the manufacture of products of leather containing chromium compounds hexavalent valence or amount of biological or infectious material and the web of light output from torn leather. 40. Organophosphorus waste. 41. Organic solvents wastes, whether halogenated or non-halogenated. 42. Non-aqueous distillation waste - halogenated and non-halogenated-resulting from organic solvents recovery processes. 43. Waste resulting from the production of aliphatic hydrocarbons halogenated like chlorine methane, and bilateral ethylene dichloride, vinyl chloride, and chloride feed, the chloride allyl, and hypochlorite. 34) Wastes, materials and equipment containing, or consisting of, or contaminated with polychlorinated biphenyls (PCBs), polychlorinated terphenyls (PCT), polychlorinated biphenyls (PCN), polybrominated biphenyls (PBBs) or any polybrominated biphenyls equivalent to these compounds.

Waste containing organic or inorganic elements
44. Waste from the production and editing of pharmaceutical products including non-conforming or expired. 45. Wastes arising from the production and preparation of pesticides. 46. Wastes resulting from the manufacture, preparation and use of wood preservative chemicals. 47. Wastes containing, consisting of, or contaminated with organic or inorganic cyanide compounds. 48. Waste oil and water mixtures, hydrocarbon and water mixtures and mileage. 49. Waste from the production, preparation and use of inks, dyes, paints, lacquers, and varnish. 50. Acidic or base solution wastes, with hydrogen acidic acid less than 2 or more than 11.5. 51. Waste from industrial pollution control devices to clean gas from factories. 52. Waste containing or compound from, or contaminated with, any of the following: 53. - Any complexes that are homogeneous for the dual sensor multiple PCBs Polychlorinated di-benzo-furan. 54. Any complexes that are homogeneous for a couple benzodioxane multiple PCBs Polychlorinated di-benzo-dioxin. 55. Waste containing or synthesized from or contaminated with peroxides. 56. Waste containers and containers containing or contaminated with any hazardous substance or hazardous waste. 57. Waste consisting of or containing hazardous chemicals non-conforming or expired. 58. Waste chemicals resulting from research and development activity plants at industrial plants. 59. used active carbon. 60. Waste containing, and / or consisting of, chlorofluorocarbons (CFCs). 61. PVC wastes. 62. Metal-containing residues arising from the melting, smelting and purification of metals: 63. - Zinc and aluminium activities. 64. Waste from copper manufacturing containing arsenic, lead and cadmium. 65. Films and papers photographic corrupted containing silver halide and silver metal or the ashes of the precious metals resulting from the burning of photographic film. 66. Fabrics, cleaning materials, absorbent materials, filters, protective clothing contaminated materials or hazardous waste. **67.** Scrap plastic (plastic) of polymers non-halogenated or polymers involved, (not polymerized completely and the remnants of post-consumer).
Ministry of Agriculture
68. Expired agricultural pesticides. 69. Expired agricultural fertilizers. 70. Expired Plant Growth Regulators. 71. Exhausted pesticides and veterinary tools. 72. Agricultural pesticides that do not meet the specifications of the Food and Agriculture Organization. 73. Agricultural fertilizers that do not meet the specifications of the Ministry of Agriculture and the Food and Agriculture Organization.

74. Plant growth regulators that do not meet the specifications of the Ministry of Agriculture and the Food and Agriculture Organization.
75. Pesticides and veterinary medicines that do not meet the specifications of the Food and Agriculture Organization and the Ministry of Agriculture.
76. All empty packages for agricultural pesticides.
77. All empty packages for agricultural fertilizers.
78. All empty packages for plant growth regulators
79. All empty packages for pesticides and veterinary medicines.
80. Waste of laboratories and research centers affiliated with the Ministry.
81. Agricultural chemical waste issued by ministerial decisions prohibiting use and attached to this list.

Ministry of Interior

82. Mercury Fulminate.
83. Lead Azide.
84. Silver Azide.
85. Barium azide.
86. Cyanuric Triazide.
87. Tetrazine.
88. Dianol.
89. Lead Acetate.
90. Hexa Methyl Tetra Pyroxy Diamin.
91. Nitromannite.
92. Nitrogen Sulfide.
93. Nitrogene Selenide.
94. 1,3,5-Trinitrobenzene.
95. Picryl Chloride.
96. Trinitrotoluene.
97. Naphta.
98. Picric Acid.
99. Picramide.
100. Ammonium Picrate.
101. Styphnic Acid.
102. 2,3,4,6-Tetranitroaniline.
103. Chrysolite.
104. Methyl picrate.
105. Ethyl picrate.
106. 2,4,7-Trinitro-9-fluorenone.
107. 4-Nitro-1H-benzotriazole.
108. 2,4,6-Trinitrobenzoic Acid.
109. bichlorure urea.
110. Hexanitrostilbene.
111. Dipicryl sulfide.
127. Guanidine picrate.
128. Octogene.
129. Nitrosoguanidine.
130. Nitroguanidine.
131. Nitrourea.
132. Trinitro trimethyl nitromethane.
133. Cyclo pentanitrate tetramethyl pentanol.
134. Pure ammonium nitrate (nitrogen level above 34.2%).
135. Ammonium perchlorate.
136. Guanidine perchlorate.
137. Dynamite (All kinds and forms).
138. Ammonpulver explosives.
139. Chlorate and perchlorate explosive mixtures.
140. Emulsion explosives.
141. ANFO (Ammonium nitrate-fuel oil) explosives.
142. Clay explosives.
143. Liquide oxygen explosives.
144. Plastic explosives.
145. Black powder.
146. Smokeless powder (All sections).
147. Fire mixtures (fireworks of all compositions).
148. Explosive mixtures containing one or more of the above.
149. Explosive or cracker mixtures, consist of materials that do not have any explosive properties in themselves.
150. Sodium Nitrate.
151. Potassium Nitrate.
152. Sodium Chloride and Perchlorate.
153. Potassium Chlorate and Perchlorate.
154. Concentrated Nitric Acid (above 70%).

112. Dinitroresorcinol. 113. Dipicrylamine. 114. Hexanitroazobenzene. 115. Hexanitroxanilide. 116. Trinitroglycerin. 117. Dinitroglycol. 118. Dinitrodiglycol. 119. Dinitrotriglycol. 120. Propylene glycol dinitrate. 121. Ammonia Nitrate. 122. Pentanitro. 123. Dipenta. 124. Nitrocellulose. 125. Hexogene. 126. Tetryl.	

10.7. Hazardous waste regulations in Egypt and International Conventions

Table 10-6 Hazardous Waste Legislations in Egypt and International Conventions (Source: BFS, 2020)

Regulation	Description
Environmental Law n°4 of year 1994, as amended by Law n°9 for year 2009	It defines terms related to HWM such as hazardous waste, substance handling, waste management, waste disposal, and waste recycling. The second chapter of this law was allocated for "materials and hazardous waste". It regulated hazardous waste trading by prohibiting all transboundary shipments without a licence.[77]
Executive regulation of the law of the environment issued by decision of the prime minister n°338 for the year 1995	It allocates responsibilities to authorities and administrative bodies for hazardous waste trading and handling, which was not mentioned in the environmental law. For example, the MoE was henceforth the "competent administrative authority". This meant that it is the authority responsible for issuing hazardous and industrial waste trading licences. In addition to that, each minister was assigned to issue a hazardous waste schedule in coordination with the EEAA. This schedule includes the types of hazardous materials generated by each sector, its disposal methods, the relevant trading regulations, among others. Several articles were also allocated to set general rules for the handling and disposal of hazardous waste.[78]
Executive regulation for the law of the Nile river protection issued according to the decision n°8 for the year 1982	One of the most serious and complicated problems faced in Egypt is the protection of water quality from degradation. The fresh waters of the main stem of the River Nile and many of the irrigation canals and agricultural drains are subject to municipal and industrial wastewater with no, or inadequate, treatment. Law 48 of 1982 governs the discharge of wastes and wastewater into the Nile and its waterways and sets standards for the quality of these discharge effluents. The law outlines the responsibilities of the ministry of water resources and irrigation and of other concerned ministries[79].

[77] Review of existing regulations and legislations addressing the area of Industrial waste management in Egypt By Ihab Tarek, PhD.Judge Environmental Legislations Expert 2016

[78] Review of existing regulations and legislations addressing the area of Industrial waste management in Egypt By Ihab Tarek , PhD.Judge Environmental Legislations Expert (2016)

[79] Revision of law 48 of 1982 for the protection of the Nile river and its waterways from pollution tranche III water benchmark c8 report (report no. 21)

Regulation	Description
Basel convention	Egypt is, since 2004, a party of the Basel Convention, which regulates the transboundary movement of hazardous waste. This commitment implies that: ▪ Egypt must reduce to the lowest possible intensity the transboundary movement of hazardous waste ▪ All movements of HW must be conducted in a manner that protects human health and the environment ▪ All exports of HW from Egyptian industrial establishments for treatment or recycling shall take place only upon approval of the EEAA
Stockholm Convention	In 2002, the Egyptian government signed the international environmental treaty on persistent organic pollutants (POPs), also referred to as the Stockholm Convention, which aims to restrict the production and use of POPs considering their severe harmful effects on human health and the environment. In this context and amongst the efforts made by Egyptian authorities to the threat of chemicals management challenge, the EEAA and German Federal Ministry of the Environment, Nature Conservation and Nuclear Safety (BMU) implemented the Egyptian-German Twinning project “Development of Integrated Hazardous Substances and Waste Management System for the Egyptian Environmental Affairs Agency (EEAA) – EG07/AA/EN10“ between December 2008 and May 2011. The purpose of the Egyptian-German Twinning was to improve the beneficiary’s capacities in: ▪ Institutional and policy development ▪ Development of an Egyptian legal framework on waste and HS management that is harmonised with relevant EU regulations and ready for implementation ▪ Human resources development ▪ Development of an integrated system for a more efficient management of hazardous substances and waste ▪ Strengthening EEAA’s institutional and policy capacities ▪ Adapting relevant EU best practices in the field of waste and HS management[80]
Minamata Convention	The Minamata Convention on mercury is a global treaty to protect human health and the environment from the adverse effects of mercury which entered into force in 2017.
Bamako Convention	The Bamako Convention is a treaty of African nations prohibiting the import into Africa of any hazardous (including radioactive) waste. The convention came into force in 1998 and is a response to Article 11 of

80 Recommendations on Chemicals Management Policy and Legislation in the framework of the Egyptian-German Twinning Project on Hazardous Substances and Waste Management

Regulation	Description
	the Basel convention which encourages parties to enter into bilateral, multilateral, and regional agreements on HW to help achieve the objectives of the convention. The impetus for the Bamako convention arose also from: ▪ The failure of the Basel Convention to prohibit trade of hazardous waste to less developed countries (LDCs) ▪ The realization that many developed nations were exporting toxic wastes to Africa (Koko case in Nigeria, Probo Koala case in Ivory Coast)[81] Egypt's Ministry of Environment has participated in the third Conference of the Parties (COP-3) to the Bamako Convention in Brazzaville, Republic of Congo. The Egyptian delegation revised the measures that Egypt has adopted with regard to the sound management of hazardous materials and waste, banning their import into Africa and controlling of their trans-boundary movement. The delegation shed light on the national projects that Egypt is implementing in the field of e-waste, medical waste and POPs residues management in a way that copes up with the country's vision of sustainable development.

[81] UNEP 1998, "The Bamako Convention". Online available at https://www.unenvironment.org/explore-topics/environmental-rights-and-governance/what-we-do/meeting-international-environmental. (last consulted 24/09/2020)

10.8. Hazardous waste related German regulations

Table 10-7 German legislation related to HWM (Source: BFS, 2020)

Regulation	Description
Directive on Waste (2008/98/EC)	Established in 2008, this directive presents definitions, perceptions, and obligations for waste management in the EU. It represents the legal basis of waste management within Europe, aiming to improve recycling rates and to protect human health, the environment, and resources. In regard to hazardous waste, the directive mainly covers the following stipulations: ▪ It clearly defines the criteria which labels a waste as hazardous (for example toxicity, flammability, etc.) and which tells hazardous from non-hazardous wastes apart ▪ It introduces a classification system for waste categories ▪ It introduces the producer pays regulation which obliges the producers to take responsibility for their obsolete products ➔ These provisions were integrated into the German circular economy act. The classification of hazardous waste was a major step towards the regulation of its packaging, storage, transportation, and transhipment.
Waste Shipment Regulations (Reg. (EC) 1013/2006)	In all European Union states, the transshipment of waste is regulated following the Basel Convention. The waste shipment regulation (WSR) monitors the transboundary movement of waste within, into and out of European countries. Through the Reg. (EC) 1013/2006, the council of the EU has established rules to reduce and control the movements of waste. In regard to hazardous waste, WSR has set up the following rules: ▪ Every trans-frontier movement of waste requires a prior written notification providing information about the classification of waste and intended disposal method ▪ In addition to the notification, Waste Shipment Regulations (WSR) specified types of waste that require consent of the destination country ▪ WSR has also listed the countries to which the shipment of hazardous waste for recovery or disposal is prohibited
Landfill Regulation (Dir. 1999/31/EC)	In Germany, the disposal of waste at landfill sites is the last resort to be considered in the waste management system and is exclusive to non-recyclable waste. According to Dir. 1999/31/EC, landfills were divided into 3 classes: landfills for hazardous waste, landfills for non-hazardous waste, and landfills for inert waste. It has also set acceptance criteria for waste in each landfill class. The transpose of the EU regulations into German law was accomplished, in 2001 and 2002, via enactment of the *Abfallablagerungsverordnung and*

	Deponieverordnung (waste storage regulation and landfill regulation), which were supplemented in 2005 by the *Verordnung über die Verwertung von Abfällen auf Deponien* regulation. In 2009, a simplified regulation was enacted (*Deponieverordnung vom 27. April 2009*). This regulation has been oft updated, whereby the most recent changes came into effect in 2016[82]. ➔ Laying down strict criteria for sanitary landfills such as mandatory treatment before disposal and ban of landfilling for certain types of waste has led to increasing the number of waste recycling facilities, treatment plants and incinerators, therefore, decreasing the landfilling rates in Germany.
Incineration Regulation (Dir. 2000/76/EC)	This directive aims at imposing strict operation conditions and technical requirements on waste incineration and co-processing plants to limit the pollutant emissions from these processes. In Germany, this regulation was transposed on the country's ordinance for the implementation of the Federal Emission Control Act (17. BlmSchV). ➔ Thermal treatment is the pillar of waste treatment in Germany. The country has numerous types of installations dedicated to different kinds of waste where energy is recovered to generate heat and/or electricity. These facilities follow the EU directive 2010/75/EU that regulates emissions control for thermal treatment facilities and presents BAT reference documents, which set regulations for facilities to improve their environmental performances.
Integrated Pollution Prevention and Control (IPPC) (Dir. 2008/1/EC)[83]	This directive aims at setting standard rules in the European Union to control and minimize pollution from industrial installations. Existing installations must comply with environmental requirements set up by the IPPC directive, and new ones are required to obtain a permit from the responsible authority at each country. ➔ In Germany, each federal state is responsible for issuing permits, monitor and inspect the industrial facilities at its territory. The prosecutor is responsible for enforcement and prosecution of relative laws.

[82] Umweltbundesamt (2016), "Landfill". Online Available at: https://www.umweltbundesamt.de/en/topics/waste-resources/waste-disposal/landfill (last consulted: 24/09/2020)

[83] Environment (2019) : Online Available at: https://ec.europa.eu/environment/archives/guide/part2f.htm (last consulted: 24/09/2020)

10.9. Function table of a digital waste tracking system

Table 10-8 Main functions of digital waste tracking system (Soure: BFS, 2020)

Functions	
Manage stakeholders	Identify and authorize all the stakeholders, including generators, transporters, and treatment centres. The administrator will create and maintain accounts at two levels. The first is the stakeholder level (e.g. a specific hospital, or a specific transporting company, or a specific treatment centre) such as the name, contact person, regulator, and other details. The second level will be to create and maintain user accounts for individual persons at each stakeholder that are authorized to use the solution.
Capture transaction details	For each shipment, the authorized user from the generator will enter particular information about the waste being shipped, including the type of waste, quantities, and packaging mode. Once the transporter arrives to collect the shipment, the transporter authorized user will confirm the collection of the waste and will capture the quantities and packaging mode. Last, once the shipment arrives at its final destination, the authorized user at the treatment centre will confirm receipt of the shipment noting the type of waste, quantities, and packaging mode. Dates and times, as well as usernames will be captured by the system automatically.
Trigger alerts	The solution will have the capability to trigger alerts and send notifications to specific persons. Such alerts will be based on pre-set rules, for example, if the information about a shipment as entered by the treatment centre is different than the information entered by the generator or the transporter.
Track shipments	Allow WMRA users to track information, such as single or multiple vehicles, or single or multiple shipments, or to view information based on a specific generator, transporter, or treatment centre. Where a single vehicle transports multiple shipments collected from different generators, the solution will differentiate between the location where each shipment was collected from. This function should function both for actual real-time and historic data. Selected users from stakeholders will also be able to use this function, but only for shipments that they were involved in (either as generator, transporter, or treatment centre).
Analysis	The WMRA users will be able to search based on all the shipment transaction parameters. The user may filter the results such as stakeholder type, actual stakeholders, types of waste, packaging mode and date ranges. WMRA users will also be able to specify spatial analysis parameters (buffer, intersect etc.) when searching for shipments, in combination with other search parameters. Results of all types of searches will be viewed in a map interface. Selected users from stakeholders will also be able to use this function, but only for

	shipments that they were involved in (either as a generator, transporter, or treatment centre).
Reporting	Create reports based on an existing stored report template, or to illustrate the results from the Analysis function. Reports may include map insets. This function includes exporting tabular results into an Excel format.

10.10. Technical specifications from hazardous waste collection vehicle

Fixed Box Body *"Mobile Collection of Hazardous Waste"*

Completely insulated cell of plastic compound with access by extendable access platform at truck

Nominal length of Body (acc. DIN)	6,500 mm
Width of Body:	2,550 mm
Height of Body:	2,600 mm (max.)
Length of cargo space:	6,420 mm
Width of cargo space:	2,450 mm
Inner Height:	2,150 mm
Body:	Fixed to truck, i.e. not removable
Equipment inside:	acc. to TRGS 520, incl. certificate
Incl. anti-spillage floor pan	acc. to German "Water Protection Act" ("Wasserhaushaltsgesetz")

The container offers space for the following cargo, including design for cargo fixing acc. To German federal regulations (ASP containers and barrels are quoted optionally):

- ASP containers (max. 800L);
- Clamping ring lidded barrels 120 L;
- Clamping ring lidded barrels 60 L;
- Clamping ring lidded barrels 30 L:
- Box for Fluorescent tubes.

10.11. Examples of EPR functioning systems in the EU

BATTERIES		AT	BE	DK	FR	NL	CH
Type of PRO responsibility		Partial organisational responsibility					
COMPETITION							
Is there competition among PROs?		Yes, 4 PROs	No, only 1 PRO	Yes, 4 PROs	Yes, 2 PROs + 1 individual scheme	No, only 1 PRO	
Is there competition among WM operators?		Transport: yes Treatment: No	Yes	No	Yes.	Transport: Yes Treatment: No.	
TRANSPARENCY AND SURVEILLANCE							
Surveillance of free-riding	How many free riders are there?	There seems to be no free rider problem	Exact percentage unknown, but probably low	N/A			
	Which sanctions are provided?	Fine of double the amount	The PRO informs the regional government	Fines and prison sentences	Fines or criminal sanctions	N/A	Retroactive charge of the due fees
Surveillance of collection and treatment operations		The federal authority and audits by the PROs	Regional governments	N/A	The National Authority verifies declarations and coherence. PROs audit on actors for which there are unusual variations	N/A	Collection points are audited by regional authorities. National authorities undertake controls of treatment activities
Surveillance of PROs	Who is in charge?	A coordination unit	Regional governments	Ministry of Environment	A consultative commission	N/A	The federal government
	How?	6 % of the total system costs are monitoring costs	1/3 of the declarations are audited yearly	Through the DPA-System	The National Authority audits 15 to 20 producers per year	N/A	
PRO's status	profit-based or not-for-profit?	3 are non-profit. 1 is for-profit	Non-profit	Elretur is non-profit Others: no clear trend	Non-profit		

Figure 10-2 Examples of EPR functioning systems for batteries (Source: European Commission, 2014)[84]

[84] European Commission (2014), "Development of Guidance on Extended Producer Responsibility (EPR)".

WEEE		DK	FI	FR	IE	LV	SE	UK
Type of PRO responsibility		HH: Partial organisational responsibility C&I: Mostly individual systems[11]	Full organisational responsibility	HH: Full organisational responsibility C&I: Possibility to delegate it to the end-user	Partialorganisational responsibility	Full organisational responsibility	Partial organisational responsibility	
COMPETITION								
Is there competition among PROs?		Yes, 3 Pros in competition. Only 1 PRO for lamps	Yes, between 3 collective schemes	HH: Yes, 3 PROs in competition. Only 1 PRO on lamps C&I: yes, 4 PROs in competition	2 PROs in competition. Operation-wise, though, they cover different geographical areas.	4 PROs in competition. Only 1 PRO for lamps	Yes, 2 PROs in competition	Yes, 39 PROs
Is there competition among WM operators?		Yes, selected by PROs	Yes, selected by PROs or individual compliers	Yes, selected by PROs	Yes, selected by PROs	Yes, selected by PROs	Yes, selected by PROs	Yes, however the system of interaction is complex
TRANSPARENCY AND SURVEILLANCE								
Surveillance on free-riding	How many free riders are there?	Not estimated, but probably very few	No estimation	No estimation, probably few on HH EEE	No estimation	No estimation, but low	No estimation	
	Which sanctions are provided?	Prison sentence up to 2 years. Fines up to 1300€.	Possibilities of fine, but no penalties applied	Financial penalties.	Severe penalties are in place, at least in theory	A higher tax set for non-reporting or non-registerd	Financial sanctions	Financial penalties
Surveillance on collection and treatment operations		Operators must be environmentally approved	Facilities must be authorised	PROs must perform regular audits	PROs perform regular audits	Facilities must be authorised	N/A	Defra is in charge of the surveillance of operators
Surveillance on PROs		DPA-System carries out audits on the information provided by PROs and individual compliers	Collective schemes must be approved by the national implementation agency	PROs and the clearinghouse must be approved by the public authorities	All producers must be registered by the clearinghouse	Authorisation requirements include: the ability to fulfil certain tasks, enough capital reserves	The Environmental Protection Agency is in charge of surveillance and performs regular audits	Producer compliance schemes must seek approval from the Environment Agencies
PRO's status	profit-based or not-for-profit?	No specific requirements		Non-profit	Existing PROs are not-for-profit	All PROs are for profit	No specific requirement	
Any multi-stakeholder dialogue procedure?		No dialogue procedure identified		Consultation committee, regrouping all stakeholders	Monitoring group chaired by the public authority.	No dialogue procedure identified	Bilateral agreements	No dialogue procedure identified

Figure 10-3 Examples of EPR functioning systems for WEEE (Source: European Commission, 2019)[84]

10.12. European Waste Codes for Hazardous Waste from Construction and Demolition

17 06 INSULATION MATERIALS AND ASBESTOS-CONTAINING CONSTRUCTION MATERIALS

- 17 06 01 insulation materials containing asbestos;
- 17 06 03 other insulation materials consisting of or containing dangerous substances;
- 17 06 04 insulation materials other than those mentioned in 17 06 01 and 17 06 02;
- 17 06 05 construction materials containing asbestos.

17 08 GYPSUM-BASED CONSTRUCTION MATERIAL

- 17 08 01 gypsum-based construction materials contaminated with dangerous substances.

17 09 OTHER CONSTRUCTION AND DEMOLITION WASTES

- 17 09 01 construction and demolition wastes containing mercury;
- 17 09 02 construction and demolition wastes containing PCB (for example PCB containing; sealants, PCB-containing resin-based floorings, PCB-containing sealed glazing units, PCB containing capacitors);
- 17 09 03 other construction and demolition wastes (including mixed wastes) containing dangerous substances.

10.13. Treatment method according to EWC code

1_Mono-Incineration	2_Co-incineration	3_CPT (organic)	4_CPT (inorganic)	5_Biological	6_Recycling	7_Landfilling	8_Other	9_N.A. (Class IV landfill)	10_Unclear

EWC Code	EWC Description	Ideal treatment method
01 05 05*	oil-containing	5
01 05 06*	drilling muds and	5
02 01 08*	Agrochemical waste	1
03 01 04*	sawdust, shavings,	1
03 02 04*	Inorganic wood	1
04 02 16*	dyestuffs and	1
04 02 19*	sludges from on-site	1
05 01 03*	tank bottom sludges	2
05 01 04*	acid alkyl sludge	1
05 01 05*	oil spills	5
05 01 06*	Oily sludges from	2
05 01 09*	sludges from on-site	5
05 01 12*	oil containing acids	4
05 01 15*	spent filter clays	7
06 01 01*	sulphuric acid and	4
06 01 02*	Hydrochloric acid	4
06 01 04*	phosphoric and	4
06 01 06*	Other acids	4
06 02 01*	calcium hydroxide	4
06 02 04*	sodium and	4
06 03 13*	Solid salts and	1
06 05 02*	sludges from on-site	1
06 10 02*	Wastes containing	1
06 13 01*	Inorganic plant	1
06 13 02*	spent activated	7
07 01 01*	aqueous washing	3
07 01 04*	other organic	3
07 01 08*	Other still bottoms	1
07 01 09*	halogenated filter	1
07 01 10*	other filter cakes	1
07 01 11*	sludges from on-site	1
07 02 01*	aqueous washing	3
07 02 03*	organic halogenated	3
07 02 04*	other organic	3
07 02 08*	Other still bottoms	1
07 02 11*	sludges from on-site	1
07 02 14*	wastes from	1
07 02 16*	waste containing	1
07 04 01*	aqueous washing	3
07 06 03*	organic halogenated	3
07 06 08*	other sill bottoms	1
07 07 01*	aqueous washing	3
07 07 03*	organic halogenated	3
07 07 04*	Other organic	2
08 01 11*	waste paint and	2

EWC Code	EWC Description	Ideal treatment method
08 01 13*	sludges from	2
08 01 15*	aqueous	2
08 01 19*	Aqueous	1
08 01 21*	Waste paint or	2
08 03 12*	waste ink	2
08 03 14*	ink sludges	2
08 03 17*	waste printing	1
08 03 19*	disperse oil	1
08 04 09*	waste	2
08 04 11*	Adhesive and	1
08 04 15*	Aqueous liquid	1
08 05 01*	waste	1
09 01 01*	Water-based	6
09 01 02*	Water-based	6
09 01 03*	Solvent-based	6
10 01 04*	oil fly ash and	7
10 01 14*	bottom ash,	7
10 01 15*	bottom ash,	7
10 01 22*	Aqueous	1
10 02 13*	sludges and	1
10 04 01*	Slags from	7
10 08 17*	sludges and	1
10 11 15*	Solid wastes	7
10 11 17*	sludges and	1
10 13 12*	Solid wastes	7
11 01 05*	Pickling acids	4
11 01 06*	acids not	4
11 01 07*	pickling bases	4
11 01 09*	Sludges and	1
11 01 11*	Aqueous	1
11 01 13*	Degreasing	1
11 01 16*	Saturated or	2
11 01 98*	Other wastes	1
11 03 02*	Other wastes	1
11 05 03*	Solid wastes	7
11 05 04*	Spent flux	1
12 01 06*	Mineral-based	1
12 01 07*	Mineral-based	2
12 01 09*	Machining	3
12 01 14*	Machining	1
12 01 18*	Metal sludge	6
12 01 20*	spent grinding	1
120116*	waste blasting	1
13 01 10*	Mineral based	2
13 01 13*	other hydraulic	1
13 02 04*	waste not	1
13 02 05*	mineral-based	6
13 02 05*	mineral-based	6
13 02 06*	Synthetic	2
13 02 08*	Other engine	2
13 03 01*	Insulating or	1

EWC Code	EWC Description	Ideal treatment method
13 03 07*	Mineral-based	2
13 04 02*	Bilge oils from	6
13 05 01*	Solids from grit	2
13 05 02*	Sludges from	2
13 05 06*	Oil from	6
13 05 07*	oily water	3
13 05 08*	Mixtures of	1
13 07 01*	fuel oil and	6
13 07 02*	petrol	6
13 07 03*	Other fuels	1
13 08 02*	other	3
13 08 02*	other	3
13 08 99*	wastes not	1
14 06 01*	chlorofluoroca	8
14 06 02*	other	1
14 06 03*	other solvents	6
15 01 10*	packaging	2
15 01 11*	metallic	7
15 02 02*	absorbents,	2
16 01 04*	end-of-life	6
16 01 07*	oil filters	6
16 01 10*	Explosive	8
16 01 11*	Brake pads	7
16 01 13*	Brake fluids	6
16 01 14*	antifreeze	6
16 01 21*	hazardous	6
16 02 09*	Transformers	1
16 02 11*	discarded	6
16 02 13*	discarded	6
16 02 15*	Hazardous	1
16 02 97*	Other	10
16 03 03*	inorganic	10
16 03 05*	Organic wastes	1
16 04 02*	fireworks	8
16 04 03*	other waste	8
16 05 04*	gases in	8
16 05 05*	gases in	8
16 05 06*	laboratory	1
16 05 07*	Discarded	1
16 05 08*	discarded	1
16 06 01*	lead batteries	6
16 06 02*	Ni-Cd batteries	8
16 06 03*	other solvents	6
16 06 06*	separately	4
16 07 08*	Wastes	2
16 07 09*	Wastes	1
16 08 02*	spent catalysts	7
16 08 07*	spent catalysts	7
16 09 01*	permanganate	9
16 09 02*	chromates, for	1

EWC Code	EWC Description	Ideal treatment method
16 09 03*	peroxides,	1
16 10 01*	aqueous	4
16 11 03*	other	7
16 11 05*	linings and	7
17 03 03*	Coal tar or	1
17 04 10*	cables	8
17 05 03*	soil and	3
17 05 05*	dredging	3
17 06 01*	insulation	7
17 06 03*	other	7
17 06 05*	Constructio	7
17 09 03*	Other	7
18 01 03*	wastes	1
18 01 06*	Chemicals	1
18 01 98*	Unsorted	1
18 02 98*	Unsorted	1
19 01 07*	solid wastes	8
19 01 11*	bottom ash	7
19 01 13*	Fly ash	7
19 02 04*	Premixed	2
19 02 05*	Sludges	9
19 02 07*	Oil and	1
19 08 08*	Membrane	1
19 08 10*	grease and	2
19 08 11*	sludges	1
19 08 13*	sludges	1
19 11 01*	spent filter	7
19 11 05*	sludges	6
19 12 06*	Wood	1
19 12 11*	Other	2
20 01 13*	Solvents	3
20 01 14*	Acids	4
20 01 15*	Alkalines	4
20 01 17*	Photochemi	6
20 01 19*	pesticides	1
20 01 21*	fluorescent	8
20 01 27*	paint, inks,	1
20 01 29*	detergents	1
20 01 32*	medicines	1
20 01 33*	Batteries	8
20 01 35*	discarded	6
20 01 37*	wood contai	1
20 01 98*	Unsorted	1

Figure 10-4 Hazardous waste treatment method according to its EWC (Source: BFS, 2020)